SECTION 15900

BUILDING AUTOMATION SYSTEMS

PART 1 – GENERAL

1.01 DESCRIPTION

Provide a Building Automation System (BAS) incorporating LONWORKS technology at the controller level and EC-NET AX (Niagara Framework) version technology at the network device level and as the network management tool. The BAS shall consist of Direct Digital Control (DDC) controllers, Building Controllers (BC), Graphical User Interface through standard Web browsers, sensors, relays, valves, actuators, and other equipment as may be necessary to provide for a complete and operational control system for the HVAC and other building related systems as described within these specifications.

A. The system installed shall seamlessly connect devices other than HVAC throughout the building regardless of subsystem type, i.e. HVAC, lighting, and security devices should easily coexists on the same network channel without the need for gateways. LONWORKS components not supplied by the primary manufacturer must meet approval of the County, and shall be integrated to share common software for network communications, time scheduling, alarm handling, and history logging.

B. The documentation contained in this section and other contract documents pertaining to HVAC Controls is schematic in nature. The Integrator shall provide the hardware, design, engineering, and software necessary to implement the functions shown or as implied in the contract documents.

C. System configuration and monitoring shall be performed via the existing Campus BAS interface computer. Modifications to the BAS database are subject to conditions review and acceptance by the County.

D. All VAV controllers, application specific controllers, free programmable controllers, and all other field-installed controllers for the HVAC system shall be provided, installed, configured, and programmed by the approved, authorized Distech Controls Integrator.

E. All system controllers shall utilize a peer-to-peer communications scheme to communicate with each other.

F. Strict adherence to the System Integrator qualifications as detailed in section 1.3 B shall be enforced to maintain the integrity, reliability, performance, and warranty of the overall campus BAS.

1.02 OPEN SYSTEMS DESIGN

The BAS provided shall maintain open interoperability in the following areas.

A. Communications - The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, LONWORKS technology, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

B. Network Management - Network management tools shall be based upon Niagara Framework technology as developed by the Tridium Corporation utilizing the Distech EC-NET AX version. All tools and hardware provided shall comply with the current release version of the AX Niagara Framework platform. The supplied computer (if required as

part of this contract) software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135-2004, BACnet and LONMARK to assure interoperability between all system components is required.

C. Network Architecture - A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.

D. User Access - The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open Data Base Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.

E. Databases - All controller program graphics and network databases shall be provided in a Niagara Framework AX format. The database shall be constructed and stored on the County PC and provided on a separate CD upon final acceptance of the project. Construction of the database and programming shall follow the Campus methods and be performed by the Integrator, not a subcontractor or contracted engineering services. The Integrator shall have employees certified in Niagara AX for a period of no less than 1 year. An updated database shall be provided on a CD at the end of the warranty period.

F. Network Level Devices - All network level devices (devices that provide for communication interface between the LON and the Ethernet) shall conform to the current released version AX of the Niagara Framework (EC-NET).

G. Field Level Controls - All field level controls shall be certified to the current LONMARK standards appropriate to their application so long as an appropriate LONMARK Certification standard exist. The XIF file shall be provided to the County for all controllers provided under this specification. All points within a controller including hard I/O and software based points such as (constants, variables, NVI, NVO, SCPT, UCPT, SNVT, UNVT) shall be available for viewing and manipulation through any LONWORKS based network device, management or Graphical User Interface (PC based or Browser) tool. Any products that use explicit messaging shall not be acceptable.

H. Software Tools - All software tools needed for full functional use, including programming of controllers, network management and expansion, and graphical user interface use and development, of the BAS described within these specifications shall be provided to the County or his designated agent. Any licensing required by the manufacturer now and into the future, including changes to the licensee of the software tools and the addition of hardware corresponding to the licenses, to allow for a complete and operational system for both normal day-to-day operation and servicing shall be provided. Any such changes to the designated license holders shall be made by the manufacturer upon written request by the County or his agent. Any cost associated with the license changes shall be identified within the BAS submittals.

I. Software License Agreement - The County shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to County as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. The County shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the County shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This

shall include all custom, job specific software code, databases and documentation for all configuration and programming that is generated for a given project and/or configured for use with the BC, BAS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the County. The System Integrator shall provide as part of the submittals a copy of the Niagara Compatibility Statement (NiCS) verifying that all aspect of the Niagara Framework maintain an Open System Design. The System as provided shall confirm with the following NiCS

Property	Value
STATION COMPATIBILITY IN	All
STATION COMPATIBILITY OUT	All
TOOL COMPATIBILITY IN	All
TOOL COMPATIBILITY OUT	All

J. Training - Manufacturer provided training on the use and operation of all products provided within these specifications shall be available for purchase and attendance by the County or his designated agent. Such training shall be of the same curriculum as the training courses provided by the manufacturer to the System Integrator. A manufacturer certified instructor shall give all training classes. A list of training courses and the associated cost shall be provided as part of the BAS submittals.

1.03 QUALITY ASSURANCE

A. General - The HVAC Control System shall be furnished, engineered, and installed by an authorized, approved Distech Controls Integrator. All work provided under this section shall be provided by direct employees of the Distech Controls System Integrator.

B. System Integrator Qualifications

1. The SI must be regularly engaged in the service and installation of LONWORKS Controls and Niagara Framework based systems as specified herein, The SI shall have a minimum of 5 years experience in the sales, installation, engineering, programming servicing and commissioning of LonWorks BAS. The Integrator shall submit a resume of no less than five LonWorks BAS projects dating back 5 years.
2. The system integrator must be an authorized factory direct representative qualified by a Distech Controls System Integrator Agreement and an EC-NET AX Agreement, and in good standing of the manufacturer of the specified hardware and software components. The Integrator must have a minimum of 18 months experience installing, engineering, and programming Distech Controls hardware and EC-NET AX software.
3. The SI shall have an office within 150 miles of the Building site that is staffed with a minimum of four technicians who have successfully completed the factory-authorized training of the specified manufactures hardware and software components and have successfully completed a Niagara AX Framework approved course thru Distech Controls. SI must provide proof of required training. The SI capabilities shall include engineering and design of control systems, programming, electrical installation of control systems, troubleshooting and service.
4. The SI shall submit a list of no less than three (3) similar projects, which consist of Distech Controls / EC-NET AX Building Automation Systems as specified herein installed by the SI. These projects must be on-line and functional such that the County /User's representative can observe the system in full operation.

5. The SI must be a licensed U.L. 508 panel shop, with the capability to manufacture, provide, and install U.L. 508 listed control panel assemblies to meet the existing Campus Standards.
6. All BAS system programming must by performed by an employee of the SI. Programming performed by outside contract services shall not be accepted. Demonstration of SI programming capabilities may be requested by County.
7. Construction of the database and programming shall follow the Campus methods and be performed by the Integrator, not a subcontractor or contracted engineering services. The Integrator shall have at minimum four employees certified in EC-NET AX.

C. Hardware and Software Component Manufacturer Qualifications
1. The manufacturer of the hardware and software components must be primarily engaged in the manufacture of LONWORKS based systems as specified herein, and must have been so for a minimum of five (5) years.
2. The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the LONMARK Association.
3. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.
4. Acceptable manufacturers of the hardware and software components as specified herein are as follows: Distech Controls - No exceptions. Distech Controls regional office contact: Brian Seiderman 760-822-0942

1.04 SUBMITTALS

A. General
1. Meet all applicable Submittal requirements of Section 01350 - Submittals, Division 15, and the following including listed below and in the Submittal checklist.
2. Provide to the Engineer and County all information or data necessary to determine compliance with these specifications.
3. Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, including specific requirements indicated.
4. All Drawings and Diagrams shall be machine-drafted using AutoCAD 2000 or later, or Microsoft Visio. At project closeout, provide vellum plots and diskette or CD copy of control drawings and layout drawings to the County.
5. Provide system device and LAN conduit routing drawing, using building plans for a background. All controllers, gateways, hubs, devices and communication cabling shall be accurately shown, except that individual sensor I/O wiring and devices need not be shown. Layout drawings shall be the same size as the Engineer's construction documents.

B. Hardware - Include a complete list of materials of equipment to be used, including technical data, performance curves, project specification sheets and installation/ maintenance instructions.

C. Control Panel Design – Provide scaled panel design drawings including panel layout, wiring diagram, bill of materials, and electrical rating. All control panels to be constructed as a U.L. 508 listed assembly. *The U.L. panel shop shall be housed by the System Integrator.*

D. Control System Diagrams - Provide schematic diagrams for each controlled system. Illustrate the relationship between control system and controlled equipment. Show all control elements. Show all terminations and cable/tube numbers.

1. Provide equipment interface details using actual equipment termination information. Blank terminals or "field verify" is not acceptable.
2. Provide individual diagrams for each mechanical system. If two systems are identical, then a single diagram may represent multiple mechanical systems. Notations like "this part here only applies to units xxx", etc. are not acceptable.
3. The control diagrams and sequence of operation shall be together on the same sheet and shall be suitable for posting.
4. The sequence of operation shall reference a schematic diagram of the controlled system. The sequence of operation shall describe in words the control strategies utilized, worded in such a way to serve as an informative reference to the maintenance and service personnel who will be responsible for unit operation.
5. Each component and instrument on the control diagrams shall have a unique tag number such as temperature element "TE-1". The sequence of operation verbiage shall make specific reference to the individual component tag numbers, such as "Controller (C-1) compares the space temperature sensor (TE-1) to set point, and modulates hot water heating coil valve (V-1) as required". The mechanical system being controlled shall be schematically drawn and show the measurement and control points, such as "TE-1" and "V-1".

E. Graphic Displays - Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.

F. Point List - Provide a point list for each system controller including both inputs and outputs (I/O) point, point number, the controlled device associated with the I/O point and the location of the I/O device. Use naming convention consistent with control diagrams and sequence of operation.

G. Software manuals - Include software manuals that describe programming, testing, system overview. The manuals shall include a detailed description of each software feature including editing and writing control programs, reading or modifying printout and logs, adding, deleting and modifying user password, creating and modifying graphics. Software manuals may be provided on CD ROM in lieu of paper copy. If submitted as a CD ROM, the vendor shall arrange to review the software manuals with the engineer at the engineer's office.

H. Other Items Requiring Submittals
1. Point to point and basic function commissioning forms to be used on site for the start, test and check of network components and systems.
2. List of specific personnel who will be involved in the system installation and commissioning.
3. Functional performance test documentation and procedures to be used in commissioning control sequences.

