SECTION 15955
D.D.C. CONTROL SYSTEM

PART 1 - GENERAL

SUMMARY OF WORK - General Scope

Provide TAC Network 8000 DDC controls for the "**NAME of BUILDING**". DDC Controls will be a NW8 system using the TAC/IA Series ASD drivers with the Universal Network Controllers (UNC). All UNC's will be connected to the Enterprise server located with in the Facilities Management department. Contact name is Jeffery Sherman at FIT (321) 674-8038.

Work included: Provide a complete fully integrated Building Automation System (BAS), UL Listed, incorporating Direct Digital Control (DDC) for energy management, equipment monitoring and control and environment monitoring.

All building network controllers shall be networkable and capable of LonMark and BACnet communications simultaneously.

The building controls shall consist of "**NAME of EQUIPMENT**" as outlined in the drawings. All controls will be integrated into UNC – 520-2(s) to communicate to the existing Invensys Niagara system.

All wiring, conduit, panels for a complete system shall be by the BAS Contractor's directly employed staff, except underground conduit which shall be done by the Electrical Contractor. Plenum wiring will be acceptable as long as it is in concealed and accessible areas, all other areas will be in conduit.

All necessary software and hardware for complete system as specified herein.

BAS Contractor shall be responsible to provide all electrical work associated for a fully functional BAS control system and not shown on the electrical plans or required by the electrical specifications.

Mechanical Contractor provides:

All openings for water monitoring devices, installation of airflow monitoring devices, opening for flow switches and alarms furnished by BAS Contractor.
Installation of control valves furnished by BAS Contractor.
Installation of smoke dampers; outdoor air, return air, exhaust air and vent dampers; with adjacent access doors furnished by Mechanical Contractor.

Electrical Contractor provides:

Provide power wiring to temperature control panels as shown on electrical plans. Run power circuit within 5 feet of equipment; installed and connected by BAS contractor.
120 volt, 20-amp breaker for each ASC and DDC Controller. Coordinated with the BAS Contractor.
Fire Alarm system shutdown of all HVAC air moving devices.

General Product Description

The Building Automation System (BAS) shall be an extension of the existing TAC/IA Series Niagara Web

Supervisor. The system shall be web based utilizing the same graphical drawings as used within the Niagara supporting all FIT buildings. The Web based supervisor, currently located in the building automation controls department, will monitor, alarm, email, etc using all functions currently set-up within the existing system. The Building Automation System (BAS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.

General: The Building Control System (BCS) shall consist of a high speed intranet/internet compatible controllers residing on the owner's network and exposed to the internet using high security firewalls in accordance with the owners information technology department (Level 1 Building Controllers, peer-to-peer network of Direct Digital Control (DDC) controllers (Level 2 controllers), and intranet/internet networked operator workstations. The system must be able to be viewed from any computer on the owner supplied network or any computer on the internet using no special software other than browsers (Microsoft Internet explorer or equivalent). The operator workstation shall be a personal computer (PC) with a color monitor, mouse, keyboard, and printer. The PC will allow the user to interface with the network via dynamic color graphics. Each mechanical system, building floor plan, and control device will be depicted by point and click graphics. A modem will be provided for remote access to the network and for paging the operators when an alarm occurs.

The system will have the ability of an open architecture that utilizes EIA standard 709.1, the LonTalk™ protocol, as the common communication protocol or native BACnet ANSI / ASHRAE™ Standard 135-2004 with a BTL listing between Level 1 controllers shall contain a high speed LAN communications bus capable of sharing data among personal computer workstations, other Level 1 controllers, and a central file server. Level 1 controllers will also contain a communication bus to Level 2 controllers. Level 1 controllers are primarily central plant controllers and network integrators (operator workstation and building controllers) to assure interoperability between all system components. Both the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135- 2004, BACnet protocols are required to assure that the project is fully supported by the two leading HVAC open protocols to reduce future building maintenance, upgrade, and expansion costs. The LonWorks products that are used in the BMS shall be LonMark™ compliant. The software tools required to network manage both the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-1995, BACnet protocol must be provided with the system. This network managing tool must not cost extra to add more nodes within the system for future expansion.

