1 General

1.1 SYSTEM REQUIREMENTS:

A.   The Building automation system (BMS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management, lighting control and historical data collection.   The Building Automation System shall be **fully compatible** and shall be **fully integrated** with the existing system presently owned and operated by Wake County.   All Control equipment and software is specified here-in.

B.   **This document serves as the BMS Master Controls Specification and is to be utilized and edited as required for all Wake County Projects.**

1.2 RELATED DOCUMENTS:

A.   Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.3 SUMMARY:

A.   This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units that are not supplied with factory-wired controls. Revised 06/17/14

B.   Related Section: Division 23 Section "Sequence of Operation" contains requirements that relate to this Section.

1.4 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION:

A.   Hydronic Piping: Installation of all wells, control valves, flow switches, temperature sensor sockets, gage taps, flow meters.

B.   Ductwork Accessories: Installation of flow stations, automatic dampers, smoke detectors. Connection of damper end switches.

1.5 RELATED SECTIONS:

A.   THE DESIGNER SHALL LIST THE SECTIONS THAT CONTAIN REQUIREMENTS RELATED TO THIS SECTION.

1.6 REFERENCES:

A.   ASHRAE 85.

B.   ASME MC85.1

C.   NEMA EMC1

1.7   DEFINITIONS:

A.   Ensure terminology used in submittals conforms to ASHRAE 89.

B.   SEC-WAN- Secure Engineered Controls Wide Area Network - Ethernet based network linking remote Wake Co. Facilities with a central location for the purpose of transmitting and receiving building control information. Traffic over this network will be TCP/IP packets.

C.   High Tier- That portion of the Vendor System that connects to the SEC-WAN directly using Ethernet as the physical medium. This is an open, interconnected system that each vendor must be capable of connecting to using standard Ethernet.

D.   Low Tier- That portion of the Vendor System that connects the network controller to the specific monitoring and control devices in the building. Physical medium is serial (RS-485, RS-232) This technology may be proprietary to the vendor system.

E.   Server- Centrally located, at General Services Center, 401 Capital Blvd., LAN attached, Intel based computer running Windows Server 2003 operating system. High and Low Tier communicate to Server via Ethernet, TCP/IP connection.

F.   177 BC, 100 meg minimum Network Controller- Located at each building, continually monitors field devices to ensure they are functioning properly. Serves as a gateway between the high and low tiers.

G.   TCC, Device Controller- Connected to the Network Controller via RS-485/RS-232E or proprietary comm. Directly regulates field devices.

H.   Workstation: Intel based computer operating on latest version of Microsoft Office Operating System software . Device used to send configuration data to either the server or the network controller. Used to upload field panel program to server or download field panel program from server to field panel.   Field Devices- Pump controller, chiller controller, actuator, etc.

1.8   SYSTEM DESCRIPTION:

A.   Building Automation System (BAS) Contractor shall provide:
1.   A fully integrated building automation system (BAS), UL listed, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and lighting security control capabilities; including interface by ethernet to the existing Wake County - Secure Engineered Controls Wide Area Network (SEC-WAN).

VERIFY PROVISIONS OF WORKSTATION REQUIREMENTS WITH OWNER.

2.   Complete temperature and lighting control system to be DDC as specified herein.

3.   All wiring, conduit, panels, for all DDC temperature controls.

4.   All final electrical connections to each stand-alone Application Specific Controller and DDC Controller.

5.   BAS Contractor shall be responsible for all electrical work associated with the BAS control system and as called for on the Drawings.

      a.   Perform all wiring in accordance with all local and national codes.

      b.   Install all line voltage wiring, concealed or exposed, in accordance with Division 16.

      c.   Electrical Contractor shall provide 120 volt, 20 amp circuits and circuit breakers from normal and/or emergency power panel for direct digital control systems.

            DESIGNER SHALL ASSIGN ELECTRICAL RESPONSIBILITY.

      d.   Surge transient protection and power conditioners shall be incorporated in design of system to protect electrical components in all DDC Controllers, Application Specific Controllers and operator's workstations.

      e.   All low voltage electrical control wiring throughout the building shall be installed in accordance with Division 16. Except that digital control wiring and 24V power bus may be run without conduit in accessible ceiling spaces under the provision of NEC, Class 2 when approved.

B.   General Product Description:

1.   The building automation system shall consist of the following:

      a.   Connection of BAS by Ethernet to existing Wake County General Services Administration Building Controls Server. Additional software and programming for BAS Workstation, as specified.

      b.   Stand-alone DDC Controllers compatible with those already installed by Wake County. (i.e., Siemens type or MBC.)

      c.   Stand-alone Application Specific Controllers (ASCs.) (ie. Gateway to central building equipment.)

      d.   Portable operator's terminal. (Laptop or PDA.)

            COORDINATE TERMINAL REQUIREMENTS WITH OWNER.

      e.   Local user display (i.e., Andover DCX.)

      f.   On-site color graphic workstation.

            VERIFY PROVISION OF WORKSTATION REQUIREMENTS WITH OWNER.

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

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

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

1.9   SUBMITTALS:

A.   General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections. A minimum of 7 complete sets of documents are required. Submit 3 copies of all submittals to owner at time of submittal to architect.

B.   Manufacturer's Product Data for each and all types of products specified. Include manufacturer's technical Product Data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, installation instructions, and startup instructions.

1.   Submit manufacturer's product information on all hardware items along with descriptive literature for all software programs to show compliance with specifications.

C.   Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Submit damper leakage and flow characteristics, plus size schedule for controlled dampers.

D.   Shop Drawings, hard copy and in CAD, containing the following information for each control system:

1.   Schematic flow diagram showing fans, pumps, coils, dampers, valves, and control devices.
2.   Each control device labeled with setting or adjustable range of control.
3.   Diagrams for all required electrical wiring. Clearly differentiate between factory-installed and field-installed wiring.
4.   Details of control panel faces, including controls, instruments, and labeling.
5.   Written description of sequence of operation.
6.   Trunk cable schematic showing programmable control unit locations and trunk data conductors.
7.   Listing of connected data points, including connected control unit and input device. Itemized list should include each point name per Wake County's name point convention, the control point name and description.

8.   System graphics, based on the final room numbers and a floor plan graphic, indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
9.   System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

10. Software description and sequence of operation. This shall include both printed and electronic copies of the program. It shall also include a layman's description of the sequence and a flow chart for a non-programmers interpretation.

11. System configuration diagram showing all panel types and locations as well as communications network and workstations.

E. Wiring diagrams detailing wiring for power, signal, and control systems and differentiating clearly between manufacturer-installed and field-installed wiring.