I. Operation and Maintenance Manuals shall be submitted indicating the correct procedures and processes to operate and maintain the system. O&M's shall be delivered either hard copy or on a CD-ROM developed specifically for the project. Contractor shall submit (3) copies of the Operation and Maintenance Manuals.

J. Parts List shall be submitted listing: manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair necessary to ensure continued operation with minimal delay.

K. Submittal Check List - The following Submittal Check list is intended to provide the SI, Consulting Engineer and County with a working document upon which to verify compliance with the major portions of the specification that can more easily be verified through printed documentation. It in no way excludes the SI from compliance or for verification of compliance of any portion of this specification.

Submittal Check List

Section	Description	Rejected	Approved	Comments	Project Acceptance Submittal
1.1D	Verify all primary HVAC controls provided by one approved manufacture				
1.2	Open System Design				
1.2A	LonTalk compliance				
1.2B	Niagara Framework Network Management Tool AX version				
1.2E	Verify that controller program graphics and network database are provided in a Niagara Framework AX format				
1.2E	Provide Database on CD				
1.2F	Verify that Network devices are current version of Niagara Framework				
1.2G	Verify all controllers are LONMARK certified. Provide XIF file to verify exposure of all points.				
1.2H	Provide evidence of what Software tools will be provided				
1.2H	Software tools license change cost				
1.2I	Software Licensing NiCS				
1.2J	Training – provide list of training courses and cost				
1.3B1	Provide evidence of ____ years in the controls business				
1.3B2	Provide evidence of authorized representative of approved BAS manufacture				
1.3B3	Provide office location, names of 2 technicians and certificate of training certification				
1.3B4	Provide list of 3 projects				
1.4A, B,C	Provide control drawings				
1.4D	Provide graphics in draft form				
1.4E	Provide points list				
1.4F	Provide software manuals				
1.4G1	Provide Commissioning forms				
1.4G2	Provide a list of personnel for install and commissioning				
1.4G3	Provide Functional performance test documentation				
1.4H	Provide Operational & maintenance manuals				
1.4I	Provide Parts List				
1.5	Provide required training materials				
1.6	Provide Verification of warranty				

	of 12 months				
4.1A	Provide verification that all configuration tools are provided as Niagara Framework AX Wizards				

1.05 TRAINING

Meet all applicable Training requirements of Division 1, Division 15, and the following.

A. Instruct the operators how to accomplish control of the system. Include basic troubleshooting and override of equipment and controls in the event of system failure.

B. Training Allowance: Provide Training Allowance for the following
   1. Not less than (16) hours formal training to the County's designated operations personnel for the site controls operation and maintenance.
   2. Training class for (2) of the County's designated technicians at Tridium University in Los Angeles for the "Niagara AX - Certification"

C. Trainers - Persons conducting the training shall be knowledgeable in the workings of the system, and shall be regularly engaged in training exercises, so as to provide effective training. Acceptability of the trainers shall be at the discretion of the County.

D. Training Manuals - Include the following in training manuals.
   1. Manufacturer's training brochures.
   2. Operation and maintenance manuals.
   3. Completed Field Acceptance Test Procedure.
   4. "As-installed" Drawings.
   5. Manufacturer's Operation Manuals.
   6. Software interaction sheets to be used in instructing students how to use the control system, on a command-by-command basis.

E. Training Classes - Prior to conducting training, prepare and submit for approval the proposed training literature and topics. Submit this information at least two weeks prior to the first class.

F. Provide approved training manuals to the County at least one week prior to the first class.

G. Provide Audio Visual Turtorials both in a CD format and on the manufactures website instructing on the operation of the programming software tools as provided under this specification.

1.06 WARRANTY

A. The HVAC Control System shall be free from defects in workmanship and material under normal use and service. If within twelve (12) months from the date of substantial completion, the installed equipment is found to be defective in operation, workmanship or materials, the building systems contractor shall replace, repair or adjust the defect at no cost. Service shall be provided within 4 hours upon notice from County's designated Representative.

B. The warranty shall extend to material that is supplied and installed by the Contractor. Material supplied but not installed by the Contractor shall be covered per the above to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation.

C. All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks.

PART 2 – NETWORK ARCHITECTURES AND DEVICES

2.01 NETWORKS

All network devices supplied under this section shall communicate over a Local Area Network (LAN). The LAN will be a 100 Megabits/sec Ethernet network supporting LonWorks, BACnet, Java, XML, HTTP, and SOAP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Building Controllers (BC), user workstations and, if specified, a local server. The LAN will be provided by others. The SI shall coordinate with the General Contractor for the access to the LAN.

A. Local area network minimum physical and media access requirements:
   1. Ethernet; IEEE standard 802.3
   2. Cable; 100 Base-T, UTP-8 wire, category 5 Minimum throughput; 100 Mbps

B. Network Access - Remote Access - For Local Area Network installations; provide access to the LAN from a remote location, via the Internet. The County shall provide a connection to the Internet to enable access via high-speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's Intranet to a corporate server providing access to an Internet Service Provider (ISP). The County agrees to pay monthly access charges for connection and ISP.

2.02 NETWORK - FIELD LEVEL CONTROLLERS

The communication network between the field level controllers shall be a peer-to-peer network incorporating the LONWORKS Technologies using Free Topology Transceivers (TP/FT-10), with specific conformance to the LONMARK Interoperability Association's v3.3 Physical and Logical Layer guidelines in all unitary, terminal unit and other controlling devices. The minimum baud rate shall be 78,000 baud for TP/FT-10 communication between controllers.

A. Strict compliance to the LonTalk communications protocol, as defined in ANSI standard EIA 709.1, shall be required for all communication between controllers and network devices to assure interoperability between all devices within the building network.

B. All TP/FT-10 based LON networks shall maintain a Bus topology in order to maintain network integrity and improve network diagnostics and maintenance. Star network topologies shall not be accepted.

C. All Network wiring – See Part 7 - Execution

2.03 NETWORK DEVICES

These various devices can service multiple functions on the network depending on network design, communication medium and needed task. These functions include management of traffic on the network, reconfiguring and strengthening of signals, the conversion of protocols, global activities such as alarms, trends and scheduling, control logic, and protocol conversion and web page hosting.

A. Building Controller (BC) - The Building Controller (BC) 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 BC.

1. It shall be capable of executing application control programs to provide:
   a) Calendar functions
   b) Scheduling
   c) Trending
   d) Alarm monitoring and routing
   e) Time synchronization
   f) Integration of LONWORKS controller data
   g) Integration of BACnet MS/TP and BACnet IP controllers as well as their BACnet objects
   h) Network Management functions for all LONWORKS based devices
2. The Building Controller must provide the following hardware features as a minimum:
   a) One Ethernet Port -10 / 100 Mbps
   b) One RS-485 port
   c) One LONWORKS Interface Port – 78KB TP/FT-10
   d) Battery Backup
   e) 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)
   f) The BC must be capable of operation over a temperature range of 0 to 55°C
   g) The BC must be capable of withstanding storage temperatures of between 0 and 70°C and a humidity range of 5 to 95% RH, non-condensing
   h) A modem port and 56K modem. Exempt if remote access is provided via the Internet
3. The BC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the BC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
4. The Building Controller will provide all scheduling, alarming, trending, and network management for the all LONWORKS devices.
5. Provide multiple Building Controllers as necessary. The BC shall support a minimum of 128 LONWORKS nodes. In order to maintain peak performance of the network, no more than 110 LONWORKS nodes may be connected to a single BC. In any event, no more than 90% of the available resources of the BC (as indicated by the resource meter of the programming tools for the BC) shall be committed. In the event that the available resources are less than 10%, the number of nodes connected to the BC shall be reduced in order to maintain a 10% or greater buffer of resources within the BC.
6. The BC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users.
7. Event Alarm Notification and actions - The BC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers. The BC 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.
   a) Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
      1) To alarm
      2) Return to normal
      3) To fault
   b) Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc
   c) Provide timed (schedule) routing of alarms by class, object, group, or node.

d) 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.

e) Alarms shall be annunciated in any of the following manners as defined by the user:
   1) Screen message text
   2) Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
      (a) Day of week
      (b) Time of day
      (c) Recipient
   3) Pagers via paging services that initiate a page on receipt of email message
   4) Graphic with flashing alarm object(s)
   5) Printed message, routed directly to a dedicated alarm printer

f) The following shall be recorded by the BC for each alarm (at a minimum):
   1) Time and date
   2) Location (building, floor, zone, office number, etc.)
   3) Equipment (air handler #, access way, etc.)
   4) Acknowledge time, date, and user who issued acknowledgement.
   5) Number of occurrences since last acknowledgement.

g) Alarm actions may be initiated by user defined programmable objects created for that purpose.

h) Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.

i) A log of all alarms shall be maintained by the BC and/or a server (if configured in the system) and shall be available for review by the user.

j) Provide a "query" feature to allow review of specific alarms by user-defined parameters.

k) A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

l) An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

8. Data Collection and Storage - The BC shall have the ability to collect data for any property of any object and store this data for future use.

a) The data collection shall be performed by log objects, resident in the BC that shall have, at a minimum, the following configurable properties:
   1) Designating the log as interval or deviation.
   2) For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
   3) 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.
   4) 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.
   5) Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

b) All log data shall be stored in a relational database in the BC 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:

1) HTML
2) XML
3) Plain Text
4) Comma or tab separated values

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

d) The BC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other BC on the network. Provide the ability to configure the following archiving properties, at a minimum:

1) Archive when log has reached it's user-defined capacity of data stores
2) Archive on time of day
3) Archive on user-defined number of data stores in the log (buffer size)
4) Provide ability to clear logs once archived

e) Audit Log - Provide and maintain an Audit Log that tracks all activities performed on the BC. 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 its user-defined buffer size. Provide the ability to archive the log locally (to the BC), to another BC on the network, or to a server. For each log entry, provide the following data:

1) Time and date
2) User ID
3) Change or activity: i.e., Change set point, add or delete objects, commands, etc.

9. Database Backup and Storage - The BC 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 BC. The age of the most recently saved database is dependent on the user-defined database save interval. The BC 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.

D. LON to LON Routers and Repeaters – A router or repeater may be used on a LON segment between controllers and a BC as a means to manage traffic and reconfigure and strengthen a transmission signal. Routers shall be fully programmable and permit a systems integrator to define message traffic, destination, and other network management functions utilizing LONWORKS. The routers, shall be capable of DIN rail or panel mounting and be equipped with status LED lights for Network traffic and power. A router may not manage more than 60 nodes on any single channel so as to allow for future expansion. A repeater or signal booster may only be used to increase ths signal strength of the communictions. Under no circumstances may it be used in the place of a router.

