BID FORM

For Bids Due: _____ **To:** Caesar Rodney School District

Name of Bidder: _____

Delaware Business License No.: _____ **Taxpayer ID No.:** _____
(A copy of Bidder's Delaware Business License must be attached to this form.)

(Other License Nos.): _____

Phone No.: ( ) _____ - _____ **Fax No.: ( ) _____ - _____**

The undersigned, representing that he has read and understands the Bidding Documents and that this bid is made in accordance therewith, that he has visited the site and has familiarized himself with the local conditions under which the Work is to be performed, and that his bid is based upon the materials, systems and equipment described in the Bidding Documents without exception, hereby proposes and agrees to provide all labor, materials, plant, equipment, supplies, transport and other facilities required to execute the work described by the aforesaid documents for the lump sum itemized below:

$_____
($)

ALTERNATES

Alternate prices conform to applicable project specification section. Refer to specifications for a complete description of the following Alternates. An "ADD" or "DEDUCT" amount is indicated by the crossed out part that does not apply.

ADD ALTERNATE #1 – Epoxy Flooring. Refer to Specification Section 01 23 00 – Alternates.

$_____
($)

ADD ALTERNATE #2 – Replace TRU-1, RTU-8, RTU-10 and RTU-15. Refer to Specification Section 01 23 00 – Alternates.

$_____
($)

ADD ALTERNATE #3 – ATC System by Modern Controls. Refer to Specification Section 01 23 00 – Alternates.

$_____
($)

ADD ALTERNATE #4 – Additional Carpet and Paint at Office Area. Refer to Specification Section 01 23 00 – Alternates.

$_____
($)

BID FORM

UNIT PRICES

Unit prices conform to applicable project specification section. Refer to the specifications for a complete description of the following Unit Prices:

	ADD	DEDUCT
UNIT PRICE No. 1: None	$ _____	$ _____

ALLOWANCES

ALLOWANCE #1: None

BID FORM

I/We acknowledge Addendums numbered _____ and the price(s) submitted include any cost/schedule impact they may have.

This bid shall remain valid and cannot be withdrawn for thirty (30) days from the date of opening of bids (60 days for School Districts and Department of Education), and the undersigned shall abide by the Bid Security forfeiture provisions. Bid Security is attached to this Bid.

The Owner shall have the right to reject any or all bids, and to waive any informality or irregularity in any bid received.

This bid is based upon work being accomplished by the Sub-Contractors named on the list attached to this bid.

Should I/We be awarded this contract, I/We pledge to achieve substantial completion of all the work within _____calendar days of the Notice to Proceed.

The undersigned represents and warrants that he has complied and shall comply with all requirements of local, state, and national laws; that no legal requirement has been or shall be violated in making or accepting this bid, in awarding the contract to him or in the prosecution of the work required; that the bid is legal and firm; that he has not, directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken action in restraint of free competitive bidding.

Upon receipt of written notice of the acceptance of this Bid, the Bidder shall, within twenty (20) calendar days, execute the agreement in the required form and deliver the Contract Bonds, and Insurance Certificates, required by the Contract Documents.

I am / We are an Individual / a Partnership / a Corporation

By _____ Trading as _____
(Individual's / General Partner's / Corporate Name)

_____
(State of Corporation)

Business Address:_____
_____
_____
_____

Witness: _____ **By:** _____
(Authorized Signature)

(SEAL)

_____
(Title)

Date: _____

ATTACHMENTS

Sub-Contractor List
Non-Collusion Statement
Affidavit(s) of Employee Drug Testing Program
Bid Security
Copy of Business License
(Others as Required by Project Manuals)

BID FORM

SUBCONTRACTOR LIST

In accordance with Title 29, Chapter 6962 (d)(10)b Delaware Code, the following sub-contractor listing must accompany the bid submittal. The name and address of the sub-contractor **must be listed for each category** where the bidder intends to use a sub-contractor to perform that category of work. In order to provide full disclosure and acceptance of the bid by the *Owner*, **it is required that bidders list themselves as being the sub-contractor for all categories where he/she is qualified and intends to perform such work.** This form must be filled out completely with no additions or deletions. **Note that all subcontractors listed below must have a signed Affidavit of Employee Drug Testing Program included with this bid.**

Subcontractor Category	Subcontractor	Address (City & State)	Subcontractors tax payer ID # or Delaware Business license #
1. CARPENTRY			
3. MECHANICAL			
4. ELECTRICAL			
5. BUILDING AUTOMATION SYSTEM			
7. FLOORING			
8. GLASS AND GLAZING			

BID FORM

NON-COLLUSION STATEMENT

This is to certify that the undersigned bidder has neither directly nor indirectly, entered into any agreement, participated in any collusion or otherwise taken any action in restraint of free competitive bidding in connection with this proposal submitted this date *(to the Office of Management and Budget, Division of Facilities Management)*.

All the terms and conditions of *(Project or Contract Number)* have been thoroughly examined and are understood.

NAME OF BIDDER: _____

AUTHORIZED REPRESENTATIVE (TYPED): _____

AUTHORIZED REPRESENTATIVE (SIGNATURE): _____

TITLE: _____

ADDRESS OF BIDDER: _____

_____

_____

E-MAIL: _____

PHONE NUMBER: _____

Sworn to and Subscribed before me this _____ day of _____ 20____.

My Commission expires _____. NOTARY PUBLIC _____.

THIS PAGE MUST BE SIGNED AND NOTARIZED FOR YOUR BID TO BE CONSIDERED.

AFFIDAVIT
OF
EMPLOYEE DRUG TESTING PROGRAM

4104 Regulations for the Drug Testing of Contractor and Subcontractor Employees Working on Large Public Works Projects requires that Contractors and Subcontractors implement a program of mandatory drug testing for Employees who work on Large Public Works Contracts funded all or in part with public funds.

We hereby certify that we have in place or will implement during the entire term of the contract a Mandatory Drug Testing Program for our employees on the jobsite that complies with this regulation:

Contractor/Subcontractor Name: _____

Contractor/Subcontractor Address: _____

_____

_____

Authorized Representative (typed or printed): _____

Authorized Representative (signature): _____

Title: _____

Sworn to and Subscribed before me this _____day of _____ 20____.

My Commission expires _____. NOTARY PUBLIC _____.

<u>THIS PAGE MUST BE SIGNED AND NOTARIZED FOR YOUR BID TO BE CONSIDERED.</u>

SECTION 01 23 00
ALTERNATES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Description of Alternates.

1.02 RELATED REQUIREMENTS

A. Document 00 21 13 - Instructions to Bidders: Instructions for preparation of pricing for Alternates.

1.03 ACCEPTANCE OF ALTERNATES

A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at Owner's option. Accepted Alternates will be identified in the Owner-Contractor Agreement.

1.04 SCHEDULE OF ALTERNATES

A. Alternate No. 1 - Epoxy Flooring:
   1. Provide epoxy flooring at Corridor and Cafeteria in lieu of sheet vinyl. Refer to drawing A3.3.

B. Alternate No. 2 - Replace RTU-1, RTU-8, RTU-10 and RTU-15:
   1. Provide all labor and materials associated with the demolition and installation of the following units: RTU-1, RTU-8, RTU-10 and RTU-15. Guardrail at unit RTU-8 shall be included in Base Bid.

C. Alternate No. 3 - ATC System by Modern Controls:
   1. Work includes but is not limited to ATC Controls by Modern Controls. Provide additional cost, if any, for ATC system by Modern Controls (Utilizing Tridium Based Johnson FX). If Modern Controls is the low ATC subcontractor, then the alternate value on the bid form shall be listed as zero ($0) dollars.

D. Alternate No. 4 - Additional Carpet and Paint at Office Area:
   1. Remove existing carpet and base at rooms A102, A103, A104 and A105. Prepare floor and install new carpet tile and new 4" rubber cove base.
   2. Clean, prepare and paint walls at rooms A102, A103, A104, A105 and Toilet.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

EMPLOYEE DRUG TESTING REPORT FORM

Period Ending:_____

4104 Regulations for the Drug Testing of Contractor and Subcontractor Employees Working on Large Public Works Projects requires that Contractors and Subcontractors who work on Large Public Works Contracts funded all or in part with public funds maintain testing data that includes but is not limited to the data elements below.

Project Number: _____

Project Name: _____

Contractor/Subcontractor Name: _____

Contractor/Subcontractor Address: _____
_____
_____

Number of employees who worked on the jobsite during the report period:_____

Number of employees subject to random testing during the report period:_____

Number of Negative Results _____ Number of Positive Results _____

Action taken on employee(s) in response to a failed or positive random test:
_____
_____
_____

Date: _____

This form is not required to be submitted to the Owner. Included as a reference to show information required to be maintained by the Contractor. The Owner shall have the right to periodically audit all Contractor and Subcontractor test results at the Contractor's or Subcontractor's offices (or by other means to make the data available for inspection by the Owner).

EMPLOYEE DRUG TESTING
REPORT OF POSITIVE RESULTS

4104 Regulations for the Drug Testing of Contractor and Subcontractor Employees Working on Large Public Works Projects requires that Contractors and Subcontractors who work on Large Public Works Contracts funded all or in part with public funds to notify the Owner in writing of a positive random drug test.

Project Number: _____

Project Name: _____

Contractor/Subcontractor Name: _____

Contractor/Subcontractor Address: _____
_____
_____

Name of employee with positive test result:_____

Last 4 digits of employee SSN:_____

Date test results received:_____

Action taken on employee in response to a positive test result:
_____
_____
_____

Authorized Representative of Contractor/Subcontractor: _____
(typed or printed)

Authorized Representative of Contractor/Subcontractor: _____
(signature)

Date: _____

This form shall be sent by mail to the Owner within 24 hours of receipt of test results.

Enclose this test results form in a sealed envelope with the notation "Drug Testing Form – DO NOT OPEN" on the face thereof and place in a separate mailing envelope.

SECTION 08 80 00
GLAZING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Glass.

B. Plastic glazing film.

C. Glazing compounds and accessories.

1.02 RELATED REQUIREMENTS

A. Section 07 90 05 - Joint Sealers: Sealant and back-up material.

B. Section 08 11 13 - Hollow Metal Doors and Frames: Glazed doors and borrowed lites.

C. Section 08 14 16 - Flush Wood Doors: Glazed lites in doors.

1.03 REFERENCE STANDARDS

A. 16 CFR 1201 - Safety Standard for Architectural Glazing Materials.

B. ANSI Z97.1 - American National Standard for Safety Glazing Materials Used in Buildings, Safety Performance Specifications and Methods of Test.

C. ASTM C864 - Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers.

D. ASTM C920 - Standard Specification for Elastomeric Joint Sealants.

E. ASTM C1036 - Standard Specification for Flat Glass.

F. ASTM C1048 - Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass.

G. ASTM C1193 - Standard Guide for Use of Joint Sealants.

H. ASTM E 773 - Standard Test Method for Accelerated Weathering of Sealed Insulating Glass Units.

I. ASTM E 774 - Standard Specification for the Classification of the Durability of Sealed Insulating Glass Units; 1997.

J. ASTM E1300 - Standard Practice for Determining Load Resistance of Glass in Buildings.

K. ASTM E2190 - Standard Specification for Insulating Glass Unit Performance and Evaluation.

L. GANA (GM) - GANA Glazing Manual.

M. GANA (SM) - GANA Sealant Manual.

N. GANA (LGRM) - Laminated Glazing Reference Manual.

O. IGMA TM-3000 - North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial & Residential Use.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Convene a preinstallation meeting one week before starting work of this section; require attendance by all affected installers.

1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data on Glass Types: Provide structural, physical and environmental characteristics, size limitations, special handling or installation requirements.

C. Product Data on Glazing Compounds: Provide chemical, functional, and environmental characteristics, limitations, special application requirements. Identify available colors.

D. Product Data on Film products: Provide product specifications, physical characteristics and properties, fire and smoke test data, impact test data, blast test data, and installation system components.

E. Samples: Submit two samples 12 x12 inch in size of glass and plastic units, showing coloration and design.

F. Samples: Submit two samples 12 x 12 inch in size of film.

G. Certificates: Certify that products meet or exceed specified requirements.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 60 00 - Product Requirements, for additional provisions.
   2. Extra Insulating Glass Units: One of each glass size and each glass type.

1.06 QUALITY ASSURANCE

A. Perform Work in accordance with GANA Glazing Manual and FGMA Sealant Manual for glazing installation methods.

B. Installer Qualifications: Company specializing in performing the work of this section with minimum 10 years documented experience.

1.07 FIELD CONDITIONS

A. Do not install glazing when ambient temperature is less than 50 degrees F.

B. Maintain minimum ambient temperature before, during and 24 hours after installation of glazing compounds.

1.08 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. Sealed Insulating Glass Units: Provide a five (5) year warranty to include coverage for seal failure, interpane dusting or misting, including replacement of failed units.

1.09 PERFORMANCE REQUIREMENTS

A. General: Provide glass capable of withstanding thermal movement and wind and impact loads (where applicable) as specified in paragraph B following.

B. Glass Design: Glass thickness designations indicated are minimums and are for detailing only. Confirm glass thicknesses by analyzing Project loads and in-service conditions. Provide glass lites in the thickness designations indicated for various size openings, but not less than thicknesses and in strengths (annealed or heat treated) required to meet or exceed the following criteria:
   1. Glass Thicknesses: Select minimum glass thicknesses to comply with ASTM E 1300, according to the following requirements:
      a. Basic Wind Speed: 120 mph.

C. Thermal Movements: Provide glazing that allows for thermal movements resulting from ambient and surface temperatures changes acting on glass framing members and glazing components.

D. Thermal and Optical Performance Properties: Provide glass with performance properties specified based on manufacturer's published test data, as determined according to procedures indicated below:
   1. For monolithic-glass lites, properties are based on units with lites 1/4 inch (6.0 mm) thick.
   2. For insulating-glass units, properties are based on units of thickness indicated for overall unit and for each lite.
   3. Center-of-Glass Values: Based on using LBL-44789 WINDOW 5.0 computer program for the following methodologies:
      a. U-Factors: NFRC 100 expressed as Btu/ sq. ft. per h per degree F.

b. Solar Heat Gain Coefficient: NFRC 200.
c. Solar Optical Properties: NFRC 300.

PART 2 PRODUCTS

2.01 GLAZING TYPES

A. Type IG-1 - Sealed Insulating Glass Units: Vision glass, double glazed.
1. Application(s): All exterior glazing unless otherwise indicated.
2. Outboard Lite: Fully tempered float glass, 1/4 inch thick, minimum.
a. Tint: Dark Gray, to match existing.
b. Coating: Low-E type, on #2 surface.
3. Inboard Lite: Fully tempered float glass, 1/4 inch thick, minimum.
a. Tint: Clear.
4. Total Thickness: 1 inch.
5. Security Film: All windows below 12 feet high shall receive security film, installed with wet glazing system by film manufacturer.

B. Type G-1 - Single Vision Glazing:
1. Applications: All interior glazing unless otherwise indicated.
2. Type: Fully tempered float glass.
3. Tint: Clear.
4. Thickness: 1/4 inch.
5. Security Film: All interior windows shall receive security film, installed with wet glazing system by film manufacturer.

2.02 GLASS MATERIALS

A. Float Glass Manufacturers:
1. PPG Industries, Inc: www.ppgideascapes.com.
2. Substitutions: Refer to Section 01 60 00 - Product Requirements.

B. Float Glass: All glazing is to be float glass unless otherwise indicated.
1. Heat-Strengthened and Fully Tempered Types: ASTM C1048.
2. Tinted Types: Color and performance characteristics as indicated.
3. Thicknesses: As indicated; for exterior glazing comply with specified requirements for wind load design regardless of specified thickness.

2.03 SEALED INSULATING GLASS UNITS

A. Manufacturers:
1. Fabricator certified by glass manufacturer for type of glass, coating, and treatment involved and capable of providing specified warranty.
2. Substitutions: Refer to Section 01 60 00 - Product Requirements.

B. Sealed Insulating Glass Units: Types as indicated.
1. Durability: Certified by an independent testing agency to comply with ASTM E2190.
2. Edge Spacers: Aluminum, bent and soldered corners.
3. Edge Seal: Glass to elastomer with supplementary silicone sealant.
4. Purge interpane space with dry hermetic air.

2.04 PLASTIC FILMS

A. Manufacturers:
1. 3M Window Film: www.3m.com/US/arch_construct/scpd/windowfilm.
a. 3M Scotchsield Safety & Security Window Film Ultra S800.
2. Substitutions: Refer to Section 01 60 00 - Product Requirements.

B. Film Requirements:

1. The film material shall consist of an optically clear polyester film, constinsting of co-extruded micro-layers, with a durable acrylic abrasion resistant coating over one surface, and a UV stabilized pressure sensitive adhesive on the other. The film color is clear and will not contain dyed polyester. The film shall have a nominal thickness of 8 mils. There shall be no evidence of coating voids. The film shall be identified as to Manufacture of Origin.
2. Flame Spread Index: 5
3. Smoke Developed Index: 25
4. Impact Resistance: Film, when applied to either side of the window glass, shall meet the 400 ft-lb impact requirements of 16 CFR 1201 (Category 2) and ANSI Z97.1 (Class A, Unlimited). Testing shall be done with film applied both on 1/8" and 1/4" annealed glass.
5. Blast Mitigation:
   a. GSA Rating of “2” (Minimal Hazard) / ASTM F1642 “Minimal Hazard” with blast pressure of 7 psi and 44 psi*msec blast impulse, on ¼” annealed single pane glass and 3M Impact Protecion Profile Attachment system
   b. GSA Rating of “2” (Minimal Hazard) / ASTM F1642 “Minimal Hazard” with blast pressure of 7 psi and 43 psi*msec blast impulse, on ¼” tempered single pane glass and 3M Impact Protecion Profile Attachment system
   c. GSA Rating of “2” (Minimal Hazard) / ASTM F1642 “Minimal Hazard” with blast pressure of 7 psi and 42 psi*msec blast impulse, on ¼” annealed single pane glass and 3M Impact Protecion Adhesive Attachment system
   d. GSA Rating of “2” (Minimal Hazard) / ASTM F1642 “No Hazard” with blast pressure of 7 psi and 42 psi*msec blast impulse, on ¼” tempered single pane glass and 3M Impact Protection Adhesive Attachment systemtion Profile Attachment system
   e. GSA Rating of “2” (Minimal Hazard) / ASTM F1642 “Minimal Hazard” with blast pressure of 9 psi and 60 psi*msec blast impulse, on 1” annealed double pane glass and 3M Impact Protection Profile Attachment system
   f. GSA Rating of “2” (Minimal Hazard) / ASTM F1642 “Minimal Hazard” with blast pressure of 10 psi and 89 psi*msec blast impulse, on 1” annealed double pane glass and 3M Impact Protection Adhesive Attachment system, on 1” annealed
6. Windborne Debris Protectino: Film shall pass ASTM E330 at a design pressure of 100 psf with 3M Impact Protection Adhesive attachment system.

2.05 GLAZING COMPOUNDS

A. Manufacturers:
   1. Pecora Corporation: www.pecora.com.
   2. Substitutions: Refer to Section 01 60 00 - Product Requirements.

B. Glazing Putty : Polymer modified latex recommended by manufacturer for outdoor use, knife grade consistency; grey color.

C. Butyl Sealant : Single component; ASTM C 920, Grade NS, Class 12-1/2, Uses M and A; Shore A hardness of 10 to 20; black color; non-skinning.

D. Acrylic Sealant : Single component, solvent curing, non-bleeding; ASTM C 920, Type S, Grade NS, Class 12-1/2, Uses M and A; cured Shore A hardness of 15 to 25; color as selected.

E. Polysulfide Sealant : Two component; chemical curing, non-sagging type; ASTM C 920, Type M, Grade NS, Class 25, Uses M, A, and G; cured Shore A hardness of 15 to 25; color as selected.

F. Polyurethane Sealant : Single component, chemical curing, non-staining, non-bleeding; Shore A Hardness Range 20 to 35; color as selected.

G. Silicone Sealant : Single component; neutral curing; capable of water immersion without loss of properties; non-bleeding, non-staining; ASTM C 920, Type S, Grade NS, Class 25, Uses M, A, and G; cured Shore A hardness of 15 to 25; color as selected.

2.06 GLAZING ACCESSORIES

A. Setting Blocks: Neoprene, 80 to 90 Shore A durometer hardness, ASTM C864 Option I. Length of 0.1 inch for each square foot of glazing or minimum 4 inch x width of glazing rabbet space minus 1/16 inch x height to suit glazing method and pane weight and area.

B. Spacer Shims: Neoprene, 50 to 60 Shore A durometer hardness, ASTM C 864 Option I. Minimum 3 inch long x one half the height of the glazing stop x thickness to suit application, self adhesive on one face.

C. Glazing Tape: Preformed butyl compound with integral resilient tube spacing device; 10 to 15 Shore A durometer hardness; coiled on release paper; black color.
   1. Manufacturers:
      a. Pecora Corporation: www.pecora.com.
      b. Substitutions: Refer to Section 01 60 00 - Product Requirements.

D. Glazing Gaskets: Resilient silicone extruded shape to suit glazing channel retaining slot; ASTM C864 Option I; black color.

E. Glazing Clips: Manufacturer's standard type.

2.07 SOURCE QUALITY CONTROL AND TESTS

A. Provide shop inspection and testing for all glass.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that openings for glazing are correctly sized and within tolerance.

B. Verify that surfaces of glazing channels or recesses are clean, free of obstructions that may impede moisture movement, weeps are clear, and ready to receive glazing.

3.02 PREPARATION

A. Clean contact surfaces with solvent and wipe dry.

B. Seal porous glazing channels or recesses with substrate compatible primer or sealer.

C. Prime surfaces scheduled to receive sealant.

D. Install sealants in accordance with ASTM C1193 and GANA Sealant Manual.

E. Install sealant in accordance with manufacturer's instructions.

3.03 GLAZING METHODS

3.04 INSTALLATION - EXTERIOR DRY METHOD (TAPE AND GASKET SPLINE GLAZING)

A. Cut glazing tape to length; install on glazing pane. Seal corners by butting tape and sealing junctions with butyl sealant.

B. Place setting blocks at 1/4 points with edge block no more than 6 inches from corners.

C. Rest glazing on setting blocks and push against fixed stop with sufficient pressure to attain full contact.

D. Install removable stops without displacing glazing spline. Exert pressure for full continuous contact.

E. Trim protruding tape edge.

3.05 INSTALLATION - INTERIOR DRY METHOD (TAPE AND TAPE)

A. Cut glazing tape to length and set against permanent stops, projecting 1/16 inch (1.6 mm) above sight line.

B. Place setting blocks at 1/4 points with edge block no more than 6 inches from corners.

C. Rest glazing on setting blocks and push against tape for full contact at perimeter of pane or unit.

D. Place glazing tape on free perimeter of glazing in same manner described above.

E. Install removable stop without displacement of tape. Exert pressure on tape for full continuous contact.

F. Knife trim protruding tape.

3.06 INSTALLATION - PLASTIC FILM

A. The window and window framing will be cleaned thoroughly with a neutral cleaning solution. The inside surface of the window glass shall bescraped with stainless steel razor blades with clean, sharp edges to ensure the removal of any foreign contaminants without damages the glass surface.

B. Install plastic film with adhesive, applied in accordance with film manufacturer's instructions.

C. Install with 3/8" minimum wet glazing compound at all sides. Prerimeter glazing compound shall be by film manufacturer.

D. Place without air bubbles, creases or visible distortion.

3.07 MANUFACTURER'S FIELD SERVICES

A. Glass and Glazing product manufacturers to provide field surveillance of the installation of their products.

B. Monitor and report installation procedures and unacceptable conditions.

3.08 CLEANING

A. Remove glazing materials from finish surfaces.

B. Remove labels after Work is complete.

C. Clean glass and adjacent surfaces.

3.09 PROTECTION

A. After installation, mark pane with an 'X' by using removable plastic tape or paste; do not mark heat absorbing or reflective glass units.

END OF SECTION

SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

A. System Description
B. Operator Interface
C. Controllers
D. Power Supplies and Line Filtering
E. System Software
F. Controller Software
G. HVAC Control Programs
H. Control equipment.
I. Software.

1.02 RELATED REQUIREMENTS

A. Section 28 31 00 - Fire Detection and Alarm.
B. Section 23 09 13 - Instrumentation and Control Devices for HVAC.
C. Section 23 09 93 - Sequence of Operations for HVAC Controls.
D. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.
E. Section 27 52 23.50 - Educational Intercommunications and Programs - Education For Sustainability Systems

1.03 REFERENCE STANDARDS

A. NFPA 70 - National Electrical Code.

1.04 SYSTEM DESCRIPTION

A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units The installation of the BAS for Charlton E.S. shall be an expansion of the existing Johnson Controls Metasys control system serving Allen Frear E.S..
B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
C. Include computer software and all hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.
D. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units. Individual terminal unit control is specified in Section 23 09 13.
E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment, power transformers and electrical feeds, and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
F. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data for each system component and software module.

C. Shop Drawings:
   1. Indicate trunk cable schematic showing programmable control unit locations, and trunk data conductors.
   2. List connected data points, including connected control unit and input device.
   3. Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations. Provide demonstration diskette containing graphics.
   4. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
   5. Indicate description and sequence of operation of operating, user, and application software.

D. Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.

E. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.
   1. Revise shop drawings to reflect actual installation and operating sequences.
   2. Include submittals data in final "Record Documents" form.

F. Operation and Maintenance Data:
   1. Include interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
   2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
   3. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

G. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner s name and registered with manufacturer.

1.06 QUALITY ASSURANCE

A. Perform work in accordance with NFPA 70.

B. Design system software under direct supervision of a Professional Engineer experienced in design of this Work and licensed at Delaware.

C. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum 10 years documented experience.

D. Installer Qualifications: Company specializing in performing the work of this section 5 years documented experience approved by manufacturer.

E. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

F. Product Line Demonstrated History: The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of 2 years since date of final completion in at least 10 installations of comparative size and complexity. Submittals shall document this requirement with references. The following requirement relates to the actual installing contractor.

G. Installer's Qualifications: Firms specializing and experienced in control system installations for not less than 5 years. Firms with experience in BAS installation projects with point counts equal to this project and systems of the same character as this project. If installer is a Value Added Reseller (VAR) of a manufacturer's product, installer must demonstrate at least three years prior experience with that manufacturer's products. Experience starts with awarded Final Completion of previous projects. Submittals must document this experience with references.

H. Installer's Experience with Proposed Product Line: Firms shall have specialized in and be experienced with the installation of the proposed product line for not less than one year from date of final completion on at least 3 projects of similar size and complexity. Submittals shall document this experience with references.

I. Installer's Field Coordinator and Sequence Programmer Qualifications: Individual(s) shall specialize in and be experienced with control system installation for not less than 5 years. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than 2 projects of similar size and complexity. Installer shall submit the names of the proposed individual and at least one alternate for each duty. Submittals shall document this experience with references. The proposed individuals must show proof of the following training:
   1. Product Line Training: Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the Manufacturer on that product line for installation and configuration
   2. Programming Training: Individuals involved with programming the site-specific sequences shall provide evidence of the most advanced programming training offered by the vendor of the programming application offered by the Manufacturer.

J. Installer's Service Qualifications: The installer must be experienced in control system operation, maintenance and service. Installer must document a minimum 5 year history of servicing installations of similar size and complexity. Installer must also document at least a one year history of servicing the proposed product line.

1.07 PRE-INSTALLATION MEETING

A. Convene one week before starting work of this Section.

B. Require attendance of parties directly affecting the work of this Section.

1.08 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. Correct defective Work within a five year period after Substantial Completion.

C. Provide five year manufacturer's warranty for field programmable micro-processor based units.

1.09 MAINTENANCE SERVICE

A. Provide service and maintenance of energy management and control systems for one years from Date of Substantial Completion.

B. Provide four complete inspections per year, two in each season, to inspect, calibrate, and adjust controls as required, and submit written reports.

C. Provide complete service of systems, including call backs. Make minimum of 4 complete normal inspections of approximately 4 hours duration in addition to normal service calls to inspect, calibrate, and adjust controls, and submit written reports.

1.10 EXTRA MATERIALS

A. See Section 01 60 00 - Product Requirements, for additional provisions.

1.11 PROTECTION OF SOFTWARE RIGHTS

A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
   1. Limiting use of software to equipment provided under these specifications.
   2. Limiting copying.
   3. Preserving confidentiality.
   4. Prohibiting transfer to a third party.

PART 2 PRODUCTS

2.01 MANUFACTURERS (PRE-APPROVED BY THE STATE)

A. Automated Logic by Radius Systems

B. BuildingLogix / Lynxspring / KMC Controls by Seiberlich Trane

C. Johnson Controls by Modern Controls

D. Substitutions: Approved by the Owner and Engineer at least 10 days prior to bidding.

2.02 SYSTEM DESCRIPTION

A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units with communications to the existing Building Management System.

B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.

C. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.

D. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units. Individual terminal unit control is specified in Section 23 09 13.

E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.

F. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

2.03 CONTROLLERS

A. BUILDING CONTROLLERS

1. General:
   a. Manage global strategies by one or more, independent, standalone, microprocessor based controllers.
   b. Provide sufficient memory to support controller's operating system, database, and programming requirements.
   c. Share data between networked controllers.
   d. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
   e. Utilize real-time clock for scheduling.
   f. Continuously check processor status and memory circuits for abnormal operation.
   g. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
   h. Communication with other network devices to be based on assigned protocol.
2. Communication:
   a. Controller to reside on a BACnet network using ISO 8802-3 (ETHERNET) Data Link/Physical layer protocol.
   b. Perform routing when connected to a network of custom application and application specific controllers.
   c. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
3. Anticipated Environmental Ambient Conditions:
   a. Outdoors and/or in Wet Ambient Conditions:

1) Mount within waterproof enclosures.
2) Rated for operation at 40 to 150 degrees F.

b. Conditioned Space:
1) Mount within dustproof enclosures.
2) Rated for operation at 32 to 120 degrees F.

4. Provisions for Serviceability:
a. Diagnostic LEDs for power, communication, and processor.
b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.

6. Power and Noise Immunity:
a. Maintain operation at 90 to 110 percent of nominal voltage rating.
b. Perform orderly shutdown below 80 percent of nominal voltage.
c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

B. INPUT/OUTPUT INTERFACE

1. Hardwired inputs and outputs tie into the DDC system through building, custom application, or application specific controllers.

2. All Input/Output Points:
a. Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.
b. Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.

3. Binary Inputs:
a. Allow monitoring of On/Off signals from remote devices.
b. Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.
c. Sense dry contact closure with power provided only by the controller.

4. Pulse Accumulation Input Objects: Conform to all requirements of binary input objects and accept up to 10 pulses per second.

5. Analog Inputs:
a. Allow for monitoring of low voltage 0 to 10 VDC, 4 to 20 mA current, or resistance signals (thermistor, RTD).
b. Compatible with and field configurable to commonly available sensing devices.

6. Binary Outputs:
a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
b. Outputs provided with three position (On/Off/Auto) override switches.
c. Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.

7. Analog Outputs:
a. Monitoring signal provides a 0 to 10 VDC or a 4 to 20 mA output signal for end device control.
b. Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
c. Drift to not exceed 0.4 percent of range per year.

8. Tri State Outputs:

a. Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
b. Limit the use of three point, floating devices to the following zone and terminal unit control applications:
c. Control algorithms run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

9. System Object Capacity:
   a. System size to be expandable to twice the number of input output objects required by providing additional controllers, including associated devices and wiring.
   b. Hardware additions or software revisions for the installed operator interfaces are not to be required for future, system expansions.

2.04 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies:
   1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
   2. Limit connected loads to 80 percent of rated capacity.
   3. Match DC power supply to current output and voltage requirements.
   4. Unit to be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
   5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
   6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
   7. Operational Ambient Conditions: 32 to 120 degrees F.
   8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD 810 for shock and vibration.
   9. Line voltage units UL recognized and CSA approved.

B. Power Line Filtering:
   1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
   2. Minimum surge protection attributes:
      a. Dielectric strength of 1000 volts minimum.
      b. Response time of 10 nanoseconds or less.
      c. Transverse mode noise attenuation of 65 dB or greater.
      d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

2.05 OPERATOR STATION

A. Work Station:
   1. Utilize existing workstation on-site.

B. System Support: Minimum ten (10) work stations connected to multi-user, multi-tasking environment with concurrent capability to:
   1. Access DDC network.
   2. Access or control same control unit.
   3. Access or modify same control unit data base.
   4. Archive data, alarms, and network actions to hard disk regardless of what application programs are being currently executed.
   5. Develop and edit data base.
   6. Implement and tune DDC control.
   7. Develop graphics.
   8. Control facility.

2.06 CONTROL UNITS

A. Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and display panel, and integral interface equipment.

B. Battery Backup: For minimum of 48 hours for complete system including RAM without interruption, with automatic battery charger.

C. Control Units Functions:
   1. Monitor or control each input/output point.
   2. Completely independent with hardware clock/calendar and software to maintain control independently.
   3. Acquire, process, and transfer information to operator station or other control units on network.
   4. Accept, process, and execute commands from other control unit's or devices or operator stations.
   5. Access both data base and control functions simultaneously.
   6. Record, evaluate, and report changes of state or value that occur among associated points. Continue to perform associated control functions regardless of status of network.
   7. Perform in stand-alone mode:
      a. Start/stop.
      b. Duty cycling.
      c. Automatic Temperature Control.
      d. Demand control via a sliding window, predictive algorithm.
      e. Event initiated control.
      f. Calculated point.
      g. Scanning and alarm processing.
      h. Full direct digital control.
      i. Trend logging.
      j. Global communications.
      k. Maintenance scheduling.

D. Global Communications:
   1. Broadcast point data onto network, making that information available to all other system control units.
   2. Transmit any or all input/output points onto network for use by other control units and utilize data from other control units.

E. Input/Output Capability:
   1. Discrete/digital input (contact status).
   2. Discrete/digital output.
   3. Analog input.
   4. Analog output.
   5. Pulse input (5 pulses/second).
   6. Pulse output (0-655 seconds in duration with 0.01 second resolution).

F. Monitor, control, or address data points. Mix shall include analog inputs, analog outputs, pulse inputs, pulse outputs and discrete inputs/outputs, as required. Install control unit's with minimum 30 percent spare capacity.

G. Point Scanning: Set scan or execution speed of each point to operator selected time from 1 to 250 seconds.

H. Upload/Download Capability: Download from or upload to operator station. Upload/Download time for entire control unit database maximum 10 seconds on hard wired LAN, or 60 seconds over voice grade phone lines.

I. Test Mode Operation: Place input/output points in test mode to allow testing and developing of control algorithms on line without disrupting field hardware and controlled environment. In test mode:
   1. Inhibit scanning and calculation of input points. Issue manual control to input points (set analog or digital input point to operator determined test value) from work station.
   2. Control output points but change only data base state or value; leave external field hardware unchanged.
   3. Enable control actions on output points but change only data base state or value.

J. Local display and adjustment panel: Portable control unit, containing digital display, and numerical keyboard. Display and adjust:
   1. Input/output point information and status.
   2. Controller set points.
   3. Controller tuning constants.
   4. Program execution times.
   5. High and low limit values.
   6. Limit differential.
   7. Set/display date and time.
   8. Control outputs connected to the network.
   9. Automatic control outputs.
   10. Perform control unit diagnostic testing.
   11. Points in "Test" mode.

2.07 LOCAL AREA NETWORK (LAN)

A. Provide communication between control units over local area network (LAN).

B. LAN Capacity: Not less than 100 stations or nodes.

C. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.

D. LAN Data Speed: Minimum 19.2 Kb.

E. Communication Techniques: Allow interface into network by multiple operation stations and by auto-answer/auto-dial modems. Support communication over telephone lines utilizing modems.

F. Transmission Median: Fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.

G. Network Support: Time for global point to be received by any station, shall be less than 3 seconds. Provide automatic reconfiguration if any station is added or lost. If transmission cable is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.

2.08 SYSTEM SOFTWARE

A. Operating System:
   1. Concurrent, multi-tasking capability.
      a. Common Software Applications Supported: Microsoft Excel.
   2. System Graphics:
      a. Allow up to 10 graphic screens, simultaneously displayed for comparison and monitoring of system status.
      b. Animation displayed by shifting image files based on object status.
      c. Provide method for operator with password to perform the following:
         1) Move between, change size, and change location of graphic displays.
         2) Modify on-line.
         3) Add, delete, or change dynamic objects consisting of:
            (a) Analog and binary values.
            (b) Dynamic text.

(c) Static text.
(d) Animation files.

3. Custom Graphics Generation Package:
   a. Create, modify, and save graphic files and visio format graphics in PCX formats.
   b. HTML graphics to support web browser compatible formats.
   c. Capture or convert graphics from AutoCAD.
4. Standard HVAC Graphics Library:
   a. HVAC Equipment:
   b. Ancillary Equipment:

B. Workstation System Applications:
1. Automatic System Database Save and Restore Functions:
   a. Current database copy of each Building Controller is automatically stored on hard disk.
   b. Automatic update occurs upon change in any system panel.
   c. In the event of database loss in any system panel, the first workstation to detect the loss automatically restores the database for that panel unless disabled by the operator.
2. Manual System Database Save and Restore Functions by Operator with Password Clearance:
   a. Save database from any system panel.
   b. Clear a panel database.
   c. Initiate a download of a specified database to any system panel.
3. Software provided allows system configuration and future changes or additions by operators under proper password protection.
4. On-line Help:
   a. Context-sensitive system assists operator in operation and editing.
   b. Available for all applications.
   c. Relevant screen data provided for particular screen display.
   d. Additional help available via hypertext.
5. Security:
   a. Operator log-on requires user name and password to view, edit, add, or delete data.
   b. System security selectable for each operator.
   c. System supervisor sets passwords and security levels for all other operators.
   d. Operator passwords to restrict functions accessible to viewing and/or changing system applications, editor, and object.
   e. Automatic, operator log-off results from keyboard or mouse inactivity during user-adjustable, time period.
   f. All system security data stored in encrypted format.
6. System Diagnostics:
   a. Operations Automatically Monitored:
      1) Workstations.
      2) Printers.
      3) Modems.
      4) Network connections.
      5) Building management panels.
      6) Controllers.
   b. Device failure is annunciated to the operator.
7. Alarm Processing:
   a. All system objects are configurable to "alarm in" and "alarm out" of normal state.
   b. Configurable Objects:
      1) Alarm limits.

2) Alarm limit differentials.
3) States.
4) Reactions for each object.

8. Alarm Messages:
   a. Descriptor: English language.
   b. Recognizable Features:
      1) Source.
      2) Location.
      3) Nature.
9. Configurable Alarm Reactions by Workstation and Time of Day:
   a. Logging.
   b. Printing.
   c. Starting programs.
   d. Displaying messages.
   e. Dialing out to remote locations.
   f. Paging.
   g. Providing audible annunciation.
   h. Displaying specific system graphics.
10. Custom Trend Logs:
    a. Definable for any data object in the system including interval, start time, and stop time.
    b. Trend Data:
       1) Sampled and stored on the building controller panel.
       2) Archivable on hard disk.
       3) Retrievable for use in reports, spreadsheets and standard database programs.
       4) Archival on LAN accessible storage media including hard disk, tape, Raid array drive, and virtual cloud environment.
       5) Protected and encrypted format to prevent manipulation, or editing of historical data and event logs.
11. Alarm and Event Log:
    a. View all system alarms and change of states from any system location.
    b. Events listed chronologically.
    c. Operator with proper security acknowledges and clears alarms.
    d. Alarms not cleared by operator are archived to the workstation hard disk.
12. Object, Property Status and Control:
    a. Provide a method to view, edit if applicable, the status of any object and property in the system.
    b. Status Available by the Following Methods:
       1) Menu.
       2) Graphics.
       3) Custom Programs.
13. Reports and Logs:
    a. Reporting Package:
       1) Allows operator to select, modify, or create reports.
       2) Definable as to data content, format, interval, and date.
       3) Archivable to hard disk.
    b. Real-time logs available by type or status such as alarm, lockout, normal, etc.
    c. Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
    d. Set to be printed on operator command or specific time(s).
14. Reports:

a. Standard:
   1) Objects with current values.
   2) Current alarms not locked out.
   3) Disabled and overridden objects, points and SNVTs.
   4) Objects in manual or automatic alarm lockout.
   5) Objects in alarm lockout currently in alarm.
   6) Logs:
      (a) Alarm History.
      (b) System messages.
      (c) System events.
      (d) Trends.
b. Custom:
   1) Daily.
   2) Weekly.
   3) Monthly.
   4) Annual.
   5) Time and date stamped.
   6) Title.
   7) Facility name.
c. Tenant Override:
   1) Monthly report showing total, requested, after-hours HVAC and lighting services on a daily basis for each tenant.
   2) Annual report showing override usage on a monthly basis.
d. Electrical, Fuel, and Weather:
   1) Electrical Meter(s):
      (a) Monthly showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
      (b) Annual summary showing monthly electrical consumption and peak demand with time and date stamp for each meter.
   2) Fuel Meter(s):
      (a) Monthly showing daily natural gas consumption for each meter.
      (b) Annual summary showing monthly consumption for each meter.
   3) Weather:
      (a) Monthly showing minimum, maximum, average outdoor air temperature and heating/cooling degree-days for the month.

C. Workstation Applications Editors:
   1. Provide editing software for all system applications at the PC workstation.
   2. Downloaded application is executed at controller panel.
   3. Full screen editor for each application allows operator to view and change:
      a. Configuration.
      b. Name.
      c. Control parameters.
      d. Set-points.
   4. Scheduling:
      a. Monthly calendar indicates schedules, holidays, and exceptions.
      b. Allows several related objects to be scheduled and copied to other objects or dates.
      c. Start and stop times adjustable from master schedule.
   5. Custom Application Programming:
      a. Create, modify, debug, edit, compile, and download custom application programming during operation and without disruption of all other system applications.
      b. Programming Features:

1) English oriented language, based on BASIC, FORTRAN, C, or PASCAL syntax allowing for free form programming.
2) Alternative language graphically based using appropriate function blocks suitable for all required functions and amenable to customizing or compounding.
3) Insert, add, modify, and delete custom programming code that incorporates word processing features such as cut/paste and find/replace.
4) Allows the development of independently, executing, program modules designed to enable and disable other modules.
5) Debugging/simulation capability that displays intermediate values and/or results including syntax/execution error messages.
6) Support for conditional statements (IF/THEN/ELSE/ELSE-F) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
7) Support for floating-point arithmetic utilizing plus, minus, divide, times, square root operators; including absolute value; minimum/maximum value from a list of values for mathematical functions.
8) Language consisting of resettable, predefined, variables representing time of day, day of the week, month of the year, date; and elapsed time in seconds, minutes, hours, and days where the variable values cab be used in IF/THEN comparisons, calculations, programming statement logic, etc.
9) Language having predefined variables representing status and results of the system software enables, disables, and changes the set points of the controller software.

2.09 CONTROLLER SOFTWARE

A. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.

B. System Security:
   1. User access secured via user passwords and user names.
   2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
   3. User Log On/Log Off attempts are recorded.
   4. Automatic Log Off occurs following the last keystroke after a user defined delay time.

C. Object or Object Group Scheduling:
   1. Weekly Schedules Based on Separate, Daily Schedules:
      a. Include start, stop, optimal stop, and night economizer.
      b. 10 events maximum per schedule.
      c. Start/stop times adjustable for each group object.

D. Provide standard application for equipment coordination and grouping based on function and location to be used for scheduling and other applications.

E. Alarms:
   1. Binary object is set to alarm based on the operator specified state.
   2. Analog object to have high/low alarm limits.
   3. All alarming is capable of being automatically and manually disabled.
   4. Alarm Reporting:
      a. Operator determines action to be taken for alarm event.
      b. Alarms to be routed to appropriate workstation.
      c. Reporting Options:

F. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.

G. Sequencing: Application software based upon specified sequences of operation in Section 23 09 93.

H. PID Control Characteristics:
   1. Direct or reverse action.
   2. Anti-windup.
   3. Calculated, time-varying, analog value, positions an output or stages a series of outputs.
   4. User selectable controlled variable, set-point, and PED gains.

I. Staggered Start Application:
   1. Prevents all controlled equipment from simultaneously restarting after power outage.
   2. Order of equipment startup is user selectable.

J. Energy Calculations:
   1. Accumulated instantaneous power or flow rates are converted to energy use data.
   2. Algorithm calculates a rolling average and allows window of time to be user specified in minute intervals.
   3. Algorithm calculates a fixed window average with a digital input signal from a utility meter defining the start of the window period that in turn synchronizes the fixed-window average with that used by the power company.

K. Anti-Short Cycling:
   1. All binary output objects protected from short-cycling.
   2. Allows minimum on-time and off-time to be selected.

L. On-Off Control with Differential:
   1. Algorithm allows binary output to be cycled based on a controlled variable and set-point.
   2. Algorithm to be direct-acting or reverse-acting incorporating an adjustable differential.

M. Run-Time Totalization:
   1. Totalize run-times for all binary input objects.
   2. Provides operator with capability to assign high run-time alarm.

2.10 OPERATING SYSTEM SOFTWARE

A. Input/Output Capability From Operator Station:
   1. Request display of current values or status in tabular or graphic format.
   2. Command selected equipment to specified state.
   3. Initiate logs and reports.
   4. Change analog limits.
   5. Add, delete, or change points within each control unit or application routine.
   6. Change point input/output descriptors, status, alarm descriptors, and engineering unit descriptors.
   7. Add new control units to system.
   8. Modify and set up maintenance scheduling parameters.
   9. Develop, modify, delete or display full range of color graphic displays.
   10. Automatically archive select data even when running third party software.
   11. Provide capability to sort and extract data from archived files and to generate custom reports.
   12. Support two printer operations.
      a. Alarm printer: Print alarms, operator acknowledgements, action messages, system alarms, operator sign-on and sign-off.
      b. Data printer: Print reports, page prints, and data base prints.
   13. Select daily, weekly or monthly as scheduled frequency to synchronize time and date in digital control units. Accommodate daylight savings time adjustments.
   14. Print selected control unit data base.

B. Operator System Access: Via software password with minimum 30 access levels at work station and minimum 3 access levels at each control unit.

C. Data Base Creation and Support: Changes shall utilize standard procedures. Control unit shall automatically check work station data base files upon connection and verify data base match. Minimum capability shall include:
   1. Add and delete points.
   2. Modify any point parameter.
   3. Change, add, or delete English language descriptors.
   4. Add, modify, or delete alarm limits.
   5. Add, modify, or delete points in start/stop programs, trend logs, etc.
   6. Create custom relationship between points.
   7. Create or modify DDC loops and parameters.
   8. Create or modify override parameters.
   9. Add, modify, and delete any applications program.
   10. Add, delete, develop, or modify dynamic color graphic displays.

D. Dynamic Color Graphic Displays:
   1. Utilizes custom symbols or system supported library of symbols.
   2. Sixteen (16) colors.
   3. Sixty (60) outputs of real time, live dynamic data per graphic.
   4. Dynamic graphic data.
   5. 1,000 separate graphic pages.
   6. Modify graphic screen refresh rate between 1 and 60 seconds.

E. Operator Station:
   1. Accept data from LAN as needed without scanning entire network for updated point data.
   2. Interrogate LAN for updated point data when requested.
   3. Allow operator command of devices.
   4. Allow operator to place specific control units in or out of service.
   5. Allow parameter editing of control units.
   6. Store duplicate data base for every control unit and allow down loading while system is on line.
   7. Control or modify specific programs.
   8. Develop, store and modify dynamic color graphics.
   9. Provide data archiving of assigned points and support overlay graphing of this data utilizing up to four (4) variables.

F. Alarm Processing:
   1. Off normal condition: Cause alarm and appropriate message, including time, system, point descriptor, and alarm condition. Select alarm state/value and which alarms shall cause automatic dial-out.
   2. Critical alarm or change-of-state: Display message, stored on disk for review and sort, or print.
   3. Print on line changeable message, up to 100 characters in length, for each alarm point specified.
   4. Display alarm reports on video. Display multiple alarms in order of occurrence.
   5. Define time delay for equipment start-up or shutdown.
   6. Allow unique routing of specific alarms.
   7. Operator specifies if alarm requires acknowledgement.
   8. Continue to indicate unacknowledged alarms after return to normal.
   9. Alarm notification:
      a. Automatic print.
      b. Display indicating alarm condition.

c. Selectable audible alarm indication.

G. Event Processing: Automatically initiate commands, user defined messages, take specific control actions or change control strategy and application programs resulting from event condition. Event condition may be value crossing operator defined limit, change-of-state, specified state, or alarm occurrence or return to normal.

H. Automatic Restart: Automatically restart field equipment on restoration of power. Provide time delay between individual equipment restart and time of day start/stop.

I. Messages:
1. Automatically display or print user-defined message subsequent to occurrence of selected events.
2. Compose, change, or delete any message.
3. Display or log any message at any time.
4. Assign any message to any event.

J. Reports:
1. Manually requested with time and date.
2. Long term data archiving to hard disk.
3. Automatic directives to download to transportable media such as floppy diskettes for storage.
4. Data selection methods to include data base search and manipulation.
5. Data extraction with mathematical manipulation.
6. Data reports shall allow development of XY curve plotting, tabular reports (both statistical and summary), and multi-point timed based plots with not less than four (4) variables displayed.
7. Generating reports either normally at operator direction, or automatically under work station direction.
8. Reports may either manually displayed or printed, or may be printed automatically on daily, weekly, monthly, yearly or scheduled basis.
9. Include capability for statistical data manipulation and extraction.
10. Provide capability to generate four types of reports: Statistical detail reports, summary reports, trend graphic plots, x-y graphic plots.

K. Parameter Save/Restore: Store most current operating system, parameter changes, and modifications on disk or diskette.

L. Data Collection:
1. Automatically collect and store in disk files.
2. Daily electrical energy consumption, peak demand, and time of peak demand for up to electrical meters over 2 year period.
3. Daily consumption for up to 30 meters over a 2 year period.
4. Daily billable electrical energy consumption and time for up to 1024 zones over a 10 year period.
5. Provide archiving of stored data for use with system supplied custom reports.

M. Graphic Display: Support graphic development on work station with software features:
1. Page linking.
2. Generate, store, and retrieve library symbols.
3. Single or double height characters.
4. Sixty (60) dynamic points of data per graphic page.
5. Pixel level resolution.
6. Animated graphics for discrete points.
7. Analog bar graphs.
8. Display real time value of each input or output line diagram fashion.

N. Maintenance Management:
   1. Run time monitoring, per point.
   2. Maintenance scheduling targets with automatic annunciation, scheduling and shutdown.
   3. Equipment safety targets.
   4. Display of maintenance material and estimated labor.
   5. Target point reset, per point.

O. Advisories:
   1. Summary which contains status of points in locked out condition.
   2. Continuous operational or not operational report of interrogation of system hardware and programmable control units for failure.
   3. Report of power failure detection, time and date.
   4. Report of communication failure with operator device, field interface unit, point, programmable control unit.

2.11 LOAD CONTROL PROGRAMS

A. General: Support inch-pounds and SI (metric) units of measurement.

B. Demand Limiting:
   1. Monitor total power consumption per power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.
   2. Input: Pulse count from incoming power meter connected to pulse accumulator in control unit.
   3. Forecast demand (kW): Predicted by sliding window method.
   4. Automatically shed loads throughout the demand interval selecting loads with independently adjustable on and off time of between one and 255 minutes.
   5. Demand Target: Minimum of 3 per demand meter; change targets based upon (1) time, (2) status of pre-selected points, or (3) temperature.
   6. Load: Assign load shed priority, minimum "ON" time and maximum "OFF" time.
   7. Limits: Include control band (upper and lower limits).
   8. Output advisory if loads are not available to satisfy required shed amount, advise shed requirements and requiring operator acknowledgement.

C. Duty Cycling:
   1. Periodically stop and start loads, based on space temperature, and according to various On/Off patterns.
   2. Modify off portion of cycle based on operator specified comfort parameters. Maintain total cycle time by increasing on portion of cycle by same amount that off portion is reduced.
   3. Set and modify following parameters for each individual load.
      a. Minimum and maximum Off time.
      b. On/Off time in one minute increments.
      c. Time period from beginning of interval until load can be cycled.
      d. Manually override the DCC program and place a load in an On or Off state.
      e. Cooling Target Temperature and Differential.
      f. Heating Target Temperature and Differential.
      g. Cycle off adjustment.

D. Automatic Time Scheduling:
   1. Self-contained programs for automatic start/stop/scheduling of building loads.
   2. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary day schedules.
   3. Special days schedule shall support up to 30 unique date/duration combinations.
   4. Any number of loads assigned to any time program; each load can have individual time program.

5. Each load assigned at least 16 control actions per day with 1 minute resolution.
6. Time schedule operations may be:
   a. Start.
   b. Optimized Start.
   c. Stop.
   d. Optimized Stop.
   e. Cycle.
   f. Optimized Cycle.
7. Minimum of 30 holiday periods up to 100 days in length may be specified for the year.
8. Create temporary schedules.
9. Broadcast temporary "special day" date and duration.

E. Start/Stop Time Optimization:
   1. Perform optimized start/stop as function of outside conditions, inside conditions, or both.
   2. Adaptive and self-tuning, adjusting to changing conditions unattended.
   3. For each point under control, establish and modify:
      a. Occupancy period.
      b. Desired temperature at beginning of occupancy period.
      c. Desired temperature at end of occupancy period.

F. Night Setback/Setup Program: Reduce heating space temperature setpoint or raise cooling space temperature setpoint during unoccupied hours; in conjunction with scheduled start/stop and optimum start/stop programs.

G. Calculated Points: Define calculations and totalization computed from monitored points (analog/digital points), constants, or other calculated points.
   1. Employ arithmetic, algebraic, Boolean, and special function operations.
   2. Treat calculated values like any other analog value, use for any function that a "hard wired point" might be used.

H. Event Initiated Programming: Event may be initiated by any data point, causing series of controls in a sequence.
   1. Define time interval between each control action between 0 to 3600 seconds.
   2. Output may be analog value.
   3. Provide for "skip" logic.
   4. Verify completion of one action before proceeding to next. If not verified, program shall be able to skip to next action.

I. Direct Digital Control: Each control unit shall provide Direct Digital Control software so that the operator may customize control strategies and sequences of operation by defining the appropriate control loop algorithms and choosing the optimum loop parameters.
   1. Control loops: Defined using "modules" that are analogous to standard control devices.
   2. Output: Paired or individual digital outputs for pulse-width modulation, and analog outputs, as required.
   3. Firmware:
      a. PID with analog or pulse-width modulation output.
      b. Floating control with pulse-width modulated outputs.
      c. Two-position control.
      d. Primary and secondary reset schedule selector.
      e. Hi/Lo signal selector.
      f. Single pole double throw relay.
      g. Single pole double throw time delay relay with delay before break, delay before make and interval time capabilities.
   4. Direct Digital Control loops: Downloaded upon creation or on operator request. On sensor failure, program shall execute user defined failsafe output.

5. Display: Value or state of each of the lines which interconnect DDC modules.

J. Fine Tuning Direct Digital Control PID or floating loops:
1. Display information:
   a. Control loop being tuned
   b. Input (process) variable
   c. Output (control) variable
   d. Setpoint of loop
   e. Proportional band
   f. Integral (reset) Interval
   g. Derivative (rate) Interval
2. Display format: Graphic, with automatic scaling; with input and output variable superimposed on graph of "time" vs "variable".

K. Trend logging:
1. Each control unit will store samples of control unit's data points.
2. Update file continuously at discretely assignable intervals.
3. Automatically initiate upload request and then store data on hard disk.
4. Time synchronize sampling at operator specified times and intervals with sample resolution of one minute.
5. Co-ordinate sampling with on/off state of specified point.
6. Display trend samples on work station in graphic format. Automatically scale trend graph with minimum 60 samples of data in plot of time vs data.

2.12 HVAC CONTROL PROGRAMS

A. General:
1. Support Inch-pounds and SI (metric) units of measurement.
2. Identify each HVAC Control system.

B. Optimal Run Time:
1. Control start-up and shutdown times of HVAC equipment for both heating and cooling.
2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.
3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
4. Use outside air temperature to determine early shut down with ventilation override.
5. Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.
6. Operator commands:
   a. Define term schedule
   b. Add/delete fan status point.
   c. Add/delete outside air temperature point.
   d. Add/delete mass temperature point.
   e. Define heating/cooling parameters.
   f. Define mass sensor heating/cooling parameters.
   g. Lock/unlock program.
   h. Request optimal run time control summary.
   i. Request optimal run time mass temperature summary.
   j. Request HVAC point summary.
   k. Request HVAC saving profile summary.
7. Control Summary:
   a. HVAC Control system begin/end status.
   b. Optimal run time lock/unlock control status.

c. Heating/cooling mode status.
d. Optimal run time schedule.
e. Start/Stop times.
f. Selected mass temperature point ID.
g. Optimal run time system normal start times.
h. Occupancy and vacancy times.
i. Optimal run time system heating/cooling mode parameters.

8. Mass temperature summary:
   a. Mass temperature point type and ID.
   b. Desired and current mass temperature values.
   c. Calculated warm-up/cool-down time for each mass temperature.
   d. Heating/cooling season limits.
   e. Break point temperature for cooling mode analysis.
9. HVAC point summary:
   a. Control system identifier and status.
   b. Point ID and status.
   c. Outside air temperature point ID and status.
   d. Mass temperature point ID and point.
   e. Calculated optimal start and stop times.
   f. Period start.

C. Supply Air Reset:
1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.
2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:
   a. Raising cooling temperatures to highest possible value.
   b. Reducing heating temperatures to lowest possible level.
3. Operator commands:
   a. Add/delete fan status point.
   b. Lock/unlock program.
   c. Request HVAC point summary.
   d. Add/Delete discharge controller point.
   e. Define discharge controller parameters.
   f. Add/delete air flow rate.
   g. Define space load and load parameters.
   h. Request space load summary.
4. Control summary:
   a. HVAC control system status (begin/end).
   b. Supply air reset system status.
   c. Optimal run time system status.
   d. Heating and cooling loop.
   e. High/low limits.
   f. Deadband.
   g. Response timer.
   h. Reset times.
5. Space load summary:
   a. HVAC system status.
   b. Optimal run time status.
   c. Heating/cooling loop status.
   d. Space load point ID.
   e. Current space load point value.

f. Control heat/cool limited.
g. Gain factor.
h. Calculated reset values.
i. Fan status point ID and status.
j. Control discharge temperature point ID and status.
k. Space load point ID and status.
l. Air flow rate point ID and status.

D. Enthalpy Switchover:
1. Calculate outside and return air enthalpy using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.
2. Operator commands:
a. Add/delete fan status point.
b. Add/delete outside air temperature point.
c. Add/delete discharge controller point.
d. Define discharge controller parameters.
e. Add/delete return air temperature point.
f. Add/delete outside air dew point/humidity point.
g. Add/delete return air dew point/humidity point.
h. Add/delete damper switch.
i. Add/delete minimum outside air.
j. Add/delete atmospheric pressure.
k. Add/delete heating override switch.
l. Add/delete evaporative cooling switch.
m. Add/delete air flow rate.
n. Define enthalpy deadband.
o. Lock/unlock program.
p. Request control summary.
q. Request HVAC point summary.
3. Control summary:
a. HVAC control system begin/end status.
b. Enthalpy switchover optimal system status.
c. Optimal return time system status.
d. Current outside air enthalpy.
e. Calculated mixed air enthalpy.
f. Calculated cooling cool enthalpy using outside air.
g. Calculated cooling cool enthalpy using mixed air.
h. Calculated enthalpy difference.
i. Enthalpy switchover deadband.
j. Status of damper mode switch.

2.13 PROGRAMMING APPLICATION FEATURES

A. Trend Point:
1. Sample up to 150 points, real or computed, with each point capable of collecting 100 samples at intervals specified in minutes, hours, days, or month.
2. Output trend logs as line graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique pattern, vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.

B. Alarm Messages:
1. Allow definition of minimum of 100 messages, each having minimum length of 100 characters for each individual message.

2. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totalized point's warning limit, hardware elements advisories.
3. Output assigned alarm with "message requiring acknowledgement".
4. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.

C. Weekly Scheduling:
1. Automatically initiate equipment or system commands, based on preselected time schedule for points specified.
2. Provide program times for each day of week, per point, with one minute resolution.
3. Automatically generate alarm output for points not responding to command.
4. Provide for holidays, minimum of 366 consecutive holidays.
5. Operator commands:
   a. System logs and summaries.
   b. Start of stop point.
   c. Lock or unlock control or alarm input.
   d. Add, delete, or modify analog limits and differentials.
   e. Adjust point operation position.
   f. Change point operational mode.
   g. Open or close point.
   h. Enable/disable, lock/unlock, or execute interlock sequence or computation profile.
   i. Begin or end point totalization.
   j. Modify totalization values and limits.
   k. Access or secure point.
   l. Begin or end HVAC or load control system.
   m. Modify load parameter.
   n. Modify demand limiting and duty cycle targets.
6. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.

D. Interlocking:
1. Permit events to occur, based on changing condition of one or more associated master points.
2. Binary contact, high/low limit of analog point or computed point shall be capable of being utilized as master. Same master may monitor or command multiple slaves.
3. Operator commands:
   a. Define single master/multiple master interlock process.
   b. Define logic interlock process.
   c. Lock/unlock program.
   d. Enable/disable interlock process.
   e. Execute terminate interlock process.
   f. Request interlock type summary.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.02 INSTALLATION

A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.

B. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 23 09 93.

C. Provide with 120v AC, 15 amp dedicated emergency power circuit to each programmable control unit.

D. Provide conduit and electrical wiring in accordance with Section 26 27 17. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

E. Ensure that all components necessary to execute the sequences of operation are coordinated and installed by all contractors.

F. Contractor shall demolish and remove all existing control components, including but not limited to thermostats, pneumatic tabing, compressors, panels, and devices unless otherwise noted on the drawings. Demolition shall be coordinated on phased projects to maintain the existing system where needed until complete charge-over has been accomplished.

3.03 MANUFACTURER'S FIELD SERVICES

A. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

B. Provide service engineer to instruct Owner's representative in operation of systems plant and equipment for 2 day period.

C. Provide basic operator training for 4 persons on data display, alarm and status descriptors, requesting data, execution of commands and request of logs. Include a minimum of 8 hours dedicated instructor time. Provide training on site.

3.04 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate complete and operating system to Owner.

3.05 SCHEDULES

A. Input/Output Schedule:
   1. Point Description:
   2. Digital Input:
      a. Demand Meter (kW):
      b. Auxiliary Contact:
      c. Switches:
         1) Switch Closing:
         2) Flow Switch:
         3) Optical:
      d. Current:
      e. Pressure:
   3. Digital Output:
      a. Control Relay:
      b. Solenoid:
      c. Contactor:
   4. Analog Input:
      a. Temperature:
      b. Relative Humidity:
      c. Pressure/Vacuum:
      d. Filter:
      e. Flow:
      f. Current:
      g. Liquid Level:
      h. Photocell:

5. Analog Output:
    a. Pneumatic Transducer:
    b. 4-20 ma Module:
    c. 0-16 v DC:
6. Alarm:

B. Input/Output Schedule:
1. Point Description:
2. Inputs:
    a. Temperature:
    b. Relative Humidity:
    c. Pressure:
    d. Flow:
    e. Level:
    f. Position:
    g. Energy:
    h. Power:
3. Outputs:
    a. Status:
    b. Alarm:
    c. Pneumatic Position:
    d. Electronic Position:
    e. Set Point Adjust:
    f. Start/Stop:
    g. Off/Low/High:
4. Software Features:
    a. PID Control (DDC):
    b. High Limit:
    c. Low Limit:
    d. Run Time Totalization:
    e. Consumption Totalization:
    f. Program Start/Stop:
    g. Load Shed:
    h. Duty Cycle:
    i. Enthalpy Switchover:
    j. Optimal Run Time:
    k. Supply Air Reset:
    l. O.A. Interlock:
    m. O.A. Temperature Reset:
    n. Free Cooling Mode:
    o. Warm-up Mode:
    p. Boiler Interlock:
    q. Chiller Sequencing:
    r. Energy Calculation:

C. Alarm Schedule:
1. High Limit: A1.
2. Low Limit: A2.
3. Run Time: A3.
4. Maintenance: A4.
5. Status: A5.
6. Override: A6.

7. Freeze: A7.
8. Low Pressure: A8.

END OF SECTION

SECTION 23 09 93

SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

NOTE: SEQUENCES OF OPERATION IN THIS SECTION APPLY ONLY TO THE NEWLY-INSTALLED HVAC SYSTEMS IN THE BASE SCOPE OF WORK.

THE MECHANICAL CONTRACTOR SHALL PROVIDE ALL NECESSARY LABOR MATERIALS TO MAINTAIN A FULLY FUNCTIONAL BUILDING AUTOMATION SYSTEM FOR THE PROJECT. THIS INCLUDES ALL CONTROL COMPONENTS, CONTROLLERS, WIRING, PROGRAMMING, AND COORDINATION BETWEEN TRADES TO ACCOMPLISH THE SEQUENCE OF OPERATIONS HEREIN. CONTRACTOR SHALL ENSURE THAT ALL COMPONENTS ARE COORDINATED BETWEEN EQUIPMENT SUPPLIERS AND CONTROLS VENDOR FOR ALL EQUIPMENT.

2.01 PART 1 GENERAL

2.02 SECTION INCLUDES

A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.

B. Sequence of operation for:
   1. Exhaust Fans
   2. Radiation and convectors.
   3. Packaged Rooftop Units
   4. Natatorium Environmental Control Units
   5. Ductless Split Systems
   6. Energy Recovey Ventilators

2.03 RELATED SECTIONS

A. Section 23 09 23 - Direct-Digital Control System for HVAC.

B. Section 23 09 13 - Instrumentation and Control Devices for HVAC.

C. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

2.04 SYSTEM DESCRIPTION

A. This Section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other Sections.

2.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.
   1. Preface: 1 or 2 paragraph overview narrative of the system describing its purpose, components and function.
   2. State each sequence in small segments and give each segment a unique number for referencing in Functional Test procedures; provide a complete description regardless of the completeness and clarity of the sequences specified in the contract documents.
   3. Include at least the following sequences:
      a. Start-up.
      b. Warm-up mode.
      c. Normal operating mode.
      d. Unoccupied mode.
      e. Shutdown.
      f. Capacity control sequences and equipment staging.

g. Temperature and pressure control, such as setbacks, setups, resets, etc.
h. Detailed sequences for all control strategies, such as economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
i. Effects of power or equipment failure with all standby component functions.
j. Sequences for all alarms and emergency shut downs.
k. Seasonal operational differences and recommendations.
l. Interactions and interlocks with other systems.

4. Include initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
5. For packaged controlled equipment, include manufacturer's furnished sequence of operation amplified as required to describe the relationship between the packaged controls and the control system, indicating which points are adjustable control points and which points are only monitored.
6. Include schedules, if known.

C. Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.
1. Label with settings, adjustable range of control and limits.
2. Include flow diagrams for each control system, graphically depicting control logic.
3. Include the system and component layout of all equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
4. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
5. Include all monitoring, control and virtual points specified in elsewhere.
6. Include a key to all abbreviations.

D. Points List: Submit list of all control points indicating at least the following for each point.
1. Name of controlled system.
2. Point abbreviation.
3. Point description; such as dry bulb temperature, airflow, etc.
4. Display unit.
5. Control point or setpoint (Yes / No); i.e. a point that controls equipment and can have its setpoint changed.
6. Monitoring point (Yes / No); i.e. a point that does not control or contribute to the control of equipment but is used for operation, maintenance, or performance verification.
7. Intermediate point (Yes / No); i.e. a point whose value is used to make a calculation which then controls equipment, such as space temperatures that are averaged to a virtual point to control reset.
8. Calculated point (Yes / No); i.e. a “virtual” point generated from calculations of other point values.

E. Project Record Documents: Record actual locations of components and setpoints of controls, including changes to sequences made after submission of shop drawings.

2.06 QUALITY ASSURANCE

A. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed in Delaware.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

4.01 GENERAL SYSTEM DESIGN AND OPERATION STANDARDS

A. The BAS shall control the mechanical systems within the site based upon the following design parameters:
   1. Central heating plant consisting of boilers circulators feeding a building-wide loop.
   2. Cooling provided by DX-mounted rooftop units with VAV terminal units.

B. Each unit shall be controlled by an individual DDC Controller and all required sensors, control valves, and appurtenances required to complete the sequence of operation. Units shall include occupied/unoccupied control, night-setback, morning warm-up/cool-down, and enthalpy-based economizer functions.

4.02 HYDRONIC FIN TUBE RADIATION AND CONVECTOR

A. The hydronic fin tube radiation shall be controlled by individual fully-modulating DDC-controlled control valves and individual temperature sensors mounted within the space being served. The control valves shall modulate to maintain temperature within the space (68 ºF, user adjustable).

B. The following items shall be displayed at the Operator's Terminal:
   1. Temperature Setpoint.
   2. Actual space temperature.
   3. Commanded position of control valve.

4.03 SINGLE ZONE PACKAGED ROOFTOP UNITS WITH HOT WATER HEAT AND CENTRAL ENERGY RECOVERY

A. Each unit shall be controlled by an individual DDC Controller. The DDC Controller shall be wired to a space temperature sensor, space-level CO2 sensor, discharge air temperature sensor, return air temperature sensor, space differential pressure sensor, damper motors, and the contacts to the factory-mounted unit control system controlling the compressor(s), hot-gas bypass, hot-gas reheat, and gas train combustion equipment.

B. Cooling Mode:
   1. During the programmed occupied mode, the supply fan shall run continuously with the outside air damper open to the minimum position (10% outdoor air unless otherwise shown on Schedule).
      a. The fan modulates to maintain space temperature while maintaining the discharge air setpoint (normally 55.0 deg. F - 60.0 deg. F). As the cooling load decreases, the fans will modulate down to minimum speed. As the space temperature continues to fall below the cooling setpoint by 1.0 deg. F (adj.) and remains at minimum speed for a period of time (default=10 minutes adj.) the fan will remain at minimum speed and enter into a discharge air reset mode. As the space temperature continues to drop toward the space occupied heating setpoint, the discharge air setpoint is reset between the “normal” discharge air cooling setpoint and the discharge air heating setpoint.
      b. The fan will remain at minimum speed until the space temperature exceeds the cooling setpoint +1.0 deg. F for 10 minutes (adj.). At that point it will revert to its fan modulating mode with its discharge setpoint equal to its Discharge Air Cooling setpoint.
      c. When in the occupied mode, the outdoor-air damper shall modulate to maintain the current outdoor airflow at setpoint. The BAS shall calculate and reset this outdoor airflow setpoint based on the current ventilation requirements based on field mounted CO2 sensor. The amount of outside air will be increased above the minimum setting on a rise in return air CO2 above the setpoint of 750 PPM (adjustable). On a return to

setpoint the reverse occurs. Upon a rise in CO2 level above 1500 PPM, a high CO2 level will be displayed at the BAS workstation.

d. Setpoints are adjustable at the BAS workstation. As the outdoor air damper and supply air fan adjusts, the return exhaust fan shall automatically adjust it's speed to maintain a constant static pressure within the space (0.3" WC, adjustable).

2. The DX cooling shall stage and modulate to maintain the discharge air temperature setpoint in cooling mode. If economizing is enabled the outside air damper shall also modulate to maintain the discharge air temperature setpoint.
   a. As noted in paragraph B-1-a above, if cooling or heating is required and the fan is at minimum airflow then the DAT setpoint shall be reset up or down to accommodate space requirements.
3. For units equipped with an outdoor air economizer: The DDC Controller shall receive input from the Global Enthalpy Sensor. If the enthalpy of the outdoor air is lower than the defined minimum level (user adjustable) the mixing box economizer sequence shall be activated upon a call for cooling. The outside air damper shall never close past the minimum position during the occupied period.
4. When dehuminidifcation is required as sensed by the factory-provided humidistat (setpoint, 60% RH, adjustable), the hot-gas reheat system will be engaged and follow the factory-programmed sequence.

C. Heating Mode:
1. During the programmed occupied mode, the supply fan shall run continuously with the outside air damper open to the minimum position (10% outdoor air unless otherwise shown on Schedule).
   a. The supply fan shall modulate airflow to maintain space temperature. The supply fan shall not modulate below the minimum OA ventilation rate required in the space. If cooling or heating is required and the fan is at minimum airflow then the DAT setpoint shall be reset up or down to accommodate space requirements.When the space temperature decreases to 1.0 deg. F below the heating setpoint, the fan will ramp up to 100% and the heat will be enabled. When the space temperature exceeds the heating setpoint +1.0 deg. F the heat will be disabled and the fan will ramp down to its minimum speed. Reset of the discharge air setpoint will occur every 5-10 minutes (adj.)
   b. When the space temperature rises above the occupied cooling setpoint the mode shall transition to cooling. When the space temperature falls below the occupied heating setpoint the mode shall transition to heating. When the space temperature is above the occupied cooling setpoint or below the occupied heating setpoint the mode shall remain in its last state. If the space temperature sensor fails the mode shall remain in its last state and an alarm shall be annunciated at the BAS. If the local and communicated setpoints fail the controller shall disable the supply fan and an alarm shall be annunciated at the BAS.
   c. When in the occupied mode, the outdoor-air damper shall modulate to maintain the current outdoor airflow at setpoint. The BAS shall calculate and reset this outdoor airflow setpoint based on the current ventilation requirements based on field mounted CO2 sensor. The amount of outside air will be increased above the minimum setting on a rise in return air CO2 above the setpoint of 750 PPM (adjustable). On a return to setpoint the reverse occurs. Upon a rise in CO2 level above 1500 PPM, a high CO2 level will be displayed at the BAS workstation.
   d. Setpoints are adjustable at the BAS workstation. As the outdoor air damper and supply air fan adjusts, the return exhaust fan shall automatically adjust it's speed to maintain a constant static pressure within the space (0.3" WC, adjustable).
2. The hot water control valve shall modulate to maintain the discharge air temperature setpoint as defined on the unit schedule. Temperatures shall be user-adjustable. As noted

in paragraph C-1-a above, If cooling or heating is required and the fan is at minimum airflow then the DAT setpoint shall be reset up or down to accommodate space requirements.

D. Energy Recovery Wheel Operation
   1. FOR UNITS EQUIPPED WITH AN ENERGY RECOVERY WHEEL: The AHU shall be in cooling recovery mode when the outdoor air temperature is greater than the space temperature and higher than the energy wheel enable setpoint (system economizer setpoint temperature). When the wheel is enabled, both outdoor & exhaust air bypass dampers shall be closed, outdoor air damper shall be at minimum, return air damper shall be open, and cooling shall be enabled. In cooling the recovery wheel shall be disabled when the outdoor air temperature is less than the space temperature and both outdoor & exhaust air bypass dampers shall be open.
   2. The AHU shall be in heating recovery mode when the outdoor air temperature is less than the space temperature and less than the energy wheel enable setpoint and the supply air temperature is less than the discharge air setpoint. When heat recovery is enabled the wheel shall be enabled as the first stage of heat, the outdoor air damper shall be at minimum, the outdoor & bypass recovery bypass dampers shall be open, and the unit heat shall be disabled. On a continued call for heat the second stage is enabled, the outdoor recovery bypass damper shall close, and the exhaust recovery bypass damper shall modulate to maintain the space temperature setpoint. If additional heat is required the third stage is enabled, the return air damper shall be open, both recovery bypass dampers shall be closed, and the unit heat shall be enabled.
   3. If the outdoor air temperature drops below the outdoor air frost protection setpoint (adj.), the outdoor air bypass damper shall modulate to maintain the exhaust-side leaving temperature at setpoint. If the outdoor air bypass damper reaches 100% open for 5 minutes (adj.), the wheel shall be turned off to prevent frosting and an alarm shall be annunciated.

E. Unoccupied Mode:
   1. During the programmed un-occupied mode, the supply fan, compressor, hot water control valve, and dampers for shall be cycled / modulated to maintain the un-occupied setpoints (55 degrees in Heating mode, 80 degrees in Cooling mode, both adjustable). Unless required for economizer cycle, the outside air damper shall remain closed.

F. All setpoints and shall be adjustable at the BAS workstation.

G. Provide a current sensor on one phase of power feeding each supply fan, exhaust fan, heat wheel, and compressor for status indication at the Operator's Terminal.

H. If the discharge temperature fails to rise to a programmed minimum temperature during a call for heating; a low temperature alarm shall be activated at the Operator's Terminal. If the discharge temperature fails to fall to a programmed minimum temperature on a call for mechanical cooling, a high temperature alarm shall be activated at the Operator's Terminal.

I. The following items shall be displayed at the Operator's Terminal:
   1. Space temperature.
   2. Space temperature setpoint.
   3. Space humidity.
   4. Space humidity setpoint.
   5. Low Space temperature alarm.
   6. High Space temperature alarm.
   7. Discharge air temperature.
   8. Discharge air temperature setpoint.
   9. Return air temperature.
   10. Outside air temperature, humidity and enthalpy.

11. Economizer enthalpy setpoint.
12. Space CO2 level.
13. Space CO2 level setpoint.
14. Space high CO2 level alarm: “1500 PPM”, adjustable.
15. Supply fan operational status and speed (percentage)
16. Commanded status of supply fan.
17. Exhaust fan operational status and speed (percentage)
18. Commanded status of exhaust fan.
19. Heat Wheel operational status via current sensor.
20. Commanded status of heat wheel.
21. Commanded status of compressor(s).
22. Commanded status of hot water control valve.
23. Commanded position of dampers.
24. Diagram showing the layout of the unit with major components and dynamic temperatures shown where temperature sensors exist in the system.

4.04 EXHAUST FANS FOR ELECTRICAL ROOMS AND TELEPHONE ROOMS

A. On room temperatures above 95 degrees F open intake damper and start exhaust fan.

4.05 DUCTLESS SPLIT SYSTEMS

A. The split system shall have a BAS DDC interface wired to the manufacturer factory central system controller to provide operation, configuration, and monitoring of the system. The manufacturer factory central controller shall operate in BACnet protocol, and be connected to manufacturer factory space temperature sensors as specified.

B. Sequence of operation:
   1. Cooling Mode: Cooling mode shall be selected based on outdoor air temperatures or manually enabled or scheduled from the workstation. During the programmed occupied mode, the supply fan shall run continuously. On a rise in space temperature above the setpoint (75 degrees, adjustable), the manufacturer central controller shall energize the central compressor to provide cooling. The internal capacity control valve in the evaporator unit shall modulate to control the flow of refrigerant to maintain space temperature. On a fall in space temperature the refrigerant capacity control valve shall modulate closed.
   2. Heating Mode: Heating mode shall be selected based on outdoor air temperatures or manually enabled or scheduled from the workstation. During the programmed occupied mode, the supply fan shall run continuously. On a drop in space temperature below the setpoint (68 degrees, adjustable), the manufacturer central controller shall energize the central compressor to with the requisite reversing valve to provide heating to the evaporator unit as required. The internal capacity control valve in the evaporator unit shall modulate to control the flow of refrigerant to maintain space temperature. On a fall in space temperature the refrigerant capacity control valve shall modulate closed.
   3. The following items shall be accessible and displayed at the Operator's Terminal:
      a. Space temperature setpoint at each fan-coil unit (user adjustable).
      b. Actual space temperature of each fan-coil unit space.
      c. Operational status of each fan-coil unit (heating, cooling, off, user adjustable).
      d. Factory error codes from each unit.
      e. Remote space temperature sensor override for each fan-coil unit (user adjustable to limit temperature adjustment range, heat/cool selection, fan speed).
      f. Compressor Status

C. Each terminal unit (fan coil) shall be controlled by the factory-provided wall-mounted controller. The controller shall be capable of allowing space temperature adjustment of +1 / -1 degrees (user adjustable).

D. Where multiple units serve the same zone, a factory-supplied control twinning kit will be provided to allow for a single temperature sensor to control both zones.

E. For all public corridors, restrooms, and vestibules, provide stainless-steel flat-plate type temeprature sensors with no setpoint adjustment.

4.06 ENERGY RECOVERY VENTILATORS (ERV) FOR VRF OR DUCTLESS SYSTEMS

A. Supply air units and ERV's shall be scheduled for occupied and unoccupied cycles based on an operator adjustable time schedule. Units may also be manually enabled and disabled at the operator workstation. Fan status shall be monitored by the BAS via the fans current sensing relay.

B. The fan speed shall be set by the balancer to deliver the minimum outdoor air to each associated terminal under fully-occupied conditions.

C. When any heat pump in the area served be the heat recovery unit is in the occupied mode the unit shall be energized.
   1. The unit exhaust and outside air isolation dampers shall open.
   2. Provide proof of airflow for each fan and provide fan failure alarms.
   3. Provide temperature indication of the supply and exhaust inlet and leaving air.
   4. The electric heating coil shall be energized when required to maintain a minimum discharge air (supply air) temperature of 75 degrees (user adjustable) to the space.

D. The following items shall be displayed at the operators workstation:
   1. Discharge temperature.
   2. Return air temperature.
   3. Outside air temperature, humidity and enthalpy.
   4. Commanded status of fan.
   5. Commanded status of heating coils (as applicable).
   6. Commanded position of dampers.
   7. Diagram showing the layout of the unit with major components and dynamic temperatures shown where temperature sensors exist in the system.

4.07 NATATORIUM ENVIRONMENTAL CONTROL UNIT AND ASSOCIATED EXHAUST FAN

A. All essential operating and logic controls shall be factory mounted and wired in the unit. Control sequences shall be designed specifically to control swimming pool environmental conditions.

B. Humidity Control
   1. When the humidity is above the set point the controller energizes the compressor and directs hot gas to air reheat condenser or the auxiliary air cooling condenser, if so equipped.

C. Space Heating
   1. When the compressor is running in the dehumidification mode and the space temperature is below the set point, the recovered heat is directed to the air reheat condenser. If the space temperature drops more than 2°F below the set point, the auxiliary space heating system (by others) shall be activated by a dry contact closure from the controller. A further drop in space temperature will activate the second stage of auxiliary heat (if available).

D. Space Humidity Reset Control based on Cold Surface Temperature
   1. When the temperature of the interior surface at the cold surface sensor drops to within 5ºF of the absolute humidity set point (dew point), the absolute humidity set point is offset downward. This condition causes the dehumidifier system to activate humidity control, lowering the space dew point and hindering the formation of condensate on the cold surfaces.

E. Air Conditioning
   1. Air Cooled Condenser (Remote)

a. In order to achieve space cooling of the natatorium by the rejection of reclaimed heat, the dehumidifier shall be equipped with a properly sized remote air cooled condenser and shall automatically change over from heating to air conditioning as a function of dry bulb cooling demand in the natatorium. The sensible and latent heat recovered in air conditioning mode is rejected via an air cooled condenser
b. The dehumidification unit shall include external hot gas and liquid connections to permit piping by the installing contractor to a remote air-cooled condenser provided by the unit manufacturer. The dehumidification unit's electrical panel shall have connections for the control of the condenser. The control voltage shall be 24 VAC.
c. . The condenser shall have one or the two head pressure controlled variable speed horsepower fan motor(s). The fan motor(s) shall be specifically designed for variable speed operation and have permanently lubricated ball bearings and an internal thermal overload. Fan blades shall be of the aluminum propeller blade type. Multiple fan units will be mounted on a common weatherized steel channel base and have common refrigerant and electrical connections. The fans shall be mounted on a close-mesh steel grill that has been vinyl coated for weather resistance. The condenser shall be of the vertical airflow type. The condenser fan and control wiring shall terminate in an electrical box integral with the cabinet. The condenser cabinet shall be zinc-coated steel covered with a high adhesive, baked on finish and/or corrosion resistant aluminum. The condenser coil shall be constructed of aluminum fins mechanically bonded to copper tubes. The condenser shall be shipped with a dry nitrogen holding charge.

F. Outside Air
1. The dehumidification unit casing shall include a manual locking damper with duct collar, to permit the introduction of up to 30% outside air to the inlet of the fan, downstream of the evaporator and reheat coil. Damper assembly shall be of heavy-duty construction, designed for industrial applications. The frame and opposing blades shall be fabricated of formed 16 gauge galvanized steel. The shaft shall be 1/2" plated steel hex.
2. The associated exhasut fan shall energize to maintain space pressurization.

G. Fire Trip
1. Upon receipt of a contact closure from a fire control system (by others) a fire trip cycle shall be initiated. Compressor and fan motor shall be de-energized. For units equipped with the optional economizer, the dry contact shall open causing the outside and exhaust air dampers to close and the return air damper to open. Contact action is programmable.

H. The following items shall be displayed at the Operator's Terminal:
1. Space temperature.
2. Space humidity levels
3. Space temperature setpoint.
4. Low Space temperature alarm
5. High Space temperature alarm
6. Discharge temperature.
7. Outside air temperature, humidity and enthalpy.
8. Return air temp sensor
9. Freeze stat status.
10. Smoke detector status.
11. Fan operational status via current sensor.
12. Commanded status of fan(s).
13. Commanded status of compressor(s).
14. Commanded position of hot water control valves.
15. Commanded position of mixing box dampers.

16. Diagram showing the layout of the unit with major components and dynamic temperatures shown where temperature sensors exist in the system

END OF SECTION