F. Where installation procedures, or any part thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Architect/Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

1.10   PROJECT RECORD DOCUMENTS:

A. Submit under provision of Division 1.

B. Accurately record actual location of control components, including but not limited to, panels, thermostats, and sensors.

C. Revise shop drawings to reflect actual installation and operating sequences.

D. Include data specified in "Submittals" in final "Record Documents" form in hard copy form and in CAD. (DWG or DXF format.)

E. Include a CD backup of all BAS control programs.

1.11   OPERATION AND MAINTENANCE DATA:

A. Submit under provisions of Division 1.

B. Maintenance instructions and spare parts list for each type of control device.

C. Interconnection wiring diagrams with identified and numbered system components and devices.

D. Keyboard illustrations and step-by-step procedures indexed for each operator function.

E. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

F. Calibration records and list of set points.

G. Submit quotation for maintenance services for years two thru five at end of the first year.

1.12   QUALIFICATIONS & QUALITY ASSURANCE:

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

B.   Install system using competent workmen who are fully trained in the installation of temperature control equipment.

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

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

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

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

G.   Design and build all system components to be fault-tolerant.

    1.   Satisfactory operation without damage at 110% and 85% of rated voltage and at plus or minus 3 Hertz variation in line frequency.

    2.   Static, transient and short-circuit protection on all inputs and outputs.

    3.   Protect communication lines against incorrect wiring, static transients and induced magnetic interference.

    4.   Network-connected devices to be A.C. coupled or equivalent so that any single device failure will not disrupt or halt network communication.

    5.   All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and system low battery indication.

    6.   It must be possible to receive and print out alarms at a central location even when the Server/workstation at that location is nonoperational or taken out of service for periodic maintenance.

H.   Supplier shall be either the authorized regional manufacturer's representative as such with Siemens Building Technologies, Inc. and TAC or the manufacturer's Authorized Controls Integrator as such with Honeywell International, Inc.

1.13   PRE-INSTALLATION CONFERENCE:

A.   Convene a conference two weeks prior to commencing work of this Section, under provisions of Division 1.

B.   Require attendance of parties directly affecting the work of this Section.

1.14   COORDINATION:

A.   The Control System Subcontractor shall schedule and attend a pre-submittal (prior to submission of control diagrams) meeting with Owner for purposes of resolving any potential problems regarding the

interface of the proposed system with those existing within General Services and present schedule for approval.

B.   The control system subcontractor shall participate in a nomenclature coordination meeting to occur after notice to proceed, but before contractor begins DDC work. Nomenclature must be approved by GSA.

C.   Programming of Control system modifications necessitated by this Project will be done at the General Services' terminal located at 401 Capital Blvd., Raleigh, NC, by the authorized Programmer representing the Control System Subcontractor. Coordination of Owner specified point designations and scheduling of the programming will be the responsibility of the Control System Subcontractor (to be coordinated with Owner). Programming must be done prior to Wake County acceptance of system maintenance responsibility.

B.   System Start-up and Acceptance: Upon completion of the installation, start-up the system and perform all necessary testing. When the system performance is deemed satisfactory in whole or part by Architect/Engineer and by the Wake County Representative, designated by Wake County officials, the system parts will be accepted for beneficial use and placed under warranty. Warranty shall not commence prior to receipt of certificate of completion from Architect.

C.   System Testing and Balancing: The Control System Subcontractor shall participate in the Testing and Balancing of the HVAC System and Wake County GSA Representative.

1.15   INPUT/OUTPUT SUMMARY:

A.   Refer to end of this Section.

DESIGNER SHALL INCLUDE I/O SUMMARY FOR EACH PROJECT.

2   Products

2.1   ACCEPTABLE MANUFACTURERS:

A.   Andover Continuum, by Schneider Electric
B.   Honeywell International, Inc. (ACI)
C.   Siemens Building Technologies, Inc.
D.   No others will be accepted

2.2   SECURED ENGINEERING CONTROLS WIDE AREA NETWORK (SEC-WAN):

A.   Physical Layer (High Tier):

1.   Network: Vendor equipment will be capable of interfacing directly over an Ethernet network, either Cat 5 big E, 10BaseT (category 5 twisted pair) or Fiber Optic. This equipment should

follow the Institute of Electrical and Electronics Engineers (IEEE) 802.3 standard for Ethernet transmission using carrier sense with multiple access (CSMA).

2.   Telco: Workstation equipment will be capable of interfacing to controller equipment via either an asynchronous phone line or other acceptable network connection for backup only.

B.   Network Layer (High Tier):

1.   TCP/IP: Vendor controller equipment will be capable of using TCP/IP as a networking protocol to communicate with workstations.   Standard 4 byte IP address of either class A,B, or C. Device will be configured with an appropriate subnet mask and a router address assigned by the owner.

2.   Routing: Devices will be capable of participating in RIP (Routing Information Protocol) routing schemes.

C.   Low Tier (Proprietary):

1.   Should use standard signal methods as needed by Vendor System to function properly with field devices.

2.3   SERVER: Minimum Specifications

 Intel based platform using Microsoft TCP/IP for network communications. Windows Server 2008 R2 Standard Edition Operating System 64 Bit, 10 CALs minimum + 1 CAL for each specified client PC in system. Hardware will consist of no less than a Dell Poweredge R720 Rackmount File Server with "ReadyRails" included. Dual Intel Xeon 2.9 GHz Processors with 12 MB cache, four (4) 500 GB 7.2K RPM SATA hard drives, 32 GB RAM, dual 870W power supplies, dual 10/100/1000 MHz NIC, DVD-R/W DRIVE, RAID five configuration. , Keyboard, mouse, and a 23" 16X9 led flat screen monitor. Server should boot into the current operating system with no errors on the screen or in the error logs.   Hardware will have a 3 year on-site warranty.

B.   OWNER will provide necessary hardware and software to ensure that the server is backed up fully on a daily basis to a single tape, and could be quickly restored from tape if necessary. This backup should be automated and require no intervention from an administrator . The backup should also be capable of sending an alert in the form of an email message or SNMP trap in the event that the server is not backed up successfully.

C.   If used as a gateway between the high and low tiers, the server must be capable of handling connections from no less than 16 separate low tier networks.

D.   Vendor will provide and install any add on software not native to the Network Operating System to ensure full functionality resulting from the addition of this contract in the area of reporting capability and database storage (SQL Server, Sybase, Crystal Reports, etc.)

E.   OWNER will ensure that the server has an open serial port in order to use a Smart UPS to shut it down gracefully in the event of a power outage.

F.   If owner does not possess manufacturers high-tier equipment, vendor must supply server, 1 workstation, and all software necessary to connect and control building per this document.