E. Server Functions and Hardware - A central server, located at Tel./Storage Room (No. 1-110), shall be provided. The server shall support all BC connected to the customer's network whether local or remote. Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, ADSL, T1 or dial-up connection. It shall be possible to provide access to all BC via a single connection to the server. In this configuration, each BC can be accessed from a remote Graphical User Interface (GUI) or from a standard Web Browser Interface (WBI) by connecting to the server. The server shall provide the following functions, at a minimum:

1. Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.
2. Distributed Control: The server shall provide the ability to execute global control strategies based on control and data objects in any BC in the network, local or remote.
3. The server shall include a master clock service for its subsystems and provide time synchronization for all BCs.
4. The server shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
5. The server shall provide scheduling for all Network Area Controllers and their underlying field control devices.
6. The server shall provide demand limiting that operates across all BCs. The server must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
7. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to the BC. Systems not employing this prioritization shall not be accepted.
8. Each BC supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
9. The server shall provide central alarm management for all BC supported by the server. Alarm management shall include:
   a. Routing of alarms to display, printer, email and pagers
   b. View and acknowledge alarms
   c. Query alarm logs based on user-defined parameters
10. The server shall provide central management of log data for all BCs supported by the server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
    a. Viewing and printing log data
    b. Exporting log data to other software applications
    c. Query log data based on user-defined parameters

F. Server Hardware Requirements: The server hardware platform shall have the following requirements:
1. The computer shall be an Intel Pentium M based computer (minimum processing speed of 2.4 GHz with 1 GB RAM and a 100-gigabyte minimum hard drive). It shall include a DVD-ROM/CD-RW Combination Drive, 2-parallel ports, 2-asynchronous serial ports and 2-USB ports. A minimum 17" flat panel color monitor, 1280 x 1024 optimal preset resolution, 25 ms response time shall also be included.
2. The server operating system shall be provided with Microsoft Windows XP professional Operating Systems software, Explorer 6.0 or later and the latest version of Symantec Antivirus Software including a 1 year upgrade subscription service to the Symantec software.
3. Connection to the FMCS network shall be via an Ethernet network interface card, 100 Mbps.
4. A system printer shall be provided. Printer shall be laser type with a minimum 600 x 600-dpi resolution and rated for 60-PPM print speed minimum.
5. For dedicated alarm printing, provide a dot matrix printer, either 80 or 132-column width. The printer shall have a parallel port interface.

PART 3 - BUILDING AUTOMATION SYSTEM CONTROLLERS

3.01 CONTROLLERS

All controllers shall be LONMARK Certified so long as a LONMARK certification exists for its intended application. If a LONMARK certification does not exist then provide the XIF file for the controller to demonstrate that it is in compliance with LONMARK standards for communication and data sharing. Where possible provide controllers that can meet the required sequence of operation that can be configured rather that custom programmed. Under no circumstances shall custom programming be implemented using Neuron C code without the use of an overlay of the manufacturer's Graphical Programming Language or Object Oriented Basic Code. All controllers shall be designed for easy installation and servicing including removable enclosures, removable terminals, and factory applied labels for all I/O. All internal points within the Free Programmable Controllers shall be fully supported by the Graphical User Interface (GUI), allowing the user to easily modify them and monitor them. All of the internal programming points (e.g. variables, constants, PID's, timers, inputs and outputs) shall be exposed to the network on dedicated network variable outputs. Each controller shall be provided with a XIF file that is fixed from the manufacture (not allowing any field modifications). Such XIF file shall be a part of the manufactures normal product offering. XIF files that can be modified in the field by the System Integrator shall not be allowed. All controllers programs and schedules shall contain non-volatile flash memory. Upon a loss of power, all controllers shall perform a self-restart.

3.02 FREE PROGRAMMABLE CONTROLLERS (FPC)

A controller designed for more complex sequences of operations such as built up AHU's, central plant operations, electrical monitoring, and control and management for chillers, boilers and generators. The FPCs are to allow for the flexibility of custom control programming to meet the needed sequences of operation.

A. Performance – Each FPC shall have a minimum of 64K of Non-volatile Flash memory for control applications and 128K non-volatile flash memory for storage with an 8-bit processor at 10 MHz. The FPC shall have a minimum ambient operating temperature range of -0°C to 70°C or 32°F to 158°F.

B. Inputs – Analog inputs shall have the following minimum level of performance: 16 bit A to D resolution; allow monitoring of platinum 100 ohms, platinum 1000 ohm, thermistor 10K type II, thermistor 10K type III, voltage input 0-10V, current input 4-20mA, digital input, pulsed input minimum 2 Hz.

C. Output – All out puts shall be software configurable to be either analog or digital - Analog outputs shall have a Voltage of 0-10 VDC (linear) and Digital outputs shall be 0-12 VDC (off/on) and PWM. Outputs shall have an adjustable range of 2 seconds to 15 minutes. All outputs shall an auto reset fuse. Output Resolution shall be a minimum 8 bits digital / analog converter. All individual outputs and power supply shall be protected by an auto reset fuse. There shall be an LED status indicator on each of the outputs.

D. FPC Features
   1. The FPC shall have minimum of 18 network variable inputs and 18 network variable outputs both with changeable type and changeable length. Products providing fixed type network variables shall not be acceptable. One of the network variable inputs on the FPC shall have a built in averaging function such that multiple network variable outputs values can be received by this one network variable input and perform a weighted average. This function shall be used to average terminal load (SNVT_lev_percent) or temperature (SNVT_temp_P). The averaging function shall have a customizable input validity period.
   2. Provide an onboard Lon communication jack

3. The FPC shall be provided with a diagnostic indicator lights for power and network communication of transmit and receive along with a light indication position for each output
4. Hand/Off/Auto Switches - Provide for the manual override and adjustment of all Analog and Digital outputs through a three-position switch giving the selection of Hand, Off and Auto (HOA). A HOA shall be provided for each separate digital and analog output from the controller and be an integral part of the controller. HOA switches external from the controller shall not be accepted. For the Analog outputs, the Hand position of the switch shall provide for the adjustment of the output signal through a linear scaled potentiometer. The position of the HOA shall be monitored and an alarm shall be delivered to the Graphical User Interface should the switch be in an Off or Hand position. An indicating LED shall be provided on the controller for each HOA indicating position of the switch. For all Analog outputs, the indicating LED shall provide a linear indication of the position of the Potentiometer through a variation in the intensity of the indicator LED and be provided as a numerical value that can be viewed at the Graphical User Interface.
5. Enclosures – Provide for a plastic enclosure with a separate back plate with terminals such that the electronic portion of the controller can be easily removed for ease of installation and servicing.

3.03 APLICATION SPECIFIC CONTROLLERS (ASC)

A controller designed through its I/O configuration and configurable control logic to be used for a specific type mechanical equipment. Typical applications are VAV boxes, Fan Coil Units, Roof Top Units, Unit Ventilators, Split DX Systems, Heat Pumps etc. All ASC's shall be LONMARK certified under the appropriate application profiles, see 3.4. ASC's that are not LONMARK certified, or are not certified under the appropriate profiles, shall not be acceptable.

A. Performance: Inputs Provide software selectable universal inputs. Analog inputs - shall have the following minimum level of performance: 12 bit A to D resolution; manage thermistors with an accuracy of $\pm 0.5^{\circ}C$; $\pm 0.9^{\circ}F$, and a Potentiometer. For VAV Applications provide a differential pressure input sensor built in to the controller with a 16 bit A to D resolution an adjustable range of 0" to 1" H_20 (0-248.8 Pa) static pressure with a minimum accuracy of ±3%. Minimum response time shall be 0.5 seconds from input to output time.

B. Output – Analog outputs shall have the following minimum level of performance: Tri-mode Voltage of 0-10 VDC (linear), digital 0-12 VDC (off/on) or PWM. All analog outputs shall be equipped with an auto reset fuse. Output Resolution shall be a minimum 8 bits digital / analog converter. Digital outputs shall be provided with a minimum of a triac output rated at 24VAC and 1 amp. All analog outputs shall be fuse protected

C. ASC Features:
1. The ASC except for the VAV shall be provided with an optimum start program internal to its control logic. The optimum start shall be activated by a SNVT_tod_event signal from its associated scheduler on the network.
2. The ASC shall allow the use of its spare I/O as dumb I/O to be shared over the network to other controllers such as FPC or the Building Controller (BC), where a sequence of operation can be applied to the I/O. Such applications shall include but not be limited to exhaust fan control, heaters, light control, etc.
3. All physical inputs and outputs by the controller should have is own network variables outputs (NVO). NVO associated to an input should be changeable in type and length up to 4 bytes. Others should be of the type SNVT_switch. so as to allow for greater flexibility in the sharing of information over the network.

4. Enclosures – Provide for all ASC except for the VAV, a plastic enclosure with a separate back plate with terminals such that the electronic portion of the controller can be easily remover for ease of installation and servicing.

