SECTION 25 0000
INTEGRATED AUTOMATION

Note: This section provides an overview of the entire Division 25. It includes background information for reference on Stanford building control systems. It includes important controls specific details related to submittals, execution, and project deliverables. These details can be retained in this section for standalone controls projects, or they can be moved and integrated within the Division 1 section for large projects.

Background note: Stanford’s original campus-wide front end control system was based upon an industrial grade Emerson Distributed Control System (DCS). The current version of this system is DeltaV. The DeltaV system is currently deployed in over 150 buildings across campus. The Delta V system can be used alone or in combination with other commercial Direct Digital Control (DDC) systems. Stanford has recently deployed a commercial DDC based software system (based upon the Tridium Niagara platform) capable of performing the same front end control system requirements previously only available through the DeltaV system. These requirements include: common user interface for all buildings, single point user authentication, user access security consistent with University IT protocols, central alarm management, automated program and data backup.

Note: Division 25 includes details to ensure that the legacy DeltaV system can be supported as needed and that new DDC based systems can be implemented to achieve all functional requirements. New building projects controls will typically be DDC based unless there are unique requirements that need to be achieved by the project.

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the general requirements for the Integrated Automation systems. This includes all building control and monitoring systems related to HVAC and utility interface.

B. Related Sections:
   1. 25 0513 Conductors and Cables
   2. 25 0528 Pathways
   3. 25 0553 Identification
   4. 25 1119 Building Control Systems Server
   5. 25 1219 Integration Protocols
   6. 25 1223 Client-Server Information/Database Integration
   7. 25 1300 Control and Monitoring Network
   8. 25 1313 Building Level Controller
   9. 25 1400 Local Control Units
  10. 25 1423 Field Equipment Panels
  11. 25 1500 Building Control Systems Server Software
  12. 25 1516 Software for Programming Local Control Unit
  13. 25 1523 Graphics
  14. 25 3313 Thermal Utility Metering Interface
  15. 25 3513 Actuators and Operators
  16. 25 3515 Switches and Relays
  17. 25 3516 Sensors and Transmitters
  18. 25 3517 Air and Gas Pressure and Flow Measurement
  19. 25 3518 Liquid Pressure and Flow Measurement
  20. 25 3519 Control Valves
  21. 25 3526 Compressed Air Supply
  22. 25 3528 Guideline for Control Sequences
C. Where architectural features govern location of work, refer to architectural drawings and coordinate with other trades.

1.2 REFERENCES

A. This section includes any rules and regulations of Federal, State, local authorities, and utility companies in force at the time of execution of contract.

B. Agencies or publications referenced herein refer to the following:
   2. ANSI/CEA Standard 709.C LonTalk protocol
   3. ASHRAE American Society for Heating, Refrigeration, Air-Conditioning Engineers
   4. ASHRAE Fundamentals Heating and Cooling Load Calculation Methods
   5. ASHRAE Standard 55 Thermal Environmental Conditions for Human Occupancy
   6. ASHRAE Standard 62.1 Ventilation for Acceptable Indoor Air Quality
   8. California Energy Commission (C.E.C.) Title 24
   9. DIN-IEC 751 Standard for platinum sensors
   10. FCC Federal Communications Commission
   12. NEC 725 ......Class 1, Class 2, and Class 3 Remote Control, Signaling And Power-Limited Circuits
   13. NEC 800 Communications Circuits
   14. NEMA National Electrical Manufacturers Association
   15. NEMA WD7 Occupancy Motion Sensors.
   16. UL Underwriters Laboratories, Inc.
   17. UL 773A Non-Industrial Photoelectric Switches for Lighting Controls.
   18. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)
   20. Stanford Guidelines for Sustainable Buildings

Note: Edit the above list for each project. Make sure each item is appropriate and are coordinated.

1.3 DEFINITIONS

A. AHU Air Handling Unit
B. AI Analog Input
C. AO Analog Output
D. Archive Data storage
E. AWG American Wire Gauge (standard wire size measurement)
F. Access Process or effort to communicate to system.
G. BACnet Building Automation and Control Network open communication protocol.
H. BTL BACnet Testing Laboratory.
I. BAS Building Automation System (Direct Digital Control)
J. Building Control System Server (BCSS) Main control system server in each building. In Niagara, the term is Supervisor PC.

K. Building Level Controller A network controller that has many functions including gateway between BCSS and Local Control Units. In Stanford Control System Architecture, the Building Level Controller is a JACE.

L. Class 1, 2, 3 Remote Control, Signaling And Power-Limited Circuits

M. CO2 Carbon Dioxide

N. Command Priorities The order in which commands are allowed to be executed. (Command Hierarchy).

O. Commissioning Process to ensure installation and functionality is per design

P. Continuous Pathway – Enclosed pathway system such as conduit, cable tray, flexible conduit, etc.

Q. DI Digital Input

R. DDC Direct Digital Control

S. dB Decibels

T. Device Intelligent controller or other automated monitoring piece of equipment

U. Delta V Process control system by Emerson utilized by Stanford

V. DO Digital Output

W. Dry Contact Contact closure without an electrical output (switch)

X. Event Alarm, transaction, or sequence.

Y. FDG Stanford Facilities Design Guide

Z. FESO Facilities Energy Systems Operations

AA. Field Equipment Panel Panel for DDC controllers and related devices

BB. Field Terminal Panel Panel for instruments to be connected to multi-pair conductors going back to a Delta V controller.

CC. Firmware Hardware imbedded with software.

DD. Front End System A control system platform with a common graphical user interface to integrate multiple subsystems.

EE. FLN Floor Level Network (Control and Monitoring network to enable communication to devices and controllers (Local Control Units) using LON, Modbus, BACnet, or other protocols. , GUI Graphical User Interface

FF. I/O Hardware inputs and outputs

GG. I/P Current to Pneumatic (Pressure) Transducer

HH. Instrument Device used to sense inputs or control outputs or both

II. Integration protocols Connection of disparate systems to a common platform using communication protocols.

JJ. IP Address Internet Protocol node address
KK. IT Information Technologies

LL. License Permit rights and restrictions for legal use and access of software and applications.

MM. LONWORKS® The generic technology that incorporates LONMARK® certified products that communicate using LonTalk® Communications protocol. The technology employs routers, gateways, bridges, and multimedia transceivers, permitting topology and media independent control solutions.