LonWorks NETWORK MANAGEMENT:

The Graphical User Interface software (GUI) shall provide a complete set of integrated LonWorks network management tools for working with LonWorks networks. These tools shall manage a database for all LonWorks devices by type and revision, and shall provide a software mechanism for identifying each device on the network. These tools shall also be capable of defining network data connections between LonWorks devices, known as "binding". Systems requiring the use of third party LonWorks network management tools shall not be accepted. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.

The Network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.

These tools shall provide the ability to "learn" an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database. The network management database shall be resident in the Network Area Controller (NAC), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times, within the control system shall not be accepted

The system will directly control each piece of mechanical equipment as indicated in the point list, schematic drawings, and sequence of operations.
The system shall be capable being expanded for future expansion to include monitoring of card access, fire alarm, lighting, and integrated systems. The BCS shall communicate to third party systems such as chillers, boilers, air-handling systems, energy metering systems, fire-life safety systems and other building management related devices by means of BACnet and/or LonWorks Protocols.

The Building Automation System shall consist of the following:

- DDC Controllers (Application Specific Controllers (ASC)
- Equipment Controllers (ECs)
- Building Network Controllers
- Terminal Equipment Controllers

The web access system shall be accessed through any FIT computer with no additional charge for the access. 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. Industry standard 1000 ohm RTDs with or without 4-20ma transmitter as required by the manufacturer will be provided for duct sensors required for AHUs. Manufacturers standard temperature sensors (including thermistor RTDs) may be used for terminal equipment room sensors, space temperatures for FCU, AHUs, including any duct sensors associated with these units as required by the sequence of operation or as indicated by the I/O schedule.

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.

DDC Controllers shall be able to access 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 unlimited email devices such as cell phones, pagers, PDAs or standard alarm terminals via remote alarm software.

RELATED WORK

Specified Elsewhere:

- Sequence of Operation (See Drawings)
- Point Schedule (See Drawings)
- Basic Mechanical Requirements
- Air Handling Units and Fan Coil Units
- Basic Electrical Materials and Methods
- Equipment Wiring

Work furnished, but installed by others:

BAS Contractor to furnish:

- Control Valves.
- Location of all wells and openings for water monitoring.
- Air dampers unless supplied by the unit manufacture.
- Air flow measurement and control equipment.

QUALITY ASSURANCE

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.

Install system using competent workmen who are fully trained in the installation of temperature control equipment. The installation shall be in strict accordance with the national and local electrical codes.

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 both existing and new. This system must be a seamless integration to the county wide network Web based system, and the existing Network 8000 currently located within the facility.

Supplier shall have an in-place support facility within 50 miles of the site with the design of the system (engineering of the control diagrams), technical staff, spare parts inventory and all necessary test and diagnostic equipment. Maximum response time shall be 3 hours.

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

All microprocessor based devices shall comply with UL 916 and be so listed at the time of bid. All electrical control and monitoring devices shall comply with UL 429 and/or UL 873.

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

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

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

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

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

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. In lieu of low battery indication, BAS may provide automatic notification of battery replacement based upon time schedule. Controller shall have double EEPROM that can restore programs if lost.

SUBMITTALS

Submit quantities as required by General Conditions to include complete sets of documentation.

Manufacturer's Product Data: All equipment component data sheets.

Shop Drawings: System wiring diagrams with sequence of operation for each system as specified.

Submit manufacturer's product information on all hardware items along with descriptive literature for

all software programs to show compliance with specifications.

Valve and damper schedules showing size, capacity, and location.

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

Data entry forms for initial parameters. Contractor shall provide English listing of all analog points with columnar blanks for high and low warning limits and high and low alarm limits, and a listing of all fan systems with columnar blanks for beginning and end of occupancy periods; and samples of proposed text for points and messages (for at least two systems of at least 15 points total).

Equipment lists of all proposed devices and equipment.

Sample graphic screens.

Where installation procedures, or any part thereof, are required to be in accordance 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.

ALTERNATE APPROVAL

The existing Web Supervisor is a TAC/IA Enterprise Server. If another vendor other than MC², Inc proposes on this project, seamless integration will be acceptable providing the licensing procedures are understood and the vendor is a representative to the Niagara product. It will be required to submit, at the time of the proposal, 10 factory certified technician certificates of employees directly employed by the controls contractor to guarantee the installation capabilities.

