TABLE OF CONTENTS

INTRODUCTORY INFORMATION

PROJECT DIRECTORY
PROJECT INFORMATION
SEALS PAGE
TABLE OF CONTENTS FOR PROJECT MANUAL

BIDDING REQUIREMENTS

ADVERTISEMENT FOR PREQUALIFICATION AND BIDS
PREQUALIFICATION PROPOSAL REQUIREMENTS
BIDDER REGISTRATION FORM
SAMPLE AIA FORM A305
INSTRUCTIONS TO BIDDERS (DCM FORM C-2)
SUPPLEMENTARY INSTRUCTIONS TO BIDDERS
CERTIFICATE OF EXEMPTION FROM SALES AND USE TAX FOR GOVERNMENTAL
ENTITIES (ABC LETTER, 10/28/2013)
PROPOSAL FORM (DCM FORM C-3)
ATTACHMENT A TO PROPOSAL FORM (UNIT PRICES)
ATTACHMENT B TO PROPOSAL FORM (SUBCONTRACTOR LISTING)
ATTACHMENT C TO PROPOSAL FORM; ACCOUNTING OF SALES TAX (DCM FORM C-
3A)
DCM DIGITAL CONSTRUCTION CONTRACT INFORMATION FORM
E-VERIFY MEMORANDUM OF UNDERSTANDING
BID BOND FORM (DCM FORM C-4)

CONTRACTING REQUIREMENTS

CONSTRUCTION CONTRACT FORM (DCM FORM C-5)
PERFORMANCE BOND FORM (DCM FORM C-6)
PAYMENT BOND FORM (DCM FORM C-7)
CERTIFICATE OF STRUCTURAL OBSERVATIONS

CONDITIONS OF THE CONTRACT

GENERAL CONDITIONS OF THE CONTRACT (DCM FORM C-8)
MODIFICATIONS TO THE GENERAL CONDITIONS OF THE CONTRACT
SPECIAL PROVISIONS TO GENERAL CONDITIONS
ELECTRONIC FILE CONVERSION AND TRANSFER AGREEMENT
GENERAL CONTRACTOR'S ROOFING GUARANTEE FORM (DCM FORM C-9)
APPLICATION AND CERTIFICATE FOR PAYMENT FORM (DCM FORM C-10)
SCHEDULE OF VALUES FORM (TO ATTACH TO DCM FORM C-10)
INVENTORY OF STORED MATERIALS FORM

PROGRESS SCHEDULE AND REPORT FORM (DCM FORM C-11)
CONTRACT CHANGE ORDER FORM (DCM FORM C-12)
CHANGE ORDER JUSTIFICATION FORM (DCM FORM B-11)
FINAL PAYMENT CHECKLIST (DCM FORM B-13)
CONTRACTOR'S AFFIDAVIT OF PAYMENT OF DEBTS AND CLAIMS (DCM FORM C-18)
CONTRACTOR'S AFFIDAVIT OF RELEASE OF LIENS (DCM FORM C-19)
CONSENT OF SURETY TO FINAL PAYMENT (DCM FORM C-20)
CERTIFICATE OF SUBSTANTIAL COMPLETION FORM (DCM FORM C-13)
ADVERTISEMENT FOR COMPLETION FORM
DISCLOSURE STATEMENT FORM

DIVISION 1 -- GENERAL REQUIREMENTS

01 0150 - SPECIAL CONDITIONS
- PERMIT FEE WORKSHEET
01 1000 - SUMMARY OF THE WORK
01 2100 - ALLOWANCES
01 2200 - UNIT PRICES
01 2500 - SUBSTITUTION PROCEDURES
01 2900 - PAYMENT PROCEDURES
01 3000 - ADMINISTRATIVE REQUIREMENTS
- SUBMITTAL NUMBERING / TRACKING
- REQUEST FOR INFORMATION
- TRANSMITTAL
01 3216 - CONSTRUCTION PROGRESS SCHEDULE
01 4000 - QUALITY REQUIREMENTS
01 4100 - STRUCTURAL TESTS AND SPECIAL INSPECTIONS
- STATEMENT OF SPECIAL INSPECTIONS
- SCHEDULE OF SPECIAL INSPECTIONS
01 4950 - REFERENCE STANDARDS AND DEFINITIONS
01 4533 - CODE-REQUIRED SPECIAL INSPECTIONS
01 5000 - TEMPORARY FACILITIES AND CONTROLS
01 6000 - PRODUCT REQUIREMENTS
- SUBSTITUTION REQUEST FORM
01 7000 - EXECUTION AND CLOSEOUT REQUIREMENTS
01 7419 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL
01 7800 - CLOSEOUT SUBMITTALS

