SECTION 23 0923 – DIRECT DIGITAL CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. A complete system of computer based, direct digital automatic temperature controls shall be installed under this contract as required to accomplish the sequence of control for various items of equipment and systems indicated on the drawings and as specified in Division 23.

B. Direct Digital Controls (DDC) upgrade for the existing building controls is part of the scope of work. Refer drawings for systems sequence of operations. Controllers, system architecture, communication cabling and network, software, graphics, etc. shall be seamlessly integrated as part of the new system.

C. This Section includes Direct Digital Control (DDC) components, including operator work station, controller/server, equipment specific and generic controllers, I/O interface, software and graphics.

D. See Sections 23 0913 "Instruments and Control Devices", Section 23 0914 "Control Wiring and Cabling" and Section 23 0993 "Sequence of Operations for Controls" for requirements that relate to this Section.

1.2 SUBMITTALS

A. Product Data: For all hardware and software.

B. Shop Drawings:

1. Schematic air and fluid flow control diagrams, sequence of operations descriptions and points list.
2. Power, wiring diagrams.
3. DDC System Hardware components, including controllers, actuators, sensors, valves, dampers, cabinet enclosures, etc.
4. Control System Software
5. Graphics- screen examples specific to the project for AH unit, VAV box, hot water system and chilled water system.

C. Software and firmware operational documentation.

D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Each control subcontractor must be an authorized temperature control contractor in the business of installing and servicing direct digital temperature control systems for over five (5) years. The

bidder must have installed and successfully completed at least ten (10) DDC systems of similar size using the same hardware that is proposed.

B. Subcontractor installation and service office must be located within 75 miles (90 minute travel time maximum) of the building site.

C. Design and installation of the digital control system shall be performed by employees trained and certified by the equipment supplier. Electrical power work other than low voltage shall be performed by licensed electricians.

D. The temperature controls subcontractor shall provide all necessary engineering support for a complete and functional system, including but not limited to engineering, programming, installation, supervision, commissioning and troubleshooting.

E. Refer to 23 0801 Mechanical Systems Commissioning.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

A. Contractors:
1. Honeywell International Inc Authorized Controls Integrator (ACI) (local authorized contractors only, branch office is not acceptable)
2. Schneider Electric (TAC, Invensys) – I/A Series
3. BuildingLogiX
4. *Alerton (Addendum 1 – 7/31/2023)*

B. Complete DDC system shall consist of operator workstation, sensors, indicators, actuators, final control elements, interface equipment, wiring, cabling, power supplies and power distribution, other apparatus, accessories, software and graphics connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems as specified here and in related Division 23 Sections.

2.2 LICENSING AGREEMENT AND OPEN PROTOCOL

A. A true Open Licensing Agreement shall be provided and executed with the Owner to permit total and open access to the system for servicing and software revisions by other qualified servicing contractors.

B. The supplied system must incorporate open protocol with the ability to access all data using Java base Web enabled browsers without requiring proprietary operator interface and configuration programs.

C. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a server. Proprietary database and user interface programs are not acceptable (except for unitary controllers as noted below).

D. The supplied computer 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 135-1995, BACnet and LonMark to assure interoperability between all present and future system components is required.

E. Proprietary programming shall not be utilized. In addition, all required programming software and graphics shall be embedded in the server or controllers without the need for external software to execute queries or revisions. All graphics shall reside in the server. Remote access via LAN or Web shall not require external software to provide complete access to all data, graphics, alarms, programming, etc.

2.3 DDC ARCHITECTURE

A. DDC system shall be complete with an Operators Workstation/Server, Configurable Controllers, Unitary Controllers, required I/O modules for controller expansion, communication cards in controlled devices such as chillers, variable frequency drives (furnished with the equipment, coordinate card requirements), arranged for a completely integrated building automation system network.

B. Physical connection of BACnet network controllers shall be via Ethernet/Ethernet IP using the Owner's Local Area Network (LAN).

C. Where data drops are not shown for the Configurable Controllers or Operator Station/Server, the temperature control subcontractor shall be responsible to provide the IP data drop to each network controller location for controller connectivity. Installation shall be subcontracted to the division 27 technology contractor; coordinate connection requirements. In addition, provide an additional IP data drop to each controller, or group of controllers to provide local access to data acquisition for the HVAC service technician.

D. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

E. 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. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

F. DDC system accessibility over the LAN or the Internet shall be user name and password protected. Provide separate user name/password for multiple level hierarchy to restrict access to appropriate personnel at the different levels (view, programming, etc.). The system must be set up to have at least 3 access levels: guest, user and administrator. Guest privileges shall be

limited to view only. Users shall be able to make setpoint and schedule changes. Administrators shall have all privileges as users in addition to being able to assign passwords.

2.4 OPERATOR WORKSTATION/SERVER

A. An operator workstation/server shall be provided to effectively program, manage and access DDC information from all of the controllers. Interface shall utilize dynamic color graphics of each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

B. All DDC information shall be accessible through the server over the LAN as well as over the Internet via Ethernet IP.

C. Operator Workstation/Server Computer: Equal to Dell Studio XPS 630.

D. Minimum Requirements (or equivalent):
1. Processor: Intel Core 2 Duo.
2. Ports/Jacks: (6) USB 2.0, (2) IEEE 1394a, headphone, microphone, 19-1 media reader, (1) RJ-45, 2.1 audio, S video in/out, S/PDIF optical
3. Random-Access Memory: 2GB Dual Channel DDR2 SDRAM.
4. Monitor: 20” wide screen, WSXGA resolution, 5ms pixel display rate, 720p high definition display flat panel.
5. Graphics: Intel GMA 3100
6. Hard-Disk Drive: 160 GB .
7. 48X combo optical drive.
8. Communications: Integrated Gigabit Ethernet (10/100/1000Base-T), internal WiFi 802.1 a/b/g/n Draft 2.0
9. 10W Stereo Speakers
10. Operating System: Microsoft Windows
11. Keyboard.
12. Mouse: Three button, optical.
13. Six outlet surge protector.
14. Printer: Laser jet type, B&W, 8Mb RAM equal to HP LaserJet 1022
15. Workstation desk and chair will be provided with loose furnishings by others.

E. The server shall provide integrated control, supervision, data logging, alarming, scheduling and network management functions. The controller/server provides the Internet connectivity and Web serving capabilities, presenting real time information in Web based, rich graphical displays for the system. Application control programs to provide: Calendar functions, Scheduling, Trending, Alarm monitoring and routing, and Time synchronization.

F. Proprietary programming shall not be utilized. In addition, all required programming software shall be embedded in the server or controllers without the need for external software to execute queries or revisions. All graphics shall reside in the server. Remote access via LAN or Web shall not require external software to provide complete access to all data, graphics, alarms, programming, etc.

G. The server shall support standard Web browser access via the Intranet/Internet.

H. Provide and maintain an Audit Log that tracks defined activities on the system. 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 a user-defined buffer size. Archive the log locally. For each log entry, provide the following data: Time and date, User ID, Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

I. The controller/server 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 the most recently saved database shall be stored in the server. The age of the most recently saved database is dependent on the user-defined database save interval. The controller/server database shall be formatted to allow for user viewing and editing, if desired.

2.5 CONFIGURABLE CONTROLLERS/SERVERS

A. Individual configurable controllers shall be provided for each central HVAC equipment or system (AH unit, boiler, chiller, etc.). Distributed HVAC equipment, such as air control box terminals, fan coils, unit heaters, etc may utilize local, unit specific controllers.

B. Controllers shall be capable of functioning in either a standalone capacity or integrated into the building network.

C. Controllers shall be fully configurable type with both control and server capabilities including integrated control and management of external devices, supervision, data logging, alarming, scheduling, network management functions, Internet connectivity, web serving. The controller shall include software technology capable of integrating a variety of devices, interoperable networks and protocols such as LonWorks, BACnet, ModBus, etc into a seamless operating platform.

D. The controllers shall be expandable by the use of input/output I/O modules to provide additional points beyond resident points provided on the controller module.

E. Each configurable controller shall include the following minimum hardware features. Where required for functionality provide additional communication cards, memory cards or I/O modules: Two (2) Ethernet Port -10/100 Mbps, One (1) RS-232 port, One (1) RS-485 ports (BacNet MS/TP), LON Tunnel service, BACnet driver (Ethernet and Ethernet IP), One LONWorks Interface Port with driver – 78KB FTT-10A, Power Supply 24V power supply module, Battery Backup, 64 Mb flash memory for long term data backup and 64 Mb RAM.

F. I/O modules shall connect to the controller with a single multi pin plug, powered through the controller with a minimum of eight (8) universal inputs, four (4) analog outputs and four (4) relay outputs, Form A contacts. Do not exceed maximum I/O modules recommended by the manufacturer.

