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Building Automation System

M15950 – Building Automation System GENERAL

(THIS SECTION MUST BE REVIEWED PRIOR TO EACH PROJECT)

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1.03 DESCRIPTION OF WORK

A. CONTRACTOR SHALL FURNISH AND INSTALL A DIRECT DIGITAL CONTROL AND BUILDING AUTOMATION SYSTEM (BAS). THE NEW BAS SHALL UTILIZE ELECTRONIC SENSING, MICROPROCESSOR-BASED DIGITAL CONTROL, AND ELECTRONIC ACTUATION OF DAMPERS AND VALVES TO PERFORM CONTROL SEQUENCES AND FUNCTIONS SPECIFIED. REFER ALSO TO CONTROL DRAWINGS, SEQUENCES OF OPERATION, AND POINT LISTS.

B. THE DISTRIBUTED DIGITAL CONTROL (DDC) AND BUILDING AUTOMATION SYSTEM (BAS) DEFINED IN THIS SPECIFICATION SHALL INTERFACE WITH THE UNIVERSITY PRIVATE VLAN, AND SHALL UTILIZE OPEN COMMUNICATIONS. TOWARDS THIS END, CONTRACTOR SHALL PROVIDE A ROUTER/GATEWAY(S) AS NECESSARY TO FACILITATE ALL SPECIFIED OBJECTS AND SERVICES AND HAVE THEM CONFIGURED/MAPPED AS APPLICABLE.

C. THE SYSTEMS TO BE CONTROLLED UNDER WORK OF THIS SECTION BASICALLY COMPRISE {DESCRIBE THE SCOPE OF THE PROJECT.} THE HVAC SYSTEMS BEING CONTROLLED ARE {DESCRIBE THE CONFIGURATION OF AND THE TYPE OF MECHANICAL SYSTEMS INCLUDED IN THE PROJECT}. THIS SECTION DEFINES THE MANNER AND METHOD BY WHICH THESE CONTROLS FUNCTION.

D. ALL CONTROL WORK SHALL BE INSTALLED BY THE BAS CONTRACTOR, UNLESS SPECIFIED OTHERWISE. CERTAIN MECHANICAL SYSTEMS SUCH AS CHILLERS, BOILERS,

COOLING TOWERS, AND ENERGY RECOVERY UNITS ARE EQUIPPED WITH MANUFACTURER FURNISHED CONTROLS. ALL LABOR, MATERIALS, EQUIPMENT, SOFTWARE, AND SERVICES NECESSARY FOR THE INSTALLATION OF A COMPLETE INTEGRATED SYSTEM SHALL BE PROVIDED.

1.04 APPLICATION OF OPEN PROTOCOLS

THE FOLLOWING REQUIREMENT APPLIES ONLY AT THE DIRECTION OF UCB AND MUST BE CAREFULLY EDITED TO ACHIEVE THE INTEROPERABILITY LEVEL APPLICABLE TO THIS PROJECT.

A. SUBJECT TO THE DETAILED REQUIREMENTS PROVIDED THROUGHOUT THE SPECIFICATIONS, THE BAS AND DIGITAL CONTROL AND COMMUNICATIONS COMPONENTS INSTALLED, AS WORK OF THIS CONTRACT SHALL BE AN INTEGRATED DISTRIBUTED PROCESSING SYSTEM UTILIZING BACNET. SYSTEM COMPONENTS SHALL COMMUNICATE USING NATIVE BACNET IN ACCORDANCE WITH ASHRAE STANDARD 135 AND CURRENT ADDENDA AND ANNEXES, INCLUDING ALL WORKSTATIONS, ALL BUILDING CONTROLLERS, AND ALL APPLICATION SPECIFIC CONTROLLERS.

1.05 QUALITY ASSURANCE

THE FOLLOWING REQUIREMENT IS RELATIVE TO THE DEMONSTRATED HISTORY OF THE PRODUCT LINE THEY ARE PROPOSING. EDIT TO SUIT PROJECT.

A. PRODUCT LINE DEMONSTRATED HISTORY: THE PRODUCT LINE BEING PROPOSED FOR THE PROJECT MUST HAVE AN INSTALLED HISTORY OF DEMONSTRATED SATISFACTORY OPERATION FOR A LENGTH OF [5] YEARS SINCE DATE OF FINAL COMPLETION IN AT LEAST [20] INSTALLATIONS OF COMPARATIVE SIZE AND COMPLEXITY. DOCUMENTATION OF THIS REQUIREMENT WITH REFERENCES SHALL BE AVAILABLE UPON REQUEST.

THE FOLLOWING REQUIREMENT RELATES TO THE ACTUAL INSTALLING CONTRACTOR.

B. INSTALLER'S QUALIFICATIONS: FIRMS SPECIALIZING AND EXPERIENCED IN CONTROL SYSTEM INSTALLATIONS FOR NOT LESS THAN [5] YEARS. FIRMS WITH EXPERIENCE IN DDC INSTALLATION PROJECTS WITH POINT COUNTS EQUAL TO THIS PROJECT AND SYSTEMS OF THE SAME COMPLEXITY AS THOSE OF THIS PROJECT. EXPERIENCE STARTS WITH AWARDED FINAL COMPLETION OF PREVIOUS PROJECTS. DOCUMENTATION OF THIS REQUIREMENT WITH REFERENCES SHALL BE AVAILABLE UPON REQUEST.

C. INSTALLER'S EXPERIENCE WITH PROPOSED PRODUCT LINE: FIRMS SHALL HAVE SPECIALIZED IN AND BE EXPERIENCED WITH THE INSTALLATION OF THE PROPOSED PRODUCT LINE FOR NOT LESS THAN [THREE] YEARS FROM DATE OF FINAL COMPLETION ON AT LEAST [5] PROJECTS OF SIMILAR SIZE AND COMPLEXITY. SUBMITTALS SHALL DOCUMENT THIS EXPERIENCE WITH REFERENCES.

THE FOLLOWING REQUIREMENTS RELATE TO THE KEY INDIVIDUALS WHO WILL BE WORKING ON THE PROJECT.

D. INSTALLER'S FIELD COORDINATOR AND SEQUENCE PROGRAMMER QUALIFICATIONS: INDIVIDUAL(S) SHALL SPECIALIZE IN AND BE EXPERIENCED WITH CONTROL SYSTEM INSTALLATION FOR NOT LESS THAN [5] YEARS. PROPOSED FIELD COORDINATOR SHALL HAVE EXPERIENCE WITH THE INSTALLATION OF THE PROPOSED PRODUCT LINE FOR NOT LESS THAN [2] PROJECTS OF SIMILAR [SIZE] [AND COMPLEXITY]. INSTALLER SHALL

SUBMIT THE NAMES OF THE PROPOSED INDIVIDUAL AND AT LEAST ONE ALTERNATE FOR EACH DUTY. SUBMITTALS SHALL DOCUMENT THIS EXPERIENCE WITH REFERENCES. {EDIT AS APPLICABLE} THE PROPOSED INDIVIDUALS MUST SHOW PROOF OF THE FOLLOWING TRAINING:

1. PRODUCT LINE TRAINING: INDIVIDUALS OVERSEEING THE INSTALLATION AND CONFIGURATION OF THE PROPOSED PRODUCT LINE MUST PROVIDE EVIDENCE OF THE MOST ADVANCED TRAINING OFFERED BY THE MANUFACTURER ON THAT PRODUCT LINE FOR INSTALLATION AND CONFIGURATION.
2. PROGRAMMING TRAINING: INDIVIDUALS INVOLVED WITH PROGRAMMING THE SITE-SPECIFIC SEQUENCES SHALL PROVIDE EVIDENCE OF THE MOST ADVANCED PROGRAMMING TRAINING OFFERED BY THE VENDOR OF THE PROGRAMMING APPLICATION OFFERED BY THE MANUFACTURER.

E. INSTALLER'S SERVICE QUALIFICATIONS: THE INSTALLER MUST BE EXPERIENCED IN CONTROL SYSTEM OPERATION, MAINTENANCE AND SERVICE. INSTALLER MUST DOCUMENT A MINIMUM [5] YEAR HISTORY OF SERVICING INSTALLATIONS OF SIMILAR SIZE AND COMPLEXITY. INSTALLER MUST ALSO DOCUMENT AT LEAST A ONE YEAR HISTORY OF SERVICING THE PROPOSED PRODUCT LINE.

F. INSTALLER'S RESPONSE TIME AND PROXIMITY

1. INSTALLER MUST MAINTAIN A FULLY CAPABLE SERVICE FACILITY WITHIN A [45 MILE] RADIUS OF THE PROJECT SITE. SERVICE FACILITY SHALL MANAGE THE EMERGENCY SERVICE DISPATCHES AND MAINTAIN THE INVENTORY OF SPARE PARTS.
2. EMERGENCY RESPONSE TIMES ARE LISTED BELOW IN THIS SECTION. INSTALLER MUST DEMONSTRATE THE ABILITY TO MEET THE RESPONSE TIMES.

G. INSTALLER'S QUALITY ASSURANCE PLAN

1. INSTALLER MUST PROVIDE A DESCRIPTION OF THEIR QUALITY ASSURANCE OPERATIONS FROM CONTRACT AWARD THROUGH FINAL DELIVERY. THE DESCRIPTION SHALL INCLUDE ORGANIZATIONAL RESPONSIBILITIES FOR EACH DEPARTMENT REPRESENTED WITHIN THE EXECUTION OF THIS DOCUMENT FROM INSTALLER'S TO ENGINEERS, SERVICE TECHNICIANS AND MANAGEMENT.

1.06 CODES AND STANDARDS

A. THE FOLLOWING CODES AND STANDARD INTENDED TO APPLY AS APPLICABLE AS NOT ALL WILL APPLY TO ALL INSTALLATIONS

B. AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR CONDITIONING ENGINEERS (ASHRAE)

1. ASHRAE 135-2004: BACNET - A DATA COMMUNICATION PROTOCOL FOR BUILDING AUTOMATION AND CONTROL NETWORKS. AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC. 2004 INCLUDING ADDENDUMS A THROUGH E

C. ELECTRONICS INDUSTRIES ALLIANCE

1. EIA-709.1-B-2002: CONTROL NETWORK PROTOCOL SPECIFICATION

2. EIA-709.3-99: FREE-TOPOLOGY TWISTED-PAIR CHANNEL SPECIFICATION
3. EIA-232: INTERFACE BETWEEN DATA TERMINAL EQUIPMENT AND DATA CIRCUIT-TERMINATING EQUIPMENT EMPLOYING SERIAL BINARY DATA INTERCHANGE.
4. EIA-458: STANDARD OPTICAL FIBER MATERIAL CLASSES AND PREFERRED SIZES
5. EIA-485: STANDARD FOR ELECTRICAL CHARACTERISTICS OF GENERATOR AND RECEIVERS FOR USE IN BALANCED DIGITAL MULTIPOINT SYSTEMS.
6. EIA-472: GENERAL AND SECTIONAL SPECIFICATIONS FOR FIBER OPTIC CABLE
7. EIA-475: GENERIC AND SECTIONAL SPECIFICATIONS FOR FIBER OPTIC CONNECTORS AND ALL SECTIONAL SPECIFICATIONS
8. EIA-573: GENERIC AND SECTIONAL SPECIFICATIONS FOR FIELD PORTABLE POLISHING DEVICE FOR PREPARATION OPTICAL FIBER AND ALL SECTIONAL SPECIFICATIONS
9. EIA-590: STANDARD FOR PHYSICAL LOCATION AND PROTECTION OF BELOW-GROUND FIBER OPTIC CABLE PLANT AND ALL SECTIONAL SPECIFICATIONS

D. UNDERWRITERS LABORATORIES
1. UL 916: ENERGY MANAGEMENT SYSTEMS.

THE FOLLOWING RATING IS REQUIRED ONLY FOR DEVICES USED FOR SMOKE CONTROL PURPOSES. IF THESE ARE NOT INTENDED, DELETE.

2. UUKL 864: UL SUPERVISED SMOKE CONTROL

E. NEMA COMPLIANCE
1. NEMA 250: ENCLOSURE FOR ELECTRICAL EQUIPMENT
2. NEMA ICS 1: GENERAL STANDARDS FOR INDUSTRIAL CONTROLS.

F. NFPA COMPLIANCE
1. NFPA 90A "STANDARD FOR THE INSTALLATION OF AIR CONDITIONING AND VENTILATING SYSTEMS" WHERE APPLICABLE TO CONTROLS AND CONTROL SEQUENCES.
2. NFPA 70 NATIONAL ELECTRICAL CODE (NEC)

G. INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
1. IEEE 142: RECOMMENDED PRACTICE FOR GROUNDING OF INDUSTRIAL AND COMMERCIAL POWER SYSTEMS
2. IEEE 802.3: CSMA/CD (ETHERNET – BASED) LAN
3. IEEE 802.4: TOKEN BUS WORKING GROUP (ARCNET – BASED) LAN

EDIT THE DEFINITIONS BELOW TO APPLY FOR A GIVEN PROJECT.

1.07 DEFINITIONS

A. ACCURACY: AS STATED IN SECTION 15951 {23 0913}, ACCURACY SHALL INCLUDE COMBINED EFFECTS OF NONLINEARITY, NON-REPEATABILITY AND HYSTERESIS.

B. ADVANCED APPLICATION CONTROLLER (AAC): A DEVICE WITH LIMITED RESOURCES RELATIVE TO THE BUILDING CONTROLLER (BC). IT MAY SUPPORT A LEVEL OF PROGRAMMING AND MAY ALSO BE INTENDED FOR APPLICATION SPECIFIC APPLICATIONS.

C. APPLICATION PROTOCOL DATA UNIT (APDU): A UNIT OF DATA SPECIFIED IN AN APPLICATION PROTOCOL AND CONSISTING OF APPLICATION PROTOCOL CONTROL INFORMATION AND POSSIBLE APPLICATION USER DATA (ISO 9545).

D. APPLICATION SPECIFIC CONTROLLER (ASC): A DEVICE WITH LIMITED RESOURCES RELATIVE TO THE ADVANCED APPLICATION CONTROLLER (AAC). IT MAY SUPPORT A LEVEL OF PROGRAMMING AND MAY ALSO BE INTENDED FOR APPLICATION-SPECIFIC APPLICATIONS. .

E. BACNET/BACNET STANDARD: BACNET COMMUNICATION REQUIREMENTS AS DEFINED BY ASHRAE/ANSI 135-2004.

F. BACNET INTEROPERABILITY BUILDING BLOCKS (BIBB): A BIBB DEFINES A SMALL PORTION OF BACNET FUNCTIONALITY THAT IS NEEDED TO PERFORM A PARTICULAR TASK. BIBBS ARE COMBINED TO BUILD THE BACNET FUNCTIONAL REQUIREMENTS FOR A DEVICE IN A SPECIFICATION.

G. BINDING: IN THE GENERAL SENSE, BINDING REFERS TO THE ASSOCIATIONS OR MAPPINGS OF THE SOURCES NETWORK VARIABLE AND THEIR INTENDED OPR REQUIRED DESTINATIONS.

H. BUILDING AUTOMATION SYSTEM (BAS): THE ENTIRE INTEGRATED MANAGEMENT AND CONTROL SYSTEM

I. BUILDING CONTROLLER (BC): A FULLY PROGRAMMABLE DEVICE CAPABLE OF CARRYING OUT A NUMBER OF TASKS INCLUDING CONTROL AND MONITORING VIA DIRECT DIGITAL CONTROL (DDC) OF SPECIFIC SYSTEMS, ACTING AS A COMMUNICATIONS ROUTER BETWEEN THE LAN BACKBONE AND SUB-LANS, AND DATA STORAGE FOR TREND INFORMATION, TIME SCHEDULES, AND ALARM DATA.

J. CHANGE OF VALUE (COV): AN EVENT THAT OCCURS WHEN A MEASURED OR CALCULATED ANALOG VALUE CHANGES BY A PREDEFINED AMOUNT (ASHRAE/ANSI 135-2004).

K. CLIENT: A DEVICE THAT IS THE REQUESTOR OF SERVICES FROM A SERVER. A CLIENT DEVICE MAKES REQUESTS OF AND RECEIVES RESPONSES FROM A SERVER DEVICE.

L. CONTINUOUS MONITORING: A SAMPLING AND RECORDING OF A VARIABLE BASED ON TIME OR CHANGE OF STATE (E.G. TRENDING AN ANALOG VALUE, MONITORING A BINARY CHANGE OF STATE).

M. CONTROLLER OR CONTROL UNIT (CU): INTELLIGENT STAND-ALONE CONTROL PANEL. CONTROLLER IS A GENERIC REFERENCE AND SHALL INCLUDE BCS, AACS, AND ASCS AS APPROPRIATE.

N. CONTROL SYSTEMS SERVER (CSS): THIS SHALL BE A COMPUTER (OR COMPUTERS) THAT MAINTAINS THE SYSTEMS CONFIGURATION AND PROGRAMMING DATABASE. THIS MAY DOUBLE AS AN OPERATOR WORKSTATION.

O. DIRECT DIGITAL CONTROL (DDC): MICROPROCESSOR-BASED CONTROL INCLUDING ANALOG/DIGITAL CONVERSION AND PROGRAM LOGIC

P. FUNCTIONAL PROFILE: A COLLECTION OF VARIABLES REQUIRED TO DEFINE A THE KEY PARAMETERS FOR A STANDARD APPLICATION. AS THIS APPLIES TO THE HVAC

INDUSTRY, THIS WOULD INCLUDE APPLICATIONS LIKE VAV TERMINAL, FAN COIL UNITS, AND THE LIKE.

Q. FACILITY MAINTENANCE INFORMATION TECHNOLOGY (FMIT): REFERENCE TO THE FACILITY'S INFORMATION TECHNOLOGY DEPARTMENT, RESPONSIBLE FOR PROVIDING AND MAINTAINING ALL OI HARDWARE.

R. GATEWAY (GTWY): A DEVICE, WHICH CONTAINS TWO OR MORE DISSIMILAR NETWORKS/PROTOCOLS, PERMITTING INFORMATION EXCHANGE BETWEEN THEM (ASHRAE/ANSI 135-2004).

S. HAND HELD DEVICE (HHD): MANUFACTURER'S MICROPROCESSOR BASED DEVICE FOR DIRECT CONNECTION TO A CONTROLLER.

T. LAN INTERFACE DEVICE (LANID): DEVICE OR FUNCTION USED TO FACILITATE COMMUNICATION AND SHARING OF DATA THROUGHOUT THE BAS

U. LOCAL AREA NETWORK (LAN): GENERAL TERM FOR A NETWORK SEGMENT WITHIN THE ARCHITECTURE. VARIOUS TYPES AND FUNCTIONS OF LANS ARE DEFINED HEREIN.

V. LOCAL SUPERVISORY LAN: ETHERNET-BASED LAN CONNECTING PRIMARY CONTROLLER LANS WITH EACH OTHER AND OWSS AND CSSS. SEE SYSTEM ARCHITECTURE BELOW. THIS LAN CAN FUNCTION AS THE PRIMARY CONTROLLING LAN.

W. MASTER-SLAVE/TOKEN PASSING (MS/TP): DATA LINK PROTOCOL AS DEFINED BY THE BACNET STANDARD. (ASHRAE/ANSI 135-2004).

X. OPEN DATABASE CONNECTIVITY (ODBC): AN OPEN STANDARD APPLICATION-PROGRAMMING INTERFACE (API) FOR ACCESSING A DATABASE DEVELOPED. ODBC COMPLIANT SYSTEMS MAKE IT POSSIBLE TO ACCESS ANY DATA FROM ANY APPLICATION, REGARDLESS OF WHICH DATABASE MANAGEMENT SYSTEM (DBMS) IS HANDLING THE DATA.

Y. OPERATOR INTERFACE (OI): A DEVICE USED BY THE OPERATOR TO MANAGE THE BAS INCLUDING OWSS, POTS, AND HHDS.

Z. OPERATOR WORKSTATION (OWS): THE USER'S INTERFACE WITH THE BAS SYSTEM. AS THE BAS NETWORK DEVICES ARE STAND-ALONE, THE OWS IS NOT REQUIRED FOR COMMUNICATIONS TO OCCUR.

AA. POINT-TO-POINT (PTP): SERIAL COMMUNICATION AS DEFINED IN THE BACNET STANDARD.

BB. PORTABLE OPERATORS TERMINAL (POT): LAPTOP PC USED BOTH FOR DIRECT CONNECTION TO A CONTROLLER AND FOR REMOTE DIAL UP CONNECTION.

CC. PROTOCOL IMPLEMENTATION CONFORMANCE STATEMENT (PICS): A WRITTEN DOCUMENT, CREATED BY THE MANUFACTURER OF A DEVICE, WHICH IDENTIFIES THE PARTICULAR OPTIONS SPECIFIED BY BACNET THAT ARE IMPLEMENTED IN THE DEVICE (ASHRAE/ANSI 135-2004).

DD. PRIMARY CONTROLLING LAN: HIGH SPEED, PEER-TO-PEER CONTROLLER LAN CONNECTING BCS AND OPTIONALLY AACS AND ASCS. REFER TO SYSTEM ARCHITECTURE BELOW.

EE. ROUTER: A DEVICE THAT CONNECTS TWO OR MORE NETWORKS AT THE NETWORK LAYER.

FF. SECONDARY CONTROLLING LAN: LAN CONNECTING AACS AND ASCS, GENERALLY LOWER SPEED AND LESS RELIABLE THAN THE PRIMARY CONTROLLING LAN. REFER TO SYSTEM ARCHITECTURE BELOW.

GG. SERVER : A DEVICE THAT IS A PROVIDER OF SERVICES TO A CLIENT. A CLIENT DEVICE MAKES REQUESTS OF AND RECEIVES RESPONSES FROM A SERVER DEVICE.

HH. SQL: STANDARDIZED QUERY LANGUAGE, A STANDARDIZED MEANS FOR REQUESTING INFORMATION FROM A DATABASE.

II. SMART DEVICE: A CONTROL I/O DEVICE SUCH AS A SENSOR OR ACTUATOR THAT CAN DIRECTLY COMMUNICATE WITH THE CONTROLLER NETWORK TO WHICH IT IS CONNECTED. THIS DIFFERS FROM AN ASC IN THAT IT TYPICALLY DEALS ONLY WITH ONE VARIABLE.

JJ. UNIVERSITY OF COLORADO AT BOULDER (UCB): OWNER OF THE FACILITY.

KK. UCB ETHERNET: REFERENCE TO THE FACILITY'S INFORMATION TECHNOLOGY NETWORK, USED FOR NORMAL BUSINESS-RELATED E-MAIL AND INTERNET COMMUNICATION. INTERNET-BASED NETWORK CONNECTING MULTIPLE FACILITIES WITH A CENTRAL DATA WAREHOUSE AND SERVER, ACCESSIBLE VIA STANDARD WEB-BROWSER.

LL. XML (EXTENSIBLE MARKUP LANGUAGE): A SPECIFICATION DEVELOPED BY THE WORLD WIDE WEB CONSORTIUM. XML IS A PARED-DOWN VERSION OF SGML, DESIGNED ESPECIALLY FOR WEB DOCUMENTS. IT ALLOWS DESIGNERS TO CREATE THEIR OWN CUSTOMIZED TAGS, ENABLING THE DEFINITION, TRANSMISSION, VALIDATION, AND INTERPRETATION OF DATA BETWEEN APPLICATIONS AND BETWEEN ORGANIZATIONS.

1.08 FUNCTIONAL INTENT

A. THROUGHOUT SECTIONS 15950 {23 0900} THROUGH 15955 {23 0905}, THE SEQUENCES OF OPERATION, AND SECTION 15959 {23 0801} DETAILED REQUIREMENTS ARE SPECIFIED, SOME OF WHICH INDICATE A MEANS, METHOD OR CONFIGURATION ACCEPTABLE TO MEET THAT REQUIREMENT. CONTRACTOR MAY SUBMIT PRODUCTS THAT UTILIZE ALTERNATE MEANS, METHODS, AND CONFIGURATIONS THAT MEET THE FUNCTIONAL INTENT. HOWEVER THESE WILL ONLY BE ALLOWED WITH PRIOR APPROVAL BY THE UNIVERSITY.

1.09 SUBMITTALS

A. SUBMIT UNDER PROVISIONS OF SECTION {INSERT APPROPRIATE SECTION NUMBER}.

B. ELECTRONIC SUBMITTALS: CONTROL SUBMITTALS AND O&M INFORMATION SHALL BE PROVIDED IN ADOBE PDF OR MICROSOFT WORD FORMAT. PREFERABLY DOCUMENTS WILL BE CONVERTED FROM THEIR NATIVE ELECTRONIC FORMAT DIRECTLY TO A PREFERRED FORMAT. ANY DOCUMENTS SCANNED AS IMAGES MUST BE CONVERTED TO A SEARCHABLE TEXT FORMAT USING OCR (OPTICAL CHARACTER RECOGNITION) AND REDUCED IN SIZE PRIOR TO SUBMISSION.

C. QUALIFICATIONS: MANUFACTURER, INSTALLER, AND KEY PERSONNEL QUALIFICATIONS AS INDICATED FOR THE APPROPRIATE ITEM ABOVE. INCLUDE QA/QC PLAN FOR ALL PHASES (DESIGN, INSTALL, CX, WARRANTY) ALONG WITH DOCUMENTATION OF INDUSTRY STANDARD QA/QC PRACTICES FOLLOWED.

D. PRODUCT DATA: SUBMIT MANUFACTURER'S TECHNICAL PRODUCT DATA FOR EACH CONTROL DEVICE, PANEL, AND ACCESSORY FURNISHED, INDICATING DIMENSIONS, CAPACITIES, PERFORMANCE AND ELECTRICAL CHARACTERISTICS, AND MATERIAL FINISHES. ALSO INCLUDE INSTALLATION AND START-UP INSTRUCTIONS.

E. SHOP DRAWINGS: SUBMIT SHOP DRAWINGS FOR EACH CONTROL SYSTEM, INCLUDING A COMPLETE DRAWING FOR EACH AIR HANDLING UNIT, SYSTEM, PUMP, DEVICE, ETC. WITH ALL POINT DESCRIPTORS, ADDRESSES AND POINT NAMES INDICATED. EACH SHOP DRAWING SHALL CONTAIN THE FOLLOWING INFORMATION:

DESIGNER SHALL PROVIDE GENERAL PANEL LOCATIONS ON BID SET MECHANICAL FLOOR PLAN DOCUMENTS.

1. SYSTEM ARCHITECTURE AND SYSTEM LAYOUT:
   a) ONE-LINE DIAGRAM INDICATING SCHEMATIC LOCATIONS OF ALL CONTROL UNITS, WORKSTATIONS, LAN INTERFACE DEVICES, GATEWAYS, ETC. INDICATE NETWORK NUMBER, DEVICE ID, DRAWING REFERENCE NUMBER, AND CONTROLLER TYPE FOR EACH CONTROL UNIT. ALL OPTICAL ISOLATORS, REPEATERS, END-OF-LINE RESISTORS, JUNCTIONS, GROUND LOCATIONS ETC. SHALL BE LOCATED ON THE DIAGRAM.

      {EDIT THE FOLLOWING FOR THE LEVEL OF DETAIL REQUIRED, PARTICULARLY WITH REGARD TO OPEN PROTOCOL APPLICATION. (I.E. CAMPUS WIDE IMPLEMENTATIONS OF BACNET REQUIRE HIGHER LEVELS OF COORDINATION)} INDICATE DEVICE INSTANCE AND MAC ADDRESS FOR EACH CU. INDICATE MEDIA, PROTOCOL, BAUD RATE, AND TYPE OF EACH LAN.

   b) PROVIDE FLOOR PLANS ON ADOBE PDF SOFTWARE LOCATING ALL CONTROL UNITS, LAN INTERFACE DEVICES, GATEWAYS, ETC. INCLUDE ALL WAN AND LAN COMMUNICATION WIRING ROUTING, POWER WIRING, POWER ORIGINATING SOURCES, AND LOW VOLTAGE POWER WIRING. WIRING ROUTING AS-BUILT CONDITIONS SHALL BE MAINTAINED ACCURATELY THROUGHOUT THE CONSTRUCTION PERIOD AND THE DRAWING SHALL BE UPDATED TO ACCURATELY REFLECT ACCURATE, ACTUAL INSTALLED CONDITIONS.

      {EDIT THE FOLLOWING FOR THE LEVEL OF DETAIL REQUIRED, PARTICULARLY WITH REGARD TO OPEN PROTOCOL APPLICATION. (I.E. CAMPUS WIDE IMPLEMENTATIONS OF BACNET REQUIRE HIGHER LEVELS OF COORDINATION)} INDICATE NETWORK NUMBER, DEVICE ID, ADDRESS, DEVICE INSTANCE, MAC ADDRESS, DRAWING REFERENCE NUMBER, AND CONTROLLER TYPE FOR EACH CONTROL UNIT. INDICATE MEDIA, PROTOCOL, BAUD RATE, AND TYPE OF EACH LAN. ALL OPTICAL ISOLATORS, REPEATERS, END-OF-LINE RESISTORS, JUNCTIONS, GROUND LOCATIONS ETC. SHALL BE LOCATED ON THE FLOOR PLANS.

2. SCHEMATIC FLOW DIAGRAM OF EACH AIR AND WATER SYSTEM SHOWING FANS, COILS, DAMPERS, VALVES, PUMPS, HEAT EXCHANGE EQUIPMENT AND CONTROL DEVICES. INCLUDE VERBAL DESCRIPTION OF SEQUENCE OF OPERATION.

3. All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
4. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number). See Section 15955 {23 0905} - Part III for additional requirements.
5. Label each control device with setting or adjustable range of control.
6. Label each input and output with the appropriate range.
7. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.
8. Provide a Control Valve Schedule listing valve and actuator information including: size, Cv, design flow, design pressure drop, manufacturer, model number, close off rating, control signal, etc. Indicate normal positions of spring return valves.
9. Provide a Control Damper Schedule listing damper and actuator information including: size, material, blade arrangement, manufacturer, model number, control signal, etc. Indicate normal positions of spring return dampers.
10. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring, which are existing, factory-installed and portions to be field-installed.
11. Provide details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations. Provide panel layout drawing including power supply, control unit(s) and wiring terminals.
12. Sheets shall be consecutively numbered.
13. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.
14. Table of Contents listing sheet titles and sheet numbers.
15. Provide a symbol legend and list of abbreviations.

Include the following whenever third party open applications will be accessing the control system.

F. Open Protocol Information

1. BACnet Systems:

a) BACnet object description, object ID, and device ID, for each I/O point.
b) Documentation for any non-standard BACnet objects, properties, or enumerations used detailing their structure, data types, and any associated lists of enumerated values.
c) Submit PICS indicating the BACnet functionality and configuration of each controller.

G. Control Logic Documentation
1. Submit control logic program listings to document the control software of all control units.
2. Include written description of each control sequence.
3. Include test plan for each unique control program.
4. Include control response, settings, setpoints, throttling ranges, gains, reset schedules, adjustable parameters and limits.

H. Operation and Maintenance Materials:
1. Submit documents under provisions of Section {Insert Appropriate Section Number}. Documents shall be provided electronically as described above (1.10/B).
2. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.
3. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual; in accordance with requirements of Division 1. Only include sections for equipment and software used on this project. Do not provide entire catalog of product data with extraneous information.
4. Submit BAS User's Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.
5. Submit BAS advanced Programming Manuals for each controller type and for all workstation software.

I. Controls contractor shall provide University with all product line technical manuals and technical bulletins, to include new and upgraded products, by the same distribution channel as to dealers or branches throughout the warranty period of the project.

J. Manufacturers Certificates: For all listed and/or labeled products, provide certificate of conformance.

K. Product Warranty Certificates: UCB shall approve all warranty start dates. Coordinate and submit manufacturers product warranty certificates covering the hardware provided once approved.

1.10 PROJECT RECORD DOCUMENTS

A. SUBMIT DOCUMENTS UNDER PROVISIONS OF SECTION {INSERT APPROPRIATE SECTION NUMBER}. DOCUMENTATION SHALL BE PROVIDED ELECTRONICALLY AS DEFINED IN SECTION1.10/B ABOVE.

B. RECORD COPIES OF PRODUCT DATA AND CONTROL SHOP DRAWINGS UPDATED TO REFLECT THE FINAL INSTALLED CONDITION.

C. RECORD COPIES OF APPROVED CONTROL LOGIC PROGRAMMING AND DATABASE ON CD/DVD. ACCURATELY RECORD ACTUAL SETPOINTS AND SETTINGS OF CONTROLS, FINAL SEQUENCE OF OPERATION, INCLUDING CHANGES TO PROGRAMS MADE AFTER SUBMISSION AND APPROVAL OF SHOP DRAWINGS AND INCLUDING CHANGES TO PROGRAMS MADE DURING SPECIFIED TESTING.

D. RECORD COPIES OF APPROVED PROJECT SPECIFIC GRAPHIC SOFTWARE ON CD/DVD.

E. RECORD COPIES SHALL INCLUDE INDIVIDUAL FLOOR PLANS WITH CONTROLLER LOCATIONS WITH ALL INTERCONNECTING WIRING ROUTING INCLUDING SPACE SENSORS, LAN WIRING, POWER WIRING, LOW VOLTAGE POWER WIRING.

F. PROVIDE RECORD RISER DIAGRAM SHOWING THE LOCATION OF ALL CONTROLLERS.

1.11 SYSTEM ARCHITECTURE

A. THE SYSTEM PROVIDED SHALL INCORPORATE HARDWARE RESOURCES SUFFICIENT TO MEET THE FUNCTIONAL REQUIREMENTS OF THESE SPECIFICATIONS. THE CONTRACTOR SHALL INCLUDE ALL ITEMS NOT SPECIFICALLY ITEMIZED IN THESE SPECIFICATIONS THAT ARE NECESSARY TO IMPLEMENT, MAINTAIN, AND OPERATE THE SYSTEM IN COMPLIANCE WITH THE FUNCTIONAL INTENT OF THESE SPECIFICATIONS.

B. THE SYSTEM SHALL BE CONFIGURED AS A DISTRIBUTED PROCESSING NETWORK(S) CAPABLE OF EXPANSION AS SPECIFIED BELOW.

C. THE SYSTEM ARCHITECTURE SHALL CONSIST OF A ETHERNET-BASED, WIDE AREA NETWORK (WAN), A SINGLE LOCAL AREA NETWORK (LAN) OR MULTI-LEVELED LANS THAT SUPPORT BCS, AACS, ASCS, OPERATOR WORKSTATIONS (OWS), SMART DEVICES (SD), AND REMOTE COMMUNICATION DEVICES (RCDS) AS APPLICABLE. THE FOLLOWING INDICATES A FUNCTIONAL DESCRIPTION OF THE BAS STRUCTURE.

1. UC WAN: INTERNET-BASED NETWORK CONNECTING MULTIPLE FACILITIES WITH A CENTRAL DATA WAREHOUSE AND SERVER, ACCESSIBLE VIA STANDARD WEB-BROWSER. THIS IS AN EXISTING INFRASTRUCTURE AND CONTRACTOR IS NOT REQUIRED TO CONFIGURE ANY COMPONENTS OF THIS WAN. REFER TO SECTION 15954 {23 0904} FOR REQUIREMENTS:
2. LOCAL SUPERVISORY LAN: THE LOCAL SUPERVISORY LAN SHALL BE AN ETHERNET-BASED, 100 MBPS LAN CONNECTING PRIMARY CONTROL LANS AND OWSS. THE LAN SERVES AS THE INTER-BC GATEWAY AND OWS-TO-BC GATEWAY AND COMMUNICATIONS PATH. CONTRACTOR SHALL PROVIDE THIS AS A DEDICATED LAN FOR THE CONTROL SYSTEM. LAN SHALL BE IEEE 802.3 ETHERNET OVER FIBER OR CATEGORY 5 CABLE WITH SWITCHES AND ROUTERS

THAT SUPPORT 100 MBPS THROUGHPUT. POWER-LINE CARRIER COMMUNICATION SHALL NOT BE ACCEPTABLE FOR COMMUNICATIONS.

THE FOLLOWING SPECIFIES A TYPICAL BACNET SYSTEM

THE HIGHER LEVEL LAYERS OF THIS NETWORK SHALL BE BACNET AS DESCRIBED BELOW:

a) BACNET SUPERVISORY LAN: BACNET/IP AS DEFINED IN ADDENDUM A (ANNEX J) OF THE BACNET STANDARD, AND SHALL SHARE A COMMON NETWORK NUMBER FOR THE ETHERNET BACKBONE, AS DEFINED IN BACNET. POINT/OBJECT NAMING CONVENTIONS ARE SPECIFIED IN 15955 {23 0905} - PART III.

3. PRIMARY CONTROLLER LAN ('PRIMARY LAN'): HIGH-SPEED, PEER-TO-PEER COMMUNICATING LAN USED TO CONNECT AACS, ASCS AND BUILDING CONTROLLERS (BCS) AND COMMUNICATE EXCLUSIVELY CONTROL INFORMATION. ACCEPTABLE TECHNOLOGIES INCLUDE:
   a) ETHERNET (IEEE802.3)
4. SECONDARY CONTROLLER LAN ('SECONDARY LAN'): NETWORK USED TO CONNECT AACS, ASCS OR SDS. THESE CAN BE MASTER SLAVE/ TOKEN PASSING OR POLLING, IN ADDITION TO THOSE ALLOWED FOR PRIMARY CONTROLLER LANS. NETWORK SPEED VS. THE NUMBER OF CONTROLLERS ON THE LAN SHALL BE DICTATED BY THE RESPONSE TIME AND TRENDING REQUIREMENTS.

D. DYNAMIC DATA ACCESS: ANY DATA THROUGHOUT ANY LEVEL OF THE NETWORK SHALL BE AVAILABLE TO AND ACCESSIBLE BY ALL OTHER DEVICES, CONTROLLERS AND OWS, WHETHER DIRECTLY CONNECTED OR CONNECTED REMOTELY.

E. REMOTE DATA ACCESS: COORDINATE REMOTE ACCESS CONNECTIVITY WITH FMIT (FACILITIES MANAGEMENT INFORMATION TECHNOLOGY) DEPARTMENT. THE SYSTEM SHALL SUPPORT THE FOLLOWING METHODS OF REMOTE ACCESS TO THE BUILDING DATA.

UCB USES ETHERNET FOR CAMPUS WIDE BAS ACCESS. SPECIAL CASES REQUIRING DIAL-UP CONNECTIVITY WILL BE ADDRESSED AS NEEDED BY UCB.

1. BROWSER-BASED ACCESS: A REMOTE USER USING A STANDARD BROWSER SHALL BE ABLE ACCESS ALL CONTROL SYSTEM FACILITIES AND GRAPHICS WITH PROPER PASSWORD. UC SHALL PROVIDE THE REQUIRED INTERNET CONNECTION. THE FOLLOWING PARADIGMS ARE ACCEPTABLE FOR BROWSER-BASED ACCESS:
   a) NATIVE INTERNET-BASED USER INTERFACES (HTML, JAVA, XML, ETC.) THAT DO NOT REQUIRE A PLUG-IN. THE USER INTERFACE MUST BE COMPATIBLE WITH THE MOST CURRENT STABLE VERSION OF THE SUPPORTING SOFTWARE (JAVA, ETC.) WITHOUT REQUIRING THE USER TO DOWNGRADE TO A LESSER VERSION.

F. THE COMMUNICATION SPEED BETWEEN THE CONTROLLERS, LAN INTERFACE DEVICES, AND OPERATOR INTERFACE DEVICES SHALL BE SUFFICIENT TO ENSURE FAST SYSTEM RESPONSE TIME UNDER ANY LOADING CONDITION. IN NO CASE SHALL DELAY TIMES BETWEEN AN EVENT, REQUEST, OR COMMAND INITIATION AND ITS COMPLETION BE

GREATER THAN THOSE LISTED HEREIN. CONTRACTOR SHALL RECONFIGURE LAN AS NECESSARY TO ACCOMPLISH THESE PERFORMANCE REQUIREMENTS. GENERALLY REQUIREMENTS DO NOT APPLY WHEN A REMOTE CONNECTION MUST BE ESTABLISHED VIA MODEM:

1. 5 SECONDS BETWEEN A LEVEL 1 (CRITICAL) ALARM OCCURRENCE AND ENUNCIATION AT OPERATOR WORKSTATION.
2. 10 SECONDS BETWEEN A LEVEL 2 ALARM OCCURRENCE AND ENUNCIATION AT OPERATOR WORKSTATION.
3. 20 SECONDS BETWEEN AND A LEVEL 3-5 ALARM OCCURRENCE AND ENUNCIATION AT OPERATOR WORKSTATION.
4. 10 SECONDS BETWEEN AN OPERATOR COMMAND VIA THE OPERATOR INTERFACE TO CHANGE A SETPOINT AND THE SUBSEQUENT CHANGE IN THE CONTROLLER.
5. 5 SECONDS BETWEEN AN OPERATOR COMMAND VIA THE OPERATOR INTERFACE TO START/STOP A DEVICE AND THE SUBSEQUENT COMMAND TO BE RECEIVED AT THE CONTROLLER.
6. 10 SECONDS BETWEEN A CHANGE OF VALUE OR STATE OF AN INPUT AND IT BEING UPDATED ON THE OPERATOR INTERFACE.
7. 10 SECONDS BETWEEN AN OPERATOR SELECTION OF A GRAPHIC AND IT COMPLETELY PAINTING THE SCREEN AND UPDATING AT LEAST 10 POINTS.

G. CONTROL SYSTEMS SERVER (CSS): THIS SHALL BE A COMPUTER (OR COMPUTERS) THAT MAINTAIN THE SYSTEMS CONFIGURATION AND PROGRAMMING DATABASE. THIS SERVER MAY OPERATE VIRTUALLY UNDER THE SUPERVISION OF FMIT. IT SHALL HOLD THE BACKUP FILES OF THE INFORMATION DOWNLOADED INTO THE INDIVIDUAL CONTROLLERS AND AS SUCH SUPPORT UPLOADING AND DOWNLOADING THAT INFORMATION DIRECTLY TO/FROM THE CONTROLLERS. IT SHALL ALSO ACT AS A CONTROL INFORMATION SERVER TO NON-CONTROL SYSTEM BASED PROGRAMS. IT SHALL ALLOW SECURE MULTIPLE-ACCESS TO THE CONTROL INFORMATION. REFER TO SECTION 15952 {23 0902} - BAS OPERATOR INTERFACES FOR ITS REQUIREMENTS.

H. THE OPERATOR INTERFACE SHALL PROVIDE FOR OVERALL SYSTEM SUPERVISION, GRAPHICAL USER INTERFACE, MANAGEMENT REPORT GENERATION, ALARM ANNUNCIATION, AND REMOTE MONITORING. REFER TO SECTION 15952 {23 0902} – BAS OPERATOR INTERFACES.

I. THE BCS, AACS, ASCS, AND SDS SHALL MONITOR, CONTROL, AND PROVIDE THE FIELD INTERFACE FOR ALL POINTS SPECIFIED. EACH BC, AAC, OR ASC SHALL BE CAPABLE OF PERFORMING ALL SPECIFIED ENERGY MANAGEMENT FUNCTIONS, AND ALL DDC FUNCTIONS, INDEPENDENT OF OTHER BCS, AACS, OR ASCS AND OPERATOR INTERFACE DEVICES AS MORE FULLY SPECIFIED IN SECTION 15953 {23 0903} - BAS FIELD PANELS.

J. INTERRUPTIONS OR FAULT AT ANY POINT ON ANY PRIMARY CONTROLLER LAN SHALL NOT INTERRUPT COMMUNICATIONS BETWEEN OTHER NODES ON THE NETWORK. IF A LAN IS SEVERED, TWO SEPARATE NETWORKS SHALL BE FORMED AND COMMUNICATIONS WITHIN EACH NETWORK SHALL CONTINUE UNINTERRUPTED.

K. ALL LINE DRIVERS, SIGNAL BOOSTERS, AND SIGNAL CONDITIONERS ETC. SHALL BE PROVIDED AS NECESSARY FOR PROPER DATA COMMUNICATION.

1.12 WARRANTY MAINTENANCE

A. CONTRACTOR SHALL WARRANT ALL PRODUCTS AND LABOR FOR A PERIOD OF TWO YEARS AFTER FINAL ACCEPTANCE BY UCB. PROVIDE UNIT PRICING FOR ADDITIONAL WARRANTY YEARS AT DISCRETION OF UCB

B. THE UNIVERSITY RESERVES THE RIGHT TO MAKE CHANGES TO THE BAS DURING THE WARRANTY PERIOD. SUCH CHANGES DO NOT CONSTITUTE A WAIVER OF WARRANTY. THE CONTRACTOR SHALL WARRANT PARTS AND INSTALLATION WORK REGARDLESS OF ANY SUCH CHANGES MADE BY THE UNIVERSITY, UNLESS THE CONTRACTOR PROVIDES CLEAR AND CONVINCING EVIDENCE THAT A SPECIFIC PROBLEM IS THE RESULT OF SUCH CHANGES TO THE BAS. ANY DISAGREEMENT BETWEEN THE UNIVERSITY AND THE CONTRACTOR ON SUCH MATTERS SHALL BE SUBJECT TO RESOLUTION THROUGH THE CONTRACT 'DISPUTES' CLAUSE.

C. AT NO COST TO THE UNIVERSITY, DURING THE WARRANTY PERIOD, THE CONTRACTOR SHALL PROVIDE MAINTENANCE SERVICES FOR SOFTWARE AND HARDWARE COMPONENTS AS SPECIFIED BELOW:

1. MAINTENANCE SERVICES SHALL BE PROVIDED FOR ALL DEVICES AND HARDWARE SPECIFIED IN SECTIONS 15951 {23 0913} THROUGH 15954 {23 0904}. SERVICE ALL EQUIPMENT PER THE MANUFACTURER'S RECOMMENDATIONS. ALL DEVICES SHALL BE CALIBRATED WITHIN THE LAST MONTH OF THE WARRANTY PERIOD.
2. EMERGENCY SERVICE: ANY MALFUNCTION, FAILURE, OR DEFECT IN ANY HARDWARE COMPONENT OR FAILURE OF ANY CONTROL PROGRAMMING THAT WOULD RESULT IN PROPERTY DAMAGE OR LOSS OF COMFORT CONTROL SHALL BE CORRECTED AND REPAIRED FOLLOWING NOTIFICATION BY THE UNIVERSITY TO THE CONTRACTOR.
    a) RESPONSE BY TELEPHONE TO ANY REQUEST FOR SERVICE SHALL BE PROVIDED WITHIN ONE (1) HOUR OF THE UNIVERSITY'S INITIAL TELEPHONE REQUEST FOR SERVICE.
    b) IN THE EVENT THAT THE MALFUNCTION, FAILURE, OR DEFECT IS NOT CORRECTED THROUGH THE TELEPHONIC COMMUNICATION, AT LEAST ONE (1) HARDWARE AND SOFTWARE TECHNICIAN, TRAINED IN THE SYSTEM TO BE SERVICED, SHALL BE DISPATCHED TO THE UNIVERSITY'S SITE WITHIN TWO (2) HOURS OF THE UNIVERSITY'S INITIAL TELEPHONE REQUEST FOR SUCH SERVICES, AS SPECIFIED.
3. NORMAL SERVICE: ANY MALFUNCTION, FAILURE, OR DEFECT IN ANY HARDWARE COMPONENT OR FAILURE OF ANY CONTROL PROGRAMMING THAT WOULD NOT RESULT IN PROPERTY DAMAGE OR LOSS OF COMFORT CONTROL SHALL BE CORRECTED AND REPAIRED FOLLOWING TELEPHONIC NOTIFICATION BY THE UNIVERSITY TO THE CONTRACTOR.
    a) RESPONSE BY TELEPHONE TO ANY REQUEST FOR SERVICE SHALL BE PROVIDED WITHIN TWO (2) WORKING HOURS (CONTRACTOR SPECIFIED 40 HR PER WEEK NORMAL WORKING PERIOD) OF THE UNIVERSITY'S INITIAL TELEPHONE REQUEST FOR SERVICE.
    b) IN THE EVENT THAT THE MALFUNCTION, FAILURE, OR DEFECT IS NOT CORRECTED THROUGH THE TELEPHONIC COMMUNICATION, AT LEAST ONE (1)

HARDWARE AND SOFTWARE TECHNICIAN, TRAINED IN THE SYSTEM TO BE SERVICED, SHALL BE DISPATCHED TO THE UNIVERSITY'S SITE WITHIN THREE (3) WORKING DAYS OF THE UNIVERSITY'S INITIAL TELEPHONE REQUEST FOR SUCH SERVICES, AS SPECIFIED.

4. TELEPHONIC REQUEST FOR SERVICE: CONTRACTOR SHALL SPECIFY A MAXIMUM OF THREE TELEPHONE NUMBERS FOR UNIVERSITY TO CALL IN THE EVENT OF A NEED FOR SERVICE. AT LEAST ONE OF THE LINES SHALL BE ATTENDED AT ANY GIVEN TIME AT ALL TIMES. ONCE CONTACTED A TECHNICIAN SHALL RESPOND TO EVERY CALL WITHIN 15 MINUTES.
5. TECHNICAL SUPPORT: CONTRACTOR SHALL PROVIDE TECHNICAL SUPPORT BY TELEPHONE THROUGHOUT THE WARRANTY PERIOD.
6. PREVENTIVE MAINTENANCE SHALL BE PROVIDED THROUGHOUT THE WARRANTY PERIOD IN ACCORDANCE WITH THE HARDWARE COMPONENT MANUFACTURER'S REQUIREMENTS.

1.13 DELIVERY, STORAGE, AND HANDLING

A. PROVIDE FACTORY-SHIPPING CARTONS FOR EACH PIECE OF EQUIPMENT AND CONTROL DEVICE. MAINTAIN CARTONS DURING SHIPPING, STORAGE AND HANDLING AS REQUIRED TO PREVENT EQUIPMENT DAMAGE, AND TO ELIMINATE DIRT AND MOISTURE FROM EQUIPMENT. STORE EQUIPMENT AND MATERIALS INSIDE AND PROTECT FROM CONSTRUCTION WORK AND WEATHER.

1.14 LISTING AND LABELING

A. THE BAS AND COMPONENTS SHALL BE LISTED BY UNDERWRITERS LABORATORIES (UL 916) AS AN ENERGY MANAGEMENT SYSTEM.

THE FOLLOWING SHOULD ONLY BE INCLUDED WHEN IT IS APPLICABLE, NAMELY WHEN THE SYSTEM IS PART OF AN ENGINEERED SMOKE CONTROL SYSTEM. SMOKE CONTROL AND FIRE ALARM SYSTEMS SHOULD BE SEGREGATED FROM THE BAS IN ANY NEW INSTALLATIONS. MODIFY THE APPLICABILITY OF THIS LISTING AS APPROPRIATE.