2.4   NETWORK CONTROLLER (High Tier/Low Tier):

A.   The network controller should have a minimum of 2 communications devices, one to communicate with the field device controller (low-tier) and to the server (high tier). Network specifications should be identical to the physical and network layer as described in Section 2.02

B.   The controller should be capable of using Simple Network Management Protocol (SNMP) for generation of error alerts (traps) to be forwarded to the server for logging and immediate action.

2.5   **NETWORKING COMMUNICATIONS (Low Tier):**

A.   The design of the BAS shall network server workstations and stand-alone DDC Controllers. The network architecture can consist of three levels, a campus-wide (Management Level Network) Ethernet network based on TCP/IP protocol, a high performance peer-to-peer building level network and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs. Ethernet connections of the DDC Controllers shall be a direct connection off the controller's communication board or the use of a lantronic type device.

B.   Peer-to-Peer Network Level: Those portable operator's terminal connected to the BMS campus network. Global networking is achieved on the SEC-WAN.

1.   Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel communications may be considered only if a similar device is provided as a standby. Upon a failure or malfunction of the primary central processor, the standby shall automatically, without any operator intervention, assume all BAS network management activities.

2.   All operator devices either network resident or connected via modem shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.

3.   To satisfy its operating procedures, Wake County specifically requires under this sub-section that operator workstations including portable operator's terminals, connected to DDC controller, have global access to all points on the network. The intent of this requirement is that an operator can call up each and every point on the network by use only of the logical point descriptor, and without limitation. Restrictions on the operator that would be considered limitations include any need to know in which DDC controller a particular point resides, any restriction on the number of points residing in a DDC controller (or residing in Application Specific Controllers connected to a DDC Controller) that can be accessed, or any requirement for a point to be identified with information additional to its logical point descriptor.

4.   Network design shall include the following provisions:

   a.   Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any DDC Controller is displayed at workstations and/or alarm printers within 5 seconds.

   b.   Support of any combination of DDC Controllers and operator workstations directly connected to the peer-to-peer network. A minimum of 32 devices shall be supported on a single network.

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

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

   e.   Synchronization of real-time clocks, to include automatic daylight savings time updating between all DDC Controllers shall be provided.

5.   Provision for future expansion of the network. To satisfy this provision Wake County requires that there be a single, (twisted shielded pair) peer-to-peer network between DDC Controllers that will accept the future connections of additional DDC Controllers and additional workstations with all the capabilities specified in this Section. To meet this requirement, future connection to the peer-to-peer network must be possible at each DDC controller and at any point on the network between the DDC controllers and workstations, without the need to install additional circuits.

C.   DDC Controller Local Area Network (LAN): (Low Tier)

1.   This level communication shall support a family of application specific controllers and shall communicate bi-directionally with SEC-WAN and the peer-to-peer network through DDC Controllers for transmission of campus and global data.

2.   Application specific controllers shall be arranged on the LANs in a functional relationship manner with DDC Controllers. For example, a VAV terminal unit controller shall be on a LAN (Low Tier) from the DDC Controller that is controlling its corresponding AHU.

3.   A maximum of 32 application specific controllers may be configured on individual DDC Controller LANs (Low Tier) to insure adequate global data and alarm response times.

F.   Wake County prefers to minimize the total number of panel boxes housing Building Level Network Controllers. Wake County also prefers to centralize, where possible, the panel boxes for the Building Level Network. A secondary panel box may not be installed within 100 feet of a primary panel box on any floor.

2.6   DDC CONTROLLER:

A. Stand-alone Controllers shall be microprocessor-based with a minimum word size of 16 bits. They shall also be

multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

B. Each DDC controller shall have a manual override point present on the controller so that the equipment may be operated directly from the controller.

C. Each DDC Controller shall have sufficient memory, a minimum of 1 megabyte, to support its own operating system and databases, including:

    1. Control processes

    2. Lighting control applications

    3. Energy management applications

    4. Alarm management applications including custom alarm messages for each level alarm for each point in the system.

    5. Historical/trend data for points specified

    6. Maintenance support applications

    7. Custom programming

    8. Operator I/O

    9. Dial-up communications

    10. Manual override monitoring

D. Each DDC Controller shall support:

    1. Monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:

        a. Analog inputs

            1) 4-20 mA

            2) 0-10 Vdc

            3) Thermistors

            4) 1000 ohm RTDs

        b. Digital inputs

1) Dry contact closure

2) Pulse Accumulator

3) Voltage Sensing

2. Direct control of electronic actuators and control devices. Each DDC Controller shall be capable of providing the following control outputs without the addition of equipment outside the DDC Controller cabinet:

a. Digital outputs (contact closure)

1) Contact closure (motor starters, sizes 1-4)

b. Analog outputs

1) 4-20 mA

2) 0-10 Vdc

E. Each DDC Controller shall have a minimum of 10 per cent spare capacity for future point connection. The type of spares shall be in the same proportion as the implemented I/0 functions of the panel, but in no case shall there be less than two spares of each implemented I/0 type. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

1. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

F. DDC Controllers shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

G. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points. These override switches shall be operable whether the panel processor is operational or not.

1. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.

2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

H. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/0 device. Graduated intensity

LEDs or analog indication of value shall also be provided for each analog output.

I.   Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

J.   Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

K.   In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days. Controls Contractor shall provide external battery back-up, if necessary to meet this requirement.

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

2.   Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via a network workstation PC and backup telephone line dial-in.

L.   Provide a separate DDC Controller for each HVAC system as indicated on the drawings and in the input/output summary, Section 1.13. It is intended that each unique system be provided with its own point resident DDC Controller.

2.7   DDC CONTROLLER RESIDENT SOFTWARE FEATURES:

A.   General:

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

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

3.   All points shall be identified per Wake County's nomenclature/naming convention provided by owner at pre-construction meeting.

4.   All digital points shall have user defined two-state status indication (descriptors with minimum of 8 characters allowed per state (i.e. summer/winter).