G. The controller/server must be capable of operation over a temperature range of 0 to 50°C and storage temperatures of between 0 and 70°C. The controller/server must be capable of operation over a humidity range of 5 to 95% RH, non-condensing.

H. The controller/server shall support standard Web browser access via the Intranet/Internet.

I. Where acting as a server, provide and maintain an Audit Log that tracks all activities performed on the controller/server. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached it's user-defined buffer size. Provide the ability to archive the log locally (to the controller/server), to another controller/server on the network, or to a server. For each log entry, provide the following data: Time and date, User ID, Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

J. The controller/server 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 controller/server. The age of the most recently saved database is dependent on the user-defined database save interval. The controller/server 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.

K. Controllers shall be fully programmable with "drag and drop" graphic representations of control algorithms and easy to use "wizards" that automate controller configurations.

L. Controllers shall be "Native" BacNet devices with interoperable native BacNet, IP, LON and MS/TP communication support.

M. Each controller with I/O modules shall include input/output capabilities with, as a minimum, sufficient universal inputs, digital inputs, universal outputs and digital outputs to perform the required function and include an additional spare two (2) universal inputs, (2) analog outputs and two (2) relay outputs for future upgrade capability (spare points are not required for unitary controllers).

2.6 UNITARY CONTROLLERS

A. Controller designed specifically for VAV reheat box terminal units, fan coil, unit heater, etc., shall be used for each distributed HVAC equipment item. Local controllers shall be capable of functioning in either a standalone capacity but shall be integrated into the building network.

B. Use of a dedicated network with a proprietary communication protocol that is compatible for integration into the configurable controllers is acceptable provided the unitary controllers use true peer to peer communication for all devices, the communication network uses simple non polarity sensitive twisted pair wiring and the network provides for interoperability between devices and controllers such as Echelon LonWorks is acceptable.

C. For VAV reheat box terminal units:
   1. The controller shall include where required a digital communications to wall sensor, velocity pressure pneumatic input via polyethylene tubing for supply air flow reading, supply air sensor, flow balancing software (damper adjustment, set point monitoring and adjustment, flow validation and calibration, sequence/calibration/control set point logs)
   2. Damper actuator shall be separate from the VAV reheat box controller; integrated controller/actuator devices are not acceptable.
   3. The remote wall sensor shall include a communication jack for connecting a laptop to the box controller for air/water balance purposes.
   4. Integral controller/damper actuator is acceptable.

D. Controllers used for remote temperature and humidity sensing, adjustment and overrride such as VAV box controllers and fan coil units shall include S-link communication via two wire, unshielded cable (non polarity sensitive) to provide power and communication interface for remote sensors.

2.7 CONTROLLER ENCLOSURE AND LISTING

A. Controllers shall be placed within enclosures that conform to NEMA-1 construction and shall further meet UL 94-5V flammability ratings for plenum application use.

B. Each controller shall be UL-916 listed and meet FCC Part 15 Class A.

2.8 GUI DISPLAY FRAMES

A. The system must be set up to have at least 3 access levels: guest, user and administrator. Guest privileges shall be limited to view only. Users shall be able to make setpoint and schedule changes. Administrators shall have all privileges as users in addition to being able to assign passwords.

B. Each AHU, heating water system and cooling system shall have a minimum of 5 graphic screens available from the tree view. One screen shall display the airflow pattern with all dampers, coils and fans shown in their correct schematic location and dynamic data for all input values shown. This main graphic screen shall show the control devices in mechanical flow diagram format with directional arrows to indicate normal flow arrangement. These screens shall be available to anyone with access to the system, and therefore shall be view only. Another screen shall display text information with the following primary categories: Unit status, temperatures, heating, cooling, economizer, static pressure, supply fan, exhaust fan including setpoints. A loop tuning screen shall also be furnished for each control loop, so that people with the appropriate access can change loop tuning parameters from PCs without needing individual programming tools. Override screens shall be furnished for each controller to permit overriding control points without the need for vendor specific software. An alarm screen shall also be furnished each AHU. The Heating systems and Cooling systems shall have similar screens as the AHUs. Each VAV shall have a graphics screen and a text screen. Systems that won't permit creating these customized screens as described herein will not be acceptable. Systems that use controllers that won't permit overrides of inputs and outputs from a browser based graphic screen will not be acceptable.