B. THE BAS SHALL BE LISTED BY UNDERWRITERS LABORATORIES (UUKL 864) FOR SUPERVISED SMOKE CONTROL.

Part II. PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. MATERIALS SHALL BE NEW, THE BEST OF THEIR RESPECTIVE KINDS WITHOUT IMPERFECTIONS OR BLEMISHES AND SHALL NOT BE DAMAGED IN ANY WAY. USED EQUIPMENT SHALL NOT BE USED IN ANY WAY FOR THE PERMANENT INSTALLATION EXCEPT WHERE DRAWINGS OR SPECS SPECIFICALLY ALLOW EXISTING MATERIALS TO REMAIN IN PLACE.

2.02 UNIFORMITY

A. TO THE EXTENT PRACTICAL, ALL EQUIPMENT OF THE SAME TYPE SERVING THE SAME FUNCTION SHALL BE IDENTICAL AND FROM THE SAME MANUFACTURER

Part III. PART 3 - EXECUTION

3.01 INSPECTION

A. EXAMINE AREAS AND CONDITIONS UNDER WHICH CONTROL SYSTEMS ARE TO BE INSTALLED. DO NOT PROCEED WITH WORK UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED IN MANNER ACCEPTABLE TO INSTALLER.

3.02 INSTALLATION OF CONTROL SYSTEMS

A. GENERAL: INSTALL SYSTEMS AND MATERIALS IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS, ROUGHING-IN DRAWINGS AND DETAILS SHOWN ON DRAWINGS.

B. REFER TO ADDITIONAL REQUIREMENTS IN OTHER SECTIONS OF THIS SPECIFICATION.

3.03 CONTROL PANELS, CONTROLLER QUANTITY AND LOCATION

A. CONTROL PANELS SHALL CONSIST OF ONE OR MULTIPLE CONTROLLERS TO MEET REQUIREMENTS OF THIS SPECIFICATION. CONTROL PANELS SHALL BE WALL MOUNTED WITHIN MECHANICAL EQUIPMENT ROOMS. IN NO CASE SHALL PANELS, OTHER THAN TERMINAL UNIT CONTROLLERS, BE LOCATED ABOVE CEILINGS. CONTROL PANELS FOR LIGHTING CONTROL MAY BE LOCATED IN THE ELECTRICAL EQUIPMENT ROOM SERVED BY THE CONTROL PANEL ONLY WITH PRIOR APPROVAL FROM UCB.

B. RESTRICTIONS IN APPLYING CONTROLLERS ARE SPECIFIED IN SECTION 15953 {23 0903}: BAS FIELD PANELS. THIS CONTRACTOR SHALL EXTEND POWER TO THE CONTROL PANEL FROM AN ACCEPTABLE POWER PANEL. IF THE CONTROL CONTRACTOR WISHES TO FURTHER DISTRIBUTE PANELS TO OTHER LOCATIONS, CONTROL CONTRACTOR IS RESPONSIBLE FOR EXTENDING POWER TO THAT LOCATION ALSO. FURTHERMORE, CONTRACTOR IS RESPONSIBLE FOR ENSURING ADEQUATE LOCATIONS FOR THE PANELS THAT DO NOT INTERFERE WITH OTHER REQUIREMENTS OF THE PROJECT AND MAINTAIN ADEQUATE CLEARANCE FOR MAINTENANCE ACCESS.

C. IT IS THE CONTRACTOR'S RESPONSIBILITY TO PROVIDE ENOUGH CONTROLLERS TO ENSURE A COMPLETELY FUNCTIONING SYSTEM, ACCORDING TO THE POINT LIST AND SEQUENCE OF OPERATIONS.

D. FOR ROOFTOP AHUS AND ERUS, CONTROLLERS RATED FOR USE OUTSIDE THE BUILDING ENVELOPE SHALL BE MOUNTED INSIDE THE UNIT CASINGS. IF ADEQUATE SPACE IS NOT AVAILABLE FOR INSTALLATION OF THE CONTROLLERS PER THE MANUFACTURER'S RECOMMENDATIONS, THEY SHALL BE INSTALLED IN NEMA4X ENCLOSURES ADJACENT TO THE UNIT SERVED. FOR ALL OTHER CONTROLLERS SERVING ROOFTOP EQUIPMENT COORDINATE WITH UCB FOR CONTROL PANEL LOCATION, TYPICALLY WITHIN THE BUILDING ENVELOPE DIRECTLY BELOW EQUIPMENT SERVED IN AN ACCESSIBLE LOCATION.

E. CONTROLLERS FOR TERMINAL EQUIPMENT:

1. FOR EQUIPMENT LOCATED IN THE CONDITIONED SPACE, CONTROLLERS SHALL BE MOUNTED INSIDE THE UNIT ENCLOSURE. WHERE SUFFICIENT MOUNTING SPACE IS NOT AVAILABLE INSIDE THE UNIT ENCLOSURE, A CONTROL PANEL SHALL BE INSTALLED ABOVE THE DROP CEILING, INSIDE THE ROOM, AS CLOSE TO THE ROOM SPACE SENSOR AS POSSIBLE. COORDINATE WITH UCB TO CLARIFY ACCEPTABLE MOUNTING LOCATIONS.
2. FOR EQUIPMENT LOCATED ABOVE THE DROP CEILING, CONTROLLERS SHALL BE UNIT MOUNTED. (NOTIFY UCB IF 36" CLEARANCE IN FRONT OF CONTROL PANEL HAS NOT OR CANNOT BE PROVIDED.) PROVIDE ADHESIVE BACKED CEILING LABELS, AFFIXED TO CEILING GRID BELOW ALL CEILING CONCEALED CONTROLLERS, AFFIX TO CEILING PANEL ACCESS DOOR FOR SOLID CEILINGS.

F. LAMINATED CONTROL DRAWINGS, INCLUDING SYSTEM CONTROL SCHEMATICS, SEQUENCES OF OPERATION AND PANEL TERMINATION DRAWINGS, SHALL BE PROVIDED IN PANELS FOR MAJOR PIECES OF EQUIPMENT. TERMINAL UNIT DRAWINGS SHALL BE LOCATED IN THE CENTRAL PLANT EQUIPMENT PANEL OR MECHANICAL ROOM PANEL.

3.04 SURGE PROTECTION

A. THE CONTRACTOR SHALL FURNISH AND INSTALL ANY POWER SUPPLY SURGE PROTECTION, FILTERS, ETC. AS NECESSARY FOR PROPER OPERATION AND PROTECTION OF ALL BCS, AAC/ASCS OPERATOR INTERFACES, PRINTERS, ROUTERS, GATEWAYS AND OTHER HARDWARE AND INTERFACE DEVICES. ALL EQUIPMENT SHALL BE CAPABLE OF HANDLING VOLTAGE VARIATIONS 10% ABOVE OR BELOW MEASURED NOMINAL VALUE, WITH NO AFFECT ON HARDWARE, SOFTWARE, COMMUNICATIONS, AND DATA STORAGE.

3.05 DEMOLITION AND REUSE OF EXISTING MATERIALS AND EQUIPMENT {INCLUDE AND EDIT IF APPLICABLE}

A. CONTRACTOR SHALL ASSUME THAT EXISTING EQUIPMENT THAT SPECIFICALLY IS INDICATED TO BE REUSED IS IN GOOD CONDITION AND IS OPERABLE. COORDINATE WITH UCB FOR CLARIFICATION OF REUSABLE EQUIPMENT. CONTRACTOR, DURING THE COURSE OF WORK, SHALL INSPECT THESE DEVICES AND DETERMINE IF ANY DEVICES ARE IN NEED OF REPLACEMENT OR REPAIR. CONTRACTOR SHALL PREPARE AN ITEMIZED LIST

OF SUGGESTED REPAIRS/REPLACEMENT. THIS REPAIR/REPLACEMENT WILL BE AT THE DISCRETION OF THE UNIVERSITY.

B. EXISTING WIRE, CONDUIT, AND CONTROL PANEL CABINETS MAY BE REUSED AT THE UNIVERSITY PROJECT ENGINEER'S DISCRETION, BUT ONLY IF SUCH MATERIALS OR EQUIPMENT COMPLY WITH THE APPLICABLE SPECIFICATION FOR NEW MATERIALS AND EQUIPMENT. SUCH MATERIALS SHALL NOT BE REUSED IF VISIBLY DAMAGED OR OTHERWISE UNSUITABLE FOR THE INTENDED SERVICE.

C. WHERE SUCH MATERIALS ARE REUSED, THE CONTRACTOR'S SHOP DRAWINGS SHALL REFLECT THE EXISTING WIRING DESIGNATION. IF EXISTING LABELING IS ILLEGIBLE OR OTHERWISE DOES NOT COMPLY WITH THE APPLICABLE SPECIFICATION FOR LABELING, WIRING RUNS SHALL BE RELABELED IN ACCORDANCE WITH THE REQUIREMENTS SPECIFIED ELSEWHERE.

D. EXISTING PNEUMATIC TUBING AND TUBING CONDUIT LOCATED BETWEEN THE EXISTING BAS PANELS AND THE PNEUMATIC OPERATORS MAY BE REUSED AS LONG AS SUCH MATERIALS COMPLY WITH THE APPLICABLE SPECIFICATION FOR NEW MATERIALS. MATERIALS SHALL NOT BE REUSED IF VISIBLY DAMAGED OR OTHERWISE UNSUITABLE FOR THE INTENDED SERVICE. ALL PNEUMATIC TUBING TO BE REUSED SHALL BE PRESSURE TESTED AND ALL LEAKS SHALL BE REPAIRED. ALL REUSED PNEUMATIC TUBING SHALL BE PURGED WITH DRY AIR OR NITROGEN.

E. THE EXISTING PNEUMATIC MAIN AIR SUPPLY SYSTEM SHALL BE MODIFIED AS REQUIRED AND REUSED TO SERVE EXISTING PNEUMATIC CONTROLS THAT ARE TO REMAIN, AND SHALL BE EXTENDED AS NECESSARY TO SERVE NEW PNEUMATIC CONTROLS. WHERE EXISTING PNEUMATIC CONTROLS ARE REMOVED, MAIN AIR PIPING SHALL BE REMOVED BACK TO THE POINT OF CONNECTION TO THE MAIN AIR SUPPLY WHICH REMAINS IN USE, AND SHALL BE CAPPED OR PLUGGED.

F. EXISTING VALVES AND DAMPERS AND THEIR OPERATORS MAY BE REUSED ONLY WHEN PREAPPROVED BY UNIVERSITY. CONTRACTOR SHALL LUBRICATE ALL DAMPER LINKAGES OF DAMPERS BEING CONTROLLED UNDER THIS PROJECT.

G. OTHER MATERIALS AND EQUIPMENT NOT SPECIFICALLY MENTIONED HEREIN MAY BE REUSED ONLY IF SPECIFICALLY ALLOWED BY INDICATIONS ON THE DRAWINGS AND APPROVED BY UCB.

H. FOR HVAC SYSTEMS WHICH ARE INDICATED TO RECEIVE A NEW BAS, ALL EXISTING MATERIALS AND EQUIPMENT ASSOCIATED WITH THE EXISTING PNEUMATIC CONTROLS AND EMCS SHALL BE REMOVED UNLESS OTHERWISE SPECIFIED OR INDICATED TO REMAIN, OR UNLESS REUSED IN ACCORDANCE WITH THE ABOVE REQUIREMENTS, EXCEPT FOR THE FOLLOWING:

1. CONDUIT AND ELECTRICAL BOXES (BUT NOT WIRING WITHIN CONDUIT) MAY REMAIN IN PLACE IF NOT REUSED (LEAVE A PULL LINE);
2. INACCESSIBLE PNEUMATIC TUBING MAY REMAIN IN PLACE IF NOT REUSED. TUBING MUST BE SEALED AND PERMANENTLY LABELED AS "ABANDONED IN PLACE".

EXISTING MATERIALS AND EQUIPMENT TO BE REMOVED SHALL BE REMOVED SUBJECT TO THE REQUIREMENTS IN PARAGRAPH "SEQUENCE OF WORK". FOR HVAC SYSTEMS,

WHICH ARE NOT TO RECEIVE A NEW DDC BAS, THE EXISTING PNEUMATIC CONTROL SYSTEM SHALL REMAIN FULLY FUNCTIONAL.

INCLUDE AND EDIT THE FOLLOWING ONLY WHEN APPLICABLE.

3.06 SEQUENCE OF WORK FOR EXISTING SYSTEMS CONVERSION

A. GENERAL: ALL WORK INVOLVING CHANGEOVER OF CONTROL FUNCTIONS FROM EXISTING PNEUMATIC CONTROL SYSTEM TO THE NEW DDC BAS SHALL BE PERFORMED IN ACCORDANCE WITH THE FOLLOWING SEQUENCE IN ORDER TO MINIMIZE THE DURATION OF EQUIPMENT OUTAGES. THE FOLLOWING DESCRIPTIONS ARE INTENDED TO INDICATE THE SEQUENCE IN WHICH THE WORK SHALL BE PERFORMED, NOT TO DEFINE FULLY THE SCOPE OF THE WORK.

B. INSTALL OPERATOR'S TERMINAL, PERIPHERALS, GRAPHIC SOFTWARE, AND LAN PRIOR TO PLACING ANY EQUIPMENT UNDER THE CONTROL OF THE NEW BAS.

C. WORK WHICH REQUIRES SHUTTING DOWN A PUMP MOTOR, FAN MOTOR, OR CHILLER SHALL BE CONSIDERED A UTILITY SHUTDOWN AND SHALL BE SUBJECT TO THE RESTRICTIONS SPECIFIED IN UCB'S POWER OUTAGE PROTOCOL "UCB OUTAGE NOTIFICATION PROTOCOL".

D. THE FOLLOWING SEQUENCE APPLIES TO AN INDIVIDUALLY CONTROLLED HVAC SUBSYSTEM, SUCH AS AN AIR HANDLING UNIT. ONLY ONE SUCH SYSTEM SHALL BE PLACED UNDER MANUAL CONTROL (AS DESCRIBED BELOW) AT ANY GIVEN TIME.

1. INSTALL CONTROLLERS ADJACENT TO (OR WITHIN) EXISTING CONTROL PANEL. PROGRAMMING SHALL BE COMPLETE (EXCEPT FOR LOADING AND DEBUGGING) PRIOR TO INSTALLATION. INSTALL ALL FIELD DEVICES, WHICH DO NOT REQUIRE INTERRUPTION OF THE EXISTING CONTROL SYSTEM.
2. INSTALL ALL CONDUIT, WIRING, AND PNEUMATIC TUBING WHICH DOES NOT REQUIRE INTERRUPTION OF THE EXISTING CONTROL SYSTEM.
3. REMOVE EXISTING CONTROLS INCLUDING WIRING, CONDUIT, AND TUBING (EXCEPT MATERIALS TO BE REUSED IN ACCORDANCE WITH PROVISIONS SPECIFIED ELSEWHERE) WHICH MUST BE REMOVED TO FACILITATE INSTALLATION OF NEW BAS MATERIALS AND EQUIPMENT.
4. REMOVE EXISTING DIGITAL CONTROL SYSTEM POINTS (IF APPLICABLE). INSTALL AND CALIBRATE REMAINDER OF NEW BAS MATERIALS AND EQUIPMENT FOR THIS SUBSYSTEM. LOAD CONTROLLER SOFTWARE. CONNECT CONTROLLER(S) TO LAN.
5. PERFORM ALL FIELD TESTING AND CALIBRATION THAT DOES NOT REQUIRE CONNECTION OF PERMANENT PNEUMATIC OUTPUTS.
6. REMOVE REMAINING EXISTING PNEUMATIC AND DIGITAL CONTROL SYSTEM MATERIALS AND EQUIPMENT (EXCEPT MATERIALS TO BE REUSED IN ACCORDANCE WITH PROVISIONS SPECIFIED ELSEWHERE). ALL EXISTING DIGITAL CONTROLS EQUIPMENT FOR THOSE SUBSYSTEMS THAT HAVE NOT YET BEEN CONVERTED SHALL REMAIN INTACT, ON-LINE, AND FULLY FUNCTIONAL.
7. SCHEDULE WORK IN UNIVERSITY OCCUPIED SPACES 10 WORKING DAYS IN ADVANCE WITH THE UNIVERSITY'S REPRESENTATIVE. SCHEDULING SHALL NOT BE REQUIRED

FOR WORK IN EQUIPMENT ROOMS, ELECTRICAL CLOSETS, AND SIMILAR SERVICE AREAS.

3.07 CONTROL POWER SOURCE AND SUPPLY

A. SECTION 15950 {23 0900} CONTRACTOR SHALL EXTEND ALL POWER SOURCE WIRING REQUIRED FOR OPERATION OF ALL EQUIPMENT AND DEVICES PROVIDED UNDER SECTIONS 15950 {23 0900} THROUGH 15955 {23 0905} AND SEQUENCES OF OPERATION.

B. GENERAL REQUIREMENTS FOR OBTAINING POWER INCLUDE THE FOLLOWING:

1. ALL CONTROL PANELS SHALL BE SERVED BY DEDICATED POWER CIRCUITS. BC CONTROL PANELS SHALL ADDITIONALLY BE PROVIDED WITH EXTERNAL UPS POWER SUPPLIES TO MEET THE REQUIREMENTS FOR BC POWER FAILURE OPERATION IN SECTION 15954 {23 0904}. CONTROL PANEL SHALL BE LABELED WITH ELECTRICAL PANEL & CIRCUIT SOURCE.
2. WHERE A CONTROLLER CONTROLS MULTIPLE SYSTEMS ON VARYING LEVELS OF POWER RELIABILITY (NORMAL, EMERGENCY, AND/OR INTERRUPTIBLE), THE CONTROLLER SHALL BE POWERED BY THE HIGHEST LEVEL OF RELIABILITY SERVED.
3. STANDALONE FUNCTIONALITY: REFER TO SECTION 15953 {23 0903}.

THE FOLLOWING APPLIES TO REPAIR/RENOVATION WORK WHERE DEDICATED POWER CIRCUITS ARE NOT AVAILABLE.

4. OBTAIN POWER FROM A SOURCE THAT FEEDS THE EQUIPMENT BEING CONTROLLED SUCH THAT BOTH THE CONTROL COMPONENT AND THE EQUIPMENT ARE POWERED FROM THE SAME PANEL. WHERE EQUIPMENT IS POWERED FROM A 460V SOURCE, OBTAIN POWER FROM THE ELECTRICALLY MOST PROXIMATE 120V SOURCE FED FROM A COMMON ORIGIN.
5. WHERE CONTROL EQUIPMENT IS LOCATED INSIDE A NEW EQUIPMENT ENCLOSURE, COORDINATE WITH THE EQUIPMENT MANUFACTURER AND FEED THE CONTROL WITH THE SAME SOURCE AS THE EQUIPMENT. IF THE EQUIPMENT'S CONTROL TRANSFORMER IS LARGE ENOUGH AND OF THE CORRECT VOLTAGE TO SUPPLY THE CONTROLS IT MAY BE USED. IF THE EQUIPMENT'S CONTROL TRANSFORMER IS NOT LARGE ENOUGH OR OF THE CORRECT VOLTAGE TO SUPPLY THE CONTROLS PROVIDE SEPARATE TRANSFORMER

3.08 BAS START UP, COMMISSIONING AND TRAINING

A. REFER TO SECTION 15959 {23 0801} – BAS COMMISSIONING

3.09 SEQUENCE OF OPERATION

A. REFER TO SECTION 15958 {23 0993} - SEQUENCES OF OPERATION

M15951 – BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

REFRESH THE TABLE OF CONTENTS AFTER EDITING SECTION. UNLESS SPECIFICALLY REQUIRED FOR A REPAIR/RENOVATION PROJECT ALL PNEUMATIC SECTIONS WILL BE REMOVED.

Part I. PART 1 - GENERAL

1.01 SECTION INCLUDES

A. [PNEUMATIC TUBING]
B. WIRING
C. CONTROL VALVES AND ACTUATORS
D. CONTROL DAMPERS AND ACTUATORS
E. CONTROL PANELS
F. SENSORS
G. FLOW METER
H. [PNEUMATIC CONTROL COMPONENTS (GAUGES, SWITCHES, RELAYS, ETC.)]
I. ELECTRIC CONTROL COMPONENTS (SWITCHES, EP VALVES, THERMOSTATS, RELAYS, SMOKE DETECTORS, ETC.)
J. TRANSDUCERS
K. AIR FLOW MEASURING STATIONS
L. CURRENT SWITCHES
M. NAMEPLATES
N. TESTING EQUIPMENT

1.02 RELATED DOCUMENTS

A. SECTION {INSERT APPLICABLE SPECIFICATION SECTION} - BASIC MECHANICAL REQUIREMENTS
B. SECTION 15950 - BUILDING AUTOMATION SYSTEM (BAS) GENERAL
C. SECTION 23 0900 – BUILDING AUTOMATION SYSTEM (BAS) GENERAL
D. SECTION 15952 - BAS OPERATOR INTERFACES
E. SECTION 23 0902 - BAS OPERATOR INTERFACES
F. SECTION 15953 - BAS FIELD PANELS
G. SECTION 23 0903 - BAS FIELD PANELS
H. SECTION 15954 - BAS COMMUNICATIONS DEVICES
I. SECTION 23 0904 - BAS COMMUNICATION DEVICES
J. SECTION 15955 - BAS SOFTWARE
K. SECTION 23 0905 - BAS SOFTWARE AND PROGRAMMING
L. SECTION 15958 - SEQUENCES OF OPERATION
M. SECTION 23 0993 - SEQUENCES OF OPERATION
N. SECTION 15959 - BAS COMMISSIONING
O. SECTION 23 0801 - BAS COMMISSIONING

1.03 DESCRIPTION OF WORK

A. Refer to Section 15950 {23 0900} for general requirements.

B. Refer to other Division-15 sections for installation of instrument wells, valve bodies, and dampers in mechanical systems; not work of this section.

C. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:

1. Control wiring between field-installed controls, indicating devices, and unit control panels.
2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
3. Wiring associated with indicating and alarm panels (remote alarm panels) and connections to their associated field devices.
4. All other necessary wiring for fully complete and functional control system as specified.

1.04 WORK BY OTHERS

A. Control Valves furnished under this section shall be installed under the applicable piping section under the direction of Section 15951 {23 0913} Contractor who will be fully responsible for the proper operation of the valve.

B. Control Dampers furnished under this section shall be installed under the applicable air distribution or air handling equipment section under the direction of Section 15951 {23 0913} Contractor who will be fully responsible for the proper operation of the damper

C. Water Pressure Taps, Thermal Wells, Flow Switches, Flow Meters, etc. that will have wet surfaces, shall be installed under the applicable piping Section under the direction of Section 15951 {23 0913} Contractor who will be fully responsible for the proper installation and application.

D. Controlled Equipment Power Wiring shall be furnished and installed under Division 16. Where control involves 120V control devices controlling 120V equipment, Division 16 Contractor shall extend power wiring to the equipment and control panel. Section 15951 {23 0913} Contractor shall extend it from the equipment to the control device and provide transformers as necessary to step the voltage down.

Part II. PART 2 – PRODUCTS

2.00 Approved Vendors

A. The approved vendors are:

1. ANDOVER
2. AUTOMATED LOGIC (ALC)

2.01 MATERIALS AND EQUIPMENT

A. GENERAL: PROVIDE ELECTRONIC [PNEUMATIC,] [AND] [ELECTRIC] CONTROL PRODUCTS IN SIZES AND CAPACITIES INDICATED, CONSISTING OF VALVES, DAMPERS, THERMOSTATS, CLOCKS, CONTROLLERS, SENSORS, AND OTHER COMPONENTS AS REQUIRED FOR COMPLETE INSTALLATION AND REVIEWED AND APPROVED BY UC. EXCEPT AS OTHERWISE INDICATED, PROVIDE MANUFACTURER'S STANDARD MATERIALS AND COMPONENTS AS PUBLISHED IN THEIR PRODUCT INFORMATION; DESIGNED AND CONSTRUCTED AS RECOMMENDED BY MANUFACTURER, AND AS REQUIRED FOR APPLICATION INDICATED.

B. INSTRUMENT PIPE AND TUBE

1. HYDRONIC AND INSTRUMENTS
   a) CONNECTION TO MAIN PIPING: PIPE FITTER TO PROVIDE ½ INCH MINIMUM SIZE THREADOLET, ½" X 2 INCH BRASS NIPPLE, AND ½" BALL VALVE FOR CONNECTION TO WELDED STEEL PIPING. PROVIDE TEE FITTING FOR OTHER TYPES OF PIPING.
   b) REMOTE INSTRUMENTS: ADAPT FROM BALL VALVE TO SPECIFIED TUBING AND EXTEND TO REMOTE INSTRUMENTS. PROVIDE A UNION OR OTHERWISE REMOVABLE FITTING AT BALL VALVE SO THAT CONNECTION TO MAIN CAN BE CLEANED WITH STRAIGHT ROD. WHERE MANIFOLDS WITH TEST PORTS ARE NOT PROVIDED FOR INSTRUMENT, PROVIDE TEES WITH ¼" FPT BRANCH WITH PLUG FOR USE AS TEST PORT. ADAPT FROM TUBING SIZE TO INSTRUMENT CONNECTION.
   c) LINE MOUNTED INSTRUMENTS: EXTEND RIGID PIPING FROM BALL VALVE TO INSTRUMENT. DO NOT USE CLOSE OR RUNNING THREAD NIPPLES. ADAPT FROM BALL VALVE OUTLET TO INSTRUMENT CONNECTION SIZE. PROVIDE A PLUGGED TEE IF PIPE MAKES 90 DEGREE BEND AT OUTLET OF VALVE TO ALLOW CLEANING OF CONNECTION TO MAIN WITH STRAIGHT ROD WITHOUT REMOVING INSTRUMENT.
   d) INSTRUMENT TUBING: SEAMLESS COPPER TUBING, TYPE K OR L, ASTM B 88; WITH CAST-BRONZE SOLDER JOINT FITTINGS, ANSI B1.18; OR WROUGHT-COPPER SOLDER-JOINT FITTINGS, ANSI B16.22; OR BRASS COMPRESSION-TYPE FITTINGS. SOLDER SHALL BE 95/5 TIN ANTIMONY, OR OTHER SUITABLE LEAD FREE COMPOSITION SOLDER. TUBING OD SIZE SHALL BE NOT LESS THAN THE LARGER OF ¼" OR THE INSTRUMENT CONNECTION SIZE.
   e) RIGID PIPING FOR LINE MOUNTED INSTRUMENTS: SCHEDULE 40 THREADED BRASS, WITH THREADED BRASS FITTINGS.
2. LOW PRESSURE AIR INSTRUMENT SENSING LINES
   a) CONNECTIONS: USE SUITABLE BULKHEAD TYPE FITTING AND STATIC SENSING TIP FOR STATIC PRESSURE CONNECTIONS. ADAPT TUBING TO INSTRUMENT CONNECTION.

b) TUBING: VIRGIN POLYETHYLENE NON-METALLIC TUBING TYPE FR, ASTM D 2737, AND WITH FLAME-RETARDANT HARNESS FOR MULTIPLE TUBING. USE COMPRESSION OR PUSH-ON BRASS FITTINGS.

C. COMMUNICATION WIRING: ALL WIRING SHALL BE IN ACCORDANCE WITH MANUFACTURER'S REQUIREMENTS, NATIONAL ELECTRICAL CODES AND DIVISION 16 OF THIS SPECIFICATION. ALL WIRE INSULATION SHALL BE COLOR-CODED AND LABELED FOR EASE OF IDENTIFICATION.

1. CONTRACTOR SHALL SUPPLY ALL COMMUNICATION WIRING BETWEEN BUILDING CONTROLLERS, ROUTERS, GATEWAYS, AAC'S, ASC'S AND LOCAL AND REMOTE PERIPHERALS (E.G., OPERATOR WORKSTATIONS, PRINTERS, AND MODEMS).
2. LOCAL SUPERVISORY LAN: FOR ANY PORTIONS OF THIS NETWORK REQUIRED UNDER THIS SECTION OF THE SPECIFICATION, CONTRACTOR SHALL USE FIBER OR CATEGORY 5E OF STANDARD TIA/EIA (100/1000BASET). NETWORK SHALL BE RUN WITH NO SPLICES AND IN SEPARATE CONDUIT FROM ANY OTHER WIRING.
3. PRIMARY AND SECONDARY CONTROLLER LANS: COMMUNICATION WIRING SHALL BE INDIVIDUALLY 100% SHIELDED PAIRS PER MANUFACTURERS RECOMMENDATIONS FOR DISTANCES INSTALLED, WITH OVERALL PVC COVER, CLASS 2, PLENUM-RATED RUN WITH NO SPLICES AND SEPARATE FROM ANY OTHER WIRING. SHIELD SHALL BE TERMINATED AND WIRING SHALL BE GROUNDED AS RECOMMENDED BY BC MANUFACTURER.

D. SIGNAL WIRING: CONTRACTOR SHALL RUN ALL SIGNAL WIRING IN ACCORDANCE WITH NATIONAL ELECTRIC CODES, DIVISION 16 OF THIS SPECIFICATION AND WITHIN THE ALLOWANCES OF UCB'S WIRING GUIDELINE. ALL SIGNAL WIRE SHALL BE RAN IN ORANGE CONDUIT FOR ANDOVER CONTROLS, BLUE FOR PHOENIX CONTROLS, IN AREAS NOT VIEWED BY THE GENERAL PUBLIC AND THE WIRING NEEDS TO BE LABELED FOR EASE OF IDENTIFICATION; ANY OTHER CONTROLS APPLICATIONS NOT LISTED PRIOR WILL HAVE COLOR DETERMINED DURING DESIGN. ALL WIRE INSULATION SHALL BE COLOR-CODED AND LABELED FOR EASE OF IDENTIFICATION.

1. SIGNAL WIRING TO ALL FIELD DEVICES, INCLUDING, BUT NOT LIMITED TO, ALL SENSORS, TRANSDUCERS, TRANSMITTERS, SWITCHES, ETC. SHALL BE PER MANUFACTURER'S REQUIREMENTS. SIGNAL WIRING SHALL BE RUN WITH NO SPLICES AND SEPARATE FROM ALL OTHER WIRING ABOVE THIRTY (30) VOLTS.
2. SIGNAL WIRING SHIELD SHALL BE GROUNDED AT CONTROLLER END ONLY UNLESS OTHERWISE RECOMMENDED BY THE CONTROLLER MANUFACTURER.

E. LOW VOLTAGE ANALOG OUTPUT WIRING: CONTRACTOR SHALL RUN ALL LOW VOLTAGE CONTROL WIRING IN ACCORDANCE WITH NATIONAL ELECTRIC CODES AND DIVISION 16 OF THIS SPECIFICATION. ALL WIRE INSULATION SHALL BE COLOR-CODED AND LABELED FOR EASE OF IDENTIFICATION.

1. LOW VOLTAGE CONTROL WIRING SHALL BE PER MANUFACTURER'S REQUIREMENTS. LOW VOLTAGE CONTROL WIRING SHALL BE RUN WITH NO SPLICES SEPARATE FROM ANY WIRING ABOVE THIRTY (30) VOLTS.

F. CONTROL PANELS: PROVIDE CONTROL PANELS WITH SUITABLE BRACKETS FOR WALL MOUNTING FOR EACH CONTROL SYSTEM. LOCATE PANEL ADJACENT TO SYSTEMS SERVED.

1. FABRICATE PANELS OF 16-GAGE FURNITURE-GRADE STEEL, OR 6063-T5 EXTRUDED ALUMINUM ALLOY, TOTALLY ENCLOSED ON FOUR SIDES, WITH HINGED DOOR AND

KEYED LOCK, WITH MANUFACTURER'S STANDARD SHOP- PAINTED FINISH AND COLOR.

2. PROVIDE UL-LISTED CABINETS FOR USE WITH LINE VOLTAGE DEVICES.
3. CONTROL PANEL SHALL BE COMPLETELY WIRED PRIOR TO DELIVERY AND ALL ELECTRICAL CONNECTIONS MADE TO A LABELED TERMINAL STRIP. CONTROL PANEL SHALL HAVE STANDARD MANUFACTURER'S COLOR.
4. ALL GAUGES AND CONTROL COMPONENTS SHALL BE IDENTIFIED BY MEANS OF NAMEPLATES.
5. ALL CONTROL TUBING AND WIRING SHALL BE RUN NEATLY AND ORDERLY IN OPEN SLOT WIRING DUCT WITH COVER.
6. COMPLETE WIRING AND TUBING TERMINATION DRAWINGS SHALL BE MOUNTED IN OR ADJACENT TO PANEL.

2.02 CONTROL VALVES

A. GENERAL: PROVIDE FACTORY FABRICATED CONTROL VALVES OF TYPE, BODY MATERIAL AND PRESSURE CLASS INDICATED. THEY SHALL BE TWO-WAY OR THREE-WAY TYPE FOR TWO-POSITION OR MODULATING SERVICE AS SCHEDULED, SHOWN ON DRAWINGS, OR AS SPECIFIED IN SEQUENCE OF OPERATION.

B. CLOSE-OFF (DIFFERENTIAL) PRESSURE RATING: VALVE ACTUATOR AND TRIM SHALL BE FURNISHED TO PROVIDE THE FOLLOWING MINIMUM CLOSE-OFF PRESSURE RATINGS:

1. WATER VALVES:
   a) TWO-WAY - 150% OF TOTAL SYSTEM (PUMP) HEAD.
   b) THREE-WAY - 300% OF PRESSURE DIFFERENTIAL BETWEEN PORTS A AND B AT DESIGN FLOW OR 100% OF TOTAL SYSTEM (PUMP) HEAD.
2. STEAM VALVES:
   a) 150% OF OPERATING (INLET) PRESSURE.

C. WATER VALVES: [THE DESIGNER SHALL PROVIDE A SCHEDULE FOR THE CONTROLS CONTRACTOR LISTING THE AVAILABLE PRESSURE DROP TO BE USED FOR VALVE SIZING FOR EACH CONTROL VALVE IN THE PROJECT, UNLESS IT IS A REVERSE-RETURN SYSTEM. IT IS NOT ACCEPTABLE TO LIST A SINGLE PRESSURE DROP TO BE USED FOR ALL VALVES. FOR A PIPING SYSTEM IN WHICH MODULATED TWO-WAY VALVES ARE USED, FOR EXAMPLE, THE VALVES NEAREST THE PUMP WILL HAVE A LARGER AVAILABLE PRESSURE DROP THAN THOSE FARTHER AWAY FROM THE PUMP.]

1. BODY AND TRIM STYLE AND MATERIALS SHALL BE PER MANUFACTURER'S RECOMMENDATIONS FOR DESIGN CONDITIONS AND SERVICE SHOWN, WITH EQUAL PERCENTAGE PORTS FOR MODULATING SERVICE, EXCEPT WHERE STATED OTHERWISE.
2. SIZING CRITERIA:
   a) TWO-POSITION SERVICE: FULL PORT LINE SIZE.
   b) TWO-WAY MODULATING SERVICE: PRESSURE DROP ACROSS THE VALVE IN A WIDE-OPEN POSITION, WITH FULL FLOW THROUGH THE VALVE, SHALL BE EQUAL TO 50% OF THE AVAILABLE PRESSURE DIFFERENTIAL BETWEEN THE MAINS, WITH A MINIMUM OF 4 PSI.

c) THREE-WAY MODULATING SERVICE: PRESSURE DROP ACROSS THE VALVE IN A WIDE-OPEN POSITION, WITH FULL FLOW THROUGH THE VALVE, SHALL BE EQUAL TO TWICE THE PRESSURE DROP THROUGH THE HEAT EXCHANGER (LOAD), WITH A 3 PSI MINIMUM..

3. CONSTRUCTION:
   a) VALVES ½" THROUGH ¾" GLOBE STYLE SERVING TERMINAL UNITS, AHU COILS AND BASEBOARD RADIATION SHALL BE:
      1) HONEYWELL VP-525A OR C SERIES:
         i. 2-WAY, N.O., VP-526A OR 2-WAY, N.O., VP-531A
         ii. 3-WAY, VP-527A
         iii. C SERIES, 2-WAY, N.O. OR PREAPPROVED EQUAL (SIEMENS POWERMITE599 SERIES (ELECTRIC) OR SIEMENS POWERMITE 599 (PNEUMATIC))
   b) VALVES 1" AND 1¼" FOR SEQUENCING APPLICATIONS MAY BE:
      i. POWERS VP-658 (2-WAY, N.O. OR N.C.)
      ii. POWERS VP-658WM (3-WAY), VP-591 ALSO ACCEPTABLE
   c) VALVES 1" THROUGH 8" GLOBE STYLE FOR CONTROL OF DIFFERENTIAL PRESSURE SHALL BE:
      1) SIEMENS 200 SERIES ELECTRIC ACTUATORS OR PRE-APPROVED EQUAL.
   d) VALVES 2" THROUGH 12" BUTTERFLY STYLE FOR CONTROL OF CONDENSER WATER TEMPERATURE (COOLING TOWER BYPASS) SHALL BE:
      1) SIEMENS 2-WAY BUTTERFLY ASSEMBLIES WITH SIEMENS ELECTRIC ACTUATORS OR PRE-APPROVED EQUAL.
   e) VALVES 2" THROUGH 12" SINGLE BUTTERFLY STYLE TWO-POSITION OR MODULATED APPLICATIONS SHALL BE:
      1) JOHNSON VF SERIES POWERS/SIEMENS BV2W SERIES WITH ELECTRIC ACTUATOR OR PRE-APPROVED EQUAL.
4. WATER VALVES SHALL FAIL AS SPECIFIED IN THE CONTROL SEQUENCES SECTION.
5. EVAPORATIVE COOLER DRAIN AND FILL VALVES:
   a) VALVE NORMAL POSITION SHALL BE AS SHOWN ON THE DRAWINGS.
6. FOR SYSTEMS WITH GLYCOL SOLUTIONS, PROVIDE DOCUMENTATION THAT THE VALVE COMPONENTS IN CONTACT WITH THE FLUID ARE COMPATIBLE WITH IT.

D. WATER VALVES – PRESSURE INDEPENDENT:
1. ACCEPTABLE BRANDS:
   a) DELTA-P
   b) BELIMO
   c) DANFOSS

THE TAPS ON THE PRESSURE INDEPENDENT VALVES ARE TO BE USED FOR TESTING PURPOSES ONLY, NO EXCEPTIONS. PROVIDE TWO EXTERNAL TAPS ON THE LINE, PIPED WITH ISOLATION VALVES, FOR INSTALLATION OF THE DIFFERENTIAL PRESSURE TRANSMITTER ACROSS THE VALVE.

E. STEAM VALVES:

1. BODY AND TRIM MATERIALS SHALL BE PER MANUFACTURER'S RECOMMENDATIONS FOR DESIGN CONDITIONS AND SERVICE, EXCEPT STAINLESS STEEL SEATS ARE REQUIRED FOR ALL APPLICATIONS. EQUAL PERCENTAGE PORTS FOR MODULATING SERVICE.
2. SIZING CRITERIA:
   a) TWO-POSITION SERVICE - PRESSURE DROP 10 TO 20% OF INLET PSIG.
   b) MODULATING SERVICE - 15 PSIG OR LESS. PRESSURE DROP 80% OF INLET PSIG.
   c) MODULATING SERVICE - 16 TO 50 PSIG. PRESSURE DROP 50% OF INLET PSIG.
   d) MODULATING SERVICE - OVER 50 PSIG. PRESSURE DROP AS SCHEDULED ON PLANS.
3. STEAM VALVES SHALL FAIL NORMALLY OPEN OR CLOSED AS SCHEDULED ON PLANS OR AS FOLLOWS:
   a) LOW PRESSURE HEATING - NORMALLY OPEN.
   b) HEATING COILS IN AIR HANDLERS - NORMALLY OPEN.
   c) STEAM-TO-WATER CONVERTERS FOR HEATING WATER - NORMALLY CLOSED.
   d) STEAM-TO-WATER CONVERTERS FOR DOMESTIC HOT WATER - NORMALLY CLOSED.
   e) HIGH-PRESSURE APPLICATIONS - AS SCHEDULED.
4. ACCEPTABLE MANUFACTURERS AS FOLLOWS:
   a) GLOBE STYLE; TERMINAL UNITS, BASEBOARD RADIATION.
      1) ½" THROUGH ¾"; HONEYWELL VP-525A (N.O., 2-WAY).
      2) SIEBE VB-9223 (N.C., 2-WAY).
      3) POWERS 591/593 (N.O. OR N.C. 2-WAY) SERIES.
   b) GLOBE STYLE; STEAM/WATER HEAT EXCHANGERS, AHU COILS.
      1) 1" THROUGH 2"; POWERS 591/593 SERIES.
      2) 2 ½" THROUGH 4"; POWERS 591/593 SERIES, FISHER EASY-E SERIES, LESLIE CLASS DLOS-2 .
   c) SMART STEAM VALVES (FOR MAINS): KEYSTONE VALVES WITH PEAKTRONICS DHC-100 SERIES OR PRE-APPROVED EQUAL.

2.03 CONTROL DAMPERS

A. GENERAL: PROVIDE FACTORY FABRICATED AUTOMATIC CONTROL DAMPERS OF SIZES, VELOCITY AND PRESSURE CLASSES AS REQUIRED FOR SMOOTH, STABLE, AND CONTROLLABLE AIR FLOW. PROVIDE PARALLEL OR OPPOSED BLADE DAMPERS AS RECOMMENDED BY MANUFACTURERS SIZING TECHNIQUES. FOR DAMPERS LOCATED NEAR FAN OUTLETS, PROVIDE DAMPERS RATED FOR FAN OUTLET VELOCITY AND CLOSE-OFF PRESSURE, AND RECOMMENDED BY DAMPER MANUFACTURER FOR FAN DISCHARGE DAMPER SERVICE. CONTROL DAMPERS USED FOR SMOKE DAMPERS SHALL COMPLY WITH UL 555S. CONTROL DAMPERS USED FOR FIRE DAMPERS SHALL COMPLY WITH UL 555.

B. For general isolation and modulating control service in rectangular ducts at velocities not greater than 1500 fpm (7.62 m/s), differential pressure not greater than 2.5" w.c. (622 Pa):

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Stainless steel in lab exhausts and galvanized steel elsewhere, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts with set screws, 16 gauge minimum thickness.
4. Blade Seals: Synthetic elastomer, mechanically attached, field replaceable.
5. Jamb Seals: Stainless steel.
6. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
9. Leakage: Less than one percent based on approach velocity of 1500 ft./min. (7.62 m/s) and 1 inches wg. (249Pa).
10. Maximum Pressure Differential: 2.5 inches wg. (622 Pa)
11. Temperature Limits: -40 to 200 °F (-40 to 93 °C).
12. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames appropriate for installation.

C. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6" w.c. (1493 Pa):

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts, 14 gauge minimum extrusion thickness.
4. Blade Seals: Synthetic elastomeric, mechanically attached, field replaceable.
5. Jamb Seals: Stainless steel.
6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame.

8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
9. Leakage: Less than 0.1 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa).
10. Maximum Pressure Differential: 6 inches wg. (622 Pa)
11. Temperature Limits: -40 to 200 °F (-40 to 93 °C).
12. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with appropriately intermediate frames.

D. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm, differential pressure not greater than 12" w.c.:

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 12-gauge minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 3/4 inch (19 mm) shafts with set screws
4. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
5. Linkage: 10-gauge minimum thickness galvanized steel clevis type crank arms, 3/16" x3/4" (4.76 mm x 19 mm) minimum thickness tie rods.
6. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
7. Leakage: Less than 0.2 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
8. Maximum Pressure Differential: 12 inches wg. (2984 Pa)
9. Temperature Limits: -40 to 300 °F (-40 to 149 °C).
10. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts.

E. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm (12.7 m/s), differential pressure not greater than 4" w.c. (994 Pa):

1. Performance: Test in accordance with AMCA 500.
2. Frames: rolled 12 gauge steel strip for sizes 6 inch and smaller, rolled 14 gauge steel channel for larger sizes, galvanized or aluminum finish.
3. Blades: Steel construction, 12 gauge minimum thickness for dampers less than 18 inches (457 mm) in size, 10 gauge minimum thickness for larger dampers.
4. Blade Seals: Full circumference neoprene.
5. Shaft: ½ inch (12.7 mm) diameter zinc or cadmium plated steel.

6. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
7. Leakage: Less than 0.2 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
8. Maximum Pressure Differential: 4 inches wg. (994 Pa)
9. Temperature Limits: -40 to 300 °F (-40 to 149 °C).

F. For general isolation and modulating control service in round ducts up to 60 inches in size at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6" w.c. (1492 Pa):

1. Performance: Test in accordance with AMCA 500.
2. Frames: rolled 10-gauge steel channel for sizes 48 inch and smaller, rolled 3/16 inch (4.76 mm) thick steel channel for larger sizes, galvanized or aluminum finish.
3. Blades: Steel construction, 10-gauge minimum thickness for dampers not greater than 48 inches in size, ¼ inch (6.35 mm) minimum thickness for larger dampers.
4. Blade stops: ½ inch x ¼ inch (12.7 mm x 6.35 mm) full circumference steel bar.
5. Blade Seals: Full circumference neoprene.
6. Shaft: zinc or cadmium plated steel, angle reinforcing as necessary.
7. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
8. Leakage: Less than 0.4 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
9. Maximum Pressure Differential: 6 inches wg. (1492 Pa)
10. Temperature Limits: -40 to 250 °F (-40 to 121 °C).

2.04 ACTUATORS

A. General: Size actuators and linkages to operate their appropriate dampers or valves with a single actuator with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Multiple actuators for any single application must be preapproved by UCB. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied. Actuators relying on batteries for any operation are not acceptable.

B. Damper Actuators

1. Ambient Operating Temperature Limits: -10 to 150°F (-12.2 to 66 °C)
2. Two Position Electric Actuators: Low voltage or line voltage with spring return.
   a) Acceptable Manufacturers:
      1) Siemens
      2) Belimo

3) Honeywell
4) Johnson Controls
5) Snyder Electric
6) Substitutions: or approved equal

3. Electronic Actuators: Provide actuators with spring return for two-position (24V), 0-5 Vdc, 0-10 Vdc, 2-10Vdc, 4-20 mA, or PWM input (subject to restrictions) as required. Actuators shall travel full stroke in less than [90] seconds. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed. Provide stroke indicator. Actuators shall have positive positioning circuit. Where two actuators are required in parallel or in sequence provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override where indicated.
   a) Close-Off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off pressure for two-way water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure plus 50 percent for low pressure steam, and 10 percent for high pressure steam. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent.
   b) Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
      1) Belimo
      2) Honeywell
      3) Invensys
      4) Johnson Controls
      5) Snyder Electric
      6) Substitutions: Must be pre-approved by UCB

C. Quarter-Turn Actuators (for ball and butterfly valves):
   1. Electric
      a) Motor: Suitable for 120 or 240 Volt single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.
      b) Gear Train. Motor output shall be directed to a self locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.
      c) Wiring: Power and control wiring shall be wired to a terminal strip in the actuator enclosure
      d) Failsafe Positioning: Actuators shall be spring return type for failsafe positioning.

e) ENCLOSURE: ACTUATOR ENCLOSURE SHALL BE NEMA-4 RATED, AND SHALL HAVE A MINIMUM OF TWO THREADED CONDUIT ENTRIES. PROVIDE AN ENCLOSURE HEATER FOR ACTUATORS LOCATED OUTSIDE OF BUILDINGS.

f) LIMIT SWITCHES: TRAVEL LIMIT SWITCHES SHALL BE UL AND CSA APPROVED. SWITCHES SHALL LIMIT ACTUATOR IN BOTH OPEN AND CLOSED POSITIONS.

g) MECHANICAL TRAVEL STOPS: THE ACTUATOR SHALL INCLUDE MECHANICAL TRAVEL STOPS OF STAINLESS STEEL CONSTRUCTION TO LIMIT ACTUATOR TO SPECIFIC DEGREES OF ROTATION.

h) MANUAL OVERRIDE: ACTUATORS SHALL HAVE MANUAL ACTUATOR OVERRIDE TO ALLOW OPERATION OF THE VALVE WHEN POWER IS OFF. FOR VALVES 4 INCHES AND SMALLER THE OVERRIDE MAY BE A REMOVABLE WRENCH OR LEVER OR GEARED HANDWHEEL TYPE. FOR LARGER VALVES, THE OVERRIDE SHALL BE A FIXED GEARED HANDWHEEL TYPE. AN AUTOMATIC POWER CUT-OFF SWITCH SHALL BE PROVIDED TO DISCONNECT POWER FROM THE MOTOR WHEN THE HANDWHEEL IS ENGAGED FOR MANUAL OPERATION.

i) VALVE POSITION INDICATOR: A VALVE POSITION INDICATOR WITH ARROW AND OPEN AND CLOSED POSITION MARKS SHALL BE PROVIDED TO INDICATE VALVE POSITION.

j) TORQUE LIMIT SWITCHES: PROVIDE TORQUE LIMIT SWITCHES TO INTERRUPT MOTOR POWER WHEN TORQUE LIMIT IS EXCEEDED IN EITHER DIRECTION OF ROTATION.

k) POSITION CONTROLLER: FOR VALVES USED FOR MODULATING CONTROL, PROVIDE AN ELECTRONIC POSITIONER CAPABLE OF ACCEPTING 4-20 MA, 0-10 VDC, 2-10 VDC, AND 135 OHM POTENTIOMETER.

l) AMBIENT CONDITIONS: ACTUATOR SHALL BE DESIGNED FOR OPERATION FROM –140 TO 150 °F AMBIENT TEMPERATURE WITH 0 TO 100 PERCENT RELATIVE HUMIDITY.

m) ACCEPTABLE MANUFACTURERS:

1) BELIMO
2) HONEYWELL
3) SIEMENS
4) SNYDER ELECTRIC
5) SUBSTITUTIONS: APPROVED EQUAL

2. [PNEUMATIC SINGLE- AND DOUBLE-ACTING CYLINDER TYPE:

a) AIR CYLINDER: SHALL CONSIST OF STEEL OR ALUMINUM CYLINDER, DUAL PISTONS, DOUBLE RACK AND PINION GEARING MECHANISM. HOUSING SHALL BE PROTECTED BOTH INTERNALLY AND EXTERNALLY WITH CORROSION RESISTANT COATING. ACTUATOR SHALL BE EQUIPPED WITH PISTON GUIDE RODS OR SIMILAR MECHANISM SO THAT SEALS ARE NOT LOADED AS LINEAR BEARINGS. SINGLE ACTING UNITS SHALL HAVE MULTIPLE SYMMETRICALLY ARRANGED SPRINGS TO APPLY EQUAL FORCE TO PISTON. CYLINDER SHALL BE CONFIGURABLE FOR DIRECTION OF FAIL-SAFE MODE IN THE FIELD. ACTUATORS SHALL BE SPRING RETURN TYPE FOR FAILSAFE POSITIONING.

b) Position Indication: Provide extended shaft position indicator that is removable for manual override of valve.

c) Two-Position Actuators: Provide appropriate three-way or four-way solenoid valve mounted on the actuator. Solenoid valve electrical enclosure shall meet NEMA-4 requirements. Provide actuator with position switches where required.

d) Modulating Actuators: Provide a rotary electronic positioner designed to accept 4-20 mA, 0-10 Vdc, 2-10 Vdc, or 135 Ohm potentiometer and operate integral 3-way or 4-way solenoid valve to position valve rotation angle as sensed by integral position feedback device to match signal input. Enclosure shall meet NEMA-4 requirements. Actuator linearity and resolution shall be 0.5% of span. Hysteresis and deadband shall be adjustable. Provide accessory mechanical or proximity type position switches and position transmitters where required. Actuators shall be spring return type for failsafe positioning. Provide an enclosure heater for positioners located outside of buildings.]