DELIVERY, STORAGE AND HANDLING

Handle all equipment and components carefully to prevent damage, breaking, denting and scoring. Do not install-damaged equipment or components; replace with new.

Store equipment and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

Comply with manufacturer's instructions for unloading equipment, and moving equipment to final location for installation.

SEQUENCING AND SCHEDULING

Coordinate the work with the mechanical and electrical contractor.

SERVICE AND GUARANTEE

General Requirements: Provide 1-year warranty and 1-year maintenance contract to include all services, labor, materials and equipment necessary for the successful operation to the entire BAS system for a period of one (1) year after completion of successful performance test. Provide necessary material required for the work. Minimize impacts on facility operations when performing

scheduled adjustments and non-scheduled work. Provide the cost of a maintenance service contract which will be included for the second year maintenance if accepted by the owner.

Description of Work: The adjustment and repair of the system includes all computer equipment, software updates, transmission equipment and all sensors and control devices. Provide the manufacturer's required adjustments and all other work necessary.

Personnel: Provide factory trained and certified personnel to accomplish all work promptly and satisfactorily. Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel. Owner may request certification paperwork on any technician servicing the system

Schedule of Work: Provide a total of 4 inspections at 3-month intervals. Schedule major inspections with one in the cooling and one in the heating season. Inspections shall include visual checks and operational tests of all equipment delivered and the following work:

Clean all equipment, including interior and exterior surfaces.

Perform signal, voltage and system isolation checks of system workstations and peripherals.

Check and calibrate (if necessary) each field device. Check all analog points and digital points.

Run all diagnostics and correct all previously diagnosed problems.

Resolve and correct any previous outstanding problems.

A report shall be submitted to Project Manager and copied to the Engineer. The report shall list all tests and results, and recommendations to amend deficiencies and upgrade performance.

Emergency Service: Owner will initiate service calls when the system is not functioning properly. Factory trained personnel shall be available to provide service to the complete system. Furnish owner with a telephone number where service representative can be reached at all times. Warrantee service shall be provided during normal business hours Monday through Friday however, service personnel shall be at the site within 24 hours after receiving a request for non-warrantee emergency service. Restore the control system to proper operating condition within 3 days.

Operation: Performance of scheduled adjustments and repair shall verify operation of the system as demonstrated by the initial performance test.

Systems Modifications: Provide any recommendations for system modifications in writing to Owner. Do not make any system modifications, including operating parameters and control settings, without prior approval of Owner. Any modifications made tot he system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

Software: Provide all software updates and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with the system operators, and shall be incorporated into the operations and maintenance manuals, and software documentation.

PART 2 - PRODUCTS

ACCEPTABLE MANUFACTURERS:

TAC/IA Series by MC2, Inc.

NETWORKING COMMUNICATIONS

Level 1 Controllers (NAC)

The Network Area Controller (NAC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. It shall be capable of executing application control programs to provide:

Calendar functions
Scheduling
Trending
Alarm monitoring and routing
Time synchronization
Integration of LonWorks controller data and BACnet controller data
Network Management functions for all LonWorks based devices
The Network Area Controller must provide the following hardware features as a minimum:
- One Ethernet Port -10 / 100 Mbps
- One RS-232 port
- One LonWorks Interface Port – 78KB FTT-10A
- Battery Backup
- Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
- The NAC must be capable of operation over a temperature range of 0 to 55°C
- The NAC must be capable of withstanding storage temperatures of between 0 and 70°C
- The NAC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing.
- The NAC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
- The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.

Event Alarm Notification and actions
- The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
- The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.
- Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
  - To alarm
  - Return to normal
  - To fault
  - Provide for the creation of an unlimited number of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.