D. Fan Coil Unit Specific functions: In addition to the features for the ASC the Fan Coil Unit controller shall provide the following functions

1. Provide for four line voltage relays rated for 85 – 265 at 33 VA for the control of the fan and other auxiliary devices. These relays shall be an integral part of the controller
2. Provide for wireless sensing capabilities.
3. Provide for a built in 24 VAC 300 Ma power supply
4. Provide for a LCD based sensor that operates as an user interface for temperature adjustment, override and display of values.
5. Accept platinum 1k ohm and thermistor 10k ohms type II sensors

E. VAV Specific functions. In addition to the features for the ASC the ASC VAV controller shall provide the following functions

1. The ASC VAV shall be a single integrated package consisting of a microprocessor, power supply, damper actuator, differential pressure transducer, field terminations, and application software. An alternate model shall be offered that allows for direct connectivity to an external actuator for those applications that employ a non-butterfly style damper configuration. All input/output signals shall be directly hardwired to the ASC VAV controller with the exception of wireless sensors. The internal actuator shall employ a manual override that allows for powered or non-powered adjustment of the damper position. In all cases, the controller shall automatically resume proper operation following the return of power to, or control by the ASC VAV. Programming, configuring and/or troubleshooting of input/output signals shall be easily executed through the ASC VAV sensor at the wall sensor location through the requisite LON connection.
2. The ASC VAV control algorithms shall be designed to limit the frequency of damper repositioning, to extend the life of the components. The ASC VAV shall provide an internal differential pressure transducer. Flows through transducers requiring filter maintenance are not acceptable. The ASC VAV shall provide zone control accuracy equal to or better than +/- 1 degree Fahrenheit. With the submittal package, supplier/provider shall provide performance data that verifies control accuracy of the ASC VAV.
3. Accept platinum 1k ohm and thermistor 10k ohms type II sensors
4. Provide for CO2 sensing and control from control logic within the ASC VAV as per the sequence of operation
5. Configuration of all I/O points shall be accomplished without physical hardware jumpers, switches or settings.
6. The built in actuator shall be a brushless constant torque actuator with direct feed back of the actuator position

F. ASC VAV - Air Balancing

1. Precalibration: Provide as part of the configuration wizard for the ASC VAV an automatic calibration tool that will calibrate the box air balance position based upon the K factor of the box and the cross section of the input duct to the VAV box. The precalibration procedure shall be implemented for all boxes within 5 working days of delivery of conditioned air to the boxes. If such a precalibration tool cannot be provided then System Integrator shall provide for manual adjustment to all VAV boxes to meet the comfort need in the respective areas.
2. Certified Air Balance: The following Air Balancing tools shall be provided:
   a. LCD sensor calibration tool. Provide for a LCD based sensor that operates as a user interface for temperature adjustment, override and display of values along with the ability to perform Air Balance task. The LCD sensor shall provide for access to all of the VAV input and out put

variables to allow for complete Air balance task. Upon completion of Air Balance the application shall deliver a code that documents the air balance calibration for each individual VAV box. In addition, the LCD sensor shall operate as a stand-alone Air Balance tool that communicates directly to the VAV through a wall-mounted sensor with communication port to the VAV.

b. The ASC VAV shall utilize a Niagara Framework wizard to be used as a web browser based balancing tool. This tool shall allow the air balancer to manually control the action of the actuator (e.g. full open, full close, open slowly, close slowly, etc...). Automatic calibration as well as two-point calibration shall be available through this web page. The air balance sequence shall step the balancing supplier/provider through the checkout and calibration of the ASC VAV. Upon completion of the balancing sequence, the flow values presented by the ASC VAV shall match those observed by the balancing supplier/provider's measurement equipment. Additionally, upon completion of the air balance, the ASC VAV shall automatically archive the balance settings for future use including a calibration code that documents the air balance calibration for each individual VAV box.

c. Systems not able to provide a web based air balance tool and a LCD Sensor based balancing tool as part of their the ASC VAV shall provide an individual full time technician during the Air-balancing process to assure full balance compliance.

3.04 SCHEDULE OF LONMARK APPLICATION PROFILES

For a complete outline of the respective profiles please consult www.LONMARK.org :

Terminal Unit Type	LONMARK Application Profile
Roof Top Unit	# 8030
Unit Ventilator	# 8080
Fan Coil Unit	# 8020
Heat Pump Unit	# 8051
Variable Air Volume Box	# 8010

3.05 SPECIAL PURPOSE APPLICATION SPECIFIC CONTROLLERS (SPASC)

A controller designed with unique functions and featues particular to a specific type of mechanical equipment or applications that may be less common and or standarizied in its use and application.

A. SPASC – Thermostat (SPASCT) – A self-contained controller with a built-in user interface that is intended for installation in the occupied space of the building. The SPASCT shall have the following features:

1. The SPASCT shall be a microprocessor-based controller with all of its control logic, sensors, inputs and outputs, network communication and user interface provided within a manufacture provided enclosure specific to the application. The enclosure shall be aesthetically appealing with a modern design that will fit in with the architecture of the building. A sample of the SPACT shall be provided as part of the submittal process.
2. The SPASCT shall be programmed through the user interface contained within the controller and through the LNS plug-in.
3. The User interface display shall be provided with three levels of password protection: Level 1 – Lockout with view only and time adjustment; Level 2 - schedule override and mode settings; Level 3 – full access to all parameters. Where required in the sequence of operation provide for within Level 2 access

the ability to change the units of measure displayed for temperature from Fahrenheit to Celsius. The display shall be backlighted for easy viewing.

4. If required within the sequence of operation, provide for a control schedule and time clock within the SPACT. The control schedule shall provide for a separate schedule for each day of the week with four events per day. The real time clock will have a six hour power reserve time
5. The SPASCT shall utilize a PI (proportional and integral) control algorithm. Upon power failure, all programmed schedules and parameters must be retained in non-volatile flash memory. Progressive temperature recovery shall be a standard feature. Two configurable digital/binary inputs will be available as well as two remote temperature sensor inputs for outdoor air and remote room/return air monitoring. Built-in frost protection, which can be disabled, will energize the heating as soon as the ambient temperature falls below 45°F (5°C). An auxiliary digital/binary output, which can be configured for normally open or normally closed operation, will also be available.

B. Lighting Control (SPASC-LC) – A standalone microprocessor based control panel utilizing LonWorks technology that contains line and or low voltage relays for control of the lighting circuits along with the appropriate schedules and local user interface.

1. The SPASC-LC shall provide as a minimum the following functionality;
   a. Occupant-Sensitive Operating Scenarios
   b. Schedule With Flick Warn
   c. Time-delay Overrides With Flick Warn
   d. Common Area Interlock With Egress Timer
   e. Master Switch Control With Flick Option
   f. Cleaning Lights
   g. Automatic Daylight Switching With Occupant Interlock/Override
   h. Status and Runtime Data
2. It shall be composed of multiple controllers, with the capacity to manage input switches and sensors, output relays as well as lighting sequences and groups, enabling the user to configure and monitor a very large number of different lighting schemes and schedules.
3. The SPASC-LC shall provide, as a minimum, the ability to interface with the hardware of the associated relay panels to allow for minimal disruption to the existing high voltage panel wiring. The SPASC-LC shall be capable of providing all logic, control, runtime data, status information, and communications functions. From any built-in operator interface of any display unit, the ability to read the status of the lighting relays and switches shall be provided.
4. It shall be configured using a Niagara Framework compatible wizard.
5. The SPASC-LC shall allow for the configuration of up to 16 schedules, each comprised of 7 weekday and 4 holiday schedules, using the lighting scheduler plug-in, which should also be LNS based.
6. The SPASC-LC display unit shall allow for the local display of lighting points as described in 5.2. It shall also contain an astrological time clock that allows for the real time calculation of the geographic location using latitude and longitude information. This is to allow for precise and efficient outside lighting control.
7. The SPASC-LC shall be able to control the General Electric® three-wire relay or a two-wire Aromat relay.

PART 4- BAS SOFTWARE TOOLS

4.01 Provide one (1) copy of all tools necessary for the development, maintenance, expansion and use of the BAS described within these specifications. All software tools shall be compatible with Microsoft Windows XP Professional. For the purpose of this specification software tools shall be divided into the following categories and meet these specified requirements.

A. Controller Programming Software

1. Provide Wizards or objects that facilitate the programming and configuration of the Application Specific Controllers (ASC), Free Programmable Controller (FPC) and or the Special Purpose Controllers (SPC) sequence of operation through menu driven wizard. The programming tools shall perform the following functions:
   a. FPC programming shall be accomplished by either: Text based codes similar to the BASIC programming language combined with objects to define normal controller functions such as PID loops, optimum start stops, I/O configurations, timers, schedules, trends, and network variables or; Graphical programming language (GPL) where objects are used to define different portions of the control sequence. All control sequences programmed into the FPC shall be stored in non-volatile memory. Systems that only allow selection of sequences from a library or table are not acceptable. All code must be exportable to a library for future use.
   b. ASC and SPASC – Provide for the programming of the required sequence of operation through an intuitive menu driven selection process. No text code or graphical programming will be allowed. The configuration tools menu shall define items such as I/O configurations, set point, delays, PID loops, optimum start stops, and network variables settings. The configuration tool must indicate the device status and allows system override.
2. Wizards shall be provided free of charge and be compatible with the current published versions of the network management tool that is provided as part of this project. The wizard software shall be available for public access from the manufacturer's web site. These wizard programming tools shall be compatible with at least three other manufactures network management tools. The SI shall demonstrate as part of their prequalification as to how they intend to comply with these requirements. Should wizards as specified herein not be available then the SI shall provide the following:
3. Provide one (1) copy of the programming or configuration tools (excluding the UIP and GUI tools) along with any manufacture specific software tools required to operate the programming or configuration tools. Such tools shall be provided with a permanent and operating system transferable license.
4. Provided free of charge to the County or his designated agent for a period of 10 years the latest manufactures updates to the software described in paragraph 1.
5. Provide a statement, as part of the prequalification, signed by an officer of the Manufacture validating the performance of the requirements in paragraph 1 & 2.

B. Network Management – A set of tools that provide for the development and management of LONWORKS networks.

1. 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.
2. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.
3. 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.
4. These tools shall provide the ability to "discover" 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.

5. The network management database shall be resident in the BC 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.
6. Provide for the ability to access all of the Network Management tool functions including controller programming from a Web Browser.

C. Building Controller Programming Software – A set of tools for the development of the BC control logic, point management, global properties such as alarm, trend and scheduling.

1. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Access to these functions shall be provided through Graphical User Interface software (GUI). 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 displays shall not be acceptable.
2. 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.
3. 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.
4. The software shall provide the ability to view the logic in an 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.
5. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.
6. 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.
7. Object Libraries Software - A standard library of software objects that represent functions and applications for the development and setup of application logic, user interface displays, system services, and communication networks.
   a. 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.
   b. 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.

c. All control objects shall conform to the control objects specified in the LonWorks specification.

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

1) 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.

2) 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, resource file and documentation for the device to facilitate device integration.

4.02 GRAPHICAL USER INTERFACE SOFTWARE

A software tool that provides for the development and management of the end user's Graphical User Interface (GUI) and as the primary point of access to the BAS for the end user.

A. 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.

B. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating or assembling objects from a GIF, 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.

2. 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.

3. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.

a) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.

b) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

4. 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.

5. 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.

C. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
   1. Create, delete or modify control strategies.
   2. Add/delete objects to the system.
   3. Tune control loops through the adjustment of control loop parameters.
   4. Enable or disable control strategies.
   5. Generate hard copy records or control strategies on a printer.
   6. Select points to be alarm-able and define the alarm state.
   7. Select points to be trended over a period of time and initiate the recording of values automatically.

D. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of 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. All system documentation and help files shall be in HTML format.

E. Security. Each operator shall be required to log on to that 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 administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

F. 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.

G. Alarm Console
   1. 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.
   2. When the Alarm Console is enabled, a separate alarm notification window will supersede 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.