5.   All subsystems that can stop or disrupt the program shall be graphically displayed as red/green status.

B.   Control Software Description:

1.   The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:

      a. Two-position control

      b.   Proportional control

      c. Proportional plus integral control

      d.   Proportional, integral, plus derivative control

      e.   Automatic tuning of control loops

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

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

4.   Upon the resumption of normal power, each DDC Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

C.   DDC Controllers shall have the ability to perform any or all the following energy management routines:

1.   Time-of-day scheduling

2.   Calendar-based scheduling

3.   Holiday scheduling

4.   Temporary schedule overrides

5.   Start-Stop Time Optimization

6.   Automatic Daylight Savings Time Switchover

7.   Night setback control

8.   Enthalpy switchover (economizer)

9.   Peak demand limiting

10.   Temperature-compensated duty cycling

11.   Fan speed/CFM control (reducing fan speed on CV AHU to save demand charges)

12.   Heating/cooling interlock (to prevent system overlap)

13.   Hot water reset

14.   Chilled water reset

15.   Condenser water reset

16.   Equipment sequencing

17.   Supply air reset

NOTE: FOR EXAMPLE, PUMP, AND CHILLER SEQUENCING TO REDUCE PEAK DEMAND. INCLUDE IN SEQUENCE OF OPERATIONS. PROVIDE FOR RAMPING DOWN CHILLERS WHEN ANOTHER CHILLER IS BROUGHT ONLINE TO REDUCE PEAK DEMAND.

a.   All programs shall be executed automatically without the need for operator intervention and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Sequence of Operations.

D.   DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1.   It shall be possible to use any of the following in a custom process:

a. Any system measured point data or status

b. Any calculated data

c. Any results from other processes

d. User-defined constants

e. Arithmetic functions (+, - * /, square root, exp, etc.)

f. Boolean logic operators (and/or, exclusive or, etc.)

g. On-delay/off-delay/one-shot timers

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

a. Time interval

b. Time-of-day

c. Date

d. Other processes

e. Time programming

f. Events (e.g., point alarms)

3. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network.

4. Processes shall be able to generate operator messages and advisories to operator I/0 devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

5.   The custom control programming feature shall be documented via English language descriptors. The document shall include plain English version of programming for a clear understanding of code and the program. It shall also include a layman's description of the sequence and a flow chart for a non-programmers interpretation.

6.   DDC and HVAC Mechanical Equipment Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.

7.   DDC and HVAC Mechanical Equipment Controller shall be capable of comment lines for sequence of operation explanation.

8.   Programming shall provide owner with the ability to override reset schedules per point at all user interfaces.

E.   Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controller's ability to report alarms be affected by either operator or activity at a PC workstation, local I/0 device or communications with other panels on the network.

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

   2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

   3. Alarm reports and messages will be directed to a user-defined list of operator devices, PCs or Pagers.

   4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

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

   5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.

F.   A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/0 summary.

1. DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

a.   Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute for a 24-hour period shall be provided. Each DDC Controller shall have a dedicated RAM based buffer for trend data and shall be capable of storing a minimum of 25,000 data samples. Provide additional RAM capacity internal or external to the DDC Controller as necessary to meet this requirement.

b.   If buffer in each DDC Controller in a building over 100,000 square feet cannot store 25,000 data samples, provide additional Controllers in Mechanical Equipment Room to obtain required minimum data storage.

2.   Trend data shall be stored at the DDC Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in 3rd party personal computer applications.

G.   DDC Controllers shall have the capability to automatically accumulate and store run-time hours for digital input and output points as specified in the point I/0 summary.

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

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

H.   DDC Controllers shall have the capability to automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/0 summary.

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

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

3.   The user shall have the ability to define a warning limit. Unique, user-specified messages shall

be generated when the limit is reached.

I.   DDC Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for points as specified in the point I/0 summary.

   1.   The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.

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

J.   The network shall allow the DDC Controllers to access any data from or send control commands and alarm reports directly to any other DDC and HVAC Mechanical Equipment Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC and HVAC Mechanical Equipment Controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device. The peer-to-peer network shall also allow any DDC and HVAC Mechanical Equipment Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.

K.   The network shall allow the DDC Controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

2.8   APPLICATION SPECIFIC CONTROLLERS (ASC):

A.   Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs).

B.   Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Provide the following types of ASCs as a minimum:

   1.   Central System Controllers

   2.   Terminal Equipment Controllers

C.   Central System Controllers:

1.   Provide for control and monitoring of central HVAC systems and equipment including, but not limited to, the following: gateways for primary building equipment.
DESIGNER SHALL LIST THE TYPES OF EQUIPMENT ON PROJECT. VERIFY REQUIREMENTS WITH OWNER.

2.   Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden. As a minimum, 50% of the point inputs and outputs shall be of the Universal type, allowing for additional system flexibility. In lieu of Universal inputs and outputs, provide a minimum of 50% spare points of each type via additional point termination boards or controllers.

3.   Each controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event communication with its DDC Controller is lost and to insure protection during power outages.

4.   Provide each central system controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in nonvolatile EEPROM or a minimum of 72-hour battery backup shall be provided. All programs shall be field-customized to meet the user's exact control strategy requirements. Central System controllers utilizing pre-packaged or canned programs shall not be acceptable. As an alternative, provide DDC Controllers for all central equipment in order to meet custom control strategy requirements.

5.   Programming of central system controllers shall utilize the same language and code as used by DDC Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide a DDC Controller to meet the specified functionality.

6.   Local alarming and trending capabilities shall be provided for convenient troubleshooting and system diagnostics. Alarm limits and trend data information shall be user-definable for any point.

7.   Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs. All new values and programs may then be restored to EEPROM via the programming tool.

8.   Provide a door-mounted interface terminal to allow for direct-user access to the controller.

   a.   The terminal shall provide the user with the following functionality as a minimum:

   1) View and set date and time
   2) Modify and override time-of-day schedules
   3) View points and alarms
   4) Monitor points
   5) Command and modify setpoints

   b.   The terminal shall use full English language and shall prompt the user for responses, thus eliminating the need to remember code commands. Provide a minimum of two levels of password protection to prevent unauthorized access to the controller.

D.   Terminal Equipment Controllers:

1.   Provide for control of each piece of equipment, including, but not limited to, the following:

   DESIGNER SHALL: ADD OR DELETE EQUIPMENT TYPES FOR SPECIFIC PROJECT.

2.   Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs (except for unit ventilator controllers) shall be of the Universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. In lieu of Universal outputs, provide a minimum of 50% spare outputs of each type via additional point termination boards or controllers. Analog outputs to field devices shall be either 4 to 20 ma or 1 to 10 volt. Tri-state signals (floating control) shall not be acceptable. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable. As an alternative, provide DDC Controllers or other ASCs with industry standard outputs for control of all terminal equipment.