Provide timed (schedule) routing of alarms by class, object, group, or node.
Provide alarm generation from binary object “runtime” and/or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
Control equipment and network failures shall be treated as alarms and annunciated.
Alarms shall be annunciated in any of the following manners as defined by the user:

Screen message text
Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
Day of week
Time of day
Recipient
Pagers via paging services that initiate a page on receipt of email message
Graphic with flashing alarm object(s)
Printed message, routed directly to a dedicated alarm printer

Audio messages
The following shall be recorded by the NAC for each alarm (at a minimum):
Time and date
Location (building, floor, zone, office number, etc.)
Equipment (air handler #, accessway, etc.)
Acknowledge time, date, and user who issued acknowledgement.
Number of occurrences since last acknowledgement.

Data Collection and Storage
The NAC shall have the ability to collect data for any property of any object and store this data for future use.
The data collection shall be performed by log objects, resident in the NAC that shall have, at a minimum, the following configurable properties:
Designating the log as interval or deviation.
For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
All log data shall be stored in a relational database in the NAC and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser.
All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

All log data shall be available to the user in the following data formats:
HTML
XML
Plain Text
Comma or tab separated values.

Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.

The NAC shall have the ability to archive it's log data either locally (to itself), or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties, at a minimum:
Archive on time of day
Archive on user-defined number of data stores in the log (buffer size)
Archive when log has reached it's user-defined capacity of data stores
Provide ability to clear logs once archived
Audit Log
Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached it's user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:
Time and date
User ID
Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

Database Backup and Storage

The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.
The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

Level 2 Controllers (IDC, IBC, and DDC Controllers (outlined 2.03 below)

Level 2 controllers must use Network 8000 technology for all standard control logic. If other integration must occur than all intergration shall be coordinated and utilize either LonMark, BACnet, or MODBus protocols as outlined below.

INTEROPERABLE DIGITAL LONMARK CONTROLLERS (IDC)

Controls shall be microprocessor based Interoperable LonMark™ or LonWorks Controllers (IDC). Where possible, all Interoperable Digital Controllers shall bear the applicable LonMark™ interoperability logo on each product delivered.
HVAC control shall be accomplished using LonMark™ based devices where the application has a LonMark profile defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device. Publicly available specifications for the Applications Programming Interface (API) must be provided for each LonWorks / LonMark controller defining the programming or setup of each device. All programming, documentation and programming tools necessary to set up and configure the supplied devices per the specified sequences of operation shall be provided.
The LonWorks network trunk shall be run to the nearest Network Area Controller (NAC). A maximum of 126 devices may occupy any one LonWorks trunk and must be installed using the appropriate trunk termination device. All LonWorks and LonMark devices must be supplied using FTT-10A LonWorks communications transceivers.
The Network Area Controller will provide all scheduling, alarming, trending, and network management for the LonMark / LonWorks based devices.

The IDCs shall communicate with the NAC at a baud rate of not less than 78.8K baud. The IDC shall provide LED indication of communication and controller performance to the technician, without cover removal.
All IDCs shall be fully application programmable and shall at all times maintain their LONMARK certification. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the IDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
The supplier of any programmable IDC shall provide one copy of the manufacturer's programming tool, with documentation, to the owner.

INTEROPERABLE NATIVE BACnet CONTROLLERS (IBC)

Controllers shall be microprocessor based Interoperable Native BACnet devices (IBC) in accordance with the ANSI/ASHRAE Standard 135-1995. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The system supplier must provide a PICS document showing the installed systems compliance level to the ANSI/ASHRAE Standard 135-1995. Minimum compliance is Level 3.
The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.
The IBC Sensor shall connect directly to the IBC and shall not utilize any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC Sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC Sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.
All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the IBC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained

DDC CONTROLLER

There shall be one or more DDC Controllers located in the building which serve Application Specific Controllers.

Stand-alone Controllers (including gateways) 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 if required for global data sharing and centralized Energy Management functions. Controller size shall be sufficient to fully meet the requirements of this.

Each DDC Controller (or Gateway Controller) shall have sufficient memory, to support its own operating system and databases, including:

Control processes
Energy management applications
Alarm management applications including custom alarm messages for each level alarm for

each point in the system.
Historical/trend data for points specified. (Engineer - Spec Points in Sequences)
Maintenance support applications
Custom processes
Operator I/O
If current network does not currently have dial-up communications, provide Dial-up communications to Central Facilities workstation.
Manual override monitoring

Each DDC Controller (or Gateway) or thru individual Equipment controllers shall support:

Monitoring of the following types of inputs:

Analog Inputs
4-20 mA
0-10 Vdc
1000 ohm RTDs

Digital Inputs
Dry Contact Closure
Pulse Accumulator
Voltage Sensing

Direct control of electronic actuators and control devices. Each DDC Controller shall be capable of providing the following control outputs:

Digital Outputs (Contact Closure)
Contact closure (motor starters, sizes 1-4)

Analog Outputs
4-20 mA
0-10 Vdc

Each DDC Controller shall have a minimum of 10 percent spare capacity for future point connection or expansion and additions of remote ASCs. The type of spares shall be in the same proportion as the implemented I/O functions of the system. Provide all processors, power supplies and communication controllers complete so that the implementation only requires the addition of the appropriate ASCs and point input/output termination module, sensors, actuators and wiring.

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

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

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.

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 72 hours.

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

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 telephone line dial-in or from a network workstation PC.

Existing Web based Server Features (For Information purposes only, Server already exist and does not need to be supplied)

System Software Workstation Operator Interface (Software, GUI, Clients)

Operating System: Furnish a concurrent multi-tasking operating system. The operating system also shall support the use of other common software applications that operate under DOS or Microsoft Windows. Examples include Lotus 123, Microsoft Word, Excel, Corel WordPerfect, and Paradox. Acceptable operating systems are Windows 2000 service pack 2 or higher, or Windows XP Professional.
The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.
System Graphics: The operator workstation software shall be graphically oriented. The system shall allow of up to 10 graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic. Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the object.
Custom Graphics: Custom graphic files shall be created with the use of a graphics generation package such as Microsoft Paint or other generic software supplied by the system. The graphics generation package shall also provide the capability of capturing or converting graphics from other programs such as Designer or AutoCAD.

Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.
Graphics shall support layering and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.

Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value. No entry of text shall be required.
Graphics Library: Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, Air Handlers, terminals, fan coils, etc. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation program.

System Applications: Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each server:
At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:

- Create, delete or modify control strategies.
- Add/delete objects to the system.
- Tune control loops through the adjustment of control loop parameters.
- Enable or disable control strategies.
- Generate hard copy records or control strategies on a printer.
- Select points to be alarmable and define the alarm state.
- Select points to be trended over a period of time and initiate the recording of values automatically.
- Save and restore databases

Manual Database Save and Restore: A system operator with the proper password clearance shall be able to save the database from any system panel. The operator also shall be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.

On-Line Help: Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.

System Security: Each operator shall be required to log on the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing the each system application, editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity id detected. This auto logoff time shall be set per operator password. All system security data shall be stored in an encrypted format.

System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

Alarm Processing: Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, alarm limit differentials, states, and reactions for each object in the system.

The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.
When the Alarm Console is enabled, a separate alarm notification window will supercede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

Alarm Messages: Alarm messages shall use the English language descriptor for the object in alarm, in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying upon acronyms or other mnemonics.

Alarm Reactions: The operator shall be able to determine (by object) what if any actions are to be taken during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation, or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day. An object in alarm that has not been acknowledged within an operator specified time period shall be moved to a higher level of priority. The actions for that level will then be followed.

Alarm and Event Log: The operator shall be able to view all system alarms and change of states from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the workstation.

Object and Property Status and Control: Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system. The status shall be available by menu, on graphics, or through custom programs.

The Graphical User Interface software (GUI) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of the GUI shall be through password access as assigned by the system administrator.
A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface display shall not be acceptable.

Programming Methods

Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.

Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.

All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.

The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

OBJECT LIBRARIES

A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.

The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.

In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.

All control objects shall conform to the control objects specified in the BACnet specification.

The library shall include applications or objects for the following functions, at a minimum:

Scheduling Object. The schedule must conform to the schedule object as defined in the BACnet specification, providing 7-day plus holiday & temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphical sliders to speed creation and selection of on-off events.

Calendar Object. . The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphical "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.

Duty Cycling Object. Provide a universal duty cycle object to allow repetitive on/off time control of equipment as an energy conserving measure. Any number of these objects may be created to control equipment at varying intervals

Temperature Override Object. Provide a temperature override object that is capable of overriding equipment turned off by other energy saving programs (scheduling, duty cycling etc.) to maintain occupant comfort or for equipment freeze protection.

Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage

of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day's performance.

Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.

The library shall include control objects for the following functions. All control objects shall conform to the objects as specified in the BACnet specification.

Analog Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.

Analog Output Object - Minimum requirement is to comply with the BACnet standard for data sharing.

Binary Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment run-time by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.

Binary Output Object - Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as interstart delay must be provided. The BACnet Command Prioritization priority scheme shall be incorporated to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide sixteen levels of priority as a minimum. Systems not employing the BACnet method of contention resolution shall not be acceptable.

PID Control Loop Object - Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable as well as to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control.

Comparison Object - Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.

Math Object - Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.

Custom Programming Objects - Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a

simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including math and logic functions, string manipulation, and e-mail as a minimum. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for re-use.

Interlock Object - Provide an interlock object that provides a means of coordination of objects within a piece of equipment such as an Air Handler or other similar types of equipment. An example is to link the return fan to the supply fan such that when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming thereby eliminating nuisance alarms during the off period.

Temperature Override Object - Provide an object whose purpose is to provide the capability of overriding a binary output to an "On" state in the event a user specified high or low limit value is exceeded. This object is to be linked to the desired binary output object as well as to an analog object for temperature monitoring, to cause the override to be enabled. This object will execute a Start command at the Temperature Override level of start/stop command priority unless changed by the user.

Composite Object - Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphical shell of this container.

The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). At a minimum, provide the following as part of the standard library included with the programming software:

LonMark/LonWorks devices. These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to facilitate simple integration of these devices. All network variables defined in the LonMark profile shall be supported. Information (type and function) regarding network variables not defined in the LonMark profile shall be provided by the device manufacturer.

For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file and documentation for the device to facilitate device integration.

For BACnet devices, provide the following objects at a minimum:

- BACnet AI
- BACnet AO
- BACnet BI
- BACnet BO
- BACnet Device

For each BACnet object, provide the ability to assign the object to a BACnet device and object's instance number.

Clock Synchronization: The real-time clocks in all building control panels and workstations shall be using the NIST Atomic Time Synchronization service. The system also shall be able to automatically synchronize all system clocks minutely from any operator-designated device in the

system. The system shall automatically adjust for daylight savings and standard time, if applicable.

Reports and Logs: Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be achievable on the hard disk for historical reporting. Provide the ability for the operator to obtain real-time logs of all objects by type or status (e.g., alarm, lockout, normal). Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications, including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer and shall be set to be printed either on operator command or at a specific time each day.

Standard Reports: The following standard system reports shall be provided for this project. Provide ability for the Owner to readily customize these reports for this project.
Electrical Meter Report: Provide a monthly report showing the daily electrical consumption and peak electrical demand for each building meter. Provide an annual (12-month) summary report showing the monthly electrical consumption and peak demand for each meter.
Weather Data Report: Provide a monthly report showing the daily minimum, maximum, and average outdoor air temperature--as well as the number of heating and cooling degree days for each day. Provide an annual (12-month) report showing the minimum, maximum, and average outdoor air temperature for the month--as well as the number of heating and cooling degree days for the month.
Tenant Override Reports: Provide a monthly report showing the daily total time in hours that each tenant has requested after-hours HVAC and lighting services.
Provide an annual summary report that shows the override usage on a monthly basis.
All Objects: All system (or sub-system) objects and their current values.
Alarm Summary: All current alarms (except those in alarm lockout).
Disabled Objects: All objects that are disabled.
Alarm Lockout Objects: All objects in alarm lockout (whether manual or automatic).
Alarm Lockout Objects in Alarm: All objects in alarm lockout that are currently in alarm.
Logs:

- Alarm History
- System Messages
- System Events
- Trends

ASHRAE Guideline 3 Report: Provide a daily report that shows the operating condition of each chiller as required by ASHRAE Guideline 3 providing the existing chiller has the capability of integration. At a minimum, this report shall include:

- Chilled Water (or other secondary coolant) inlet and outlet temperature Chilled Water (or other secondary coolant) flow
- Chilled Water (or other secondary coolant) inlet and outlet pressures
- Evaporator refrigerant pressure and temperature
- Condenser refrigerant pressure and liquid temperature
- Condenser water inlet and outlet temperatures
- Condenser water flow
- Refrigerant levels
- Oil pressure and temperature
- Oil level
- Compressor refrigerant discharge temperature
- Compressor refrigerant suction temperature
- Addition of refrigerant

Addition of oil
Vibration levels or observation that vibration is not excessive
Motor amperes per phase
Motor volts per phase
PPM refrigerant monitor level
Purge exhaust time or discharge count
Ambient temperature (db and wb)
Date and time logged

LEED™ EA Credit 5 – Measurement and Verification. Comply with the long term continuous measurement of performance as stated in Option B: Methods by Technology of the US DOE's International Performance Measurement and Verification Protocol (IPMVP) for the following:

Lighting systems and controls
Constant and variable motor loads
Variable frequency drive (VFD) operation
Chiller efficiency at variable loads (kW/ton)
Cooling load
Air and water economizer and heat recovery cycles
Air distribution static pressures and ventilation air volumes
Boiler efficiencies
Building specific process energy efficiency systems and equipment (such as laboratory fume hoods)
Indoor water risers and outdoor irrigation systems

Custom Reports: Provide the capability for the operator to easily define any system data into a daily, weekly, monthly, or annual report. These reports shall be time and date stamped, and shall contain a report title and the name of the facility.

PERSONAL COMPUTER OPERATOR WORKSTATION HARDWARE

Provide a computer workstation at the facility for operators to change setpoints, schedules, etc.

Provide a personal computer operator workstation 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.

Workstation shall consist of a 17" flat panel color monitor, personal computer with minimum 512 MB RAM, 80 GB hard drive and controller, CD-RW Drive, 3-1/2" diskette drive, mouse and 101-key enhanced keyboard. Personal computer shall be a DELL and shall include a 3.2 GHz Pentium processor or higher.

17" LCD Flat Panel Display will be included at high resolution 1024 X 768 as a minimum

All Manufacturers: Workstation shall have a Read/Write CD Rom for IAQ monitoring permanent data storage or an internal tape backup drive.

All Manufacturer: Upgrade all software and hardware as required on the existing Facilities Energy Control Systems and Maintenance Department Workstations of equal capability. Workstation shall also have a Read/Write CD Rom for IAQ monitoring permanent data storage and an internal tape backup drive.

FIELD DEVICES

All devices and equipment shall meet Local and County code requirements for installation.

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

1.	Accuracy	± 1°F (±0.6°C)
2.	Operating Range:	35° to 115°F (2° to 46°C)
3.	Set Point Adjustment Range:	55° to 95°F (2° to 30°C)
4.	Set Point Modes	Cooling, Night Setback-Heating, Night Setback-Cooling, Heating
5.	Calibration Adjustments	None required
6.	Installation	Up to 250 ft. from Controller

Room Sensors:

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.

Each room sensor shall also include the following auxiliary devices:

Override Push-button

For Common areas such as Hallways and as selected by the Owner, sensors will be flush mounted to match the decor and provided without setpoint, thermometer or override switch. Override switch for these areas shall be located remotely in a secured area.

The setpoint adjustment shall only be through the central station. No local adjustment and no temperature indication.

An override switch shall initiate override of the unoccupied mode to normal (day) operation when activated by the occupant and have a visible override indicator on the sensor the override function may be locked out, overridden or limited as to the time period for each sensor through software by an authorized operator at the central workstation, DDC Controller or via the portable operator's terminal. The manual override period shall be one hour.

Temperature Sensors:

Temperature sensors for duct installation shall be RTD type, 10K Thermistor or 1000 ohms Industry standard with integral or panel mounted 4 to 20 mA transmitters as required by the manufacturer. RTDs shall have a range of minus 40 to plus 240 degrees F. The RTD shall be encapsulated in epoxy, series 300 stainless steel, or a copper sheath. The RTDs shall be

provided in either probe mounting, averaging element, or for mounting in a separable well for liquid sensing applications. Thermistors types may be used on split systems, heat pumps and FCUs.

Accuracy shall be plus or minus 0.2% at 32 degrees calibration point.