DIVISION 2 -- SITE CONSTRUCTION

02 4100 - DEMOLITION
02 4119 - SELECTIVE DEMOLITION

DIVISION 3 -- CONCRETE

09 2116 - GYPSUM BOARD ASSEMBLIES
09 3000 - TILING
09 5100 - ACOUSTICAL CEILINGS
09 6500 - RESILIENT FLOORING
09 6723 - RESINOUS FLOORING
09 6813 - TILE CARPETING
09 9100 - PAINTING
09 9310 - HARDWOOD FLOOR

DIVISION 10 -- SPECIALTIES

10 2113.19 - PLASTIC TOILET COMPARTMENTS
10 2601 - WALL AND CORNER GUARDS
10 2800 - TOILET ACCESSORIES
10 4400 - FIRE PROTECTION SPECIALTIES
107316.13 - METAL CANOPIES

DIVISION 11 -- EQUIPMENT

11 6623 - GYMNASIUM EQUIPMENT

DIVISION 12 -- FURNISHINGS

12 3200 - MANUFACTURED WOOD CASEWORK
12 3600 - COUNTERTOPS

DIVISION 13 -- SPECIAL CONSTRUCTION - NOT USED

DIVISION 14 -- CONVEYING EQUIPMENT - NOT USED

DIVISION 21 -- FIRE SUPPRESSION - NOT USED

DIVISION 22 -- PLUMBING

MECHANICAL SEAL SHEET
22 0100 - GENERAL PLUMBING REQUIREMENTS
22 0517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING
22 0518 - ESCUTCHEONS FOR PLUMBING PIPING
22 0519 - METERS AND GAGES FOR PLUMBING PIPING
22 0523.12 - BALL VALVES FOR PLUMBING PIPING
22 0523.13 - BUTTERFLY VALVES FOR PLUMBING PIPING
22 0523.14 - CHECK VALVES FOR PLUMBING PIPING
22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

22 0719 - PLUMBING PIPING INSULATION
22 0440 - PLUMBING FIXTURES
22 1116 - DOMESTIC WATER PIPING
22 1119 - DOMESTIC WATER PIPING SPECIALTIES
22 1316 - SANITARY WASTE AND VENT PIPING
22 1319 - SANITARY WASTE PIPING SPECIALTIES
22 4200 - COMMERCIAL PLUMBING FIXTURES

DIVISION 23 -- HEATING, VENTILATING, AND AIR CONDITIONING

23 0010 - GENERAL HVAC REQUIREMENTS
23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
23 0548.13 - VIBRATION CONTROLS FOR HVAC
23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC
23 0713 - DUCT INSULATION
23 0923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
23 1123 - FACILITY NATURAL-GAS PIPING
232300 - REFRIGERANT PIPING
23 3113 - METAL DUCTS
23 3300 - AIR DUCT ACCESSORIES
23 3346 - FLEXIBLE DUCTS
23 3423 - HVAC POWER VENTILATORS
23 3713.13 - AIR DIFFUSERS
23 3713.23 - REGISTERS AND GRILLES
23 3716 - FABRIC AIR-DISTRIBUTION DEVICES
23 7416.11 - PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS
23 7416.13 - PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS
238239.19 - WALL AND CEILING UNIT HEATERS

DIVISION 26 -- ELECTRICAL

ELECTRICAL SEAL SHEET
26 0000 - ELECTRICAL
26 0715 COMMUNICATIONS SYSTEM

DIVISION 28 -- ELECTRONIC SAFETY AND SECURITY - NOT USED

DIVISION 31 -- EARTHWORK

31 1000 - SITE PREPARATION
31 2000 - EARTH MOVING
31 3116 - TERMITE CONTROL

DIVISION 32 -- EXTERIOR IMPROVEMENTS

DIVISION 33 -- UTILITIES

END OF TABLE OF CONTENTS

This page intentionally left blank

SECTION 01 2100
ALLOWANCES

PART 1 GENERAL

1.01 SECTION INCLUDES

A.   Cash allowances.

B.   Contingency allowance.

1.02 CONTINGENCY ALLOWANCE

A.   Contractor's costs for products, delivery, installation, labor, insurance, payroll, taxes, bonding, equipment rental, overhead and profit will be included in Change Orders authorizing expenditure of funds from this Contingency Allowance.

