Date: June 28, 2023

To: All Holders of the CONTRACT DOCUMENTS FOR:
41C2106 Marin County Civic Center AHU #3 Fan Array Retrofit

From: Erin Riley
Capital Planning and Senior Project Manager, DPW

RE: ADDENDUM NO. 2

You are hereby advised of the following revision to said Contract Documents:

1. The SPECIFICATIONS are revised as follows:
   PART 2 - PRODUCTS
   2.1 DDC SYSTEM MANUFACTURERS
   A. Manufacturers: Andover Continuum, match the current manufacturer at the facility.

   See revised SPECIFICATIONS included herein.

   Bidders shall acknowledge receipt of this addendum, and any subsequent addenda, on the Proposal form as indicated. Failure to do so may render bidder’s bid non-responsive.

END OF ADDENDUM NO. 2
SECTION 251100 – CONTROL EQUIPMENT AND SOFTWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Direct Digital Control (DDC) Systems Hardware.
   2. DDC Systems Software
   3. DDC Networking and Monitoring Devices

1.2 DEFINITIONS

A. BACnet Specific Definitions:
   2. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
   4. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

B. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.
   1. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.
   2. Programmable Application Controller: Microprocessor based controllers, capable of accepting project specific programming of firmware.
   3. Application Specific Controller: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.
C. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

D. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

E. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

F. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

G. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), digital input (DI), analog output (AO) and digital output (DO) field hardware. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

H. LAN: Local area network.

I. LON Specific Definitions:
   1. LonMark: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
   2. LonTalk: An open standard protocol developed by the Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
   3. LonWorks: Network technology developed by Echelon.
   4. TP/FT-10: Free Topology Twisted Pair network defined by CEA-709.3 and is most common media type for a CEA-709.1-C control network.

J. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

K. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

L. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

M. Router: Device connecting two or more networks at network layer.

N. TCP/IP: Transport control protocol/Internet protocol.

O. UPS: Uninterruptible power supply.
P. USB: Universal Serial Bus.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 SUBMITTALS

A. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

B. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.

C. Shop Drawings:

1. Panel layouts and mounting details, for each unique panel arrangement.
2. Schematic drawings for each controlled HVAC system indicating the following:
   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
   d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
   f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
   g. Narrative sequence of operation.
   h. Graphic sequence of operation, showing all inputs and output logical blocks.

3. DDC system network riser diagram indicating the following:
   a. Each device connected to network with unique identification for each.
   b. Interconnection of each different network in DDC system.
   c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.

4. DDC system electrical power riser diagram indicating the following:
   a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
   b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.

5. Monitoring and control signal diagrams indicating the following:
   a. Control signal cable and wiring between controllers and I/O.
   b. Point-to-point schematic wiring diagrams for each product.
   c. Pneumatic control signal tubing to sensors, switches and transmitters.

6. Color graphics indicating the following:
   a. Itemized list of color graphic displays to be provided.
   b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
   c. Intended operator access between related hierarchical display screens.

D. Qualification Data:
1. Systems Provider Qualification Data:
   a. Resume of project manager assigned to Project.
   b. Resumes of application engineering staff assigned to Project.
   c. Resumes of installation and programming technicians assigned to Project.
   d. Resumes of service technicians assigned to Project.
   e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity and building's primary function.
   f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
   g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
   h. Owner contact information for past project including name, phone number, and e-mail address.
   i. Contractor contact information for past project including name, phone number, and e-mail address.
   j. Architect contact information for past project including name, phone number, and e-mail address.

2. Manufacturer's qualification data.
3. Testing agency's qualifications data.

E. Product Certificates:
   1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.
   2. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with LonWorks.

F. Field quality-control reports.

G. Sample Warranty: For manufacturer's warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
      b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
d. Engineering, installation, and maintenance manuals that explain how to:

   1) Design and install new points, panels, and other hardware.
   2) Perform preventive maintenance and calibration.
   3) Debug hardware problems.
   4) Repair or replace hardware.

e. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
f. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
g. List of recommended spare parts with part numbers and suppliers.
h. Licenses, guarantees, and warranty documents.
i. Owner training materials.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.7 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

   1. Nationally recognized manufacturer of DDC systems and products.
   2. DDC systems and products that have been successfully tested and in use on at least five past projects.