3.   Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:

Accuracy: $\pm1°F$

Operating Range: 0° to 115°F

Set Point Adjustment Range: 55° to 95°F

Set Point Modes: Independent Heating,

<div style="text-align:center">

Cooling, Night Setback

Heating, Night Setback

Cooling

</div>

Calibration Adjustments: None required

Installation: Up to 150 ft. from Controller

a. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. In lieu of an internal jack, provide a separate terminal jack mounted on a stainless steel wall plate adjacent to the sensor to facilitate direct access to the controller via the terminal.

b. Each room sensor shall also include the following auxiliary devices:

Setpoint Adjustment Dial

Temperature Indicator

Override Switch

c. The setpoint adjustment dial shall allow for modification of the temperature by the occupant Setpoint adjustment may be locked out overridden or limited as to time or temperature through software by an authorized operator at the central workstation, DDC Controller, or via the portable operator's terminal. In lieu of an integral adjustment dial, provide a separate dial mounted on a stainless steel wall plate adjacent to the sensor to perform the specified functionality.

d. The temperature indicator shall be a bi-metal thermometer and shall be visible without removing the sensor cover. In lieu of integral indication, provide a separate thermometer or digital readout mounted on a stainless steel wall place adjacent to the sensor for local temperature indication.

e. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, DDC Controller or via the portable operator's terminal. In lieu of an integral switch, provide a separate momentary contact switch mounted on a stainless steel wall plate adjacent to the sensor to perform the specified functionality.

4. Each controller shall perform its primary control function independent of other DDC Controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time

data from the DDC Controller time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

5. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

6. Variable Air Volume (VAV) Box Controllers: shall support the following types of pressure independent terminal boxes as a minimum:

VAV cooling only

Fan-powered VAV with hot water reheat

a. All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

b. The VAV box controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller. The controllers shall also function normally under ambient conditions of 32° to 122°F and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

c. The controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the average differential pressure in the duct. The controller shall convert this value to actual

airflow. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 4000 fpm and measurement accuracy of ☐5% at 400 to 4000 fpm, insuring primary air flow conditions shall be controlled and maintained to within ☐5% of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.

d.   Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

e.   The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ☐1.5F of setpoint at the room sensor location.

f.   Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve as required to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.

g.   Each controller shall have a discharge air temperature sensor on the VAV box for system operator to use for diagnostics.

2.9   PORTABLE OPERATOR'S TERMINAL (POT or Laptop/PDA):

(OWNER SHALL DELETE AS REQUIRED FOR SPECIFIC PROJECT)

A.   Provide one portable operator terminal with a minimum LCD display of 80 characters by 25 lines and a full-featured keyboard. The POT shall be handheld and plug directly into individual distributed control panels as described below. Provide a user-friendly, English language-prompted interface for quick access to system information, not codes requiring look-up charts.

B.   Functionality of the portable operator's terminal connected at any DDC Controller:

1.   Access all DDC Controllers on the network.

2.   Backup and/or restore DDC Controller databases for all system panels, not just the DDC

Controller connected to.

3.   Display all point, selected point and alarm point summaries.

4.   Display trending and totalization information.

5.   Add, modify and/or delete any existing or new system point.

6.   Command, change setpoint, enable/disable any system point.

7.   PROGRAM AND LOAD CUSTOM CONTROL SEQUENCES AS WELL AS STANDARD ENERGY MANAGEMENT PROGRAM.

C.   Functionality of the portable operator's terminal connected to any application specific controller:

1.   Provide connection capability at either the ASC or a related room sensor to access controller information.

2.   Provide status, setup, and control reports.

3.   Modify, select, and store controller database.

4.   Command, change setpoint, enable/disable any controller point.

D.   If the same portable operator's terminal cannot be used for both DDC Controllers and Application Specific Controllers, provide separate Laptop or PDA to accomplish the above functional requirements.

1.   Provide one of each type portable operator's terminals as specified in A above.

2.   Provide as a minimum, a POT connection in each mechanical room capable of accessing entire system information.

E.   Connection of a POT to a distributed control processor shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.

F.   Portable operator terminal access to controller shall be password controlled.

2.10   LOCAL USER DISPLAY

(OWNER SHALL DELETE AS REQUIRED FOR SPECIFIC PROJECT)

A.   Where specified in the sequence of operation or point's list, the controllers on the peer-to-peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.

1.   The display shall use the same security password and access rights for points in the display as is used in the associated controller.

2.   The LCD display shall be a minimum of a 2 line 40 character displays.

3.   The LCD display shall include the full point name, value (numeric, digital or state text).

4.   Point priority and alarm status on one screen.

5.   The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.

6.   The display shall be mounted either on the door of the enclosure or remote from the controller.

2.11   PERSONAL COMPUTER OPERATOR WORKSTATION HARDWARE:

(OWNER SHALL DELETE AS REQUIRED FOR SPECIFIC PROJECT)

A.   Personal computer operator workstations shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.

(OWNER SHALL DELETE AS REQUIRED FOR SPECIFIC PROJECT)

1.   Provide workstation located at project site (as located on drawings).

2.   Workstation shall consist of an Intel based platform, Windows 7 Professional 64 Bit Operating System, using TCP/IP for network communications. Hardware will consist of no less than a Intel Core i5 3.0 GHz with 4 MB cache, 4 MB RAM and an 500 GB Hard drive. It will also have dual output 512 MB RAM Video Card, DVD R/W drive, 10/100/1000 Ethernet LAN adapter, Keyboard, mouse and a 22" 16X9 LED screen color monitor. Workstation should boot into the operating system with no errors on the screen or in the error logs. Hardware will have a 3 year on-site warranty. Workstations should be capable of communicating with the server via the network using Ethernet and TCP/IP as described in Section 2.02.

3.   The display provided for system operation shall have a diagonal screen measurement of no less than 22" and a minimum display resolution of up to 1920x by 1080 pixels. Separate controls

shall be provided for color contrasts and brightness. The screen shall be non-reflective.

2.12   **WORKSTATION OPERATOR INTERFACE:**

OWNER SHALL DELETE AS REQUIRED FOR SPECIFIC PROJECT. ONCE SYSTEM IS LOADED ON THE CENTRAL SERVER THE FOLLOWING CONFIGURATION IS REQUIRED

A.   Basic Interface Description

   1.   Operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification and industry standard PC application software. The software shall provide, as a minimum, the following functionality:

      a.   Real-time Graphical viewing and control of environment

      b.   Scheduling and override of building operations

      c.   Collection and analysis of historical data

      d.   Definition and construction of dynamic color graphic displays

      e.   Editing, programming, storage and downloading of controller databases

   2.   Provide a graphical user interface which shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

      a.   Provide functionality such that all operations can also be performed using the keyboard as a backup interface device.

      b.   Provide additional capability that allows at least 10 special function keys to perform often-used operations.