2.05 GENERAL FIELD DEVICES

A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.

B. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

C. Field devices specified herein are generally 'two-wire' type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with 'two-wire' type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide 'four-wire' type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

2.06 TEMPERATURE SENSORS (TS)

A. Sensor range: When matched with A/D converter of BC, AAC/ASC, or SD, sensor range shall provide a resolution of no worse than 0.3°F (0.16 °C)

(UNLESS NOTED OTHERWISE). WHERE THERMISTORS ARE USED, THE STABILITY SHALL BE BETTER THAN 0.25°F OVER 5 YEARS.

INCLUDE AND EDIT WHERE MATCHED SENSORS ARE REQUIRED FOR THE SPECIFIC PROJECT.

B. MATCHED SENSORS: THE FOLLOWING APPLICATIONS SHALL REQUIRE MATCHED SENSORS:

1. BUILDING LOOP CONNECTIONS: PROVIDE MATCHED LOOP AND BUILDING SUPPLY SENSORS WHERE CONTROL SEQUENCE REQUIRES CONTROLLING TO A TEMPERATURE RISE (DIFFERENTIAL).
2. HYDRONIC TEMPERATURE DIFFERENCE CALCULATIONS: PROVIDE MATCHED SUPPLY AND RETURN TEMPERATURE SENSORS WHERE THE PAIR IS USED FOR CALCULATING TEMPERATURE DIFFERENCE FOR USE IN LOAD CALCULATIONS OR SEQUENCING SUCH AS ACROSS CHILLERS AND PLANTS.
3. AIR HANDLING UNIT SEQUENCING: PROVIDE MATCHED PAIR FOR THE COOLING AND HEATING COIL LEAVING SENSORS WHERE THE SEQUENCE INCLUDES CALCULATING AN OFFSET FROM THE SUPPLY AIR SETPOINT TO MAINTAIN A LEAVING HEATING COIL TEMPERATURE.

C. ROOM TEMPERATURE SENSOR: SHALL BE AN ELEMENT CONTAINED WITHIN A VENTILATED COVER, SUITABLE FOR WALL MOUNTING. PROVIDE INSULATED BASE. FOLLOWING SENSING ELEMENTS ARE ACCEPTABLE:

1. SENSING ELEMENT SHALL BE PLATINUM RTD, THERMISTOR, OR INTEGRATED CIRCUIT, +/- 0.4°F ACCURACY AT CALIBRATION POINT.
2. PROVIDE SETPOINT ADJUSTMENT WHERE INDICATED. THE SETPOINT ADJUSTMENT SHALL BE A WARMER/COOLER INDICATION THAT SHALL BE SCALABLE VIA THE BAS (INITIAL RANGE OF +/- 2°F).
3. PROVIDE AN OCCUPANCY OVERRIDE BUTTON ON THE ROOM SENSOR ENCLOSURE WHERE INDICATED. THIS SHALL BE A MOMENTARY CONTACT CLOSURE
4. PROVIDE CURRENT TEMPERATURE INDICATION VIA AN LCD READOUT WHERE INDICATED.

D. SINGLE-POINT DUCT TEMPERATURE SENSOR: SHALL CONSIST OF SENSING ELEMENT, JUNCTION BOX FOR WIRING CONNECTIONS AND GASKET TO PREVENT AIR LEAKAGE OR VIBRATION NOISE. TEMPERATURE RANGE AS REQUIRED FOR RESOLUTION INDICATED IN PARAGRAPH A. SENSOR PROBE SHALL BE 316 STAINLESS STEEL.

1. SENSING ELEMENT SHALL BE PLATINUM RTD, THERMISTOR, OR INTEGRATED CIRCUIT, +/- 0.2°F ACCURACY AT CALIBRATION POINT

E. AVERAGING DUCT TEMPERATURE SENSOR: SHALL CONSIST OF AN AVERAGING ELEMENT, JUNCTION BOX FOR WIRING CONNECTIONS AND GASKET TO PREVENT AIR LEAKAGE. PROVIDE SENSOR LENGTHS AND QUANTITIES TO RESULT IN ONE LINEAL FOOT OF SENSING ELEMENT FOR EACH THREE SQUARE FEET OF COOLING COIL/DUCT FACE AREA. TEMPERATURE RANGE AS REQUIRED FOR RESOLUTION INDICATED IN PARAGRAPH A.

1. SENSING ELEMENT SHALL BE PLATINUM RTD, OR THERMISTOR, +/- 0.2°F ACCURACY AT CALIBRATION POINT.

F. LIQUID IMMERSION TEMPERATURE SENSOR SHALL INCLUDE BRASS THERMOWELL, SENSOR AND CONNECTION HEAD FOR WIRING CONNECTIONS. TEMPERATURE RANGE SHALL BE AS REQUIRED FOR RESOLUTION OF 0.15°F.

1. SENSING ELEMENT SHALL BE PLATINUM RTD, THERMISTOR, OR INTEGRATED CIRCUIT, +/- 0.4°F ACCURACY AT CALIBRATION POINT. TEMPERATURE RANGE SHALL BE AS REQUIRED FOR RESOLUTION OF 0.3°F.

INCLUDE AND EDIT WHERE SURFACE-MOUNT MAY BE ALLOWED IN THE PROJECT WITH PRIOR APPROVAL BY UCB

G. [PIPE SURFACE-MOUNT TEMPERATURE SENSOR: SHALL INCLUDE METAL JUNCTION BOX AND CLAMPS AND SHALL BE SUITABLE FOR SENSING PIPE SURFACE TEMPERATURE AND INSTALLATION UNDER INSULATION. PROVIDE THERMALLY CONDUCTIVE PASTE AT PIPE CONTACT POINT. TEMPERATURE RANGE SHALL BE AS REQUIRE FOR RESOLUTION INDICATED IN PARAGRAPH A.

1. SENSING ELEMENT SHALL BE PLATINUM RTD, THERMISTOR, OR INTEGRATED CIRCUIT, +/- 0.4°F ACCURACY AT CALIBRATION POINT.]

H. OUTSIDE AIR SENSORS SHALL CONSIST OF A SENSOR, SUN SHIELD, UTILITY BOX, AND WATERTIGHT GASKET TO PREVENT WATER SEEPAGE. TEMPERATURE RANGE SHALL BE AS REQUIRE FOR RESOLUTION INDICATED IN PARAGRAPH A

1. SENSING ELEMENT SHALL BE PLATINUM RTD, THERMISTOR, OR INTEGRATED CIRCUIT, +/- 0.4°F ACCURACY AT CALIBRATION POINT.

2.07 HUMIDITY TRANSMITTERS

A. UNITS SHALL BE SUITABLE FOR DUCT, WALL (ROOM) OR OUTDOOR MOUNTING. UNIT SHALL BE TWO-WIRE TRANSMITTER UTILIZING BULK POLYMER RESISTANCE CHANGE OR THIN FILM CAPACITANCE CHANGE HUMIDITY SENSOR. UNIT SHALL PRODUCE LINEAR CONTINUOUS OUTPUT OF 4-20 MA FOR PERCENT RELATIVE HUMIDITY (% RH). A COMBINATION TEMPERATURE AND HUMIDITY SENSOR MAY BE USED FOR ZONE LEVEL MONITORING. SENSORS SHALL HAVE THE FOLLOWING MINIMUM PERFORMANCE AND APPLICATION CRITERIA:

1. INPUT RANGE: 0 TO 100% RH.
2. ACCURACY(% RH): +/- 2% (WHEN USED FOR ENTHALPY CALCULATION, DEWPOINT CALCULATION OR HUMIDIFIER CONTROL) OR +/- 3% (MONITORING ONLY) BETWEEN 20-90% RH AT 77°F, INCLUDING HYSTERESIS, LINEARITY, AND REPEATABILITY.
3. SENSOR OPERATING RANGE: AS REQUIRED BY APPLICATION
4. LONG TERM STABILITY: LESS THAN 1% DRIFT PER YEAR.

B. ACCEPTABLE MANUFACTURERS: UNITS SHALL BE VAISALA HM SERIES. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.08 DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

A. GENERAL PURPOSE - WATER: TWO-WIRE TRANSMITTER, 4-20 MA OUTPUT WITH ZERO AND SPAN ADJUSTMENTS. PLUS OR MINUS 0.5% OVERALL ACCURACY, 450 PSIG (3103 KPA) MAXIMUM STATIC PRESSURE RATING, 200 PSID MAXIMUM OVERPRESSURE RATING FOR 6 THROUGH 60 PSID RANGE, 450 PSID FOR 100 THROUGH 300 PSID RANGE.

B. INDUSTRIAL APPLICATION, LIQUID, STEAM AND GAS:

1. General: Two-wire smart DP cell type transmitter, 4-20 mA or 1-5 Vdc user-selectable linear or square root output, adjustable span and zero, stainless steel wetted parts.
2. Environmental limits: –40 to 250 °F (-40 to 121°C), 0 to 100% RH..
3. Accuracy: less than 0.1 percent of span.
4. Output Damping: Time constant user selectable from 0 to 36 seconds.
5. Vibration Effect: Less than ±0.1% of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
6. Electrical Enclosure: NEMA-4, -4X, -7, -9.
7. Approvals: FM, CSA.
8. Acceptable Manufacturers: Rosemount Inc. 3051 Series, Foxboro, Johnson-Yokagawa, Setra, or Mamac. Substitutions shall be allowed per Division 1.

C. General Purpose Low Pressure Air: Generally for use in static measurement of duct pressure or constant volume air velocity pressure measurement where the range is applicable.

1. General: Loop powered two-wire differential capacitance cell-type transmitter.
2. Output: two wire 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 1%.
4. Minimum Range: 0.1 in. w.c.
5. Maximum Range: 10 inches w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Ashcroft, Modus T30. Substitutions shall be allowed per Division 1.
8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
9. Range: Select for specified setpoint to be between 25% and 75% full-scale.

D. General Purpose Low Pressure/Low Differential Air: Generally for use in static measurement of space pressure or constant volume air velocity pressure measurement where the range is applicable.

1. General: Loop powered, two-wire differential capacitance cell type transmitter.
2. Output: Two-wire 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 1%.
4. Minimum Range: 0 in. w.c.
5. Maximum Range: 0.1, 0.25, or 0.5 inches w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Ashcroft, Modus T30. Substitutions shall be allowed per Division 1.

8. STATIC SENSING ELEMENT: PITOT-TYPE STATIC PRESSURE SENSING TIPS SIMILAR TO DWYER MODEL A-301 AND CONNECTING TUBING.
9. RANGE: SELECT FOR SPECIFIED SETPOINT TO BE BETWEEN 25% AND 75% FULL-SCALE.

E. VAV VELOCITY PRESSURE: GENERALLY FOR USE IN VARIABLE VOLUME AIR VELOCITY PRESSURE MEASUREMENT WHERE THE RANGE IS APPLICABLE.

1. GENERAL: LOOP POWERED TWO-WIRE DIFFERENTIAL CAPACITANCE CELL TYPE TRANSMITTER.
2. OUTPUT: TWO-WIRE, 4-20 MA OUTPUT WITH ZERO ADJUSTMENT.
3. OVERALL ACCURACY: PLUS OR MINUS 0.25%
4. MINIMUM RANGE: 0 IN. W.C.
5. MAXIMUM RANGE: 1 INCH W.C.
6. HOUSING: POLYMER HOUSING SUITABLE FOR SURFACE MOUNTING.
7. ACCEPTABLE MANUFACTURERS:
   a) ASHCROFT
   b) MODUS
   c) SETRA.
   d) SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.
8. RANGE: SELECT FOR MINIMUM RANGE THAT WILL ACCEPT THE MAXIMUM VELOCITY PRESSURE EXPECTED.

2.09 VALVE BYPASS FOR DIFFERENTIAL PRESSURE SENSORS

A. PROVIDE A THREE OR FIVE VALVE BYPASS KIT FOR PROTECTION OF DP SENSORS WHERE THE STATIC ON THE PIPE CAN CAUSE ON OVER PRESSURE WHEN CONNECTED TO ONE PORT WITH THE OTHER AT ATMOSPHERIC PRESSURE. KIT SHALL INCLUDE HIGH AND LOW PRESSURE ISOLATION VALVES, HIGH AND LOW PRESSURE VENT VALVES (FIVE VALVE KIT) AND A BYPASS VALVE CONTAINED IN A NEMA-1 ENCLOSURE. ENCLOSURE SHALL BE MOUNTED NO HIGHER THAN 6 FEET ABOVE FLOOR LEVEL.

2.10 DIFFERENTIAL PRESSURE SWITCHES (DPS)

A. GENERAL SERVICE - AIR: DIAPHRAGM WITH ADJUSTABLE SETPOINT AND DIFFERENTIAL AND SNAP ACTING FORM C CONTACTS RATED FOR THE APPLICATION. PROVIDE MANUFACTURER'S RECOMMENDED STATIC PRESSURE SENSING TIPS AND CONNECTING TUBING

B. GENERAL SERVICE - WATER: DIAPHRAGM WITH ADJUSTABLE SETPOINT, 2 PSIG OR ADJUSTABLE DIFFERENTIAL, AND SNAP-ACTING FORM C CONTACTS RATED FOR THE APPLICATION. 60 PSID MINIMUM PRESSURE DIFFERENTIAL RANGE. 0°F TO 160°F OPERATING TEMPERATURE RANGE.

2.11 PRESSURE SWITCHES (PS)

A. DIAPHRAGM OR BOURDON TUBE WITH ADJUSTABLE SETPOINT AND DIFFERENTIAL AND SNAP-ACTING FORM C CONTACTS RATED FOR THE APPLICATION. PRESSURE SWITCHES SHALL BE CAPABLE OF WITHSTANDING 150% OF RATED PRESSURE.

B. ACCEPTABLE MANUFACTURERS: SQUARE D, ITT NEO-DYN, ASCO, PENN, HONEYWELL, AND JOHNSON CONTROLS. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.12 TRANSDUCERS

A. STANDARD CAPACITY ELECTRONIC-TO-PNEUMATIC (E-P) TRANSDUCERS: E-P TRANSDUCERS SHALL BE VOLTAGE-TO-PNEUMATIC (V-P) TYPE, CURRENT-TO-PNEUMATIC (I-P) TYPE:

1. ELECTRICAL POWER SUPPLY: 24 VAC OR 24 VDC.
2. PNEUMATIC AIR SUPPLY: 30 PSIG (2.07 BAR) MAXIMUM.
3. AIR CAPACITY: 1100 SCIM @ 20 PSIG (300 CM3/SEC @ 1.4 BAR).
4. AIR CONSUMPTION: ZERO AT STEADY STATE.
5. OUTPUT SPAN: 0-20 PSIG (0-1.4 BAR).
6. INPUT: 4-20 MA, 0-5 VDC, 1-5 VDC, 0-10 VDC, 2-10 VDC, 0-15 VDC, OR 3-15 VDC INPUT.
7. ENCLOSURE: POLYMER DESIGNED FOR SURFACE OR PANEL MOUNT.
8. AIR CONNECTIONS: ¼" (6.35 MM) BARBED.
9. FAILURE MODE ON POWER LOSS: NON-FAILSAFE TRANSDUCERS SHALL HAVE NO OUTPUT AIR LOSS. FAILSAFE TRANSDUCERS SHALL EXHAUST OUTPUT UPON POWER LOSS.
10. ACCEPTABLE MANUFACTURERS: MAMAC EP-313-020, JOHNSON CONTROLS. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1

2.13 PHASE-VOLTAGE-FREQUENCY MONITOR

INCLUDE ONLY WHEN REQUESTED BY UCB.

A. PROVIDE WITH TWO (2) SETS OF ALARM RELAY OUTPUTS:

1. ONE MONITORED BY THE BAS
2. ONE MONITORED BY UCB

B. PROVIDE MOTOR SAVER MODEL MS250A OR EQUAL.

2.14 CURRENT SWITCHES (CS)

UCB PREFERS USING CURRENT TRANSDUCERS; UNLESS THERE IS A SPECIFIC APPLICATION FOR CURRENT SWITCHES.

A. CLAMP-ON DESIGN CURRENT OPERATED SWITCH (FOR CONSTANT SPEED MOTOR STATUS INDICATION)

1. RANGE: 1.5 TO 150 AMPS.
2. TRIP POINT: ADJUSTABLE.

3. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
4. Lower Frequency Limit: 6 Hz.
5. Trip Indication: LED
6. Approvals: UL, CSA
7. Max. Cable Size: 350 MCM
8. Acceptable Manufacturers: Veris Industries H-708/908; Inc., RE Technologies SCS1150A-LED. Substitutions shall be allowed per Division 1.

B. Clamp-on Wire Through Current Switch (CS/CR) (for Constant Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable Manufacturers shall be Veris Industries, Inc., Model # H938/735; or RE Technologies RCS 1150. Substitutions shall be allowed per Division 1.

1. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing similar with override switch to Kele RIBX. Substitutions shall be allowed per Division 1.

C. Clamp-On Design Current Operated Switch for Variable Speed Motor Status Indication

1. Where VFD is utilized, run status off VFD.
2. Range: 1.5 to 135 Amps.
3. Trip Point: Self-calibrating based on VA memory associated with frequency to detect loss of belt with subsequent increase of control output to 60 Hz.
4. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
5. Frequency Range: 5-75 Hz
6. Trip Indication: LED
7. Approvals: UL, CSA
8. Max. Cable Size: 350 MCM
9. Acceptable Manufacturers: Veris Industries, Inc. H-904. Substitutions shall be allowed per Division 1.

D. Clamp-On Wire Through Current Switch (CS/CR) (for Variable Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable manufacturer shall be Veris Industries, Inc., Model # H934. Substitutions shall be allowed per Division 1.

E. Variable Speed Status: Where current switches are used to sense the status for variable speed devices, the CT shall include on-board VA/Hz memory to allow distinction between a belt break and subsequent ramp up to 60 Hz,

VERSUS OPERATION AT LOW SPEED. THE BELT BREAK SCENARIO SHALL BE INDICATED AS A LOSS OF STATUS AND THE OPERATION AT LOW SPEED SHALL INDICATE NORMAL STATUS.

2.15 CURRENT TRANSDUCER (CT)

A. CLAMP-ON DESIGN CURRENT TRANSDUCER (FOR MOTOR CURRENT SENSING)

1. RANGE: 1-10 AMPS MINIMUM, 20-200 AMPS MAXIMUM
2. TRIP POINT: ADJUSTABLE
3. OUTPUT: 0-5 VDC.
4. ACCURACY: ±0.2% FROM 20 TO 100 HZ.
5. ACCEPTABLE MANUFACTURERS:
   a) VERIS # 7222, 822, 922
   b) SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.16 OUTDOOR AIR STATIC PRESSURE SENSING TIP

A. PRESSURE SENSOR: PRESSURE SENSING TIP SHALL BE DESIGNED TO MINIMIZE THE EFFECTS OF WIND AND RESULTING VELOCITY PRESSURE UP TO 80 MPH. ACCEPTABLE MANUFACTURERS SHALL BE DWYER A-306. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

B. LOW AIR PRESSURE SURGE DAMPENER: 30-SECOND TIME CONSTANT. ACCEPTABLE MANUFACTURER SHALL BE MODUS SD030. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.17 CONTINUOUS LEVEL TRANSMITTERS

A. ULTRASONIC TYPE

1. PROVIDE A NON-CONTACTING, TEMPERATURE COMPENSATING, NARROW BEAM, ULTRASONIC TYPE LEVEL TRANSMITTER WITH ADJUSTABLE SPAN AND ZERO.
2. OUTPUT: 4-20 MA.
3. TRANSDUCER MATERIALS: PC/ABS, POLYPROPYLENE, PVC AND/OR TEFLON.
4. ELECTRICAL ENCLOSURE: NEMA-4X, -6.
5. APPROVALS: UL, CE OR CSA.
6. ACCURACY: ±.5% OF CALIBRATED SPAN.
7. ACCEPTABLE MANUFACTURERS: FLOWLINE ECHOSPAN, PRINCO INSTRUMENTS, & GREYLINE. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

B. CAPACITANCE TYPE

1. PROVIDE A LOOP POWERED, CONTINUOUS CAPACITANCE TYPE LEVEL TRANSMITTER WITH ADJUSTABLE SPAN AND ZERO.
2. OUTPUT: 4-20 MA.
3. PROBE: FLUOROPOLYMER COATED STAINLESS STEEL ROD OR CABLE. PROVIDE CABLE PROBE WITH END ATTACHMENT HARDWARE OR WEIGHT.
4. ELECTRICAL ENCLOSURE: NEMA-4, -7.

5. APPROVALS: UL OR CSA.
6. ACCURACY: ±1% OF CALIBRATED SPAN.
7. PROCESS CONNECTION: MPT OR ANSI FLANGE AS REQUIRED.
8. ACCEPTABLE MANUFACTURERS: DREXELBROOK, ENDRESS & HAUSER. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.18 INSERTION TYPE TURBINE METER FOR WATER SERVICE

A. TURBINE INSERTION FLOW METER SENSING METHOD SHALL BE IMPEDANCE SENSING (IRON MAGNETIC AND NON-PHOTOELECTRIC), WITH VOLUMETRIC ACCURACY OF +/- 2% OF READING OVER MIDDLE 80% OF OPERATING RANGE, AND +/- 4% OF READING OVER THE ENTIRE OPERATING RANGE. TURBINE INSERTION FLOW METER SHALL HAVE MAXIMUM OPERATING PRESSURE OF 400 PSI AND MAXIMUM OPERATING TEMPERATURE OF 200°F CONTINUOUS (220°F PEAK). ALL WETTED METAL PARTS SHALL BE CONSTRUCTED OF 316 STAINLESS STEEL. FLOW METER SHALL MEET OR EXCEED ALL OF THE ACCURACY, HEAD LOSS, FLOW LIMITS, PRESSURE AND MATERIAL REQUIREMENTS OF THE AWWA STANDARD C704-70 FOR THE RESPECTIVE PIPE OR TUBE SIZE. ANALOG OUTPUTS SHALL CONSIST OF NON-INTERACTIVE ZERO AND SPAN ADJUSTMENTS, A DC LINEARLY OF 0.1% OF SPAN, VOLTAGE OUTPUT OF 0-10 V, AND CURRENT OUTPUT OF 4-20 MA.

1. INSTALL IN WATER SYSTEMS WITH A MINIMUM OF 10 PIPE DIAMETERS UNOBSTRUCTED FLOW.
2. ACCEPTABLE MANUFACTURERS: ONICON CORP. AND HERSEY. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.19 FLOW METER FOR STEAM

A. FLOW COMPUTER: KEP SUPERTROL II WITH MODBUS RTU COMMUNICATION CARD
B. MAXIMUM FLUID TEMPERATURE: 800 °F (427 °C)
C. WETTED PARTS: STAINLESS STEEL
D. HOUSING: NEMA 4X
E. TURNDOWN: 10:1 MINIMUM.
F. ACCURACY: 1% OF CALIBRATED SPAN
G. BODY: WAFER STYLE OR ANSI FLANGED TO MATCH PIPING SPECIFICATION.
H. ACCEPTABLE MANUFACTURERS: VERIS ACCELEBAR AND ONICON VORTEX. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.20 VORTEX SHEDDING FLOW METER FOR LIQUID AND GAS SERVICE

A. OUTPUT: 4-20 MA, 0-10 VDC, 0-5 VDC
B. MAXIMUM FLUID TEMPERATURE: 800 °F (427 °C)
C. WETTED PARTS: STAINLESS STEEL
D. HOUSING: NEMA 4X
E. TURNDOWN: 10:1 MINIMUM.

F. ACCURACY: 0.5% OF CALIBRATED SPAN FOR LIQUIDS, 1% OF CALIBRATED SPAN FOR GASES.

G. BODY: WAFER STYLE OR ANSI FLANGED TO MATCH PIPING SPECIFICATION.

H. ACCEPTABLE MANUFACTURERS: FOXBORO 83 SERIES, JOHNSON-YOKAGAWA, AND ROSEMOUNT. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.21 AIRFLOW MEASURING STATIONS (AFMS)

A. PITOT TUBE GRIDS: PROVIDE AN ARRAY OF VELOCITY PRESSURE SENSING ELEMENTS WITH AVERAGING MANIFOLDS AND AIR STRAIGHTENING VANES PACKAGED IN A SHEET METAL CASING. DISTRIBUTE SENSING ELEMENTS IN ACCORDANCE WITH ASHRAE FOR TRAVERSING DUCTS. PROVIDE TAPS TO CONNECT TUBING FROM INSTRUMENTATION. LABEL AFM WITH DRAWING NUMBER DESIGNATION, DESIGN FLOW, VELOCITY PRESSURE, AND PRESSURE DROP. APPLICATION OF PITOT GRIDS SHALL BE ALLOWED ONLY WHERE MINIMUM EXPECTED FLOW IS GREATER THAN 30% OR MAXIMUM FLOW

B. VORTEX SHEDDING GRID: PROVIDE AN ARRAY OF VORTEX SHEDDING ELEMENTS DESIGNED TO PRODUCE STABLE 'KARMEN VORTICES' THAT ARE LINEAR WITH AIR VELOCITY. PROVIDE THE ELECTRONICS TO TOTALIZE THE PULSES AND OUTPUT AVERAGE VELOCITY PROPORTIONAL TO AN OUTPUT SIGNAL OF 4-20MA.

1. SENSOR ACCURACY: ±1.5%
2. ELECTRONICS ACCURACY: ±0.5%
3. RANGE: SELECT MINIMUM RANGE TO ACCOMMODATE THE EXPECTED FLOW RANGE OF THE PROJECT
4. TEMPERATURE LIMITS: 20-140°F
5. ACCEPTABLE MANUFACTURER: TEK-AIR SYSTEMS INC. 'VORTEK' MODEL. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.22 AIR VELOCITY PRESSURE SENSORS (INSERTION TYPE)

A. SINGLE OR MULTI-POINT AVERAGING (AS INDICATED): SENSING TIP SHALL BE FOR INSERTION INTO DUCT WITH MOUNTING FLANGE AND PUSH ON TUBE CONNECTIONS. MATERIAL SHALL BE SUITABLE TO THE APPLICATION.

2.23 CO2 SENSORS/TRANSMITTERS (CO2)

A. CO2 SENSORS SHALL USE SILICON BASED, DIFFUSION ASPIRATED, INFRARED SINGLE BEAM, DUAL-WAVELENGTH SENSOR.

B. ACCURACY: ±36PPM AT 800 PPM AND 68°F.

C. STABILITY: 5% OVER 5 YEARS.

D. OUTPUT: 4-20 MA, 0-10 VDC OR RELAY.

E. MOUNTING: DUCT OR WALL AS INDICATED.

F. ACCEPTABLE MANUFACTURER: VAISALA, INC. GMD20 (DUCT) OR GMW20 (WALL).

THE FOLLOWING APPLIES TO REPAIR OR MINOR MODIFICATION OF EXISTING PNEUMATIC SYSTEMS.

2.24 [PNEUMATIC CONTROL COMPONENTS

A. ANALOG PRESSURE GAUGES: GAUGES SHALL BE PNEUMATIC TYPE, MINIMUM 1-1/2" IN (38 MM) DIAMETER, WITH WHITE FACE AND BLACK NUMERALS. SURFACE-MOUNTED GAUGES SHALL HAVE CHROME PLATED TRIM AND BE A MINIMUM OF 2-1/2" IN (64 MM) DIAMETER.

B. PNEUMATIC ACTUATED PRESSURE SWITCHES (PE) (FOR 30 PSIG MAX PRESSURE CONTROL SYSTEMS): PRESSURE RANGES AND SENSITIVITY OF PES SHALL MATCH CONTROL SYSTEM SEQUENCE OF OPERATION. SWITCH OPERATION SHALL BE EXTERNALLY ADJUSTABLE OVER THE OPERATING PRESSURE RANGE (NOMINAL 0-20 PSIG, 0 TO 138 KPA). PE SWITCHES SHALL BE SPDT TYPE, RATED FOR THE PARTICULAR APPLICATION, AND SHALL BE UL LISTED. PE SHALL BE AS MANUFACTURED BY PENN. SUBSTITUTIONS SHALL BE ALLOWED AS PER DIVISION 1

C. PILOT POSITIONERS: OPERATING SPAN ADJUSTMENT RANGE IS FROM 3 TO 13 PSI (21 TO 91 KPA). POSITIONER SHALL BE FURNISHED WITH A MOUNTING BRACKET FOR ATTACHMENT DIRECTLY TO THE ACTUATOR.]

2.25 ELECTRIC CONTROL COMPONENTS

A. LIMIT SWITCHES (LS): LIMIT SWITCHES SHALL BE UL LISTED, SPDT OR DPDT TYPE, WITH ADJUSTABLE TRIM ARM. LIMIT SWITCHES SHALL BE AS MANUFACTURED BY SQUARE D, ALLEN BRADLEY. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

B. [ELECTRIC SOLENOID-OPERATED PNEUMATIC VALVES (EP): EP VALVES SHALL BE RATED FOR A MINIMUM OF 1.5 TIMES THEIR MAXIMUM OPERATING STATIC AND DIFFERENTIAL PRESSURE.. VALVES SHALL BE PORTED 2-WAY, 3-WAY, OR 4-WAY AND SHALL BE NORMALLY CLOSED OR OPEN AS REQUIRED BY THE APPLICATION. EPS SHALL BE SIZED FOR MINIMUM PRESSURE DROP, AND SHALL BE UL AND CSA LISTED. FURNISH AND INSTALL GAUGES ON ALL INPUTS OF EPS. FURNISH AN ADJUSTABLE AIR PRESSURE REGULATOR ON INPUT SIDE OF SOLENOID VALVES SERVING ACTUATORS OPERATING AT GREATER THAN 30 PSIG.

1. COIL ENCLOSURE: INDOORS SHALL BE NEMA-1, OUTDOORS AND NEMA-3, 4, 7, 9.
2. FLUID TEMPERATURE RATING: VALVES FOR COMPRESSED AIR AND COLD WATER SERVICE SHALL HAVE 150 °F (66 °C) MINIMUM RATING. VALVES FOR HOT WATER OR STEAM SERVICE SHALL HAVE FLUID TEMPERATURE RATING HIGHER THAN THE MAXIMUM EXPECTED FLUID TEMPERATURE.
3. ACCEPTABLE MANUFACTURERS: EP VALVES SHALL BE AS MANUFACTURED BY ASCO OR PARKER. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.
4. COIL RATING: EP VALVES SHALL HAVE APPROPRIATE VOLTAGE COIL RATED FOR THE APPLICATION (I.E., 24 VAC, 120 VAC, 24 VDC, ETC.).]

C. LOW TEMPERATURE DETECTOR ('FREEZESTAT') (FZ): LOW TEMPERATURE DETECTOR SHALL CONSIST OF A 'COLD SPOT' ELEMENT WHICH RESPONDS ONLY TO THE LOWEST TEMPERATURE ALONG ANY ONE FOOT OF ENTIRE ELEMENT, MINIMUM BULB SIZE OF 1/8" X 20' (3.2MM X 6.1M), JUNCTION BOX FOR WIRING CONNECTIONS AND GASKET TO PREVENT AIR LEAKAGE OR VIBRATION NOISE, DPST (4 WIRE, 2 CIRCUIT) WITH MANUAL RESET. TEMPERATURE RANGE 15 TO 55°F (-9.4 TO 12.8°C), FACTORY SET AT 38°F.

D. SURFACE-MOUNTED THERMOSTAT: SURFACE-MOUNTED THERMOSTAT SHALL CONSIST OF SPDT CONTACTS, OPERATING TEMPERATURE RANGE OF 50 TO 150° F (10 TO 65°C) , AND A MINIMUM 10°F FIXED SETPOINT DIFFERENTIAL.

E. LOW VOLTAGE WALL THERMOSTAT: WALL-MOUNTED THERMOSTAT SHALL CONSIST OF SPDT SEALED MERCURY CONTACTS, OPERATING TEMPERATURE RANGE OF 50 TO 90°F (10 TO 32°C), SWITCH RATING OF 24 VAC (30 VAC MAX.), AND BOTH MANUAL AND AUTOMATIC FAN OPERATION IN BOTH THE HEAT AND COOL MODES.

F. CONTROL RELAYS: ALL CONTROL RELAYS SHALL BE UL LISTED, WITH CONTACTS RATED FOR THE APPLICATION, AND MOUNTED IN MINIMUM NEMA-1 ENCLOSURE FOR INDOOR LOCATIONS, NEMA-4 FOR OUTDOOR LOCATIONS.

1. CONTROL RELAYS FOR USE ON ELECTRICAL SYSTEMS OF 120 VOLTS OR LESS SHALL HAVE, AS A MINIMUM, THE FOLLOWING:
   a) AC COIL PULL-IN VOLTAGE RANGE OF +10%, -15% OR NOMINAL VOLTAGE.
   b) COIL SEALED VOLT-AMPERES (VA) NOT GREATER THAN FOUR (4) VA.
   c) SILVER CADMIUM FORM C (SPDT) CONTACTS IN A DUSTPROOF ENCLOSURE, WITH 8 OR 11 PIN TYPE PLUG.
   d) LED PILOT LIGHT INDICATION OF POWER-TO-COIL AND COIL RETAINER CLIPS.
   e) COIL RATED FOR 50 AND 60 HZ SERVICE.
   f) ACCEPTABLE MANUFACTURERS: RELAYS SHALL BE POTTER BRUMFIELD, MODEL KRPA. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.
2. RELAYS USED FOR ACROSS-THE-LINE CONTROL (START/STOP) OF 120V MOTORS, 1/4 HP, AND 1/3 HP, SHALL BE RATED TO BREAK MINIMUM 10 AMPS INDUCTIVE LOAD. RELAYS SHALL BE IDEC. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.
3. RELAYS USED FOR STOP/START CONTROL SHALL HAVE LOW VOLTAGE COILS (30 VAC OR LESS), AND SHALL BE PROVIDED WITH TRANSIENT AND SURGE SUPPRESSION DEVICES AT THE CONTROLLER INTERFACE.

G. GENERAL PURPOSE POWER CONTACTORS: NEMA ICS 2, AC GENERAL-PURPOSE MAGNETIC CONTACTOR. ANSI/NEMA ICS 6, NEMA TYPE 1ENCLOSURE. MANUFACTURER SHALL BE SQUARE 'D', CUTLER-HAMMER OR WESTINGHOUSE.

H. CONTROL TRANSFORMERS: FURNISH AND INSTALL CONTROL TRANSFORMERS AS REQUIRED. CONTROL TRANSFORMERS SHALL BE MACHINE TOOL TYPE, AND SHALL BE US AND CSA LISTED. PRIMARY AND SECONDARY SIDES SHALL BE FUSED IN ACCORDANCE WITH THE NEC. TRANSFORMER SHALL BE PROPER SIZE FOR APPLICATION, AND MOUNTED IN MINIMUM NEMA-1 ENCLOSURE.

1. TRANSFORMERS SHALL BE MANUFACTURED BY:
   a) WESTINGHOUSE
   b) SQUARE ‘D’
   c) JEFFERSON
   d) VERIS X100, X040, X020
   e) SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

I. TIME DELAY RELAYS (TDR): TDRS SHALL BE CAPABLE OF ON OR OFF DELAYED FUNCTIONS, WITH ADJUSTABLE TIMING PERIODS, AND CYCLE TIMING LIGHT. CONTACTS

SHALL BE RATED FOR THE APPLICATION WITH A MINIMUM OF TWO (2) SETS OF FORM C CONTACTS, ENCLOSED IN A DUSTPROOF ENCLOSURE.

1. TDRS SHALL HAVE SILVER CADMIUM CONTACTS WITH A MINIMUM LIFE SPAN RATING OF ONE MILLION OPERATIONS. TDRS SHALL HAVE SOLID STATE, PLUG-IN TYPE COILS WITH TRANSIENT SUPPRESSION DEVICES.
2. TDRS SHALL BE UL AND CSA LISTED, CROUZET TYPE. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

J. ELECTRIC PUSH BUTTON SWITCH: SWITCH SHALL BE MOMENTARY CONTACT, OIL TIGHT, PUSH BUTTON, WITH NUMBER OF N.O. AND/OR N.C. CONTACTS AS REQUIRED. CONTACTS SHALL BE SNAP-ACTION TYPE, AND RATED FOR MINIMUM 120 VAC OPERATION. SWITCH SHALL BE 800T TYPE, AS MANUFACTURED BY ALLEN BRADLEY. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

K. PILOT LIGHT: PANEL-MOUNTED PILOT LIGHT SHALL BE NEMA ICS 2 OIL TIGHT, TRANSFORMER TYPE, WITH SCREW TERMINALS, PUSH-TO-TEST UNIT, LED TYPE, RATED FOR 120 VAC. UNIT SHALL BE 800T TYPE, AS MANUFACTURED BY ALLEN-BRADLEY. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

L. ELECTRIC SELECTOR SWITCH (SS): SWITCH SHALL BE MAINTAINED CONTACT, NEMA ICS 2, OIL-TIGHT SELECTOR SWITCH WITH CONTACT ARRANGEMENT, AS REQUIRED. CONTACTS SHALL BE RATED FOR MINIMUM 120 VAC OPERATION. SWITCH SHALL BE 800T TYPE, AS MANUFACTURED BY ALLEN-BRADLEY. SUBSTITUTIONS SHALL BE ALLOWED PER DIVISION 1.

2.26 REFRIGERANT MONITOR

A. GENERAL: CONTRACTOR SHALL PROVIDE A REFRIGERANT SENSITIVE INFRARED-BASED STATIONARY REFRIGERANT GAS LEAK MONITOR SYSTEM DESIGNED TO CONTINUOUSLY MEASURE REFRIGERANTS. REFRIGERANT MONITOR SHALL BE COORDINATED TO DETECT {INSERT REFRIGERANT TYPES HERE IF KNOWN OR DELETE} REFRIGERANTS USED IN CHILLER EQUIPMENT INSTALLED UNDER SECTION {INSERT APPROPRIATE SECTION}. THE ALARM SYSTEM SHALL COMPLY WITH ANSI/ASHRAE 15-1994 AND LOCAL CODE REQUIREMENTS.

B. THE REFRIGERANT MONITOR SHALL BE CAPABLE OF MONITORING MULTIPLE REFRIGERANT GAS COMPOUNDS AT MULTIPLE LOCATIONS IN CONCENTRATIONS OF 0 PPM TO A MINIMUM OF 1000 PPM. THE MONITOR SHALL HAVE A LOW RANGE RESOLUTION OF 1 PPM IN THE RANGE OF 1 PPM THROUGH 100 PPM. READINGS ABOVE 100 PPM MUST BE ACCURATE TO WITHIN ±5% OF READING. ACCURACY SHALL BE MAINTAINED WITHIN AMBIENT ENVIRONMENTAL RANGES OF 0°C. THROUGH 50°C., (32°F. THROUGH 122°F.) AND 5% THROUGH 90% RELATIVE HUMIDITY, NON-CONDENSING.

C. THE REFRIGERANT MONITOR SHALL AUTOMATICALLY AND CONTINUOUSLY MONITOR THE AREAS THROUGH A SAMPLE DRAW TYPE TUBULAR PICK UP SYSTEM WITH AN INTERNAL PUMP AND FILTER. THE INSTALLATION OF THE MONITORING CONTROL AND THE TUBING SHALL BE IN STRICT ACCORDANCE WITH THE MANUFACTURES INSTRUCTIONS. THE LOCATION, ROUTING, AND FINAL POSITION OF THE SAMPLE TUBES SHALL BE SUBMITTED TO THE ENGINEER WITH ALL NECESSARY SHOP DRAWINGS AND MONITOR SPECIFICATIONS AND INSTALLATION INSTRUCTIONS. TUBING SIZE, TUBING MATERIAL, AND TUBE LENGTH LIMITATIONS SHALL BE WITHIN THE SPECIFICATIONS OF THE MONITOR MANUFACTURE.

THE LOCATION AND METHOD OF TUBE SUPPORT AND HANGERS MUST BE IDENTIFIED ON THE SHOP DRAWINGS. EACH OF THE SAMPLING TUBES SHALL HAVE END OF LINE FILTERS.

D. THE ANALYZER WILL BE BASED ON INFRARED DETECTION TECHNOLOGY, AND WILL BE FACTORY TESTED AND CALIBRATED FOR THE SPECIFIED REFRIGERANT OR REFRIGERANTS. FACTORY CERTIFICATION OF THE CALIBRATIONS SHALL BE PROVIDED WITH THE O&M MANUALS. . THE ANALYZER SHALL PROVIDE A MENU DRIVEN OR AUTOMATIC METHOD OF CHECKING BOTH ZERO, SPAN CALIBRATION FOR EACH SENSOR, AND ALLOW FOR ADJUSTMENT.

E. THE MONITOR SHALL BE EQUIPPED WITH 4 OUTPUTS. THREE RELAYS SHALL ENERGIZE AT AN ADJUSTABLE USER DEFINED SET POINT BASED ON REFRIGERANT CONCENTRATION LEVELS. THE RELAY THRESHOLD ADJUSTMENT SHALL BE PROTECTED BY KEYED OR PASSWORD ACCESS CONTROLS. ADJUSTMENTS AND OBSERVATIONS SHALL BE MADE AT THE FRONT PANEL OPERATOR INTERFACE. THE RELAY THRESHOLD VALUES CAN BE VIEWED WITHOUT A PASSWORD. THE DIGITAL DISPLAY WILL CONTINUOUSLY DISPLAY THE REFRIGERANT CONCENTRATION LEVEL AND ALARM STATUS. THE FOURTH OUTPUT SHALL INDICATE A MONITOR MALFUNCTION ALARM. THE MONITOR SHALL ALSO HAVE AN ANALOG OUTPUT THAT WILL PROVIDE A LINER SCALED REFERENCE TO THE REFRIGERANT CONCENTRATION IN PARTS PER MILLION. THE ANALOG OUTPUT SIGNAL SHALL BE AN INDUSTRY STANDARD DC VOLTAGE, OR MA CURRENT SIGNAL.

F. THE MONITOR SHALL HAVE A NEMA-4 MOISTURE RESISTANT ENCLOSURE WITH A GASKETED, HINGED FRONT COVER. CONDUITS AND TUBE CONNECTIONS SHALL BE LOCATED ON THE BOTTOM OF THE ENCLOSURE. THE ENCLOSURE SHALL HAVE A RUST AND CORROSION RESISTANT FINISH.

G. THE FOLLOWING ALARM MODES WILL BE PROVIDED BY THE REFRIGERANT MONITOR:

1. ALARM LEVEL ONE – LOW LEVEL OF REFRIGERANT CONCENTRATION AT ONE OF THE SAMPLING POINTS HAS DETECTED THE PRESENCE OF A POSSIBLE REFRIGERANT LEAK. THE INITIAL ALARM THRESHOLD SHALL BE SET TO 5 PPM (ADJ.) AND INCREASED IF THERE ARE NUISANCE ALARMS. THIS ALARM LEVEL SHALL BE DISPLAYED ON THE REFRIGERANT MONITOR INTERFACE PANEL, INDICATING WHICH SENSOR HAS TRIGGERED THE ALARM, AND THE ASSOCIATED CONCENTRATION OF REFRIGERANT IN PPM. THIS EVENT WILL ALSO SEND AN ALARM LEVEL ONE SIGNAL TO THE BAS THROUGH A DIGITAL OUTPUT FROM THE MONITOR RELAY. THIS ALARM WILL REMAIN ACTIVE UNTIL THE REFRIGERANT CONCENTRATION IS REDUCED BELOW SET POINT.
2. ALARM LEVEL TWO – THIS ALARM SHALL INDICATE THAT ONE OF THE SENSORS HAS DETECTED A REFRIGERANT CONCENTRATION THAT IS APPROACHING DANGEROUS LEVELS IN THE AREA BEING MONITORED. THIS ALARM SHALL BE SET TO 25% BELOW THE MAXIMUM CALCULATED REFRIGERANT LEVEL SPECIFIED IN ANSI/ASHRAE 15-1994 AND ASHRAE 34-1992. THIS ALARM WILL BE DISPLAYED ON THE MONITOR INTERFACE, AND WILL INDICATE WHICH OF THE SENSORS HAS CAUSED THE ALARM, AND THE HIGHEST CONCENTRATION IN PPM. THIS EVENT WILL ALSO ACTIVATE THE BEACON AND AUDIBLE ALARM MOUNTED ON THE REFRIGERANT MONITORING ENCLOSURE. THIS ALARM WILL ALSO BE SENT TO THE BAS THROUGH THE DIGITAL OUTPUT OF THE RELAY. IN THIS MODE THE AUDIBLE ALARM CAN BE SILENCED, BUT THE BEACON SHALL REMAIN ACTIVE UNTIL THE FAULT IS CLEARED

3. ALARM LEVEL THREE – THIS ALARM SHALL BE SET AT THE MAXIMUM CALCULATED REFRIGERANT LEVEL SPECIFIED IN ANSI/ASHRAE 15-1994 AND ASHRAE 34-1992 WHICHEVER IS THE LOWEST CONCENTRATION. THE REFRIGERANT MONITOR INTERFACE WILL DISPLAY WHICH SENSOR HAS CAUSED THE ALARM, AND THE ASSOCIATED CONCENTRATION IN PPM. THIS EVENT WILL ALSO ACTIVATE THE BEACON AND AUDIBLE ALARM MOUNTED ON THE REFRIGERANT MONITORING ENCLOSURE. IF THE AUDIBLE ALARM HAD BEEN SILENCED BY AN EARLIER ALARM, THE ACTIVATION OF THIS LEVEL THREE ALARM WILL CAUSE THE AUDIBLE ALARM TO BE ACTIVATED AGAIN. THE RELAY IN THE REFRIGERANT MONITORING PANEL SHALL ACTIVATE THE SPACE VENTILATION SYSTEM, AND WILL DISABLE ALL COMBUSTION OR FLAME-PRODUCING EQUIPMENT VIA HARDWIRED CONTROL INTERLOCKS. IN ADDITION, THIS EVENT AND WILL DE-ENERGIZE THE ENERGY SOURCE FOR ANY HOT SURFACE (850°F OR 454°C) LOCATED IN THE SPACE. INTERLOCKS MUST ALSO BE PROVIDED TO CLOSE ANY NORMALLY OPEN DOORS OR OPENINGS TO THE SPACE FOR PROPER VENTILATION AND ISOLATION DURING THIS ALARM CONDITION. THIS ALARM LEVEL WILL ALSO SIGNAL THE BAS THROUGH THE DIGITAL OUTPUT THROUGH THE SAME RELAY. IN THIS MODE, THE AUDIBLE ALARM CAN BE SILENCED, BUT THE BEACON SHALL REMAIN ACTIVE UNTIL THE FAULT IS CLEARED.

H. ALL ALARM CONDITIONS SHALL BE REPORT TO THE BAS SYSTEM AS FOLLOWS:

1. ALARM LEVEL ONE - THE LOWEST REFRIGERANT ALARM LEVEL SHALL DETECT THE PRESENCE OF REFRIGERANT IN LOW CONCENTRATIONS AND ENERGIZE A RELAY TO SIGNAL A LOW LEVEL ALARM TO THE BAS OPERATOR TERMINAL(S). THE ALARM SHALL DISPLAY AN ALARM MESSAGE STATING THAT THERE IS A POTENTIAL REFRIGERANT LEAK IN THE DESIGNATED AREA.
2. ALARM LEVEL TWO - THE SECOND REFRIGERANT LEVEL ALARM SHALL BE A HIGH REFRIGERANT ALARM ALERT. THIS ALARM SHALL ENERGIZE A RELAY TO SIGNAL THE BAS SYSTEM INDICATING A HIGH LEVEL ALARM ON THE BAS OPERATOR TERMINAL(S). THIS BAS ALARM SHALL STATE THAT HIGH LEVELS OF REFRIGERANT HAVE BEEN DETECTED IN THE DESIGNATED AREA.
3. FAULT ALARM – REPORTS A HIGH LEVEL ALARM TO THE BAS OPERATOR TERMINAL(S) THAT THERE IS A FAULT IN THE REFRIGERANT MONITORING ALARM SYSTEM.

THE FOLLOWING ONLY APPLIES FOR SMOKE CONTROL APPLICATIONS. UCB WILL PROVIDE DETAILS FOR INTERFACE TO SIMPLEX SYSTEM.

2.27 [SMOKE CONTROL/FIREMAN'S OVERRIDE PANEL

A. INTEGRAL ENUNCIATOR/CONTROL PANEL PART OF COMPLETE ENGINEERED AND UUKL 864 LISTED SYSTEM.

B. PROVIDE CLEAR, LAMINATED GRAPHIC SCHEMATICALLY REPRESENTING THE BUILDING AIR SYSTEMS. STATUS LEDS SHALL BE ASSOCIATED WITH GRAPHIC REPRESENTATIONS OF FANS. OVERRIDE SWITCHES SHALL BE PROVIDED AS REQUIRED BY NFPA 110 TO ALLOW OVERRIDE OF THE FANS AND DAMPERS APPLICABLE TO THE CODE REQUIREMENTS.

C. INTERFACE WITH FIRE ALARM SYSTEM (SIMPLEX) AS REQUIRED TO IMPLEMENT THE REQUIREMENTS SPECIFIED IN THE SEQUENCE OF OPERATIONS.]