B.   Funds will be drawn from the Contingency Allowance only by Change Order.

C.   At closeout of Contract, funds remaining in Contingency Allowance will be credited to Owner by Change Order.

1.03 DESCRIPTION OF REQUIREMENTS:

A.   Definitions and Explanations: Certain requirements of the work related to each allowance are shown and specified in contract documents. The allowance has been established in lieu of additional requirements for that work, and further requirements thereof (if any) will be issued by change order.

B.   Types of allowances scheduled herein for the work included the following:
1.   Unit cost allowances.
2.   Lump sum allowances.

C.   Selection and Purchase:
1.   At earliest feasible date after award of Contract, advise Architect/Engineer of scheduled date when final selection and purchase of each product or system described by each allowance must be accomplished in order to avoid delays in performance of the work.
2.   As requested by the Architect/Engineer, obtain and submit proposals for the work of each allowance for use in making final selections; include recommendations for selection which are relevant to the proper performance of the work.
3.   Purchase products and systems as specified, and as selected (in writing) by the Architect/Engineer.
4.   Submit proposals and recommendations, for purchase of products or systems of allowances, in form specified for change orders.

D.   Change Order Data: Include in each change order proposal both the quantities of products being purchased and unit costs, along with total amount of purchases to be made. Where requested, furnish survey-of-requirements data to substantiate quantities. Indicate applicable delivery charges, amounts of applicable trade discounts, and other relevant details as requested by the Architect.
1.   Each change order amount for allowances shall be based on the unit price difference between the actual purchase amount and the allowance, multiplied by the final measure or count of work-in-place, with reasonable allowances, where applicable, for cutting losses, tolerances, mixing wastes, normal product imperfections and similar margins.
2.   Include overhead and profit in the Contractor's Allowance.
3.   When requested, prepare explanations and documentation to substantiate the quantities, costs, and margins as claimed.

E.   Change Order Mark-Up:
1.   Except as otherwise indicated, comply with provisions of General Conditions. For each allowance, Contractor's claims for increased costs (for either purchase amount or

Contractor's handling, labor, installation, overhead, and profit), because of a change in scope or nature of the allowance work as described in contract documents, must be submitted within 60 days of initial change order authorizing work to proceed on that allowance; otherwise, such claims will be rejected.

2. Where it is not economically feasible to return unused material to the manufacturer/supplier for credit, prepare unused material for the Owner's storage, and deliver to the Owner's storage space as directed. Otherwise, disposal of excess material is the Contractor's responsibility.

F. Time and Allowance Amounts:
1. Nothing in the Bid or Contract Documents shall be so construed or interpreted as to provide a Contract time extension, due to use or non-use of any Allowance amount.
2. Nothing in the Bid or Contract Documents shall be so construed or interpreted as to allow unused Allowances or any portion thereof, nor any overhead and profit therefor to be retained by or paid to the Contractor.
   a. Full amount of unused allowances shall be returned to the Owner.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 SCHEDULE OF ALLOWANCES:

A. <u>**Allowance No. 1**</u> **- OWNER CONTINGENCY:**
1. Allow a lump sum allowance of $150,000.00 as an Owner Contingency Allowance.
2. Include overhead and profit in Base Bid and not part of Allowance.

B. <u>**Allowance No. 2**</u> **- BRICK MASONRY:**
1. Thin Brick: Allow a unit cost of thin brick is $1.60/ps for flat units and $1.80/ps for corner units, including purchase, delivery to the job site, and all related costs. Brick colors to be selected by Architect, after award of the Contract for construction of this project.
2. Include overhead and profit in Base Bid, and not as part of Allowance.
3. Installation of thin brick masonry and mortar installation and installation materials (grout, lathe, reinforcing, etc.) shall be included in Base Bid, and not as part of Allowance.
4. Concrete masonry units (CMU), mortar, installation, and installation materials (grout, ties, reinforcing, etc.) shall be in Base Bid, and not as part of Allowance.
5. The thin brick will be modular (7-5/8" x 2-1/4" x 5/8" depth), unless otherwise indicated, selected by Architect after bidding, with special shapes as indicated and specified.