NN. LonTalk® Protocol: Protocol implemented on LONWORKS® networks to standardize communications. It defines a standard way for devices to exchange information. The LonTalk protocol is an openly published non-proprietary protocol.

OO. LONMARK® International Association: An organization dedicated to issuing guidelines to ensure that devices from different vendors can coexist and operate on a single LONWORKS® network. The organization establishes functional profiles and LONMARK® certification to devices in order to ensure interoperability between vendors.

PP. mA Milliamps

QQ. Modbus Serial communication protocol developed by Modicon. Modbus protocol utilizes 3 frame formats:
   1. Modbus RTU Used to connect a supervisory computer with a remote terminal unit (RTU) for supervisory control and data acquisition.
   2. Modbus TCP/IP (More commonly Modbus TCP) is Modbus protocol encapsulated in a TCP frame.
   3. Modbus ASCII Not used for Stanford control systems.

RR. MS/TP Master/Slave Token Passing communications bus

SS. NEMA 1 General Purpose - for use in dry indoor locations.

TT. NEMA 3R Rain tight-for use in outdoor locations subjected to rainfall

UU. NEMA 4 Watertight - for use in outdoor locations and where subjected to direct water spray.

VV. Non-Continuous Pathway Open air pathway systems such as J-hooks, bridal rings, etc.

WW. NO/NC Normally Open/Closed

XX. Object Hardware or Software component such as a device or point.

YY. Ohm Unit of electrical resistance

ZZ. Pathways Support and protection system for conductors and cabling.

AAA. P-E Pressure to Electric Transducer

BBB. PICS Protocol Implementation Conformance Statement

CCC. PID Proportional Integral Derivative (the three parameters required in control loops)

DDD. Point Single hardware input/output or software data object such as setpoints and attributes.

EEE. Point Mapping system server. The act of integrating data points from building level controllers to building control system server.

FFF. Points list List of inputs, outputs and parameters for specific systems.

GGG. Programming Interface Tools: Software utilized to set up custom control or application.

HHH. Protocol An agreed-upon format for transmitting data between two devices.
III. Real-time Live data
JJJ. RFI Request for Interpretation
KKK. RH Relative Humidity
LLL. RTD Resistance Temperature Detector
MMM. PSIG Pounds per Square Inch Gauge
NNN. SCFM Standard Cubic Feet Per Minute
OOO. Stand-Alone Capable to operate or control without the need to communicate to other controllers.
PPP. LON Segment A single piece of uninterrupted wire. One LON network segment (i.e. JACE to devices)
QQQ. Network Segment A logical group of computers that share a network resource. This can be accomplished with a router, VLAN, switch segmentation, etc.
RRR. Trend Record data for specified time intervals
SSS. TAB Test Adjust and Balance
TTT. VAC Voltage Alternating Current
UUU. VDC Voltage Direct Current
VVV. Wiring Duct Pathway for wire management inside of panels.
WWW. Wire sheet Program logic diagram showing overall flow of control data to achieve sequence.
XXX. Wiring Trough Wiring enclosure used to manage wiring outside of panels.

Note: Edit the above list for each project. Make sure each item is appropriate. If the above referenced definitions are not included in the project, consider incorporating them or delete them from the list.

1.4 TRIDIUM NIAGARA-SPECIFIC DEFINITIONS
A. oBIX Open Building Information Xchange
B. FOX Fox is the TCP/IP protocol which is used for all network communication between Stations as well as between Workbench and stations. Fox is a multiplexed peer to peer protocol which sits on top of a TCP connection.
C. FOXS Secure Fox SSL. The Fox protocol run over an SSL encrypted connection following certificate based server authentication. The Niagara implementation of the industry-standard Secure Socket Layer (SSLv3) and Transport Layer Security (TLSv1) protocols provides server authentication and encryption/decryption of data transmitted between client and server.
D. Workbench Tridium’s brand name for the Niagara configuration tool, a Java VM which hosts Niagara plugin components. The Distech-specific brand name for Workbench is EC-NetAX Pro.
E. BAJA Building Automation Java Architecture. The core framework that the Niagara framework is built upon is published as an open standard. This standard is being developed through Java Community Process JSR 60.
F. HTTP Hypertext Transfer Protocol is an application-level protocol for distributed, collaborative, hypermedia information systems. HTTP is the standard protocol used by web browsers to access web pages from a station.
G. HTTPS Hypertext Transfer Protocol Secure is a communications protocol for secure communication over a network. It is the result of layering the Hypertext Transfer Protocol (HTTP) on top of the SSL/TLS protocol, thus adding the security capabilities of SSL/TLS to standard HTTP communications.

H. HTML HyperText Markup Language is the standard markup language used to create web pages. Web browsers can read HTML files and compose them into visible web pages.

I. XML Extensible Markup Language is a markup language that defines a set of rules for encoding documents in a format which is both human-readable and machine-readable. XML code is similar to Hypertext Markup Language (HTML). XML is a text-based format that allows for the structuring of electronic documents and is not limited to a set of labels. XML is used to describe data. The XML standard is a flexible way to create information formats and electronically share structured data via the public Internet, as well as via corporate networks. Both XML and HTML contain markup symbols to describe page or file contents. HTML code describes Web page content (mainly text and graphic images) only in terms of how it is to be displayed and interacted with.

J. PX Presentation XML. A PX file is a special XML file, used by Niagara, to display webpages. PX describes the components in a database and can be any collection of components, up to a complete database. A PX view can be used to provide a complete variety of options in the development of dynamic user interfaces.

K. Niagara Framework The Niagara Framework is a system designed to manage and control information. Its primary application is for control systems because of its powerful and flexible integration capabilities. The system is made up of Stations that run the components of the Niagara Framework and views that provide the ability to view and command these components.

L. Niagarad The protocol used for workbench-to-daemon communication.

M. Daemon Typically refers to the Niagara platform daemon, a native daemon server process required by a Niagara host to run a station. The daemon is used to boot stations and to manage platform configuration such as IP settings.

N. Normalization In Niagara, this term is used to indicate “data normalization”. This is the process of making data and features from various different communications protocols work together so that they can be integrated. The Niagara framework provides a way to normalize data across various protocols so that it may be viewed and controlled from a single user interface.

O. Host This is a term for a hardware system (or platform) that provides the operating environment for a Niagara application. In a navigation tree, the host node is used to depict the platform, which is the first level of the navigation tree. Hosts always represent a physical piece of hardware. Localhost is a term used to indicate the local machine.

P. Platform The name for everything that is installed on a Niagara host that is not part of a Niagara station. The platform interface provides a way to address all the support tasks that allow you to setup support and troubleshoot a Niagara host.

Q. Service In the context of enterprise architecture, service-orientation and service-oriented architecture, the term service refers to a set of related software functionalities that can be reused for different purposes, together with the policies that should control its usage.

R. Station A station is the main unit of server processing in the Niagara architecture. A station runs the components of the Niagara Framework and provides the access for client browsers to view and control these components. The primary parts of a station include components and services. It is the combination of a database, a web server, and a control engine. The station either runs on a Web Supervisor PC or a JACE controller. Often the term Supervisor or Jace will be used interchangeably with station. Technically the term station describes the component runtime environment common to all platforms, and Supervisor and Jace describe the hosting platform.
S. Supervisor  In Niagara, the Supervisor or Supervisor PC is a flexible network server used in applications where multiple Niagara-based stations are networked together. The Niagara Supervisor serves real-time graphical information displays to standard web-browser clients and also provides server-level functions such as centralized data logging, archiving, alarming, real-time graphical displays, master scheduling, and integration with enterprise software applications. Optional SQL and Oracle drivers enable seamless data transfer to these industry standard databases. In addition, the Niagara Supervisor provides a comprehensive, graphical engineering toolset for application development. On the Stanford Building Controls Network Architecture drawing, the Supervisor PC is designated as Building Controls System Server. Common industry generic terms for the Supervisor PC include: Operator Workstation, Front End Computer, Head End Computer, etc.

T. Supervisor Station  The station that is running on the Supervisor PC

U. JACE  JAVA Application Control Engine. A variety of headless embedded platforms. Typically a Jace runs on a Flash file system and provides battery backup or other means of orderly shutdown upon sudden power loss. Jaces usually host a Station and a Niagara Daemon process, but not Workbench. Jaces typically run QNX as their operating system. In Stanford Control System Architecture, the Building Level Controller is a JACE. The Distech-specific brand name for a JACE is EC-Bos.

V. ORD  Object Resolution Descriptor. The ORD is the Niagara universal identification system and is used throughout the Niagara framework. ORDs can be relative or absolute. An absolute ORD usually takes the general format of “host | session | space.” The ORD unifies and standardizes access to all information. It is designed to combine different naming systems into a single string and has the advantage of being parsable by a host of public APIs.

W. Thin Client  A thin client (sometimes also called a lean, zero or slim client) is a computer program that depends heavily on another computer (its server) to fulfill its computational roles. This is different from the traditional fat client, which is a computer designed to take on these roles by itself.

1.5 SYSTEM DESCRIPTION

Stanford utilizes multiple control system platforms based upon the application level (see below) and the functional requirements of the associated processes.

A. Utilities:
   1. Building thermal utility metering and interface data is consolidated in the Utility Interface Panel. This includes chilled water, hot water, and process steam.

B. Building Level:
   1. Stanford utilizes Tridium Niagara to integrate DDC based systems for campus wide monitoring and control. This is one of two campus wide front end systems.
   2. Stanford also maintains the legacy DeltaV system for overall campus monitoring and control. It is the second campus wide front end system.

C. Air Handling Unit Level:
   1. DDC controllers may be used to control and monitor air handling units.
   2. The Delta V system may also be used to control and monitor air handling units.
   3. Which platform to use is a project specific decision based upon performance requirements and costs.

Note: Discuss with FESO to determine option to pursue for each project. DDC controls will be typical.

D. Zone Level:
   1. Use DDC controllers to control and monitor zone level (variable air volume, fan coils, etc) units.
Note: Scope of Work, Alternates, and Unit Prices must be defined for each project. The following language is a template from a typical DDC retrofit project.

1.6 SCOPE OF WORK

A. The contractor shall furnish and install a fully integrated temperature control system, UL listed, incorporating a Lon-based direct digital control (DDC) for energy management, equipment monitoring and control, including color graphics.

B. Furnish and install Distech EC-Bos Building Level Controllers connected by TCP/IP network and one LonMark Certified DDC Controller per VAV box and fan coil unit. Location and minimum quantity of Network Controllers is specified in the System Architecture Schematic.

C. Furnish and install all network cabling, routers and hubs required to provide a fully functional network.

D. Furnish and install a Building Control System Server connected to the Distech EC-Bos Building Level Controller via TCP/IP network.

E. Furnish and install a Modbus 485 RTU connection from the Distech EC-Bos Building Level Controller to the Delta V system as specified in the System Architecture Schematic.

F. Furnish and install all instrumentation specified in the sequence of operations and/or control schematics required for a complete and operating system.

G. Furnish and install transformers and all associated wiring, conduit, panels, and tubing for all DDC controls.

H. The contractor shall be responsible for work associated with the temperature control system. The contractor shall be responsible for system integration and commissioning.

I. The contractor shall be responsible for installation of field devices necessary for measurement, verification and control of the various HVAC components that make up the DDC System. A list of VAV boxes and fan coil units can be found in the attached Updated Mechanical Schedule. Locations of thermostats and Updated Mechanical Drawings.