2.28 NAMEPLATES

A. PROVIDE ENGRAVED PHENOLIC OR MICARTA NAMEPLATES FOR ALL EQUIPMENT, COMPONENTS, AND FIELD DEVICES FURNISHED. NAMEPLATES SHALL BE 1/8 THICK, BLACK, WITH WHITE CENTER CORE, AND SHALL BE MINIMUM 1" X 3", WITH MINIMUM 1/4" HIGH BLOCK LETTERING. NAMEPLATES FOR DEVICES SMALLER THAN 1" X 3" SHALL BE ATTACHED TO ADJACENT SURFACE.

B. EACH NAMEPLATE SHALL IDENTIFY THE FUNCTION FOR EACH DEVICE.

C. FOR PUMP VARIABLE SPEED DRIVES (VSDS), PROVIDE AN ENGRAVED NAMEPLATE AT THE VSD INDICATING THE LOCATION OF THE CONTROLLING REMOTE DIFFERENTIAL PRESSURE (RDP) TRANSMITTER(S). LOCATION SHALL INCLUDE THE 'PLAN' ROOM NUMBER AS WELL AS THE ACTUAL 'BUILDING' ROOM NUMBER.

2.29 TESTING EQUIPMENT

A. CONTRACTOR SHALL TEST AND CALIBRATE ALL SIGNALING CIRCUITS OF ALL FIELD DEVICES TO ASCERTAIN THAT REQUIRED DIGITAL AND ACCURATE ANALOG SIGNALS ARE TRANSMITTED, RECEIVED, AND DISPLAYED AT SYSTEM OPERATOR TERMINALS, AND MAKE ALL REPAIRS AND RECALIBRATIONS REQUIRED TO COMPLETE TEST. CONTRACTOR SHALL BE RESPONSIBLE FOR TEST EQUIPMENT REQUIRED TO PERFORM THESE TESTS AND CALIBRATIONS. TEST EQUIPMENT USED FOR TESTING AND CALIBRATION OF FIELD DEVICES SHALL BE AT LEAST TWICE AS ACCURATE AS RESPECTIVE FIELD DEVICE (E.G., IF FIELD DEVICE IS +/-0.5% ACCURATE, TEST EQUIPMENT SHALL BE +/-0.25% ACCURATE OVER SAME RANGE).

Part III. PART 3 - EXECUTION

3.01 INSPECTION

A. EXAMINE AREAS AND CONDITIONS UNDER WHICH CONTROL SYSTEMS ARE TO BE INSTALLED. DO NOT PROCEED WITH WORK UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED IN MANNER ACCEPTABLE TO INSTALLER.

3.02 INSTALLATION OF CONTROL SYSTEMS

A. GENERAL: INSTALL SYSTEMS AND MATERIALS IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS, ROUGHING-IN DRAWINGS AND DETAILS SHOWN ON DRAWINGS. INSTALL ELECTRICAL COMPONENTS AND USE ELECTRICAL PRODUCTS COMPLYING WITH REQUIREMENTS OF NATIONAL ELECTRIC CODE AND ALL LOCAL CODES.

B. [MAIN CONTROL AIR PIPING: ALL MAIN AIR PIPING BETWEEN THE COMPRESSORS AND THE CONTROL PANELS SHALL BE COPPER, RUN PER ASTM B88

C. BRANCH CONTROL AIR PIPING: ACCESSIBLE TUBING IS DEFINED AS THAT TUBING RUN IN MECHANICAL EQUIPMENT ROOMS; INSIDE MECHANICAL EQUIPMENT ENCLOSURES, SUCH AS HEATING AND COOLING UNITS, INSTRUMENT PANELS; ACROSS ROOFS, IN PIPE CHASES, ETC. INACCESSIBLE TUBING IS DEFINED AS THAT TUBING RUN IN CONCRETE SLABS; FURRED WALLS; OR CEILINGS WITH NO ACCESS.

1. PROVIDE COPPER TUBING WITH MAXIMUM UNSUPPORTED LENGTH OF 3'-0", FOR ACCESSIBLE TUBING RUN EXPOSED TO VIEW. POLYETHYLENE TUBING MAY BE USED IN LIEU OF ABOVE, WHEN RUN WITHIN ADEQUATELY SUPPORTED, RIGID ENCLOSURE, SUCH AS METALLIC RACEWAYS, OR EMT. TERMINAL SINGLE-LINE CONNECTIONS LESS THAN 18 IN LENGTH MAY BE COPPER TUBING, OR POLYETHYLENE TUBING RUN INSIDE FLEXIBLE STEEL PROTECTION. ACCESSIBLE TUBING RUN IN CONCEALED LOCATIONS, SUCH AS PIPE CHASES, SUSPENDED CEILINGS WITH EASY ACCESS, ETC. MAY BE COPPER OR POLYETHYLENE BUNDLED AND SHEATHED TUBING.
2. PROVIDE COPPER OR POLYETHYLENE TUBING FOR INACCESSIBLE TUBING, OTHER THAN IN CONCRETE POUR. IF POLYETHYLENE TUBING IS USED, INSTALL IN EMT OR VINYL-JACKETED POLYETHYLENE TUBING.
3. PRESSURE TEST CONTROL AIR PIPING AT 30 PSI (207 KPA) FOR 24 HOURS. TEST FAILS IF MORE THAN 2 PSI LOSS OCCURS.
4. FASTEN FLEXIBLE CONNECTIONS BRIDGING CABINETS AND DOORS, NEATLY ALONG HINGE SIDE, AND PROTECT AGAINST ABRASION. TIE AND SUPPORT TUBING NEATLY.
5. NUMBER-CODE OR COLOR-CODE TUBING, EXCEPT LOCAL INDIVIDUAL ROOM CONTROL TUBING, FOR FUTURE IDENTIFICATION AND SERVICING OF CONTROL SYSTEM. CODE SHALL BE AS INDICATED ON APPROVED INSTALLATION DRAWINGS.]

D. CONTROL WIRING: THE TERM "CONTROL WIRING" IS DEFINED TO INCLUDE PROVIDING OF WIRE, CONDUIT AND MISCELLANEOUS MATERIALS AS REQUIRED FOR MOUNTING AND CONNECTION OF ELECTRIC CONTROL DEVICES.

1. WIRING SYSTEM: INSTALL COMPLETE WIRING SYSTEM FOR ELECTRIC CONTROL SYSTEMS. CONCEAL WIRING EXCEPT IN MECHANICAL ROOMS AND AREAS WHERE OTHER CONDUIT AND PIPING ARE EXPOSED. INSTALLATION OF WIRING SHALL GENERALLY FOLLOW BUILDING LINES. INSTALL IN ACCORDANCE WITH NATIONAL ELECTRICAL CODE AND DIVISION 16 OF THIS SPECIFICATION. FASTEN FLEXIBLE CONDUCTORS BRIDGING CABINETS AND DOORS, NEATLY ALONG HINGE SIDE, AND PROTECT AGAINST ABRASION. TIE AND SUPPORT CONDUCTORS NEATLY.
2. CONTROL WIRING CONDUCTORS: INSTALL CONTROL WIRING CONDUCTORS, WITHOUT SPLICES BETWEEN TERMINAL POINTS, LABELED WITH DEVICE SERVED. INSTALL IN NEAT WORKMANLIKE MANNER, SECURELY FASTENED. INSTALL IN ACCORDANCE WITH NATIONAL ELECTRICAL CODE AND DIVISION 16 OF THIS SPECIFICATION.
3. COMMUNICATION WIRING SHALL BE RUN IN SEPARATE CONDUIT FROM ALL OTHER WIRING. SIGNAL WIRING AND LOW VOLTAGE CONTROL WIRING SHALL BE INSTALLED SEPARATE FROM ANY WIRING OVER THIRTY (30) VOLTS. SIGNAL WIRING SHIELD SHALL BE GROUNDED AT CONTROLLER END ONLY, UNLESS OTHERWISE RECOMMENDED BY THE CONTROLLER MANUFACTURER. ALL COMMUNICATION WIRE SHALL BE RAN IN ORANGE CONDUIT FOR ANDOVER CONTROLS, BLUE FOR PHOENIX CONTROLS, IN AREAS NOT VIEWED BY THE GENERAL PUBLIC AND THE WIRING

NEEDS TO BE LABELED FOR EASE OF IDENTIFICATION; ANY OTHER CONTROLS APPLICATIONS NOT LISTED PRIOR WILL BE HAVE COLOR DETERMINED DURING DESIGN.

4. ALL WAN AND LAN COMMUNICATION WIRING SHIELD SHALL BE TERMINATED AS RECOMMENDED BY CONTROLLER MANUFACTURER. ALL WAN AND LAN COMMUNICATION WIRING SHALL BE ORANGE JACKETED AND LABELED WITH A NETWORK NUMBER, DEVICE ID AT EACH TERMINATION AND SHALL CORRESPOND WITH THE WAN AND LAN SYSTEM ARCHITECTURE AND FLOOR PLAN SUBMITTALS.
5. ALL COMMUNICATIONS WIRING SHALL BE IN CONDUIT UNLESS PRE-APPROVED BY UCB.
6. ALL LOW-VOLTAGE WIRING EXTERNAL TO CONTROL PANELS SHALL BE IN CONDUIT, UNLESS PRE-APPROVED. CONDUIT TYPE, SIZING, AND INSTALLATION REQUIREMENTS SHALL CONFORM TO NEC AND DIVISION 16.

   THE FOLLOWING ONLY APPLIES WHEN A PRE-APPROVED EXCEPTION TO CONDUIT HAS BEEN GRANTED.

   INSTALLATION OF WIRING SHALL GENERALLY FOLLOW BUILDING LINES. RUN IN A NEAT AND ORDERLY FASHION, BUNDLED WHERE APPLICABLE, AND COMPLETELY SUSPENDED (STRAPPED TO RIGID ELEMENTS OR ROUTED THROUGH WIRING RINGS) AWAY FROM AREAS OF NORMAL ACCESS. TIE AND SUPPORT CONDUCTORS NEATLY WITH SUITABLE NYLON TIES. CONDUCTORS SHALL NOT BE SUPPORTED BY THE CEILING SYSTEM OR CEILING SUPPORT SYSTEM. CONDUCTORS SHALL BE PULLED TIGHT AND BE INSTALLED AS HIGH AS PRACTICALLY POSSIBLE IN CEILING CAVITIES. WIRING SHALL NOT BE LAID ON THE CEILING OR DUCT. CONDUCTORS SHALL NOT BE INSTALLED BETWEEN THE TOP CORD OF A JOIST OR BEAM AND THE BOTTOM OF ROOF DECKING. CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR NOISE IMMUNITY AND REWIRE IN CONDUIT IF ELECTRICAL OR RF NOISE AFFECTS PERFORMANCE.
7. NUMBER-CODE OR COLOR-CODE CONDUCTORS APPROPRIATELY FOR FUTURE IDENTIFICATION AND SERVICING OF CONTROL SYSTEM. CODE SHALL BE AS INDICATED ON APPROVED INSTALLATION DRAWINGS. PREFERRED IDENTIFICATION SYSTEM: BRADY

E. CONTROL VALVES: INSTALL SO THAT ACTUATORS, WIRING, [AND TUBING] CONNECTIONS ARE ACCESSIBLE FOR MAINTENANCE. WHERE POSSIBLE, INSTALL WITH VALVE STEM AXIS VERTICAL, WITH OPERATOR SIDE UP. WHERE VERTICAL STEM POSITION IS NOT POSSIBLE, OR WOULD RESULT IN POOR ACCESS, VALVES MAY BE INSTALLED WITH STEM HORIZONTAL. DO NOT INSTALL VALVES WITH STEM BELOW HORIZONTAL, OR DOWN.

F. FREEZESTATS: INSTALL FREEZESTATS IN A SERPENTINE FASHION WHERE SHOWN ON DRAWING. PROVIDE ONE FOOT OF ELEMENT FOR EACH SQUARE FOOT OF COIL FACE AREA. WHERE COIL FACE AREA EXCEEDS REQUIRED LENGTH OF ELEMENT, PROVIDE MULTIPLE DEVICES, WIRED IN PARALLEL FOR NORMALLY OPEN CLOSE ON TRIP APPLICATION, WIRED IN SERIES FOR NORMALLY CLOSED, OPEN ON TRIP APPLICATION. ADEQUATELY SUPPORT WITH COIL CLIPS.

G. SPACE TEMPERATURE SENSORS: SENSORS SHALL BE LOCATED AS INDICATED ON DRAWINGS.

1. MOUNT NON-ADJUSTABLE SENSORS WITH CENTERLINE 60" ABOVE FINISHED FLOOR. SENSORS WITH ADJUSTABLE SETPOINTS AND/OR OVERRIDE SWITCHES MUST BE MOUNTED 36" TO 48" ABOVE FINISHED FLOOR; COORDINATE WITH UCB.
2. COORDINATE LOCATION OF SENSOR WITH WORK OF OTHER TRADES SO SENSOR DOES NOT CONFLICT WITH OR IS OBSTRUCTED BY SUCH ITEMS AS BLACKBOARDS, BLEACHERS, BOOKCASES, ETC.
3. CONCEAL ALL CONTROL WIRING TO SENSORS LOCATED IN NEW FINISHED SPACES; THE USE OF WIREMOLD IS PROHIBITED.
4. THERMOSTATS LOCATED IN LOCKER ROOMS, TEAM ROOMS, STOREROOMS, AND CORRIDORS SHALL BE FLUSH MOUNTED TYPE.

H. AVERAGING TEMPERATURE SENSORS: COVER NO MORE THAN THREE SQUARE FEET PER LINEAR FOOT OF SENSOR LENGTH EXCEPT WHERE INDICATED. GENERALLY WHERE FLOW IS SUFFICIENTLY HOMOGENEOUS/ADEQUATELY MIXED AT SENSING LOCATION, CONSULT AE FOR REQUIREMENTS.

I. AIRFLOW MEASURING STATIONS: INSTALL PER MANUFACTURER'S RECOMMENDATIONS IN AN UNOBSTRUCTED STRAIGHT LENGTH OF DUCT (EXCEPT THOSE INSTALLATIONS SPECIFICALLY DESIGNED FOR INSTALLATION IN FAN INLET). FOR INSTALLATIONS IN FAN INLETS, PROVIDE ON BOTH INLETS OF DOUBLE INLET FANS AND PROVIDE INLET CONE ADAPTER AS RECOMMENDED BY AFM STATION MANUFACTURER.

J. FLUID FLOW SENSORS: INSTALL PER MANUFACTURER'S RECOMMENDATIONS IN AN UNOBSTRUCTED STRAIGHT LENGTH OF PIPE.

K. RELATIVE HUMIDITY SENSORS: PROVIDE ELEMENT GUARD AS RECOMMENDED BY MANUFACTURER FOR HIGH VELOCITY INSTALLATIONS. FOR HIGH LIMIT SENSORS, POSITION REMOTE ENOUGH TO ALLOW FULL MOISTURE ABSORPTION INTO THE AIR STREAM BEFORE REACHING THE SENSOR.

L. DIFFERENTIAL PRESSURE TRANSMITTERS: PROVIDE VALVE BYPASS ARRANGEMENT TO PROTECT AGAINST OVER PRESSURE DAMAGING THE TRANSMITTER.

M. FLOW SWITCHES: WHERE POSSIBLE, INSTALL IN A STRAIGHT RUN OF PIPE AT LEAST 15 DIAMETERS IN LENGTH TO MINIMIZE FALSE INDICATIONS.

N. PHASE-VOLTAGE-FREQUENCY MONITOR: ELECTRICAL CONTRACTOR SHALL PROVIDE AND INSTALL. CONTROL CONTRACTOR SHALL COORDINATE INSTALLATION OF CONTROL WIRING WITH ELECTRICAL CONTRACTOR.

O. CURRENT SWITCHES FOR MOTOR STATUS MONITORING: ADJUST SO THAT SETPOINT IS BELOW MINIMUM OPERATING CURRENT AND ABOVE MOTOR NO LOAD CURRENT.

P. SUPPLY DUCT PRESSURE TRANSMITTERS:

1. GENERAL: INSTALL PRESSURE TIPS WITH AT LEAST 4 'ROUND EQUIVALENT' DUCT DIAMETERS OF STRAIGHT DUCT WITH NO TAKEOFFS UPSTREAM. INSTALL PRESSURE TIPS SECURELY FASTENED WITH TIP FACING UPSTREAM IN ACCORDANCE WITH MANUFACTURER'S INSTALLATION INSTRUCTIONS. LOCATE THE TRANSMITTER AT AN ACCESSIBLE LOCATION TO FACILITATE CALIBRATION.
2. VAV SYSTEM 'DOWN-DUCT' TRANSMITTERS: LOCATE PRESSURE TIPS APPROXIMATELY 2/3 OF THE HYDRAULIC DISTANCE TO THE MOST REMOTE TERMINAL IN THE AIR SYSTEM. UCB MUST APPROVE FINAL LOCATION.

Q. TEST PORTS: PROVIDE TEST PORTS IN DUCTWORK AT EACH TEMPERATURE AND HUMIDITY SENSOR LOCATION TO FACILITATE SENSOR CALIBRATION. TEST PORTS SHALL BE 3/4" DIAMETER MINIMUM AND ACCESSIBLE VIA A 2" X 4" JUNCTION BOX WITH INSULATED COVER.

R. CUTTING AND PATCHING INSULATION: REPAIR INSULATION TO MAINTAIN INTEGRITY OF INSULATION AND VAPOR BARRIER JACKET. USE HYDRAULIC INSULATING CEMENT TO FILL VOIDS AND FINISH WITH MATERIAL MATCHING OR COMPATIBLE WITH ADJACENT JACKET MATERIAL.

M15952- BAS Operator Interfaces

Part I. PART 1 - GENERAL

1.01 SECTION INCLUDES

A. OPERATOR WORKSTATIONS
B. CONTROL SYSTEM SERVERS
C. PORTABLE OPERATOR TERMINAL

1.02 RELATED DOCUMENTS

A. 15510 - BASIC MECHANICAL REQUIREMENTS.
B. 15950 - BUILDING AUTOMATION SYSTEM (BAS) GENERAL
C. SECTION 23 0900 - BUILDING AUTOMATION SYSTEM (BAS) GENERAL
D. 15951 - BAS BASIC MATERIALS, AND DEVICES
E. SECTION 23 0913 – BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS
F. 15953 - BAS FIELD PANEL
G. SECTION 23 0903 - BAS FIELD PANEL
H. 15954 - BAS COMMUNICATIONS DEVICES
I. SECTION 23 0904 - BAS COMMUNICATION DEVICES
J. 15955 - BAS SOFTWARE AND PROGRAMMING
K. SECTION 23 0905 - BAS SOFTWARE AND PROGRAMMING
L. 15958 – BAS SEQUENCE OF OPERATION
M. SECTION 23 0993 - SEQUENCES OF OPERATION
N. 15959 – BAS COMMISSIONING
O. SECTION 23 0801 - BAS COMMISSIONING

1.03 DESCRIPTION OF WORK

A. Furnish and install software for Operator Interfaces and Control System Servers as required for the BAS functions specified. All installed software shall be supported by the manufacturer for a period of two years after Substantial Completion at no additional cost to the University.

B. Refer to Section 15950 {23 0900} for general requirements.

Part II. PART 2 - PRODUCTS

2.01 OPERATOR WORKSTATION (OWS)

A. Operator Workstation hardware and operating system will be provided and maintained by the University. Contractor shall coordinate hardware and operating system requirements with FMIT to meet software and specification requirements.

Edit the following as applicable.

B. Operator Workstations shall be placed as follows and as indicated on the drawings or as directed by the University.

2.02 Control System Server (CSS)

A. Control System Server hardware and operating system will be provided and maintained by the University. Contractor shall coordinate hardware and operating system requirements with FMIT to meet software and specification requirements.

Edit the following as applicable

B. Control System Server shall be placed as follows and as indicated on the drawings or as directed by the University.

2.03 PORTABLE OPERATORS TERMINAL (POT)

A. Portable Operators Terminal hardware and operating system will be provided and maintained by the University. Contractor shall coordinate hardware and operating system requirements with FMIT to meet software and specification requirements.

Part III. PART 3 - EXECUTION

3.01 INSTALLATION

A. Install all software on the provided workstations and verify that the systems are fully operational. Ensure licensing is provided for all software.

B. NO LICENSE, SOFTWARE COMPONENT, KEY, ETC OR ANY PIECE OF INFORMATION REQUIRED TO INSTALL, CONFIGURE, OPERATE, DIAGNOSE AND MAINTAIN THE SYSTEM SHALL BE WITHHELD FROM THE UNIVERSITY.

C. INSTALL ELECTRONIC CONTROL SYSTEM OPERATION AND MAINTENANCE MANUALS, PROGRAMMING GUIDES, NETWORK CONFIGURATION TOOLS, CONTROL SHOP DRAWINGS ETC ON EACH OWS AND CSS. PROVIDE INTERFACE OR SHORTCUTS TO GUIDE USER TO THE APPROPRIATE INFORMATION.

D. SET UP PORTABLE OPERATOR TERMINAL AND CONFIGURE IT AS A REMOTE WORKSTATION. INSTALL ALL SOFTWARE AND VERIFY THAT THE SYSTEM IS FULLY OPERATIONAL.

E. INSTALL SYSTEMS AND MATERIALS IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS.

M15953 – BAS Field Panels

PART 1 - GENERAL

1.01 SECTION INCLUDES:

A. BUILDING CONTROLLER (BC)

B. ADVANCE APPLICATION SPECIFIC CONTROLLER (AAC)

C. APPLICATION SPECIFIC CONTROLLER (ASC)

1.02 RELATED DOCUMENTS:

A. SECTION {INSERT APPLICABLE SPECIFICATION SECTION} - BASIC MECHANICAL REQUIREMENTS

B. SECTION 15950 - BUILDING AUTOMATION SYSTEM (BAS) GENERAL – REFER TO THIS SECTION FOR DEFINITIONS OF TERMINOLOGY

C. SECTION 23 0900 - BUILDING AUTOMATION SYSTEM (BAS) GENERAL

D. SECTION 15951 - BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

E. SECTION 23 0913 – BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

F. SECTION 15952 - BAS OPERATOR INTERFACES

G. SECTION 23 0902 - BAS OPERATOR INTERFACES

H. SECTION 15954 - BAS COMMUNICATIONS DEVICES

I. SECTION 23 0904 - BAS COMMUNICATION DEVICES

J. SECTION 15955 - BAS SOFTWARE

K. SECTION 23 0905 - BAS SOFTWARE AND PROGRAMMING
L. SECTION 15958 - SEQUENCE OF OPERATION
M. SECTION 23 0993 - SEQUENCES OF OPERATION
N. SECTION 15959 - BAS COMMISSIONING
O. SECTION 23 0801 - BAS COMMISSIONING

1.03 DESCRIPTION OF WORK:

A. FURNISH AND INSTALL DDC CONTROL UNITS AND/OR SMART DEVICES REQUIRED TO SUPPORT SPECIFIED BUILDING AUTOMATION SYSTEM FUNCTIONS.
B. REFER TO SECTION 15950 {23 0900} FOR GENERAL REQUIREMENTS.

Part II. PART 2 - PRODUCTS

2.01 STAND-ALONE FUNCTIONALITY

A. GENERAL: THESE REQUIREMENTS CLARIFY THE REQUIREMENT FOR STAND-ALONE FUNCTIONALITY RELATIVE TO PACKAGING I/O DEVICES WITH A CONTROLLER. STAND-ALONE FUNCTIONALITY IS SPECIFIED WITH THE CONTROLLER AND FOR EACH APPLICATION CATEGORY SPECIFIED IN PART 3. THIS ITEM REFERS TO ACCEPTABLE PARADIGMS FOR ASSOCIATING THE POINTS WITH THE PROCESSOR.
B. FUNCTIONAL BOUNDARY: PROVIDE CONTROLLERS SO THAT ALL POINTS ASSOCIATED WITH AND COMMON TO ONE UNIT OR OTHER COMPLETE SYSTEM/EQUIPMENT SHALL RESIDE WITHIN A SINGLE CONTROL UNIT. THE BOUNDARIES OF A STANDALONE SYSTEM SHALL BE AS DICTATED IN THE CONTRACT DOCUMENTS. GENERALLY SYSTEMS SPECIFIED FOR THE APPLICATION CATEGORY WILL DICTATE THE BOUNDARY OF THE STANDALONE CONTROL FUNCTIONALITY. SEE RELATED RESTRICTIONS BELOW. WHEN REFERRING TO THE CONTROLLER AS PERTAINS TO THE STANDALONE FUNCTIONALITY, REFERENCE IS SPECIFICALLY MADE TO THE PROCESSOR. ONE PROCESSOR SHALL EXECUTE ALL THE RELATED I/O CONTROL LOGIC VIA ONE OPERATING SYSTEM THAT USES A COMMON PROGRAMMING AND CONFIGURATION TOOL.
C. THE FOLLOWING CONFIGURATIONS ARE CONSIDERED ACCEPTABLE WITH REFERENCE TO A CONTROLLER'S STANDALONE FUNCTIONALITY:
    1. POINTS PACKAGED AS INTEGRAL TO THE CONTROLLER SUCH THAT THE POINT CONFIGURATION IS LISTED AS AN ESSENTIAL PIECE OF INFORMATION FOR ORDERING THE CONTROLLER (HAVING A UNIQUE ORDERING NUMBER).
    2. CONTROLLERS WITH PROCESSORS AND MODULAR BACK PLANES THAT ALLOW PLUG IN POINT MODULES AS AN INTEGRAL PART OF THE CONTROLLER.
    3. I/O POINT EXPANDER BOARDS, PLUGGED DIRECTLY INTO THE MAIN CONTROLLER BOARD TO EXPAND THE POINT CAPACITY OF THE CONTROLLER.
    4. I/O POINT EXPANSION DEVICES CONNECTED TO THE MAIN CONTROLLER BOARD VIA WIRING AND AS SUCH MAY BE REMOTE FROM THE CONTROLLER AND THAT COMMUNICATE VIA A SUB LAN PROTOCOL. THESE ARRANGEMENTS TO BE CONSIDERED STANDALONE SHALL HAVE A SUB LAN THAT IS DEDICATED TO THAT

CONTROLLER AND INCLUDE NO OTHER CONTROLLER DEVICES (AACS OR ASCS). ALL WIRING TO INTERCONNECT THE I/O EXPANDER BOARD SHALL BE:

a) CONTAINED IN THE CONTROL PANEL ENCLOSURE;

b) OR RUN IN CONDUIT. WIRING SHALL ONLY BE ACCESSIBLE AT THE TERMINATIONS.

D. THE FOLLOWING CONFIGURATIONS ARE CONSIDERED UNACCEPTABLE WITH REFERENCE TO A CONTROLLER'S STANDALONE FUNCTIONALITY:

1. MULTIPLE CONTROLLERS ENCLOSED IN THE SAME CONTROL PANEL TO ACCOMPLISH THE POINT REQUIREMENT.

2.02 BUILDING CONTROLLER (BC)

A. GENERAL REQUIREMENTS:

1. THE BC(S) SHALL PROVIDE FULLY DISTRIBUTED CONTROL INDEPENDENT OF THE OPERATIONAL STATUS OF THE OWSS AND CSS. ALL NECESSARY CALCULATIONS REQUIRED TO ACHIEVE CONTROL SHALL BE EXECUTED WITHIN THE BC INDEPENDENT OF ANY OTHER DEVICE. ALL CONTROL STRATEGIES PERFORMED BY THE BC(S) SHALL BE BOTH OPERATOR DEFINABLE AND MODIFIABLE THROUGH THE OPERATOR INTERFACES.

2. BCS SHALL PERFORM OVERALL SYSTEM COORDINATION, ACCEPT CONTROL PROGRAMS, PERFORM AUTOMATED HVAC FUNCTIONS, CONTROL PERIPHERAL DEVICES AND PERFORM ALL NECESSARY MATHEMATICAL AND LOGICAL FUNCTIONS. BCS SHALL SHARE INFORMATION WITH THE ENTIRE NETWORK OF BCS AND AACS/ASCS FOR FULL GLOBAL CONTROL. EACH CONTROLLER SHALL PERMIT MULTI-USER OPERATION FROM MULTIPLE WORKSTATIONS AND PORTABLE OPERATOR TERMINALS CONNECTED EITHER LOCALLY OR OVER THE PRIMARY CONTROLLER LAN. EACH UNIT SHALL HAVE ITS OWN INTERNAL RAM, NON-VOLATILE MEMORY, MICROPROCESSOR, BATTERY BACKUP, REGULATED POWER SUPPLY, POWER CONDITIONING EQUIPMENT, PORTS FOR CONNECTION OF OPERATING INTERFACE DEVICES, AND CONTROL ENCLOSURE. BCS SHALL BE PROGRAMMABLE FROM AN OPERATOR WORKSTATION, PORTABLE OPERATORS TERMINAL, OR HAND HELD OPERATING DEVICE. BC SHALL CONTAIN SUFFICIENT MEMORY FOR ALL SPECIFIED GLOBAL CONTROL STRATEGIES, USER DEFINED REPORTS AND TRENDING, COMMUNICATION PROGRAMS, AND CENTRAL ALARMING.

3. BCS SHALL BE CONNECTED TO A CONTROLLER NETWORK THAT QUALIFIES AS A PRIMARY CONTROLLING LAN.

4. ALL BCS SHALL BE PROTECTED FROM ANY MEMORY LOSS DUE TO A LOSS OF POWER BY ONE OR A COMBINATION OF THE FOLLOWING:

a) VOLATILE RAM SHALL HAVE A BATTERY BACKUP USING A LITHIUM BATTERY WITH A RATED SERVICE LIFE OF FIFTY (50) HOURS, AND A RATED SHELF LIFE OF AT LEAST FIVE YEARS. SELF-DIAGNOSTIC ROUTINE SHALL REPORT AN ALARM FOR A LOW BATTERY CONDITION.

b) EEPROM, EPROM, OR NOVROM NON-VOLATILE MEMORY

5. In addition BCs may provide intelligent, standalone control of HVAC functions. Each BC may be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices. Refer to standalone functionality specified above.
6. The BC may provide for point mix flexibility and expandability. This requirement may be met via either a family of expander boards, modular input/output configuration, or a combination thereof. Refer to stand alone functionality specified above.
7. All BC point data, algorithms and application software shall be modifiable from the Operator Workstation.
8. Each BC shall execute application programs, calculations, and commands via a microprocessor resident in the BC. The database and all application programs for each BC shall be stored in non-volatile or battery backed volatile memory within the BC and will be able to upload/download to/from the OWS and/or CSS.
9. BC shall provide buffer for holding alarms, messages, trends etc.
10. Each BC shall include self-test diagnostics, which allow the BC to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.
11. Each BC shall contain software to perform full DDC/PID control loops.
12. For systems requiring end-of-line resistors those resistors shall be located in the BC.
13. Input-Output Processing
    a) Digital Outputs (DO): Outputs shall be rated for a minimum 24 Vac or Vdc, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and [a manual hand off or auto switch to allow for override]. [If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure.] Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
    b) Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10 Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 12 bits.
    c) Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.

d) UNIVERSAL INPUTS (UI-AI OR DI): TO SERVE AS EITHER AI OR DI AS SPECIFIED ABOVE.

e) ELECTRONIC ANALOG OUTPUTS (AO): VOLTAGE MODE: 0-5 VDC AND 0-10 VDC; CURRENT MODE: 4-20 MA. PROVIDE ZERO AND SPAN CALIBRATION AND CIRCUIT PROTECTION. PULSE WIDTH MODULATED (PWM) ANALOG VIA A DO [AND TRANSDUCER] IS ACCEPTABLE ONLY WITH UNIVERSITY APPROVAL (GENERALLY THESE WILL NOT BE ALLOWED ON LOOPS WITH A SHORT TIME CONSTANT SUCH AS DISCHARGE TEMPERATURE LOOPS, ECONOMIZER LOOPS, PRESSURE CONTROL LOOPS AND THE LIKE. THEY ARE GENERALLY ACCEPTABLE FOR STANDARD ROOM TEMPERATURE CONTROL LOOPS.). WHERE THESE ARE ALLOWED, TRANSDUCER/ACTUATOR SHALL BE PROGRAMMABLE FOR NORMALLY OPEN, NORMALLY CLOSED, OR HOLD LAST POSITION AND SHALL ALLOW ADJUSTABLE TIMING. EACH DO SHALL BE DISCRETE OUTPUTS FROM THE BC'S BOARD (MULTIPLEXING TO A SEPARATE MANUFACTURERS BOARD IS UNACCEPTABLE). D/A CONVERTERS SHALL HAVE A MINIMUM RESOLUTION OF 10 BITS.

f) PULSED INPUTS: CAPABLE OF COUNTING UP TO 8 PULSES PER SECOND WITH BUFFER TO ACCUMULATE PULSE COUNT. PULSES SHALL BE COUNTED AT ALL TIMES.

14. A COMMUNICATION PORT FOR OPERATOR INTERFACE THROUGH A TERMINAL SHALL BE PROVIDED IN EACH BC. IT SHALL BE POSSIBLE TO PERFORM ALL PROGRAM AND DATABASE BACK-UP, SYSTEM MONITORING, CONTROL FUNCTIONS, AND BC DIAGNOSTICS THROUGH THIS PORT. STANDALONE BC PANELS SHALL ALLOW TEMPORARY USE OF PORTABLE DEVICES WITHOUT INTERRUPTING THE NORMAL OPERATION OF PERMANENTLY CONNECTED MODEMS, PRINTERS, OR WORKSTATIONS.
15. EACH BC SHALL BE EQUIPPED WITH LOOP TUNING ALGORITHM FOR PRECISE PROPORTIONAL, INTEGRAL, DERIVATIVE (PID) CONTROL. LOOP TUNING TOOLS PROVIDED WITH THE OPERATOR WORKSTATION SOFTWARE IS ACCEPTABLE. IN ANY CASE, TOOLS TO SUPPORT LOOP TUNING MUST BE PROVIDED SUCH THAT P, I, AND D GAINS ARE AUTOMATICALLY CALCULATED.
16. ALL ANALOG OUTPUT POINTS SHALL HAVE A SELECTABLE FAILURE SETPOINT. THE BC SHALL BE CAPABLE OF MAINTAINING THIS FAILURE SETPOINT IN THE EVENT OF A SYSTEM MALFUNCTION, WHICH CAUSES LOSS OF BC CONTROL, OR LOSS OF OUTPUT SIGNAL, AS LONG AS POWER IS AVAILABLE AT THE BC. THE FAILURE SETPOINT SHALL BE SELECTABLE ON A PER POINT BASIS.
17. SLOPE INTERCEPTS AND GAIN ADJUSTMENTS SHALL BE AVAILABLE ON A PER-POINT BASIS.
18. BC POWER LOSS:
    a) UPON A LOSS OF POWER TO ANY BC, THE OTHER UNITS ON THE PRIMARY CONTROLLING NETWORK SHALL NOT IN ANY WAY BE AFFECTED.
    b) UPON A LOSS OF POWER TO ANY BC, THE BATTERY BACKUP SHALL ENSURE THAT THE ENERGY MANAGEMENT CONTROL SOFTWARE, THE DIRECT DIGITAL CONTROL SOFTWARE, THE DATABASE PARAMETERS, AND ALL OTHER PROGRAMS AND DATA STORED IN THE RAM ARE RETAINED FOR A MINIMUM OF

FIFTY (50) HOURS. AN ALARM DIAGNOSTIC MESSAGE SHALL INDICATE THAT THE BC IS UNDER BATTERY POWER.

c) UPON RESTORATION OF POWER WITHIN THE SPECIFIED BATTERY BACKUP PERIOD, THE BC SHALL RESUME FULL OPERATION WITHOUT OPERATOR INTERVENTION. THE BC SHALL AUTOMATICALLY RESET ITS CLOCK SUCH THAT PROPER OPERATION OF ANY TIME DEPENDENT FUNCTION IS POSSIBLE WITHOUT MANUAL RESET OF THE CLOCK. ALL MONITORED FUNCTIONS SHALL BE UPDATED.

d) SHOULD THE DURATION OF A LOSS OF POWER EXCEED THE SPECIFIED BATTERY BACK-UP PERIOD OR BC PANEL MEMORY BE LOST FOR ANY REASON, THE PANEL SHALL AUTOMATICALLY REPORT THE CONDITION (UPON RESUMPTION OF POWER) AND BE CAPABLE OF RECEIVING A DOWNLOAD VIA THE NETWORK, AND CONNECTED COMPUTER. IN ADDITION, THE UNIVERSITY SHALL BE ABLE TO UPLOAD THE MOST CURRENT VERSIONS OF ALL ENERGY MANAGEMENT CONTROL PROGRAMS, DIRECT DIGITAL CONTROL PROGRAMS, DATABASE PARAMETERS, AND ALL OTHER DATA AND PROGRAMS IN THE MEMORY OF EACH BC TO THE OPERATOR WORKSTATION VIA THE LOCAL AREA NETWORK, OR VIA THE TELEPHONE LINE DIAL-UP MODEM WHERE APPLICABLE, OR TO THE LAPTOP PC VIA THE LOCAL RS-232C PORT.

19. BC FAILURE:

a) BUILDING CONTROLLER LAN DATA TRANSMISSION FAILURE: BC SHALL CONTINUE TO OPERATE IN STAND-ALONE MODE. BC SHALL STORE LOSS OF COMMUNICATION ALARM ALONG WITH THE TIME OF THE EVENT. ALL CONTROL FUNCTIONS SHALL CONTINUE WITH THE GLOBAL VALUES PROGRAMMABLE TO EITHER LAST VALUE OR A SPECIFIED VALUE. PEER BCS SHALL RECOGNIZE THE LOSS, REPORT ALARM AND RECONFIGURE THE LAN.

b) BC HARDWARE FAILURE: BC SHALL CEASE OPERATION AND TERMINATE COMMUNICATION WITH OTHER DEVICES. ALL OUTPUTS SHALL GO TO THEIR SPECIFIED FAIL POSITION.

20. EACH BC SHALL BE EQUIPPED WITH FIRMWARE RESIDENT SELF-DIAGNOSTICS FOR SENSORS AND BE CAPABLE OF ASSESSING AN OPEN OR SHORTED SENSOR CIRCUIT AND TAKING AN APPROPRIATE CONTROL ACTION (CLOSE VALVE, DAMPER, ETC.).
21. BCS MAY INCLUDE LAN COMMUNICATIONS INTERFACE FUNCTIONS FOR CONTROLLING SECONDARY CONTROLLING LANS REFER TO SECTION 15954 {23 0904} - BAS SYSTEM COMMUNICATIONS DEVICES FOR REQUIREMENTS IF THIS FUNCTION IS PACKAGED WITH THE BC.
22. BCS SHALL BE MOUNTED ON EQUIPMENT, IN PACKAGED EQUIPMENT ENCLOSURES, OR LOCKING WALL MOUNTED IN A NEMA 1 ENCLOSURE, AS SPECIFIED ELSEWHERE.

THE FOLLOWING ONLY APPLIES TO STRICT BACNET PROJECTS; COORDINATE WITH UCB

B. BACNET BUILDING CONTROLLER REQUIREMENTS:

1. THE BC(S) SHALL SUPPORT ALL BIBBS DEFINED IN THE BACNET BUILDING CONTROLLER (B-BC) DEVICE PROFILE AS DEFINED IN THE BACNET STANDARD.
2. BCS SHALL COMMUNICATE OVER THE BACNET BUILDING CONTROLLER LAN.

3. EACH BC SHALL BE CONNECTED TO THE BACNET BUILDING CONTROLLER LAN COMMUNICATING TO/FROM OTHER BCS.

2.03 ADVANCED APPLICATION SPECIFIC CONTROLLER (AAC) AND APPLICATION SPECIFIC CONTROLLER (ASC)

A. GENERAL REQUIREMENTS:

1. AACS AND ASCS SHALL PROVIDE INTELLIGENT, STANDALONE CONTROL OF HVAC EQUIPMENT. EACH UNIT SHALL HAVE ITS OWN INTERNAL RAM, NON-VOLATILE MEMORY AND WILL CONTINUE TO OPERATE ALL LOCAL CONTROL FUNCTIONS IN THE EVENT OF A LOSS OF COMMUNICATIONS ON THE ASC LAN OR SUB-LAN. REFER TO STANDALONE REQUIREMENTS BY APPLICATION SPECIFIED IN PART 3 OF THIS SECTION. IN ADDITION, IT SHALL BE ABLE TO SHARE INFORMATION WITH EVERY OTHER BC AND AAC /ASC ON THE ENTIRE NETWORK.
2. EACH AAC AND ASC SHALL INCLUDE SELF-TEST DIAGNOSTICS THAT ALLOW THE AAC /ASC TO AUTOMATICALLY RELAY TO THE BC, LAN INTERFACE DEVICE OR WORKSTATION, ANY MALFUNCTIONS OR ABNORMAL CONDITIONS WITHIN THE AAC /ASC OR ALARM CONDITIONS OF INPUTS THAT EXCEED DESIRED PARAMETERS AS DETERMINED BY PROGRAMMING INPUT.
3. AACS AND ASCS SHALL INCLUDE SUFFICIENT MEMORY TO PERFORM THE SPECIFIC CONTROL FUNCTIONS REQUIRED FOR ITS APPLICATION AND TO COMMUNICATE WITH OTHER DEVICES.
4. EACH AAC AND ASC MUST BE CAPABLE OF STAND-ALONE DIRECT DIGITAL OPERATION UTILIZING ITS OWN PROCESSOR, NON-VOLATILE MEMORY, INPUT/OUTPUT, MINIMUM 8 BIT A TO D CONVERSION, VOLTAGE TRANSIENT AND LIGHTNING PROTECTION DEVICES. ALL VOLATILE MEMORY SHALL HAVE A BATTERY BACKUP OF AT LEAST FIFTY- (50) HRS WITH A BATTERY LIFE OF FIVE YEARS.
5. ALL POINT DATA; ALGORITHMS AND APPLICATION SOFTWARE WITHIN AN AAC /ASC SHALL BE MODIFIABLE FROM THE OPERATOR WORKSTATION.
6. AAC AND ASC INPUT-OUTPUT PROCESSING
   a) DIGITAL OUTPUTS (DO): OUTPUTS SHALL BE RATED FOR A MINIMUM 24 VAC OR VDC, 1 AMP MAXIMUM CURRENT. EACH SHALL BE CONFIGURABLE AS NORMALLY OPEN OR NORMALLY CLOSED. EACH OUTPUT SHALL HAVE AN LED TO INDICATE THE OPERATING MODE OF THE OUTPUT AND [A MANUAL HAND OFF OR AUTO SWITCH TO ALLOW FOR OVERRIDE]. [IF THESE HOA SWITCHES ARE NOT PROVIDED ON THE MAIN BOARD THEY SHALL BE PROVIDED VIA ISOLATION RELAYS WITHIN THE CONTROL ENCLOSURE.] EACH DO SHALL BE DISCRETE OUTPUTS FROM THE AAC/ASC'S BOARD (MULTIPLEXING TO A SEPARATE MANUFACTURER'S BOARD IS UNACCEPTABLE). PROVIDE SUPPRESSION TO LIMIT TRANSIENTS TO ACCEPTABLE LEVELS.
   b) ANALOG INPUTS (AI): AI SHALL BE O-5 VDC, 0-10VDC, 0-20VDC, AND 0-20 MA. PROVIDE SIGNAL CONDITIONING, AND ZERO AND SPAN CALIBRATION FOR EACH INPUT. EACH INPUT SHALL BE A DISCRETE INPUT TO THE BC'S BOARD (MULTIPLEXING TO A SEPARATE MANUFACTURERS BOARD IS UNACCEPTABLE

UNLESS SPECIFICALLY INDICATED OTHERWISE). A/D CONVERTERS SHALL HAVE A MINIMUM RESOLUTION OF 8-10 BITS DEPENDING ON APPLICATION.

c) DIGITAL INPUTS (DI): MONITOR DRY CONTACT CLOSURES. ACCEPT PULSED INPUTS OF AT LEAST ONE PER SECOND. SOURCE VOLTAGE FOR SENSING SHALL BE SUPPLIED BY THE BC AND SHALL BE ISOLATED FROM THE MAIN BOARD. SOFTWARE MULTIPLEXING OF AN AI AND RESISTORS MAY ONLY BE DONE IN NON-CRITICAL APPLICATIONS AND ONLY WITH PRIOR APPROVAL OF ARCHITECT/ENGINEER

d) UNIVERSAL INPUTS (UI-AI OR DI): TO SERVE AS EITHER AI OR DI AS SPECIFIED ABOVE.

e) ELECTRONIC ANALOG OUTPUTS (AO) AS REQUIRED BY APPLICATION: VOLTAGE MODE, 0-5VDC AND 0-10VDC; CURRENT MODE (4-20 MA). PROVIDE ZERO AND SPAN CALIBRATION AND CIRCUIT PROTECTION. D/A CONVERTERS SHALL HAVE A MINIMUM RESOLUTION OF 8 BITS.

f) [ANALOG OUTPUT PNEUMATIC (AOP), 0-20 PSI: PNEUMATIC OUTPUTS VIA AN I/P TRANSDUCER OR 0-10VDC TO PNEUMATIC TRANSDUCER ARE ACCEPTABLE. MULTIPLEXED PNEUMATIC OUTPUTS OF A SEPARATE MANUFACTURER ARE UNACCEPTABLE.]

THE FOLLOWING ONLY APPLIES TO STRICT BACNET PROJECTS; COORDINATE WITH UCB

B. BACNET AAC(S) AND ASC(S) REQUIREMENTS:

1. THE AAC(S) AND ASC(S) SHALL SUPPORT ALL BIBBS DEFINED IN THE BACNET BUILDING CONTROLLER (B-AAC AND B-ASC) DEVICE PROFILE AS DEFINED IN THE BACNET STANDARD.
2. AAC(S) AND ASC(S) SHALL COMMUNICATE OVER THE BACNET BUILDING CONTROLLER LAN OR THE ASC LAN OR SUB-LAN.
3. EACH BC SHALL BE CONNECTED TO THE BACNET BUILDING CONTROLLER LAN COMMUNICATING TO/FROM OTHER BCS.

C. TERMINAL BOX CONTROLLERS:

1. TERMINAL BOX CONTROLLERS CONTROLLING DAMPER POSITIONS TO MAINTAIN A QUANTITY OF SUPPLY OR EXHAUST AIR SERVING A SPACE SHALL HAVE AN AUTOMATICALLY INITIATED FUNCTION THAT RESETS THE VOLUME REGULATOR DAMPER TO THE FULLY CLOSED POSITION ON A SCHEDULED BASIS. THE CONTROLLERS SHALL INITIALLY BE SET UP TO PERFORM THIS FUNCTION ONCE EVERY 24 HOURS. THE PURPOSE OF THIS REQUIRED FUNCTION IS TO RESET AND SYNCHRONIZE THE ACTUAL DAMPER POSITION WITH THE CALCULATED DAMPER POSITION AND TO ASSURE THE DAMPER WILL COMPLETELY CLOSE WHEN COMMANDED. THE SOFTWARE SHALL SELECT SCHEDULED BOXES RANDOMLY AND SHALL NOT ALLOW MORE THAN 5% OF THE TOTAL QUANTITY OF CONTROLLERS IN A BUILDING TO PERFORM THIS FUNCTION AT THE SAME TIME. WHEN POSSIBLE THE CONTROLLERS SHALL PERFORM THIS FUNCTION WHEN THE SUPPLY OR EXHAUST AIR SYSTEM IS NOT OPERATING OR IS UNOCCUPIED.

Part III. PART 3 - EXECUTION

3.01 INSPECTION:

A. EXAMINE AREAS AND CONDITIONS UNDER WHICH CONTROL SYSTEMS ARE TO BE INSTALLED. DO NOT PROCEED WITH WORK UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED IN MANNER ACCEPTABLE TO INSTALLER.

3.02 INSTALLATION OF CONTROL SYSTEMS:

A. GENERAL: INSTALL SYSTEMS AND MATERIALS IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS, SPECIFICATIONS ROUGHING-IN DRAWINGS AND DETAILS SHOWN ON DRAWINGS. CONTRACTOR SHALL INSTALL ALL CONTROLLERS IN ACCORDANCE WITH MANUFACTURER'S INSTALLATION PROCEDURES AND PRACTICES.

3.03 HARDWARE APPLICATION REQUIREMENTS

A. GENERAL: THE FUNCTIONAL INTENT OF THIS SPECIFICATION IS TO ALLOW COST EFFECTIVE APPLICATION OF MANUFACTURERS STANDARD PRODUCTS WHILE MAINTAIN THE INTEGRITY AND RELIABILITY OF THE CONTROL FUNCTIONS. A BUILDING CONTROLLER AS SPECIFIED ABOVE IS GENERALLY FULLY FEATURED AND CUSTOMIZABLE WHEREAS THE AAC/ASC REFERS TO A MORE COST-EFFECTIVE UNIT DESIGNED FOR LOWER-END APPLICATIONS. SPECIFIC REQUIREMENTS INDICATED BELOW ARE REQUIRED FOR THE RESPECTIVE APPLICATION. MANUFACTURER MAY APPLY THE MOST COST-EFFECTIVE UNIT THAT MEETS THE REQUIREMENT OF THAT APPLICATION.

B. STANDALONE CAPABILITY: EACH CONTROL UNIT SHALL BE CAPABLE OF PERFORMING THE REQUIRED SEQUENCE OF OPERATION FOR THE ASSOCIATED EQUIPMENT. ALL PHYSICAL POINT DATA AND CALCULATED VALUES REQUIRED TO ACCOMPLISH THE SEQUENCE OF OPERATION SHALL ORIGINATE WITHIN THE ASSOCIATED CU WITH ONLY THE EXCEPTIONS ENUMERATED BELOW. REFER TO ITEM 2.01 ABOVE FOR PHYSICAL LIMITATIONS OF STANDALONE FUNCTIONALITY. LISTED BELOW ARE FUNCTIONAL POINT DATA AND CALCULATED VALUES THAT SHALL BE ALLOWED TO BE OBTAINED FROM OR STORED BY OTHER CUS OR SDS VIA LAN.

C. WHERE ASSOCIATED CONTROL FUNCTIONS INVOLVE FUNCTIONS FROM DIFFERENT CATEGORIES IDENTIFIED BELOW, THE REQUIREMENTS FOR THE MOST RESTRICTIVE CATEGORY SHALL BE MET.