PART 5 - USER INTERFACES

5.01 WEB BROWSER CLIENTS

The primary means of access to the BAS for day-to-day operation from any PC connected to the LAN (and or remote via the Internet if so required) without the need for any proprietary software...

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Netscape Navigator™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.

B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine

requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the Building Automation System (BAS), shall not be acceptable.

C. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

D. The Web browser client shall support at a minimum, the following functions:
   1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
   2. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
   3. HTML programming shall not be required to display system graphics or data on a Web page
   4. Storage of the graphical screens shall be in the Building Controller (BC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
   5. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
   6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
      a) Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
         1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
         2) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
      b) 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.
      c) View logs and charts
      d) View and acknowledge alarms
   7. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
   8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

5.02 LCD DISPLAY

A wall mounted easy to operate User Interface that provides direct read / write access to any point on the network. The LCD Display shall provide the following:

A. The Display shall consist of an alphanumeric LCD display of 16 lines x 16 characters, and a multi-function keyboard. At total of 250 points shall be available for display and or control in groups of 50. Each group shall have a minmun of 13 alpha numeric character descriptor and each point shall have up to a minimun of 16 character alpha numeric descriptor.

B. The display shall have a graphical logo displayed on its default screen. This logo shall be a standard monochrome bitmap of 89x128 pixels that the user can replace. Configuration of the display shall be made available from a wizard contained within the system programming tools

C. The Display User access shall be through a simple to use directional and entry buttons. Full keyboards shall be accepted

D. The LCD Display shall be provided as a surface mount or flush mount as shown on the mechanical drawings.

5.03 LCD SENSOR

Where required provide for a LCD based sensor to connect to the VAV and or FCU that operates as a user interface for temperature adjustment, override and display of values along with the ability to perform Air Balance task (for VAV).

PART 6 – PERIPHERAL DEVICES

6.01 TEMPERATURE SENSORS AND TRANSMITTERS

General Sensor & Transmitter Requirements

A. Provide sensors and transmitters required as outlined in the input/output summary and sequence of operation, and as required to achieve the specified accuracy as specified herein.

B. Temperature transmitters shall be equipped with individual zero and span adjustments. The zero and span adjustments shall be non-interactive to permit calibration without iterative operations. Provide a loop test signal to aid in sensor calibration.

C. Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored. Transmitters shall be equipped with a linearization circuit to compensate for non-linearities of the sensor and bridge and provide a true linear output signal.

D. Temperature sensors shall be of the resistance type and shall be either platinum 1k ohm or thermistor 10k ohms type II as specficied elsewhere.

E. Thermistors are acceptable provided the mathematical relationship of a thermistor with respect to resistance and temperature with the thermistor fitting constraints is contained with the CU operating software and the listed accuracy's can be obtained. Submit proof of the software mathematical equation and thermistor manufacturer fitting constants used in the thermistor mathematical/expressions. Thermistors shall be of the Thermistor (NTC) Type with a minimum of 100 ohm/°F. resistance change versus temperature to insure good resolution and accuracy. Thermistors shall be certified to be stable ±0.24°F. over 5 years and ±0.36°F. accurate and free from drift for 5 years.

F. CU operating software shall be equipped with a self-calibrating feature for temperature sensors.

G. The following accuracy's are required and include errors associated with the sensor, lead wire and A to D conversion.

Point Type	Accuracy
Outside Air	0.5°F.

Chilled Water	0.5°F.
Room Temperature	1.00°F.
Hot Water/Steam	0.75°F.
Duct Temperature	0.5°F.
Sensors Used in Energy Water (BTU) or Process Calculations	0.1°F.

H. Sensors used in BTU or process calculations shall be accurate to ±0.10°F. over the process temperature range. Submit a manufacturer's calibration report indicating that the calibration certification is traceable to the National Bureau of Standards (NBS) Calibration Report Nos. 209527/222173.

I. Thermowells
1. When thermowells are required, the sensor and well shall be supplied as a complete assembly including well head and greenfield fitting.
2. Thermowells shall be pressure rated and constructed in accordance with the system working pressure
3. Thermowells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
4. Thermowells shall be constructed of the following materials: Chilled and Hot Water: brass; Steam: 316 stainless steel; Brine (salt solutions): marine grade stainless steel.

J. Outside Air Sensors
1. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
2. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.
3. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

K. Duct Type Sensors
1. Duct mount sensors shall mount in a hand box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A neoprene grommet (sealtite fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
2. Duct sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. Duct sensors probe shall be constructed of 304 stainless steel.
3. For outdoor air duct applications, use a weatherproof mounting box with weatherproof cover and gasket.
4. Averaging Duct Type Sensors - For ductwork greater any dimension than 48 inches and/or where air temperature stratification exists, utilize an averaging sensor with multiple sensing points. The averaging sensor shall be a 304 stainless steel tube with holes extending across the duct or plenum to be sampled. A bleed hole outside the duct or plenum causes air to enter the sample tube and exit at the bleed hole, thus bathing the sensor in average air. The averaging sensor shall be installed complete with end cap, compression fittings, gaskets, mounting flange and required accessories. Provide capillary supports at the sides of the duct to support the sensing string.

L. Acceptable Manufacturers:
1. Duct/Immersion Sensors – BAPI or Mamac
2. Room Sensors – Distech Controls or BAPI

M. Relative Humidity Sensors/Transmitter

1. The sensor shall be a solid state, resistance type relative humidity sensor of the Bulk Polymer Design. The sensor element shall be washable and shall resist surface contaminations.
2. Humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2 wire isolated loop powered, 4-20ma, 0-10 vdc linear proportional output.
3. The humidity transmitter shall meet the following overall accuracy including lead loss and A to D conversion.
4. Room Type Sensor ±3% RH
5. Provide a single point humidity calibrator, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
6. Acceptable Manufacturers: VERIS

N. Differential Pressure Transmitters and Accessories
1. General Air and Water Pressure Transmitter Requirements:
2. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
3. Pressure transmitters shall provide the option to transmit a 0 to 5V dc, 0 to 10V dc, or 4 to 20 mA output signal.
4. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device and shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (3 valve manifolds).
5. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.
6. Low air pressure, differential pressure transmitters used for room filter monitoring. Shall be equipped with a LED display indicating the transmitter output signal.
7. Low Air Pressure Applications (0 to 0.5" WC)
   a. The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
   b. Span: Not greater than two times the design space DP.
   c. Accuracy: Plus or minus 0.5% of F.S.
   d. Dead Band: Less than 0.3% of output.
   e. Repeatability: Within 0.2% of output.
   f. Linearity: Plus or minus 0.2% of span.
   g. Response: Less than one second for full span input.
   h. Temperature Stability: Less than 0.01% output shift per degree °F. change.
8. The transmitter shall utilize variable capacitance sensor technology and be immune to shock and vibration.
9. Provide a 18-month warranty for each transmitter. Replace all transmitters found to be defective at no cost to the County during the warranty period. Acceptable Manufacturers: VERIS

O. Flow, Pressure, and Electrical Measuring Apparatus
1. Airflow/Temperature Measurement Devices
   a. Provide airflow/temperature measurement devices where indicated on the plans.
   b. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.
   c. Each measurement device shall consist of one or more sensor probe assemblies and a single microprocessor-based transmitter.
   d. Each sensor probe assembly will contain one or more independently wired sensor housings. Multiple sensor housings shall be equally weighted and averaged by the transmitter prior to output. Pitot tubes and

arrays are not acceptable. Vortex shedding flow meters are not acceptable.

e. All Sensor Probe Assemblies

f. Each sensor housing shall be manufactured of a U.L. listed engineered thermoplastic.

g. Each sensor housing shall utilize two hermetically sealed, bead-in-glass thermistor probes to determine airflow rate and ambient temperature. Devices that use "chip" type thermistors are unacceptable. Devices that do not have two thermistors in each sensor housing are not acceptable.

h. Each sensor housing shall be calibrated at a minimum of 16 airflow rates and have an accuracy of +/-2% of reading over the entire operating airflow range. Each sensor assembly shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).

i. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

j. The operating temperature range for the sensor probe assembly shall be -20° F to 160° F. The operating humidity range for the sensor probe assembly shall be 0-99% RH (non-condensing).

k. Each temperature sensor shall be calibrated at a minimum of three temperatures and have an accuracy of +/-0.15° F over the entire operating temperature range. Each temperature sensor shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).

l. Each sensor probe assembly shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to a remotely mounted transmitter.

m. Each sensor assembly shall not require matching to the transmitter in the field.

n. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location.

2. Duct and Plenum Sensor Probe Assemblies

a. Sensor housings shall be mounted in an extruded 6063 aluminum tube probe assembly.

b. The number of sensor housings provided for each location shall be determined by the manufacturer based on the requirements of the application.

c. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:

d. Insertion mounted through the side or top of the duct

e. Internally mounted inside the duct or plenum

f. Standoff mounted inside the plenum

g. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

3. Fan Inlet Sensor Probe Assemblies

a. Sensor housings shall be mounted on 304 stainless steel blocks.

b. Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel-plated steel.

c. Mounting feet shall be constructed of 304 stainless steel.

d. The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.

4. Transmitters

a. The transmitter shall operate on 24 VAC. The transmitter shall not require an isolated power source.

b. The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be protected from weather and water.

c. The transmitter shall be capable of communicating with the host controls using one of the following interface options:

d. Linear analog output signal: Field selectable, fuse protected and isolated, 0-10VDC and 4-20mA (4-wire)

e. The measuring device shall be UL listed as an entire assembly.

f. Acceptable Manufacturer: Ebtron ONLY - provide per part number on contract drawings.

5. Energy (BTU) Measurement System (Chilled Water, Hot Water, Condenser Water)

a. The BTU meter shall provide the following points both at the integral LCD and as outputs to the building control system: Energy Total, Energy Rate, Flow Rate, Supply Temperature and Return Temperature.

b. The Energy Measurement System shall consist of an insertion turbine flow meter, two temperature sensors, a BTU meter, temperature thermo-wells, and all required mechanical installation hardware.

c. Output signals shall be either serial network (protocol conforming to LONWORKS®) or via individual analog and pulse outputs.

d. Each BTU meter shall be factory programmed for its specific application, and shall be re-programmable using the front panel keypad (no special interface device or computer required).

e. A certificate of calibration shall be provided with each system.

f. Temperature sensors:

1) Temperature sensors shall be loop-powered current based (mA) sensors and shall be bath-calibrated and matched (NIST* traceable) for the specific temperature range for each application.