1. VAV boxes with integrated flow sensor – Reuse existing where operational.
2. VAV box controller – Remove and replace with DDC controller and differential pressure transducer.
3. Pneumatic Damper actuator – Remove and replace with electric actuator. Actuator may be integrated into DDC controller.
4. Thermostats – Remove and replace with DDC thermostat.

J. The Contractor shall be responsible to provide power from the control power distribution to all control devices per latest NEC code and FDG requirements. Contractor to conduct field survey and provide construction documents, including power floor plans and panel schedules, for electrical work.

K. Non-operational VAV boxes, reheat valves and fan coil hot water valves shall be replaced as additional work.

1.7 ALTERNATES AND UNIT PRICES

A. Alternates

1. VAV Box Replacement
   a. Replace existing VAV box with reheat coil with larger VAV box with reheat and new control valve and VAV box controls.
   2. Reheat Valve & actuator replacement
      a. Replace existing reheat valve & pneumatic actuator with DDC control valve with actuator.
3. Re-piping for valves that do not fit  
   a. Re-pipe the existing reheat valve where a retrofit actuator will not fit.

B. Unit Prices
   1. Unit Pricing No. 1 - Replace existing reheat coils at VAV terminals and modify existing ductwork as required. Heat hot water coils shall be designed as follows:
      a. Select coil to match existing coil capacity as listed on original record drawing
      b. Select coil with 50°F delta-T, 155°F inlet water temperature, and 105°F leaving water temperature.
      c. Use 2-row coils.
      d. See Stanford FDG for coil specification.
   2. Unit Pricing No. 2 - Completely replace existing VAV terminals with new VAV terminals with factory reheat coils and piping. Modify existing ductwork as required.
   3. Unit Pricing No. 3 - Replace existing reheat control valves with new ball type control valves. Modifying existing piping as required. Replace existing 2-way and 3-way reheat coil control valve as follows:
      a. Belimo CCV Spring return or electronic fail-safe normally closed chrome plated brass ball or approved equal.

1.8 SUBMITTALS

| Note: These are unique building controls related submittal requirements. These can be combined with the project Division 1 document, or retained in this document. |

A. All submittals, record documents, operations manuals should be indexed. PDF documents should include searchable text. Scanned documents are not allowed.

B. Submit complete schedule/outline of product submittals prior to submittal submission. Submit each section independent and separate from other sections.

C. Engineering Drawings
   1. Network Architecture
   2. Mechanical P&ID
   3. Detailed panel layout & wiring drawings
   4. Electrical Load Calculations
   5. Points List (I/O Spreadsheet)
   6. Controller Spreadsheet
   7. Sequence of Operations
   8. Bill of Materials

D. Product Data: For each product submission, include the following:
   1. Table of contents for each submission.
   2. Submit each section independent and separate from other sections. Include only products within referenced specification section submission.
   3. Product data sheets for all required components and accessories.
   4. Identify actual product model number used for each drawing.
   5. Identify any proposed modifications to system design. (Specifications or Drawings)
   6. Organize product data by system.
   7. A paragraph-by-paragraph specification compliance report indicating compliance for each numbered paragraph. The following format shall be used in completing the compliance report:
      a. Comply—without exception.
      b. Qualify—meet the functional intent. For each paragraph, the contractor shall identify all differences in specific functions stated in the given paragraph and provide a description of what is excluded or how the qualifying system will meet the function specified.
c. Does not comply—cannot meet specified function.
d. Does not apply – not used or not required.

E. Submit an Integration Plan. At a minimum include the following
   1. Network architecture and communications concepts/diagrams. Network architecture includes but is not limited to:
      a. Nodes
      b. Switches and Routers
      c. Integrated systems and/or sub-systems
      d. Dedicated I/O locations
   2. Coordination of vendor protocol and point list submission. Include an integration matrix detailing systems and protocols to be used.
   3. Workflow processes to integrate systems.
   4. Include communication hardware, software, and protocols to implement full systems integration.
   5. Identify proposed enhancements or deviations from project documents. Include specific drawings or specifications impacted.
   6. Identify coordination efforts to accommodate complete integration of systems including Vendor protocol requirements.

Note: Each project will determine what systems need to be integrated prior to bidding. Complexity will vary based on project scope.

F. Submit a Start-up Plan. At a minimum include the following:
   1. Coordination of equipment controlled and monitored
   2. Workflow process to start equipment
   3. Equipment start-up requirements
   4. Checklist
   5. Intended sequence of work items
   6. Start dates of individual work items
   7. Duration of individual work items
   8. Planned delivery dates for major material and equipment, and expected lead times
   9. Milestones indicating possible restraints on work by other trades or situations

G. Provide Acceptance Test Procedures. At a minimum include the following:
   1. Sequence of Operation for each system with testing instructions
   2. Commissioning data sheets
   3. Test results template
   4. Trend logging plan for proof of performance
   5. Submit at least (4) weeks before start of testing

H. Submit an Owner Training Plan. At a minimum include the following:
   1. Organized list of specific equipment or systems that require training
   2. Proposed training binder
   3. Separate agenda for each training session including but be not limited to:
      a. Construction Document review of systems
      b. Installation and as-built conditions
      c. Theory of operation
      d. Demonstration of operation
      e. Operation and Maintenance Document
      f. Servicing and Maintenance Schedules
g. Interlocks and Safeties
4. Manufactures’ recommended classroom training and schedule
5. Provide focused training for multiple audience types (i.e. operations vs. maintenance staff)

I. Submit a Project Schedule
1. For details of Project Schedule requirements, refer to 3.3 Scheduling

J. Record Documents:
1. Provide two versions of electronic copies of close out documents. Include one PDF for record
and one in original format that can be edited for documenting future changes.
2. Include field condition updates
3. Document material, make and model numbers where appropriate
4. Update details, schedules, risers, etc.
5. I/O point as-builts
6. Sequence details, modifications, or updates
7. Control loops including final set-points and parameters (other than default)
8. Mark and detail on coordination drawings, exact locations of equipment installed and wiring
drawings of both power and communication.
9. Panel details for each unique panel