D. APPLICATION CATEGORY 0 (DISTRIBUTED MONITORING)

1. APPLICATIONS IN THIS CATEGORY INCLUDE THE FOLLOWING:
   a) MONITORING OF VARIABLES THAT ARE NOT USED IN A CONTROL LOOP, SEQUENCE LOGIC, OR SAFETY.
2. POINTS ON BCS, AACS, AND ASCS MAY BE USED IN THESE APPLICATIONS AS WELL AS SDS AND/OR GENERAL-PURPOSE I/O MODULES.
3. WHERE THESE POINTS ARE TRENDED, CONTRACTOR SHALL VERIFY AND DOCUMENT THAT THE NETWORK BANDWIDTH IS ACCEPTABLE FOR SUCH TRENDS AND IS STILL CAPABLE OF ACCEPTABLE AND TIMELY CONTROL FUNCTION.

E. APPLICATION CATEGORY 1 (APPLICATION SPECIFIC CONTROLLER):

1. APPLICATIONS IN THIS CATEGORY INCLUDE THE FOLLOWING:
   a) FAN COIL UNITS
   b) AIRFLOW CONTROL BOXES (VAV AND CONSTANT VOLUME TERMINAL UNITS)
   c) MISC. HEATERS
   d) UNITARY EQUIPMENT <15 TONS (PACKAGE TERMINAL AC UNITS, PACKAGE TERMINAL HEAT PUMPS, SPLIT-SYSTEM AC UNITS, SPLIT-SYSTEM HEAT PUMPS, WATER-SOURCE HEAT PUMPS)
   e) INDUCTION UNITS
   f) VARIABLE SPEED DRIVE (VSD) CONTROLLERS NOT REQUIRING SAFETY SHUTDOWNS OF THE CONTROLLED DEVICE.
2. ASCS MAY BE USED IN THESE APPLICATIONS.
3. STANDALONE CAPABILITY: PROVIDE CAPABILITY TO EXECUTE CONTROL FUNCTIONS FOR THE APPLICATION FOR A GIVEN SETPOINT OR MODE, WHICH SHALL GENERALLY BE OCCUPIED MODE CONTROL. ONLY THE FOLLOWING DATA (AS APPLICABLE) MAY BE ACQUIRED FROM OTHER CONTROLLERS VIA LANS. IN THE EVENT OF A LOSS OF COMMUNICATIONS WITH ANY OTHER CONTROLLER, OR ANY FAULT IN ANY SYSTEM HARDWARE THAT INTERRUPTS THE ACQUISITION OF ANY OF THESE VALUES, THE ASC SHALL USE THE LAST VALUE OBTAINED BEFORE THE FAULT OCCURRED. IF SUCH FAULT HAS NOT BEEN CORRECTED AFTER THE SPECIFIED DEFAULT DELAY TIME, SPECIFIED DEFAULT VALUE(S) SHALL THEN BE SUBSTITUTED UNTIL SUCH FAULT HAS BEEN CORRECTED.

PHYSICAL/VIRTUAL POINT	DEFAULT VALUE
SCHEDULING PERIOD	NORMAL
MORNING WARM-UP	OFF (COLD DISCHARGE AIR)
LOAD SHED	OFF (NO SHEDDING)
SUMMER/WINTER	WINTER

4. MOUNTING:
   a) ASCS THAT CONTROL EQUIPMENT LOCATED ABOVE ACCESSIBLE CEILINGS SHALL BE MOUNTED ON THE EQUIPMENT IN AN ACCESSIBLE ENCLOSURE (36" CLEARANCE REQUIRED) AND SHALL BE RATED FOR PLENUM USE.
   b) ASCS THAT CONTROL EQUIPMENT MOUNTED IN A MECHANICAL ROOM MAY EITHER BE MOUNTED IN, ON THE EQUIPMENT, OR ON THE WALL OF THE MECHANICAL ROOM AT AN ADJACENT, ACCESSIBLE LOCATION.
   c) ASCS THAT CONTROL EQUIPMENT MOUNTED OUTSIDE OR IN OCCUPIED SPACES SHALL EITHER BE LOCATED IN THE UNIT OR IN A PROXIMATE MECHANICAL SPACE.
   d) SECTION 15953 {23 0913} CONTRACTOR MAY FURNISH ASCS TO THE TERMINAL UNIT MANUFACTURER FOR FACTORY MOUNTING.

5. PROGRAMMABILITY: OPERATOR SHALL BE ABLE TO MODIFY ALL SETPOINTS (TEMPERATURE AND AIRFLOW), SCHEDULING PARAMETERS ASSOCIATED WITH THE UNIT, TUNING AND SET UP PARAMETERS, INTERSTAGE TIMING PARAMETERS, AND MODE SETTINGS. APPLICATION-SPECIFIC BLOCK CONTROL ALGORITHMS MAY BE USED TO MEET THE SEQUENCE OF OPERATIONS. THE ABILITY TO CUSTOMIZE THE CONTROL ALGORITHM IS NOT REQUIRED UNLESS SPECIFICALLY INDICATED OTHERWISE.
6. NETWORK RESTRICTIONS: LIMIT THE NUMBER OF NODES ON THE NETWORK TO THE MAXIMUM RECOMMENDED BY THE MANUFACTURER.

F. APPLICATION CATEGORY 2 (GENERAL PURPOSE TERMINAL CONTROLLER)

1. APPLICATIONS IN THIS CATEGORY INCLUDE THE FOLLOWING:
   a) UNITARY EQUIPMENT >= 15 TONS (AIR CONDITIONERS, HEAT PUMPS, PACKAGED HEATING/COOLING UNITS, AND THE LIKE)
   b) SMALL, CONSTANT VOLUME SINGLE ZONE AIR HANDLING UNITS
   c) CONSTANT VOLUME PUMP START/STOP
   d) MISC. EQUIPMENT (EXHAUST FAN) START/STOP
   e) MISC. MONITORING (NOT DIRECTLY ASSOCIATED WITH A CONTROL SEQUENCE AND WHERE TRENDING IS NOT CRITICAL)
   f) STEAM CONVERTER CONTROL
2. BCS MAY BE USED IN THESE APPLICATIONS.
3. ASC'S MAY BE USED IN THESE APPLICATIONS PROVIDED THE ASC MEETS ALL REQUIREMENTS SPECIFIED BELOW. THIS CATEGORY REQUIRES A GENERAL-PURPOSE ASC TO WHICH APPLICATION-SPECIFIC CONTROL ALGORITHMS CAN BE ATTACHED.
4. STANDALONE CAPABILITY: ONLY THE FOLLOWING DATA (AS APPLICABLE) MAY BE ACQUIRED FROM OTHER ASCS VIA LANS. IN THE EVENT OF A LOSS OF COMMUNICATIONS WITH ANY OTHER ASCS, OR ANY FAULT IN ANY SYSTEM HARDWARE THAT INTERRUPTS THE ACQUISITION OF ANY OF THESE VALUES, THE AAC/ASC SHALL USE THE LAST VALUE OBTAINED BEFORE THE FAULT OCCURRED.
5. MOUNTING:
   a) ASCS THAT CONTROL EQUIPMENT LOCATED ABOVE ACCESSIBLE (36" CLEARANCE REQUIRED) CEILINGS SHALL BE MOUNTED ON THE EQUIPMENT AND SHALL BE RATED FOR PLENUM USE.
   b) ASCS THAT CONTROL EQUIPMENT LOCATED IN OCCUPIED SPACES OR OUTSIDE SHALL EITHER BE MOUNTED WITHIN THE EQUIPMENT ENCLOSURE (RESPONSIBILITY FOR PHYSICAL FIT REMAINS WITH THE CONTRACTOR) OR IN A NEAR BY MECHANICAL/UTILITY ROOM IN WHICH CASE IT SHALL BE ENCLOSED IN A NEMA 1, LOCKING ENCLOSURE.
6. PROGRAMMABILITY: OPERATOR SHALL BE ABLE TO MODIFY ALL SETPOINTS (TEMPERATURE AND AIRFLOW), SCHEDULING PARAMETERS ASSOCIATED WITH THE UNIT, TUNING AND SET UP PARAMETERS, INTERSTAGE TIMING PARAMETERS, AND MODE SETTINGS. OPERATOR SHALL BE ABLE TO ADDRESS AND CONFIGURE SPARE INPUTS FOR MONITORING. [OPERATOR SHALL BE ABLE TO ADDRESS AND CONFIGURE SPARE OUTPUTS FOR SIMPLE SINGLE LOOP CONTROL ACTIONS OR EVENT INITIATED

ACTIONS.] APPLICATION-SPECIFIC BLOCK CONTROL ALGORITHMS MAY BE USED TO MEET THE SEQUENCE OF OPERATIONS.

7. NETWORK RESTRICTIONS: LIMIT THE NUMBER OF NODES SERVICING ANY ONE OF THESE APPLICATIONS ON THE AAC/ASC LAN TO 32.

G. APPLICATION CATEGORY 3 (ADVANCED APPLICATION CONTROLLER)

1. APPLICATIONS IN THIS CATEGORY INCLUDE THE FOLLOWING:
   a) LARGE CONSTANT VOLUME AIR HANDLERS
   b) VAV AIR HANDLERS {GENERALLY >5,000 AND <10,000CFM}
   c) DUAL DUCT AIR HANDLERS {GENERALLY >5000 AND < 10,000 CFM}
   d) MULTIZONE AIR HANDLERS
   e) SELF CONTAINED VAV UNITS
2. BCS MAY BE USED IN THESE APPLICATIONS.
3. AAC'S MAY BE USED IN THESE APPLICATIONS PROVIDED:
   a) THE AAC'S MEETS ALL REQUIREMENTS SPECIFIED BELOW.
   b) ALL CONTROL FUNCTIONS AND PHYSICAL I/O ASSOCIATED WITH A GIVEN UNIT RESIDES IN ONE AAC.
   c) INPUT A/D IS 10-BIT. EXCEPTION: 8-BIT INPUT A/D CAN BE USED WHEN MATCHED WITH HIGH ACCURACY SENSORS, THE RANGE OF WHICH MEETS THE RESOLUTION REQUIREMENTS SPECIFIED FOR THE APPLICABLE SENSOR IN SECTION 15951 {23 0900}.
   d) PULSED INPUTS REQUIRED FOR THE APPLICATION CAN BE MONITORED AND ACCUMULATED EFFECTIVELY.
4. STANDALONE CAPABILITY: ONLY THE FOLLOWING DATA (AS APPLICABLE) MAY BE ACQUIRED FROM OTHER AACS VIA LANS. IN THE EVENT OF A LOSS OF COMMUNICATIONS WITH ANY OTHER AACS, OR ANY FAULT IN ANY SYSTEM HARDWARE THAT INTERRUPTS THE ACQUISITION OF ANY OF THESE VALUES, THE AAC SHALL USE THE LAST VALUE OBTAINED BEFORE THE FAULT OCCURRED.
5. MOUNTING:
   a) AACS THAT CONTROL EQUIPMENT LOCATED ABOVE ACCESSIBLE (36" CLEARANCE REQUIRED) CEILINGS SHALL BE MOUNTED ON THE EQUIPMENT AND SHALL BE RATED FOR PLENUM USE.
   b) AACS THAT CONTROL EQUIPMENT LOCATED IN OCCUPIED SPACES OR OUTSIDE SHALL EITHER BE MOUNTED WITHIN THE EQUIPMENT ENCLOSURE (RESPONSIBILITY FOR PHYSICAL FIT REMAINS WITH THE CONTRACTOR) OR IN A NEAR BY MECHANICAL/UTILITY ROOM IN WHICH CASE IT SHALL BE ENCLOSED IN A NEMA 1, LOCKING ENCLOSURE.
6. PROGRAMMABILITY: OPERATOR SHALL BE ABLE TO MODIFY ALL SETPOINTS (TEMPERATURE AND AIRFLOW), SCHEDULING PARAMETERS ASSOCIATED WITH THE UNIT, TUNING AND SET UP PARAMETERS, INTERSTAGE TIMING PARAMETERS, AND MODE SETTINGS. OPERATOR SHALL BE ABLE TO ADDRESS AND CONFIGURE SPARE INPUTS FOR MONITORING. OPERATOR SHALL BE ABLE TO PROGRAM CUSTOM DDC CONTROL ALGORITHMS AND SPECIFY TRENDING PARAMETERS, WHICH WILL BE RETAINED IN MEMORY IN THE EVENT OF A LOSS OF COMMUNICATIONS.

APPLICATION-SPECIFIC BLOCK CONTROL ALGORITHMS MAY BE USED PROVIDED THEY MEET THE SEQUENCE OF OPERATIONS. THE CONTROL ALGORITHMS SHALL BE COMPLETELY CUSTOMIZABLE.

7. NETWORK RESTRICTIONS: EACH LAN WHICH PARTICIPATES IN THE TRANSFER OF DATA BETWEEN THE CU AND THE LOCAL OPERATOR WORKSTATION SHALL BE SUBJECT TO THE FOLLOWING CRITERIA:
   a) LIMIT THE NUMBER OF NODES SERVICING ANY ONE OF THESE APPLICATIONS ON THE AAC/ASC LAN TO 16.
   b) THE BUILDING CONTROLLER LAN SHALL BE SUBJECT ONLY TO MANUFACTURER'S PUBLISHED LAN LIMITATIONS.

H. APPLICATION CATEGORY 4
1. APPLICATIONS IN THIS CATEGORY INCLUDE THE FOLLOWING:
   a) CENTRAL COOLING PLANT
   b) CENTRAL HEATING PLANT
   c) COOLING TOWERS
   d) SEQUENCED OR VARIABLE SPEED PUMP CONTROL
   e) LOCAL CHILLER CONTROL (UNIT SPECIFIC)
   f) LOCAL FREE COOLING HEAT EXCHANGER CONTROL
   g) AIR HANDLERS OVER 10,000 CFM OR SERVING CRITICAL AREAS
2. BCS SHALL BE USED IN THESE APPLICATIONS.

THE FOLLOWING DOES NOT APPLY TO ALL PROJECTS; COORDINATE WITH UCB

3.04 NETWORK BANDWIDTH MANAGEMENT

A. THIS SECTION IS DESIGNED TO ADDRESS THE MS/TP NETWORKS WITHIN THE DDC SYSTEMS. INFORMATION PASSED WITHIN THE MS/TP NETWORK WILL GREATLY AFFECT THE OVERALL PERFORMANCE OF THE BUILDING SYSTEMS. SCAN TIMES FROM THE FIRST CONTROLLER TO THE LAST CONTROLLER WITHIN THE BUILDING NETWORK THAT EXCEED 2 SECONDS ARE NOT ACCEPTABLE. IF SCAN TIMES OF 2 SECONDS OR LESS CANNOT BE ACHIEVED, CONTACT UCB.

B. ONCE THE NETWORK IS PROPERLY CONFIGURED THE CONTRACTOR SHALL PROVIDE A NETWORK BANDWIDTH ANALYSIS OF THE CONTROLLER NETWORK. THE ANALYSIS SHALL DOCUMENT NETWORK BANDWIDTH UTILIZATION DOES NOT EXCEED THE REQUIREMENTS STATED ABOVE FOR A CONTINUOUS ONE HOUR PERIOD.

3.05 CONTROL UNIT REQUIREMENTS

A. REFER TO SECTION 15950 {23 0900} FOR REQUIREMENTS PERTAINING TO CONTROL UNIT QUANTITY AND LOCATION.

M15954 – BAS COMMUNICATION DEVICES

Part I. PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Network Connection
B. Local Supervisory LAN Gateways/Routers
C. Chiller Controls Interface Device (CID)

1.02 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
B. Section 15010 - Basic Mechanical Requirements
C. Section 15950 - Building Automation System (BAS) General
D. Section 23 0900 - Building Automation System (BAS) General
E. Section 15951 - BAS Basic Materials, Interface Devices, and Sensors
F. Section 23 0913 – BAS Basic Materials, Interface Devices, and Sensors
G. Section 15952 - BAS Operator Interfaces
H. Section 23 0902 - BAS Operator Interfaces
I. Section 15953 - BAS Field Panels
J. Section 23 0903 - BAS Field Panels
K. Section 15955 - BAS Software
L. Section 23 0905 - BAS Software and Programming
M. Section 15958 - Sequences of Operation
N. Section 23 0993 - Sequences of Operation
O. Section 15959 - BAS Commissioning
P. Section 23 0801 - BAS Commissioning

1.03 DESCRIPTION OF WORK

A. Contractor shall provide all interface devices and software to provide an integrated system connecting BCs, AACs, ASCs and Gateways to the University network.

Part II. PART 2 - PRODUCTS

2.01 NETWORK CONNECTION

A. UCB PRIVATE VLAN: INTERNET-BASED NETWORK CONNECTING THE BAS ACROSS MULTIPLE FACILITIES WITH A CENTRAL DATA WAREHOUSE AND SERVER, ACCESSIBLE VIA STANDARD WEB-BROWSER. THIS IS AN EXISTING INFRASTRUCTURE AND CONTRACTOR IS NOT REQUIRED TO CONFIGURE ANY COMPONENTS OF THIS VLAN.

THE FOLLOWING ONLY APPLIES TO STRICT BACNET SYSTEMS AND WILL TYPICALLY BE DELETED.

CONTRACTOR IS HOWEVER REQUIRED TO PROVIDE BACNET OBJECTS AND SERVICES AT THE LOCAL SUPERVISORY LAN VIA BACNET OVER IP.

2.02 LOCAL SUPERVISORY LAN GATEWAYS/ROUTERS

A. THE SUPERVISORY GATEWAY SHALL BE A MICROPROCESSOR-BASED COMMUNICATIONS DEVICE THAT ACTS AS A GATEWAY/ROUTER BETWEEN THE SUPERVISORY LAN CSSS OR OWS AND THE PRIMARY LAN.

B. THE GATEWAY SHALL PERFORM INFORMATION TRANSLATION BETWEEN THE PRIMARY LAN AND THE LOCAL SUPERVISORY LAN, WHICH IS 100 MBPS ETHERNET TCP/IP AND SHALL PREFERABLY USE BACNET OVER IP.

C. THE GATEWAY SHALL CONTAIN ITS OWN MICROPROCESSOR, RAM, BATTERY, REAL-TIME CLOCK, COMMUNICATION PORTS, AND POWER SUPPLY AS SPECIFIED FOR A BC IN SECTION 15953 {23 0903}. EACH GATEWAY/ROUTER SHALL BE MOUNTED IN A LOCKABLE ENCLOSURE UNLESS IT IS A PC THAT ALSO SERVES AS AN OWS.

D. THE GATEWAY/ROUTER SHALL ALLOW CENTRALIZED OVERALL SYSTEM SUPERVISION, OPERATOR INTERFACE, MANAGEMENT REPORT GENERATION, ALARM ANNUNCIATION, ACQUISITION OF TREND DATA, AND COMMUNICATION WITH CONTROL UNITS. IT SHALL ALLOW SYSTEM OPERATORS TO PERFORM THE FOLLOWING FUNCTIONS FROM THE CSS, OWSS, AND POTS:

1. CONFIGURE SYSTEMS.
2. MONITOR AND SUPERVISE CONTROL OF ALL POINTS.
3. CHANGE CONTROL SETPOINTS.
4. OVERRIDE INPUT VALUES.
5. OVERRIDE OUTPUT VALUES
6. ENTER PROGRAMMED START/STOP TIME SCHEDULES.
7. VIEW AND ACKNOWLEDGE ALARMS AND MESSAGES.
8. RECEIVE, STORE AND DISPLAY TREND LOGS AND MANAGEMENT REPORTS.
9. UPLOAD/DOWNLOAD PROGRAMS, DATABASES, ETC. AS SPECIFIED.

E. UPON LOSS OF POWER TO THE GATEWAY, THE BATTERY SHALL PROVIDE FOR MINIMUM 100 HOUR BACKUP OF ALL PROGRAMS AND DATA IN RAM. THE BATTERY SHALL BE SEALED AND SELF-CHARGING.

F. THE GATEWAY SHALL BE TRANSPARENT TO CONTROL FUNCTIONS AND SHALL NOT BE REQUIRED TO CONTROL INFORMATION ROUTING ON THE PRIMARY LAN

2.03 CHILLER CONTROLS INTERFACE DEVICE (CID)

A. THE CID SHALL BE A MICROPROCESSOR-BASED COMMUNICATIONS DEVICE THAT ACTS AS A GATEWAY BETWEEN THE CONTROL PROTOCOL AND THE APPLICABLE CHILLER CONTROLLER PROTOCOL.

B. THE CID SHALL CONTAIN ITS OWN MICROPROCESSOR, RAM, BATTERY, COMMUNICATION PORTS AND, POWER SUPPLY.

C. EACH CID SHALL SUPPORT FULL BI-DIRECTIONAL COMMUNICATIONS TRANSLATION AS MORE FULLY SPECIFIED IN SECTION 15955 {23 0905}.

EDIT THE FOLLOWING LIST AS NECESSARY TO MEET THE NEEDS OF UCB BASED ON CHILLER SIZE AND APPLICATION.

D. THE FOLLOWING POINTS SHALL BE MAPPED AS A MINIMUM:

1. CHW SUPPLY AND RETURN TEMPERATURES
2. CW SUPPLY AND RETURN TEMPERATURES
3. POWER CONSUMPTION (KW)
4. PERCENT OF POWER CONSUMPTION (COMPARED TO MAXIMUM)
5. BEARING TEMPERATURE
6. SUCTION AND HEAD PRESSURES
7. SUCTION AND HEAD TEMPERATURES
8. ALL AVAILABLE ALARMS; COMMON ALARM AS MINIMUM
9. CHILLER STATUS
10. ENABLE/DISABLE
11. CURRENT LIMIT PERCENT
12. CHW SETPOINT AND SETPOINT RESET

Part III. PART 3 - EXECUTION

3.01 INSPECTION:

A. EXAMINE AREAS AND CONDITIONS UNDER WHICH CONTROL SYSTEMS ARE TO BE INSTALLED. DO NOT PROCEED WITH WORK UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED IN MANNER ACCEPTABLE TO INSTALLER.

3.02 INSTALLATION OF CONTROL SYSTEMS:

A. GENERAL: INSTALL SYSTEMS AND MATERIALS IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS, ROUGHING-IN DRAWINGS AND DETAILS SHOWN ON DRAWINGS.

B. CONTRACTOR SHALL PROVIDE ALL INTERFACE DEVICES AND SOFTWARE TO PROVIDE AN INTEGRATED SYSTEM.

C. CONTRACTOR SHALL CLOSELY COORDINATE WITH THE UNIVERSITY, OR DESIGNATED REPRESENTATIVE, TO ESTABLISH IP ADDRESSES AND COMMUNICATIONS TO ASSURE PROPER OPERATION OF THE BUILDING CONTROL SYSTEM ON THE UNIVERSITY VLAN.

M15955 – BAS SOFTWARE AND PROGRAMMING

Part I. PART 1 - GENERAL

1.01 SECTION INCLUDES

A. SYSTEM SOFTWARE
B. PROGRAMMING DESCRIPTION
C. CONTROL ALGORITHMS
D. ENERGY MANAGEMENT APPLICATIONS
E. PASSWORD PROTECTION
F. ALARM REPORTING
G. TRENDING
H. DATA ACQUISITION AND STORAGE
I. DYNAMIC COLOR GRAPHICS

1.02 RELATED DOCUMENTS:

A. DRAWINGS AND GENERAL PROVISIONS OF CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION-1 SPECIFICATION SECTIONS, APPLY TO WORK OF THIS SECTION.

B. SECTION 15010 - BASIC MECHANICAL REQUIREMENTS
C. SECTION 15950 - BUILDING AUTOMATION SYSTEM (BAS) GENERAL
D. SECTION 23 0900 – BUILDING AUTOMATION SYSTEM (BAS) GENERAL
E. SECTION 15951 - BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS
F. SECTION 23 0913 –BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS
G. SECTION 15952 - BAS OPERATOR INTERFACES
H. SECTION 23 0902 - BAS OPERATOR INTERFACES
I. SECTION 15953 - BAS FIELD PANELS
J. SECTION 23 0903 - BAS FIELD PANELS
K. SECTION 15954 - BAS COMMUNICATIONS DEVICES
L. SECTION 23 0904 - BAS COMMUNICATION DEVICES
M. SECTION 15958 - SEQUENCES OF OPERATION
N. SECTION 23 0993 - SEQUENCES OF OPERATION
O. SECTION 15959 - BAS COMMISSIONING
P. SECTION 23 0801 - BAS COMMISSIONING

1.03 DESCRIPTION OF WORK:

A. FULLY CONFIGURE SYSTEMS AND FURNISH AND INSTALL ALL SOFTWARE, PROGRAMMING AND DYNAMIC COLOR GRAPHICS FOR A COMPLETE AND FULLY FUNCTIONING SYSTEM AS SPECIFIED.
B. REFER TO SECTION 15950 {23 0900} - BUILDING AUTOMATION SYSTEM (BAS) FOR GENERAL REQUIREMENTS
C. REFER TO 15958 {23 0993} - SEQUENCE OF OPERATION FOR GENERAL SEQUENCE OF OPERATION REQUIREMENTS.

1.04 LICENSING

A. INCLUDE LICENSING FOR ALL SOFTWARE PACKAGES AT ALL REQUIRED WORKSTATIONS.
B. ALL SOFTWARE USED FOR THE OPERATOR INTERFACE, PROGRAMMING ENVIRONMENT, NETWORKING, DATABASE MANAGEMENT AND ANY OTHER SOFTWARE USED BY THE CONTRACTOR TO INSTALL THE SYSTEM OR NEEDED TO OPERATE THE SYSTEM TO ITS FULL CAPABILITIES SHALL BE LICENSED AND PROVIDED TO THE UNIVERSITY.
C. ALL SOFTWARE SHOULD BE AVAILABLE ON ALL OPERATOR WORKSTATIONS OR CSSS PROVIDED, AND ON ALL PORTABLE OPERATOR TERMINALS. HARDWARE AND SOFTWARE KEYS TO PROVIDE ALL RIGHTS SHALL BE INSTALLED ON ALL WORKSTATIONS. AT LEAST 2 SETS OF CDS SHALL BE PROVIDED WITH BACKUP SOFTWARE FOR ALL SOFTWARE PROVIDED, SO THAT THE UNIVERSITY MAY REINSTALL ANY SOFTWARE AS NECESSARY. INCLUDE ALL LICENSING FOR WORKSTATION OPERATING SYSTEMS, AND ALL REQUIRED THIRD-PARTY SOFTWARE LICENSES.
D. PROVIDE LICENSING AND ORIGINAL SOFTWARE COPIES FOR EACH OWS OR CSS.
E. PROVIDE LICENSING AND ORIGINAL SOFTWARE COPIES FOR EACH REMOTE GRAPHIC WORKSTATION. LICENSES FOR REMOTE GRAPHIC WORKSTATIONS SHALL ALLOW FOR

ACCESS TO ANY SITE AND SHALL NOT BE RESTRICTED TO ACCESSING ONLY THE LANS INCLUDED IN THIS PROJECT.

F. UPGRADE ALL SOFTWARE PACKAGES TO THE RELEASE (VERSION) IN EFFECT AT THE END OF THE WARRANTY PERIOD.

G. REFER TO SECTION 15950 {23 0900} - BUILDING AUTOMATION SYSTEM (BAS) GENERAL FOR FURTHER REQUIREMENTS.

Part II. PART 2 - PRODUCTS

2.01 SYSTEM SOFTWARE-GENERAL

A. FUNCTIONALITY AND COMPLETENESS: THE CONTRACTOR SHALL FURNISH AND INSTALL ALL SOFTWARE AND PROGRAMMING NECESSARY TO PROVIDE A COMPLETE AND FUNCTIONING SYSTEM AS SPECIFIED. THE CONTRACTOR SHALL INCLUDE ALL SOFTWARE AND PROGRAMMING NOT SPECIFICALLY ITEMIZED IN THESE SPECIFICATIONS, WHICH IS NECESSARY TO IMPLEMENT, MAINTAIN, OPERATE, AND DIAGNOSE THE SYSTEM IN COMPLIANCE WITH THESE SPECIFICATIONS.

B. CONFIGURATION: THE SOFTWARE SHALL SUPPORT THE SYSTEM AS A DISTRIBUTED PROCESSING NETWORK CONFIGURATION.

2.02 CONTROLLER SOFTWARE

A. BC SOFTWARE RESIDENCY: EACH BC AS DEFINED BELOW SHALL BE CAPABLE OF CONTROL AND MONITORING OF ALL POINTS PHYSICALLY CONNECTED TO IT. ALL SOFTWARE INCLUDING THE FOLLOWING SHALL RESIDE AND EXECUTE AT THE BC:

1. REAL-TIME OPERATING SYSTEM SOFTWARE
2. REAL-TIME CLOCK/CALENDAR AND NETWORK TIME SYNCHRONIZATION
3. BC DIAGNOSTIC SOFTWARE
4. LAN COMMUNICATION SOFTWARE/FIRMWARE
5. DIRECT DIGITAL CONTROL SOFTWARE
6. ALARM PROCESSING AND BUFFERING SOFTWARE
7. ENERGY MANAGEMENT SOFTWARE
8. DATA TRENDING, REPORTING, AND BUFFERING SOFTWARE
9. I/O (PHYSICAL AND VIRTUAL) DATABASE
10. REMOTE COMMUNICATION SOFTWARE

B. AAC/ASC SOFTWARE RESIDENCY: EACH AAC/ASC AS DEFINED BELOW SHALL BE CAPABLE OF CONTROL AND MONITORING OF ALL POINTS PHYSICALLY CONNECTED TO IT. AS A MINIMUM, SOFTWARE INCLUDING THE FOLLOWING SHALL RESIDE AND EXECUTE AT THE AAC/ASC. OTHER SOFTWARE TO SUPPORT OTHER REQUIRED FUNCTIONS OF THE AAC/ASC MAY RESIDE AT THE BC OR LAN INTERFACE DEVICE (SPECIFIED IN SECTION 15954 {23 0904}) WITH THE RESTRICTIONS/EXCEPTIONS PER APPLICATION PROVIDED IN SECTION 15953 {23 0903}:

1. REAL-TIME OPERATING SYSTEM SOFTWARE
2. AAC/ASC DIAGNOSTIC SOFTWARE

3. LAN COMMUNICATION SOFTWARE
4. CONTROL SOFTWARE APPLICABLE TO THE UNIT IT SERVES THAT WILL SUPPORT A SINGLE MODE OF OPERATION
5. I/O (PHYSICAL AND VIRTUAL) DATABASE TO SUPPORT ONE MODE OF OPERATION

C. STAND ALONE CAPABILITY: BC SHALL CONTINUE TO PERFORM ALL FUNCTIONS INDEPENDENT OF A FAILURE IN OTHER BC/AAC/ASC OR OTHER COMMUNICATION LINKS TO OTHER BCS/AACS/ASCS. TRENDS AND RUNTIME TOTALIZATION SHALL BE RETAINED IN MEMORY. RUNTIME TOTALIZATION SHALL BE AVAILABLE ON ALL DIGITAL INPUT POINTS THAT MONITOR ELECTRIC MOTOR STATUS. REFER ALSO TO SECTION 15953 {23 0903} FOR OTHER ASPECTS OF STAND ALONE FUNCTIONALITY.

D. OPERATING SYSTEM: CONTROLLERS SHALL INCLUDE A REAL-TIME OPERATING SYSTEM RESIDENT IN ROM. THIS SOFTWARE SHALL EXECUTE INDEPENDENTLY FROM ANY OTHER DEVICES IN THE SYSTEM. IT SHALL SUPPORT ALL SPECIFIED FUNCTIONS. IT SHALL PROVIDE A COMMAND PRIORITIZATION SCHEME TO ALLOW FUNCTIONAL OVERRIDE OF CONTROL FUNCTIONS. REFER ALSO TO SECTION 15953 {23 0903} FOR OTHER ASPECTS OF THE CONTROLLERS OPERATING SYSTEM.

E. NETWORK COMMUNICATIONS: EACH CONTROLLER SHALL INCLUDE SOFTWARE/FIRMWARE THAT SUPPORTS THE NETWORKING OF CUS ON A COMMON COMMUNICATIONS TRUNK THAT FORMS THE RESPECTIVE LAN. NETWORK SUPPORT SHALL INCLUDE THE FOLLOWING:

1. BUILDING CONTROLLER/PRIMARY LAN SHALL BE A HIGH-SPEED NETWORK DESIGNED AND OPTIMIZED FOR CONTROL SYSTEM COMMUNICATION. IF A PRIMARY LAN COMMUNICATIONS TRUNK IS SEVERED, BCS SHALL RECONFIGURE INTO TWO SEPARATE LANS AND CONTINUE OPERATIONS WITHOUT INTERRUPTION OR OPERATOR INTERVENTION.
2. CONTROLLER COMMUNICATION SOFTWARE SHALL INCLUDE ERROR DETECTION, CORRECTION, AND RE-TRANSMISSION TO ENSURE DATA INTEGRITY.
3. OPERATOR/SYSTEM COMMUNICATION SOFTWARE SHALL FACILITATE COMMUNICATIONS BETWEEN OTHER BCS, ALL SUBORDINATE AACS/ASCS, GATEWAYS AND LAN INTERFACE DEVICES OR OPERATOR WORKSTATIONS. SOFTWARE SHALL ALLOW POINT INTERROGATION, ADJUSTMENT, ADDITION/DELETION, AND PROGRAMMING WHILE THE CONTROLLER IS ON LINE AND FUNCTIONING WITHOUT DISRUPTION TO UNAFFECTED POINTS. THE SOFTWARE ARCHITECTURE SHALL ALLOW NETWORKED CONTROLLERS TO SHARE SELECTED PHYSICAL AND VIRTUAL POINT INFORMATION THROUGHOUT THE ENTIRE SYSTEM.

F. DIAGNOSTIC SOFTWARE: CONTROLLER SOFTWARE SHALL INCLUDE DIAGNOSTIC SOFTWARE THAT CHECKS MEMORY AND COMMUNICATIONS AND REPORTS ANY MALFUNCTIONS

G. ALARM/MESSAGING SOFTWARE: CONTROLLER SOFTWARE SHALL SUPPORT ALARM/MESSAGE PROCESSING AND BUFFERING SOFTWARE AS MORE FULLY SPECIFIED BELOW.

H. APPLICATION PROGRAMS: CUS SHALL SUPPORT AND EXECUTE APPLICATION PROGRAMS AS MORE FULLY SPECIFIED BELOW:

1. All Direct Digital Control software, Energy Management Control software, and functional block application programming software templates shall be provided in a 'ready-to-use' state, and shall not require (but shall allow) Owner programming.

I. Security: Controller software shall support multiple level password access restriction as more fully specified below.

J. Direct Digital Control: Controller shall support application of Direct Digital Control Logic. All logic modules shall be provided pre-programmed with written documentation to support their application. Provide the following logic modules as a minimum:

1. Proportional-Integral-Derivative (PID) control with analog, PWM and floating output
2. Two Position control (Hi or Low crossing with deadband)
3. Single-Pole Double-Throw relay
4. Delay Timer (delay-on-make, delay-on-break, and interval)
5. Hi/Low Selection
6. Reset or Scaling Module
7. Logical Operators (AND, OR, NOT, XOR)

K. Psychrometric Parameters: Controller software shall provide preprogrammed functions to calculate and present psychrometric parameters (given temperature and relative humidity) including the following as a minimum: Enthalpy, Wet Bulb Temperature.

L. Updating/Storing Application Data: Site-specific programming residing in volatile memory shall be uploadable/downloadable from an OWS or CSS connected locally, to the Primary LAN, to the Local Supervisory LAN and remotely via the internet. Initiation of an upload or download shall include the following methods; Manually and Automatically upon detection of a loss or change.

M. Restart: System software shall provide for orderly shutdown upon loss of power and automatic restart upon power restoration. Volatile memory shall be retained; outputs shall go to programmed fail (open, closed, or last) position. Equipment restart shall include a user definable time delay on each piece of equipment to stagger the restart. Loss of power shall be alarmed at operator interface indicating date and time.

N. Time Synchronization: Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device, devices on a single network, or all devices simultaneously. Automatic time synchronization shall be provided.

O. Misc. Calculations: System software shall automate calculation of psychometric functions, calendar functions, kWh/kW, and flow determination and totalization from pulsed or analog inputs, curve-fitting, look-up table, input/output scaling, time averaging of inputs and A/D conversion coefficients.

2.03 APPLICATION PROGRAMMING DESCRIPTION

A. THE APPLICATION SOFTWARE SHALL BE USER PROGRAMMABLE.

B. THIS SPECIFICATION GENERALLY REQUIRES A PROGRAMMING CONVENTION THAT IS LOGICAL, EASY TO LEARN, USE, AND DIAGNOSE. GENERAL APPROACHES TO APPLICATION PROGRAMMING SHALL BE PROVIDED BY ONE, OR A COMBINATION, OF THE FOLLOWING CONVENTIONS:

1. POINT DEFINITION: PROVIDE TEMPLATES CUSTOMIZED FOR POINT TYPE, TO SUPPORT INPUT OF INDIVIDUAL POINT INFORMATION. USE STANDARD BACNET OBJECTS AS APPLICABLE.
2. GRAPHICAL BLOCK PROGRAMMING: MANIPULATION OF GRAPHIC ICON 'BLOCKS', EACH OF WHICH REPRESENTS A SUBROUTINE, IN A FUNCTIONAL/LOGICAL MANNER FORMING A CONTROL LOGIC DIAGRAM. BLOCKS SHALL ALLOW ENTRY OF ADJUSTABLE SETTINGS AND PARAMETERS VIA POP-UP WINDOWS. PROVIDE A UTILITY THAT SHALL ALLOW THE GRAPHIC LOGIC DIAGRAMS TO BE DIRECTLY COMPILED INTO APPLICATION PROGRAMS. LOGIC DIAGRAMS SHALL BE VIEWABLE EITHER OFF-LINE, OR ON-LINE WITH REAL-TIME BLOCK OUTPUT VALUES.

C. PROVIDE A MEANS FOR TESTING AND/OR DEBUGGING THE CONTROL PROGRAMS BOTH OFF-LINE AND ON-LINE.

2.04 ENERGY MANAGEMENT APPLICATIONS

A. SYSTEM SHALL HAVE THE ABILITY TO PERFORM ALL OF THE FOLLOWING ENERGY MANAGEMENT ROUTINES VIA PREPROGRAMMED FUNCTION BLOCKS OR TEMPLATE PROGRAMS. AS A MINIMUM PROVIDE THE FOLLOWING WHETHER OR NOT REQUIRED IN THE SOFTWARE:

1. TIME-OF-DAY SCHEDULING
2. CALENDAR-BASED SCHEDULING
3. HOLIDAY SCHEDULING
4. TEMPORARY SCHEDULE OVERRIDES
5. OPTIMAL START/OPTIMAL STOP-BASED ON SPACE TEMPERATURE OFFSET, OUTDOOR AIR TEMPERATURE, AND BUILDING HEATING AND COOLING CAPACITANCE FACTORS AS A MINIMUM
6. NIGHT SETBACK AND MORNING RECOVERY CONTROL, WITH VENTILATION ONLY DURING OCCUPANCY
7. ECONOMIZER CONTROL (ENTHALPY OR DRY-BULB)
8. ECONOMIZER CONTROL (HYDRONIC)
9. PEAK DEMAND LIMITING / LOAD SHEDDING
10. LIGHTING/OCCUPANCY CONTROL
11. DEAD BAND CONTROL

B. ALL PROGRAMS SHALL BE EXECUTED AUTOMATICALLY WITHOUT THE NEED FOR OPERATOR INTERVENTION, AND SHALL BE FLEXIBLE ENOUGH TO ALLOW OPERATOR

CUSTOMIZATION. PROGRAMS SHALL BE APPLIED TO BUILDING EQUIPMENT AS DESCRIBED IN SECTION 15958 {23 0993} - SEQUENCE OF OPERATION'.

2.05 PASSWORD PROTECTION

A. MULTIPLE-LEVEL PASSWORD ACCESS PROTECTION SHALL BE PROVIDED TO ALLOW THE UNIVERSITY'S AUTHORIZED BAS ADMINISTRATOR TO LIMIT WORKSTATION CONTROL, DISPLAY AND DATABASE MANIPULATION CAPABILITIES AS THEY DEEM APPROPRIATE FOR EACH USER, BASED UPON AN ASSIGNED USER NAME WITH A UNIQUE PASSWORD.

B. ALL PASSWORDS FOR THE SYSTEM SHALL BE PROVIDED TO THE UNIVERSITY INCLUDING ADMINISTRATOR, DEALER, OR FACTORY LEVEL PASSWORDS FOR THE SYSTEMS PROVIDED UNDER THIS PROJECT.

C. PASSWORDS SHALL RESTRICT ACCESS TO ALL CONTROL UNITS.

D. EACH USER NAME SHALL BE ASSIGNED TO A DISCRETE ACCESS LEVEL. A MINIMUM OF FIVE LEVELS OF ACCESS SHALL BE SUPPORTED. ALTERNATELY, A COMPREHENSIVE LIST OF ACCESSIBILITY/FUNCTIONALITY ITEMS SHALL BE PROVIDED, TO BE ENABLED OR DISABLED FOR EACH USER.

E. A MINIMUM OF 50 USER NAMES SHALL BE SUPPORTED AND PROGRAMMED PER THE UNIVERSITY'S DIRECTION.

F. OPERATORS SHALL BE ABLE TO PERFORM ONLY THOSE COMMANDS AVAILABLE FOR THE ACCESS LEVEL ASSIGNED TO THEIR USER NAME.

G. USER-DEFINABLE, AUTOMATIC LOG-OFF TIMERS OF FROM 1 TO 60 MINUTES SHALL BE PROVIDED TO PREVENT OPERATORS FROM INADVERTENTLY LEAVING INTERFACE DEVICE SOFTWARE ON-LINE.

2.06 ALARM AND EVENT MANAGEMENT REPORTING

A. ALARM MANAGEMENT SHALL BE PROVIDED TO MONITOR, BUFFER, AND DIRECT ALARMS AND MESSAGES TO OPERATOR DEVICES AND MEMORY FILES. THE CSS 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 A BCS ABILITY TO REPORT ALARMS BE AFFECTED BY EITHER OPERATOR ACTIVITY AT AN OPERATOR WORKSTATION OR LOCAL HANDHELD DEVICE, OR BY COMMUNICATIONS WITH OTHER PANELS ON THE NETWORK.

1. ALARM DESCRIPTOR: EACH ALARM OR POINT CHANGE SHALL INCLUDE THAT POINT'S ENGLISH LANGUAGE DESCRIPTION, AND THE TIME AND DATE OF OCCURRENCE. IN ADDITION TO THE ALARM'S DESCRIPTOR AND THE TIME AND DATE, THE USER SHALL BE ABLE TO PRINT, DISPLAY AND STORE AN ALARM MESSAGE TO MORE FULLY DESCRIBE THE ALARM CONDITION OR DIRECT OPERATOR RESPONSE.
2. ALARM PRIORITIZATION: THE SOFTWARE SHALL ALLOW USERS TO DEFINE THE HANDLING AND ROUTING OF EACH ALARM BY THEIR ASSIGNMENT TO DISCRETE PRIORITY LEVELS. A MINIMUM OF FIVE PRIORITY LEVELS SHALL BE PROVIDED. FOR EACH PRIORITY LEVEL, USERS SHALL HAVE THE ABILITY TO ENABLE OR DISABLE AN AUDIBLE TONE WHENEVER AN ALARM IS REPORTED AND WHENEVER AN ALARM

RETURNS TO NORMAL CONDITION. USERS SHALL HAVE THE ABILITY TO MANUALLY INHIBIT ALARM REPORTING FOR EACH INDIVIDUAL ALARM AND FOR EACH PRIORITY LEVEL. CONTRACTOR SHALL COORDINATE WITH THE UNIVERSITY ON ESTABLISHING ALARM PRIORITY DEFINITIONS. ALARM LEVEL 1 LIFE SAFETY (I.E. SMOKE DETECTOR), LEVEL 2 CRITICAL (I.E. CONTROLLER FAILURE), LEVEL 3 ABNORMAL (I.E. OUT-OF-RANGE TEMPERATURE), LEVEL 4 ENERGY WASTE (I.E. FIGHTING VALVES), LEVEL 5 MAINTENANCE MESSAGE (I.E. RUNTIME MONITOR, FILTER STATUS).

3. ALARM REPORT ROUTING: EACH ALARM PRIORITY LEVEL SHALL BE ASSOCIATED WITH A UNIQUE USER-DEFINED LIST OF OPERATOR DEVICES INCLUDING ANY COMBINATION OF LOCAL OR REMOTE WORKSTATIONS, PRINTERS, EMAIL ACCOUNTS, SMS ACCOUNTS AND WORKSTATION DISK FILES. ALL ALARMS ASSOCIATED WITH A GIVEN PRIORITY LEVEL SHALL BE ROUTED TO ALL OPERATOR DEVICES ON THE USER-DEFINED LIST ASSOCIATED WITH THAT PRIORITY LEVEL. FOR EACH PRIORITY LEVEL, ALARMS SHALL BE AUTOMATICALLY ROUTED TO A DEFAULT OPERATOR DEVICE IN THE EVENT THAT ALARMS ARE UNABLE TO BE ROUTED TO ANY OPERATOR DEVICE ASSIGNED TO THE PRIORITY LEVEL.
4. ALARM ACKNOWLEDGMENT: FOR ALARM PRIORITY LEVELS THAT ARE DIRECTED TO A WORKSTATION SCREEN, AN INDICATION OF ALARM RECEIPT SHALL BE DISPLAYED IMMEDIATELY REGARDLESS OF THE APPLICATION IN USE AT THE WORKSTATION, AND SHALL REMAIN ON THE SCREEN UNTIL ACKNOWLEDGED BY A USER HAVING A PASSWORD THAT ALLOWS ALARM ACKNOWLEDGMENT. UPON ACKNOWLEDGMENT, THE COMPLETE ALARM MESSAGE STRING (INCLUDING DATE, TIME, AND USER NAME OF ACKNOWLEDGING OPERATOR) SHALL BE STORED IN THE CSS DATABASE.

B. IT SHALL BE POSSIBLE FOR ANY OPERATOR TO RECEIVE A SUMMARY OF ALL ALARMS REGARDLESS OF ACKNOWLEDGEMENT STATUS; FOR WHICH A PARTICULAR RECIPIENT IS ENROLLED FOR NOTIFICATION; BASED ON CURRENT EVENT STATE; BASED ON THE PARTICULAR EVENT ALGORITHM (E.G., CHANGE OF VALUE, CHANGE OF STATE, OUT OF RANGE, AND SO ON); ALARM PRIORITY; AND NOTIFICATION CLASS.

INCLUDE THE FOLLOWING ONLY IF YOU ARE TRYING TO MANDATE STRICT BACNET INTEROPERABILITY.

C. BACNET ALARMING SERVICES: ALL ALARMS AND EVENTS SHALL BE IMPLEMENTED USING STANDARD BACNET EVENT DETECTION AND NOTIFICATION MECHANISMS. THE WORKSTATION SHALL RECEIVE BACNET ALARM AND EVENT NOTIFICATIONS FROM ANY GATEWAY OR BACNET CONTROLLER IN THE SYSTEM AND DISPLAY THEM TO AN OPERATOR. THE WORKSTATION SHALL ALSO LOG ALARMS AND EVENTS, PROVIDE A WAY FOR AN OPERATOR WITH SUFFICIENT PRIVILEGE TO ACKNOWLEDGE ALARMS, AND LOG ACKNOWLEDGEMENTS OF ALARMS. IT SHALL BE POSSIBLE FOR AN OPERATOR TO RECEIVE, AT ANY TIME, A SUMMARY OF ALL ALARMS THAT ARE CURRENTLY IN EFFECT AT ANY SITE WHETHER OR NOT THEY HAVE BEEN ACKNOWLEDGED. OPERATORS SHALL ALSO BE ABLE TO VIEW AND CHANGE ALARM LIMITS FOR ANY ALARM AT THE APPROPRIATE PASSWORD LEVEL.

D. ALARM HISTORICAL DATABASE: THE DATABASE SHALL STORE ALL ALARMS AND EVENTS OBJECT OCCURRENCES IN AN ODBC OR AN OLE DATABASE-COMPLIANT RELATIONAL DATABASE. PROVIDE A COMMERCIALLY AVAILABLE ODBC DRIVER OR

OLE DATABASE DATA PROVIDER, WHICH WOULD ALLOW APPLICATIONS TO ACCESS THE DATA USING STANDARD MICROSOFT WINDOWS DATA SERVICES.

2.07 TRENDING

A. THE SOFTWARE SHALL DISPLAY HISTORICAL DATA IN BOTH A TABULAR AND GRAPHICAL FORMAT. THE REQUIREMENTS OF THIS TRENDING SHALL INCLUDE THE FOLLOWING:

1. PROVIDE TRENDS FOR ALL PHYSICAL POINTS, VIRTUAL POINTS AND CALCULATED VARIABLES.
2. THE SAMPLE RATE AND DATA SELECTION SHALL BE SELECTABLE BY THE OPERATOR.
3. THE TRENDED VALUE RANGE SHALL BE SELECTABLE BY THE OPERATOR.
4. WORKSTATIONS SHALL BE ABLE TO DISPLAY UP TO FOUR SIMULTANEOUS TREND GRAPHS WITH UP TO FOUR DATA POINTS PER GRAPH.
5. THE DATA POINTS MUST BE EXPORTABLE FROM ANY OPERATOR INTERFACE IN CSV OR MS EXCEL FORMAT.

B. CONTROL LOOP PERFORMANCE TRENDS: CONTROLLERS INCORPORATING PID CONTROL LOOPS SHALL ALSO PROVIDE HIGH RESOLUTION SAMPLING IN LESS THAN FIVE SECOND INCREMENTS FOR VERIFICATION OF CONTROL LOOP PERFORMANCE.

C. DATA BUFFERING AND ARCHIVING: TREND DATA SHALL BE BUFFERED AT THE CUS, AND UPLOADED TO CSS STORAGE WHEN ARCHIVAL IS DESIRED. ALL ARCHIVED TRENDS SHALL BE TRANSMITTED TO THE ON-SITE OWS AS APPLICABLE. UPLOADS SHALL OCCUR BASED UPON A USER-DEFINED INTERVAL, MANUAL COMMAND, OR AUTOMATICALLY WHEN THE TREND BUFFERS BECOME FULL.

D. TIME SYNCHRONIZATION: PROVIDE A TIME MASTER THAT IS INSTALLED AND CONFIGURED TO SYNCHRONIZE THE CLOCKS OF ALL BACNET DEVICES SUPPORTING TIME SYNCHRONIZATION. SYNCHRONIZATION SHALL BE DONE USING COORDINATED UNIVERSAL TIME (UTC). ALL TREND SAMPLE TIMES SHALL BE ABLE TO BE SYNCHRONIZED. THE FREQUENCY OF TIME SYNCHRONIZATION MESSAGE TRANSMISSION SHALL BE SELECTABLE BY THE OPERATOR.