2) The calculated differential temperature used in the energy calculation shall be accurate to within +0.150F (including the error from individual temperature sensors, sensor matching, input offsets, and calculations).

3) Flow Meter (Insertion Turbine):

4) Provide an ONICON Model F-1200 Dual Turbine Flow Meter, complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown.

5) The flow meter shall be hand-insertable up to 400 psi.

6) The flow meter shall have two contra-rotating axial turbines, with electronic impedance-based sensing and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion.

7) Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST*.

8) A certificate of calibration shall be provided with each flow meter.

9) Accuracy shall be within ± 0.5% of rate at the calibrated velocity, within ± 1% of rate over a 10:1 turndown (3.0 to 30 ft/s) and within ± 2% of rate over a 50:1 turndown (from 0.4 to 20 ft/s).

10) Output signal shall be a 0-15 V square wave pulse. Bi-directional meters shall be FB-1200 Series and shall include an isolated contact closure output for direction.

11) Acceptable Manufacturer: ONICON System-10 BTU Meter ONLY - provide per part number on contract drawings.

P. Shielded Static Pressure Sensor

1. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber with minimum volume of 50 cubic inches, airflow

shielding, and 3/8" compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.

2. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow of 1000 FPM from a radial source.
3. The shielded static sensing devices shall be used for both reference and space pressure sensing.
4. Pressure sensors used for outside air pressure reference purposes shall be equipped with a conduit seal for pneumatic tubing and bushings for a weather tight installation.
5. Acceptable Manufacturer: Veris ONLY

Q. Static Pressure Traverse Probe - Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.

1. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
2. The duct static traverse probe shall be of 304 stainless steel construction and (except for 3/4" dia. probes with lengths of 24" or less) be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure without need for correction factors, with an instrument accuracy of 21.
3. Acceptable Manufacturer: Veris ONLY

R. Carbon Dioxide Sensor for Demand Controlled Ventilation. Provide a general purpose indoor transmitter/sensor assembly with removable sensor, UL listed. 4-20 mA DC output representing 0-2000 ppm. Minimum (5) year sensor life, with field-replaceable sensor unit. Accuracy +/- 1 percent of reading at 77 degrees F. Long-term drift less than 1 percent of scale per year. For wall-mounted sensors, provide local readout display. Acceptable manufactures: Vaisala GMW/GMD 20, or approved equivalent.

S. Venturi Flowmeter – Provide venture flowmeters with the following features:

1. Pressure drop on venturi type flow meters shall not exceed 0.25" WC. Each venturi low and high-pressure taps shall be equipped with nipples, valves and quick disconnects.
2. Equip each venturi with a metal identification tag indicating the size, location, GPM and meter reading for the GPM specified.
3. Provide one 6" dial differential pressure meter of the proper range to determine piping system flow rate. The meter shall be the property of the County.
4. Venturi meters shall utilize flanged or screwed connections for removal purposes and shall be rated for the system operating pressures.
5. The venturi flow meter shall be factory calibrated to provide a minimum of flow accuracy between actual and factory flow calibration data.

T. Current Transformers – Provide current transformers with the following features:

1. The current transformers shall be designed to be installed or removed without dismantling the primary bus or cables. The transformer shall be of a split core design.
2. The core and windings shall be completely encased in a UL approved thermoplastic rated 94VA. No metal parts shall be exposed other than the terminals.
3. Frequency Limits: 50 to 400 Hz. Insulation: 0.6 KV Class, 10 KV BIL.
4. Accuracy: ± 1% at 5.0 to 25.0 VA accuracy class with U.P.F. burden.
5. Provide a disconnect switch for each current transformer.
6. Acceptable Manufacturer: Senva ONLY

U. Current Sensing Switches - Current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. Current sensing switches shall consist of a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over current up to twice its trip into range. Acceptable Manufacturer: Senva ONLY.

V. Relays - Relays other than those associated with digital output cards shall be general purpose, enclosed plug-in type with 8-pin octal plug and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.

W. Solid State Relays (SSR): Input/output isolation shall be greater than IOE9 ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz. The contact life shall be 10 x 10 E6 operations or greater. The ambient temperature range of SSRs shall be -20 to +140F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.

X. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semipermanent magnets. Contractor shall be double-break-silver-to-silver type protected by arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

Y. Dirty Filter Differential Air Pressure Switch – Provide for a large diaphragm operated, SPDT switch, exposed adjustment, 1% repetitive accuracy. Dwyer 1638 with A-302 static tips, or equivalent

Z. Differential Water Pressure Switch – Provide a double diaphragm type, brass or stainless wetted parts, min. 200-psi working pressure. Adjustable cut-in and differential, SPDT snap acting switch suitable for 120 VAC control circuit. Mercoid, Model DP or equivalent.

AA. Water Flow Switch (Paddle Type) – Provide a brass body, aluminum housing, and stainless steel segmented paddle. Magnetic link between paddle movement and switch movement. W.E. Anderson V4-2-U or equivalent.

6.02 VALVES AND ACTUATORS

A. Hardware Warranty - Ball Valves, Ball Valve Actuators and Electronic Valve Actuators for Butterfly Valves shall be covered by a 4-year product warranty from the date of substantial project completion. Industrial-type Electronic Valve Actuators and Butterfly Valves shall be covered by a 36-month product warranty from date of substantial project completion

B. Labor Warranty - All labor to replace failed Valves and Actuators shall be provided during the first 12 months of the warranty starting from the date of project completion.

C. Approved manufactures are: Belimo. Other manufacturers must be approved, in writing, no less than 10 days prior to the bid date.

D. Electronic Air Damper Actuators
   1. Electronic actuators shall be UL listed under standard 873, CUL, and have a CE certification. Electronic actuators shall be produced in accordance to ISO 9002 quality certification standards in a certified production facility.
   2. Electronic air damper actuators shall be capable of coupling directly to the damper shaft. Standard actuator mounting clamp shall be operated with a single

fastener, and shall center the damper shaft in the actuator spline (hollow-shaft), with toothed edges gripping four sides of the shaft. Clamps that do not center the shaft, and as such require concentric motion for operation, are not acceptable. Universal U-shaped bolts, single point, or set screw type fastening techniques are not acceptable. Adaptors form fit to the damper shaft are acceptable.

3. All electronic actuators shall include a manual positioning feature to allow for the full rotation of the actuator, in each direction with or without electrical power applied.
4. All actuators shall be designed, developed, life cycle tested and manufactured with a high performance, brushless DC motor to offer a constant running time, independent of torque load and offer maximum product reliability and life expectancy. DC motors with brushes are not acceptable.
5. Actuators shall be fully modulating/proportional and accept both 2...10 VDC and 0...10 VDC control inputs (as well as 4...20 mA using a load resistor) factory set or field selectable, floating/tri-state, two-position/on-off control. Actuators shall have visual position indicators for both standard mount and short-shaft mounting requirements.
6. All proportional actuators shall include a direct and reverse acting switch, to allow for easy adjustment of control direction of rotation. This switch must be concealed to protect it from damage and to avoid incorrect adjustment.
7. Actuators shall be capable of operating on 24, 110, or 230 VAC, or 24 VDC and Class 2 wiring as needed for the application. Power consumption shall not exceed 20 VA for AC, including 110 VAC actuators.
8. Optional, add-on auxiliary switches shall be available in NEMA 4 watertight housings. Separate moisture protection covers are not required and will not be accepted.
9. Actuators shall have an operating temperature range of -22 deg. F to 122 deg. F.
10. Actuators shall be constructed with a high-protection NEMA 4 rated housing to protect the internal electronics and mechanical parts. Separate moisture protection covers are not required and will not be accepted.
11. Actuators shall include a 3 ft. long (minimum) factory installed and pre-wired electrical cable and strain relief with threaded conduit fitting requiring no tools. Actuators requiring removal of the actuator cover for access to the wiring terminals are not acceptable.
12. Actuators shall have internal electronic overload protection to protect the actuator from damage throughout its operating range. End switches to deactivate the actuator at the end of its rotation are not acceptable.
13. For power-failure/safety applications, an internal spring-return mechanism shall be built into the actuator housing. Spring-return actuators shall be capable of both CW and CCW mounting orientation. Electronic energy storage fail-safe systems incorporating high-energy capacitors are an acceptable alternative to mechanical spring return mechanisms. These fail-safe systems shall provide sufficient energy to operate the actuator under full torque load. They shall include thermal compensation to the charging system of the Gold Cap capacitors, and incorporate the capacitor in the actuator control electronics to ensure long-term and consistent maintenance of voltage stored via the capacitor. During a loss of power, the electronic fail-safe systems shall mechanically lock the damper via its gear train into the desired fail-safe position.
14. For proportional actuators using a 2...10 VDC control signal, the actuator shall fail open or closed based on receiving a minimum control signal of 1 VDC or less. Upon loss of power, a non spring-return actuator shall maintain the last control position.
15. All proportional, electronic air damper and valve actuators shall be field switch adjustable for 0...10 VDC, 2...10 VDC (or 4...20 mA using a load resistor) control input. Position feedback, running time and the programming of the microprocessor shall be factory set to avoid the introduction of electronic noise or

interference with the BAS controller or other equipment. Field programming or changing of the factory set programming of the actuators is not acceptable.