   3.   The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows (latest version available at time of installation.)

      a.Provide functionality such that any of the following may be performed simultaneously, and in any combination, via user-sized windows:

1) Dynamic color graphics and graphic control
2) Alarm management coordinated with section 2.4.E
3) Time-of-day scheduling
4) Trend data definition and presentation (x and y line trends)
5) Graphic definition
6) Graphic construction

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

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

1) Level 1 = View all applications, but perform no database modification

2) Level 2 = Custodial privileges plus the ability to acknowledge alarms

3) Level 3 = All privileges except system configuration

4) Level 4 = All configuration privileges except passwords

5) Level 5 = All privileges

b. A minimum of 50 unique passwords, including user initials, shall be supported.

c. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used to log-on.

d. The system shall automatically generate a report of log-on/log-off time and system activity for each user.

e. User-definable, automatic log-off timers of from 5 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

5. Software shall allow the operator to perform commands including, but not limited to, the following:

a. Start-up or shutdown selected equipment

b. Adjust setpoints

c. Add/modify/delete time programming

d. Enable/disable process execution

e.   Lock/unlock alarm reporting for points

f.   Enable/disable totalization for points

g. Enable/disable trending for points

h.   Override PID loop setpoints

i.   Enter temporary override schedules

j.   Define holiday schedules

k. Change time/date

l.   Automatic daylight savings time adjustments

m.   Enter/modify analog alarm limits

n.   Enter/modify analog warning limits

o.   View limits

p.   Enable/disable demand limiting for each meter

q.   Enable/disable duty cycle for each load

6.   Reports shall be generated and directed to either monitors, printers or a storage device. As a minimum, the system shall allow the user to easily obtain the following types of reports:

a. A general listing of all points in the network

b.   List of all points currently in alarm

c. List of all points currently in override status

d.   List of all disabled points

e .   List of all points currently locked out

f.   DDC Controller trend overflow warning

g. List all weekly schedules

h.   List of holiday programming

i.   List of limits and deadbands

1) Summaries shall be provided for specific points, for a logical point group, for a user-selected group or groups or for the entire facility without restriction due to the hardware configuration of the building automation system.

B. Scheduling

1. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations.

   a. Provide the following spreadsheet graphic types as a minimum.

      1) weekly schedules

      2) zone schedules

      3) monthly schedules

2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupancy and vacancy times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.

3. Zone schedules shall be provided for each building zone previously described. Each schedule shall include a commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.

4. Monthly calendars for a 24-month period shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

C. Collection and Analysis of Historical Data

1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity for at least 3 years. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

2. Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least 6 points.

a.Provide additional functionality to allow any trended data to be transferred easily to an off-the-shelf spreadsheet package such as Excel. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.

3. Provide additional functionality at the existing BAS Terminal located at 401 Capital Blvd., Raleigh, NC, that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A minimum of 4 points may be viewed simultaneously on a single graph, with color selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.

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

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

4. Data trends must be able to be trended over a period of at least 2 years at a time continuously at a minimum of hourly intervals. Items

D. Dynamic Color Graphic Displays

1. Color graphic floor plan displays with all walls, partitions, and door swings using electronic CAD files of floor plan (with final room numbers displayed) and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, shall be provided by the BAS contractor as indicated in the point I/0 summary of this specification to optimize system performance analysis and speed alarm recognition. The floor plan should include electronic CAD drawings to display ductwork and terminal/VAV boxes as designed with each system differentiated by color or fill to clearing represent each system. Floor plans shall indicate all as-built locations of the equipment, ductwork, and temperature sensors.

2. If the floor plan is too large to clearly show all systems, the floor plan shall be divided into sections that match the architectural plans unless the architectural plans separate a suite in the building or a mechanical system shown on the drawings.

3. Key plans shall be provided to navigate floors. Key plans shall be provided in plan view in

buildings that have multiple areas, and in elevation view for buildings with multiple floors. Key Plan shall be navigable by clicking on the desired floor or area in which one may want to see associated equipment. The key plan shall take up the bottom right 1/16th of the display. (split the screen into four (4) rows and four (4) columns and it shall occupy the cell in the lower right hand corner. Key Plans shall not encroach on any legends nor shall they overlap the main graphic.

4.   Terminal boxes, VAVs, and FPUs shall be highlighted in yellow on the floor plan to clearly indicate their location in the building.

5.   Ductwork shall be colored by air handler, or fan served. Return air duct does not need to be colored unless it is a completely ducted return. Then return air shall be colored a similar color to supply but a few shades lighter to indicate return.

6.   End switch information is required on the graphics with damper open or closed status indicated.

7.   The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text based commands.

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

9.   The windowing environment of the PC operator workstation shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

10.   Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays.

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

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

1)   Define symbols

2)   Position and size symbols

3)   Define background screens

4)   Define connecting lines and curves

5)   Locate, orient and size descriptive text

6) Define and display colors for all elements

7) Establish correlation between symbols or text and associated system points or other displays

8) Support importing common graphic file types

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

1) To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC Controllers including Application Specific Controllers used for DDC equipment or VAV terminal unit control.

2) To satisfy its operating procedures, Wake County specifically requires under this sub-section that graphics for mechanical systems, including Air Handling Units and VAV Terminal Units, be constructed so that set-points can be commanded directly from an associated graphic. To satisfy this requirement, graphics for Air Handling Units and VAV Terminal Units shall include a bar-graph type presentation of set-point or an equivalently clear display. The operator shall be able to readily manipulate the set-point presentation to adjust the set-point, without any need to exit from the graphic display to make the adjustment, or without any need to call-up a procedure for making set-point adjustments.

Status conditions of equipment should be noted as "On" or "Off. Run/Alarm background color designations shall be yellow for run and red for alarm.

3) The project shall not be considered 80% complete or greater until the graphical displays required by the contract are 100% complete and functional.

d. Each air handling unit shall have a VAV Terminal Unit table that lists the VAV Terminal Units in alpha-numerical order. The VAV table shall display any point the VAV Terminal Unit's control box is able to out-put, including any set-points and virtual points associated with that VAV Terminal Unit. Any point or set point that can be controlled on the box must be able to be changed or over ridden from the VAV Terminal Unit table.