B. DDC System Provider Qualifications:

   1. Authorized representative of, and trained by, DDC system manufacturer.
   2. In-place facility located within 150 miles of Project.
   3. Demonstrated past experience with installation of DDC system products being installed for period within three consecutive years before time of bid.
   4. Demonstrated past experience on three projects of similar complexity, scope and value.
   5. Each person assigned to Project shall have demonstrated past experience.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
   a. Install updates only after receiving Owner's written authorization.
3. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS
   A. Manufacturers: Andover Continuum, match the current manufacturer at the facility.

2.2 DDC SYSTEM DESCRIPTION
   A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.
   B. DDC system shall consist of a peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.
   C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS
   A. DDC system software shall be based on server thin-client architecture, designed around open standards of web technology. DDC system server shall be accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet.
      1. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.

2.4 PERFORMANCE REQUIREMENTS
   A. Engage a qualified professional to design DDC system to satisfy requirements indicated.
      1. DDC system shall manage HVAC systems.
2. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
3. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
4. DDC system shall operate while unattended by an operator and through operator interaction.
5. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated.

C. DDC Data Access:
   1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
   2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

D. Environmental Conditions for Controllers, Gateways, and Routers:
   1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
      a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

E. Continuity of Operation after Electric Power Interruption:
   1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 SYSTEM ARCHITECTURE
A. System architecture shall consist of no more than two levels of LANs.
B. System architecture shall be modular and have inherent ability to expand to not less than two times system size indicated with no impact to performance indicated.

C. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

2.6 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator workstation with wireless connection through LAN router.
4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
5. Remote connection through web access.

B. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message, and prerecorded phone message to mobile and landline phone numbers.

2.7 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.
C. CEA-709.1-C Protocol:
   1. DDC system shall be an open implementation of LonWorks technology using CEA 709.1-C communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for communication throughout DDC system.
   2. LNS shall be used for all network management including addressing and binding of network variables.
      a. Final LNS database shall be submitted with Project closeout submittals.
      b. All devices shall be online and commissioned into LNS database.
   3. All devices connected to DDC system network(s) shall use CEA-709.1-C protocol and be installed so SCPT output from any node on network can be bound to any other node in the domain.

D. Industry Standard Protocols:
   1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:
      a. ASHRAE 135.
      b. CEA-709.1-C.
   2. Gateways shall be used to connect networks and network devices using different protocols.

2.8 DESKTOP WORKSTATIONS
   A. Description: A tower or all-in-one computer designed for normal use at a single, semi-permanent location.

2.9 ASHRAE 135 GATEWAYS
   A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable.
   B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specified in contract documents.

2.10 CEA-709.1-C NETWORK HARDWARE
   A. Routers:
1. Network and IP routers, including routers configured as repeaters, shall comply with requirements of CEA-709.1-C and CEA 852-B.

B. Gateways:

1. Perform bidirectional protocol translation from one non-CEA-709.1-C protocol to CEA-709.1-C.

2.11 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

1. Provide most current version of hardware design expected to be available at time of construction. Where less current design is required for compatibility with existing equipment, clearly state the intent in bid documents and submittals.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

D. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
3. Controllers located outdoors shall be rated for operation at 0 to 150 deg F.

E. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

F. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

   a. Network Controllers: Not less than 50 percent.
   b. Programmable Application Controllers: Not less than 70 percent.
   c. Application-Specific Controllers: Not less than 70 percent.
G. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each Network or Programmable Application controller as follows:
   1. At least 20 percent of each AI, AO, DI, and DO point connected to controller, but not less than two per point type. Do not double count universal inputs and outputs.
      a. Programmable Application Controllers shall support addition of input/output cards.

H. Input and Output Point Interface:
   1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
   2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
   3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.