C. All shapes shall be 3-D with a common perspective. All dampers shall have a minimum of 4 animation levels to show partially open, half open, mostly open, fully open, and closed position of dampers. All analog inputs shall show the actual value and engineering units on the graphic screen. Binary inputs shall be linked to flashing animated displays. Safety alarms will flash when in alarm. Filter status shall be indicated when value indicates that they are dirty. To prevent clutter on the graphic displays, symbols will only be shown for equipment that is controlled or monitored by the DDC system. Also, normal status for safeties will not be indicated, and normal status for safeties will be indicated by an image of a clean filter. Pumps and fans shall rotate when flow is proven by a monitoring device. Coils shall change color when valves are open to permit water flow through the coils.

D. Graphics shall use common color schemes to make the overall system easy to understand. All overall backgrounds shall be white. All text shall be black. Any value that is in alarm shall have a red background. Any value that is overridden shall have a blue background. All like sensors shall be the same color. For example, all temperature devices shall be yellow, all pressure devices shall be purple, all humidity devices shall be teal, all fire alarm devices shall be red, and all CO2 devices shall be green.

E. Current setpoints and occupancy status shall be shown at the bottom of each graphic screen.

F. Floor plan drawings shall be provided, and permit access to each zone's individual floor plan sections. On the individual floor plan sections, room numbers and room temperatures shall be displayed. Values that are out of the acceptable range shall appear in a different background color and / or flash. Each VAV shall have its own graphic that contains the points from within its controller including the box flow setpoint, room temperature setpoint, maximum cooling flow setpoint, minimum cooling flow setpoint, and minimum heating flow setpoint, plus the discharge air temperature from the AHU supplying the unit. The VAV text screen shall have the same information as the graphic screen plus high and low flow calibration values, damper rotation adjustment (CW or CCW), and air balance set-up features. GUI shall permit operator the ability to enable, set or disable high and low occupied and unoccupied limits for each room temperature reading.

G. Text Screens shall be available for all levels of access. Setpoint and output values are changeable from the text screen for users with appropriate access privileges and administrators, but not guests. When a value can be overridden or edited, a red box shall appear around it when the cursor is position on it. A single click of the mouse shall bring up pop up menu that provide options to make a permanent override, change setpoint, or release a previous override of an output point. Analog inputs shall have pop up menus that allow setting high and low alarm limits and the ability to enable and disable alarm limits as appropriate for the sensing device. Pop up menus must be customized to include a description of the point that is being modified. Generic override menus are not permitted because they would not describe to an operator what is about to be modified. The Control Contractor shall set up all initial alarms as indicated in the point matrix.

H. Text screens shall include schedule information including current state and date and time of next scheduled event. Positioning the mouse over the current state shall permit single click access to the schedule. The schedule screen shall allow the operator to edit a yearly, weekly, daily, holiday or special event schedule for the system being viewed. Temperature values and setpoints shall be displayed below the schedule information, and shall have a minimum of 1 decimal place. Heating, cooling and damper ouputs shall be displayed next. The OA temperature for economizer switchover shall be displayed and adjustable from the text screen. Air flow readings shall be shown with setpoint and actual readings. Fan information shall be shown next, followed by static pressure readings and setpoints, which shall have a minimum of 2 decimal places. Miscellaneous setpoints including night setback cooling and heating, average zone temperature, return air warm-up and cool-down, dehumidification, and unoccupied mixed air temperature setpoints shall all be shown and adjustable. All safeties shall be shown, followed by coil pump control information.

I. Each system shall have its own specific alarm screen available to all operators but only editable by operators with user and administration access privileges. From the alarm screen, users and administrators shall be able to enable and disable alarms. Points that are in alarm shall have an

alarm symbol highlighted in red. Points that are not in alarm shall be shown in gray. Alarms that are disabled shall have a way to indicate this on the alarm screen graphic.

J. Loop tuning screens shall be available through the web browser interface to save the owner the cost and time associated with using vendor specific software for tuning loops. Access to these screens shall not be provided to guests. Air handling units shall have dedicated screens for discharge air temperature, static pressure, and outside air control loops. Loop tuning screen for discharge air temperature shall include the discharge air temperature, discharge air temperature setpoint, cooling loop throttling range, I-gain and ramp time, heating loop throttling range, I-gain and ramp time, economizer loop throttling range, I-gain and ramp time, unoccupied heating loop throttling range, I-gain and ramp time, cooling valve output, heating valve output, and damper control output. Screens shall also have graphs that show 5 minutes of live data for the discharge air temperature, setpoint, cooling valve, heating valve and mixed air dampers. Each loop tuning screen shall include the appropriate throttling range, I-gain and ramp time.

K. Each non-unitary controller shall have an override screen. These screens shall be available on-site for use during point-to-point check-out and commissioning. The override screen shall show the inputs and outputs for each controller with the points in their wired location. Unused points shall be shown as spares. Points that are in alarm shall have a red background, and points that are overridden shall have a blue background just as on other screens. These screens shall show the actual values that come back from the controller, not the values that may have been typed in for override at the GUI if the controller software is not accepting the override value. The override screen shall also permit timed overrides.

L. Each AHU shall also have a overview screen listing every VAV terminals data in a text format that includes occupancy mode, room temperature, room setpoint, box flow, flow setpoint, temperature leaving VAV terminal, % cooling and % heating. Also, each VAV AHU shall have an air balance screen that will permit balancing the system through a computer connected to the Ethernet or directly to the appropriate BC without vendor specific software. The air balancing screens shall permit at least 8 manual override commands: normal, position (%), flow value, flow percent, open, close, min flow, and max flow.

M. Heating systems and cooling systems with multiple pieces of equipment such as pumps with lead-lag control shall display which device is lead and when the other device will become lead on the text screen.

N. Although only one outside air temperature sensor is needed per building, the GUI shall use independent outside air temperature points, so that during check-out and commissioning, the outside air temperature for a system can be changed without changing the outside air temperature for the whole building. The GUI shall also have a global outside air temperature point that can be overridden from the screen for the controller where the point is physically connected. Overriding this outside air temperature value will change it for all systems, except when outside air temperature has been overridden for an individual system.

O. The system shall allow for the easy development and editing of dynamic graphics. Wizards shall be utilized to assist the operator with their manipulation of the graphic system. The operator shall be able to, through a single mouse function, select between the dynamic display mode and the graphic edit mode for the currently viewed graphic frame, assuming appropriate access level is provided to the operator. Systems requiring multiple mouse or operator keyboard commands to enter the graphic edit mode are not desirable and require thorough definition of steps involved to accomplish function.

P. Animation of system data shall be provided via graphic elements on the display frames. Standard graphic element library shall be provided to assist the operator with their implementation. The ability to define and add new animated graphic elements shall be provided. As a minimum, the ability to move, size, draw, arrange, align, layer, space, rotate, invert, duplicate, cut, copy, paste, erase any animated element shall be provided. System parameters and setpoints shall be assignable and modifiable by the animated graphic elements, relieving the need for keyboard commands for system manipulation.

Q. The ability to simultaneously display a dynamic X/Y chart of selected points, shall be provided. The chart shall be an element of the graphic display and shall automatically update with the display data. The chart shall allow for dynamic manipulation to modify the range, rate, and timeframe of view, in both a real-time as well as historical configuration. A minimum of 4 values shall be included on any chart display element. There shall not be a limit to the quantity of chart elements displayed on a graphic frame. Trace colors and X values shall be User configurable. Systems not providing this capability are required to provide an equivalent charting package with the GUI offering.

R. The ability to provide graphically displayed global scheduling and editing functions shall be provided. The ability to link these functions to the associated equipment or zone frames shall be a standard feature. A calendar shall be provided for display and modification of the SDC time clock functions. The User shall be able to view a daily, weekly, monthly, annual, special or holiday schedule from a defined display frame. A list of served areas shall be displayed on the same screen, this list shall be displayed at all times, pull down menus or other means of accessing these areas shall not be acceptable. The system shall have a master override screen that will allow an operator to change the schedule for every piece of equipment in every building by changing the master schedule.

S. All analog values shall be trended every 15 minutes. The trend samples shall be saved in the BC for at least 36 hours. Access to trended data shall be available by the single click of a mouse on the analog value. Systems that open other windows and require a selection of the desired data are not acceptable.

2.9 GUI ALARMING

A. The GUI shall provide, as standard, alarm annunciation of system data. On every display frame, the ability to view, acknowledge, delete and manipulate real-time and historical alarms shall be provided. The ability to provide a unique and custom alarm display for every display frame shall be provided. The ability to continuously or upon request, view the alarm display, shall be provided.

B. Alarm conditions shall be capable of invoking, as a minimum; a display frame, an email message, a text message sent to a pager or cellular phone.

C. Alarm logging shall be provided in a user definable configuration. All alarms shall be displayed and/or routed as follows, as a minimum; GUI display frame, local printer, server printer, client printer, logged to file, and archived in standard format for information management. Alarm groupings shall be hierarchical in nature allowing up to 8 alarm groups and 16 sub-groups. The

GUI shall not possess any limits on the quantity of alarms that can be logged, including historical data archiving. Systems possessing limits must define the restrictions and may not be acceptable.

D. Provide up to 999 alarm priorities with up to 5 alarm color changes, per priority, according to alarm status.

2.10 GUI TRENDING

A. The GUI shall automatically perform time based, user defined, periodic collection of real time point data. The data shall be presented as an X/Y chart in the display frame. The data shall be stored and archived in a file format that allows for the manipulation and utilization of the data by third party applications.

B. A dynamic trend shall be defined as a group of at least 4 data points, with a circular buffer of 2000 data points. A historical trend shall be defined as a group of at least 8 data points, with the sampled points limited only by archival disk space. Sampling rates shall be user selectable from instantaneous (one per second) to once a week. Collection of data shall be user selectable to start and stop on a specific time and date. There shall be no limit to the number of X/Y charts within a display frame.

C. X/Y charting and column and row reporting shall be an integral part of the system. All points shall be chartable or reportable. Analytical data shall be displayed for any of the selected points in a clearly displayed X/Y chart. This analytical data shall consist of at least the following: Average Mean, Standard Deviation, Simple Average, Current Value, Cycle Length, Cycle High and Cycle Low.

D. X/Y charting shall provide for the following chart manipulation: display, zoom, scroll, centering, pen legend and export to Excel, Text via Dynamic Data Exchange.

PART 3 - EXECUTION

3.1 Furnish a complete set of shop drawings showing the kind of control equipment for each of the various systems and their functions, along with indication on the drawing of all original setpoints and calibration values and set up parameters, and sequence of operation and also that of the automation system. These drawings shall be submitted for approval to the Engineer, together with a complete brochure describing the equipment and their function and operation.

3.2 The control equipment supplier shall submit a detailed outline of the owner training material for review and comment by the Engineer during the shop drawing phase. The control system training program shall be customized to reflect the systems installed under this contract and shall cover, as a minimum: software navigation (via custom graphics and Windows based icons), system architecture, pass wording and system security features, input/output control functions, alarm functions/acknowledgement, trending/long term reporting, and control component operation.

3.3 Upon completion of the project, furnish and turn over to the Owner and Architect (3) complete sets of brochures describing the various items of equipment, their functions and directions for operation and maintenance.

3.4 Upon completion of the control system, the Control Contractor shall adjust all components of the system. ATC Contractor shall make all adjustments in the control system required and as directed by the air balance contractor to achieve the desired air balance quantities. All instruments shall be carefully calibrated and each control function shall be demonstrated to function properly, to the satisfaction of the Engineer and the Owner. Provide a complete instruction manual covering the function and operation of all components. At the time of demonstration, each function shall be simulated to insure that controls respond properly to all signals, and the Owner shall be instructed in the proper operation of the system.

3.5 In addition to the adjustments and fine tuning, the Contractor shall include as a part of this contract an additional 40 hours of service technician time for work as directed or authorized by the Engineer to make software changes or field adjustments to hardware.

3.6 During the first year of operation, after acceptance by the Owner, the Control Contractor shall provide complete service to adjust or assist the Owner in adjusting the equipment to obtain optimum performance form the control equipment and from the heating and air conditioning systems in general. This shall be done without additional expense to the Owner. This work shall include revisions to DDC software programs and controller programs, and all PC front end software upgrades. All software shall be provided to the Owner in disk form, including back-ups of final field programs.

3.7 The control equipment manufacturer shall provide instruction and training of the Owner's personnel regarding the hardware and software of the system. Software training shall include programs, methods of programming, control loops, scheduling and reports. Training covering

hardware shall include operation information, functional use, wiring diagrams and schematic diagrams necessary to troubleshoot the operating system. Training shall include "hands on" instructions to completely familiarize Owner's personnel with the equipment and system. Training of Owner's personnel shall be equal in scope and detail to that provided by the manufacturer to its service technicians.

3.8 TRAINING

The control equipment supplier shall provide 40 hours of instruction at the job site to familiarize the Owner's personnel in the application and details of the installed system. Site training classes shall not be scheduled for longer than 4 hours duration except at the discretion of the Owner.

3.9 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check dampers. Verify that proper blade alignment, either parallel or opposed, has been provided.
9. Check DDC system as follows:

a. Verify that DDC controller power supply is from emergency power supply, if applicable.
b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
c. Verify that spare I/O capacity has been provided.
d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

END OF SECTION 23 0923