K. Operation Manuals (Soft copy only):
1. Include a table of contents
2. Tab manual based on specification chapters or sections
3. Network architecture and communications concepts/diagrams
4. Uploading and downloading software to the field hardware
5. Detailed descriptions of all software programs
6. Complete set of software engineering manuals
7. Complete system design and engineering manual same as used by manufactures’ personnel
8. Application Programming
9. DVD of any configuration tools used in project
10. Operator training or User Manual
11. Calibration and/or verification sheets

L. Maintenance Manuals:
1. Include a table of contents
2. 1 copy on DVD
3. Organize by manual by specification section number
4. Index sheet listing contents in alphabetical order
5. Include the following:
   a. Installation instructions
   b. Manufacturer's operating and maintenance instructions (not product submittals)
   c. Factory and field-test records, including calibration and factory setup
   d. Printout of application control programs (typical)
   e. Snapshot printout of each system installed
   f. Signed checklist of each system
   g. Factory training schedule and course description catalog
   h. Archived backup of software, drawings, and record documents
   i. Installation contractor and service representative information
   j. Licensing and warranty information
1.9 QUALITY ASSURANCE

Note: These are unique building controls related QA requirements. These can be combined with the project Division 1 document, or retained in this document.

A. The Contractor shall be regularly engaged in the installation and maintenance of DDC systems and shall have a minimum of five (5) years of demonstrated technical expertise and experience in the installation and maintenance of BAS and HVAC systems similar in size and complexity to the project and have a maintained service organization. Provide evidence of such work in higher education environment.

B. The Contractor shall have at least 2 full-time employees who are Tridium Niagara Certified at the time of bid and contract award with at least one Tridium Niagara Certified employee assigned to the project.

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

D. Owner shall reserve the right to have Employees or Agents of Contractor removed from the project. Owner shall make final determination of qualifications of Contractor’s employee. Owner shall make a request in writing to Contractor citing the circumstances, i.e. Contractor’s employee applying programming practices that are in clear violation of Tridium’s published standards. Contractor shall replace unqualified employee within three business days of Owner’s request with no impact to project schedule.

E. All controls shall be accomplished using LonMark based devices (where the application has a LonMark profile defined) or BACnet Testing Laboratory (BTL) listed devices. All controllers shall be freely programmable to their application and shall at all times maintain their LonMark and BTL certifications.

F. All systems, equipment, components, accessories, software and installation hardware must be new, free from defects, and currently in production.

G. Provide the same manufacturer components of a given type product throughout project.

H. Digital equipment furnished under this contract shall have been tested and made to comply with limits of Class A computing device pursuant to Subpart J of Part 15 of FCC Rules.

I. Maintain NEC workspace clearances and comply with all aspects of NEC requirements.

J. Install and operationally check systems utilizing factory-trained competent technicians skilled in the setting and adjustment of equipment used in this project.

K. Test, adjust, and calibrate all end to end instruments.

L. The practice of adding point extensions to Niagara Network Proxy Points (read-only copies of Niagara Proxy Points) is not acceptable under any circumstances.

M. Follow project communication protocol for all correspondence. Any changes, decisions, etc. must be properly documented. The Engineer will not issue verbal directions. Verbal interpretations, clarifications, conversations, etc., are non-binding without proper documentation.

N. Request for Interpretation (RFI) shall include:
   1. Referenced drawing and/or Specification Section number
   2. Single request per RFI
   3. Single proposed solution per RFI
4. Attached sketch of solution (if applicable)
5. Attached specification verbiage (if applicable)
6. Contact person
7. Incomplete RFI’s will be returned without response
8. RFI answers are for clarification only and do not authorize additional work or change orders.

**Note:** If the above RFI requirements are already in the Div 1, delete them. Coordinate with Div. 1 requirements

O. Install devices in appropriate enclosure and in an accessible location.

P. Install systems and devices in a neat, workmanlike manner and in accordance with manufacturer’s recommendations.

Q. Continually monitor the field installation for code compliance and quality workmanship.

R. Remove and re-install any systems or devices where installation is deemed of poor quality by Owner or Engineer.

S. Comply with all health and safety regulations.

T. Include automatic restart logic for loss of power, safeties, fire alarm shutdown, etc.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Store products according to manufacturer’s recommendations.

B. Store products in original manufacturers packaging.

C. Do not store products more than 3 months prior to schedule installation.

D. Coordinate deliveries of material with construction schedule and appropriate trades.

1.11 WARRANTY

A. Submit warranty documentation upon completion of project or phase and acceptance by Engineer and Owner.

B. Warranty start date shall be the date of project written acceptance by Engineer and Owner.
   1. Warranty period shall be minimum 1 year parts and labor. Any manufacturer’s warranty that exceeds one year shall be extended to Owner.

C. Repair or replace systems or parts found defective at no cost to Owner including: but not limited to:
   1. Building Controls System Server software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies, as identified by the Contractor or Owner, shall be provided and installed at no charge during the warranty period.
   2. Contractor to apply all software updates and security patches immediately (within 72 hours) as they become available, from the start of the project until the end of the warranty period.
   3. All corrective software modifications made during the warranty period shall be updated on all user documentation and on user and manufacturer archived software disks.
   4. Include parts, labor, and necessary travel during warranty.
   5. All parts should be replaced with the exact products. If exact parts are not available then the equivalency determination rests with the Owner.
   6. Troubleshooting service, preventative maintenance, and scheduled re-calibration of the system is the responsibility of the Owner. Such routine tasks shall not impact Contractor warranty obligations.

D. Owner will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the complete system. Furnish Owner with a telephone
number where service representative can be reached at all times. Service personnel shall be at the site within 24 hours after receiving a request for service.

E. Provide vendor specific warranty information.

F. At the end of the warranty period, Contractor shall ensure every instance of Tridium Niagara software has the latest Tridium software maintenance release installed.

G. Expiration of the warranty period does not relieve Contractor of the responsibility for correcting all deficiencies identified during the warranty period. Expiration of the warranty period does not relieve Contractor of the responsibility for fulfilling all specified obligations during warranty period.