16. All hazardous location shall require explosion-proof direct-coupled actuator enclosure NEMA 7 and NEMA 9 construction for field-mounted, direct-mount style actuators. The enclosure shall be aluminum housing with explosion proof rating for Class I, Division 1, Groups C, D and Class II, Division 1, Groups E, F, G.
17. Acceptable Manufacturer: Belimo ONLY

E. Electronic Ball Valve Actuators

1. Electronic actuators shall be UL listed under standard 873, CUL, and have a CE certification.
2. Electronic valve actuators shall be capable of coupling directly to the valve stem, shaft or ISO mounting pad. Valve body and actuator shall be pre-assembled by the manufacturer to ensure adequate torque to operate and close the valve, and to provide accurate control direction and fail-safe direction assembly according to project specifications.
3. Control valve actuator shall provide minimum torque required for full valve shutoff position.
4. All electronic actuators shall include a manual positioning feature to allow for the full rotation of the actuator, in each direction with or without electrical power applied.
5. All actuators shall be designed, developed, life cycle tested and manufactured with a high performance, brushless DC motor to offer a constant running time, independent of torque load and offer maximum product reliability and life expectancy. DC motors with brushes are not acceptable.
6. All proportional actuators shall include a direct and reverse acting switch, to allow for easy adjustment of control direction of rotation. This switch must be concealed to protect it from damage and to avoid incorrect adjustment.
7. Actuators shall be capable of operating on 24, 110, or 230 VAC, or 24 VDC and Class 2 wiring as needed for the application. Power consumption shall not exceed 20 VA for AC, including 110 VAC actuators.
8. Optional, add-on auxiliary switches and potentiometers shall be available in NEMA 4 watertight housings. Separate moisture protection covers are not required and will not be accepted.
9. Actuators shall have an operating temperature range of -22 deg. F to 122 deg. F.
10. Where required, actuators shall be constructed with a high-protection NEMA 4 rated housing to protect the internal electronics and mechanical parts. Separate moisture protection covers are not required and will not be accepted.
11. Actuators shall include a 3 ft. long (minimum) factory installed and pre-wired electrical cable and strain relief with threaded conduit fitting requiring no tools. When required, actuators with 10-ft electrical cable shall be available. When required, actuators with NEMA 1 rated housing with wiring terminals accessible on the cover shall be available. Actuators requiring removal of the actuator cover for access to the wiring terminals are not acceptable.
12. Actuators shall have internal electronic overload protection to protect the actuator from damage throughout its operating range. End switches to deactivate the actuator at the end of its rotation are not acceptable.
13. For power-failure/safety applications, an internal spring-return mechanism shall be built into the actuator housing. Spring-return actuators shall be capable of both CW and CCW mounting orientation. Electronic energy storage fail-safe systems incorporating high-energy capacitors are an acceptable alternative to mechanical spring return mechanisms. These fail-safe systems shall provide sufficient energy to operate the actuator under full torque load. They shall include thermal compensation to the charging system of the Gold Cap capacitors, and incorporate the capacitor in the actuator control electronics to ensure long-term and consistent maintenance of voltage stored via the capacitor. During a loss of

power, the electronic fail-safe systems shall mechanically lock the damper via its gear train into the desired fail-safe position.

14. For proportional actuators using a 2...10 VDC control signal, the actuator shall fail open or closed based on receiving a minimum control signal of 1 VDC or less. Upon loss of power, a non spring-return actuator shall maintain the last control position.
15. All proportional, electronic air damper and valve actuators shall be field switch adjustable for 0...10 VDC, 2...10 VDC (or 4...20 mA using a load resistor) control input. Position feedback, running time and the programming of the microprocessor shall be factory set to avoid the introduction of electronic noise or interference with the BAS controller or other equipment. Field programming or changing of the factory set programming of the actuators is not acceptable. Actuators shall have visual position indicators for both standard mount and short-shaft mounting requirements
16. When required, in hazardous locations explosion-proof direct-coupled actuator enclosures in NEMA 7 and NEMA 9 construction for field-mounted, direct-mount style actuators shall be available. The enclosure shall be aluminum housing with explosion proof rating for Class I, Division 1, Groups C, D and Class II, Division 1, Groups E, F, G.
17. Acceptable Manufacturer: Belimo ONLY.

F. Equal Percentage Ball Valves 1/2" to 3" Threaded
1. Actuated Ball Valve
   a. Valve housing shall consist of forged brass CuZn39Pb2 rated at no less than 360 psi at 250°F.
   b. Valve ball shall consist of chemically nickel-plated brass. 2-Way Valve: Manufacturer shall be able to provide optional 316 SS ball and stem.
   c. Valve shall have a blowout proof stem with two EPDM O-Rings with minimum 600 psi rating.
   d. Manufacturer shall be able to provide glass-filled polymer ball insert to make flow control equal percentage.
2. 2-Way Valve: Valve shall have EPDM O-Rings behind ball seals to allow for a minimum close-off pressure of 100 psi for 1/2" - 2" sizes. 3-Way Valve: 40 psi.
3. 2-Way Valve: Valve shall be available with a minimum of 25 unique Cv values. 3-Way Valve: Bypass Cv shall be 80% of Through Cv.
4. Valve shall be available with fixed end female end connections.
5. 3-Way Valve: Valves shall be installed in Tee configuration with actuator perpendicular to shaft. Valve shall not require elbows of any kind.
6. Acceptable Manufacturer: Belimo ONLY.

G. Accessories
1. Identification tags shall be available for all valves; tags shall be indelibly marked with Cv, model number and location.

PART 7 - EXECUTION

7.01 EXAMINATION

A. Verification
1. Verify that all systems are ready to receive work.
2. The project plans shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.
3. The contractor shall inspect the site to verify that equipment is installable as show, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

4. The Control System Contractor shall examine the drawings and specifications for other parts of the work, and if head room or space conditions appear inadequate or if any discrepancies occur between the plans and his work and the plans for the work of others, he shall report such discrepancies to the Architect/Engineer and shall obtain written instructions for any changes necessary to accommodate his work with the work of others.

B. General Installation Requirements
1. Install all control components in accordance with manufacturer's instructions and recommendations.
2. If the controls contractor is responsible for providing the damper then provide mixing dampers of parallel blade construction arranged to mix streams. Provide separate minimum outside air damper section adjacent to variable outside air damper.
3. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide nameplates for instruments and controls inside cabinet and nameplates on cabinet face.
4. After completion of installation, test and adjust control equipment. Submit data showing setpoints and final adjustments of controls.
5. Install equipment, piping, wiring/conduit parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
6. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
7. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
8. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

C. Graphical User Interface PC Location
1. Install Graphical User Interface PC in the location indicated. Do not deliver the Graphical User Interface PC to the job site until a proper location has been prepared. Location shall be clean and dry, free from construction dust and debris.
2. Location shall have a dedicated work surface (table or desk with chair). Work surface shall be provided by County or General Contractor for use by this Contractor.
3. Location shall have ample storage provisions for documentation and manuals, either shelving or a four drawer upright filing cabinet. Storage provisions shall be provided by County or General Contractor for use by this Contractor.
4. Location shall have a dedicated locked electrical circuit for use by this Contractor.

D. Ethernet Network Connection
1. All nevices that require a connection to the LAN or access to an ISP shall be approved by the Countys Information Technology representitive prior to installation.
2. All ethernet communication connections shall be provided by the County or General Contractor.

7.02 ELECTRICAL SYSTEM INSTALLATION

A. Comply with all Division 16 Installation Requirements.

B. Provide interlock wiring between supply and exhaust fans, electrical wiring for relays (including power feed) for temperature and pressure indication.

C. Provide power wiring, conduit and connections for low temperature thermostats, high temperature thermostats, alarms, flow switches, actuating devices for temperature, humidity, pressure and flow indication, point resets and user disconnect switches for electric heating, appliances controlled by this Section.

D. Provide all other wiring required for the complete operation of the specified systems.

E. Where required install all wiring raceway systems complying with the requirements of the National Electrical Code. All required conduit shall be installed in EMT.

F. Provide interlock wiring between supply and exhaust fans, electrical wiring for relays (including power feed) for temperature and pressure indication.

G. Surge Protection and Lighting Protection
   1. All equipment and all communication media shall be suitably protected from damage associated with electrical surge and lightning strike. Submittal and approval is required for all such devices.
   2. All input-output hardware and instrumentation located outdoors shall be isolated using approved surge suppression devices.
   3. All telephone modem connections shall be isolated using approved surge suppression devices.
   4. All building-to-building communication connections shall be isolated using approved surge suppression devices.
   5. All temperature control panels and controllers shall be provided with a control power transformer with fuse protection on both the primary and secondary sides.

H. Provide electrical disconnecting means for servicing, for each control panel, digital controller, router, transformer, power supply, and other devices that are served by 120VAC or higher voltage.

I. Enclosures shall be fabricated of 14ga. steel with sub-panels for component mounting and have removable, hinged doors. Enclosures shall be sized to house the controllers, power supplies, transformers, relays, wire duct and miscellaneous equipment required to support the application. Enclosures shall be provided for all controllers that are not located within an OEM provided mechanical equipment or on a VAV box. Control panels shall be fabricated as UL 508 listed assemblies.

J. Enclosure power supply shall provide at least one 40VA and one 100VA transformer with individual on/off switches and circuit breakers and two 120VAC outlets. Enclosures and power supplies shall be UL listed Class II.

K. LONWORKS Network Communication Requirements
   1. LONWORKS network communication shall be via channels consisting of a 22 AWG unshielded twisted pair in compliance with manufactures recommendations for LonTalk communications
   2. In all communication conduits, provide one spare twisted pair to be installed, tagged and labeled at each end.
   3. Communication conduits shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible.
   4. There shall be no power wiring, in excess of 30 VAC rms, run in conduit with communications wiring.

L. Input/Output Control Wiring
   1. Platinum 1k ohm and 10k ohms thermistor type II wiring shall be two-wire or four-wire twisted, shielded, minimum number 22 gauge.

2. Other analog inputs shall be a minimum of number 22 gauge, twisted, shielded.
3. Binary control function wiring shall be a minimum of number 18 gauge.
4. Analog output control functions shall be a minimum of number 18 gauge, twisted, shielded.
5. Binary input wiring shall be a minimum of number 18 gauge.

M. Splices in shielded cables shall consist of terminations and the use of shielded cable couplers, which maintain the integrity of the shielding. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties as specified herein.

N. Conduit and Fittings
1. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.
2. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.
3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.
5. Install low voltage power and LON and LAN communication trunks in conduit in the following locations regardless of local building code allowances otherwise.
   a. Mechanical rooms.
   b. Electrical rooms.
   c. Vertical risers (exception: fire rated continuous closet like a telephone closet).
   d. Open Areas where the wiring will be exposed to view or tampering.
6. Conceal conduit within finished shafts, ceilings and wall as required. Install exposed conduit parallel with or at right angles to the building walls.

O. Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that:
1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
2. All cables shall be UL listed for application, i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.

P. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

Q. Where Class 2 wiring is run exposed, wiring to be run parallel along a surface or perpendicular to it, and NEATLY tied at 3m (10 ft.) intervals.

R. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

S. Plug or cap all unused conduit openings and stub-ups. Do not use caulking compound.

T. Route all conduit to clear beams, plates, footings and structure members. Do not route conduit through column footings or grade beams.

U. Set conduits as follows:

1. Expanding silicone fire stop material sealed watertight where conduit is run between floors and through walls of fireproof shaft.
2. Oakum and lead, sealed watertight penetration through outside foundation walls.

V. Cap open ends of conduits until conductors are installed.

W. Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with a minimum length of 18 inches and maximum length of 36 inches shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the rigid conduit.

X. Where exposed to the elements or in damp or wet locations, waterproof flexible conduit shall be installed. Installation shall be as specified for flexible metal conduit.