2.08 TOTALIZATION

A. THE SOFTWARE SHALL SUPPORT TOTALIZING ANALOG, DIGITAL, AND PULSED INPUTS AND BE CAPABLE OF ACCUMULATING, STORING, AND CONVERTING THESE TOTALS TO ENGINEERING UNITS USED IN THE DOCUMENTS. THESE VALUES SHALL GENERALLY BE ACCESSIBLE TO THE OPERATOR INTERFACES TO SUPPORT MANAGEMENT-REPORTING FUNCTIONS.

B. TOTALIZATION OF ELECTRICITY USE/DEMAND SHALL ALLOW APPLICATION OF TOTALS TO DIFFERENT RATE PERIODS, WHICH SHALL BE USER DEFINABLE.

C. WHEN SPECIFIED TO PROVIDE ELECTRICAL OR UTILITY USE/DEMAND, THE CONTRACTOR SHALL OBTAIN FROM THE LOCAL UTILITY ALL INFORMATION REQUIRED TO OBTAIN METER DATA, INCLUDING K FACTORS, CONVERSION CONSTANTS, AND THE LIKE.

2.09 SCHEDULING

A. PROVIDE A GRAPHIC UTILITY FOR USER-FRIENDLY OPERATOR INTERFACE TO ADJUST EQUIPMENT-OPERATING SCHEDULES.

B. SCHEDULING FEATURE SHALL INCLUDE MULTIPLE SEVEN-DAY MASTER SCHEDULES, HOLIDAY SCHEDULES AND OVERRIDE SCHEDULES, EACH WITH START TIME AND STOP TIME. MASTER SCHEDULES SHALL BE INDIVIDUALLY EDITABLE FOR EACH DAY AND HOLIDAY.

C. SCHEDULING FEATURE SHALL ALLOW FOR EACH INDIVIDUAL EQUIPMENT UNIT TO BE ASSIGNED TO ONE OF THE MASTER SCHEDULES.

D. TIMED OVERRIDE FEATURE SHALL ALLOW AN OPERATOR TO TEMPORARILY CHANGE THE STATE OF SCHEDULED EQUIPMENT. AN OVERRIDE COMMAND SHALL BE SELECTABLE TO APPLY TO AN INDIVIDUAL UNIT, ALL UNITS ASSIGNED TO A GIVEN MASTER SCHEDULE, OR TO ALL UNITS IN A BUILDING. TIMED OVERRIDE SHALL TERMINATE AT THE END OF AN OPERATOR SELECTABLE TIME, OR AT THE END OF THE SCHEDULED OCCUPIED/UNOCCUPIED PERIOD, WHICHEVER COMES FIRST. A PASSWORD LEVEL THAT DOES NOT ALLOW ASSIGNMENT OF MASTER SCHEDULES SHALL ALLOW A TIMED OVERRIDE FEATURE.

E. A YEARLY CALENDAR FEATURE SHALL ALLOW ASSIGNMENT OF HOLIDAYS, AND AUTOMATIC RESET OF SYSTEM REAL TIME CLOCKS FOR TRANSITIONS BETWEEN DAYLIGHT SAVINGS TIME AND STANDARD TIME.

2.10 OVERRIDES

A. BAS SHALL PROVIDE AN AUDIT LOG REPORT OF ALL OVERRIDES CURRENTLY ACTIVE, HISTORICAL OVERRIDES ALONG WITH THE USER WHO INITIATED THE OVERRIDE.

B. PROVIDE A SCREEN GRAPHIC FOR MANUAL OVERRIDE OF THE "OFF" FOR ALL SCHEDULED START/STOP ZONES. PROVIDE THE NECESSARY SOFTWARE TO START ANY DESIRED ZONE'S EQUIPMENT BY TOUCH SCREEN. THE PROGRAM SHALL PERMIT OPERATOR SELECTION OF ZONES AND SHALL ENABLE ALL RELATED EQUIPMENT FOR THAT PARTICULAR ZONE. THE PROGRAM SHALL INDEX THE SELECTED ZONE TO AN "ON" MODE IN A MINIMUM OF ONE-HOUR INCREMENTS FOR A PERIOD OF UP TO SIX HOURS IN THE OVERRIDE CONDITION. ONCE OVERRIDDEN, THE ZONE EQUIPMENT SHALL OPERATE IN THE OCCUPIED MODE, INCLUDING EXHAUST FAN INTERLOCKS.

C. TIMED OVERRIDE FEATURE SHALL ALLOW AN OPERATOR TO TEMPORARILY CHANGE THE STATE OF SCHEDULED EQUIPMENT. AN OVERRIDE COMMAND SHALL BE SELECTABLE TO APPLY TO AN INDIVIDUAL UNIT, ALL UNITS ASSIGNED TO A GIVEN MASTER SCHEDULE, OR TO ALL UNITS IN A BUILDING. TIMED OVERRIDE SHALL TERMINATE AT THE END OF AN OPERATOR SELECTABLE TIME, OR AT THE END OF THE SCHEDULED OCCUPIED/UNOCCUPIED PERIOD, WHICHEVER COMES FIRST. A PASSWORD LEVEL THAT DOES NOT ALLOW ASSIGNMENT OF MASTER SCHEDULES SHALL ALLOW A TIMED OVERRIDE FEATURE.

D. PROVIDE EQUIPMENT OVERRIDE PROGRAMS FOR ALL ENERGY RECOVERY UNITS, AIR HANDLING UNITS, AND HEATING AND VENTILATING UNITS. PROGRAM SHALL ALLOW OPERATOR TO OVERRIDE ERU, AHU, OR HVU "OFF" COMMAND TO ENABLE INDIVIDUAL UNITS FOR OPERATION WITHOUT OVERRIDING ZONE COMMAND. DURATION OF

OVERRIDE SHALL BE FOR 3 HOURS. INTENT IS TO ALLOW ERUS, AHUS, OR HVUS TO RUN FOR MAINTENANCE SERVICING WITHOUT REQUIRING OTHER EQUIPMENT IN THE ZONE TO OPERATE AS WOULD BE REQUIRED IF THE ZONE WERE OVERRIDDEN ON.

E. PROVIDE A SINGLE POINT OUTDOOR AIR DAMPER OVERRIDE. INTENT IS TO ALLOW THE BAS OPERATOR TO COMMAND ALL OUTDOOR AIR INTAKE DAMPERS CONTROLLED BY BAS TO BE CLOSED BY A SINGLE COMMAND.

F. PROVIDE A SINGLE POINT ZONES OVERRIDE. INTENT IS TO ALLOW THE BAS OPERATOR TO COMMAND ALL ZONES TO THE UNOCCUPIED MODE, EFFECTIVELY CLOSING ALL OUTDOOR AIR DAMPERS AND SHUTTING DOWN EXHAUST FANS.

G. OVERRIDE SHALL BE POSSIBLE FOR ANALOG OR TIME CLOCK VALUES FOR A GIVEN PERIOD OF TIME, UNTIL A GIVEN TIME OR PERMANENTLY. OVERRIDES MAY BE CLEARED AT THE KEYBOARD OR THROUGH PROGRAMMABLE USER FUNCTIONS.

2.11 OPERATOR INTERFACE GRAPHIC SOFTWARE

A. GRAPHIC SOFTWARE SHALL FACILITATE USER-FRIENDLY INTERFACE TO ALL ASPECTS OF THE SYSTEM SOFTWARE SPECIFIED ABOVE. THE INTENT OF THIS SPECIFICATION IS TO REQUIRE A GRAPHIC PACKAGE THAT PROVIDES FOR INTUITIVE OPERATION OF THE SYSTEMS WITHOUT EXTENSIVE TRAINING AND EXPERIENCE. IT SHALL FACILITATE LOGICAL AND SIMPLE SYSTEM INTERROGATION, MODIFICATION, CONFIGURATION, AND DIAGNOSIS.

B. GRAPHIC SOFTWARE SHALL SUPPORT MULTIPLE SIMULTANEOUS SCREENS TO BE DISPLAYED AND RESIZABLE IN A 'WINDOWS'-LIKE ENVIRONMENT. ALL FUNCTIONS EXCEPTING TEXT ENTRY FUNCTIONS SHALL BE EXECUTABLE WITH A MOUSE.

C. GRAPHIC SOFTWARE SHALL PROVIDE FOR MULTITASKING SUCH THAT THIRD-PARTY PROGRAMS CAN BE USED WHILE THE OWS SOFTWARE IS ON LINE. SOFTWARE SHALL PROVIDE THE ABILITY TO ALARM GRAPHICALLY EVEN WHEN OPERATOR IS IN ANOTHER SOFTWARE PACKAGE.

D. OPERATING SYSTEM SOFTWARE SHALL BE MICROSOFT WINDOWS XP PROFESSIONAL, OR LATEST VERSION OF WINDOWS SUPPORTED BY THE BAS MANUFACTURER AND APPROVED BY UC.

E. THE SOFTWARE SHALL ALLOW FOR THE UNIVERSITY'S CREATION OF USER-DEFINED, COLOR GRAPHIC DISPLAYS OF GEOGRAPHIC MAPS, BUILDING PLANS, FLOOR PLANS, AND MECHANICAL AND ELECTRICAL SYSTEM SCHEMATICS. THESE GRAPHICS SHALL BE CAPABLE OF DISPLAYING ALL POINT INFORMATION FROM THE DATABASE INCLUDING ANY ATTRIBUTES ASSOCIATED WITH EACH POINT (I.E., ENGINEERING UNITS, ETC.). IN ADDITION, OPERATORS SHALL BE ABLE TO COMMAND EQUIPMENT OR CHANGE SETPOINTS FROM A GRAPHIC THROUGH THE USE OF THE MOUSE

F. SCREEN PENETRATION: THE OPERATOR INTERFACE SHALL ALLOW USERS TO ACCESS THE VARIOUS SYSTEM GRAPHIC SCREENS VIA A GRAPHICAL PENETRATION SCHEME BY USING THE MOUSE TO SELECT FROM MENUS OR 'BUTTON' ICONS. EACH GRAPHIC SCREEN SHALL BE CAPABLE OF HAVING A UNIQUE LIST OF OTHER GRAPHIC SCREENS THAT ARE DIRECTLY LINKED THROUGH THE SELECTION OF A MENU ITEM OR BUTTON ICON.

G. DYNAMIC DATA DISPLAYS: DYNAMIC PHYSICAL POINT VALUES SHALL AUTOMATICALLY UPDATED AT A MINIMUM FREQUENCY OF 6 UPDATES PER MINUTE

WITHOUT OPERATOR INTERVENTION. POINT VALUE FIELDS SHALL BE DISPLAYED WITH A COLOR CODE DEPICTING NORMAL, ABNORMAL, OVERRIDE AND ALARM CONDITIONS.

H. POINT OVERRIDE FEATURE: EACH DISPLAYED POINT SHALL BE INDIVIDUALLY ENABLED/DISABLED TO ALLOW MOUSE-DRIVEN OVERRIDE OF DIGITAL POINTS OR CHANGING OF ANALOG POINTS. SUCH OVERRIDES OR CHANGES SHALL OCCUR IN THE CONTROL UNIT, NOT JUST IN THE WORKSTATION SOFTWARE. THE GRAPHIC POINT OVERRIDE FEATURE SHALL BE SUBJECT TO PASSWORD LEVEL PROTECTION. POINTS THAT ARE OVERRIDDEN SHALL BE REPORTED AS AN ALARM, AND SHALL BE DISPLAYED IN A CODED COLOR. THE ALARM MESSAGE SHALL INCLUDE THE OPERATOR'S USER NAME. A LIST OF POINTS THAT ARE CURRENTLY IN AN OVERRIDE STATE SHALL BE AVAILABLE THROUGH MENU SELECTION.

I. DYNAMIC SYMBOLS: PROVIDE A SELECTION OF STANDARD SYMBOLS THAT CHANGE IN APPEARANCE BASED ON THE VALUE OF AN ASSOCIATED POINT.

1. ANALOG SYMBOL: PROVIDE A SYMBOL THAT REPRESENTS THE VALUE OF AN ANALOG POINT AS THE LENGTH OF A LINE OR LINEAR BAR.
2. DIGITAL SYMBOL: PROVIDE SYMBOLS SUCH AS SWITCHES, PILOT LIGHTS, ROTATING FAN WHEELS, ETC. TO REPRESENT THE VALUE OF DIGITAL INPUT AND OUTPUT POINTS.
3. POINT STATUS COLOR: GRAPHIC PRESENTATIONS SHALL INDICATE DIFFERENT COLORS FOR DIFFERENT POINT STATUSES. (FOR INSTANCE, GREEN = NORMAL, RED = ALARM, GRAY (OR '???') FOR NON-RESPONSE).
4. TERMINAL EQUIPMENT COLOR: FLOOR PLAN GRAPHICS SHALL BE COLOR CODED BY THE EQUIPMENT SERVED AS FOLLOWS; GREEN = ZONE TEMPERATURE WITHIN SETPOINT, BLUE = ZONE TEMPERATURE BELOW SETPOINT, YELLOW = ZONE TEMPERATURE ABOVE SETPOINT, RED = ZONE TEMPERATURE IN ALARM RANGE.

J. GRAPHICS DEVELOPMENT PACKAGE: GRAPHIC DEVELOPMENT AND GENERATION SOFTWARE SHALL BE PROVIDED TO ALLOW THE USER TO ADD, MODIFY, OR DELETE SYSTEM GRAPHIC DISPLAYS.

1. THE CONTRACTOR SHALL PROVIDE LIBRARIES OF PRE-ENGINEERED SCREENS AND SYMBOLS DEPICTING STANDARD AIR HANDLING UNIT COMPONENTS (E.G. FANS, COOLING COILS, FILTERS, DAMPERS, ETC.), MECHANICAL SYSTEM COMPONENTS (E.G., PUMPS, CHILLERS, COOLING TOWERS, BOILERS, ETC.), COMPLETE MECHANICAL SYSTEMS (E.G. CONSTANT VOLUME-TERMINAL REHEAT, VAV, ETC.) AND ELECTRICAL SYMBOLS.
2. THE GRAPHIC DEVELOPMENT PACKAGE SHALL USE A MOUSE OR SIMILAR POINTING DEVICE TO ALLOW THE USER TO PERFORM THE FOLLOWING:
   a) DEFINE SYMBOLS
   b) POSITION ITEMS ON GRAPHIC SCREENS
   c) ATTACH PHYSICAL OR VIRTUAL POINTS TO A GRAPHIC
   d) DEFINE BACKGROUND SCREENS
   e) DEFINE CONNECTING LINES AND CURVES
   f) LOCATE, ORIENT AND SIZE DESCRIPTIVE TEXT
   g) DEFINE AND DISPLAY COLORS FOR ALL ELEMENTS

h) ESTABLISH CORRELATION BETWEEN SYMBOLS OR TEXT AND ASSOCIATED SYSTEM POINTS OR OTHER DISPLAYS.

i) CREATE HOT SPOTS OR LINK TRIGGERS TO OTHER GRAPHIC DISPLAYS OR OTHER FUNCTIONS IN THE SOFTWARE.

j) INSERT FRAMES OF HTML PAGES LINKED INTERNALLY OR EXTERNALLY TO THE CSS.

2.12 REMOTE PERSONAL COMPUTER WORKSTATION GRAPHIC SOFTWARE

EDIT THE FOLLOWING BASED ON HOW OPERATORS WILL REMOTELY CONNECT

A. REMOTE GRAPHIC OPERATOR SOFTWARE SHALL PROVIDE ALL THE FUNCTIONALITY SPECIFIED FOR THE LOCAL GRAPHIC SOFTWARE.

B. SYSTEM CONFIGURATION USES AN INTERNET SERVER AND PRESENTS WEB PAGES THAT CAN BE PULLED UP USING A STANDARD BROWSER.

C. SOFTWARE SHALL BE CAPABLE OF INITIATING COMMUNICATION TO SYSTEM, UPON USER COMMAND, TO PERFORM ALL SPECIFIED FUNCTIONS. SOFTWARE SHALL BE CAPABLE OF INITIATING COMMUNICATION TO THE LANS IN ACCORDANCE WITH USER-PROGRAMMED TIME SCHEDULES TO UPLOAD TREND AND REPORT DATA. SOFTWARE SHALL BE CAPABLE OF COMMUNICATING FROM THE LAN IN ACCORDANCE WITH USER-PROGRAMMED TIME SCHEDULES TO REPORT ALARMS, UPLOAD TREND, AND REPORT DATA.

Part III. PART 3 - EXECUTION

3.01 SYSTEM CONFIGURATION

A. CONTRACTOR SHALL THOROUGHLY AND COMPLETELY CONFIGURE BAS SYSTEM SOFTWARE, SUPPLEMENTAL SOFTWARE, NETWORK COMMUNICATIONS, CSS, OWS, [REMOTE OPERATOR WORKSTATION], PORTABLE OPERATORS TERMINAL, PRINTER, AND REMOTE COMMUNICATIONS.

3.02 SITE-SPECIFIC APPLICATION PROGRAMMING

A. PROVIDE ALL DATABASE CREATION AND SITE-SPECIFIC APPLICATION CONTROL PROGRAMMING AS REQUIRED BY THESE SPECIFICATIONS, NATIONAL AND LOCAL STANDARDS AND FOR A FULLY FUNCTIONING SYSTEM. CONTRACTOR SHALL PROVIDE ALL INITIAL SITE-SPECIFIC APPLICATION PROGRAMMING AND THOROUGHLY DOCUMENT PROGRAMMING. GENERALLY MEET THE INTENT OF THE WRITTEN SEQUENCES OF OPERATION. IT IS THE CONTRACTOR'S RESPONSIBILITY TO REQUEST CLARIFICATION ON SEQUENCE ISSUES THAT REQUIRE SUCH CLARIFICATION.

B. ALL SITE-SPECIFIC PROGRAMMING SHALL BE FULLY DOCUMENTED AND SUBMITTED FOR REVIEW AND APPROVAL, BOTH PRIOR TO DOWNLOADING INTO THE PANEL, AT THE COMPLETION OF FUNCTIONAL PERFORMANCE TESTING, AND AT THE END OF THE WARRANTY PERIOD.

C. ALL PROGRAMMING, GRAPHICS AND DATA FILES MUST BE MAINTAINED IN A LOGICAL SYSTEM OF DIRECTORIES WITH SELF-EXPLANATORY FILE NAMES. ALL FILES DEVELOPED FOR THE PROJECT WILL BE THE PROPERTY OF THE UNIVERSITY AND SHALL REMAIN ON THE WORKSTATION(S)/SERVER(S) AT THE COMPLETION OF THE PROJECT.

3.03 PASSWORD SETUP

A. SET UP THE FOLLOWING PASSWORD LEVELS TO INCLUDE THE SPECIFIED CAPABILITIES:

1. LEVEL 1: (UNIVERSITY'S BAS ADMINISTRATOR)
   a) LEVEL 2 CAPABILITIES
   b) VIEW, ADD, CHANGE AND DELETE USER NAMES, PASSWORDS, PASSWORD LEVELS
   c) ALL UNRESTRICTED SYSTEM CAPABILITIES INCLUDING ALL NETWORK MANAGEMENT FUNCTIONS.
2. LEVEL 2: (SYSTEM ENGINEERS)
   a) LEVEL 3 CAPABILITIES
   b) CONFIGURE SYSTEM SOFTWARE
   c) MODIFY CONTROL UNIT PROGRAMS
   d) MODIFY GRAPHIC SOFTWARE
   e) ESSENTIALLY UNRESTRICTED EXCEPT FOR VIEWING OR MODIFYING USER NAMES, PASSWORDS, PASSWORD LEVELS
3. LEVEL 3: (SENIOR MAINTENANCE TECHNICIAN)
   a) LEVEL 4 CAPABILITIES
   b) OVERRIDE OUTPUT POINTS
   c) CHANGE SETPOINTS
   d) CHANGE EQUIPMENT SCHEDULES
   e) EXIT BAS SOFTWARE TO USE THIRD PARTY PROGRAMS
4. LEVEL 4: (MAINTENANCE / SERVICE DESK)
   a) LEVEL 5 CAPABILITIES
   b) ACKNOWLEDGE ALARMS
   c) TEMPORARILY OVERRIDE EQUIPMENT SCHEDULES
5. LEVEL 5: (READ ONLY)
   a) DISPLAY ALL GRAPHIC DATA
   b) TREND POINT DATA

B. CONTRACTOR SHALL ASSIST UNIVERSITY'S OPERATORS WITH ASSIGNING USER NAMES, PASSWORDS AND PASSWORD LEVELS. UCB HAS DESIGNATED CUSTOM ACCESS LEVELS FOR USE BY CONTRACTORS ACTIVELY USING THE SYSTEM.

3.04 POINT PARAMETERS

A. PROVIDE THE FOLLOWING MINIMUM PROGRAMMING FOR EACH ANALOG INPUT:

1. NAME
2. ADDRESS
3. SCANNING FREQUENCY OR COV THRESHOLD
4. ENGINEERING UNITS
5. OFFSET CALIBRATION AND SCALING FACTOR FOR ENGINEERING UNITS

6. HIGH AND LOW ALARM VALUES AND ALARM DIFFERENTIALS FOR RETURN TO NORMAL CONDITION
7. HIGH AND LOW VALUE REPORTING LIMITS (REASONABLENESS VALUES), WHICH SHALL PREVENT CONTROL LOGIC FROM USING SHORTED OR OPEN CIRCUIT VALUES.
8. DEFAULT VALUE TO BE USED WHEN THE ACTUAL MEASURED VALUE IS NOT REPORTING. THIS IS REQUIRED ONLY FOR POINTS THAT ARE TRANSFERRED ACROSS THE PRIMARY AND/OR SECONDARY CONTROLLING NETWORKS AND USED IN CONTROL PROGRAMS RESIDING IN CONTROL UNITS OTHER THAN THE ONE IN WHICH THE POINT RESIDES. EVENTS CAUSING THE DEFAULT VALUE TO BE USED SHALL INCLUDE FAILURE OF THE CONTROL UNIT IN WHICH THE POINT RESIDES, OR FAILURE OF ANY NETWORK OVER WHICH THE POINT VALUE IS TRANSFERRED.
9. SELECTABLE AVERAGING FUNCTION THAT SHALL AVERAGE THE MEASURED VALUE OVER A USER SELECTED NUMBER OF SCANS FOR REPORTING.

B. PROVIDE THE FOLLOWING MINIMUM PROGRAMMING FOR EACH ANALOG OUTPUT:
1. NAME
2. ADDRESS
3. OUTPUT UPDATING FREQUENCY
4. ENGINEERING UNITS
5. OFFSET CALIBRATION AND SCALING FACTOR FOR ENGINEERING UNITS
6. OUTPUT RANGE
7. DEFAULT VALUE TO BE USED WHEN THE NORMAL CONTROLLING VALUE IS NOT REPORTING.

C. PROVIDE THE FOLLOWING MINIMUM PROGRAMMING FOR EACH DIGITAL INPUT:
1. NAME
2. ADDRESS
3. ENGINEERING UNITS (ON/OFF, OPEN/CLOSED, FREEZE/NORMAL, ETC.)
4. DEBOUNCE TIME DELAY (DIGITAL FILTER)
5. MESSAGE AND ALARM REPORTING AS SPECIFIED
6. REPORTING OF EACH CHANGE OF STATE, AND MEMORY STORAGE OF THE TIME OF THE LAST CHANGE OF STATE
7. TOTALIZATION OF ON-TIME (FOR ALL MOTORIZED EQUIPMENT STATUS POINTS), AND ACCUMULATED NUMBER OF OFF-TO-ON TRANSITIONS.

D. PROVIDE THE FOLLOWING MINIMUM PROGRAMMING FOR EACH DIGITAL OUTPUT:
1. NAME
2. ADDRESS
3. OUTPUT UPDATING FREQUENCY
4. ENGINEERING UNITS (ON/OFF, OPEN/CLOSED, FREEZE/NORMAL, ETC.)
5. DIRECT OR REVERSE ACTION SELECTION
6. MINIMUM ON-TIME
7. MINIMUM OFF-TIME
8. STATUS ASSOCIATION WITH A DI AND FAILURE ALARMING (AS APPLICABLE)

9. Reporting of each change of state, and memory storage of the time of the last change of state.
10. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
11. Default value to be used when the normal controlling value is not reporting.

3.05 Trends

A. Contractor shall establish and store trend logs. Trend logs shall be prepared for each physical input and output point, and all dynamic virtual points such as setpoints subject to a reset schedule, intermediate setpoint values for cascaded control loops, and the like as directed by the University.

B. The University will analyze trend logs of the system operating parameters to evaluate normal system functionality. Contractor shall establish these trends and ensure they are being stored properly.

1. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field or single date stamp. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals and be presented in a maximum of two separate 2-dimensional formats with time being the row heading and field name being the column heading.

C. The Contractor shall demonstrate functional trends as specified for a period of 30 days after successful system demonstration before Substantial Completion of the system.

3.06 ALARMS

A. General: Contractor will be responsible for setting initial alarm parameters. Reporting actions will be setup by UCB. No reporting actions will be initiated unless directed by UCB.

B. Override Alarms: Any point that is overridden through the override feature of the graphic workstation software shall be reported as a Level 3 alarm.

C. Analog Input Alarms: For each analog input, program an alarm message for reporting whenever the analog value is outside of the programmed alarm limits. Report a 'Return-to-Normal' message after the analog value returns to the normal range, using a programmed alarm differential. The alarm limits shall be individually selected by UCB. Contractor shall coordinate with UCB for final values based on the following parameters:

1. Space temperature, except as otherwise stated in sequence of operation: Level 3
   a) Low alarm: 64°F
   b) Low return-to-normal: 68°F

c) HIGH ALARM: 85°F

d) HIGH RETURN-TO-NORMAL: 80°F

2. CONTROLLED MEDIA TEMPERATURE OTHER THAN SPACE TEMPERATURE (E.G. AHU DISCHARGE AIR TEMPERATURE, STEAM CONVERTER LEAVING WATER TEMPERATURE, CONDENSER WATER SUPPLY, CHILLED WATER SUPPLY, ETC.): LEVEL 3 (IF CONTROLLED MEDIA TEMPERATURE SETPOINT IS RESET, ALARM SETPOINTS SHALL BE PROGRAMMED TO FOLLOW SETPOINT)
   a) LOW ALARM: 3°F BELOW SETPOINT
   b) LOW RETURN-TO-NORMAL: 2°F BELOW SETPOINT
   c) HIGH ALARM: 3°F ABOVE SETPOINT
   d) HIGH RETURN-TO-NORMAL: 2°F ABOVE SETPOINT.
3. AHU MIXED AIR TEMPERATURE: LEVEL 4
   a) LOW ALARM: 45°F
   b) LOW RETURN-TO-NORMAL: 46°F
   c) HIGH ALARM: 90°F
   d) HIGH RETURN-TO-NORMAL: 89°F
4. DUCT PRESSURE:
   a) LOW ALARM: 0.5"W.G. BELOW SETPOINT
   b) LOW RETURN-TO-NORMAL: 0.25"W.G. BELOW SETPOINT
   c) HIGH ALARM: 0.5"W.G. ABOVE SETPOINT
   d) HIGH RETURN-TO-NORMAL: 0.25"W.G. ABOVE SETPOINT
5. SPACE HUMIDITY:
   a) LOW ALARM: 35%
   b) LOW RETURN-TO-NORMAL: 40%
   c) HIGH ALARM: 75%
   d) HIGH RETURN-TO-NORMAL: 70%

D. BAS SYSTEM FAILURE ALARM: GENERATE ALARM THAT READS "BAS SYSTEM FAILURE". ALARM SHALL BE GENERATED WHEN COMMUNICATION IS LOST TO ANY CONTROLLER OR WHEN ANY CONTROLLER IS DETERMINED TO BE IN AN ABNORMAL STATE.

3.07 GRAPHIC SCREENS

A. FLOOR PLAN SCREENS: THE CONTRACT DOCUMENT DRAWINGS WILL BE MADE AVAILABLE TO THE CONTRACTOR IN AUTOCAD FORMAT UPON REQUEST. THESE DRAWINGS MAY BE USED ONLY FOR DEVELOPING BACKGROUNDS FOR SPECIFIED GRAPHIC SCREENS; HOWEVER THE UNIVERSITY DOES NOT GUARANTEE THE SUITABILITY OF THESE DRAWINGS FOR THE CONTRACTOR'S PURPOSE.

1. PROVIDE GRAPHIC FLOOR PLAN SCREENS FOR EACH FLOOR, WING, OR TOWER OF THE BUILDING. INDICATE THE LOCATION OF ALL EQUIPMENT THAT IS NOT LOCATED ON THE EQUIPMENT ROOM SCREENS. INDICATE ALL EQUIPMENT ZONES WITH CORRESPONDING ON/OFF STATUS. INDICATE THE LOCATION OF TEMPERATURE

SENSORS ASSOCIATED WITH EACH TEMPERATURE-CONTROLLED ZONE (I.E., VAV TERMINALS, FAN-COILS, SINGLE-ZONE AHUS, ETC.) ON THE FLOOR PLAN SCREENS. DISPLAY THE SPACE TEMPERATURE POINT ADJACENT TO EACH TEMPERATURE SENSOR SYMBOL. USE A DISTINCT LINE SYMBOL TO DEMARCATE EACH TERMINAL UNIT ZONE BOUNDARY. USE DISTINCT COLORS TO DEMARCATE EACH AIR HANDLING UNIT ZONE. MECHANICAL FLOOR PLAN DRAWINGS WILL BE MADE AVAILABLE TO THE CONTRACTOR UPON REQUEST FOR THE PURPOSE OF DETERMINING ZONE BOUNDARIES. INDICATE ROOM NUMBERS AS PROVIDED BY THE OWNER. PROVIDE A DRAWING LINK FROM EACH SPACE TEMPERATURE SENSOR SYMBOL AND EQUIPMENT SYMBOL SHOWN ON THE GRAPHIC FLOOR PLAN SCREENS TO EACH CORRESPONDING EQUIPMENT SCHEMATIC GRAPHIC SCREEN.

2. PROVIDE GRAPHIC FLOOR PLAN SCREENS FOR EACH MECHANICAL EQUIPMENT ROOM AND A PLAN SCREEN OF THE ROOF. INDICATE THE LOCATION OF EACH ITEM OF MECHANICAL EQUIPMENT. PROVIDE A DRAWING LINK FROM EACH EQUIPMENT SYMBOL SHOWN ON THE GRAPHIC PLAN VIEW SCREEN TO EACH CORRESPONDING MECHANICAL SYSTEM SCHEMATIC GRAPHIC SCREEN.
3. IF MULTIPLE FLOOR PLANS ARE NECESSARY TO SHOW ALL AREAS, PROVIDE A GRAPHIC BUILDING KEY PLAN. USE ELEVATION VIEWS AND/OR PLAN VIEWS AS NECESSARY TO GRAPHICALLY INDICATE THE LOCATION OF ALL OF THE LARGER SCALE FLOOR PLANS. LINK GRAPHIC BUILDING KEY PLAN TO LARGER SCALE PARTIAL FLOOR PLANS. PROVIDE LINKS FROM EACH LARGER SCALE GRAPHIC FLOOR PLAN SCREEN TO THE BUILDING KEY PLAN AND TO EACH OF THE OTHER GRAPHIC FLOOR PLAN SCREENS.
4. PROVIDE A GRAPHIC SITE PLAN WITH LINKS TO AND FROM EACH BUILDING PLAN.

B. SYSTEM SCHEMATIC SCREENS: PROVIDE GRAPHIC SYSTEM SCHEMATIC SCREEN FOR EACH HVAC SUBSYSTEM CONTROLLED WITH EACH I/O POINT IN THE PROJECT APPEARING ON AT LEAST ONE GRAPHIC SCREEN. SYSTEM GRAPHICS SHALL INCLUDE FLOW DIAGRAMS WITH STATUS, SETPOINTS, CURRENT ANALOG INPUT AND OUTPUT VALUES, OPERATOR COMMANDS, ETC. AS APPLICABLE. GENERAL LAYOUT OF THE SYSTEM SHALL BE SCHEMATICALLY CORRECT. INPUT/OUTPUT DEVICES SHALL BE SHOWN IN THEIR SCHEMATICALLY CORRECT LOCATIONS. INCLUDE APPROPRIATE ENGINEERING UNITS FOR EACH DISPLAYED POINT VALUE. VERBOSE NAMES (ENGLISH LANGUAGE DESCRIPTORS) SHALL BE INCLUDED FOR EACH POINT ON ALL GRAPHICS; THIS MAY BE ACCOMPLISHED BY THE USE OF A POP-UP WINDOW ACCESSED BY SELECTING THE DISPLAYED POINT WITH THE MOUSE. INDICATE ALL ADJUSTABLE SETPOINTS ON THE APPLICABLE SYSTEM SCHEMATIC GRAPHIC SCREEN OR, IF SPACE DOES NOT ALLOW, ON A SUPPLEMENTAL LINKED-SETPOINT SCREEN.

1. PROVIDE GRAPHIC SCREENS FOR EACH AIR HANDLING SYSTEM. INDICATE OUTSIDE AIR TEMPERATURE AND ENTHALPY, AND MODE OF OPERATION AS APPLICABLE (I.E., OCCUPIED, UNOCCUPIED, WARM-UP, COOL-DOWN). LINK SCREENS FOR AIR HANDLERS TO THE HEATING SYSTEM AND COOLING SYSTEM GRAPHICS. LINK SCREENS FOR SUPPLY AND EXHAUST SYSTEMS IF THEY ARE NOT COMBINED ONTO ONE SCREEN.
2. PROVIDE A GRAPHIC SCREEN FOR EACH ZONE. PROVIDE LINKS TO GRAPHIC SYSTEM SCHEMATIC SCREENS OF AIR HANDLING UNITS THAT SERVE THE CORRESPONDING ZONE.

3. PROVIDE A COOLING SYSTEM GRAPHIC SCREEN SHOWING ALL POINTS ASSOCIATED WITH THE CHILLERS, COOLING TOWERS AND PUMPS. INDICATE OUTSIDE AIR DRY-BULB TEMPERATURE AND CALCULATED WET-BULB TEMPERATURE. LINK SCREENS FOR CHILLED WATER AND CONDENSER WATER SYSTEMS IF THEY CANNOT FIT ONTO ONE COOLING PLANT GRAPHIC SCREEN.
4. LINK SCREENS FOR HEATING AND COOLING SYSTEM GRAPHICS TO UTILITY HISTORY REPORTS SHOWING CURRENT AND MONTHLY ELECTRIC USES, DEMANDS, PEAK VALUES, AND OTHER PERTINENT VALUES.

C. ALARMS: EACH PROGRAMMED ALARM SHALL APPEAR ON AT LEAST ONE GRAPHIC SCREEN. IN GENERAL, ALARMS SHALL BE DISPLAYED ON THE GRAPHIC SYSTEM SCHEMATIC SCREEN FOR THE SYSTEM THAT THE ALARM IS ASSOCIATED WITH (FOR EXAMPLE, CHILLER ALARM SHALL BE SHOWN ON GRAPHIC COOLING SYSTEM SCHEMATIC SCREEN). FOR ALL GRAPHIC SCREENS, DISPLAY ANALOG AND DIGITAL VALUES THAT ARE IN A 'ALARM' CONDITION IN A RED COLOR.

M15956 – SEQUENCE OF OPERATION

GENERAL

1.01 SECTION INCLUDES

A. AIR HANDLING UNITS
B. GLYCOL RECOVERY SYSTEM
C. STEAM TO HOT WATER CONVERTER
D. CENTRAL PLANT MONITORING

1.02 RELATED DOCUMENTS:

A. DRAWINGS AND GENERAL PROVISIONS OF CONTRACT, INCLUDING THE GENERAL CONDITIONS AND SUPPLEMENTARY CONDITIONS AND OTHER DIVISION-1 SPECIFICATION SECTIONS, APPLY TO THIS SECTION.

B. SECTION 15010 - BASIC MECHANICAL REQUIREMENTS

C. SECTION 23 0500 – COMMON WORK RESULTS FOR HVAC

D. SECTION 15950 - BUILDING AUTOMATION SYSTEM (BAS) GENERAL

E. SECTION 23 0900 - BUILDING AUTOMATION SYSTEM (BAS) GENERAL

F. SECTION 15951 - BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

G. SECTION 23 0913 – BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

H. SECTION 15953 - BAS FIELD PANELS

I. SECTION 23 0903 – BAS FIELD PANELS

J. SECTION 15954 - BAS COMMUNICATIONS DEVICES

K. SECTION 23 0904 - BAS COMMUNICATION DEVICES

L. SECTION 15955 - BAS SOFTWARE

M. SECTION 23 0905 - BAS SOFTWARE AND PROGRAMMING

N. SECTION 15959 – BAS COMMISSIONING

O. SECTION 23 0801 - BAS COMMISSIONING

1.03 SYSTEM DESCRIPTION

A. THIS SECTION DEFINES THE MANNER AND METHOD BY WHICH CONTROLS OPERATE AND SEQUENCE THE CONTROLLED EQUIPMENT. INCLUDED IN THIS SECTION ARE GENERAL REQUIREMENTS AND LOGIC STRATEGIES THAT EXPAND ON THE SPECIFIC SEQUENCES SHOWN ON THE DRAWINGS. SPECIFIC DRAWING SEQUENCES REFER TO THIS SECTION AND REFERENCE THE LOGIC STRATEGIES AS REQUIRED.

B. REFER TO THE CONTROL DRAWINGS FOR SPECIFIC SEQUENCES FOR INDIVIDUAL SYSTEMS.

1.04 SUBMITTALS

A. REFER TO SECTION 15950 {23 0900} AND DIVISION 1 FOR REQUIREMENTS FOR CONTROL SHOP DRAWINGS, PRODUCT DATA, USERS MANUAL, ETC.[]

Part II. PRODUCTS

NOT USED

Part III. EXECUTION

3.01 GENERAL

A. SEQUENCES SPECIFIED HEREIN INDICATE THE FUNCTIONAL INTENT OF THE SYSTEMS OPERATION AND MAY NOT FULLY DETAIL EVERY ASPECT OF THE PROGRAMMING THAT MAY BE REQUIRED TO OBTAIN THE INDICATED OPERATION. CONTRACTOR SHALL PROVIDE ALL PROGRAMMING NECESSARY TO OBTAIN THE SEQUENCES/SYSTEM OPERATION INDICATED.

B. WHEN AN AIR HANDLING UNIT IS NOT IN OPERATION, CONTROL DEVICES SHALL REMAIN IN THEIR "OFF" POSITIONS. "OFF" POSITIONS MAY DIFFER FROM THE "NORMAL" (MEANING FAILED) POSITION. EXCEPT AS SPECIFIED OTHERWISE, "OFF" AND "NORMAL" POSITIONS OF CONTROL DEVICES SHALL BE AS FOLLOWS:

DEVICE	"OFF" POSITION	"NORMAL" POSITION
HEATING COIL VALVES	CLOSED	OPEN
COOLING COIL VALVES	CLOSED	CLOSED
OUTSIDE AIR DAMPER	CLOSED	CLOSED
RETURN AIR DAMPER	OPEN	OPEN
EXHAUST/RELIEF AIR DAMPER	CLOSED	CLOSED
VAR. FREQ. DRIVE	OFF	MIN. SPEED

C. UNLESS SPECIFIED OTHERWISE, THROTTLING RANGES, PROPORTIONAL BANDS, AND CYCLE DIFFERENTIALS SHALL BE CENTERED ON THE ASSOCIATED SETPOINT. ALL MODULATING FEEDBACK CONTROL LOOPS SHALL INCLUDE THE CAPABILITY OF HAVING PROPORTIONAL, INTEGRAL, AND DERIVATIVE ACTION. UNLESS THE LOOP IS SPECIFIED "PROPORTIONAL ONLY" OR "P+I", CONTRACTOR SHALL APPLY APPROPRIATE ELEMENTS OF INTEGRAL AND DERIVATIVE GAIN TO EACH CONTROL LOOP WHICH SHALL RESULT IN STABLE OPERATION, MINIMUM SETTLING TIME, AND SHALL MAINTAIN THE PRIMARY VARIABLE WITHIN THE SPECIFIED MAXIMUM ALLOWABLE VARIANCE.

D. SCHEDULING TERMINOLOGY: WHEN AIR HANDLERS ARE SCHEDULED THROUGHOUT THE DAY, THE FOLLOWING DEFINES THE TERMINOLOGY USED:

COORDINATE OCCUPANCY SCHEDULES WITH UCB ON A PER BUILDING BASIS.

1. OCCUPIED PERIOD: PERIOD OF TIME WHEN THE BUILDING IS IN USE AND OCCUPIED. UNLESS INDICATED OTHERWISE, THIS PERIOD IS DEFINED AS X:XX AM - X:XX PM WEEKDAYS AND X:XX AM TO XX:XX PM WEEKENDS. EXCLUDE ALL NATIONAL HOLIDAYS. GENERALLY SYSTEMS WILL BE FULLY OPERATIONAL THROUGHOUT THIS PERIOD AND VENTILATION AIR SHALL BE CONTINUOUSLY INTRODUCED. SPACE TEMPERATURE SETPOINTS WILL GENERALLY BE IN THE "NORMAL" RANGE OF 69°-77°F.
2. UNOCCUPIED PERIOD: PERIOD OF TIME WHEN THE BUILDING OR ZONE IS NOT IN USE AND UNOCCUPIED. VENTILATION AIR SHALL NOT BE INTRODUCED.

3. PREOCCUPANCY PERIOD: TIME PRIOR TO THE OCCUPIED PERIOD WHEN THE SYSTEMS ARE RETURNING THE SPACE TEMPERATURES FROM SETBACK TO "NORMAL" OR OCCUPIED SETPOINTS (WARM-UP AND COOL-DOWN). VENTILATION AIR SHALL NOT BE INTRODUCED UNLESS OUTSIDE AIR CONDITIONS PERMIT FREE-COOLING. TIME PERIOD SHALL BE DETERMINED BY AN OPTIMUM START STRATEGY UNLESS OTHERWISE SPECIFIED.
4. SETBACK PERIOD: SETBACK WILL TYPICALLY COINCIDE START WITH THE END OF THE OCCUPIED PERIOD AND END WITH THE START OF THE PREOCCUPACY PERIOD, HOWEVER IT SHALL BE PROVIDED WITH ITS OWN SCHEDULE. GENERALLY SYSTEMS WILL BE OFF EXCEPT TO MAINTAIN A "SETBACK" TEMPERATURE.

E. WHERE ANY SEQUENCE OR OCCUPANCY SCHEDULE CALLS FOR MORE THAN ONE MOTORIZED UNIT TO START SIMULTANEOUSLY, THE BAS START COMMANDS SHALL BE STAGGERED BY 5 SECOND (ADJ.) INTERVALS TO MINIMIZE INRUSH CURRENT.

F. ALARM MESSAGES SPECIFIED THROUGHOUT THE SEQUENCES ARE ASSIGNED TO DISCRETE PRIORITY LEVELS. PRIORITY LEVELS DICTATE THE HANDLING AND DESTINATION OF ALARM REPORTS, AND ARE DEFINED IN SECTION 15955 {23 0905} - ATC SYSTEM SOFTWARE AND PROGRAMMING.

G. WHEREVER A VALUE IS INDICATED AS ADJUSTABLE (ADJ.), IT SHALL BE MODIFIABLE, WITH THE PROPER PASSWORD LEVEL, FROM THE OPERATOR INTERFACE OR VIA A FUNCTION BLOCK MENU. FOR THESE POINTS, IT IS UNACCEPTABLE TO HAVE TO MODIFY PROGRAMMING STATEMENTS TO CHANGE THE SETPOINT.

H. WHEN A POWER FAILURE IS DETECTED IN ANY PHASE, THE BAS START COMMANDS SHALL BE RETRACTED IMMEDIATELY FROM ALL ELECTRICALLY POWERED UNITS SERVED BY THE FAILED POWER SOURCE. IF THE ASSOCIATED PRIMARY CONTROL UNIT (PCU) IS POWERED BY NORMAL OR EMERGENCY POWER, IT MAY MONITOR ITS OWN POWER SOURCE AS AN INDICATION OF POWER STATUS. IF THE PCU IS POWERED BY UNINTERRUPTABLE POWER SUPPLY (UPS), OR IF PCU IS NOT CAPABLE OF MONITORING ITS OWN POWER FOR USE IN SEQUENCES, CONTRACTOR SHALL PROVIDE AT LEAST ONE VOLTAGE MONITOR (THREE PHASE WHEN APPLICABLE) PER BUILDING. WHEN THE BAS DETECTS THAT POWER HAS BEEN RESTORED, ALL EQUIPMENT FOR WHICH THE BAS START COMMAND HAD BEEN RETRACTED SHALL BE AUTOMATICALLY RESTARTED ON STAGGERED 5 SECOND INTERVALS TO MINIMIZE INRUSH CURRENT. WHEN LOSS OF EQUIPMENT STATUS COINCIDES WITH A POWER FAILURE, SYSTEM SHALL NOT ALARM INDIVIDUAL EQUIPMENT FAILURES. INSTEAD, ONLY A SINGLE LEVEL 2 ALARM SHALL BE ENUNCIATED.

I. WHERE RESET ACTION IS SPECIFIED IN A SEQUENCE OF OPERATION, BUT A RESET SCHEDULE IS NOT INDICATED ON THE DRAWINGS, ONE OF THE FOLLOWING METHODS SHALL BE EMPLOYED:

1. CONTRACTOR SHALL DETERMINE A FIXED RESET SCHEDULE WHICH SHALL RESULT IN STABLE OPERATION AND SHALL MAINTAIN THE PRIMARY VARIABLE WITHIN THE SPECIFIED MAXIMUM ALLOWABLE VARIANCE.
2. A FLOATING RESET ALGORITHM SHALL BE USED WHICH INCREMENTS THE SECONDARY VARIABLE SETPOINT (SETPOINT OF CONTROL LOOP BEING RESET) ON A PERIODIC BASIS TO MAINTAIN PRIMARY VARIABLE SETPOINT. THE RECALCULATION

TIME AND RESET INCREMENT SHALL BE CHOSEN TO MAINTAIN THE PRIMARY VARIABLE WITHIN THE SPECIFIED MAXIMUM ALLOWABLE VARIANCE.

J. WHERE A SUPPLY AIR TEMPERATURE OR DUCT PRESSURE SETPOINT IS SPECIFIED TO BE RESET BY THE SPACE TEMPERATURE OF THE ZONES CALLING FOR THE MOST COOLING/HEATING, THE FOLLOWING METHOD SHALL BE EMPLOYED:

1. A FLOATING RESET ALGORITHM SHALL BE USED WHICH INCREMENTS THE SECONDARY VARIABLE (E.G., SUPPLY AIR TEMPERATURE OR DUCT PRESSURE) SETPOINT ON A PERIODIC BASIS TO MAINTAIN PRIMARY VARIABLE (E.G. SPACE TEMPERATURE) SETPOINT. THE RESET INCREMENT SHALL BE DETERMINED BY THE QUANTITY OF "NEED HEAT" OR "NEED COOL" REQUESTS FROM INDIVIDUAL SCU'S. A SCU'S "NEED HEAT" VIRTUAL POINT SHALL ACTIVATE WHENEVER THE ZONE'S SPACE TEMPERATURE FALLS BELOW THE CURRENTLY APPLICABLE (OCCUPIED OR UNOCCUPIED) HEATING SETPOINT THROTTLING RANGE. A SCU'S "NEED COOL" VIRTUAL POINT SHALL ACTIVATE WHENEVER THE ZONE'S SPACE TEMPERATURE RISES ABOVE THE CURRENTLY APPLICABLE (OCCUPIED, UNOCCUPIED, OR ECONOMY) COOLING SETPOINT THROTTLING RANGE. THE RECALCULATION TIME AND RESET INCREMENT SHALL BE CHOSEN TO MAINTAIN THE PRIMARY VARIABLE WITHIN THE SPECIFIED MAXIMUM ALLOWABLE VARIANCE WHILE MINIMIZING OVERSHOOT AND SETTLING TIME. RESET RANGE MAXIMUM AND MINIMUM VALUES SHALL LIMIT THE SETPOINT RANGE.

K. WHERE A SUPPLY AIR TEMPERATURE, DUCT PRESSURE, OR DIFFERENTIAL WATER PRESSURE SETPOINT IS SPECIFIED TO BE RESET BY VALVE OR DAMPER POSITION OF THE ZONE OR ZONES CALLING FOR THE MOST COOLING/HEATING, THE FOLLOWING METHOD SHALL BE EMPLOYED:

1. A FLOATING RESET ALGORITHM SHALL BE USED WHICH INCREMENTS THE SECONDARY VARIABLE (E.G., SUPPLY AIR TEMPERATURE, PIPE OR DUCT PRESSURE) SETPOINT ON A PERIODIC BASIS TO MAINTAIN PRIMARY VARIABLE (E.G. COOLING VALVE, HEATING VALVE, DAMPER POSITION) SETPOINT OF 85% OPEN. THE RESET INCREMENT SHALL BE CALCULATED BASED ON THE AVERAGE POSITION OF THE QUANTITY OF THE WORST (MOST OPEN VALVE/DAMPER) ZONE(S) AS SPECIFIED. THE RECALCULATION TIME, RESET INCREMENT AND CONTROL DEVICE POSITION INFLUENCE SHALL BE CHOSEN TO MAINTAIN THE PRIMARY VARIABLE WITHIN THE SPECIFIED MAXIMUM ALLOWABLE VARIANCE WHILE MINIMIZING OVERSHOOT AND SETTLING TIME. THE BAS ANALOG OUTPUT VALUE SHALL BE ACCEPTABLE AS INDICATING THE POSITION OF THE CONTROL DEVICE.
2. ALTERNATIVELY TO CONTINUOUSLY CALCULATING THE AVERAGE OF THE QUANTITY OF WORST VALVE/DAMPER POSITIONS, A METHOD SIMILAR TO THE ONE DESCRIBED ABOVE MAY BE EMPLOYED WHEREBY THE "NEED HEAT" OR "NEED COOL" VIRTUAL POINT SHALL INCREMENT BY ONE UNIT EACH TIME A ZONE'S VALVE/DAMPER POSITION RISES TO GREATER THAN 95%. THE QUANTITY OF "NEED HEAT" OR "NEED COOL" POINTS SHALL THEN BE THE BASIS FOR RESET.

L. WHERE "PROVE OPERATION" OF A DEVICE (GENERALLY CONTROLLED BY A DIGITAL OUTPUT) IS INDICATED IN THE SEQUENCE, IT SHALL REQUIRE THAT THE BAS SHALL, AFTER AN ADJUSTABLE TIME DELAY AFTER THE DEVICE IS COMMANDED TO OPERATE (FEEDBACK DELAY), CONFIRM THAT THE DEVICE IS OPERATIONAL VIA THE STATUS INPUT. IF THE STATUS POINT DOES NOT CONFIRM OPERATION AFTER THE TIME DELAY OR

ANYTIME THEREAFTER FOR AN ADJUSTABLE TIME DELAY (DEBOUNCE DELAY) WHILE THE DEVICE IS COMMANDED TO RUN, AN ALARM SHALL BE ENUNCIATED AUDIBLY AND VIA AN ALARM MESSAGE AT THE OPERATOR INTERFACE AND PRINT AT THE ALARM PRINTERS. A DESCRIPTIVE MESSAGE SHALL BE ATTACHED TO THE ALARM MESSAGE INDICATING THE NATURE OF THE ALARM AND ACTIONS TO BE TAKEN. CONTRACTOR SHALL PROVIDE MESSAGES TO MEET THIS INTENT. [UPON FAILURE, RUN COMMAND SHALL BE REMOVED AND THE DEVICE SHALL BE LOCKED OUT UNTIL THE ALARM IS MANUALLY ACKNOWLEDGED UNLESS SPECIFIED OTHERWISE.]

M. BAS SHALL PROVIDE FOR ADJUSTABLE MAXIMUM RATES OF CHANGE FOR INCREASING AND DECREASING OUTPUT FROM THE FOLLOWING ANALOG OUTPUT POINTS:

1. SPEED CONTROL OF VARIABLE SPEED DRIVES
2. CHILLER SUPPLY WATER TEMPERATURE SETPOINT RESET
3. CHILLER DEMAND LIMIT
4. TRAVEL RATE OF TOWER ISOLATION AND CHILLER ISOLATION VALVES

N. WHEREVER A VALUE IS INDICATED TO BE DEPENDENT ON ANOTHER VALUE (I.E.: SETPOINT PLUS 5°F) BAS SHALL USE THAT EQUATION TO DETERMINE THE VALUE. SIMPLY PROVIDING A VIRTUAL POINT THAT THE OPERATOR MUST SET IS UNACCEPTABLE. IN THIS CASE THREE VIRTUAL POINTS SHALL BE PROVIDED. ONE TO STORE THE PARAMETER (5°F), ONE TO STORE THE SETPOINT, AND ONE TO STORE THE VALUE WHICH IS THE RESULT OF THE EQUATION.

3.02 DEMAND LIMITING CONTROL:

A. BAS SHALL MONITOR KW DEMAND OVER A 15-MINUTE SLIDING WINDOW PERIOD.

B. DEMAND LIMITING SHALL BE DISABLED DURING THE WINTER BILLING PERIOD. WHEN DEMAND LIMITING IS ENABLED, IT SHALL BE POSSIBLE FOR THE OPERATOR TO DISABLE IT ON A DAILY BASIS DURING, BUT IT SHALL BE AUTOMATICALLY RE-ENABLED EACH DAY AT 12 MIDNIGHT.

C. ON A RISE IN KW TO WITHIN [200] KW (ADJ.) OF SETPOINT, A LEVEL 4 ALARM SHALL BE ENUNCIATED AND BAS SHALL BEGIN TO MAKE ONE "LOAD SHED" COMMAND EVERY [3] MINUTES (ADJ.). ON A FALL IN KW TO [200] KW LESS THAN THE DEMAND SETPOINT, BAS SHALL BEGIN TO BROADCAST ONE "LOAD RESTORE" COMMAND EVERY [3] (ADJ.) MINUTES ON A FIRST SHED, FIRST RESTORED BASIS. IF DEMAND EXCEEDS THE DEMAND SETPOINT AND THERE ARE NO MORE LOADS LEFT TO SHED, THE DEMAND SETPOINT SHALL BE INCREASED TO THE MAXIMUM DEMAND EXPERIENCED. DEMAND SETPOINT SHALL BE AUTOMATICALLY RESET TO AN ADJUSTABLE VALUE AT THE BEGINNING OF EACH BILLING PERIOD.

D. "LOADS" AVAILABLE FOR SHEDDING ARE DEFINED ELSEWHERE IN THIS SPECIFICATION SECTION.

E. ON A RISE IN KW TO WITHIN [50] KW (ADJ.) OF SETPOINT, A LEVEL 3 AND LEVEL 4 ALARM SHALL BE ENUNCIATED.

3.03 AIR HANDLING UNITS - GENERAL

A. LOGIC STRATEGIES: THE BAS SHALL FULLY CONTROL THE AIR HANDLERS. GENERALLY THE BAS SHALL ENERGIZE THE AH (START THE FANS AND ACTIVATE CONTROL LOOPS)

AS DICTATED FOR EACH AIR HANDLE. THE FOLLOWING INDICATES WHEN AND HOW THE BAS SHALL ENERGIZE THE AHS AND CONTROL VARIOUS COMMON ASPECTS OF THEM. THE FOLLOWING "LOGIC STRATEGIES" SHALL BE INCLUDED BY REFERENCE, IF REQUIRED, FROM EACH AHU SEQUENCE OF OPERATION:

1. SCHEDULED OCCUPANCY: BAS SHALL DETERMINE THE OCCUPANCY PERIODS (OCCUPIED, UNOCCUPIED, PREOCCUPANCY, AND SETBACK) AS DEFINED ABOVE. THE FOLLOWING DETAILS THE COMMON CONTROL ASPECTS RELATED TO THE SCHEDULED OCCUPANCY.
    a) OCCUPIED PERIOD: BAS SHALL ENERGIZE THE AH DURING ALL OCCUPIED PERIODS. NOTE THAT THE BEGINNING OF THE OCCUPANCY PERIOD SHALL BE SET SUFFICIENTLY BEFORE THE ACTUAL START OF OCCUPANCY TO OBTAIN THE REQUIRED BUILDING COMPONENT OF VENTILATION PER ASHREA 62. MINIMUM OA FLOW SETPOINT SHALL BE AS SCHEDULED ON THE DRAWINGS. "NORMAL" SETPOINTS SHALL APPLY.
    b) UNOCCUPIED PERIOD: MINIMUM OA FLOW SHALL BE 0 CFM OR THE MINIMUM OA DAMPER POSITION SHALL BE 0%. IF DURING THE UNOCCUPIED PERIOD THERE IS A REQUEST FOR OCCUPANCY OVERRIDE, THE OCCUPANCY MODE SHALL BECOME ACTIVE FOR AN ADJUSTABLE PERIOD. THE UNOCCUPIED PERIOD AND THE PREOCCUPANCY PERIOD WILL TYPICALLY OVERLAP.
    c) SETBACK PERIOD: THE BAS SHALL DEENERGIZE THE UNIT EXCEPT AS REQUIRED TO MAINTAIN A SETBACK TEMPERATURE AS INDICATED IN THE INDIVIDUAL SEQUENCES WITH A 5°F CYCLE DIFFERENTIAL. GENERALLY, WHERE SETBACK TEMPERATURES APPLY IN MULTIPLE ZONES, THE WORST ZONE SHALL CONTROL THE SYSTEM. SETBACK SETPOINTS GENERALLY APPLY EXCEPT DURING PREOCCUPANCY [AND NIGHT PURGE]. IF DURING THE UNOCCUPIED PERIOD THERE IS A REQUEST FOR OCCUPANCY OVERRIDE, THE OCCUPANCY MODE SHALL BECOME ACTIVE FOR AN ADJUSTABLE PERIOD.
    d) PREOCCUPANCY: BAS SHALL ENERGIZE THE AH CONTINUOUSLY DURING THE PREOCCUPANCY PERIOD. MINIMUM OA FLOW SHALL BE 0 CFM OR THE MINIMUM OA DAMPER POSITION SHALL BE 0%. "NORMAL" SETPOINTS SHALL APPLY. PREOCCUPANCY DURATION SHALL BE ONE OF THE FOLLOWING AS SPECIFIED BY REFERENCE:
        1) FIXED: THE DURATION OF THE PREOCCUPANCY PERIOD SHALL BE FIXED AS SCHEDULED BY THE OPERATOR/
        2) OPTIMUM: THE DURATION OF THE MORNING WARM-UP PERIOD SHALL VARY ACCORDING TO OUTSIDE AIR TEMPERATURE AND SPACE TEMPERATURE SUCH THAT THE SPACE TEMPERATURE RISES TO OCCUPIED PERIOD HEATING SETPOINT AT THE BEGINNING OF, BUT NOT BEFORE, THE SCHEDULED OCCUPIED PERIOD. THE DURATION OF THE COOL-DOWN PERIOD SHALL VARY ACCORDING TO OUTSIDE AIR TEMPERATURE AND SPACE TEMPERATURE SUCH THAT THE SPACE TEMPERATURE FALLS TO THE OCCUPIED PERIOD COOLING SETPOINT AT THE BEGINNING OF, BUT NOT BEFORE, THE SCHEDULED OCCUPIED PERIOD

2. NIGHT PURGE CYCLE: THE NIGHT PURGE CYCLE SHALL CONFIGURE THE AH FOR 100% FRESH AIR INTAKE OPERATION AND WILL BE ENABLED/DISABLED MANUALLY VIA A GRAPHIC ICON. WHILE THE MODE IS ENABLED AND DURING THE UNOCCUPIED PERIOD, BAS SHALL ENERGIZE THE UNIT (AND ASSOCIATED EXHAUST/RELIEF FANS) WHEN THE OA TEMPERATURE FALLS TO 10°F BELOW SPACE TEMPERATURE AND SPACE TEMPERATURE IS GREATER THAN THE OCCUPIED HEATING SETPOINT AND outdoor air enthalpy is below 24 Btu/#. BAS SHALL DE-ENERGIZE AH WHEN THE SPACE TEMPERATURE FALLS TO WITHIN 5°F OF OA TEMPERATURE OR THE SPACE TEMPERATURE FALL(S) BELOW THE OCCUPIED HEATING SETPOINT OR outdoor air enthalpy rises to 25 Btu/#.DURING THE NIGHT PURGE CYCLE ANY APPLICABLE TERMINAL UNITS SHALL BE INDEXED TO THEIR NORMAL SETPOINTS.
3. MINIMUM OA CONTROL: BAS SHALL MAINTAIN MINIMUM VENTILATION DURING THE OCCUPIED PERIOD. THE FOLLOWING STRATEGIES MAY APPLY:
   a) BALANCED POSITION: DURING THE OCCUPIED PERIOD, APPLICABLE MIXING AND OA DAMPERS SHALL NEVER BE POSITIONED LESS THAN THE POSITION SET FOR THE REQUIRED MINIMUM OA VENTILATION RATE. IF THE AIR HANDLER HAS A SINGLE OA DAMPER THAT IS CAPABLE OF ECONOMIZER, THE MINIMUM POSITION OUTPUT SHALL BE DETERMINED BY THE BALANCER. IF THE AH HAS A TWO POSITION MINIMUM OA DAMPER, THAT POSITION SHALL BE FULLY OPEN TO ITS BALANCED POSITION. THIS LOGIC STRATEGY IS ONLY APPLICABLE TO CONSTANT VOLUME AHS.
   b) RESET BALANCED POSITION: DURING THE OCCUPIED PERIOD, APPLICABLE MIXING AND OA DAMPERS SHALL NEVER BE POSITIONED LESS THAN THE MINIMUM POSITION. MINIMUM POSITION SHALL BE RESET BETWEEN LIMITS OF A POSITION DELIVERING SYSTEM EXHAUST MAKE-UP AIR CFM AND THE DESIGN MINIMUM POSITION DELIVERING DESIGN MINIMUM CFM TO MAINTAIN A CO2 SETPOINT OF 900 PPM (ADJ.). LOOP SHALL BE A "SAMPLE AND BUMP" OR DYNAMIC PROPORTIONAL ONLY LOOP TUNED FOR THE SLOW RESPONSE. THE BALANCER SHALL DETERMINE THE MINIMUM POSITION OUTPUTS AT BOTH EXTREME POINTS. THIS LOGIC STRATEGY IS ONLY APPLICABLE TO CONSTANT VOLUME AHS.
   c) DAMPER CONTROLLED FIXED: DURING THE OCCUPIED PERIOD, APPLICABLE MIXING DAMPERS SHALL BE MODULATED TO MAINTAIN AN OA FLOW RATE OF NO LESS THAN THE MVR AS DICTATED IN THE DESIGN AND REQUIRED BY ASHRAE 62. SETPOINT FLOW RATES SHALL BE PROVIDED BY THE A/E. FLOW RATE SHALL BE DETERMINED IN ANY OF THE FOLLOWING WAYS AS SPECIFIED FOR THE PARTICULAR AH:
      1) MEASURED DIRECTLY BY AN OA FLOW STATION
      2) AS DETERMINED BY CO2 MIXING EQUATIONS USING THE SA, OA, AND RA CO2 SENSORS
   d) DAMPER CONTROLLED RESET: DURING THE OCCUPIED PERIOD, APPLICABLE MIXING DAMPERS SHALL BE MODULATED TO MAINTAIN AN OA FLOW RATE SETPOINT. SETPOINT SHALL BE RESET BETWEEN LIMITS OF SYSTEM EXHAUST MAKE-UP AIR CFM AND THE DESIGN MINIMUM CFM TO MAINTAIN AN RA CO2 SETPOINT OF 900 PPM (ADJ.). LOOP SHALL BE A "SAMPLE AND BUMP" OR DYNAMIC PROPORTIONAL ONLY LOOP TUNED FOR THE SLOW RESPONSE.

SETPOINT FLOW RATES SHALL BE PROVIDED BY THE A/E. FLOW RATE SHALL BE DETERMINED IN ANY OF THE FOLLOWING WAYS AS SPECIFIED FOR THE PARTICULAR AH:

1) MEASURED DIRECTLY BY AN OA FLOW STATION
2) AS DETERMINED BY CO2 MIXING EQUATIONS USING THE SA, OA, RA, AND/OR SPACE CO2 SENSORS

e) MIXED AIR TEMPERATURE CONTROL: MINIMUM POSITION OF THE OA DAMPER SHALL BE SET TO OBTAIN THE DESIGN REQUIRED MINIMUM OA. THIS BALANCED MINIMUM POSITION SHALL REMAIN FIXED. WHENEVER THE MINIMUM LOOP IS ACTIVE BAS SHALL CONTROL THE DAMPERS TO MAINTAIN A MIXED AIR TEMPERATURE SETPOINT WHICH WILL BE 2°F BELOW DISCHARGE AIR TEMPERATURE COOLING SETPOINT (ADJ.).

4. VAV RETURN FAN CAPACITY CONTROL: BAS SHALL CONTROL THE OUTPUT OF THE RETURN FAN AS FOLLOWS:

a) FLOW TRACKING: THE RETURN AIR FAN SHALL RUN TO MAINTAIN A RETURN FLOW SETPOINT OF THE SUPPLY FLOW MINUS AN OFFSET VALUE. THE OFFSET VALUE SHALL BE DETERMINED AS FOLLOWS:

1) FIXED DIFFERENTIAL: IT SHALL BE FIXED AT THE DESIGN MINIMUM OA VALUE.] ⊗
2) DIFFERENTIAL RESET FROM RA CO2: IT SHALL BE RESET BETWEEN LIMITS OF SYSTEM EXHAUST MAKE-UP AIR CFM AND THE DESIGN MINIMUM CFM TO MAINTAIN AN RA CO2 SETPOINT OF 900 PPM (ADJ.). LOOP SHALL BE A "SAMPLE AND BUMP" OR DYNAMIC PROPORTIONAL ONLY LOOP TUNED FOR THE SLOW RESPONSE. SETPOINT FLOW RATES SHALL BE PROVIDED BY THE A/E] ⊗
3) DIFFERENTIAL RESET FROM MEASURED OA TO MAINTAIN FIXED OA: IT SHALL BE RESET TO MAINTAIN THE MEASURED MINIMUM OA FLOW AT THE DESIGN VALUE ANY TIME THE ECONOMIZER MODE IS INACTIVE. WHENEVER IT IS INACTIVE, IT SHALL BE SET TO THE VALUE THAT EXISTED WHEN THE UNIT BECAME ACTIVE.] ⊗
4) DIFFERENTIAL RESET FROM MEASURED OA TO MAINTAIN RESET OA WHEN THE ECONOMIZER MODE IS INACTIVE, IT SHALL BE RESET TO MAINTAIN THE MEASURED OA FLOW SETPOINT. THE OA SETPOINT SHALL BE RESET BETWEEN LIMITS OF SYSTEM EXHAUST MAKE-UP AIR CFM AND THE DESIGN MINIMUM CFM TO MAINTAIN A CO2 SETPOINT OF 900 PPM (ADJ.). LOOP SHALL BE A "SAMPLE AND BUMP" OR DYNAMIC PROPORTIONAL ONLY LOOP TUNED FOR THE SLOW RESPONSE. SETPOINT FLOW RATES SHALL BE PROVIDED BY THE A/E. WHENEVER THE ECONOMIZER IS ACTIVE, IT SHALL BE SET TO THE VALUE THAT EXISTED WHEN THE UNIT BECAME ACTIVE.

b) RESCALED OUTPUT CAPACITY CONTROL: THE OUTPUT FOR THE RETURN FAN CAPACITY CONTROL SHALL BE RESCALED FROM THE OUTPUT OF THE TO THE SUPPLY DEVICE SUCH THAT THE DESIGN MINIMUM OA TEMPERATURE IS MAINTAINED AT BOTH MAXIMUM AND 50% FLOW CONDITIONS. THE BALANCING CONTRACTOR SHALL DETERMINE THE COORDINATED OUTPUT.

5. AIRSIDE ECONOMIZER: BAS SHALL MODULATE THE MIXING DAMPERS TO PROVIDE "FREE COOLING" WHEN CONDITIONS MERIT. THE FREE COOLING SHALL GENERALLY BE STAGED BEFORE ANY MECHANICAL COOLING. WHILE CONDITIONS MERIT, DAMPERS SHALL BE MODULATED IN A DA PID LOOP TO MAINTAIN MIXED AIR TEMPERATURE AT A SETPOINT AS SPECIFIED FOR THE INDIVIDUAL UNIT. ECONOMIZER LOGIC SHALL REMAIN ENABLED DURING SETBACK COOLING WHERE APPLICABLE. ONE OF THE FOLLOWING STRATEGIES SHALL BE USED TO ENABLE THE ECONOMIZER MODE:
   a) DRY BULB COMPARISON: ECONOMIZER MODE SHALL BE ACTIVE WHILE THE UNIT IS ENERGIZED AND WHEN OA ENTHALPY FALL BELOW 28 BTU/# AND OUTSIDE AIR TEMPERATURE FALLS BELOW RETURN AIR TEMPERATURE (WITH 2°F CYCLE DIFFERENTIAL). ECONOMIZER MODE SHALL BE INACTIVE WHEN OA ENTHALPY RISES ABOVE 29 BTU/# OROUTSIDE AIR TEMPERATURE RISES ABOVE RETURN AIR TEMPERATURE (WITH 2°F CYCLE DIFFERENTIAL), DAMPERS SHALL RETURN TO THEIR SCHEDULED MINIMUM POSITIONS AS SPECIFIED ABOVE. ECONOMIZER SHALL REMAIN ENABLED DURING SETBACK COOLING.
   b) DRY BULB SWITCH: ECONOMIZER MODE SHALL BE ACTIVE WHILE THE UNIT IS ENERGIZED AND WHEN OA ENTHALPY FALL BELOW 28 BTU/# AND OUTSIDE AIR TEMPERATURE FALLS BELOW THE SWITCHING SETPOINT OF 70°F (ADJ.) (WITH 5°F CYCLE DIFFERENTIAL). ECONOMIZER MODE SHALL BE INACTIVE WHEN OA ENTHALPY RISES ABOVE 29 BTU/# OR OUTSIDE AIR TEMPERATURE RISES ABOVE SWITCHING SETPOINT, DAMPERS SHALL RETURN TO THEIR SCHEDULED MINIMUM POSITIONS AS SPECIFIED ABOVE.
   c) ENTHALPY COMPARISON: ECONOMIZER MODE SHALL BE ACTIVE WHILE THE UNIT IS ENERGIZED AND WHEN OUTSIDE AIR ENTHALPY FALLS BELOW RETURN AIR ENTHALPY (WITH 2BTU/# CYCLE DIFFERENTIAL). ECONOMIZER MODE SHALL BE INACTIVE WHEN OUTSIDE AIR ENTHALPY RISES ABOVE RETURN AIR ENTHALPY, DAMPERS SHALL RETURN TO THEIR SCHEDULED MINIMUM POSITIONS AS SPECIFIED ABOVE.
6. SEQUENCED HEATING AND COOLING: BAS SHALL CONTROL THE HEATING AND COOLING COILS AND AIR SIDE ECONOMIZER AS DETAILED FOR THE PARTICULAR AH. PROGRAM LOGIC SHALL DIRECTLY PROHIBIT THE HEATING AND COOLING VALVES AS WELL AS THE HEATING VALVE AND ECONOMIZER DAMPER TO BE OPEN (OR ABOVE MINIMUM) SIMULTANEOUSLY. THIS DOES NOT APPLY TO COOLING AND REHEAT VALVES THAT ARE USED SIMULTANEOUSLY FOR DEHUMIDIFICATION.
7. MIXED AIR LOW LIMIT OVERRIDE: BAS SHALL OVERRIDE THE SIGNAL TO THE OA DAMPER VIA A PROPORTIONAL ONLY LOOP TO MAINTAIN A MINIMUM MIXED AIR TEMPERATURE OF 45°F (ADJ.) (LOOP SHALL OUTPUT 0% AT 45°F WHICH SHALL BE PASSED TO THE OUTPUT VIA A LOW SELECTOR).
8. FREEZE SAFETY: UPON OPERATION OF A FREEZESTAT THE FOLLOWING SEQUENCE SHALL OCCUR:
   a) THE UNIT FANS SHALL BE DEENERGIZED. TYPICALLY SUPPLY AND RETURN FANS WHERE APPLICABLE SHALL BE DEENERGIZED VIA A HARDWIRED INTERLOCK[, AND AN INDICATION OF THE OPERATION SHALL BE DISPLAYED BY THE BAS.

b) ALL HOT WATER VALVES AND CHILLED WATER VALVES WILL BE COMMANDED TO 100% OPEN.

c) ALL HOT WATER COIL PUMPS AND CHILLED WATER COIL PUMPS WILL BE COMMANDED TO RUN.

d) OUTSIDE AIR DAMPERS SHALL FULLY CLOSE AND RETURN AIR DAMPERS SHALL FULLY OPEN.

e) BAS SHALL ENUNCIATE APPROPRIATE ALARM AND REMOVE AND LOCK OUT THE START COMMAND], [WHICH SHALL INITIATE "FAN FAILURE" ALARMS].

9. SMOKE SAFETY: UPON INDICATION OF SMOKE BY A SMOKE DETECTOR, FAC SHALL DEENERGIZE THE AH. SMOKE DETECTOR SHALL NOTIFY THE FIRE ALARM SYSTEM AND BAS, SHUT DOWN THE FANS, AND CLOSE THE SMOKE DAMPERS VIA HARD-WIRED INTERLOCK.
10. HIGH OR LOW PRESSURE SAFETY: UPON ACTIVATION OF A HIGH OR LOW PRESSURE SAFETY SWITCH, AH SHALL BE DEENERGIZED, FANS SHALL BE DEENERGIZED VIA A HARD WIRED INTERLOCK[, AND AN INDICATION OF THE OPERATION SHALL BE SENSED BY THE BAS. BAS SHALL ENUNCIATE APPROPRIATE ALARM AND REMOVE AND LOCK OUT THE START COMMAND], [WHICH SHALL INITIATE "FAN FAILURE" ALARMS].
11. VIBRATION SAFETY (APPLICABLE TO UNITS >50,000 CFM): UPON ACTIVATION OF A VIBRATION SAFETY SWITCH, RESPECTIVE FAN SHALL BE DEENERGIZED, FAN SHALL BE DEENERGIZED VIA A HARD WIRED INTERLOCK AND AN INDICATION OF THE OPERATION SHALL BE SENSED BY THE BAS]. BAS SHALL ENUNCIATE APPROPRIATE ALARM AND REMOVE AND LOCK OUT THE START COMMAND.

B. THE DETAILED "LOGIC STRATEGIES" ABOVE SHALL BE REQUIRED BY REFERENCE TO THEM IN EACH OF THE INDIVIDUAL SEQUENCES SPECIFIED ELSEWHERE.

3.04 AIR HANDLING UNIT DIAGNOSTICS - GENERAL

A. DIAGNOSTIC STRATEGIES: IN ADDITION TO THE STANDARD ALARM LIMITS SPECIFIED FOR ALL SENSED VARIABLES THE BAS MONITOR AND DIAGNOSE ANOMALIES IN THE OPERATION OF THE AIR HANDLERS. THE FOLLOWING "DIAGNOSTIC STRATEGIES" SHALL BE INCLUDED BY REFERENCE WITH EACH AIR HANDLER WITH ANY SPECIFIC CLARIFICATIONS REQUIRED:

1. RUN TIME LIMIT: BAS SHALL ACCUMULATE THE RUNTIME OF THE STATUS OF ASSOCIATED ROTATING EQUIPMENT AND ENUNCIATE A LEVEL 5 ALARM TO INDICATE THAT THE UNIT IS IN NEED OF SERVICE.
2. FILTER MONITORING: BAS SHALL MONITOR THE DIFFERENTIAL PRESSURE TRANSMITTER ACROSS THE FILTER BANK(S). A LEVEL 5 ALARM SHALL BE REPORTED WHEN PRESSURE DROP EXCEEDS THE TRANSMITTER'S SETTING.
3. START MONITORING: BAS SHALL ACCUMULATE THE STARTS OF CYCLING EQUIPMENT. BAS SHALL FURTHER ENUNCIATE A LEVEL 5 ALARM WHEN THE NUMBER OF STARTS EXCEEDS THE SPECIFIED VALUE WITHIN THE SPECIFIED TIME PERIOD. (IE: MORE THAN 3 STARTS IN A 30 MIN PERIOD)

3.05 AIR HANDLER MONITORING AND MANAGEMENT

A. GENERAL: THE BAS SHALL MONITOR VARIOUS ASPECTS OF THE AIR HANDLING SYSTEMS AND CALCULATE PARAMETERS AS SPECIFIED BELOW TO FACILITATE OPERATIONS AND MANAGEMENT.

1. TRENDING: THE BAS SHALL CONTINUOUSLY MONITOR, CALCULATE AND DISPLAY THE FOLLOWING PARAMETERS AT THE INTERVALS INDICATED. THESE VALUES SHALL BE STORED INITIALLY IN THE BUFFER OF THE CONTROLLING CONTROL UNIT, AND THEN BE UPLOADED PERIODICALLY AND STORED ON A SPECIFIED HARD DISC.
2. PARAMETERS TO BE TRENDED:
   a) ALL TEMPERATURE SENSORS AT 1 HOUR INTERVALS
   b) ALL RELATIVE HUMIDITY SENSORS AT 1 HOUR INTERVALS
   c) ALL PRESSURE SENSORS AT 1 HOUR INTERVALS
   d) ALL RUN REQUESTS AND STATUSES ON A CHANGE IN VALUE
   e) ALL ANALOG LOOP OUTPUTS ON 1 HOUR INTERVALS
   f) CALCULATED ENTHALPIES IN 2 HOUR INTERVALS
   g) SUMMED COOLING AND HEATING REQUESTS ON 2 HOUR INTERVALS

3.06 GLYCOL HEAT RECOVERY RUN AROUND LOOP

A. GENERAL: BAS SHALL CONTROL THE GLYCOL HEAT RECOVERY SYSTEM AND EQUIPMENT AND PROVIDE MONITORING AND DIAGNOSTIC INFORMATION FOR MANAGEMENT PURPOSES.

a) SYSTEM ENABLE: SYSTEM SHALL BE ENABLED WHENEVER THE FOLLOWING CRITERIA ARE MET:
   1) SYSTEM MANUALLY ENABLED BY THE OPERATOR AT THE OPERATOR INTERFACE, AND
   2) AIR SYSTEMS SERVED BE RECOVERY SYSTEM ARE OPERATIONAL, AND
   3) THE CRITERIA FOR EFFICIENT OPERATION OF THE SYSTEM AS WRITTEN BELOW ARE MET.

b) SYSTEM DISABLE: SYSTEM SHALL BE DISABLED WHENEVER ANY OF THE FOLLOWING OCCURS:
   1) SYSTEM MANUALLY DISABLED BY THE OPERATOR AT THE OPERATOR INTERFACE, OR
   2) AIR SYSTEMS SERVED BY THE RECOVERY SYSTEM ARE OFF, OR
   3) THE CRITERION FOR EFFICIENT OPERATION OF THE SYSTEM AS WRITTEN BELOW IS NOT MET.

B. ENABLE CRITERIA:

1. OUTSIDE AIR TEMPERATURE MUST BE LOWER THAN THE EXHAUST AIR TEMPERATURE ENTERING THE HEAT RECOVERY COIL. .

2. Outside air temperature must be higher than the lower limit temperature of the glycol system.

C. Circulating Pump Control

1. Whenever the system is enabled, circulating pump shall run continuously. .
2. BAS shall prove operation of the pump. Upon failure of a pump, an alarm shall be enunciated.
3. BAS shall monitor pump status and accumulate runtime of the pump.

3.07 Steam to HW converterS wITH VV pumps

A. General: BAS shall control the hot water systems and equipment and provide monitoring and diagnostic information for management purposes.

B. Heating Enable: Heating shall be enabled when:

1. Any hot water valve opens to more than 50% continuously for 10 min. (adj.).
2. OR, the Outside Air temperature is below 55°F
3. OR, whenever manually enabled by the operator at the operator interface. Once enabled, the Heating Water System shall run for a minimum of 1 hour.

C. HW Pump Control:

1. Whenever the system is enabled, a minimum of one heating water pump shall run continuously.
2. BAS shall use a PID loop to maintain the differential pressure setpoint across the remote differential pressure sensor. The differential pressure setpoint shall initially be set at 15 psi (adj. as determined by the balance contractor).
3. The output of this loop shall control the starting, stopping, and speed of the pumps as follows:
   a) On a PID output of greater than 95% for 5 min (adj.), the BAS shall start an additional pump. The new pump shall ramp to speed per adjustable acceleration rates.
   b) If more that one pump is running, on a PID output of less than 40% for 5 min (adj.), the BAS shall stop a pump.
4. The output of the PID loop shall control the VSD's of all operating pumps at the same speed.
5. BAS shall prove operation of each pump individually. Upon failure of a pump, the standby shall be started (if not already running) and an alarm shall be enunciated.
6. BAS shall monitor pump status and accumulate runtime of the pumps. The BAS shall rotate the lead and lag pumps as follows:
   a) Whenever a pump is started, the BAS shall start the pump with the least runtime.

7. WHENEVER A PUMP IS STOPPED, THE BAS SHALL STOP THE PUMP WITH THE HIGHEST RUNTIME.

D. HEATING WATER TEMPERATURE CONTROL: BAS SHALL RESET THE HOT WATER SUPPLY TEMPERATURE SETPOINT VIA LINEAR RESET FROM 180°F (ADJ.) TO 110°F (ADJ.) AS THE OA TEMPERATURE RISES FROM 20°F (ADJ.) TO 60°F (ADJ.)

1. THE BAS SHALL MODULATE THE 1/3 [AND 2/3 STEAM] VALVES TO THE HEAT EXCHANGER IN SEQUENCE VIA A PID LOOP TO MAINTAIN THE HW SUPPLY TEMPERATURE SETPOINT.
2. THE VALVES SHALL REMAIN CLOSED UNTIL PUMP STATUS IS PROVEN.
3. STEAM SUPPLY PRESSURE TO THE HEAT EXCHANGER SHALL BE MONITORED BY THE BAS AND ENUNCIATE AN ALARM IF IT FALLS BELOW 5 PSI (ADJ.)

3.08 CENTRAL PLANT MONITORING AND MANAGEMENT

A. GENERAL: THE BAS SHALL MONITOR VARIOUS ASPECTS OF THE HEATING AND COOLING SYSTEMS AND CALCULATE PARAMETERS AS SPECIFIED BELOW TO FACILITATE PLANT OPERATIONS AND MANAGEMENT.

B. TRENDING: THE BAS SHALL CONTINUOUSLY MONITOR, CALCULATE AND DISPLAY THE FOLLOWING PARAMETERS AT THE INTERVALS INDICATED. THESE VALUES SHALL BE STORED INITIALLY IN THE BUFFER OF THE CONTROLLING CONTROL UNIT, AND THEN BE UPLOADED PERIODICALLY AND STORED ON A SPECIFIED HARD DISC. CONTRACTOR SHALL FORMAT REPORTS FROM THIS DATA TO SUPPORT ONE OF THE FOLLOWING DATA FORMATS:

1. QUOTE (TEXT STRINGS) AND COMMA DELIMITED
2. MICROSOFT EXCEL

C. PARAMETERS TO BE TRENDED:

1. LOAD ON THE SECONDARY SYSTEMS IN MBH PER THE FOLLOWING EQUATION: (RETURN TEMP-SUPPLY TEMP) * (GPM) / .5. THIS SHOWS COOLING AS A POSITIVE HEAT LOAD AND HEATING AS A NEGATIVE HEAT LOAD. NOTE THAT MULTIPLIERS ON THIS VALUE TO ACCOMMODATE THE BAS PROCESSORS ARE ACCEPTABLE AS LONG AS THEY ARE CLEARLY INDICATED. THIS VALUE SHALL BE TRENDED AND STORED EVERY TWO HOURS.
2. ALL TEMPERATURE SENSORS AT 1 HOUR INTERVALS.
3. ALL RELATIVE HUMIDITY SENSORS AT 1 HOUR INTERVALS.
4. ALL PRESSURE SENSORS AT 1 HOUR INTERVALS.
5. ALL RUN REQUESTS AND STATUSES ON A CHANGE IN VALUE.
6. ALL ANALOG LOOP OUTPUTS ON 1 HOUR INTERVALS.
7. CALCULATED ENTHALPIES IN 2 HOUR INTERVALS.
8. SUMMED COOLING AND HEATING REQUESTS ON 2 HOUR INTERVALS.

M15957 – BAS SYSTEM COMMISSIONING

Part I. GENERAL

1.01 SECTION INCLUDES

A. BAS AND EQUIPMENT TESTING AND START-UP
B. VALIDATION OF PROPER AND THOROUGH INSTALLATION OF BAS AND EQUIPMENT
C. FUNCTIONAL TESTING OF CONTROL SYSTEMS
D. DOCUMENTATION OF TESTS, PROCEDURES, AND INSTALLATIONS
E. COORDINATION OF BAS TRAINING
F. DOCUMENTATION OF BAS OPERATION AND MAINTENANCE MATERIALS

1.02 RELATED SECTIONS:

A. DRAWINGS AND GENERAL PROVISIONS OF CONTRACT, INCLUDING GENERAL AND SUPPLEMENTARY CONDITIONS AND DIVISION-1 SPECIFICATION SECTIONS, APPLY TO WORK OF THIS SECTION.
B. SECTION 15950 – BAS GENERAL REQUIREMENTS
C. SECTION 23 0900 - BAS GENERAL REQUIREMENTS
D. SECTION 15951 - BAS BASIC MATERIALS, INTERFACE DEVICES AND SENSORS
E. SECTION 23 0913 – BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS
F. SECTION 15952 - BAS OPERATOR INTERFACES
G. SECTION 23 0902 - BAS OPERATOR INTERFACES
H. SECTION 15953 - BAS FIELD PANELS
I. SECTION 23 0903 - BAS FIELD PANELS
J. SECTION 15954 - BAS COMMUNICATION DEVICES
K. SECTION 23 0904 - BAS COMMUNICATION DEVICES
L. SECTION 15955 - BAS SOFTWARE AND PROGRAMMING
M. SECTION 23 0905 - BAS SOFTWARE AND PROGRAMMING
N. SECTION 15958 - SEQUENCE OF OPERATION
O. SECTION 23 0993 - SEQUENCES OF OPERATION

1.03 GENERAL DESCRIPTION

A. THIS SECTION DEFINES RESPONSIBILITIES OF THE CONTROLS CONTRACTOR TO COMMISSION THE BAS.

EDIT THIS TO CLARIFY WHETHER THERE IS A FORMAL CX PROCESS AND INDICATE RESPONSIBILITIES.

B. [THE GOVERNMENT, AT GOVERNMENT'S EXPENSE, SHALL RETAIN A COMMISSIONING AUTHORITY (CA) WHO SHALL WORK WITH THE CONTRACTOR TO ENSURE THAT THE SYSTEMS, EQUIPMENT, AND INTERFACES ARE INSTALLED, TESTED, AND OPERATE PER THE DESIGN INTENT; THAT THE SYSTEMS ARE ADEQUATELY DOCUMENTED; AND THAT THE GOVERNMENT IS ADEQUATELY TRAINED ON SYSTEM INTENT, OPERATION, AND MAINTENANCE.]REFER TO SECTION 01800 FOR AN OVERVIEW OF THE COMMISSIONING PROCESS, ENTITIES INVOLVED IN THE PROCESS, TRAINING REQUIREMENTS, START-UP REQUIREMENTS, AND REQUIREMENTS FOR FUNCTIONAL PERFORMANCE TESTING.

THE FOLLOWING IS WRITTEN BASED ON THE USE OF A SEPARATE COMMISSIONING AUTHORITY (CA). IF THAT IS NOT THE CASE ON THE PROJECT, THE CONTRACTOR MUST STILL START UP AND COMMISSION THE BAS. THEREFORE EDIT THE RESPONSIBILITIES AS APPROPRIATE FOR THE PROJECT COMMISSIONING REQUIREMENTS.

1.04 CONTRACTOR RESPONSIBILITIES

A. COMPLETELY INSTALL AND THOROUGHLY INSPECT, STARTUP, TEST, ADJUST, BALANCE, AND DOCUMENT ALL SYSTEMS AND EQUIPMENT.

B. [ASSIST COMMISSIONING AUTHORITY IN] PERFORM VERIFICATION AND PERFORMANCE TESTING. THIS WILL GENERALLY INCLUDE THE FOLLOWING:

1. [ATTEND COMMISSIONING (CX) PROGRESS AND COORDINATION MEETINGS.]
2. [PREPARE AND SUBMIT REQUIRED DRAFT FORMS AND SYSTEMS INFORMATION.]
3. ESTABLISH TREND LOGS OF SYSTEM OPERATION AS SPECIFIED HEREIN.
4. DEMONSTRATE SYSTEM OPERATION.
5. MANIPULATE SYSTEMS AND EQUIPMENT TO FACILITATE TESTING.
6. PROVIDE INSTRUMENTATION NECESSARY FOR VERIFICATION AND PERFORMANCE TESTING.
7. MANIPULATE CONTROL SYSTEMS TO FACILITATE VERIFICATION AND PERFORMANCE TESTING.
8. TRAIN UNIVERSITY'S REPRESENTATIVES AS SPECIFIED IN PART III OF THIS SECTION.

THE FOLLOWING TWO ITEMS ONLY APPLY TO FORMAL COMMISSIONING PROCESSES. EDIT AS APPLICABLE.

C. PROVIDE A BAS TECHNICIAN TO WORK AT THE DIRECTION OF COMMISSIONING AUTHORITY FOR SOFTWARE OPTIMIZATION ASSISTANCE FOR A MINIMUM OF [80] HOURS FOR SCOPE 1 AND [40] HOURS FOR SCOPE 2. REFER TO PART 3 FOR A DESCRIPTION OF THE SOFTWARE OPTIMIZATION.

EDIT THE FOLLOWING TO SUIT THE PROGRAM AND APPLICATION.

1.05 SUBMITTALS

A. SUBMIT THE FOLLOWING QUALITY ASSURANCE / QUALITY CONTROL DOCUMENTATION DIRECTLY TO UCB [AND THE CA]:

1. QUALITY ASSURANCE PLAN
   a) CONTRACTOR MUST PROVIDE A DESCRIPTION OF THEIR QUALITY ASSURANCE OPERATIONS FOR THE COMMISSIONING PHASE OF THIS PROJECT. THE

DESCRIPTION SHALL INCLUDE PROTOCOLS FOR EACH STEP OF COMMISSIONING LISTED WITHIN THIS SECTION INCLUDING TESTING, REPORTING, COORDINATION WITH THE CA AND REMEDIATION OF ALL ACTION ITEMS.

B. SUBMIT THE FOLLOWING ITEMS DIRECTLY TO THE [CA] [GC]:

1. BAS START-UP REPORT (REFERENCE DIV. 1 AND SECTION 3.01 BELOW): SUBMIT FOUR (4) COPIES PRIOR TO SCHEDULING OF FUNCTIONAL PERFORMANCE TESTING.
2. BAS TRAINING PLAN (DEFINED BELOW): SUBMIT PRIOR TO SCHEDULING BAS DEMONSTRATION.
3. TREND AND ALARM LOGS AS REQUIRED DURING THE ACCEPTANCE PERIOD AND WARRANTY PERIOD.

Part II. PART 2 - PRODUCTS

2.01 INSTRUMENTATION

A. INSTRUMENTATION REQUIRED TO VERIFY READINGS AND TEST THE SYSTEM AND EQUIPMENT PERFORMANCE SHALL BE PROVIDED BY CONTRACTOR [AND MADE AVAILABLE TO COMMISSIONING AUTHORITY]. GENERALLY, NO TESTING EQUIPMENT WILL BE REQUIRED BEYOND THAT REQUIRED TO PERFORM CONTRACTORS WORK UNDER THESE CONTRACT DOCUMENTS. ALL EQUIPMENT USED FOR TESTING AND CALIBRATION SHALL BE NIST/NBS TRACEABLE AND CALIBRATED WITHIN THE PRECEDING 12-MONTH PERIOD. CERTIFICATES OF CALIBRATION SHALL BE MADE AVAILABLE WHEN REQUESTED.

Part III. PART 3 – EXECUTION

EDIT THE FOLLOWING TO SUIT THE APPLICATION.

3.01 BAS START-UP TESTING, ADJUSTING, CALIBRATION

A. WORK AND/OR SYSTEMS INSTALLED UNDER THIS DIVISION SHALL BE FULLY FUNCTIONING PRIOR TO DEMONSTRATION AND ACCEPTANCE PHASE. CONTRACTOR SHALL START, TEST, ADJUST, AND CALIBRATE ALL WORK AND/OR SYSTEMS UNDER THIS CONTRACT, AS DESCRIBED BELOW:

1. INSPECT THE INSTALLATION OF ALL DEVICES. REVIEW THE MANUFACTURER'S INSTALLATION INSTRUCTIONS AND VALIDATE THAT THE DEVICE IS INSTALLED IN ACCORDANCE WITH THEM.
2. VERIFY PROPER ELECTRICAL VOLTAGES AND AMPERAGES, AND VERIFY THAT ALL CIRCUITS ARE FREE FROM FAULTS.
3. VERIFY INTEGRITY/SAFETY OF ALL ELECTRICAL CONNECTIONS.
4. [FOR THE FOLLOWING CONTROL SETTINGS, INITIALLY USE THE CONTROL SETTING THAT WAS USED BY EXISTING CONTROL SYSTEM, UNLESS OTHERWISE INDICATED. FOR AHUS THAT USE A THROTTLED OUTSIDE AIR DAMPER POSITION WHEN MINIMUM OUTSIDE AIR IS REQUIRED, CONTRACTOR SHALL MARK EXISTING MINIMUM OUTSIDE AIR DAMPER POSITION TO ALLOW REPLICATION BY NEW CONTRCOORDINATE WITH TAB SUBCONTRACTOR TO OBTAIN [AND CA TO FINE-TUNE] CONTROL SETTINGS THAT ARE DETERMINED FROM BALANCING PROCEDURES. RECORD THE FOLLOWING CONTROL SETTINGS AS OBTAINED FROM TAB CONTRACTOR, AND NOTE ANY TAB DEFICIENCIES IN THE BAS START-UP REPORT:
   a) OPTIMUM DUCT STATIC PRESSURE SETPOINTS FOR VAV AIR HANDLING UNITS.
   b) MINIMUM OUTSIDE AIR DAMPER SETTINGS FOR AIR HANDLING UNITS.
   c) OPTIMUM DIFFERENTIAL PRESSURE SETPOINTS FOR VARIABLE SPEED PUMPING SYSTEMS.
   d) CALIBRATION PARAMETERS FOR FLOW CONTROL DEVICES SUCH AS VAV BOXES AND FLOW MEASURING STATIONS.
      1) BAS CONTRACTOR SHALL PROVIDE PORTABLE DEVICE AS A MINIMUM TO THE TAB [AND CA] TO FACILITATE CALIBRATION. CONNECTION FOR ANY GIVEN DEVICE SHALL BE LOCAL TO IT (I.E. AT THE VAV BOX, WIRELESS, OR AT THE THERMOSTAT). PORTABLE OPERATOR'S TERMINAL SHALL ALLOW QUERYING AND EDITING OF PARAMETERS REQUIRED FOR PROPER CALIBRATION AND START-UP.
5. TEST, CALIBRATE, AND SET ALL DIGITAL AND ANALOG SENSING AND ACTUATING DEVICES. CALIBRATE EACH INSTRUMENTATION DEVICE BY MAKING A COMPARISON BETWEEN THE BAS DISPLAY AND THE READING AT THE DEVICE. RECORD THE MEASURED VALUE AND DISPLAYED VALUE FOR EACH DEVICE IN THE BAS START UP REPORT.
6. CHECK AND SET ZERO AND SPAN ADJUSTMENTS FOR ALL TRANSDUCERS AND TRANSMITTERS. EXCESSIVE SIGNAL BUFFERING IS NOT ACCEPTABLE, SPAN ADJUSTMENTS MUST BE WITHIN 2% OF THEIR RESPECTIVE END POINTS. (I.E. DO NOT

CONTROL A 2-10VDC ACTUATOR WITH A 0-10VDC SIGNAL; WORST CASE SIGNAL SHOULD BE 1.8-10.2VDC.)

7. FOR DAMPERS AND VALVES:
   a) CHECK FOR ADEQUATE INSTALLATION INCLUDING FREE TRAVEL THROUGHOUT RANGE AND ADEQUATE SEAL.
   b) WHERE LOOPS ARE SEQUENCED, CHECK FOR PROPER CONTROL WITHOUT OVERLAP.
8. FOR ACTUATORS:
   a) CHECK TO INSURE THAT DEVICE SEALS TIGHTLY WHEN THE APPROPRIATE SIGNAL IS APPLIED TO THE OPERATOR.
   b) CHECK FOR APPROPRIATE FAIL POSITION, AND THAT THE STROKE AND RANGE IS AS REQUIRED.
   c) [FOR PNEUMATIC OPERATORS, ADJUST THE OPERATOR SPRING COMPRESSION AS REQUIRED TO ACHIEVE CLOSE-OFF. IF POSITIONER OR VOLUME BOOSTER IS INSTALLED ON THE OPERATOR, CALIBRATE PER MANUFACTURER'S PROCEDURE TO ACHIEVE SPRING RANGE INDICATED. CHECK SPLIT-RANGE POSITIONERS TO VERIFY PROPER OPERATION.]
   d) FOR SEQUENCED ELECTRONIC ACTUATORS, CALIBRATE PER MANUFACTURER'S INSTRUCTIONS TO REQUIRED RANGES.
9. CHECK EACH DIGITAL CONTROL POINT BY MAKING A COMPARISON BETWEEN THE CONTROL COMMAND AT THE CU AND THE STATUS OF THE CONTROLLED DEVICE. CHECK EACH DIGITAL INPUT POINT BY MAKING A COMPARISON OF THE STATE OF THE SENSING DEVICE AND THE OPERATOR INTERFACE DISPLAY. RECORD THE RESULTS FOR EACH DEVICE IN THE BAS START-UP REPORT.
10. FOR OUTPUTS TO RESET OTHER MANUFACTURER'S DEVICES (FOR EXAMPLE, VSDS) AND FOR FEEDBACK FROM THEM, CALIBRATE RANGES TO ESTABLISH PROPER PARAMETERS. COORDINATE WITH REPRESENTATIVE OF THE RESPECTIVE MANUFACTURER AND OBTAIN THEIR APPROVAL OF THE INSTALLATION.
11. VERIFY PROPER SEQUENCES BY USING THE APPROVED CHECKLISTS TO RECORD RESULTS AND SUBMIT WITH BAS START-UP REPORT. VERIFY PROPER SEQUENCE AND OPERATION OF ALL SPECIFIED FUNCTIONS.
12. VERIFY THAT ALL SAFETY DEVICES TRIP AT APPROPRIATE CONDITIONS. ADJUST SETPOINTS ACCORDINGLY.

EDIT TO SUIT PROJECT

13. TUNE ALL CONTROL LOOPS TO OBTAIN THE FASTEST STABLE RESPONSE WITHOUT HUNTING, OFFSET OR OVERSHOOT. RECORD TUNING PARAMETERS AND RESPONSE TEST RESULTS FOR EACH CONTROL LOOP IN THE BAS START UP REPORT. EXCEPT FROM A STARTUP, MAXIMUM ALLOWABLE VARIANCE FROM SET POINT FOR CONTROLLED VARIABLES UNDER NORMAL LOAD FLUCTUATIONS SHALL BE AS FOLLOWS. WITHIN 3 MINUTES OF ANY UPSET (FOR WHICH THE SYSTEM HAS THE CAPABILITY TO RESPOND) IN THE CONTROL LOOP, TOLERANCES SHALL BE MAINTAINED (EXCEPTIONS NOTED):
    a) DUCT AIR TEMPERATURE: ±1°F.

b) Space Temperature: ±2°F
c) Chilled Water: ±1°F
d) Hot water temperature: ±3°F.
e) Duct pressure: ± 0.25" w.g.
f) Water pressure: ±1 psid
g) Duct or space Humidity: ±5%
h) Air flow control: ±5% of setpoint velocity.
i) Space Pressurization (on active control systems): ±0.05" wg with no door or window movements.

14. For interface and DDC control panels:
    a) Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
    b) Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
    c) Check power supplies for proper voltage ranges and loading.
    d) Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
    e) Check for adequate signal strength on communication networks.
    f) Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
    g) Ensure that all outputs and devices fail to their proper positions/states.
    h) Ensure that buffered and/or volatile information is held through power outage.
    i) With all system and communications operating normally, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
    j) Check for adequate grounding of all DDC panels and devices.
    k) Thoroughly clean interior and exterior of control panel per manufacturer's instructions.
15. For Operator Interfaces:
    a) Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
    b) Output all specified BAS reports for review and approval.
    c) Verify that the alarm printing and logging is functional and per requirements.

d) Verify that trends are archiving to disk and provide a sample to the [Commissioning Authority and] University for review.

e) Verify that paging/dial-out alarm annunciation is functional.

f) Verify the functionality of remote Operator Interfaces and that a robust connection can be established consistently.

g) Verify that required third party software applications required with the bid are installed and are functional.

16. Start-up and check out control air compressors, air drying, and filtering systems in accordance with the appropriate section and with manufacturer's instructions.

17. Verify proper interface with fire alarm system.

B. Submit Start-Up Test Report: Report shall be completed, submitted, and approved prior to Substantial Completion.

3.02 Sensor CHeckout and Calibration

A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading of each other for pressure. Tolerances for critical applications may be tighter.

B. Calibration: Calibrate all sensors using one of the following procedures:

1. Sensors Without Transmitters - Standard Application: Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20% of the expected range.

2. Sensors With Transmitters - Standard Application: Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until the ammeter reads 4 mA. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

C. SENSOR TOLERANCE: SENSORS SHALL BE WITHIN THE TOLERANCES SPECIFIED FOR THE DEVICE. REFER TO SECTION 15951.

3.03 COIL VALVE LEAK CHECK

A. VERIFY PROPER CLOSE-OFF OF THE VALVES. ENSURE THE VALVE SEATS PROPERLY BY SIMULATING THE MAXIMUM ANTICIPATED PRESSURE DIFFERENCE ACROSS THE CIRCUIT. CALIBRATE AIR TEMPERATURE SENSORS ON EACH SIDE OF COIL TO BE WITHIN 0.5°F OF EACH OTHER. VIA THE OPERATOR INTERFACE, COMMAND THE VALVE TO CLOSE. ENERGIZE FANS. AFTER 5 MINUTES OBSERVE AIR TEMPERATURE DIFFERENCE ACROSS COIL. IF A TEMPERATURE DIFFERENCE IS INDICATED, AND THE PIPING SURFACE TEMPERATURE ENTERING THE COIL IS WITHIN 3°F OF THE WATER SUPPLY TEMP, LEAKAGE IS PROBABLY OCCURRING. IF IT APPEARS THAT IT IS OCCURRING, CLOSE THE ISOLATION VALVES TO THE COIL TO ENSURE THE CONDITIONS CHANGE. IF THEY DO, THIS VALIDATES THE VALVE IS NOT CLOSING. REMEDY THE CONDITION BY ADJUSTING THE STROKE AND RANGE, INCREASING THE ACTUATOR SIZE/TORQUE, REPLACING THE SEAT, OR REPLACING THE VALVE AS APPLICABLE.

3.04 VALVE STROKE SETUP AND CHECK

A. FOR ALL VALVE AND ACTUATOR POSITIONS CHECKED, VERIFY THE ACTUAL POSITION AGAINST THE OPERATOR INTERFACE READOUT.

B. SET PUMPS TO NORMAL OPERATING MODE. COMMAND VALVE CLOSED, VERIFY THAT VALVE IS CLOSED, AND ADJUST OUTPUT ZERO SIGNAL AS REQUIRED. COMMAND VALVE OPEN, VERIFY POSITION IS FULL OPEN AND ADJUST OUTPUT SIGNAL AS REQUIRED. COMMAND THE VALVE TO VARIOUS FEW INTERMEDIATE POSITIONS. IF ACTUAL VALVE POSITION DOESN'T REASONABLY CORRESPOND, REPLACE ACTUATOR OR ADD PILOT POSITIONER (FOR PNEUMATICS).

3.05 BAS DEMONSTRATION

A. DEMONSTRATE THE OPERATION OF THE BAS HARDWARE, SOFTWARE, AND ALL RELATED COMPONENTS AND SYSTEMS TO THE SATISFACTION OF THE [COMMISSIONING AUTHORITY AND] UNIVERSITY. SCHEDULE THE DEMONSTRATION WITH THE UNIVERSITY'S REPRESENTATIVE 1 WEEK IN ADVANCE. DEMONSTRATION SHALL NOT BE SCHEDULED UNTIL ALL HARDWARE AND SOFTWARE SUBMITTALS, AND THE START-UP TEST REPORT ARE APPROVED. IF THE WORK FAILS TO BE DEMONSTRATED TO CONFORM WITH CONTRACT SPECIFICATIONS, SO AS TO REQUIRE SCHEDULING OF ADDITIONAL SITE VISITS BY THE [COMMISSIONING AUTHORITY] UNIVERSITY FOR RE-DEMONSTRATION, CONTRACTOR SHALL REIMBURSE UNIVERSITY FOR COSTS OF SUBSEQUENT [COMMISSIONING AUTHORITY] SITE VISITS.

B. THE CONTRACTOR SHALL SUPPLY ALL PERSONNEL AND EQUIPMENT FOR THE DEMONSTRATION, INCLUDING, BUT NOT LIMITED TO, INSTRUMENTS, LADDERS, ETC. CONTRACTOR-SUPPLIED PERSONNEL MUST BE COMPETENT WITH AND KNOWLEDGEABLE OF ALL PROJECT-SPECIFIC HARDWARE, SOFTWARE, AND THE HVAC SYSTEMS. ALL TRAINING DOCUMENTATION AND SUBMITTALS SHALL BE AT THE JOB SITE.

C. DEMONSTRATION SHALL TYPICALLY INVOLVE SMALL REPRESENTATIVE SAMPLES OF SYSTEMS/EQUIPMENT RANDOMLY SELECTED BY THE UNIVERSITY [AND CA].

D. THE SYSTEM SHALL BE DEMONSTRATED FOLLOWING THE SAME PROCEDURES USED IN THE START-UP TEST BY USING THE APPROVED COMMISSIONING CHECKLISTS. DEMONSTRATION SHALL INCLUDE, BUT NOT NECESSARILY BE LIMITED TO, THE FOLLOWING:

1. DEMONSTRATE THAT REQUIRED SOFTWARE IS INSTALLED ON BAS WORKSTATIONS. DEMONSTRATE THAT GRAPHIC SCREENS, ALARMS, TRENDS, AND REPORTS ARE INSTALLED AS SUBMITTED AND APPROVED.
2. DEMONSTRATE THAT POINTS SPECIFIED AND SHOWN CAN BE INTERROGATED AND/OR COMMANDED (AS APPLICABLE) FROM ALL WORKSTATIONS, AS SPECIFIED.
3. DEMONSTRATE THAT REMOTE COMMUNICATION ABILITIES ARE IN ACCORDANCE WITH THESE SPECIFICATIONS.
4. DEMONSTRATE CORRECT CALIBRATION OF INPUT/OUTPUT DEVICES USING THE SAME METHODS SPECIFIED FOR THE START-UP TESTS. A MAXIMUM OF 10 PERCENT OF I/O POINTS SHALL BE SELECTED AT RANDOM BY THE [COMMISSIONING AUTHORITY AND/OR] UNIVERSITY FOR DEMONSTRATION. UPON FAILURE OF ANY DEVICE TO MEET THE SPECIFIED END-TO-END ACCURACY, AN ADDITIONAL 10 PERCENT OF I/O POINTS SHALL BE SELECTED AT RANDOM [BY COMMISSIONING AUTHORITY] FOR DEMONSTRATION. THIS PROCESS SHALL BE REPEATED UNTIL 100 PERCENT OF RANDOMLY SELECTED I/O POINTS HAVE BEEN DEMONSTRATED TO MEET SPECIFIED END-TO-END ACCURACY.
5. DEMONSTRATE THAT ALL DDC AND OTHER SOFTWARE PROGRAMS EXIST AT RESPECTIVE FIELD PANELS. THE DIRECT DIGITAL CONTROL (DDC) PROGRAMMING AND POINT DATABASE SHALL BE AS SUBMITTED AND APPROVED.
6. DEMONSTRATE THAT ALL DDC PROGRAMS ACCOMPLISH THE SPECIFIED SEQUENCES OF OPERATION.
7. DEMONSTRATE THAT THE PANELS AUTOMATICALLY RECOVER FROM POWER FAILURES, AS SPECIFIED.
8. DEMONSTRATE THAT THE STAND-ALONE OPERATION OF PANELS MEETS THE REQUIREMENTS OF THESE SPECIFICATIONS. DEMONSTRATE THAT THE PANELS' RESPONSE TO LAN COMMUNICATION FAILURES MEETS THE REQUIREMENTS OF THESE SPECIFICATIONS.
9. IDENTIFY ACCESS TO EQUIPMENT SELECTED [BY COMMISSIONING AUTHORITY] [BY THE UNIVERSITY]. DEMONSTRATE THAT ACCESS IS SUFFICIENT TO PERFORM REQUIRED MAINTENANCE.
10. DEMONSTRATE THAT REQUIRED TREND GRAPHS AND TREND LOGS ARE SET UP PER THE REQUIREMENTS.

E. BAS DEMONSTRATION SHALL BE COMPLETED AND APPROVED PRIOR TO SUBSTANTIAL COMPLETION.

F. ANY TESTS SUCCESSFULLY COMPLETED DURING THE DEMONSTRATION WILL BE RECORDED AS PASSED FOR THE FUNCTIONAL PERFORMANCE TESTING AND WILL NOT HAVE TO BE RETESTED.

3.06 TREND LOGS

A. CONTRACTOR SHALL CONFIGURE AND ANALYZE ALL TRENDS REQUIRED UNDER SECTION 15955.

THE FOLLOWING ITEM ONLY APPLIES TO A FORMAL CX PROCESS.

3.07 WARRANTY PERIOD:

A. WARRANTY PERIOD SHALL NOT COMMENCE UNTIL SUCCESSFUL COMPLETION OF THE BAS DEMONSTRATION.

B. TRENDING: THROUGHOUT THE WARRANTY PERIOD, TREND LOGS SHALL BE MAINTAINED. CONTRACTOR SHALL FORWARD ARCHIVE TREND LOGS TO THE COMMISSIONING AUTHORITY/UNIVERSITY FOR REVIEW UPON COMMISSIONING AUTHORITY/UNIVERSITY REQUEST. COMMISSIONING AUTHORITY/UNIVERSITY WILL REVIEW THESE AND NOTIFY CONTRACTOR OF ANY WARRANTY WORK REQUIRED.

C. OPPOSITE SEASON TESTING: WITHIN 6 MONTHS OF COMPLETION OF THE ACCEPTANCE PHASE, COMMISSIONING AUTHORITY/UNIVERSITY SHALL SCHEDULE AND CONDUCT OPPOSITE SEASON FUNCTIONAL PERFORMANCE TESTING. CONTRACTOR SHALL PARTICIPATE IN THIS TESTING AND REMEDY ANY DEFICIENCIES IDENTIFIED

D. END OF WARRANTY VISIT: COMMISSIONING AUTHORITY/UNIVERSITY WILL CONDUCT AN END OF WARRANTY WALKTHROUGH PRIOR TO THE END OF THE WARRANTY PERIOD. CONTRACTOR SHALL PARTICIPATE IN THIS WALKTHROUGH AND REMEDY ANY DEFICIENCIES IDENTIFIED.

3.08 SOFTWARE OPTIMIZATION ASSISTANCE

A. THE CONTRACTOR SHALL PROVIDE THE SERVICES OF A BAS TECHNICIAN AS SPECIFIED ABOVE AT THE PROJECT SITE TO BE AT THE DISPOSAL OF THE [COMMISSIONING AUTHORITY/] UNIVERSITY. THE PURPOSE OF THIS REQUIREMENT IS TO MAKE CHANGES, ENHANCEMENTS AND ADDITIONS TO CONTROL UNIT AND/OR WORKSTATION SOFTWARE THAT HAVE BEEN IDENTIFIED BY THE [COMMISSIONING AUTHORITY/] UNIVERSITY DURING THE CONSTRUCTION AND COMMISSIONING OF THE PROJECT AND THAT ARE BEYOND THE SPECIFIED CONTRACT REQUIREMENTS. THE COST FOR THIS SERVICE SHALL BE INCLUDED WITH THE BID. REQUESTS FOR ASSISTANCE SHALL BE FOR CONTIGUOUS OR NON-CONTIGUOUS 8-HOUR DAYS, UNLESS OTHERWISE MUTUALLY AGREED UPON BY CONTRACTOR, [COMMISSIONING AUTHORITY,] AND UNIVERSITY. THE UNIVERSITY'S REPRESENTATIVE SHALL NOTIFY CONTRACTOR 2 DAYS IN ADVANCE OF EACH DAY OF REQUESTED ASSISTANCE.

B. THE BAS TECHNICIAN PROVIDED SHALL BE THOROUGHLY TRAINED IN THE PROGRAMMING AND OPERATION OF THE CONTROLLER AND WORKSTATION SOFTWARE. IF THE BAS TECHNICIAN PROVIDED CANNOT PERFORM EVERY SOFTWARE TASK REQUESTED BY THE [COMMISSIONING AUTHORITY/] UNIVERSITY IN A TIMELY FASHION, CONTRACTOR SHALL PROVIDE ADDITIONAL QUALIFIED PERSONNEL AT THE PROJECT SITE AS REQUESTED BY THE [COMMISSIONING AUTHORITY/] UNIVERSITY, TO MEET THE TOTAL SPECIFIED REQUIREMENT [PER BUILDING] ON-SITE.

3.09 BAS OPERATOR TRAINING AND O&M MANUALS

A. CONTRACTOR SHALL SUBMIT A TRAINING PLAN FOR THE SCOPE OF TRAINING FOR WHICH THEY ARE RESPONSIBLE. TRAINING PLAN SHALL BE FORWARDED TO THE DIVISION 15 CONTRACTOR WHO WILL COMPILE, ORGANIZE, FORMAT, AND FORWARD TO THE ENGINEER FOR REVIEW.

B. ON-SITE TRAINING: PROVIDE SERVICES OF CONTROLS CONTRACTOR'S QUALIFIED TECHNICAL PERSONNEL FOR [FIVE] 8-HOUR DAYS TO INSTRUCT UNIVERSITY'S PERSONNEL IN OPERATION AND MAINTENANCE OF BAS. INSTRUCTION SHALL BE IN CLASSROOM SETTING AT THE PROJECT SITE FOR APPROPRIATE PORTIONS OF THE TRAINING. TRAINING MAY BE IN NON-CONTIGUOUS DAYS AT THE REQUEST OF THE UNIVERSITY. THE UNIVERSITY'S REPRESENTATIVE SHALL NOTIFY CONTRACTOR 1 WEEK IN ADVANCE OF EACH DAY OF REQUESTED TRAINING. THE CONTRACTOR'S DESIGNATED TRAINING PERSONNEL SHALL MEET WITH THE ENGINEER AND UNIVERSITY'S REPRESENTATIVE FOR THE PURPOSE OF DISCUSSING AND FINE-TUNING THE TRAINING AGENDA PRIOR TO THE FIRST TRAINING SESSION. TRAINING AGENDA SHALL GENERALLY BE AS FOLLOWS:

1. BASIC OPERATOR WORKSTATION (OWS) TRAINING – FOR ALL POTENTIAL USERS OF THE OWS:
   a) BRIEF WALK-THROUGH OF BUILDING, INCLUDING IDENTIFICATION OF ALL CONTROLLED EQUIPMENT AND CONDENSED DEMONSTRATION OF CONTROLLER PORTABLE AND BUILT-IN OPERATOR INTERFACE DEVICE DISPLAY CAPABILITIES.
   b) BRIEF OVERVIEW OF THE VARIOUS PARTS OF THE O&M MANUALS, INCLUDING HARDWARE AND SOFTWARE PROGRAMMING AND OPERATING PUBLICATIONS, CATALOG DATA, CONTROLS INSTALLATION DRAWINGS, AND DDC PROGRAMMING DOCUMENTATION.
   c) DEMONSTRATION OF WORKSTATION LOGIN/LOGOUT PROCEDURES, PASSWORD SETUP, AND EXCEPTION REPORTING.
   d) DEMONSTRATION OF WORKSTATION MENU PENETRATION AND BROAD OVERVIEW OF THE VARIOUS WORKSTATION FEATURES.
   e) OVERVIEW OF SYSTEMS INSTALLED.
   f) PRESENT ALL SITE-SPECIFIC POINT NAMING CONVENTIONS AND POINTS LISTS, OPEN PROTOCOL INFORMATION, CONFIGURATION DATABASES, BACK-UP SEQUENCES, UPLOAD/DOWNLOAD PROCEDURES, AND OTHER INFORMATION AS NECESSARY TO MAINTAIN THE INTEGRITY OF THE BAS.
   g) OVERVIEW OF ALARM FEATURES.
   h) OVERVIEW OF TREND FEATURES.
   i) OVERVIEW OF WORKSTATION REPORTS.
2. BAS HARDWARE TRAINING – FOR MAINTENANCE AND CONTROL TECHNICIANS
   a) REVIEW OF INSTALLED COMPONENTS AND HOW TO INSTALL/REPLACE, MAINTAIN, COMMISSION, AND DIAGNOSE THEM
3. BAS TECHNICIAN TRAINING
   a) INTRODUCTION TO CONTROLLER PROGRAMMING AND OVERVIEW OF THE PROGRAMMING APPLICATION INTERFACE.

b) General review of sequence of operation and control logic for the project site, including standalone and fail-safe modes of operation.
c) Uploading/Downloading and backing up programs.
d) Network administration.
e) Review of setpoint optimization and fine-tuning concepts.

The following item must be coordinated with UCB with regard to applicability and cost.

4. Advanced Training: Advanced Training shall be provided for [two] individuals and be provided at an off-site training facility containing installations of the proposed system. Contractor shall pay training registration and materials fee and the University shall pay all employee expenses (travel, per diem, salary).
   a) Contractor shall provide the standard, advanced training offering on all Control Programming Applications.
   b) Contractor shall provide the standard, advanced training offering on Advanced Installation, Configuration, Maintenance, and Network Administration.

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CONTROL SEQUENCE OF OPERATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Hot Water Heating.

B. Related Sections:

1. Section 15010 - Basic Mechanical Requirements.
2. Section 15190 - Mechanical Identification.
3. Section 15950 - Controls.
4. Section 15990 - Testing, Adjusting and Balancing.

1.02 SYSTEM DESCRIPTION

A. Design Requirements:

1. General:

a. The intent of this design guide Section is to provide representative control sequences that the University has found satisfactory to use as an example in the final design of typical projects.

B. THE TYPICAL SYSTEMS DESCRIBED ARE SIMPLE SOLUTIONS TO TYPICAL CONTROL DESIGNS. BEFORE USING THEM, BE SURE THE CONTROL DESIGN FOR THE PROJECT SYSTEM IS TYPICAL. BE AWARE THAT THE FINAL DESIGN IS THE RESPONSIBILITY OF THE DESIGN CONSULTANT.

C. THE UNIVERSITY REQUIRES FUNCTIONAL PERFORMANCE TESTING OF THE COMPLETE CONTROL SYSTEM PRIOR TO OWNER ACCEPTANCE.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 SEQUENCE OF OPERATION

A. VAV AIR HANDLER

[NOTE TO CONSULTANT: CUSTOMIZE, EDIT, AND INCLUDE CONTROL SEQUENCES FOR EACH PIECE OF EQUIPMENT ON THE PROJECT TO BE CONTROLLED.]

1. THE OCCUPANCY MODE (OCCUPIED-UNOCCUPIED) SHALL BE DETERMINED THROUGH A USER-ADJUSTABLE, GRAPHICAL, SEVEN-DAY SCHEDULE WITH AN ADDITIONAL HOLIDAY SCHEDULE.

2. OCCUPIED MODE:

   A. THE SUPPLY FAN SHALL BE ENERGIZED. THE SUPPLY FAN SPEED SHALL MODULATE TO MAINTAIN DUCT STATIC PRESSURE SETPOINT OF 1" W.G. INITIALLY (ADJUSTABLE). THE FINAL SETPOINT SHALL BE DETERMINED IN CONSULTATION WITH THE BALANCING CONTRACTOR.

   B. WHENEVER THE SUPPLY FAN IS ENERGIZED, THE RETURN FAN SHALL BE ENERGIZED. THE RETURN FAN SPEED SHALL MODULATE TO MAINTAIN THE RETURN AIR PLENUM PRESSURE SETPOINT OF 0.10" W.G. (ADJUSTABLE).

   C. THE OUTDOOR AIR FAN SHALL BE ENERGIZED AND ITS DAMPER SHALL BE OPEN.

D. THE EXHAUST AIR DAMPER SHALL MODULATE TO MAINTAIN THE SPACE STATIC PRESSURE SETPOINT OF 0.05″ W.G.

E. DISCHARGE AIR TEMPERATURE SETPOINT SHALL BE RESET BASED UPON OUTDOOR AIR TEMPERATURE ACCORDING TO THE FOLLOWING RESET SCHEDULE:

DISCHARGE AIR TEMPERATURE SETPOINT	OUTDOOR TEMPERATURE
55°F	> 70°F
65°F	< 30°F

ALL PARAMETERS SHALL BE INDEPENDENTLY ADJUSTABLE.

F. EVAPORATIVE COOLER SECTION [INCLUDE WHERE APPLICABLE]:

1. EVAPORATIVE COOLER PUMP SHALL NOT OPERATE UNLESS:

   A. OUTSIDE DAMPERS ARE 100% OPEN.

   B. SUMP LEVEL SWITCH IS MADE.

   C. DISCHARGE AIR CONTROLLER OUTPUT IS CALLING FOR THE EVAPORATIVE COOLER PUMP(S) TO BE ON.

   D. HIGH SPACE HUMIDITY LOCK OUT IS BELOW 65% (ADJUSTABLE).

   E. SUPPLY FAN IS ON.

2. STAGING OF EVAPORATIVE COOLER PUMPS (WHERE APPLICABLE) SHALL USE THE OUTPUT OF THE DISCHARGE AIR CONTROLLER TO STAGE THE PUMPS.

3. THE EVAPORATIVE COOLER SUMP SHALL DRAIN WHEN THE OUTSIDE AIR TEMPERATURE DROPS BELOW 40°F (ADJUSTABLE) FOR 60 MINUTES (ADJUSTABLE). THE EVAPORATIVE COOLER SUMP SHALL FILL ONLY WHEN THE OUTSIDE AIR TEMPERATURE EXCEEDS 55°F.

4. THERE SHALL BE A DAILY DRY-OUT CYCLE OF 60 MINUTES (ADJUSTABLE). THIS DRY-OUT SHALL OCCUR DAILY BETWEEN 5 A.M. AND 6 A.M. (ADJUSTABLE).

5. PROGRAM A WEEKLY SUMP DRAINAGE CYCLE TO COINCIDE WITH THE EVAPORATIVE COOLER PAD DRY-OUT PERIOD.

6. SPRING RETURN:

A. PROVIDE SPRING RETURN FOR ALL AHU COMPONENTS (E.G., COIL VALVES AND DAMPERS) TO ACHIEVE THE DESIRED OPEN OR CLOSED FAILURE MODE.

G. INDIRECT TOWER COOLING SECTION [INCLUDE WHERE APPLICABLE]: FILL THE TOWER SUMP IF THE OUTSIDE AIR TEMPERATURE IS ABOVE 55°F (ADJUSTABLE). MAINTAIN TOWER SUMP WATER TEMPERATURE BY CYCLING TOWER FAN'S 'OFF-LOW-HIGH' USING A LOCAL TEMPERATURE CONTROLLER MOUNTED TO THE TOWER SUMP. PROVIDE HARDWIRED TIME DELAY INTERNAL TO THE MAGNETIC MOTOR STARTER WHEN GOING FROM FAN HIGH-SPEED TO LOW-SPEED TO ALLOW FOR FAN DECELERATION. THE TOWER SUMP SHALL DRAIN WHENEVER THE OUTDOOR AIR TEMPERATURE IS BELOW 35°F (ADJUSTABLE) FOR 60 MINUTES (ADJUSTABLE).

3. UNOCCUPIED MODE:

A. THE SUPPLY, RETURN AND MINIMUM-OUTDOOR-AIR FANS SHALL BE DE-ENERGIZED. BOTH OUTDOOR AIR DAMPERS AND EXHAUST DAMPERS SHALL BE CLOSED.

B. THE HEATING COIL VALVE AND PUMP SHALL CYCLE TO MAINTAIN MIXED-AIR TEMPERATURE OF 45°F (ADJUSTABLE).

4. SAFETY SHUTDOWNS:

A. DUCT SMOKE DETECTION, HIGH PRESSURE SAFETIES AND LOW TEMPERATURE LIMIT TRIPS SHALL DE-ENERGIZE THE AIR-HANDLING UNIT AND CLOSE THE OUTDOOR AIR AND EXHAUST AIR DAMPERS.

5. FREEZE-PROTECTION

A. WHEN THE OUTDOOR AIR TEMPERATURE IS BELOW 40°F (ADJUSTABLE) THE HW AND CHW PUMPS SHALL BE ENERGIZED CONTINUOUSLY FOR FREEZE PROTECTION. THE HEATING COIL VALVE SHALL CYCLE AS DESCRIBED ELSEWHERE.

B. IF THE UNIT HAS SHUTDOWN ON THE LOW TEMPERATURE LIMIT SWITCH, ENERGIZE THE RETURN FAN UNTIL THE CONDITION HAS BEEN RESOLVED.

B. CHILLED WATER SYSTEM [INCLUDE WHERE APPLICABLE]

1. THE CHILLER SHALL BE ENABLED WHENEVER THE OUTSIDE AIR TEMPERATURE IS ABOVE 55°F FOR 30 MINUTES (BOTH ADJUSTABLE). THE CHILLER SHALL BE DISABLED WHEN THE OAT DROPS BELOW 54°F FOR 30 MINUTES (BOTH ADJUSTABLE).

2. THE CHILLER SHALL NOT BE ENABLED UNLESS THE COOLING TOWER SUMP IS FILLED.

3. THE CHILLER SHALL START AND STOP THE CHILLED WATER AND CONDENSER WATER PUMPS THROUGH ITS INTERNAL CONTROLS.

4. THE COOLING TOWER FAN SHALL SEQUENCE 'OFF-LOW-HIGH' TO MAINTAIN CONDENSER WATER SUPPLY TEMPERATURE SETPOINT OF 74°F (ADJUSTABLE). THE FAN SHALL BE LOCKED OUT WHENEVER THE CHILLER IS DE-ENERGIZED.

5. THE COOLING TOWER SUMP DRAIN AND FILL LINES SHALL DRAIN WHENEVER THE OUTDOOR AIR TEMPERATURE IS LESS THAN 35°F FOR 30 MINUTES (BOTH ADJUSTABLE). THE TOWER SUMP SHALL BE FILLED WHENEVER THE OAT > 54°F FOR 30 MINUTES (BOTH ADJUSTABLE).

6. THE CHILLED WATER SUPPLY TEMPERATURE SHALL BE RESET FROM 45° TO 52°F. THE CHILLED WATER SUPPLY TEMPERATURE SHALL BE AS WARM AS POSSIBLE WHILE ATTAINING THE DISCHARGE AIR TEMPERATURE SETPOINT FOR THE AIR HANDLING UNIT.

CHILLED WATER SUPPLY TEMPERATURE SETPOINT	OUTDOOR TEMPERATURE
52°F	≤ 55°F
45°F	≥ 80°F

7. ACTIVATION OF ANY EMERGENCY-STOP SWITCHES OR REFRIGERANT-DETECTION ALARMS SHALL DE-ENERGIZE ALL CENTRAL PLANT EQUIPMENT EXCEPT MAKEUP-AIR UNITS AND EXHAUST FANS.

C. CABINET UNIT HEATER [INCLUDE WHERE APPLICABLE]

1. THE SPACE THERMOSTAT SHALL MODULATE THE CONTROL VALVE AND CYCLE THE UNIT FAN TO MAINTAIN SPACE TEMPERATURE AT SETPOINT OF 68°F. FOR STEAM HEATING, WHEN STEAM IS NOT AVAILABLE, AS SENSED BY THE AQUASTAT, THE FAN SHALL BE DE-ENERGIZED.

D. UNIT HEATER [INCLUDE WHERE APPLICABLE]

1. FOR HEATING SYSTEMS OPERATING IN WINTER ONLY (NO REHEAT), THE SPACE THERMOSTAT SHALL CYCLE THE UNIT FAN TO MAINTAIN SPACE TEMPERATURE AT SETPOINT OF 68°F. FOR YEAR-ROUND HEATING/REHEATING, OPERATE SAME AS CABINET UNIT HEATER. FOR STEAM HEATING, WHEN STEAM IS NOT AVAILABLE AS SENSED BY THE AQUASTAT THE FAN SHALL BE DE-ENERGIZED.

E. BASE-BOARD HEATING [INCLUDE WHERE APPLICABLE]

1. FINTUBE RADIATION SHALL BE SEQUENCED WITH THE ASSOCIATED VAV BOX. HEATING WITH FINTUBE AND COOLING WITH THE VAV BOX SHALL NOT OCCUR SIMULTANEOUSLY. FOR PNEUMATIC CONTROLS, USE NON-OVERLAPPING SPRING RANGES OR SEQUENCING RELAYS ON THE FINTUBE CONTROL VALVE AND VAV DAMPER ACTUATOR. FOR DDC, AVOID OVERLAP BETWEEN HEATING AND COOLING UNLESS NEEDED TO COMPENSATE FOR VENTILATION LOAD. FOR DDC, ACTUATOR SHALL FAIL "IN POSITION" (NO SPRING RETURN).

F. VAV BOXES [INCLUDE WHERE APPLICABLE]

1. A SPACE THERMOSTAT VARIES THE AIRFLOW FROM MAXIMUM TO MINIMUM AND MODULATES THE HEATING VALVE IN SEQUENCE TO MAINTAIN SPACE TEMPERATURE SETPOINT. THE HEATING VALVE SHALL NOT BEGIN TO OPEN UNTIL THE AIRFLOW HAS REACHED ITS MINIMUM SETTING. PNEUMATIC VAV CONTROLLER COMPENSATES FOR VARIATION IN SYSTEM PRESSURE. SET MINIMUM AND MAXIMUM CFM AS SHOWN ON THE DRAWINGS. FOR DDC, ACTUATOR SHALL FAIL "IN POSITION" (NO SPRING RETURN).

G. REHEAT COILS [INCLUDE WHERE APPLICABLE]

1. FOR DDC, ACTUATOR SHALL FAIL "IN POSITION" (NO SPRING RETURN).

H. FACE AND BYPASS PREHEAT COIL [INCLUDE WHERE APPLICABLE]

1. TWO-POSITION PREHEAT COIL VALVE SHALL OPEN FULL WHEN OUTSIDE AIR TEMPERATURE IS BELOW 35°F. FACE AND BYPASS DAMPERS SHALL MODULATE TO MAINTAIN 50°F (ADJUSTABLE) PREHEAT COIL DISCHARGE AIR TEMPERATURE.

I. ANIMAL-HOLDING AREAS

1. SAFETY SHUTDOWNS:

a. AHU HEATING COIL WILL FAIL WITH HEAT ON.

b. AHU FAN WILL TURN OFF WHEN HARD-WIRED SPACE SENSOR DETECTS HIGH TEMPERATURE OR LOW TEMPERATURE AT (ADJUSTABLE) SETTINGS AGREED TO WITH UCB CONTROLS SHOP. ALARM CONTACTS WILL CONNECT TO DDC SYSTEM FOR REMOTE ALARMING.

3.02 HOT WATER HEATING

A. HEATING WATER SUPPLY:

1. A SUB-MASTER REMOTE BULB THERMOSTAT, LOCATED IN THE HEATING WATER SUPPLY, SHALL MAINTAIN ITS SETTING BY MODULATING IN SEQUENCE, TWO NORMALLY CLOSED CONTROL VALVES IN PARALLEL IN THE STEAM SUPPLY TO THE HOT WATER HEAT EXCHANGER. FAIL SAFE OPERATION OF STEAM VALVE SHALL BE TO FAIL OPEN.

2. HOT WATER SUPPLY TEMPERATURE SHALL BE RESET INVERSELY WITH CHANGES IN OUTSIDE TEMPERATURE BY A MASTER THERMOSTAT LOCATED ON NORTH EXPOSURE.

B. ZONE CONTROL:

1. BUILDING TO BE ZONED AS REQUIRED BY FLOORS, ORIENTATION AND FUNCTION AS DETERMINED FOR SPECIFIC PROJECT.

2. PROVIDE FOR EACH ZONE A NIGHT, WEEK-END AND HOLIDAY SETBACK.

3. PROVIDE EACH ZONE WITH ADJUSTABLE MORNING WARM-UP TIME PERIOD.

C. TEMPERATURE RESET OF A CONTROLLED VARIABLE IS ENCOURAGED WHERE OVERALL SYSTEM ENERGY USE WILL BE MINIMIZED WHILE STILL MAINTAINING BUILDING TEMPERATURE CONTROL REQUIREMENTS.

3.03 ELEVATOR SHAFT VENTING

*NOTE: THE FOLLOWING IS APPLICABLE ONLY WHERE REQUIRED BY THE IBC.

A. THE FOLLOWING CONTROL SEQUENCE RESULTED FROM A MEETING BETWEEN UCB AND THE BOULDER FIRE DEPARTMENT STAFF TO DISCUSS WHAT THEY PREFER FOR CONTROL OF THE ELEVATOR HOISTWAY VENT, BASED ON UCB'S REQUESTS FOR CLARIFICATION TO ICBO. WE AGREED ON THE FOLLOWING CONTROL SEQUENCE:

1. THE VENT FOR THE ELEVATOR SHAFT SHALL HAVE A MOTORIZED DAMPER. THIS DAMPER SHALL BE NORMALLY-CLOSED (ENERGIZED TO OPEN). THE DAMPER OPERATOR SHALL BE ELECTRIC ONLY. PNEUMATIC IF CONTROL AIR IS AVAILABLE IN THE BUILDING, ELECTRIC OTHERWISE. THE DAMPER SHALL BE OPENED BY A MANUALLY-OPERATED REMOTE SWITCH. THE SWITCH SHALL BE LOCATED IN

FIRE-ALARM PANEL, OR IN OR NEXT TO THE ELEVATOR-RECALL PANEL IF THE BUILDING DOES NOT HAVE A FIRE-ALARM PANEL.

M15959 – TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.01 SUMMARY

A. SECTION INCLUDES: REQUIREMENTS FOR BALANCING THE AIR AND HYDRONIC HEATING, VENTILATING AND COOLING SYSTEMS TO SATISFY THE PROJECT BUILDING DESIGN CONDITIONS.

B. THIS CONTRACTOR SHALL DO THE WORK UNDER THE GENERAL CONTRACTOR, NOT THE MECHANICAL CONTRACTOR.

C. APPROVED CONTRACTORS:

CHECKPOINT

FINN & ASSOCIATES

GRIFFITH ENGINEERING SERVICES

JEDI BALANCING

JPG ENGINEERING

1.02 REFERENCES

A. LATEST ASHRAE EDITION OF THE "SYSTEMS HANDBOOK".

B. LATEST ASHRAE EDITION OF THE "FUNDAMENTALS HANDBOOK".

C. NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB) REQUIREMENTS FOR CERTIFICATION TO PERFORM AND MANAGE TESTING AND BALANCING OF AIR AND HYDRONIC ENVIRONMENTAL SYSTEMS.

1.03 SYSTEM DESCRIPTION

A. PERFORMANCE REQUIREMENTS:

1. COMPLY WITH THE APPLICABLE PROCEDURES IN THE CHAPTER ON TESTING, ADJUSTING AND BALANCING IN THE LATEST ASHRAE EDITION OF THE SYSTEMS HANDBOOK.

2. COMPLY WITH PROCEDURAL STANDARDS FOR TESTING, BALANCING AND ADJUSTING OF ENVIRONMENTAL SYSTEMS AS OUTLINED IN THE LATEST EDITION OF SMACNA, NEBB, AND/OR AABC PROCEDURAL MANUALS.

3. CALIBRATION AND MAINTENANCE OF INSTRUMENTS IN ACCORDANCE WITH MANUFACTURER'S STANDARDS AND RECOMMENDATIONS, AND CALIBRATION HISTORIES FOR EACH INSTRUMENT AVAILABLE FOR EXAMINATION.

4. ACCURACY OF MEASUREMENTS IN ACCORDANCE WITH THE APPLICABLE MEASUREMENT MEANS AS LISTED IN THE CHAPTER ON MEASUREMENT AND INSTRUMENTS IN THE LATEST EDITION OF ASHRAE FUNDAMENTALS HANDBOOK.

5. ALLOWABLE TOLERANCES:

a. TOLERANCES OF ADJUSTMENT FOR AIR HANDLING SYSTEMS: PLUS OR MINUS 5 PERCENT FOR SUPPLY SYSTEMS AND PLUS OR MINUS 10 PERCENT FOR RETURN AND EXHAUST SYSTEMS FROM FIGURES SHOWN ON DRAWINGS.

b. TOLERANCES OF ADJUSTMENT FOR HYDRONIC SYSTEMS: PLUS OR MINUS 10 PERCENT OF DESIGN CONDITIONS SHOWN ON DRAWINGS.

6. Final Testing, Adjusting and Balancing of all hydronic and air systems performed by an professional Testing, Adjusting and Balancing sub-contractor meeting the following Quality Assurance requirements.

1.04 QUALITY ASSURANCE

A. Qualifications:

The consultants' specifications shall state that:

1. The Testing, Adjusting and Balancing (TAB) contractor shall perform the work with personnel certified by the National Environmental Balancing Bureau (NEBB). No other certification is acceptable.

Depending on the level of experience of the TAB contractor and proven quality of work at the University, the University may require that the work be executed under the direct supervision of a Registered Professional Engineer having an established professional office in the State of Colorado, and having an experience record of not less than five (5) years in testing, balancing and adjusting of air and hydronic mechanical systems.

2. Specify that this contractor shall have obtained CAD reduced-size drawings from Engineer for the TAB report.

3. Specify in Submittals Section that this Balancing Contractor shall review the contract documents and submittals for location and type of balancing devices being installed by the mechanical and sheet metal contractors, and shall issue a letter to UCB that s/he is in agreement with them or shall identify deficiencies needing attention.

1.05 STATUS OF SYSTEMS

A. Air and water testing and balancing shall not begin until the system to be tested has been cleaned and flushed, and is in full working order. Where glycol is used, it shall be installed prior to hydronic balancing.

1. Coordinate scheduling of work with the General Contractor and appropriate subcontractors. Schedule TAB work to coincide with testing and verification of control systems where practical.

2. Provide written notification (within 24 hours) to the General Contractor, Engineer, and Owner or his representative of any component and/or system deficiencies.

B. Review available plans and specifications for the project and make visual observations during construction to determine that required balancing devices are being installed properly, and access is provided for.

C. Before any air balance work is done, systems shall be checked for:

1. Excessive duct leakage.

2. Dirt and debris in ducts and/or AHUs

3. Filters are installed (and changed in they are dirty)

4. Coil fins are clean and combed where needed

5. Correct motor rotation

6. Excessive vibration

7. Equipment lubrication

8. Proper operation of automatic control and smoke dampers

9. Manual control dampers, fire dampers, and air outlet dampers are wide open

10. Duct end caps installed and access doors closed

11. GRILLES, REGISTERS, AND DIFFUSERS ARE PROPERLY INSTALLED

D. BEFORE ANY HYDRONIC BALANCING WORK IS DONE, THE SYSTEM SHALL BE CHECKED FOR:

1. PROPER CLEANING AND FLUSHING; GLYCOL INSTALLED WHEN SPECIFIED
2. DIRTY STRAINERS
3. CORRECT PUMP ROTATION
4. PROPER CONTROL VALVE INSTALLATION AND OPERATION
5. PROPER SYSTEM STATIC PRESSURE TO ASSURE A COMPLETELY FILLED SYSTEM
6. AIR IN SYSTEM ELIMINATED
7. PROPER FLOW METER AND CHECK VALVE INSTALLATION
8. MANUAL BALANCING DEVICES, CONTROL AND SHUT-OFF VALVES ARE OPEN

E. PUT HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS AND EQUIPMENT INTO FULL OPERATION AND CONTINUE OPERATION OF SAME DURING EACH WORKING DAY OF TESTING AND BALANCING.

PART 2 - PRODUCTS

2.01 EQUIPMENT

A. PROVIDE ALL INSTRUMENTS, TOOLS, SCAFFOLDING, AND LADDERS NECESSARY TO PERFORM THE WORK.

PART 3 - EXECUTION

3.01 PERFORMANCE OF WORK

A. AIR BALANCE:

1. BALANCE AIR SUPPLY, RETURN, AND EXHAUST SYSTEMS AND RECORD AIR QUANTITIES FOR EACH AIR DEVICE.

   a. THE PILOT TUBE TRAVERSE METHOD FOR DETERMINING MAIN DUCT CFM SHALL BE USED AND RECORDED WHEREVER POSSIBLE; FLOW HOOD MEASUREMENTS AT REGISTERS AND DIFFUSERS MAY BE TOTALIZED FOR BRANCH DUCT QUANTITIES.

2. AIR DIFFUSER PATTERN SHALL BE SET TO MINIMIZE OBJECTIONABLE DRAFTS ANDS NOISE.

3. THE SUPPLY, RETURN, AND EXHAUST FAN STATIC PRESSURES SHALL BE SET BY THE BALANCING FIRM (AND THE CONTROLS CONTRACTOR IF THE SYSTEMS HAVE FAN VOLUME CONTROL.)

   a. THE LOWEST FAN SPEED RESULTING IN SATISFACTORY SYSTEM PERFORMANCE SHALL BE DETERMINED AT FULL DESIGN DELIVERY. ANY INLET OR OUTLET FAN VOLUME (BALANCING) DAMPERS SHALL BE IN THE WIDE-OPEN POSITION, AND ONE PATH PRESENTING THE GREATEST RESISTANCE TO FLOW SHALL BE FULLY OPEN AND UNOBSTRUCTED.

   b. FAN RPM'S SHALL NOT BE INCREASED BY MORE THAN 10% WITHOUT PRIOR AUTHORIZATION FROM THE ENGINEER.

   c. ALL ADJUSTABLE SPEED SHEAVES ON MULTIPLE-BELT SYSTEMS SHALL BE REPLACED WITH FIXED-SPEED SHEAVES BY THE BALANCING CONTRACTOR.

4. PROVIDE SYSTEM STATIC PRESSURE PROFILES THAT IDENTIFY PRESSURE DIFFERENCES ACROSS ALL COMPONENTS OF AIR HANDLING UNITS AND BUILT-UP SYSTEMS. PRESSURE DROPS SHALL BE INDIVIDUALLY MEASURED AND RECORDED FOR INTAKE AND EXHAUST VENTS, HOODS, LOUVERS, MANUAL AND AUTO CONTROL DAMPERS, FILTERS, COILS, EVAP. COOLERS, FANS, ETC.

   a. ON SYSTEMS WITH OSA ECONOMIZERS, PRESSURE DROP VALUES SHALL BE RECORDED FOR BOTH MINIMUM AND 100% OSA MODES.

b. On multi-zone air handlers, all zone dampers shall be checked for excessive leakage at both full-heat and full-cool positions. Manual zone balance dampers shall then be set. Correct location and operation of zone thermostats shall be verified.

5. Building static pressure adjacent to entries shall be measured and recorded. Adjust systems to maintain a positive pressure of 0.05" w.c. when possible. Note any discrepancies.

6. When air balancing is done and manual dampers are set, all test holes shall be plugged and all manual damper positions shall be marked.

B. Hydronic Balance:

1. Converters: Record all steam and/or water inlet and leaving temperatures, pressure drops, and flows.

2. Record inlet and outlet water temperatures of all air handling unit coils, unit heaters, convectors, finned tube radiation, and other heat release equipment, as well as the corresponding media flows and pressure drops.

3. Boilers: Provide data for boiler operating conditions and thermal efficiencies. (Provide a copy of the independent testing agency reports if testing is not performed by the TAB Contractor.) The TAB Contractor shall measure water side temperatures, pressures, and flow rates if so requested by Owner and/or boiler testing agency.

4. Chilled Water Systems: Measure and record chilled and condenser inlet and leaving fluid temperatures, evaporator and condenser fluid pressure drops and flows, full load motor running voltage and amperage, chiller refrigerant pressures and temperatures.

5. DX Cooling Systems: Record condensing unit full and part load amperages, condenser fan(s) rotation and running amperage(s), high and low side refrigerant pressures, coil entering and leaving air temperatures at full load condition. Verify operation of condenser fan and head pressure controls.

6. Hydronic Pumps: Record flow rates, pressures, running amperage, and full load amperage at design flow and shutoff conditions. Verify impeller size and shutoff head.

7. When all hydronic balancing is done, all balancing valve positions shall be markede and the locking devices set. Control valve bypass loops (where used) shall be set with the balancing valve to provide equal flow in either mode.

C. Electric Heat:

1. Record full-load and part-load (when staged) amperage and voltage of all electric heating elements.

2. Verify that electric heat is locked out when the flow rate drops below minimum requirements.

D. Smoke Systems:

1. Test all smoke management systems per Chapter 4 of the latest version of NFPA 92A.

2. Refer to Division 15, Section 15950, Basic Control Material and Methods, for smoke management sequences.

E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.02 TAB REPORT

A. The report shall include all test and balance data as well as information on any discrepancy from specifications or performance standards. All discrepancies shall be included in a separate section. As a minimum, the following items shall be included:

1. Belt and drive sheave information (as installed and as changed), fan nameplate information, motor nameplate information, and amperage and voltage to all

MOTORS (IN VARIOUS OPERATING MODES WHERE APPLICABLE). ALSO, MAXIMUM AND MINIMUM RPM SETTINGS ON VFD UNITS.

2. STATIC PRESSURE DROPS ACROSS ALL COMPONENTS OF THE AIR SYSTEMS. STATIC PRESSURE PROFILE FOR EACH AIR HANDLING UNIT SYSTEM.

3. REQUIRED AND FINAL BALANCED CFM AT EACH SYSTEM TERMINAL UNIT. INCLUDE THE TERMINAL SIZE, INLET STATIC PRESSURE, TEMPERATURE, AND VELOCITIES READ TO ATTAIN THE REQUIRED CFM.

4. PUMP AND MOTOR NAMEPLATE INFORMATION, AMPERAGE AND VOLTAGE TO ALL MOTORS, FLOW AND PRESSURE DROP ACROSS ALL SYSTEM TERMINALS, PRESSURE RISE ACROSS THE PUMP IN PSI AND FEET OF HEAD, BOTH OPERATING AND SHUT-OFF, AND MAXIMUM OPERATING GPM.

5. REFRIGERANT SYSTEM OPERATING AMPERAGES, PRESSURES, AND TEMPERATURES.

OVERLOAD PROTECTION DATA FOR ALL MOTORS SHALL BE RECORDED. STARTER AND/OR VFD BRAND, MODEL, ENCLOSURE TYPE, INSTALLED OVERLOAD DEVICES, ORIGINAL RATINGS AND SET POINTS (AND REVISED DEVICE RATINGS AND SET POINTS WHEN APPLICABLE) SHALL BE RECORDED. IF THE STARTERS (AND/OR VFDS) WERE FURNISHED BY THE MECHANICAL CONTRACTOR, THE OVERLOADS SHALL BE VERIFIED AND CHANGED TO THE CORRECT SIZE WHEN NECESSARY, AND SO NOTED IN THE REPORT. IF THE STARTERS WERE FURNISHED BY THE ELECTRICAL CONTRACTOR, THE CORRECT OVERLOAD DEVICE SIZES AND SETTINGS SHALL BE NOTED IN THE REPORT AND THE ELECTRICAL CONTRACTOR SHALL BE ADVISED OF ALL DISCREPANCIES.

B. A REDUCED SET OF DRAWING (11" X 17") SHALL BE INCLUDED IN THE REPORT WITH ALL TERMINALS (VAV BOXES, AIR OUTLETS, INLETS, COILS, UNIT HEATERS, FIN TUBE LOOPS, RADIANT PANEL LOOPS, ETC.) CLEARLY MARKED, AL EQUIPMENT DESIGNATED, AND ALL REFERENCED TO THE DEVICE TEST REPORTS. THE CONTRACT DRAWINGS MAY BE REDUCED AND USED FOR THIS PURPOSE, IF THEY REMAIN LEGIBLE. OTHERWISE, CAD REDUCED SIZE DRAWINGS SHALL BE OBTAINED FROM THE ENGINEER.

C. THE TAB CONTRACTOR SHALL SUBMIT BOUND COPIES OF THE FINAL TESTING AND BALANCING REPORT TO THE OWNER OR HIS REPRESENTATIVE AT LEAST 15 DAYS PRIOR TO THE MECHANICAL CONTRACTOR'S REQUEST FOR FINAL INSPECTION. THE REPORT SHALL INCLUDE ALL OPERATING DATA AS PREVIOUSLY LISTED, A LIST OF ALL EQUIPMENT US4ED IN THE TESTING AND BALANCING WORK, AND SHALL BE SIGNED BY THE SUPERVISING REGISTERED ENGINEER OR CERTIFIED TAB SUPERVISOR AND CERTIFIED TAB TECHNICIAN, AND AFFIXED WITH HIS CERTIFICATION SEAL. FINAL ACCEPTANCE OF THIS PROJECT WILL NOT TAKE PLACE UNTIL A SATISFACTORY REPORT IS RECEIVED.

3.03 FIELD VERIFICATION

A. UPON REQUEST OF THE OWNER OR ENGINEER, A REPRESENTATIVE OF THE BALANCING FIRM PERFORMING THE WORK SHALL DEMONSTRATE TO HIM FLUID FLOW QUANTITIES SHOWN IN THE REPORT BY READING BACK OUTLETS OR TERMINALS SELECTED AT RANDOM. IT IS UNDERSTOOD THAT THE OPERATING MODE OF THE SYSTEM SHALL BE THE SAME FOR READBACK AS IT WAS DURING BALANCING, AND THE NUMBER OF READINGS VERIFIED WILL NOT EXCEED 10% OF THE TOTAL IN THE REPORT.

B. WHEN DEEMED NECESSARY BY THE OWNER OR ENGINEER, THE BALANCING FIRM SHALL RUN TEMPERATURE, PRESSURE, AND/OR HUMIDITY RECORDINGS, AND SHALL BE PREPARED TO VERIFY ANY OF THE REPORT TEST RESULTS IN THE PRESENCE OF THE OWNER AND/OR ENGINEER WHEN REQUESTED.