Provide averaging style for all mixed air applications. OA sensors shall be furnished with sun-shield.

Water sensors to be provided with Stainless Steel wells.

Humidity Sensors

There will be at least one humidity sensor per room. This sensor shall be integral to the room temperature sensor with no extra devices mounted in the space.

Provide a solid state humidity sensor with a range of 0 to 99 percent relative humidity with an accuracy of plus or minus 5% at 70 degrees F.

The sensing element shall be of the non-saturating type. Provide either duct or wall mounted versions based on the application required.

Accuracy at 77 degrees F shall be as a minimum 4%.

Provide Room or duct mounting as required by sequence of operation.

Current Switches (C/T):

Provide a solid state switch which when the current level sensed by the internal current transformer exceeds the adjustable trip point. Internal circuits are to be totally powered by induction from the line being monitored. Provide a zero off-state leakage in the solid-state relay output, while switching both AC and DC circuits. Provide an LED that will show three pieces of information (Rapids Flashing-switch is tripped, Slow Flashing-current is present but below the trip point and No Flashing-current is either off or below the bottom of the range) and permits setting the trip point adjustment prior to system connection.

Current switches (CIT) shall be used in lieu of pressure switches whenever possible.

Acceptable Manufacturers: Veris Industries and Greystone.

Control Dampers:

Provide automatic control dampers as indicated, with damper frames not less than formed 13-ga. Galvanized steel. Provide mounting holes for enclosed duct mounting. Provide damper blades not less than formed 16-gallon galvanized steel, with maximum blade width

of 8". Equip dampers with motors, with proper rating for each application.

Secure blades to 1/2" diameter zinc-plated axles using steel hex hardware. Seal off against flexible metal jamb seals. Provide blade bearings of nylon or synthetic and provide thrust bearings at each end of every blade. Construct blade linkage hardware of zinc-plated steel and brass. Submit leakage and flow characteristics, plus size schedule for controlled dampers.

Operating Temperature Range: From -25 to 180 deg. F.

For standard applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with optional PVC coated blade seals.

Provide for all, low-leakage applications parallel or opposed blade design (as selected by manufacturer's sizing techniques) with seal blade edging, or replaceable seals, flexible metal jamb seals, rated for leakage (1/2%) at less than 10 cfm/sq. Ft. of damper area, at differential pressure of 4" w.g. when damper is being held by torque of 50 inch-pounds.

Acceptable Manufacturers: Ruskin RCD46, Honeywell D641/642, Vart Products, and Nailor Hart.

Low Temperature Limit Sensors:

Provide low-temperature protection thermostats of manual-reset type, with sensing elements 8'-0" or 20'-0" in length. Provide thermostat designed to operate in response to coldest 1'-0" length of sensing element, regardless of temperature at other parts of element. Support element properly to cover entire duct width. Provide separate thermostats for each 25-sq. ft. of coil face area or fraction thereof.

Water Flow Switches:

Provide differential pressure water flow switches of stainless steel or bronze paddle types. Where flow switches are used in chilled water applications, provide vapor-proof type to prevent condensation of electrical switch. Provide pressure-flow switches of bellows actuated mercury type or snap-acting type, with appropriate scale range and differential adjustment for service indicated.

Acceptable Manufacturers: Dwyer, Barksdale, and McDonnell-Miller.

PART 3 - EXECUTION See Above for all this info below.

SEQUENCE OF OPERATION

Systems Designer to determine.

ELECTRICAL INSTALLATION

All wire shall be stranded copper and shall meet the minimum wire size and insulation class listed in strict accordance with NEC requirements. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per NEC.

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

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

All wiring in Mechanical Rooms and other exposed areas shall be in conduit. All concealed wiring shall be in plenum rated cable strapped to structure. Wiring to space sensors shall be in conduit from sensor to 24" above wall with 90 degree turn.

All wire shall be stranded copper and shall meet the minimum wire size and insulation class listed in strict accordance with NEC requirements.

Surge transient protection shall be provided with the system to protect electrical components in all DDC Controllers, Equipment Controllers and operator's workstations. As a minimum, each building shall be isolated from other parts of the system.

END OF SECTION 15955