E. System Configuration and Definition

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

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

a.Add/delete modify stand-alone DDC Controller panels

b. Add/delete/modify operator workstations

c. Add/delete/modify application specific controllers

d. Add/delete/modify points of any type and all associated point parameters and tuning constants

e. Add/delete/modify alarm reporting definition for points

f. Add/delete/modify control loops

g. Add/delete/modify energy management applications

h. Add/delete/modify time and calendar-based programming

i. Add/delete/modify totalization for points

j. Add/delete/modify historical data trending for points

k. Add/delete/modify custom control processes

l. Add/delete/modify any and all graphic displays, symbols and cross-reference to point data

m. Add/delete/modify dial-up telecommunication definition

n. Add/delete/modify all operator passwords

o. Add/delete/modify alarm messages

3. Definition of operator device characteristics, DDC Controllers individual points, applications and control sequence shall be performed using instructive prompting software.

a. Libraries of standard application modules such as temperature, humidity and static pressure control may be used as "building blocks" in defining or creating new control sequences. In addition, the user shall have the capability to easily create and archive new modules and control sequences as desired via a word processing type format. Provide a library of standard forms to facilitate definition of point characteristics. Forms shall be self-prompting and incorporate a fill-in-the-blank approach for definition of all parameters. The system shall immediately detect an improper entry and automatically display an error message explaining the nature of the mistake.

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

c. Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Similarly, changes made at the DDC

Controllers shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.

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

2.13   INPUT/OUTPUT SENSORS:

    A.   Temperature:

        1.   Unless otherwise stated in this specification temperature sensors to be platinum RTD type.

        2.   Resistance tolerance at calibration point to be no more than $\square 0.2\%$ $Calibration$ $point$ 0 $degrees$ F.

        3.   Use insertion elements in ducts not affected by temperature stratification or smaller than one square meter. Use averaging elements where larger or prone to stratification, sensor length 18" to 25 ft as required.

        4.   Insertion elements for liquids shall be with brass socket with minimum insertion length of 2-1/2 inches.

        5.   Room temperature sensors used with terminal equipment controllers to be either thermistor or RTD type with set-point adjustment, temperature indicator, terminal jack and over-ride switch. Refer to Terminal Equipment Controller Specification for detailed requirements.

        6.   Provide outside air sensors with watertight inlet fitting, shielded from direct rays of sun.

    B.   Humidity Sensors:

        1.   Elements: Accurate within 5 percent over 20-95% RH range with linear output.

        2.   Room Sensors: Range of 0-99 percent RH

        3.   Duct and Outside Air Sensors: With element guard and mounting plate, range of 0-99 percent relative humidity.

    C.   Dew Point Temperature Sensor:

        1.   Duct type shall include a dew point probe with an adjustable/removable draft shield and a transmitter mounted to the sensor probe case.

        2.   Outside Air type shall include a probe in a weather-proof housing and a transmitter for indoor mounting.

        3.   Dew Point monitoring range -40 to +115 degrees F, dewpoint.

        4.   Relative Humidity 12% to 99% RH.

5.   Output signal 4-20MA DC.

6.   Accuracy at Calibration Point:

        a.Dewpoint Element +-1.1 degrees F, dewpoint.

        b.   Dewpoint Sensor +- 1.5 degrees F, dewpoint.

7.   Voltage, probe heater - 120 Vac.

8.   Voltage, transmitter - 26 Vdc.

D.   Static Pressure Sensors:

1.   Undirectional with ranges not exceeding 150 percent of maximum expected input.

2.   Temperature compensated with typical thermal error of $\Box.015$ percent of full scale per degree F. in temperature range of 35 to 135 degrees F.

3.   Accuracy: One percent of full scale with repeatability 0.3 percent.

4.   Output: 1-5 vdc or 4-20ma with power at 13 to 36 vdc.

E.   Equipment Operation Sensors:

1.   Status Inputs for Fans: Differential pressure switch with adjustable range of 0 to 5 inches wg.

2.   Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 psi and on the pump side from any check valve or triple duty valve.

3.   Status Inputs where differential pressure sensing is impractical: Current sensitive relay with current transformers, adjustable and set to 175 percent of rated motor current.

F.   Low Temperature Protection Thermostats:

1   Low temperature protection thermostats shall be the manual reset type and shall have sensing elements not less than 20 feet in length. The thermostat shall operate in response to the coldest temperature at other parts of the element. The element shall be properly supported to cover the entire duct width. Separate thermostats shall be provided for each 25 sq. ft. of coil face areas of fraction thereof.

1. Low temperature protection thermostats shall be installed such that freezestats do not trip during normal operation of the system.

2. Controls should be programmed such that freezestats do not trip during normal winter operation.

3. Controls should be programmed such that freezestats do not trip during smoke evacuation operation. This is usually accomplished by automatically opening the hot water valves on the hot water coils during operation of the smoke evacuation system.

G.   Fan Inlet Airflow Traverse Probes:

(ADD SECTION FOR AIR FLOW SECTIONS WHEN REQUIRED BY PROJECT)

3.   Provide on the indicated fans, airflow traverse probes mounted in the fan inlets capable of continuously measuring the air handling capacity (air volume) of the respective centrifugal fan(s). The fan inlet airflow traverse probes shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probe and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.

4.   The fan inlet airflow traverse probes (two per inlet) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings, and shall be of aluminum construction with hard anodized finish.

5.   The fan inlet airflow traverse probes shall not induce a measurable pressure drop, nor shall the sound level within the system be amplified by its presence in the fan inlet bell. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 3% of actual flow over a fan operating range of 6 to 1 capacity turndown.

6.   The fan inlet airflow traverse probes shall be the VOLU-probe/Fl as manufactured by Air Monitor Corporation, Santa Rosa, California or approved equal.

2.14   CONTROL VALVES:

A.   Control Valves: Factory fabricated, of type, body material, and pressure class indicated.

Where type or body material is not indicated, make selection as determined by manufacturer. For

installation requirements and pressure class, based on maximum pressure and

temperature rating of piping system.

B.   Globe Pattern: As follows:

1.   Up to 2 inches (DN 50): Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.

2.   Over 2 inches (DN 50): Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.

3.   Hydronic Systems: As follows:

    a)   Rating: Service at 125 psi WSP (862 kPa) and 250 deg F (121 deg C).

    b)   Internal Construction: Replaceable plugs and seats of stainless steel or brass.

        1)   Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

        2)   Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.

    c)   Sizing: 3-psi (21-kPa) maximum pressure drop at design flow rate.

    d)   Flow Characteristics: 2-way valves have equal percentage characteristics; 3-way valves have linear characteristics. Select operators to close valves against pump shutoff head.

5.   Steam Systems: As follows:

    a)   Rating: Service at 125 psi WSP (862 kPa) and 250 deg F (121 deg C).

    b)   Internal Construction: Replaceable plugs and seats of stainless steel.

        1)   Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

        2)   Double-Seated Valves: Balanced plug; Cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.

    c)   Sizing: 10-psi (69-kPa) inlet pressure and 5-psi (35-kPa) pressure drop.

    d)   Sizing: Pressure drop across steam valve at a maximum flow of 80 percent of inlet pressure for low-pressure systems and 42 percent for high-pressure systems.

    e)   Flow Characteristics: Modified linear characteristics.

6.   Butterfly Pattern: Iron body; bronze, aluminum-bronze, or stainless-steel disc;

resilient, replaceable seat for service to 200 deg F (93 deg C) wafer or lug ends; extended neck.

    a)   Rating: Service at 125 psi WSP (862 kPa) and 250 deg F (121 deg C).

    b)   Sizing: 1-psi (7-kPa) maximum pressure drop at design flow rate.

7.   Terminal Unit Control Valves: Bronze body, bronze trim, 2 or 3 port as indicated, replaceable plugs and seats, union and threaded ends.

    a)   Rating: Service at 125 psi WSP (862 kPa) and 250 deg F (121 deg C).

b) Sizing: 3-psi (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.

c) Flow Characteristics: 2-way valves have equal percentage characteristics; 3-way valves have linear characteristics.

d) Operators (2 Position): Synchronous motor with enclosed gear train, dual-return springs, valve-position indicator. Valves spring return to normal position for temperature protection.

e) Operators (Modulating): Self-contained, linear motor, actuator with 60-second full travel, with transformer and single-throw, double-pole contacts.

2.15   DAMPERS:

A.   Dampers: AMCA-rated, parallel or opposed blade design; form frames from not less than 0.1084-inch (2.8-mm) galvanized steel with mounting holes for duct mounting; damper blades not less than 0.0635-inch (1.6-mm) galvanized steel, with maximum blade width of 8 inches (203 mm).

1.   Blades secured to 1/2-inch (13-mm) diameter, zinc-plated axles keyed, hexagonal square or other shape solid shaft that has positive (no slip) engagement with the provided actuator. Provided with zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass. Ends sealed against spring-stainless-steel blade bearings. Thrust bearings at each end of every blade.

2.   Operating Temperature Range: From -40 to 200 deg F (-40 to 93 deg C).

3.   For standard applications as indicated, (as selected by manufacturer's sizing techniques) with optional closed-cell neoprene edging.

4.   For low-leakage applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm/sq. ft. (51 L/s/sq. m) of damper area, at differential pressure of 4 inches wg (995 Pa) when damper is being held by torque of 50 inch-pounds (5.6 N x m); test in accordance with AMCA 500.

5.   Dampers shall be provided with mechanical end switches independent of the actuator position sensor to indicate a positive open or closed position of the damper blade it's self.

2.16   ACTUATORS:

A.   Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or 2-position action.

1.   Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed

2.   Nonspring-Return Motors for Valves Larger Than 2-1/2 Inches (DN 65): Size for running torque of 150 inch-pounds (16.9 N x m) and breakaway torque of 300 inch-pounds (33.9 N x m).

3.   Spring-Return Motors for Valves Larger Than 2-1/2 Inches (64 mm): Size for running and breakaway torque of 150 inch-pounds (16.9 N x m).

4.   Nonspring-Return Motors for Dampers Larger Than 25 sq. ft. (2.3 sq. m): Size for running torque of 150 inch-pounds (16.9 N x m) and breakaway torque of 300 inch-pounds (33.9 N x m).

5.   Spring-Return Motors for Dampers Larger Than 25 sq. ft. (2.3 sq. m): Size for running and breakaway torque of 150 inch-pounds (16.9 N x m).

2.17   MISCELLANEOUS CONTROLS:

A.   The control manufacturer shall furnish all two-position relays, current transformers, NEMA rated enclosures, thermostats and all other controls necessary to meet the specifications and provide for a properly operating automatic control system. All control devices connected in line-voltage circuits shall be U.L. listed and of a type to meet the current and voltage requirements of the particular application.

B.   Today If a device or piece of equipment is provided with the ability to communicate directly with the controls   system through any form of communication protocol (such as BACnet or lon) and the device is indicated to be connected to the BAS the controls contractor shall integrate their controls to that device.

3 Execution

3.1   EXAMINATION:

A.   Verify that conditioned power supply is available to control units and operator workstation. Verify that field end devices and wiring are installed before proceeding with installation.

3.2   INSTALLATION:

A.   Install equipment as indicated to comply with manufacturer's written instructions.

B.   Install software in control units and operator workstation. Implement all features of programs to specified requirements and appropriate to sequence of operation.

C.   Connect and configure equipment and software to achieve the sequence of operation specified.

D.   Verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate 60 inches (1524 mm) above floor.

E.   Install damper motors on outside of duct in warm areas, not where exposed to outdoor temperatures.

F.   Install labels and nameplates to identify control components.

G   Install electrical work in accordance with Division 16. Electrical material and installation shall be in accordance with appropriate requirements of Division 16.

H   Install color graphic floor plan displays using electronic CAD files of floor plan (with final room numbers displayed) and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, shall be provided by the BAS contractor as indicated in the point I/0 summary of this specification to optimize system performance analysis and speed alarm recognition. The floor plan should include electronic CAD drawings to display ductwork and terminal/VAV boxes as designed with each system differentiated by color or fill and labeled to clearing represent each system.

3.3   MANUFACTURER'S FIELD SERVICES:

A.   Prepare and start systems under provisions of Division 1.

B.   Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

C.   Provide service engineer to instruct Owner's representatives in operation of systems plant and equipment, for one 8 hour period.

      SCHEDULING OF TRAINING SHALL BE COORDINATED WITH OWNER.

D.   Provide basic operator training for a minimum of 4 persons on sequence of operations data display, alarm and status descriptions, requesting data, execution of commands and request of logs. Include a minimum of (12) hours dedicated instructor time. Provide as-built documents and O & M manuals for each person. A portion of the instruction time shall be specifically dedicated to the building life safety systems. As built drawings on paper and cad. As built drawings shall have a link to them shown on the controls front-end.

E.   Provide follow-up field services for one (1) year after beneficial occupancy. This shall include four (4), eight (8) hour site visits; once every three (3) months for the first year. This shall be for any necessary device calibrations, system debugging, or instruction. All visits shall be scheduled with owner.

3.4   COMMISSIONING:

A.   Manufacturer's Field Services: Provide the services of a factory-authorized service representative to start control systems. Shall be scheduled with owner.

B.   Test and adjust controls and safeties.

C.   Replace damaged or malfunctioning controls and equipment.

D.   Start, test, and adjust control systems.

E.   Demonstrate compliance with requirements.

F.   Adjust, calibrate, and fine tune circuits and equipment to achieve the sequence of operation specified without fault or failure.

3.5   DEMONSTRATION:

A.   Demonstrate a complete and fully operational system to Owner as required by contract documents near completion of project.

END OF SECTION