APPENDIX E
MECHANICAL REQUIREMENTS

Building Automation Systems – Major Projects

PART 1 - GENERAL

A. SCOPE OF WORK

1. Furnish and install, as hereinafter specified a complete Building Automation System (BAS) utilizing the existing campus wide Apogee BAS System, incorporating direct digital control (DDC) for energy management, equipment monitoring and control.

B. THE ENGINEER WILL PROVIDE

1. Sequence of Operation.

2. System architecture and design including system riser diagrams.

3. Point lists including point address and point names.

4. Building automation and auxiliary transducer panel layouts including terminal strip identification.

5. Point to point wiring diagrams.

6. Final review of installed systems.

C. BUILDING AUTOMATION SYSTEM (BAS) CONTRACTOR SHALL PROVIDE:

1. System shall include all components, control devices, programming, incorporating Siemens System 600 direct digital control (DDC) controllers and Siemens component/power panels.

2. Provide LonMark certified unitary devices and/or controllers. TEC for VAV and fan powered terminal units shall be field mounted by this Contractor.

3. Programming shall be as follows:

a. Base Bid: Building Automation System programming will be by the University at no cost ($0) to the Contractor.

b. Alternate: Building Automation System programming will be by Siemens Building Technologies or Innovative Control Corporation.

4. Programmer shall be responsible for DDC controller programming, graphical user interface, development of all graphical screens, update existing campus wide graphics to reflect system additions, Lon Works network management, supervisory control applications, system integration and HVAC applications if documented by the Sequence of Operations as follows:

   a. Load Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, occupied/unoccupied setback/setup, DDC with PID and trend logging.

   b. HVAC Control Programs: Optimal run time, supply-air reset and enthalpy/economizer switchover.

   c. Convertor Control Programs: Convertor optimization with hot water reset, convertor and pump equipment selection and sequencing.

   d. Programming Application Features: Trend point, alarm reporting, alarm lockout, weekly scheduling, staggered start, sequencing, anti-short cycling and calculated point.

5. BAS Contractor shall provide programming modifications necessary to adjust set points, and sequences etc. during start up and through warranty period of systems at no additional cost to the University.

6. Connection of building's DDC panels to the University of Toledo's existing Energy Management System (EMS) host computer via trunk connection to the existing campus Ethernet.

7. System shall be installed complete by competent certified mechanics regularly employed in the installation of pneumatic and DDC temperature control systems.

8. Necessary conduit, wiring, enclosures, and panels, for all DDC temperature control equipment and devices. Installation shall comply with applicable local and national codes.

9. All final electrical connections to each stand-alone DDC Controller. Connect to 120VAC power as provided by the Division 16 contractor, and terminated in the DDC Controller.

10. BAS Contractor shall be responsible for all electrical work associated with the BAS control system including termination of all wires for external I/O devices, i.e. at sensors, H/O/A switches, etc. and as called for on the Drawings. This BAS control wiring shall be furnished and installed in accordance with the Electrical requirements as specified in Division 16, the National Electric Code, and all applicable local codes.

11. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers, Application Specific Controllers and operator's workstations. Provide an external protection device listed under UL 1449 with minimum clamping voltage of 400 Volts and surge current capability of 26,000 Amps.

12. All 120V and low voltage electrical control wiring exposed throughout the building shall be run in conduit in accordance with the Electrical requirements as specified in Division 16, the National Electric Code, and all applicable local codes.

13. All 24V power required for operation of the BAS shall be by the BAS Contractor.

14. Provide compressed air system, refrigerated air dryers, operators, control air tubing, etc.

15. Provide sensors gauges, indicating devices, electric and electronic control accessories, and other control system devices.

16. Provide calibration and start-up services of temperature control systems.

17. Failure to mention specific item or device does not relieve the Building Automation System (BAS) Contractor of the responsibility for furnishing and installing such items or devices in order to comply with the intent of the Drawings and/or this Specification.

C. HVAC CONTRACTOR PROVIDES:

1. All wells and openings for water and air monitoring devices, temperature sensors, flow switches and alarms furnished by BAS Contractor.

2. Installation of all control valves.

3. Installation of dampers and adjacent access doors for smoke; outdoor air, return air, exhaust air, and ventilation dampers. All package unit control panels.

D. ELECTRICAL CONTRACTOR PROVIDES:

1. Electrical Contractor shall provide dedicated 120 volt, 20 amp circuits and circuit breakers from normal and/or emergency power panel for each DDC Controller.

E. QUALITY ASSURANCE

1. The BAS system shall be installed, commissioned and serviced by manufacturer employed, factory trained personnel. Distributors and wholesalers of BAS systems herein specified, shall not be acceptable.

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

3. BAS shall comply with UL 916 PAZX and 864 UDTZ, and other subsystem listings as applicable, and herein specified, and be so listed at the time of bid.

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

F. SUBMITTALS

1. Submit 10 complete sets of documentation in the following phased delivery schedule:

2. Equipment data cut sheets

3. Auto-CAD compatible as-built drawings

4. Upon project completion, submit operation and maintenance manuals, consisting of the following:

   a. Index sheet, listing contents in alphabetical order.

   b. Manufacturer's equipment parts list of all functional components of the system.

   c. As-Built interconnection wiring diagrams.

   d. Operator's Manual.

   e. Trunk cable schematic showing remote terminal equipment controllers, electronic panel locations, and all trunk data.

   f. List of connected data points, including panels to which they are connected and input device (ionization detector, thermostat, etc.).

   g. Conduit routing diagrams

G. WARRANTY

1. Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of three years after beneficial use.

2. The adjustment, required testing, and repair of the system includes all transmission equipment, all sensors and control devices.

3. The on-line support services shall allow the BAS Contractor to dial out over telephone lines to monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

4. If the problem cannot be resolved with on-line support services of the BAS Contractor shall dispatch the appropriate personnel to the job site to resolve the problem within 3 hours of the time that the problem is reported.

H. COORDINATION

1. Coordinate Building Automation System based on the "Scope of Work" as specified in this section.

2. Ensure installation of components is complementary to installation of similar components in other systems.

3. Coordinate installation of system components with installation of other mechanical system equipment.

4. Coordinate control wiring requirements, including actual terminal block numbers, with mechanical equipment manufacturers.

PART 2 - PRODUCTS

A. ACCEPTABLE MANUFACTURERS

1. The complete Building Automation System hereinafter referred to as the BAS system, including Section 15900 and all related system integration specified in Sections 15000 and 16000 shall be supplied and installed by only one manufacturer. Acceptable manufacturers are:

a. Siemens Building Technologies, Inc., System 600

b. Johnson Controls Metasys

c. Invensys

d. Honeywell

2. The BAS system herein listed shall be installed, commissioned and serviced by factory trained personal that are under the direct employment of the above listed manufacturers. Certified factory distributors and product wholesalers of all listed BAS systems herein specified shall not be acceptable.

3. Substitutions to system herein specified will not be acceptable.

B. GENERAL

1. Siemens 600 DDC panels provide the following functions:

a. Mathematical: Absolute value, calculate, square root, power, sign, average, totals.

b. Logic: OR, AND, compare negate.

c. Fixed Formula: High and low select, span, rate, ramp, enthalpy, wet bulb, dewpoint, relative humidity, humidity ratio, filter.

d. Data Manipulation: Store, file and set.

e. Control Routines: Real-time based functions, proportional, proportional-integral, proportional-integral-derivative, direct-acting, reverse acting, feed forward, fixed setpoint, calculated setpoint, adjustable setpoint, lead lag and hysteresis correction.

f. Energy Management: Time scheduling, optimum start/stop, enthalpy optimization, duty cycle, trend, demand limiting, zero energy, warm up cycle, night cycle, night purge, reset optimization, runtime totals and holiday and daylight savings time correction.

g. LonMark interface capability.

2. DDC panels will provide self-test procedure. Notify host with advisories for maintenance, performance, software, cable break, or data transmission problems. Identify variables as reliable or unreliable. Variables identified as unreliable shall use default in calculation.

3. Panel will notify host for alarms and deviations such as abnormal alarm, high/low alarm, and floating alarm. Alarm scan shall show alarms and identification. Continue alarm indication until acknowledged and alarms condition is corrected.

4. Panel shall have two communication interface ports for communication between processor, other processors, central processing unit and portable terminal. Provide a communication network to connect the new processor to the existing in the building and to the HOST, including modem(s) and surge protection as required.

C. LON MARK

1. The LonMark certified unitary controller shall communicate with the direct digital control (DDC) system over a LonWorks network. The Building Automation System shall communicate with the equipment to monitor and command points as shown in the points list, sequences of operation and control schematics.

2. The LonMark device supplier shall provide all hardware and software necessary to integrate the controls with the LonWorks network and meet the system's functional specification. The LonMark device supplier shall provide proof of experience with integration of the type outlined in this Specification. The supplier shall provide individuals experienced with the installation and startup of equipment relating to LonWorks.

3. The LonMark device supplier shall supply the Owner with all necessary documentation for integration. This must include, at a minimum, the following for each device installed:

   a. Two (2) copies of the External Interface File from the actual installed device is required.

   b. Application Manual

   c. Device cut sheets

4. The LonMark device supplier shall supply the Owner with a unit of the same type as the devices to be installed for integration testing and troubleshooting. This unit will remain with the system integrator.

5. The LonMark device supplier shall install, configure and start-up the LonMark devices. The LonMark equipment supplier shall independently start-up, checkout and test all hardware and software and verify communication between all components.

   a. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

   b. Verify that all analog and binary input/output points read properly.

   c. Verify alarms and interlocks.

d. Do NOT add devices to LonWorks network without presence and assistance from the Owner.

6. Joint Commissioning – Verify operation of the integrated system.

a. Upon review of the integrated solution, a point to point test of the integrated control installation shall commence. The LonMark device supplier representative in conjunction with the building control installer shall test actual field operation of each control and sensing point. Compare the values read in the Owners system to those indicated by the LonMark device.

b. When the point to point input/output testing is successfully completed a series of hardware/software systems tests shall be performed. All groups of points that yield a system control shall be tested for compliance with the sequences of operation. The tests shall include but not be limited to:

1) Control interlocks and any miscellaneous sequences shall be tested.

2) All alarm and shutdown modes shall be tested for proper operation.

3) The Engineer and Owner may elect to be present to observe and review these tests. They shall be notified at least ten days in advance of the start of the testing procedures.

D. FIELD DEVICES

1. Temperature sensor assemblies shall consist of a Resistive Temperature Device (RTD's) with a 4-20 mA transmitter and enclosure. Sensing element shall be platinum with 100 ohms resistance at 32 ° F. Accuracy shall be +/- 1/2 ° F over the entire range.

a. Single point duct temperature sensor shall be rigid bulb type and have a calibrated span of 20-120 ° F or higher for heating applications.

b. Averaging element duct mounted temperature sensor shall be 25-ft. long sensor probe type and have a calibrated span of 20-120 ° F.

c. Liquid immersion temperature sensors shall have 5 1/2" long probe with well, and weather tight enclosure. Transmitters for chilled water shall have a calibrated span of 20-120 ° F.

d. Room temperature sensors shall have a minimum span of 40-90 ° F, locking covers and shall match the pneumatic thermostats used.

2. Outside Air Master Temperature and Humidity Sensors - Dual System:

   a. Single point outside air temperature RTD shall be 1000 ohm thin film platinum resistor sensor with 4-20 mA output transmitter with solar shield.

   b. Outside air humidity sensor shall be thin film alumina substrate capacitance signal generating sensor with 4-20 mA output transmitter with 0-100% relative humidity range within +/-1% RH as manufactured by Hy-Cal Engineering, equivalent to Model No. CT-830-E-LNF,-25-125 ° F, 0-100%.

      X21, Internal Probe Wall Mount,
      X5, Temp. Transmitter matched to sensor Ice Point,
      X52, PVC Solar Shield
      X53, SST Filter-Humidity Sensor

3. High Precision Temperature Transmitters (for CHWS and CHWR temperature inputs used for BTU calculations):

   a. Temperature transmitter with platinum RTD sensor and 4-20 mA DC output. Zero and span shall be continuously adjustable. Sensor and transmitter shall be a matched assembly. Accuracy shall be +/- 0.1% of calibrated transmitter span, including combined effects of repeatability, hysteresis and linearity. Calibrated range shall be 20 to 120 ° F. Both CHWS and CHWR sensor/transmitter assemblies shall have the same span and shall be factory calibrated as a matched pair.

   b. Liquid immersion sensors shall have welded stainless steel thermowell. Transmitters shall be of the potted type or shall have a thermally isolated watertight enclosure. Length of sensor and thermowell shall be selected based on the diameter of the pipe to provide accurate, reliable and homogeneous sensing of the liquid temperature. Thermowell pressure rating as noted for each system in section 15510 - Hydronic Piping, 15520 - Steam and Condensate Piping and 15411 - Water Distribution Piping.

4. Humidity Sensors:

   a. Elements: Thin film capacitive type or bulk polymer resistance type, accuracy of +/- 2% RH, range of 0-99% RH with 4-20 mA linear output. Factory calibrate for maximum accuracy at mid-range of normal operating humidity. All humidity sensors shall be resistant to chlorine and other cleaning agents.

   b. Room Sensors: With locking cover.

c. Duct Sensors: With duct probe and mounting plate.

5. Air Static Pressure Transmitters:

a. Variable capacitance type with ranges not exceeding 150% of maximum expected input. Transmitter shall have zero and span adjustment. Output shall be 4-20 mA.

b. Safe over pressure rating shall be minimum 5 times the range.

c. Temperature compensated with thermal error of not greater than 0.04% of full scale in temperature range of 40 to 100 ° F.

d. Accuracy: 1% of full scale.

e. Provide a 4" Magnehelic gauge of appropriate span and units (in. WC, etc.) for each transmitter. Gauges shall be graduated in inches W.C. for static pressure sensing measurement.

6. Water/Steam Differential Pressure Transmitters and Sensors:

a. Transmitters used for measuring flow rates:

1) Each differential pressure transmitter shall be selected and calibrated for operations between 0 and 125% of the normal differential pressure and up to 150-psig line pressure. The calibration point shall be rounded upward to the nearest 10 inches WC (for spans less than 200" WC) or to the nearest 5 psi for larger spans. Calibration date shall be included on an embossed tag attached to each transmitter.

2 The accuracy, including linearity, hysteresis and repeatability, of the transmitter for measuring differential pressure shall be better than 0.25% of the span stated above throughout a minimum of a 6:1 turndown. Turndown ratio shall be selected on the actual flow span.

3) The transmitter shall not be damaged by pressures of up to 1000 psig on either side of the transmitter and all wetted parts shall be essentially inert in the presence of up to a 40% concentration of ethylene glycol in water.

4) Provide a drain valve for each side of the pressure chamber. Furnish and install mounting brackets appropriate for the installation location.

5) Span and zero shall be individually adjustable.

7. Transmitters used for measuring differential pressure only:

   a. Each differential pressure transmitter shall be selected and calibrated for operations between 0 and 200% of the normal differential pressure. The calibration point shall be rounded upward to the nearest 10 inches WC (for spans less than 200" WC) or to the nearest 5 psi for larger spans. Calibration date shall be included on an embossed tag attached to each transmitter.

   b. The accuracy, including linearity, hysteresis and repeatability, of the transmitter for measuring differential pressure shall be better than 2% of the span stated above throughout a minimum of a 4:1 turndown. Turndown ratio shall be selected on the actual differential span.

   c. The transmitter shall not be damaged by pressures of up to 500 psig on either side of the transmitter and all wetted parts shall be essentially inert in the presence of up to a 40% concentration of ethylene glycol in water.

   d. Provide a drain valve for each side of the pressure chamber. Furnish and install mounting brackets appropriate for the installation location.

   e. Span and zero shall be individually adjustable.

8. Three Valve Manifold:

   a. Provide a three-valve manifold for each transmitter. Pressures of up to 500 psig shall not damage the manifold and all wetted parts shall be essentially inert in the presence of up to a 40% concentration of ethylene glycol in water.

   b. The manifold shall be designed for direct mounting on the transmitter it serves and utilizes two quarter turn valves to provide zeroing, blocking and normal service modes.

9. Waterflow Sensors:

   a. Uni-directional waterflow sensors shall be of the venturi type or velocity pressure type. They shall be constructed of stainless steel, sized to the system's range of flow, and have an accuracy of 0.5%.

   b. Bi-directional waterflow sensors shall be of the velocity pressure type. They shall be constructed of stainless steel, sized to the system's range of flow, and have an accuracy of 0.5%.

10. Electro-magnetic Flow Meters

a Chilled water flow measurement sensors shall be of the electro-magnetic flowmeter type and shall be bi-directional, microprocessor-based, and flange mounted. The flow sensor liner shall be suitable for the media it will be measuring. The electrodes shall be Stainless Steel or Hasteloy C. The transmitter shall be furnished with an integral universal wall/pipe mounting bracket and cable for remote mounting, integral LCD display, and NEMA 4X housing, shall indicate flow rate, totalize flow, and shall have an isolated 4-20 mA linear output signal. The unit shall be factory calibrated for the specified flow and shall be calibrated in both directions if the application is bi-directional. Calibration shall be minimum three point. The unit shall be mounted in an accessible location and shall be capable of being field calibrated and reprogrammed from the outside housing via magnetic probe or integral keypad menu switching. Unit shall have the capability to maintain flow total in non-volatile memory. Power to the unit shall be 120 VAC. The flowmeter shall be provided with a 2-year warrantee and application performance guarantee. The flowmeter and transmitter as a unit shall have the following minimum characteristics:

1) Flowmeter Liner:
Chilled water: Polyurethane or Teflon.
Steam condensate: Ceramic.

2) Accuracy: (Over an operating range of 30-120 ° F.)
At 1 to 33 feet per second velocity: +/-0.5% of rate.
At 0.3 feet per second velocity: +/-2% of rate.

3) Bi-directional requirements:
Chilled water de-coupler flow shall be bi-directional.
Unit shall provide two analog 4-20 mA signals or a single 4-20 mA signal and a digital contact closure on reverse flow.

b Flow meters shall be installed with at least 10 diameter of straight pipe length upstream and five diameter of straight pipe length down stream. If this requirement cannot be met, contact design engineer prior to installing any related pipe and the flow meter.

11. Current Sensing Relays

a. Provide current sensors with donut transformers capable of monitoring AC current, maximum input current ranges from 20 to 300 amp, peak, with digital output signals having adjustable high and low current trips. LED model is not acceptable.

12. Electronic to Pneumatic Transducers

a. Provide Bellafram transducers to convert electronic signals from the Siemens Building Technologies analog output modules to linear proportional pneumatic signals for all DDC controlled modulating pneumatic devices. The transducer shall be a panel-mounted device, with hand/auto switch, override dial for manual override control, and a 0-30 psig output gauge. Supply voltage shall be 19-26 VAC. Control signal shall be 0-10 VDC or 4-20 mA. Output accuracy shall be 1/4 psig at 75 ° F, producing a 0-15 psig pneumatic signal. Output repeatability shall be .05 psig maximum. Transducers shall be high capacity non-bleed devices with a minimum output capacity of 500 SCIM, except special circumstances, which require a constant, bleed controller with branch exhaust on signal loss.

13. Limit Switches

a. Oil tight type with operator as required to provide required function. Limit switches used on dampers should be set at approximately 75% of full stroke.

14. Airflow Sensors:

a. Provide where indicated amplified signal airflow traverse probe(s) or airflow stations, complete with straighteners when required, capable of continuously monitoring the fan or duct capacities (air volumes) it serves.

15. Carbon Dioxide Sensors:

a. Carbon dioxide sensing cell shall consist of a nondispersive infrared carbon dioxide gas cell that uses a pulsed source and has no free air optical path. Output shall be linearized 4-20 mA with the 24 VDC input. In addition, the unit shall be capable of providing SPDT switching of an external low voltage circuit at an adjustable setpoint. The unit shall be specifically designed for the wall or duct application specified. Return air aspiration boxes shall be designed by and approved by the manufacturer. Unit shall have single point setpoint and span adjustment. The unit shall have no moving parts. Power for the sensor shall be extended from a transformer or adapter installed adjacent to the DDC control panel, and shall be run parallel to the 4-20 mA signal cable.

b. Minimum requirements:

Range	0-2,000 ppm
Accuracy	3 % full scale
Repeatability	1% of full scale
Power Consumption	less than 3 watts

Relay contact rating	1 amp at 28 VDC|
Zero Drift at Constant Temp.	100 ppm per 24 hrs (random not cumulative)
Max. allowable Drift in 1 year	100 ppm

c. Contractor shall provide all necessary equipment and test gas for calibration and shall calibrate all carbon dioxide sensors in accordance with the manufacturers recommendations.

E. PNEUMATIC AND ELECTRIC COMPONENTS:

1. Electric-Pneumatic Relays (To be installed in the component panel): Electric, solenoid operated, two-position air valve for panel mounting. Solenoid coil to be 120 VAC. Valve to be 3 or 4 port.

2. Pneumatic-Electric Relays: Electric, two-position type, range and element shall be suitable for the service, single or two pole, normally open or normally closed as required. Setpoint shall adjustable over the full range. Switch rating shall be 8.0 amps at 120 VAC, minimum.

3. Low Temperature Detection Thermostat: Duct type, fixed 5 ° F differential, range 30 to 60 ° F Sensing element shall be a 20 foot long capillary tube responding to the lowest temperature sensed along any 12 inches of bulb length. Switch shall be DPDT 120 VAC, UL listed, rated for 10 amps at 120 VAC full load, one pole wired to unit starter, one switch to Building Automation System. Unit shall be manually reset. Provide one thermostat for every 20 square feet of coil surface.

4. High Temperature Detection Thermostat: Electric, two-position type, range and element shall be suitable for the service, single or two pole, normally open or normally closed as required. Setpoint shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load. Unit shall be manually reset.

5. Immersion Thermostat: Electric, two position type, range and element shall be suitable for the service, single or two pole, normally open or normally closed as required with stainless steel separable well. Setpoint shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load.

6. Strap-on Thermostat: Electric, tow position type, range and element shall be suitable for the service, single or two pole, normally open or normally closed as required. Setpoint shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load.

7. Panel Mounted Pneumatic Gauges: Provide door mounted visual analog indicator gauges with accuracy as listed below:

Size	Accuracy
3-1/2"	+/- 1%

F. ELECTRICAL ACCESSORIES:

1. Wiring and Conduit

a. The contractor shall provide all DDC and related control wiring and conduit. All low voltage control wiring shall be in EMT conduit. Wire and cable shall be pulled from device or control point to the DDC panel with 6'-0" spare coiled at the panel. All wire and cable shall be labeled and tagged.

b. A dedicated 20-amp circuit shall be provided by the division 16 contractor for each DDC cabinet and each auxiliary control cabinet from power or receptacle panels shown on electrical drawings. Coordinate panel locations with Division 16 Contractor.

c. Conduits shall be sized on a maximum fill of 40% capacity, minimum size ¾".

d. All control wiring shall have insulation rated for 300 volts minimum and run in conduit. Refer to Division 16000 Specification Sections for requirements.

e. Separate conduit systems shall be provided:

1) 120 volt DO and 120 VAC control wiring.

2) AO/AI/DI and 24 volt DO wiring. Data transmission cable/phone line/LAN cable.

3) Pneumatic tubing

f. Data transmission cabling and equipment grounding procedures shall meet the latest FCC guidelines for electromagnetic field generation.

g. All control wiring sizes and types shall meet the equipment manufacturer's recommendations.

h. DDC Wiring and Cable requirements for new DDC panels:

Digital Output	*Minimum #14 AWG THHN
Digital Input	*Teflon jacketed twisted pair #16 AWG or #16 AWG THHN
Analog Output	*Teflon jacketed twisted pair #18 AWG
Analog Input	*Teflon jacketed twisted pair #18 AWG

Data Transmission	*Teflon jacketed twisted shielded pair #22 AWG

* Wire sizes listed for lengths up to 750'. For distances over 750', contact engineer.

i. DDC Wiring and Cable requirements for existing DDC panels:

Digital Output	*Minimum #14 AWG THHN
Digital Input	*Teflon jacketed twisted Shielded pair #18 AWG or #16 AWG THHN
Analog Output	*Teflon jacketed twisted shielded pair #18 AWG
Analog Input	*Teflon jacketed twisted shielded pair #18 AWG
Data Transmission	*Teflon jacketed twisted shielded pair #22 AWG

* Wire sizes listed for lengths up to 750'. For distances over 750', contact engineer.

j. All junction boxes containing DDC related wiring or pneumatic tubing shall be painted a sky blue color. All conduits containing DDC related wiring or pneumatic tubing shall have a 6" long sky blue color band painted at 20' intervals. Conduits containing DDC wiring or pneumatic tubing which pass through walls or floors shall have a 6" long band painted on each side of the penetration.

k. For DDC terminal equipment controllers (TEC's) that do not have an enclosure for terminating conduits, the conduit shall end no more than 18" from the device and shall include a junction box, terminal fitting or insulating bushing as required by NEC section 300-16.

a. Exception: For DDC VAV boxes replacing pneumatic boxes, control wiring between the controller, room sensors, damper actuators and valve actuators need not be located in conduit. Wiring not installed in conduit shall follow the route of the pneumatic tubing it replaces and shall use the same supports, as closely as possible. Wiring shall be supported in a neat and workman like manner.

G. TEMPERATURE CONTROL SYSTEM VALVES:

1. General: Valve bodies 2 inches IPS and smaller shall be single seated bronze and shall have screwed end connections. Valve bodies 2-1/2 inches IPS shall be cast iron and shall have flanged end connections. Valve stem packing shall be tetrafluorethylene, spring-loaded, self-adjusting. Packless construction is acceptable. Valve linkage shall have an adjustment for valve lift. Valve to have rising stem, renewable seat and disc, repackable under pressure. Valves 3" and larger shall be high performance butterfly valves per Section 15100.

2. Steam: Steam valve bodies and trim shall be rated for scheduled saturated steam service pressures. Steam valve replaceable plugs and seats shall be stainless steel, hardened to not less than 500 Brinnel. Pressure drop across any steam valve at maximum flow and valve size shall be as indicated. Valves shall have modified linear characteristics.

3. Hydronic: Hydronic system valve bodies and trim shall be rated for service pressures through 125 psig at 250 °F. Hydronic system valves shall have replaceable plugs and seats of SAE 72 brass or AISI 300 series stainless steel, selected for maximum lift under application conditions. Maximum pressure drop across any hydronic system valve at maximum flow and valve size shall be as indicated. Size valve operators to close off against pump shut off head. Two-way valves shall have equal percentage characteristics and three way valves shall have linear characteristics.

4. Operators:

    a. Pneumatic, rolling diaphragm, spring loaded, piston type.

    b. Spring range shall be as required for non-overlapping sequencing or as indicated on drawings.

    c. Ratio relays or cumulators used for sequencing valves are not acceptable unless specifically indicated on the drawings.

    d. Valves shall spring return to normal position as indicated.

    e. Select with sufficient shut-off power for system pressure and highest operating torque, and torque requirements of valves, which may stick because of infrequent use.

    f. Select to provide smooth proportioning control under operating conditions normal to the system.

    g. Pilot positioners shall be used when required to achieve the requirements as specified and on all valves 2 ½” and larger.

    h. Butterfly control valve actuators shall be pneumatic rotary type with rack and pinion to provide constant output torque, positive positioner, spring return, adjustable travel stops, factory tested, factory lubricated, self draining body, integral pneumatic parting, localized mechanical position indicator readable at 25 feet, 0-90 ° reversible operation, capable of operating in any valve mounting attitude, capable of being mounted in line or transverse to pipeline, bolt directly to valve top plate. Valves 5" and above shall be actuated with 70 lbs. air with 3-15 lbs. pilot service.

i. Electric Butterfly Control Valve Actuators: Permanent split capacitor, reversible electric motor which drives a compound epicyclic gear, thermal overload protection, factory tested, factory lubricated, localized mechanical position indicator readable at 25 feet, 0-90 degree reversible operation, bolt directly to valve top plate. Housing shall be weatherproof and suitable for outdoor location. Provide thermostatically controlled heater for prevention of condensation at low temperatures, 120 VAC. Actuator ambient temperature range shall be -20 ° F to +140 ° F. Provide separate limit switches, which close at the full open and full closed position, respectively. Actuator shall include a manually operated handwheel for manual override of the valve position.

H. DAMPER OPERATORS:

1. General: Provide smooth, proportional control with sufficient power for air velocities 20% greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return to normal position. Damper operators shall be installed in accessible locations. Damper operators shall not be installed inside exhaust air ducts, or exhaust air units.

2. Pneumatic Operators: Rolling diaphragm piston type with spring range as indicated on drawings.

3. Electric Operators: Maintenance free electric actuator, reversible, with push rod and bracket for swivel mounting and for the transmission of power. Synchronous motor with load independent running time providing parallel operation of several operators. Gear train with low noise level. Magnetic hysteresis coupling with magnetic transmission of torque, with no mechanical contact between the coupling members. The actuator shall be safe against blocking and overload proof even when operated continuously.

4. Number: Sufficient to achieve unrestricted movement throughout damper range. Provide sufficient number of operators such that one operator does not operate more than the maximum square footage of damper area as recommended in standard catalog of manufacturer.

5. Inlet Vane Operators: Provide inlet vane operators where indicated with pilot positioners and sufficient force to move vanes when fan is started with vanes in the closed position. Where required to meet these conditions, provide high-pressure operators with pilot positioners.

I. DDC TERMINAL EQUIPMENT PANELS (TEC'S):

1. Provide application specific DDC TEC's for field mounting to the VAV box. Coordinate to provide a complete operating package in accordance with the

sequence of operation requirements. Only TEC's with Lon Mark certification will be acceptable.

2. LonMark Certified Terminal Equipment Controllers

   a. Provide LonMark certified ASC for control of each piece of equipment, including, but not limited to, the following:

      1) Variable air volume (VAV) boxes.
      2) Fan powered variable air volume (VAV) boxes.

   b. Controllers shall provide a selection of control applications performable through configuration (not programming) of the device without violating the LonMark certification.

   c. Controllers shall operate in stand-alone mode as needed for specific control applications if network communication fails.

   d. Controller must include a FTT-10A transceiver for communication on the LonWorks network at 78.8K bps.

   e. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Inputs shall be universal for support of 0-10V, 100k therm, 40-29mA or dry contact.

   f. Controllers shall include spare inputs/outputs not used in the application to wire accessories.

3. Packaging shall be such that field wiring can be performed prior to the installation of the controller. Board terminations shall be detachable from controller to facilitate troubleshooting, repair, and replacement.

   a. Utilize standard configuration parameter types (SCPT's) for all product configuration parameters. Do not use network variable for this purpose.

4. A common network management tool must be used for all LTECs and 3rd party LonMark devices connected to the LonWorks FLN. This tool will perform all node addressing, network setup and maintenance for the network regardless of device manufacturer.

   a. Shall include the following minimum services:

      1) Device installation
      2) Device configuration
      3) Device diagnostics
      4) Field programming
      5) Device maintenance

6) Network variable binding
7) Network variable browsing
8) Network variable monitoring

b. Shall include all software modules necessary for complete network management, installation and maintenance.

c. Shall support multiple service tools in client/server network fashion.

5. If a manufacturer specific management tool is necessary, it shall be used only for application programming. It should be used for configuring and installing the device ONLY and not for any network function.

6. All LonMark ASC sensors, LonMark ASCs, and DDC Controllers with a LonWorks FLN must provide the Network Management Tool access to the entire LonWorks FLN via a RJ-11 port.

7. The VAV box manufacturer shall provide the averaging air velocity sensor.

8. Provide wall mounted temperature sensors where shown on the Drawings.

9. Power Requirements for TEC's

a. Provide all necessary 24 VAC transformers, 24 VAC power distribution wiring, etc. to TEC's for a complete operating system. Transformers shall be mounted in an electrical closet or other suitable accessible location. All power wiring shall be sized to handle the connected load and not to have voltage drops because of long wire runs.

J. COMPONENT/POWER PANELS:

1. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face, or as detailed on drawings. Provide panel with locking door. Panels to be manufactured by Siemens Building Technologies and have matching locks as the S600 Automation panels.

K. PNEUMATIC ACCESSORIES:

1. Control Air Supply

a. Compressed Air System: A duplex compressed air system shall be provided, installed and guaranteed by the Temperature Control Contractor. Each compressor shall be of 3/4 HP minimum and of enough capacity under normal conditions to run not more than 33-1/3% of the time. Air compressors should be sized to include air

requirements for steam pressure reducing stations and steam de-superheater, when compressed air is required. The compressor shall be of the type, which is proven to be satisfactory for temperature control system air supply. The crankcase must be vented to the atmosphere, not to the compressor suction. The air compressor suction filter shall have a 10-micron filtering ability. It shall be of the replaceable impingement type. Each compressor shall be driven by an electric motor with nameplate voltage of that available at the installation. Each motor shall be oil pressure controlled by a pressure operated, enclosed pilot switch connected to the combination motor starter/alternator. Pressure switches for start-up controls shall be set to operate between 70 and 100 psi and shall be adjustable. Air storage tanks shall be constructed, tested and stamped in accordance with ASME Code of Unfired Pressure Vessels. Tank shall be constructed of steel plate, welded and designed for a working pressure of not less than 125 psi. Tanks mounted with compressors may be horizontal or vertical. The safety valve, placed between the compressor and the discharge hand valve, shall be set for a pressure 10% above the control switch off pressure. The air storage vessel shall have sufficient capacity to allow no more than 12 starts of the compressor per hour. Include compressor-sizing calculations with submittals. Acceptable manufacturer - Quincy

b. Refrigerated Air Dryer: After coolers of the mechanical refrigeration type shall be provided. They are to be of sufficient capacity to assure a dew point of a maximum of 10 degrees F in the 20 psi supply(-5 degrees F at atmosphere). The compressed air treatment unit will run continuously whenever any part of the control system is in operation. A water rejection system will be provided to discharge all water and oil condensed in the after cooler and the pressure-reducing valve. Pressure reducing valve shall have a 150-psi inlet pressure rating or higher. They shall be of the relieving type with an operating temperature of 200 degrees F or better. The pressure reducing valves shall have a capacity equal to or greater than the system they serve. Provide filtration system capable of removing oil vapors and 5-micron particles from the air stream. Provide one 30-psig-pressure control and relief valve per pressure regulator.

c. Compressor Sequencer: Furnish and install an electric sequencer for the dual air compressors to automatically alternate the compressor motors after each running cycle. Sequencer shall be further connected to energize the lag compressor at the setting of the lower pressure switch if the lead compressor fails.

2. Tubing

a. Copper tubing shall be new hard drawn, Type L, ASTM B68, with solder joint or compression type fittings, at the option of the Contractor.

b. Plastic Tubing (all sizes): Black virgin, polyethylene, ASTM D1248, Type 1, Class C, Grade 5, meeting crack test performance required by ASTM D1693 and be fire retardant (FR) rated. Multi-tube harness material shall be as specified above with the polyester film barrier and vinyl jacket not less than 0.062 inches thick. All non-metallic tubing shall be 1/4" O.D.. minimum, micro-sleeve is not acceptable.

c. Plastic tubing may be used (unless indicated otherwise) in concealed locations only. In mechanical rooms and other exposed locations, plastic tubing shall be in conduit.

d. Tubing shall not be attached to conduits with current carrying conductors or fire protection piping. Tubing shall be adequately supported with no noticeable sagging between supports.

3. All pneumatic tubing shall be concealed in finished areas, except mechanical rooms.

L. AIR FILTERS:

1. Provide air filter for main air supply to all DDC panels.

M. IDENTIFICATION AND LABELS:

1. The contractor shall provide phenolic nameplates for each DDC or auxiliary panel, permanently attached, to identify field panel number, trunk number, building, area, etc.

2. All control devices located within auxiliary panels shall be labeled with identification that corresponds with the as-built drawings.

PART 3 – EXECUTION

A. INSTALLATION:

1. Install the system as recommended by the manufacturer.

2. Comply with all codes for electrical work. Run all power wiring in conduit. All wiring shall be in conduit. All equipment located outside shall be in suitable weathertight enclosure.

3. Install all conduit, wiring, cable and tubing. Install all equipment in a first-class manner, using proper tools, equipment, hangers, and supports, and in

locations as required for a neat, attractive installation. No material shall be exposed if it is possible to conceal it. Exposed materials shall be installed only with consent of the Owner. Conduit and tubing shall not be supported from work of other trades.

4. Support all sensors as recommended by the manufacturer where located inside equipment such as ductwork, fan housings, etc. Sensors in the space shall be in small, attractive housings, designed for that purpose and mounted on an electrical junction box.

5. Extreme care shall be used in making connections to other equipment to see that the safeties on this equipment are not inadvertently bypassed or overridden by the DDC.

6. All equipment having moving parts and controlled by the DDC shall be provided with warning labels no less than 2 in. (50 mm) in height, and in bright warning color, stating that the equipment is remotely started by automatic controls. Such labels shall be posted clearly in the area of any moving parts, such as belts, fans, pumps, etc.

7. Caulk both sides of damper frames to duct walls to prevent leakage between damper frame and duct.

8. Provide valve or damper operators with positive positioners where indicated or where required for positive shut-off of for sequencing with other controls.

9. Splicing of DDC sensor cabling at junction boxes shall not be acceptable.

10. Locate all control components and accessories such that they are easily accessible for adjustment, service and replacement.

11. Installation that wires back to the Siemens Building Technologies panels shall be installed to the wiring guidelines as published in the submittals and Apogee wiring guidelines manual.

B. CALIBRATION AND START-UP:

1. Provide calibration and start-up of DDC panels and associated sensors and transducers. Provide calibration and start-up for all other temperature control devices and systems.

2. After installation and connection of control components, test, adjust and re-adjust as required all control components in terms of function, design, systems balance and performance. Make systems ready for environmental equipment acceptance tests.

3. After environmental equipment has been accepted and after the systems have operated in normal service for two weeks, check the adjustment on

control components and recalibrate where required. Components not in calibration shall be recalibrated to function as required, or shall be replaced. Control devices, linkages and other control components shall be calibrated and adjusted for stable and accurate operation in accordance with the design intent and to obtain optimum performance from the equipment controlled. Cause every device to automatically operate as intended to ensure its proper functionality.

4. Verify operation of all control valves. Stroke valves prior to installation, verify range and operation. Verify that valves will completely close under full system pressure.

C. ACCEPTANCE PROCEDURE:

1. Upon successful completion of start-up and recalibration as indicated in this section, the engineer shall be requested in writing to inspect the satisfactory operation of the control systems.

D. COORDINATION OF WORK:

1. Portions of this Specification may call for various control items to be supplied by the Temperature Control Contractor to equipment manufacturers for factory mounting and various control items supplied by the equipment manufacturers to be installed by the Temperature Control Contractor portions of the Specification to provide all of the necessary materials and labor for a complete installation in the field. The Control Contractor shall be responsible for familiarizing himself with all portions of the Specification to provide all of the necessary materials and labor for a complete installation.

E. TRAINING:

1. The TC installer shall provide a factory-trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The contractor shall provide all students with a student binder containing project specific training modules for the system installed. All training shall be held during normal working hours of 8:00 AM to 4:30 PM weekdays.

2. Provide 8 hours of training for Owner's designated operating personnel in maximum 4-hour long sessions. Training shall include:

   a. Explanation of drawings, operations and maintenance manuals

   b. Walk-through of the job to locate control components

   c. Operator workstation and peripherals

d. DDC controller and ASC operation/function

e. Operator control functions including graphic generation and field panel programming

f. Operation of portable operator's terminal

g. Explanation of adjustment, calibration and replacement procedures.

h. Student binder with training modules.

Building Automation Systems – Minor Projects

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Furnish and install, as hereinafter specified a complete Building Automation System (BAS) utilizing the existing campus wide Apogee BAS System, incorporating direct digital control (DDC) for energy management, equipment monitoring, and control.

B. System shall include all components, control devices, programming, incorporating Siemens System 600 direct digital control (DDC) controllers and Siemens component/power panels. Integration systems are not acceptable.

C. Programming, supervisory control applications, and HVAC applications if documented by the Sequence of Operations as follows:

1. Load Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, occupied/unoccupied setback/setup, DDC with PID and trend logging.
2. HVAC Control Programs: Optimal run time, supply-air reset and enthalpy/economizer switchover.
3. Convertor Control Programs: Convertor optimization with hot water reset, convertor and pump equipment selection and sequencing.
4. Programming Application Features: Trend point, alarm reporting, alarm lockout, weekly scheduling, staggered start, sequencing, anti-short cycling and calculated point.

D. Provide programming modifications necessary to adjust set points, and sequences etc. during start up and through warranty period of systems at no additional cost to the University.

E. Connection of building's DDC panels to the University of Toledo's existing Energy Management System (EMS) host computer via trunk connection to the existing campus Ethernet.

F. System shall be installed complete by competent certified mechanics regularly employed in the installation of pneumatic and DDC temperature control systems.

G. Necessary conduit, wiring, enclosures, and panels, for all DDC temperature control equipment and devices. Installation shall comply with applicable local and national codes.

H. All final electrical connections to each stand-alone DDC Controller. Connect to 120VAC power as provided by the Division 16 contractor, and terminated in the DDC Controller.

I. All electrical work associated with the BAS control system including termination of all wires for external I/O devices, i.e. at sensors, H/O/A switches, etc. and as called for on the Drawings. This BAS control wiring shall be furnished and installed in accordance with the Electrical requirements as specified in Division 16, the National Electric Code, and all applicable local codes.

J. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers. Provide an external protection device listed under UL 1449 with minimum clamping voltage of 400 Volts and surge current capability of 26,000 Amps.

K. All 120V and low voltage electrical control wiring exposed throughout the building shall be run in conduit in accordance with the Electrical requirements as specified in Division 16, the National Electric Code, and all applicable local codes.

L. All 24V power required for operation of the BAS shall be by the BAS Contractor.

M. Provide electric (<2 1/2" diameter valves)/pneumatic operators (=>2 1/2" diameter valves), control air tubing, etc.

N. Provide sensors gauges, indicating devices, electric and electronic control accessories, and other control system devices.

O. Provide calibration and start-up services of temperature control systems.

P. Failure to mention specific item or device does not relieve the Building Automation System (BAS) Contractor of the responsibility for furnishing and installing such items or devices in order to comply with the intent of the Drawings and/or this Specification.

Q. Submit 3 copies of preliminary shop drawings for Associate and University designee review. BAS contractor shall then meet with the Associate and University designee to review comments and coordinate within 10 business days of submittal.

1.2 HVAC CONTRACTOR PROVIDES

A. All wells and openings for water and air monitoring devices, temperature sensors, flow switches and alarms furnished by BAS Contractor.

B. Installation of all control valves.

C. Installation of dampers and adjacent access doors for smoke; outdoor air, return air, exhaust air, and ventilation dampers. All package unit control panels.

1.3 ELECTRICAL CONTRACTOR PROVIDES

A. Electrical Contractor shall provide dedicated 120 volt, 20 amp circuits and circuit breakers from normal and/or emergency power panel for each DDC Controller.

1.4 QUALITY ASSURANCE

A. The BAS system shall be installed, commissioned and serviced by manufacturer employed, factory trained personnel. Distributors and wholesalers of BAS systems herein specified shall not be acceptable.

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

C. BAS shall comply with UL 916 PAZX and 864 UDTZ, and other subsystem listings as applicable, and herein specified, and be so listed at the time of bid.

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

1.5 SUBMITTALS

A. Submit 7 complete sets of the following documentation prior to installation for review:

1. Sequence of Operation.

2. Point lists including point address and point names.

3. System architecture and design including system riser diagrams.

4. Building automation and auxiliary transducer panel layouts including terminal strip identification.

5. Point to point wiring diagrams.

6. Equipment data cut sheets

B. Auto-CAD compatible as-built drawings

C. Upon project completion, submit 2 operation and maintenance manuals, consisting of the following:

1. Index sheet, listing contents in alphabetical order.

2. Manufacturer's equipment parts list of all functional components of the system.

3. As-Built interconnection wiring diagrams.

4. Operator's Manual.

5. Trunk cable schematic showing remote terminal equipment controllers, electronic panel locations, and all trunk data.

6. List of connected data points, including panels to which they are connected and input device (ionization detector, thermostat, etc.).

7. Conduit routing diagrams

1.6 WARRANTY

A. Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of three years after beneficial use.

B. The adjustment, required testing, and repair of the system includes all transmission equipment, all sensors and control devices.

C. The on-line support services shall allow the BAS Contractor to dial out over telephone lines to monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

D. If the problem cannot be resolved with on-line support services of the BAS Contractor shall dispatch the appropriate personnel to the job site to resolve the problem within 3 hours of the time that the problem is reported.

1.7 COORDINATION

A. Coordinate Building Automation System based on the "Scope of Work" as specified in this section.

B. Ensure installation of components is complementary to installation of similar components in other systems.

C. Coordinate installation of system components with installation of other mechanical system equipment.

D. Coordinate control wiring requirements, including actual terminal block numbers, with mechanical equipment manufacturers.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The complete BAS system, including Section 15900 and all related system integration specified in Sections 15000 and 16000 shall be supplied per performance specifications or as noted.

2.2 GENERAL

A. Siemens 600 DDC panels provide the following functions:

1. Mathematical: Absolute value, calculate, square root, power, sign, average, totals.

2. Logic: OR, AND, compare negate.

3. Fixed Formula: High and low select, span, rate, ramp, enthalpy, wet bulb, dew point, relative humidity, humidity ratio, filter.

4. Data Manipulation: Store, file and set.

5. Control Routines: Real-time based functions, proportional, proportional-integral, proportional-integral-derivative, direct-acting, reverse acting, feed forward, fixed set point, calculated set point, adjustable set point, lead lag and hysteresis correction.

6. Energy Management: Time scheduling, optimum start/stop, enthalpy optimization, duty cycle, trend, demand limiting, zero energy, warm up cycle, night cycle, night purge, reset optimization, runtime totals and holiday and daylight savings time correction.

B. DDC panels will provide self-test procedure. Notify host with advisories for maintenance, performance, software, cable break, or data transmission problems. Identify variables as reliable or unreliable. Variables identified as unreliable shall use default in calculation.

C. Panel will notify host for alarms and deviations such as abnormal alarm, high/low alarm, and floating alarm. Alarm scan shall show alarms and identification. Continue alarm indication until acknowledged and alarms condition is corrected.

D. Panel shall have two communication interface ports for communication between processor, other processors, central processing unit and portable terminal. Provide a communication network to connect the new processor to the existing in the building and to the HOST, including modem(s) and surge protection as required.

2.3 FIELD DEVICES

A. Temperature sensor assemblies shall consist of a Resistive Temperature Device (RTD's) with a 4-20 mA transmitter and enclosure. Sensing element shall be platinum with 100 ohms resistance at 32 ° F. Accuracy shall be +/- 1/2 ° F over the entire range.

1. Single point duct temperature sensor shall be rigid bulb type and have a calibrated span of 20-120 ° F or higher for heating applications.

2. Averaging element duct mounted temperature sensor shall be 25-ft. long sensor probe type and have a calibrated span of 20-120 ° F.

3. Liquid immersion temperature sensors shall have 5 1/2" long probe with well, and weather tight enclosure. Transmitters for chilled water shall have a calibrated span of 20-120 ° F.

4. Room temperature sensors shall have a minimum span of 40-90 ° F, locking covers and shall match the pneumatic thermostats used.

B. Outside Air Master Temperature and Humidity Sensors - Dual System

1. Single point outside air temperature RTD shall be 1000 ohm thin film platinum resistor sensor with 4-20 mA output transmitter with solar shield.

2. Outside air humidity sensor shall be thin film alumina substrate capacitance signal generating sensor with 4-20 mA output transmitter with 0-100% relative humidity range within +/-1% RH as manufactured by Hy-Cal Engineering, equivalent to Model No. CT-830-E-LNF,-25-125 ° F, 0-100%.

A. X21, Internal Probe Wall Mount,
B. X5, Temp. Transmitter matched to sensor Ice Point,
C. X52, PVC Solar Shield
D. X53, SST Filter-Humidity Sensor

C. High Precision Temperature Transmitters (for CHWS and CHWR temperature inputs used for BTU calculations)

1. Temperature transmitter with platinum RTD sensor and 4-20 mA DC output. Zero and span shall be continuously adjustable. Sensor and transmitter shall be a matched assembly. Accuracy shall be +/- 0.1% of calibrated transmitter span, including combined effects of repeatability, hysteresis and linearity. Calibrated range shall be 20 to 120 ° F. Both CHWS and CHWR sensor/transmitter assemblies shall have the same span and shall be factory calibrated as a matched pair.

2. Liquid immersion sensors shall have welded stainless steel thermowell. Transmitters shall be of the potted type or shall have a thermally isolated watertight enclosure. Length of sensor and thermowell shall be selected based on the diameter of the pipe to provide accurate, reliable and homogeneous sensing of the liquid temperature. Thermowell pressure rating as noted for each system in section 15510 - Hydronic Piping, 15520 - Steam and Condensate Piping and 15411 - Water Distribution Piping.

D. Humidity Sensors

1. Elements: Thin film capacitive type or bulk polymer resistance type, accuracy of +/- 2% RH, range of 0-99% RH with 4-20 mA linear output. Factory calibrate for maximum accuracy at mid-range of normal operating humidity. All humidity sensors shall be resistant to chlorine and other cleaning agents.

2. Duct Sensors: With duct probe and mounting plate.

E. Air Static Pressure Transmitters

1. Variable capacitance type with ranges not exceeding 150% of maximum expected input. Transmitter shall have zero and span adjustment. Output shall be 4-20 mA.

2. Safe over pressure rating shall be minimum 5 times the range.

3. Temperature compensated with thermal error of not greater than 0.04% of full scale in temperature range of 40 to 100 ° F.

4. Accuracy: 1% of full scale.

5. Provide a 4" Magnehelic gauge of appropriate span and units (in. WC, etc.) for each transmitter. Gauges shall be graduated in inches W.C. for static pressure sensing measurement.

F. Water/Steam Differential Pressure Transmitters and Sensors

1. Transmitters used for measuring flow rates:

A. Each differential pressure transmitter shall be selected and calibrated for operations between 0 and 125% of the normal differential pressure and up

to 150-psig line pressure. The calibration point shall be rounded upward to the nearest 10 inches WC (for spans less than 200" WC) or to the nearest 5 psi for larger spans. Calibration date shall be included on an embossed tag attached to each transmitter.

B. The accuracy, including linearity, hysteresis and repeatability, of the transmitter for measuring differential pressure shall be better than 0.25% of the span stated above throughout a minimum of a 6:1 turndown. Turndown ratio shall be selected on the actual flow span.

C. The transmitter shall not be damaged by pressures of up to 1000 psig on either side of the transmitter and all wetted parts shall be essentially inert in the presence of up to a 40% concentration of ethylene glycol in water.

D. Provide a drain valve for each side of the pressure chamber. Furnish and install mounting brackets appropriate for the installation location.

E. Span and zero shall be individually adjustable.

G. Transmitters used for measuring differential pressure only

1. Each differential pressure transmitter shall be selected and calibrated for operations between 0 and 200% of the normal differential pressure. The calibration point shall be rounded upward to the nearest 10 inches WC (for spans less than 200" WC) or to the nearest 5 psi for larger spans. Calibration date shall be included on an embossed tag attached to each transmitter.

2. The accuracy, including linearity, hysteresis and repeatability, of the transmitter for measuring differential pressure shall be better than 2% of the span stated above throughout a minimum of a 4:1 turndown. Turndown ratio shall be selected on the actual differential span.

3. The transmitter shall not be damaged by pressures of up to 500 psig on either side of the transmitter and all wetted parts shall be essentially inert in the presence of up to a 40% concentration of ethylene glycol in water.

4. Provide a drain valve for each side of the pressure chamber. Furnish and install mounting brackets appropriate for the installation location.

5. Span and zero shall be individually adjustable.

H. Three Valve Manifold

1. Provide a three-valve manifold for each transmitter. Pressures of up to 500 psig shall not damage the manifold and all wetted parts shall be essentially inert in the presence of up to a 40% concentration of ethylene glycol in water.

2. The manifold shall be designed for direct mounting on the transmitter it serves and utilizes two quarter turn valves to provide zeroing, blocking and normal service modes.

I. Waterflow Sensors

1. Uni-directional waterflow sensors shall be of the venturi type or velocity pressure type. They shall be constructed of stainless steel, sized to the system's range of flow, and have an accuracy of 0.5%.

2. Bi-directional waterflow sensors shall be of the velocity pressure type. They shall be constructed of stainless steel, sized to the system's range of flow, and have an accuracy of 0.5%.

J. Current Sensing Relays

1. Provide current sensors with donut transformers capable of monitoring AC current, maximum input current ranges from 20 to 300 amp, peak, with digital output signals having adjustable high and low current trips. LED model is not acceptable.

K. Electronic to Pneumatic Transducers

1. Provide Bellafram transducers to convert electronic signals from the Siemens Building Technologies analog output modules to linear proportional pneumatic signals for all DDC controlled modulating pneumatic devices. The transducer shall be a panel-mounted device, with hand/auto switch, override dial for manual override control, and a 0-30 psig output gauge. Supply voltage shall be 19-26 VAC. Control signal shall be 0-10 VDC or 4-20 mA. Output accuracy shall be 1/4 psig at 75 ° F, producing a 0-15 psig pneumatic signal. Output repeatability shall be .05 psig maximum. Transducers shall be high capacity non-bleed devices with a minimum output capacity of 500 SCIM, except special circumstances, which require a constant, bleed controller with branch exhaust on signal loss.

L. Limit Switches

1. Oil tight type with operator as required to provide required function. Limit switches used on dampers should be set at approximately 75% of full stroke.

M. Airflow Sensors

1. Provide where indicated amplified signal airflow traverse probe(s) or airflow stations, complete with straighteners when required, capable of continuously monitoring the fan or duct capacities (air volumes) it serves.

2.4 PNEUMATIC AND ELECTRIC COMPONENTS

A. Electric-Pneumatic Relays (To be installed in the component panel): Electric, solenoid operated, two-position air valve for panel mounting. Solenoid coil to be 120 VAC. Valve to be 3 or 4 port.

B. Pneumatic-Electric Relays: Electric, two-position type, range and element shall be suitable for the service, single or two pole, normally open or normally closed as required. Set point shall adjustable over the full range. Switch rating shall be 8.0 amps at 120 VAC, minimum.

C. Low Temperature Detection Thermostat: Duct type, fixed 5 ° F differential, range 30 to 60 ° F Sensing element shall be a 20 foot long capillary tube responding to the lowest temperature sensed along any 12 inches of bulb length. Switch shall be DPDT 120 VAC, UL listed, rated for 10 amps at 120 VAC full load, one pole wired to unit starter, one switch to Building Automation System. Unit shall be manually reset. Provide one thermostat for every 20 square feet of coil surface.

D. High Temperature Detection Thermostat: Electric, two-position type, range and element shall be suitable for the service, single or two pole, normally open or normally closed as required. Set point shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load. Unit shall be manually reset.

E. Immersion Thermostat: Electric, two position type, range and element shall be suitable for the service, single or two pole, normally open or normally closed as required with stainless steel separable well. Set point shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load.

F. Strap-on Thermostat: Electric, tow position type, range and element shall be suitable for the service, single or two pole, normally open or normally closed as required. Set point shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load.

G. Panel Mounted Pneumatic Gauges: Provide door mounted visual analog indicator gauges with accuracy as listed below:

	Size	Accuracy
1.	3-1/2"	+/- 1%

2.5 ELECTRICAL ACCESSORIES

A. Wiring and Conduit

1. The contractor shall provide all DDC and related control wiring and conduit. All low voltage control wiring shall be in EMT conduit. Wire and cable shall be pulled from device or control point to the DDC panel with 6'-0" spare coiled at the panel. All wire and cable shall be labeled and tagged.

2. A dedicated 20-amp circuit shall be provided by the division 16 contractor for each DDC cabinet and each auxiliary control cabinet from power or receptacle panels shown on electrical drawings. Coordinate panel locations with Division 16 Contractor.

3. Conduits shall be sized on a maximum fill of 40% capacity, minimum size ¾".

4. All control wiring shall have insulation rated for 300 volts minimum and run in conduit. Refer to Division 16000 Specification Sections for requirements.

5. Separate conduit systems shall be provided

   A. 120 volt DO and 120 VAC control wiring.

   B. AO/AI/DI and 24 volt DO wiring. Data transmission cable/phone line/LAN cable.

   C. Pneumatic tubing

6. Data transmission cabling and equipment grounding procedures shall meet the latest FCC guidelines for electromagnetic field generation.

7. All control wiring sizes and types shall meet the equipment manufacturer's recommendations.

8. DDC Wiring and Cable requirements for new DDC panels

Digital Output	*Minimum #14 AWG THHN
Digital Input	*Teflon jacketed twisted pair #16 AWG or #16 AWG THHN
Analog Output	*Teflon jacketed twisted pair #18 AWG
Analog Input	*Teflon jacketed twisted pair #18 AWG
Data Transmission	*Teflon jacketed twisted shielded pair #22 AWG

   A. Wire sizes listed for lengths up to 750'. For distances over 750', contact engineer.

9. DDC Wiring and Cable requirements for existing DDC panels

Digital Output	*Minimum #14 AWG THHN
Digital Input	*Teflon jacketed twisted Shielded pair #18 AWG or #16 AWG THHN
Analog Output	*Teflon jacketed twisted shielded pair #18 AWG
Analog Input	*Teflon jacketed twisted shielded pair #18 AWG
Data Transmission	*Teflon jacketed twisted shielded pair #22 AWG

   A. Wire sizes listed for lengths up to 750'. For distances over 750', contact engineer.

10. All junction boxes containing DDC related wiring or pneumatic tubing shall be painted a sky blue color. All conduits containing DDC related wiring or pneumatic tubing shall have a 6" long sky blue color band painted at 20' intervals. Conduits containing DDC wiring or pneumatic tubing which pass through walls or floors shall have a 6" long band painted on each side of the penetration.

11. For DDC terminal equipment controllers (TEC's) that do not have an enclosure for terminating conduits, the conduit shall end no more than 18" from the device and shall include a junction box, terminal fitting or insulating bushing as required by NEC section 300-16.

12. Exception: For DDC VAV boxes replacing pneumatic boxes, control wiring between the controller, room sensors, damper actuators and valve actuators need not be located in conduit. Wiring not installed in conduit shall follow the route of the pneumatic tubing it replaces and shall use the same supports, as closely as possible. Wiring shall be supported in a neat and workman like manner.

2.6 TEMPERATURE CONTROL SYSTEM VALVES

A. General: Valve bodies 2 inches IPS and smaller shall be single seated bronze and shall have screwed end connections. Valve bodies 2-1/2 inches IPS shall be cast iron and shall have flanged end connections. Valve stem packing shall be tetrafluorethylene, spring-loaded, self-adjusting. Packless construction is acceptable. Valve linkage shall have an adjustment for valve lift. Valve to have rising stem, renewable seat and disc, repackable under pressure. Valves 3" and larger shall be high performance butterfly valves per Section 15100.

B. Steam: Steam valve bodies and trim shall be rated for scheduled saturated steam service pressures. Steam valve replaceable plugs and seats shall be stainless steel, hardened to not less than 500 Brinnel. Pressure drop across any steam valve at maximum flow and valve size shall be as indicated. Valves shall have modified linear characteristics.

C. Hydronic: Hydronic system valve bodies and trim shall be rated for service pressures through 125 psig at 250 °F. Hydronic system valves shall have replaceable plugs and seats of SAE 72 brass or AISI 300 series stainless steel, selected for maximum lift under application conditions. Maximum pressure drop across any hydronic system valve at maximum flow and valve size shall be as indicated. Size valve operators to close off against pump shut off head. Two-way valves shall have equal percentage characteristics and three way valves shall have linear characteristics.

D. Operators

1. Pneumatic, rolling diaphragm, spring loaded, piston type.

2. Spring range shall be as required for non-overlapping sequencing or as indicated on drawings.

3. Ratio relays or cumulators used for sequencing valves are not acceptable unless specifically indicated on the drawings.

4. Valves shall spring return to normal position as indicated.

5. Select with sufficient shut-off power for system pressure and highest operating torque, and torque requirements of valves, which may stick because of infrequent use.

6. Select to provide smooth proportioning control under operating conditions normal to the system.

7. Pilot positioners shall be used when required to achieve the requirements as specified and on all valves 2 ½" and larger.

8. Butterfly control valve actuators shall be pneumatic rotary type with rack and pinion to provide constant output torque, positive positioner, spring return, adjustable travel stops, factory tested, factory lubricated, self draining body, integral pneumatic parting, localized mechanical position indicator readable at 25 feet, 0-90 ° reversible operation, capable of operating in any valve mounting attitude, capable of being mounted in line or transverse to pipeline, bolt directly to valve top plate. Valves 5" and above shall be actuated with 70 lbs. air with 3-15 lbs. pilot service.

9. Electric Butterfly Control Valve Actuators: Permanent split capacitor, reversible electric motor which drives a compound epicyclic gear, thermal overload protection, factory tested, factory lubricated, localized mechanical position indicator readable at 25 feet, 0-90 degree reversible operation, bolt directly to valve top plate. Housing shall be weatherproof and suitable for outdoor location. Provide thermostatically controlled heater for prevention of condensation at low temperatures, 120 VAC. Actuator ambient temperature range shall be -20 ° F to +140 ° F. Provide separate limit switches, which close at the full open and full closed position, respectively. Actuator shall include a manually operated handwheel for manual override of the valve position.

2.7 DAMPER OPERATORS

A. General: Provide smooth, proportional control with sufficient power for air velocities 20% greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return to normal position. Damper operators shall be installed in accessible locations. Damper operators shall not be installed inside exhaust air ducts, or exhaust air units. Damper operators shall be pneumatic unless pneumatic system is not available in building.

B. Pneumatic Operators: Rolling diaphragm piston type with spring range as indicated on drawings.

C. Electric Operators: Maintenance free electric actuator, reversible, with push rod and bracket for swivel mounting and for the transmission of power. Synchronous motor with load independent running time providing parallel operation of several operators. Gear train with low noise level. Magnetic hysteresis coupling with magnetic transmission of torque, with no mechanical contact between the coupling members. The actuator shall be safe against blocking and overload proof even when operated continuously.

D. Number: Sufficient to achieve unrestricted movement throughout damper range. Provide sufficient number of operators such that one operator does not operate more than the maximum square footage of damper area as recommended in standard catalog of manufacturer.

2.8 COMPONENT/POWER PANELS

A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face, or as detailed on drawings. Provide panel with locking door and match lock to the existing System 600 Automation panel locks.

2.9 PNEUMATIC ACCESSORIES

A. Tubing

1. Copper tubing shall be new hard drawn, Type L, ASTM B68, with solder joint or compression type fittings, at the option of the Contractor.

2. Plastic Tubing (all sizes): Black virgin, polyethylene, ASTM D1248, Type 1, Class C, Grade 5, meeting crack test performance required by ASTM D1693 and be fire retardant (FR) rated. Multi-tube harness material shall be as specified above with the polyester film barrier and vinyl jacket not less than 0.062 inches thick. All non-metallic tubing shall be 1/4" O.D.. minimum, micro-sleeve is not acceptable.

3. Plastic tubing may be used (unless indicated otherwise) in concealed locations only. In mechanical rooms and other exposed locations, plastic tubing shall be in conduit.

4. Tubing shall not be attached to conduits with current carrying conductors or fire protection piping. Tubing shall be adequately supported with no noticeable sagging between supports.

5. All pneumatic tubing shall be concealed in finished areas, except mechanical rooms.

B. Gauges

1. Provide 1 ½" air pressure gauges on branch lines of pneumatic systems at controllers, transmitters, valve and damper operators, relays, switches, regulators, and DDC output points.

C. Air Filters

1. Provide air filter for main air supply to all DDC panels.

2.10 IDENTIFICATION AND LABELS

A. The contractor shall provide phenolic nameplates for each DDC or auxiliary panel, permanently attached, to identify field panel number, trunk number, building, area, etc.

B. All control devices located within auxiliary panels shall be labeled with identification that corresponds with the as-built drawings.

PART 3 – EXECUTION

3.1 INSTALLATION

A. The BAS system shall be installed, commissioned, and serviced by trained personal with a minimum 5 years documented installation experience.

B. Comply with all codes for electrical work. Run all power wiring in conduit. All wiring shall be in conduit. All equipment located outside shall be in suitable weather tight enclosure.

C. Install all conduit, wiring, cable and tubing. Install all equipment in a first-class manner, using proper tools, equipment, hangers, and supports, and in locations as required for a neat, attractive installation. No material shall be exposed if it is possible to conceal it. Exposed materials shall be installed only with consent of the Owner. Conduit and tubing shall not be supported from work of other trades.

D. Support all sensors as recommended by the manufacturer where located inside equipment such as ductwork, fan housings, etc. Sensors in the space shall be in small, attractive housings, designed for that purpose and mounted on an electrical junction box.

E. Extreme care shall be used in making connections to other equipment to see that the safeties on this equipment are not inadvertently bypassed or overridden by the DDC.

F. All equipment having moving parts and controlled by the DDC shall be provided with warning labels no less than 2 in. (50 mm) in height, and in bright warning color, stating that the equipment is remotely started by automatic controls. Such labels shall be posted clearly in the area of any moving parts, such as belts, fans, pumps, etc.

G. Caulk both sides of damper frames to duct walls to prevent leakage between damper frame and duct.

H. Provide valve or damper operators with positive positioners where indicated or where required for positive shut-off of for sequencing with other controls.

I. Splicing of DDC sensor cabling at junction boxes shall not be acceptable.

J. Locate all control components and accessories such that they are easily accessible for adjustment, service and replacement.

K. Installation that wires back to the Siemens Building Technologies panels shall be installed to the wiring guidelines as published in the submittals and Apogee wiring guidelines manual.

3.2 CALIBRATION AND START-UP

A. Provide calibration and start-up of DDC panels and associated sensors and transducers. Provide calibration and start-up for all other temperature control devices and systems.

B. After installation and connection of control components, test, adjust and re-adjust as required all control components in terms of function, design, systems balance and performance. Make systems ready for environmental equipment acceptance tests.

C. After environmental equipment has been accepted and after the systems have operated in normal service for two weeks, check the adjustment on control components and recalibrate where required. Components not in calibration shall be recalibrated to function as required, or shall be replaced. Control devices, linkages and other control components shall be calibrated and adjusted for stable and accurate operation in accordance with the design intent and to obtain optimum performance from the equipment controlled. Cause every device to automatically operate as intended to ensure its proper functionality.

D. Verify operation of all control valves. Stroke valves prior to installation, verify range and operation. Verify that valves will completely close under full system pressure.

3.3 ACCEPTANCE PROCEDURE

A. Upon successful completion of start-up and recalibration as indicated in this section, the engineer shall be requested in writing to inspect the satisfactory operation of the control systems.

3.4 TRAINING

A. The TC installer shall provide a trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal working hours of 8:30 AM to 3:00 PM weekdays.

B. Provide 2 hours of training for Owner's designated operating personnel. Training shall include:

C. Explanation of drawings, operations and maintenance manuals

D. Walk-through of the job to locate control components

E. Operator workstation and peripherals

F. DDC controller and ASC operation/function

G. Operator control functions including field panel programming

H. Explanation of adjustment, calibration and replacement procedures.

I. 3 Student binders with project specific training modules.

ENERGY CONSERVATION REPORT

(To be submitted with basic review documents)

A. BUILDING CONSTRUCTION

Building Area Gross (Sq. Ft.) _____sq. ft.

Overall "U" Factor for wall envelope U = _____BTU/hr/sq. ft./degrees F

(Include walls, glass, doors)

Overall "U" Factor for Roof U = _____BTU/hr/sq. ft./degrees F

Percent Glass Area _____ Type of Glass _____

B. HEATING

Design Heat Loss _____BTU/hr

Ventilation Load _____BTU/hr

Total _____BTU/hr

_____BTU/hr/sq. ft.

Boiler Capacity _____BTU/hr

Fuel _____

C. VENTILATION SYSTEMS

Supply Air _____ CFM _____ HP _____ KW _____

(Total Supply and Return Fan)

_____CFM/sq. ft. _____CFM/ton

_____KW/ton _____KW/sq. ft.

Exhaust Fans _____ CFM _____ HP _____ KW _____

D. COOLING SYSTEM

Chiller 100% _____ Tons _____ KW _____ KW/ton _____ KW/sq. ft.

50% _____ Tons _____ KW

Auxiliaries (Tower Fans, CHW Pumps, Cond. Pumps)

_____ HP _____ KW _____ KW/Ton _____ KW/sq. ft.

E. HEATING AUXILIARIES

Pump, etc.

_____ HP _____ KW _____ Kw/sq. ft.

F. LIGHTING

- INTERIOR

Fluorescent Watts per sq. ft._____Total KW _____

Incandescent Watts per sq. ft._____ Total KW _____

Interior Total KW _____

- EXTERIOR

All lights

Exterior Total KW _____

G. MAXIMUM BUILDING ENERGY LOAD

Building Sq. Ft. _____

Total BTU per year _____

BTU per sq. ft. per year _____

(Non-elect. HVAC)

BTU per sq. ft. per year (Electric) _____

Total BTU per sq. ft. per year _____