Y. Provide floor, wall, and ceiling plates for all conduits passing through walls, floors or ceilings. Use prime coated cast iron, split-ring type plates, except with polished chrome-plated finish in exposed finished spaces.

7.03 TEMPERATURE SENSORS

A. Temperature sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.

B. Strap-on mountings shall not be permitted.

C. Outdoor installations shall be; of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.

D. Sensors shall be with enclosure where located in finished space.

E. Sensors in ducts shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces or positions obstructed by ducts, equipment, and so forth. Locations where installed shall be within the vibration and velocity limit of the sensing element. Ducts shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.

F. All sensors measuring temperatures in pipes larger than 2 inches in diameter or in pressure vessels shall be supplied with wells properly fabricated for the service. Wells shall be noncorrosive to the medium being measured and shall have sufficient physical strength to withstand pressures and velocities to which they are subjected. Wells shall be installed in the piping at elbows where piping is smaller than the length of the well to effect proper flow across the entire area of the well.

G. All field sensors, transmitters, actuators, switches, etc. shall be field calibrated. The calibration shall be guaranteed for the period of the control system warranty. Any corrections or re-calibration required during the warranty will be performed at no cost to County. Calibration methods, means, instruments, and standards shall be in strict accordance with ISO-9000 standards.

7.04 CONTROLS VALVES, CONTROL DAMPERS AND ACTUATORS

A. Control Valves.
1. Control valves shall be installed by the Div. 15 contractor.
2. Coordinate with the Div. 15 contractor and verify that each control valve can be serviced, including adjustment and removal of the actuator.

3. All control valves shall have unions installed at each inlet and outlet to permit removal of the valve for servicing.
4. Valves shall be installed with stems vertical where possible. Where space conditions require valves to be mounted with stems greater than 45° off vertical the actuator shall be externally supported. In no case will the control valve be mounted with the stem greater than 90° off of vertical.

B. Control Dampers.
1. Control dampers shall be installed by Div. 15 contractor.
2. Coordinate with the Div. 15 contractor the service access requirements of the control dampers, and verify that each control damper can be serviced, including adjustment and removal of the actuator.
3. Div. 15 Contractor shall provide necessary blank-off plates required for installation of reduced-size dampers (dampers that are smaller than duct size).
4. Furnish interconnecting hardware, linkages, etc. for installation of multiple section dampers by Div. 15 Contractor.

7.05 ACCESS DOORS

A. Div. 15 Contractor shall provide access doors or other approved means of access through ducts for service to control equipment.

7.06 INSTRUMENT ENCLOSURES AND CONTROL PANELS

A. Securely mount all control panels and enclosures to wall or structure using bolts, anchors, etc. Mount enclosures and control panels with top at 60 inches above finished floor, unless noted otherwise. Field fabricate enclosure mounting rack from Unistrut or Kindorf, where required. Locate enclosures and control panels to ensure full door swing.

B. Seal all conduit entrances into enclosures and control panels, water tight.

C. Locate enclosures indoors where possible. Provide drains and block heaters for all panels located outdoors.

7.07 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum 1 inch letters on nameplates.

D. Identify all other control components with permanent labels. Identifiers shall match record documents.

E. Affix engraved tags plates on each motor starter controlled through the EMS. Minimum tag size shall be 1 in. X 3 in. Minimum lettering size shall be 3/16 in. high. Tag shall be red with white lettering. Tags shall indicate the following:

CAUTION **This equipment is operating under automatic control and may start at any time without warning**

F. Identify room sensors relating to terminal box or valves with nameplates.

7.08 CLEANING

A. This contractor shall clean up all debris resulting from his or her activities daily. The contractor shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Construction Manager or General Contractor.

B. At the completion of work in any area, the Contractor shall clean all of his/her work, equipment, etc., making it free from dirt and debris, etc.

C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

7.09 PROTECTION

A. The Contractor shall protect all work and material from damage by his/her work or workers, and shall be liable for all damage thus caused.

B. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on-site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

7.10 FIELD QUALITY CONTROL

A. All work, materials and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this Section.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship. All visible piping and/or wiring runs shall be installed parallel to building lines and properly supported.

C. Contractor shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.

7.11 PERFORMANCE EVALUATION/ACCEPTANCE PROCEDURE

A. General: Acceptance of the control system depends in part upon successful demonstration of control system performance. The SI shall prepare a detailed final functional test and verification plan indicating in a step-by-step logical fashion the procedures by which the control system will be tested. This shall include the following procedures:

1. Sequence of Operation - Demonstrate all sequences of operation.
2. Test Documentation - Provide standard formatted documentation for each controlled system and element test.
3. Pre-Testing - The control system installer shall have performed pre-testing of all tests on all components before final testing. If during final testing more than 10 percent of the points or sequences checked are found to be faulty, the Contractor shall halt the test and re-check all parts of the system test.
4. Testing Plan. Submit test plan for approval not less than 4 weeks prior to tests. Meet with County's representative, discuss the test plan, and make necessary

revisions. The test plan shall include, as a minimum, for each control system and sub-system the following:

a. System name.
b. List of devices with brief description of functional purpose of each.
c. The expected signal values transmitted by the sensors/transmitters.
d. The expected signal values transmitted by the controller to the controlled device or actuator.
e. The expected values of the control medium from limit-to-limit.
f. A description of the instrumentation required to test the system, including proof of calibration.
g. A detailed step-by-step process in conducting test and verification.
h. Log sheets on which expected and actual values will be recorded.
i. Other criteria for test to indicate that the system is operating in accordance with Contract requirements.

B. Testing - Inform the Engineer and County of all test dates for attendance, so that the Engineer and/or County may attend the test if desired. Perform all tests. Correct all system maladies found in the testing procedure. Retest as required. If County's representative does not witness test, provide performance certification.

C. Acceptance- The control systems will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction of both the Engineer and County. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the completion requirements if stated as such in writing by the County's representative.

7.12 SCHEDUE OF RESPONSIBILITIES

A. The following schedule identifies the responsible Division for the installation of the building automation system. This schedule should be used as a general guide. The General Contractor is the central authority governing the total responsibility of all trade contractors. Therefore, deviations and clarifications of this schedule are permitted provided the General Contractor assumes responsibility to coordinate the trade contractors different than as indicated herein. If deviations or clarifications to this schedule are implemented, submit a record copy to the Architect.

Item			Furnish By	Install By	Power By	Control Wiring By
1.	Equipment Motors		M	M	E	—
2.	Magnetic Motor Starters:					
	a.	Automatically controlled, with or without HOA switches.	E	E	E	SI
	b.	Manually controlled.	E	E	E	—
	c.	Manually controlled, and which are furnished as part of factory wired equipment.	M	M	E	E
	d.	Special duty type (part winding, multi-speed, etc.)	M	See Note 1.	E	See Note 1.
	e.	Adjustable frequency drives with manual bypass.	SI	SI	E	SI See Note 2.
	f.	Domestic booster pump. Motor Controls	M	M	E	SI
3.	General equipment disconnect switches, thermal overload switches, manual operating switches.		E	E	E	—
4.	Sprinkler system water flow and		M	M	E	—

	Item	Furnish By	Install By	Power By	Control Wiring By
	tamper switches.				
5.	Outside fire alarm horn and light (at Siamese connection).	M	M	E	—
6.	Line voltage contactors.	E	E	E	SI
7.	Control relay transformers (other than starters).	SI	SI	E	SI
8.	Main fuel oil tank alarms (high and low level) and remote indicating lights.	M	M	SI	SI
9.	Day tank fuel oil alarms (high and low level) and remote indicating lights.	E	E	E	SI
10.	Line voltage control items such as line voltage thermostats not connected to control panel systems.	M	E	E	E
11.	Loose controls and instruments furnished as part of the packaged mechanical equipment or required for operation such as valves, float controls, relays, sensors, etc.	M	M	M	M
12.	Control and Instrumentation panels	SI	SI	E	SI
13.	Automatic control valves, automatic dampers and damper operators, solenoid valves, insertion temperature and pressure sensors.	SI	M	E	SI
14.	Duct type fire and smoke detectors, including relays for fan shut down.	E	E	E	E
15.	Contactors for cooling tower basin heaters.	M	M	E	M
16.	Mechanical piping heat tracing (including relays, contactors, thermostats, etc.)	M	M	E	M
17.	Emergency power off (EPO) shut down pushbutton(s) (break glass station) and controls.	M	M	M	M
18.	Control interlock wiring or software bindings between chillers, pumps and cooling towers, fans and air handling units and other miscellaneous mechanical equipment.	SI	SI	E	SI
19.	Electric radiant heating panels un-ducted electric unit heaters and cabinet heaters, and electric baseboard radiation.	E	E	E	E
20.	Airflow control devices with transmitter.	SI	SI	E	SI
21.	Air terminal devices (i.e., VAV and fan powered boxes).	M	M	E	SI
22.	Intelligent Devices and Control Units provided with packaged mechanical equipment such as:	M	M	E	SI
	Valve and damper operators. Heat pumps, AC units.				

	Item	Furnish By	Install By	Power By	Control Wiring By
	Fan Coil Units. Air Terminal Units. Boilers, chillers.				
23.	Intelligent Devices and Control Units provided with electrical systems such as:	E	E	E	SI
	Occupancy/motion sensors. Lighting Control Panels. Switches and Dimmers. Switch Multiplexing Control Units. Door Entry Control Units.				
24.	Gateways for protocol conversion with a non-LONWORKS based system	SI	SI	**SI**	**SI**
25.	Routers, Bridges and Repeaters.	SI	SI	**SI**	**SI**

Abbreviations	
Furnish.	Furnished by
Install.	Installed by
Power	Power Wiring Connection, Low and Medium Voltage
SI	System Integrator
M	Mechanical Contractor
E	Electrical Contractor

B. Notes to Schedule of Responsibilities:

1. Magnetic motor starters (special duty type) shall be set in place under electrical division except when part of factory wired equipment, in which case set in place under mechanical division.
2. Where a remote motor disconnect is required in addition to the one provided integral to an Variable Frequency Drive (VFD), the SI Contractor shall provide the necessary control interlock between the disconnects.
3. The System Integrator shall inform the Mechanical Contractor and the Electrical Contractor of the additional capacity required of control power transformers.
4. Mechanical Contractor shall refer to the electrical specifications and plans for all power and control wiring and shall advise the Architect of any discrepancies prior to bidding. The System Integrator shall be responsible for all control wiring as outlined, whether called for by the mechanical or electrical drawings and specifications.

END OF SECTION