Note: Coordinate specific Warranty requirements with Owner. Coordinate with Div. 1 requirements

1.12 OWNER’S TRAINING

A. In no case shall training be scheduled until all graphics are approved and accepted by FESO.

B. Training shall not proceed until FESO has reviewed and approved the Training Submittal.

C. Provide a minimum of 16 hours of training, organized into 4 separate sessions of 4 hours each session.

D. Provide a factory-trained instructor or representative to give full instructions to designated personnel in the operation, maintenance, and programming of each piece of equipment or system. Instructors shall be thoroughly familiar with all aspects of the subject matter. The Contractor shall provide all equipment and material required for classroom training.

E. Qualifications of proposed training instructor is subject to Owner approval.

F. The training shall be specifically oriented to the system and interfacing equipment installed.

G. Organize training per user group and into different training sessions. Owner to provide user groups.

H. Include classroom instruction and field demonstration.

I. Classroom instruction should include at a minimum:
   1. Detailed review of as-built documentation and conditions with general equipment layout
   2. In depth discussion of theory or sequence of operations
   3. Review organization and usability of O&M documentation
   4. Maintenance (preventative, sensor calibration, etc.) procedures and schedules
   5. Pertinent safety requirements
   6. Operator control functions including graphic operation and navigation
   7. Explanation of adjustment, calibration and replacement procedures
   8. Explanation of procedures to restore any building level controller or building control system server database. Training manual shall include screen captures, including instructional annotation, of each step required to accomplish the task.
   9. Explanation of procedures to restore any local control unit database. Scenarios to explain include: restoring a database that is corrupted in an existing unit; restoring a database in a new unit that replaces an identical existing unit; and restoring a database in a new unit that is a different controller than the failed unit being replaced. Training manual shall include screen captures, including instructional annotation, of each step required to accomplish the task, for each type of DDC controller installed.
   10. Topics requested by Owner

J. Field instruction should include at a minimum
   1. Normal maintenance procedures
2. Demonstration of operation
3. Demonstration of safeties and interlocks
4. Walk-through of the job to locate control components

Note: Edit the above training requirements for each project. Make sure each item is appropriate and coordinate with Owner. Coordinate with Div. 1 requirement.

1.13 CALIBRATION AND COMMISSIONING

A. Contractor shall participate in the commissioning process, as directed by Owner’s Representative.
B. Refer to section 3.8 below for unique commissioning requirements for Division 25 work.

Note: Coordinate specific commissioning requirements with Commissioning Authority and Stanford for unique project requirements, specifically the scope relative to the DDC and Delta V systems.

1.14 ACCEPTANCE TESTING

A. Submit a detailed acceptance test procedure designed to demonstrate compliance with contract requirements at least 4 weeks before the start of testing. This procedure to be approved prior to the start of the testing.
B. During acceptance testing provide services of a fully qualified building automation technician who is knowledgeable of the project.
C. Using the commissioning test data Owner and/or its representative shall select, at random, functions to be demonstrated. These functions shall be demonstrated by the Contractor in accordance with the acceptance test procedure. At least 10% of the terminal unit control systems (VAV box, CAV box, FCU, etc.) shall be demonstrated. All 100% of the primary equipment controllers, (AHU, building hot water system, building chilled water system, etc.) shall be demonstrated. All 100% of the functions demonstrated must perform as specified and documented on commissioning data sheets or the system must be re-tested.
D. Calibration of analog inputs:
   1. Use calibration tool with twice the accuracy of instrument being tested. Record calibration offset on spreadsheet.
   2. Provide documentation to show that calibration tool has been calibrated in the last year.
E. Instrument Air Piping Pressure Test:
   1. Test all high pressure (80 psig) piping at 100 psig sustained for 24 hours. Pressure loss shall not exceed 10 psig at the end of the 24 hour test period.
   2. Test all low pressure (25 psig) piping at 30 psig sustained for 24 hours. Pressure loss shall not exceed 3 psig at the end of the 24 hour test period.
   3. Notify FESO and HVAC Shops of the testing schedule, with 1 week advance notice, so that operating personnel may observe testing.
F. Submit the results of functional and diagnostic tests, loop tuning parameters and calibrations in a three ring binder (including table of contents and tabs) for final system acceptance. System will not be considered complete until all tests are successfully completed and documented. Provide documentation of all On-Site Testing to Owner as part of the O&M package.

1.15 SYSTEM TESTING

A. General: Upon completion of all system start-up and checkout procedures, and while the mechanical systems are monitoring and controlling in a "normal operating" condition, the Contractor and Owner shall jointly demonstrate the performance of the complete system to maintain flows, temperatures, levels, relative humidity, and pressures. The test shall cover a continuous time period of at least three consecutive days. The test must meet the particular building’s design requirements to be considered passed and acceptable. Any failures shall require the test to be restarted.
PART 2 - PRODUCTS

2.1 NOT USED

Note: Products are defined in the various sections of Division 25

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to start of any work, check, verify, and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations, or adjustments necessary to complete work or to avoid interference with other trades.

B. Promptly request clarification and instruction or report any conflicts, inadequate conditions or missing information in the Project Documents. Report unacceptable conditions immediately.

C. Inspect site to verify that equipment can be installed as shown.

D. Examine drawings and specifications for work of others.

E. Perform necessary changes in specified work caused by failure or neglect to report discrepancies.

Note: The following sections on Project Management and Scheduling contain additional details required for retrofit applications. These can be edited out for New Construction projects.

3.2 PROJECT MANAGEMENT

A. No later than the project kick-off meeting, Contractor shall identify in writing:
   1. One employee of the Contractor who has the primary responsibility for managing the project. For purposes of scheduling and project management, this person shall be known as the Contractor’s Project Manager.
   2. One employee of the Contractor who has the primary responsibility for supervising the control system physical installation. For purposes of scheduling and project management, this person shall be known as the Contractor’s Installation Supervisor.
   3. One employee of the Contractor who has the primary responsibility for programming controllers, programming control system database and developing graphics. For purposes of scheduling and project management, this person shall be known as the Contractor’s Chief Programmer.
   4. Depending on size of project, the three above-listed roles may be performed by the same Contractor’s employee.

B. For purposes of scheduling and project management, the project shall generally be divided into 3 phases.
   1. Installation Phase shall be the period from project start until physical installation of all controllers, appurtenant devices and computers is complete.
   2. Database/Graphics Finalizing Phase shall be the period from the completion of Installation Phase until Contractor has completed all system programming and graphics development.
   3. Project Close Out Phase shall be the period from the completion of the Database/Graphics Finalizing Phase until Owner has accepted the project.

C. The Contractor shall attend all project meetings and provide meeting minutes and action items to all attendees within 3 working days of each meeting.
   1. During the Installation Phase, project meetings shall occur weekly at a regularly scheduled meeting time. Contractor’s Project Manager and Contractor’s Installation Supervisor shall attend all meetings during the Installation Phase. If requested by Owner, Contractor’s Chief
Programmer shall attend any meeting during the Installation Phase. Contractor shall furnish updated project schedule, with all applicable milestones, at least 1 day prior to the meeting.

2. During the Database/Graphics Finalizing Phase, project meetings shall occur as determined by Owner. Owner will give 1 week advance notice of any project meetings during this phase. Contractor’s Project Manager and Contractor’s Chief Programmer shall attend all meetings during the Database/Graphics Finalizing Phase. If requested by Owner, Contractor’s Installation Supervisor shall attend any meeting during the Database/Graphics Finalizing Phase. Contractor shall furnish updated project schedule, with all applicable milestones, at least 1 day prior to the meeting.

3. During the Project Close Out Phase, project meetings shall occur as determined by Owner. Owner will give 1 week advance notice of any project meetings during this phase. Contractor’s Project Manager and Contractor’s Chief Programmer shall attend all meetings during the Project Close Out Phase. If requested by Owner, Contractor’s Installation Supervisor shall attend any meeting during the Project Close Out Phase. Contractor shall furnish updated project schedule, with all applicable milestones, at least 1 day prior to the meeting.

D. Meeting minutes shall represent a true and accurate record of the meeting. Corrections or clarifications to the meeting minutes shall be by a written request for correction within 7 days of the date of issuance of meeting minutes.

E. Contractor accepts that during the Project Close Out Phase, Owner may rely on third party consultants, i.e. Commissioning Authority, to complete independent test and review of project deliverables from Contractor.

F. The Contractor shall maintain a “red-lined” copy of the as-built drawings on-site at all times.

G. The contractor shall have Functional Performance Test and start up sheets available on-site at all times.

3.3 SCHEDULING

A. The contractor is required to provide a schedule of activities and continually update the schedule as the project progresses. Clearly distinguish between commissioning activities performed solely by the temperature control contractor and commissioning activities involving the Commissioning Authority.

B. During Installation Phase, the Contractor shall update schedule weekly, at least 1 day prior to the project meeting, to provide a 3-week look-ahead schedule with a list of construction impacts for occupants.

C. Project Schedule shall include, at a minimum, with at least 3 weeks advance notice, the following project milestones:
   1. Contractor start physical installation.
   2. Any Utility Shut Down required by project.
   3. Contractor ready to connect Building Control System Server to Stanford Campus Controls Network.
   4. Contractor complete physical installation.
   5. Contractor complete and ready for Commissioning (Cx) Modbus Points (If applicable).
   6. Contractor ready for preliminary controller FPT and programming review (1 of each type of controller or controller application).
   7. Contractor ready for final zone terminal unit controller FPT and programming review (10% of each type of controller).
   8. Contractor ready for air handler FPT (Verifies AHU reset strategies and occupancy scheduling are functioning correctly).
   9. Contractor ready for building heating/cooling, central plant or whole building FPT (as applicable).
12. Contractor ready for Cx trend review.
13. Contractor submits Training Agenda and Training Binder for FESO review. Note: Graphics, Training Agenda and Training Binder must be reviewed and approved by FESO before training can be scheduled.
14. Training sessions.

D. Included in this project are connections to equipment provided by others. Coordinate deliveries, final locations, factory mounting, and various connections required.

E. Coordinate activities with contract project schedule.
   1. Ensure integration activities are incorporated into project schedule.
   2. Communicate requirements to prevent potential damage from paint, dust, water, weather, etc. Monitor and take measures to assure protection for all equipment.

F. Coordinate all IT requirements with owner and contract project schedule.

3.4 INSTALLATION

A. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

B. Provide sufficient slack, flexible connections and isolation to allow for equipment vibration.

C. Verify elevations and measurements prior to installation of materials.

D. Beginning installation means contractor accepts existing conditions.

E. Conceal wiring in conduit in mechanical spaces, above hard ceilings, and other spaces where exposed wiring could be damaged.

F. Provide temporary service, routing of service, or other temporary requirements to minimize downtime of service.

G. Equipment and wiring shall be selected and installed for conditions in which it will be required to perform. (i.e., general purpose, weatherproof, rain-tight, explosion proof, dust tight, or any other special type as required.)

H. Arrange for necessary openings in building to allow for admittance of all apparatus.

I. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without requiring movement of other equipment, which is to be installed or which is already in place.

J. Coordinate all systems in order to minimize access door requirements.

K. Coordinate final locations, sizes and rough-in dimensions for access doors.

L. Verify door swings for proper clearance before installing.

M. Perform the work in a safe and competent manner and use industry accepted installation procedures required for the work.

3.5 CONTROL SYSTEM SWITCH-OVER (CONTROLS RETROFIT PROJECTS)

A. Switch-over from the existing control system to the new system shall be fully coordinated with the Owner. A representative of the Owner may be on site during switch-over.
B. The control system downtime during switch-over shall be limited to 48 hours for each zone. Temperatures shall be maintained between 64 degrees and 78 degrees throughout the switch-over. Sufficient installation mechanics shall be on site so that the entire switch-over can be accomplished in this time frame. Sufficient testing of equipment shall be completed before switch-over to ensure readiness, including point to point checkouts and functional testing if necessary.