2.12 CONTROLLER SOFTWARE

A. General Controller Software: Provide the most current version of software expected to be available at time of construction. Where less current design is required for compatibility with existing equipment, clearly state the intent in bid documents and submittals. Software shall be capable of all customary DDC operations, including:
   2. Scheduling
   3. Alarming, Alarm reporting based on priority
   4. Predictive Power Demand Limiting and Load Shedding
   5. Energy Monitoring and Management
   6. Maintenance Management and Run-time calculation
   7. Equipment Sequencing
   8. Control Methods: Proportional, Integral, and Derivative control, Adaptive Tuning

2.13 ENCLOSURES

A. House each controller and associated control accessories in an enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers. Enclosure shall provide environmental protection based on NEMA standards.
   1. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.
   2. Provide fans, cooling systems and heaters to meet temperature requirements of the most restrictive devices located within.
2.14 CONTROL POWER WIRING AND RACEWAYS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" electrical power conductors and cables.

B. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.

   a. Variable Frequency Drives
   b. Third Party Equipment Controls
   c. Et cetera
3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS
   A. Deliver selected control devices, specified in indicated HVAC equipment sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

3.4 GENERAL INSTALLATION REQUIREMENTS
   A. Install products to satisfy more stringent of all requirements indicated.
   B. Install products level, plumb, parallel, and perpendicular with building construction.
   C. Support products, tubing, piping wiring and raceways.
   D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
   E. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.5 WORKSTATIONS
   A. Install workstation(s) at location(s) directed by Owner.
      1. Develop Project-specific graphics, trends, reports, logs and historical database.
   B. Portable Workstations: Turn over portable workstations to Owner at Substantial Completion. Install software on workstation(s) and verify software functions properly.
   C. Color Graphics Application:
      1. Develop project-specific graphics as submitted. Use owner’s library of symbols for representing system equipment and products to match existing. Use controller manufacturer standard libraries where no other standards exist. Use consistent imagery in either case.
      2. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
      3. Refine graphics as necessary for Owner acceptance.

3.6 ENCLOSURES INSTALLATION
   A. Install the following items in enclosures, to comply with indicated requirements:
      1. Gateways.
      2. Routers.
      3. Controllers.
      4. Electrical power devices.
5. UPS units.
6. Relays.
7. Accessories.

B. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.7 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

C. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

B. Install laminated acrylic or melamine plastic signs with unique identification on face for each of the following:
   1. DDC controller.
   2. Enclosure.
   3. Electrical power device.
   4. UPS unit.

C. Install unique instrument identification on face of each instrument connected to a DDC controller.

D. Install unique identification tag on each control damper and valve actuator connected to a DDC controller.

E. Warning Labels and Signs shall be permanently attached to equipment that can be automatically started by DDC control system.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
3.10 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After testing is complete, submit completed test checklist.

C. Pretest Checklist: Submit the following list with items checked off once verified:

   1. Detailed explanation for any items that are not completed or verified.
   2. Required DDC system components, wiring, and accessories are installed.
   3. Installed DDC system architecture matches approved Drawings.
   4. Control electric power circuits operate at proper voltage and are free from faults.
   5. Required surge protection is installed.
   6. DDC system network communications function properly, including uploading and downloading programming changes.
   7. Each controller's programming is backed up.
   8. Equipment, products, tubing, wiring cable and conduits are properly labeled.
   9. All I/O points are programmed into controllers.
  10. Testing, adjusting and balancing work affecting controls is complete.

D. Test Plan:

   1. Prepare and submit a validation test plan including test procedures for performance validation tests.
   2. Test plan shall address all specified functions of DDC system and sequences of operation.
   3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
   4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
   5. Include a test checklist to be used to check and initial that each test has been successfully completed.
   6. Submit test plan documentation at least 15 business days before start of tests.

3.11 FINAL REVIEW

A. Submit written request to Architect Construction Manager, and Commissioning Agent when DDC system is ready for final review. Written request shall state the following:

   1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
   2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
   3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Architect Construction Manager, or Commissioning Agent shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

3.12 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.13 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by DDC system manufacturer's authorized service representative.

3.14 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:
   1. Minimum Training Requirements:
      a. Provide not less than one days of training total.
      b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
      c. Total days of training shall be broken into not more than two separate training classes.

C. Attendee Training Manuals:
   1. Provide each attendee with a color hard copy of all training materials and visual presentations.
   2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter.
Organize material to provide space for attendees to take handwritten notes within training manuals.

3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

D. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Instructors shall have not less than three years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

E. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
   a. Daily operators.
   b. Advanced operators.
   c. System managers and administrators.
2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

F. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.

G. Video of Training Sessions:

1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.
3. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION