SECTION 15952
HVAC INSTRUMENTATION AND CONTROLS
(Applicable to IUPUI Only)

I. GENERAL

A. NOTES

1. The University has a pre-purchase agreement (PPA) with Johnson Controls (JCI) and Siemens Building Technologies (SBT). The University will directly purchase all of the required control components as described in the PPA contractor bid documents, and control system engineering, to accomplish the design intent of the designer of record.

2. Installation of controls shall be performed by the Controls Installation Contractor (CIC) as part of Division 15 and not by the PPA contractor (JCI or SBT) . Installation shall be subject to all applicable federal, state, and local codes as well as the installation standards specified herein. Contact Indiana University / IUPUI Engineering Services with questions and for further details. Contract issues should be referred to the designer of record.

B. MANUFACTURERS

1. Johnson Controls Systems and Services
2. Siemens Building Technologies

C. SYSTEM

1. Distributed direct digital control system (DDC)
2. Electric/electronic actuation on primary control devices or as shown on construction documents
3. Electric/electronic actuation on terminal units or as shown on construction documents
4. Exceptions to actuation made on a project-by-project basis per direction of owner and designer of record.
5. Pneumatic system to match existing, if appropriate

D. DOCUMENTATION

1. All products to be used and not specifically called out in this document shall be submitted to IUPUI Energy Systems Project Manager for review prior to ordering and installation.

2. All documentation for all products in this document and installed equipment shall be maintained in a vendor specific operations and maintenance manual located at the Energy Systems Project Manger's, Energy Systems Engineer's, and IUPUI office of Indiana University Architect's Offices. Ten original copies of documentation shall be required for any installed equipment not already documented in the operations and maintenance manual.

II. BUILDING AUTOMATION SYSTEMS

A. ACCEPTABLE PRODUCTS

1. Johnson Controls – Metasys Extended Architecture Network
2. Siemens Building Technologies – Apogee

B. PANEL

1. Provide one DDC panel for each control system adjacent to the system served, or as indicated on contract documents. Panels shall include all applicable microprocessor based controllers, communication controllers, power supplies, input/output modules. Deviations shall be considered on a case-by-case basis.
2. The system architecture shall support expansion of all types of DDC panels by either spare capacity in the panel provided or by adding expansion panels to the system.
3. Each device shall be free of functional and operational defects. All controller output, input, and communication capacities shall be fully functional.
4. Each applicable controller shall be supplied with sufficient memory to support its own operating system and databases.
5. Each panel shall support:
   a) Digital inputs for status and alarm contacts
   b) Digital outputs for ON/OFF equipment control
   c) Analog inputs for temperature, pressure, humidity, CO2, flow, and position measurements.
   d) Analog outputs for valve, damper, and capacity control of primary equipment
   e) Pulse inputs for pulsed contact monitoring
6. Each microprocessor controller shall continuously perform self diagnosis, communication diagnosis and diagnosis of all subsidiary equipment. The controller shall have the capability to provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication.
7. In the event of power failure and/or restart:

a) Each panel shall shutdown in an orderly manner to prevent the loss of database or operating system software. Use non-volatile memory for all controller configuration data. Use non-volatile memory and/or battery back-up to support the real-time clock and all volatile memory for a minimum of 72 hours.

b) Each panel shall automatically resume full operation without manual intervention. Should DDC panel memory be lost the DDC panel shall request download from the front end and resume normal operations after completion of the download. The user shall have the capability of reloading the DDC panel via the local area network, and/or via telephone line dial-in.

C. SOFTWARE

1. Use English language and industry standard software for command entry and menu selection. All temperature units shall be programmed and displayed in degrees Fahrenheit. Provide all applicable displays and modifications to existing front end workstations to enable operators to view all system points, modify all system set points, and allocation data. Provide at a minimum:
   a) ON/OFF control
   b) Adjustable set points
   c) Add/Modify/Delete time programming
   d) Enable/Disable a control process execution
   e) Lock/Unlock alarm reporting for each point
   f) Enable/Disable totaling and trending for each point
   g) Override PID loop set points and parameters
   h) Enter temporary override schedules
   i) Define Holiday schedules
   j) Change time and date
   k) Enter/Modify analog alarm and warning limits
   l) View all point attributes and limits
   m) Enable/Disable demand limiting for each meter
   n) Duty cycle for each load
   o) Access levels to be determined by password code

2. Provide and install software upgrades/hot fixes/patches to give the operator's workstation the ability to read the most current revision of software and firmware installed in the project. This upgrade/hot fix/patch shall be installed prior to new the DDC panels communicating to the primary network so as to not interrupt the owner's communication with any panels in a completed project.

Provide technical instruction/training to Building Automation staff with regard to upgrades/hot fixes/patches at time of installation.

3. This section is intended to assure that the owner's operator's workstation will communicate with the hardware and firmware that is installed in the project.

D. NETWORK

1. DDC panels shall interface with the existing campus Ethernet fiber system and existing operator's workstation located at the Physical Plant Control Room and as indicated on contract documents.
2. Network communication devices
   a) Fiber optic switches shall concentrate multiple fiber sections into one. All signals present on any section are repeated in real time on all other sections. Fiber optic switch options are subject to change based on fiber availability and should be verified with owner prior to purchase and installation.
   b) Fiber optic interfaces/media converters shall convert light energy on its fiber input port to RS-485 levels to be used by the installed building automation system panels and converts RS-485 levels to light energy for the fiber output port. Fiber optic interfaces/media converter options are subject to change based on fiber availability and should be verified with owner prior to purchase and installation.
3. All network additions or modifications to existing conditions shall be coordinated with the Physical Plant Control Room and the Energy Systems Project Manager prior to any changes. Physical Plant Control Room and/or the Energy Systems Project Manager shall provide a written list of acceptable component addresses for each project during control design.

III. ELECTRIC\ELECTRONIC

A. SENSORS

1. Temperature Sensors
   a) Coil discharge sensors, located within an air handler, shall be 1K ohm platinum RTD sensors with a flexible averaging element. Sensing elements shall be a minimum of 17'. Exceptions made only when it is impossible to install a flexible averaging sensor due to air handler physical dimensions, in which case use the longest possible rigid duct averaging sensor.

b) Temperature only sensors located within ductwork shall be 1K ohm platinum RTD sensors with a rigid element.
c) DDC primary equipment space sensors shall be RTD with an accuracy of 1% over the sensed temperature range. Verify with owner and designer of record the sensor options required for the project. Owner and /or designer of record will provide written documentation of required options.
d) DDC terminal equipment space sensors shall be RTD with an accuracy of 1% over the sensed temperature range. Verify with owner and designer of record the sensor options required for the project. Owner and /or designer of record will provide written documentation of required options.
e) DDC outdoor air temperature sensors shall be 1K ohm platinum RTD and have a watertight fitting and adequate protection form the effect of solar radiation.
f) DDC fluid immersion sensors shall be 1K ohm platinum RTD and have a bulb type element mounted within a brass or stainless steel well filled with a heat conductive compound and in direct contact with the fluid within the pipe or vessel.

2. Humidity Sensors
a) DDC duct relative humidity sensors shall utilize resistance elements to operate with a minimum accuracy of +/- 2% within a range of 10% to 90% relative humidity. Note that many humidity sensors require an auxiliary power source.
b) DDC space relative humidity sensors shall utilize resistance elements to operate with a minimum accuracy of +/- 2% within a range of 10% to 90% relative humidity. Note that many humidity sensors require an auxiliary power source.
c) DDC combination duct temperature/relative humidity sensors shall utilize 4-20mA output signal. The humidity portion shall be a minimum +/- 2% within a rage of 0% to 100% relative humidity. Utilize a combination sensor if duct temperature and humidity sensing is required. Note that many humidity sensors require an auxiliary power source.
d) DDC combination space temperature/relative humidity sensors shall utilize 4-20mA output signal. The humidity portion shall be a minimum +/- 2% within a rage of 0% to 100% relative humidity. Utilize a combination sensor if duct temperature and humidity sensing is required. Note that many humidity sensors require an auxiliary power source.

3. Status Sensors
   a) Primary constant speed equipment shall use a solid state electronic device with a split core design to indicate status of electrical motor.
   b) Primary variable speed equipment shall utilize the internal drive status relay to indicate status of electrical motor.

4. Differential Pressure Sensors
   a) DDC air differential pressure sensors shall be accurate within 1% of the span over an ambient operating temperature of 30 Deg. F. to 140 Deg. F.. Pressure sensors shall utilize a 4-20mA or 0-10 VDC output signal.
   b) DDC fluid differential pressure sensors shall be adjustable from 0 psid to 50 psid, over pressure to 2000 psi, with and accuracy rating of +/- 0.25% of full scale. Actual installed range shall be verified with designer of record to provide a sensor with a full scale limit not to exceed twice the desired differential set point.

5. Pressure Transmitters
   a) DDC pressure sensors shall be accurate within +/- 0.25% of full scale, over pressure of 2000 psi, over an ambient operating temperature of -40 Deg. F to 200 Deg. F. The case shall be constructed of 304 stainless steel with a 1/8" NPT male 316 stainless steel connection. Pressure sensors shall utilize a 4-20mA or 0-10VDC output signal. Options shall be verified with owner and designer of record prior to purchase and installation.

6. Carbon Dioxide Sensors
   a) DDC space carbon dioxide sensors shall be a non-dispersive infrared sensor incorporating a reflective, gold plated light pipe or waveguide surrounded by a gas permeable Teflon based hydrophobic diffusion filter. Sensor shall provide simultaneous analog voltage and milliamp outputs. Sensor options shall be confirmed with the owner and designer of record prior to ordering and installation.
   b) DDC duct carbon dioxide sensors shall be a non-dispersive infrared sensor incorporating a reflective, gold plated light pipe or waveguide surrounded by a gas permeable Teflon based hydrophobic diffusion filter. Sensor shall provide simultaneous analog voltage and milliamp outputs. Sensor options shall be confirmed with the owner and designer of record prior to ordering and installation.

7. Water Detectors
   a) Shall be considered for each mechanical room, especially below grade.
   b) Alarm shall report to campus control room.

B. THERMOSTATS

1. Line voltage thermostats shall be heat/cool type with a maximum dead band of 2 Deg. F. They shall be rated for full motor load with single or two poles as required. They shall have concealed temperature adjustment and locking cover. Thermostat options shall be confirmed with the owner and designer of record prior to ordering and installation.

C. TRANSDUCERS

1. Electric to Pneumatic transducers shall convert a 0-10 VDC signal from a DDC panel to a 0-20 psig pneumatic signal. It shall have integral override capability.

D. SWITCHES

1. Air differential pressure switches shall have an adjustable set point range of 0.05" W.C. to 12" W.C. Contacts shall be snap acting SPST with manual reset.
2. Low temperature detectors shall be manual reset, line voltage, DPST, 4W-2 circuit, with 20' flexible sensing element. Then thermostats shall be wired in series, each set at 35 Deg. F. Automatic reset low temperature detectors may be used if specifically specified in the control contractors approved bid documents.
3. Temperature control air pressure switches shall be installed on the high side of the control compressed air supply out of the air dryer, before the first controlled device and electrically connected to the installed building automation system dry contacts to alarm on a momentary drop in pressure below 60 psig. Switch shall be manual reset type**.**
4. Damper position switches shall be and encapsulated SPDT Mercury switch.

E. ACTUATORS

1. Terminal Units, Fan Coils, Unit Ventilators

a) Valve Actuators
(1) Electric valve actuators which do not require fail safe positions shall be UL873 listed and suitable for plenum installations. Actuators shall utilize magnetic hysteretic coupling to protect against overload and provide a manual adjustment. Actuator shall maintain its last commanded position upon a power failure.
(2) Electric valve actuators which require fail safe positions shall be UL873 listed and suitable for plenum installations. Actuators shall utilize magnetic hysteretic coupling to protect against overload and provide a manual adjustment. Actuator shall return to a fail safe position upon a power failure
b) Terminal Box Actuators
(1) Electric damper actuator shall be provided for terminal units and unit ventilators with a synchronous motor with load independent running time. Actuators shall utilize magnetic hysteretic coupling to protect against overload. Actuator shall maintain its last commanded position upon a power failure, unless specified differently in contract documents.

2. System Components
a) Valve Actuators
(1) Electric valve actuators which require fail safe positions shall be UL873 listed and suitable for plenum installations. Actuators shall utilize magnetic hysteretic coupling to protect against overload and provide a manual adjustment. Actuator shall return to a fail safe position upon a power failure
b) Damper Actuators
(1) Electric damper actuator shall be provided for air handling units with a synchronous motor with load independent running time. Actuators shall utilize magnetic hysteretic coupling to protect against overload. Actuator shall maintain its last commanded position upon a power failure, unless specified differently in contract documents.

II. PNEUMATIC

A. THERMOSTATS

1. Pneumatic room thermostats shall be adjustable proportioning type with a single set point and utilizing a single bimetallic element for heating and cooling with locking covers. The thermostat shall have

a single concealed set point adjustment with a minimum of 10 Deg. F. set point adjustment and an adjustable dead band. Thermostat options shall be confirmed with the owner and designer of record prior to ordering and installation.

B. HUMIDISTATS

1. Pneumatic space humidistat shall be two pipe modulating type, reverse acting with sensing element capable of operation from 10% to 95% control range. Span 15% to 75% relative humidity for 3 to 15 psig pressure change.
2. Pneumatic duct humidistat may be one pipe for high limit service with sensing element capable of operation form 20% to 90% control range.

C. ACTUATORS

1. Pneumatic valve actuators shall be of the molded rubber diaphragm type with spring return to their failed position. Actuator spring ranges shall be chosen to provide proper sequencing. All actuators shall be provided with 20 psig pneumatic pilot positioner, excluding small terminal box valves, small fan coil valves, and the 2/3 valve in a 1/3 2/3 valve scheme. Pilot positioner shall be full relay type with mechanical feed back linkage for accurate positioning and control.
2. Pneumatic actuator for Neles Control R-Series valves shall be a spring diaphragm capable of torque outputs from 10 ft. lbs. to 587 ft. lbs. Actuator shall utilize acetyl lined stainless steel backed bearings and a pneumatic proportional positioner.
3. Pneumatic damper actuators shall be corrosion resistant piston type with ozone resistant rolling diaphragms. Provide pilot positioner on split outdoor air dampers and where system static pressure exceeds 5” w.g. Pilot positioner shall be full relay type with mechanical feed back linkage for accurate positioning and control. Multiple section dampers require one actuator with a pilot positioner for one section and slave actuators without pilot positioner for the balance of the sections.

III. DAMPERS

A. All dampers for modulating control shall be proportioning type as indicated on the contract documents. Damper frames may be constructed out of extruded aluminum or galvanized sheet metal.

1. Galvanized sheet metal damper frames shall be constructed of 16 gauge galvanized sheet metal while louvers shall be double 22 gauge or single thickness 16 gauge; louvers shall not exceed 8" in width. Bearings shall be nylon with oil impregnated sintered iron or brass bushings. All linkages shall be fastened to blades with the damper. Provide control actuator for each section on dampers over 42" wide or for every 25 square feet whichever provides the greater number of actuators. Outside air, multi-zone, relief, and intake dampers shall be designed for tight shut-off so that leakage does not exceed 8 CFM per square foot at 4" w.g. pressure differential with rubber seals installed on all blade edges as well as the sides, top, and bottom stops of each damper.
2. Extruded aluminum damper frames shall not be less than 0.080 inches in thickness. Damper frame shall be 4 inches. Blades to be extruded aluminum profiles. Blade ends to be capped in order to deal hollow interior and reduce air leakage rate. Blade gaskets and frame seals shall be a minimum of extruded silicone. Gaskets to be secured in an integral slot within the aluminum extrusions. Bearing are composed of a celcon inner bearing fixed to a 7/16 inch aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame. All linkage hardware shall be installed in the frame side and be constructed of aluminum and corrosion-resistant, zinc plated steel, complete with cup-point trunnion screws for slip-proof grip. Air leakage through a 48 inch by 48 inch damper shall not exceed 1.7 CFM per square foot against 1 inch water gauge differential static pressure. Pressure drop of a fully open 48 inch by 48 inch damper shall not exceed 0.022 inch water gauge at 1000 fpm.
3. Where appropriate dampers exposed to outdoor air shall be thermally broken.

B. Damper blade operation and orientation shall be as follows: Modulating dampers shall be opposed blade type. Two position dampers shall be parallel blade type. Outdoor air dampers shall be insulated opposed blade. All dampers, less fan isolation dampers, shall be mounted as horizontal blades. Fan isolation dampers shall be normally open and may be mounted either direction as long as the damper manufacturer provides for a normal vertical damper blade configuration.

IV. FLOW STATIONS

A. Air flow measuring stations in main HVAC equipment shall be of type specified by engineer of record and/or Energy Systems Project Manager. Controls contractor shall assist in the coordination of installation to insure manufacturers guidelines for installation are met.

V. VALVES

A. All automatic control valves shall be fully proportioning with equal percentage modulating plug or V-port inner guides unless otherwise specified. Valves shall be quiet in operation and fail-safe as applicable in either the normally open or normally closed position as indicated on contract documents. All control valves shall be sized by the designer of record and/or the controls contractor to meet heating and cooling loads specified. Maximum pressure drop through the valve shall not exceed 5 psig unless otherwise indicated. All valves shall be suitable for the pressure and temperature conditions and shall close against the differential pressure involved. Valve body pressure rating and connection type shall conform to the scheduled piping to which it is installed. Proved bubble-tight shut off in the closed position. Valves for hot or chilled service shall be single –seated with bronze trim and composition seats. Butterfly valves, in-line, or three-way shall be heavy duty pattern with a body rating compatible to the piping rating and a stainless steel vane. Two position butterfly valves shall be line size.

VI. METERING DEVICES

A. CHILLED WATER

1. Magnetic type primary chilled water loop flow meters shall be provided with a 24VAC remote mounted display. Coordination of meter installation, to include piping guidelines and placement of remote display and or flow computer in a location accessible by standing on the finished floor and not higher than eye level, is the responsibility of the controls provider. Confirm the need for a flow computer to interface with the campus automation system.
2. Insertion type primary chilled water loop flow meters shall be turbine type with accuracy of 1% of flow rate when flow velocities are 1 to 30 fps. Meter shall output a 4-20mA or 0-10VDC signal.

B. STEAM

1. Primary steam flow meter shall be of vortex shedding type with temperature and pressure compensation and a properly sized flow conditioner. Meter shall be provided with a 24VAC remote mounted flow computer display and a steam flow conditioner to minimize installation input run out length requirements. Coordination of meter installation, to include piping guidelines and placement of remote display in a location accessible by standing on

the finished floor and not higher than eye level, is the responsibility of the controls provider.

VII. VARIABLE FREQUENCY DRIVES

A. Variable frequency drives shall be selected to be consistent with existing drives in the same building if applicable. Variable frequency drives shall be provided with a bypass package unless specifically negated in contract documents. All drives shall be provided with the appropriate integral hardware to communicate directly with the existing and installed temperature control manufacturer without added temperature control or variable frequency manufacturer communication translators, integrators, or migrators.

B. Startup: VFD shall be started by factory authorized service provider. Manufacturer's startup checklist and motor operational data shall be provided to the owner. A hard copy of the completed program shall be provided to the owner. VFD startup shall be coordinated with controls installation, mechanical and electrical contractors. Training shall be provided by a factory authorized service provider at a separate time from startup.

VIII. AIR COMPRESSORS AND DRYERS

A. AIR COMPRESSOR

1. The package shall include multiple scroll compressors mounted inside of a rigid steel enclosure. Enclosure shall have a powder coated finish, and shall include sound deadening insulation. System shall include a solid state controller to operate the necessary compressors to maintain the pressure requirement and minimize the operating cost.
2. Each compressor shall be of the following design: belt driven, rotary scroll type, single stage, air-cooled, oil-less construction with no oil needed for operation. The rotary design shall not require any inlet or exhaust valves. Each compressor shall have a capacity of 14.7 SCFM @ 100 PSIG and shall be capable of continuous–duty operation. Tip seals shall be of composite PTFE material and be rated for 10,000 hours operation. Compressor bearings shall be external to the air compression chamber and shall be all serviceable. Bearing maintenance shall not be required until 10,000 run hours. Each compressor shall have flexible connectors on intake and discharge and air cooled aftercooler.

3. Each compressor shall be belt driven by a 5 HP, 3 phase, 60 cycle, 460 volt, 1725 RPM, TEFC motor.
4. Air-cooled aftercoolers shall be provided for each compressor and shall be sized to provide an approach temperature of not more than 20 degree F. Each unit shall be constructed of copper tubing with metal headers and shall be factory mounted integral to the compressor enclosure.
5. Each compressor shall be supplied with full voltage motor starter with overload protection and shall be sequenced with the circuit card logic controller with digital display. Controller shall have four display modes to monitor the operation of the unit. Operating mode shall display the compressors running status, unit run hours and system pressures. Caution mode shall indicate high temperature shutdown status, high current draw and failure of temperature switch. Service mode shall inform user when scheduled maintenance interval is reached. Set mode shall allow the user to adjust some of the parameters of the operational mode such as start/stop pressures. Compressors shall be sequenced on and off based on the air demand of the system.
6. Equipment supplier shall provide safety valve, pressure gauge and automatic electric timer drain valve.
7. The air compressor system shall have a 12 month parts and labor warranty. Each compressor in the system shall have an extended, replacement/parts only warranty of not less than 24 months (minimum 3 years).

B. REFRIGERATED AIR DRYER

1. Twin tower, desiccant air dryer/filtration: packaged, fully assembled, piped and wired heatless type regenerative desiccant dryer is to be complete with; two pressure vessels each containing a desiccant bed fully charged with activated alumina; energy saving controller and control valves to direct inlet and purge air flows from tower to tower; and a means of regulating purge air usage. All components are to be mounted on a structural steel frame with floor stand and lifting lugs. Dryer is to be ready to start up after utility connections are made. Dryer shall be sized for an inlet capacity of 60 SCFM and an outlet pressure dew point of at least -40 degree F. Include a coalescing type oil removal filter, with automatic moisture removal trap and differential pressure gauge, factory piped to the inlet of the dryer and a one micron, reverse flow particulate filter, with differential pressure gauge, factory piped to the outlet of the dryer. Power supply shall be 120V, 1 phase, 60 HZ corded plug. The power cord plug configuration shall conform

to NEMA standards. Approved manufacturers: Hankison HHL Series, Gardner Denver DGH Series.

2. Unit shall include an adjustable pressure regulator with gauge on the final outlet with an adjustable pressure range of 0-160 PSIG.
3. Compressor manufacturer/supplier shall provide check, test and start-up with owner's maintenance staff. Provide written check list with signatures and date of start-up. Manufacturer/supplier shall be responsible to work with owner to change any factory default controller settings and program the system, as required, for the specific application and proper operation.
4. Compressor manufacturer/supplier shall include a 4 hour training session with the owner's maintenance staff at a time other than at start-up.
5. Successful equipment supplier shall send copies of shop drawing submittals including compressor system specifications, written warranty, wiring diagrams, physical dimensions, etc. for engineer's approval prior to placing order. Also required with shop drawings is the manufacturer's complete parameter list, including default settings for the solid state controller. The final operational parameter list should be supplied with operation and maintenance manuals.
6. Successful equipment supplier shall provide complete copies of manufacturer's operation and maintenance manuals. Manuals shall have parts lists, electrical diagrams, trouble shooting guides, compressor specifications, installation instructions, etc. Also, include a copy of the approved shop drawing submittal in the manuals.

IX. GENERAL SEQUENCE OF OPERATIONS GUIDELINES

A. SAFETIES

1. Interlock low temperature detectors directly with the supply fan via the starter coil control circuit. On certain applications with VFD's, low voltage interlock or interposing relay is acceptable. Low temperature detectors shall be mounted on the entering face of the next downstream coil from the protected coil. No software interlocks are acceptable.

B. COIL TEMPERATURES

1. On systems without heat recovery, the preheat coil shall be the first heating coil in the air handler. On systems with heat recovery, the preheat coil shall be the first heating coil after the heat recovery coil. If there is a single coil after the cooling coil, it is to be named the heating coil. If there is a second heating coil on the air handler

or in the associated ductwork, the second coil is to be named the reheat coil.

C. ECONOMIZER CYCLE

1. Outdoor air enthalpy economizer sequence shall be utilized as applicable. Mixed air temperature sensor shall be used to control mixed, return, and relief dampers as applicable. When enthalpy is used, there shall be a software switch to allow end user to easily switch between enthalpy control and mixed air temperature control without reprogramming the controller or installing any new equipment.
2. Maintaining minimum outdoor air requirements during occupied and unoccupied cycles in accordance with ASHRAE standards shall override any type of economizer control.

D. EQUIPMENT STATUS

1. Current sensing relays shall be utilized for equipment status monitoring of constant velocity motors.
2. Integral status relays shall be utilized for equipment status monitoring of variable frequency drives.

E. EQUIPMENT OCCUPIED/UNOCCUPIED SCHEDULING

1. All scheduling shall be accomplished at the owner's operator's workstation located at the Physical Plant Control Room.

X. TRAINING AND DOCUMENTATION

A. TRAINING

1. Contractor shall be required to provide 8 hours of project related training for a maximum of 8 maintenance employees at owner's discretion. Training curriculum shall be approved by owner prior to training.

B. DOCUMENTATION

1. Contractor shall provide two hard copies of as-build documents and one electronic copy on compact disk under Microsoft format.
2. Contractor shall provide one hard copy of all calibration and checkout sheets.
3. Contractor shall provide one electronic copy of all final installed programming and files on compact disk under Microsoft format.

END OF SECTION