C. The control system downtime during switch-over shall be limited to 8 hours for 100% of zones. Temperatures shall be maintained between 64 degrees and 78 degrees throughout the switch-over. Sufficient installation mechanics shall be on site so that the entire switch-over can be accomplished in this time frame. Sufficient testing of equipment shall be completed before switch-over to ensure readiness, including point to point checkouts and functional testing if necessary.

D. Functional performance testing shall be performed on the first terminal unit of each type after switch-over prior to uploading the programs on the remaining terminal unit controllers. Testing shall be conducted with an Owner's Representative. The Contractor shall provide notice of two weeks for testing. Contractor shall review Controls Logic Documentation with Owner's Representatives. Contractor must have written acceptance from Owner's Representative approving the programming and the completeness of the programming documentation prior to uploading the programs on the remaining terminal unit controllers.

E. Demolition of the existing control system shall occur after the new temperature control system is in place and fully functional.

3.6 CLEANING

A. Upon completion of each phase (system, panel, etc.) clean all system panels, enclosures and field device enclosures.

B. Clean debris from equipment, control panels, security panels, fire panel enclosures, junction boxes, and pull boxes and arrange wire neatly with surplus length cut off prior to installation of covers.

C. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

3.7 DEMONSTRATION

A. Demonstrate operation of systems with Owner or Engineer.

B. Coordinate with commissioning activities.

3.8 COMMISSIONING, TESTING, AND ACCEPTANCE

A. The calibration and commissioning procedure shall consist of validating field I/O calibration, loop checks, actuator stroking, and integrated system operation validation. Document all commissioning information on commissioning data sheets, which shall be submitted to Owner for approval prior to testing. Notify Owner of the testing schedule so that operating personnel may observe calibration and commissioning.

B. Field I/O Calibration and Commissioning: Prior to system program commissioning, bring on-line each control device by:
   1. Performing a single point measurement validation of all analog devices.
   2. It is not acceptable to use an infrared non-contact thermometer to calibrate temperature sensors.
   3. Verifying instrument ranges.
   4. Verifying and documenting binary switch settings.
   5. Verifying and documenting actuator operating ranges.
   6. Verifying and documenting fail-safe position on loss of control signal.
7. Submit calibration data sheets. Data sheets shall include the device designation, the date of calibration and the name of person who performed calibration.

C. Loop checks: Perform test of every control device with Owner personnel.

D. System Program Commissioning: After control devices have been calibrated and loop control verified, each program shall be put on-line and commissioned. Owner shall confirm that the program logic follows the approved software flow chart and sequence of operation. Each control loop shall be adjusted to provide stable control within the specified accuracies.

E. Point to Point Installation Verification Procedure to consist of the following (as a minimum):
   1. Documentation - An Excel spreadsheet listing all I/O in the system including point name, address, Controller ID#, analog range or digital normal state, engineering units. Provide one signature block per page for contractor’s representative and Owner’s Representative to accept the test results.
   2. Digital Inputs: Jumper or open the wires at the device and verify change of state at controller and/or GUI. Record results on spreadsheet.
   3. Analog Inputs: Lift wire at device to see change of state and record default value on spreadsheet.
   4. Digital/Analog Outputs: Command the field device from the controller and verify corresponding change of state at the field device. Record results on spreadsheet.

F. Functional Testing and Sequence of Operation Verification Procedures to consist of the following (as a minimum):
   1. Control Loop Tuning:
      a. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop as part of the O&M package. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows for general space conditioning applications. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained:
         1). Duct air temperature: ± 1°F.
         2). Space Temperature: ± 2°F.
         3). Chilled Water: ± 1°F.
         4). Hot water temperature: ± 3°F.
         5). Duct pressure: ± 0.25” w.g.
         6). Water pressure: ± 1 psid.
         7). Duct or space Humidity: ± 5%.
         8). Air flow control: ± 5% of setpoint velocity.
      b. Where the same mechanical system is installed in multiple locations, one system must be tuned and the same tuning parameters may be used in other controllers.
      c. Tuning constants shall be set so that continuous oscillation of actuators does not occur. A steady state shall be achievable.
      d. When floating (3-point, incremental) control is used for VAV control, continual pulsing of actuator against end stops (end stop dithering) shall not occur when box is full open or closed.
      e. Trend logging or other graphical proof of loop tuning stability shall be submitted.
      f. Actuator movement shall not occur before the effects of previous movement have had sufficient time (minimum one time constant) to have affected the sensor.
      g. A detailed sequence of operation is provided for each system, including instructions for testing the sequence.
      h. A checkout form is provided for each system/sequence. Checkout form is to include areas to check and record each facet of the sequence of operations including, but not limited to the following:
1). Start/Stop  
2). Interlocks  
3). Safeties  
4). Valve and damper stroke  
5). PID Loops  
6). Modes of Operation  
7). Power failure/Recovery  
   i. Checkout form is intended to be a functions (yes/no/comment) test form.

G. 72 Hour test Procedures to consist of the following (as a minimum):  
   1. Place Entire System in Automatic Operation.  
   2. Generate Trends and Trend Logs of all I/O as directed by Owner’s Representative.  
   3. Review Trend Logs with Owner’s Representative to ensure system is controlling properly and that control loops do not exhibit excessive oscillation.  
   4. Owner’s Representative shall have the right to change set points and verify that system responds properly.  
   5. Repair any deficiencies found during 72 Hour test.  
   6. Re-Execute 72 Hour Test until no deficiencies are found.

3.9 PROTECTION  
   A. Protect installation against and be liable for damage to work and to material caused by Contractor’s work or employees.  
   B. Maintain protection for work and equipment until inspected, tested, and accepted.  
   C. Protect material not immediately installed.  
   D. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.  
   E. Material sensitive to temperature, dust, humidity, or other elements found unprotected shall be replaced.  
   F. Material showing signs of exposure shall be replaced.

END OF SECTION