C. <u>**Allowance No. 3**</u> **- DOOR HARDWARE:**
1. Allow a lump sum of <u>$7,500.00</u> for purchase of door hardware required beyond what is included in the drawings and specifications.
2. Includedoor hardware and installation material costs in Base Bid, and not as part of Allowance.
3. Include overhead and profit in Base Bid, and not as part of Allowance.

D. <u>**Allowance No. 4**</u> **- IT ALLOWANCE:**
1. Allow a lump sum of <u>$10,000.00</u> for Owner's IT scope beyond items shown on the drawings.
2. Include overhead and profit in Base Bid, and not as part of Allowance.

E. <u>**Allowance No. 5**</u> **- AID-TO-CONSTRUCT:**
1. Allow a lump sum of <u>$20,000.00</u> for aid-to-construct.
2. Include overhead and profit in Base Bid, and not as part of Allowance.

F. <u>**Allowance No. 6**</u> **- HAZARDOUS MATERIALS:**
1. Allow a lump sum of <u>$25,000.00</u> for removal, encapsulation, abatement, etc. of harzardous materials not outlined in the drawings or specifications.

   2.   Include overhead and profit in Base Bid, and not as part of Allowance.

G. **<u>Allowance No. 7</u> - EMERGENCY RESPONDER RADIO:**
   1.   Allow a lump sum of <u>$30,000.00</u> for work associated with the purchase and installation of an emergency responder radio covdrage system, if found to be required after testing the facilities radio covereage.
   2.   Include overhead and profit in Base Bid, and not as part of Allowance.

H. **<u>Allowance No. 8</u> - DIRECT DIGITAL CONTROL SYSTEM FOR HVAC:**
   1.   Allow a lump sum of <u>$65,600.00</u> for HVAC Automated Controls Direct Digital Control System for HVAC. Refer to specification section 230923.
   2.   Include overhead and profit in Base Bid, and not as part of Allowance.

END OF SECTION

This page intentionally left blank

SECTION 08 5400
COMPOSITE WINDOWS

PART 1 GENERAL

1.01 SECTION INCLUDES

A.   Factory fabricated composite windows with operating sash.

B.   Operating hardware.

1.02 RELATED REQUIREMENTS

A.   Section 08 8000 - Glazing.

1.03 REFERENCE STANDARDS

A.   AAMA/WDMA/CSA 101/I.S.2/A440 - North American Fenestration Standard/Specification for Windows, Doors, and Skylights; 2022, with Errata (2023).

B.   ASTM F2090 - Standard Specification for Window Fall Prevention Devices with Emergency Escape (Egress) Release Mechanisms; 2021.

1.04 SUBMITTALS

A.   See Section 01 3000 - Administrative Requirements for submittal procedures.

B.   Product Data: Provide component dimensions, anchorage and fasteners, glass, internal drainage details, and _____.

C.   Shop Drawings: Indicate opening dimensions, framed opening tolerances, affected related work, installation requirements, and _____.

D.   Test and Evaluation Reports: Submit certified label or test report on products as indicated under performance requirements to validate product compliance.

E.   Installer's Qualification Statement.

F.   Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE

1.06 DELIVERY, STORAGE, AND HANDLING

1.07 FIELD CONDITIONS

PART 2 PRODUCTS

2.01 MANUFACTURERS

A.   Composite Windows:
    1.   Andersen Windows, Inc; 100 Series Single-Hung Window:
          www.andersenwindows.com/#sle.
    2.   Marvin; https://www.marvin.com/.
    3.   Pella; https://www.pella.com/.
    4.   Substitutions: See Section 01 6000 - Product Requirements.

2.02 COMPOSITE WINDOW UNITS

A.   Composite Windows: Hollow, extruded composite material consisting of 40 percent wood fiber and 60 percent thermoplastic polymer by weight; factory fabricated; with vision glass, related flashings, anchorage and attachment devices.
    1.   Interior Color: As selected by Architect from manufacturer's standard line.
    2.   Exterior Color: As selected by Architect from manufacturer's standard line.
    3.   Frame Depth: 3-1/4 inch (83 mm), minimum.

4. Frame Joining System: Attachment system for horizontal and vertical multiple window frames in compliance with designated project requirements.
   a. Joining Strip: Kerfed and reinforced fiberglass strip, 3-11/64 inch (81 mm) wide by 1/2 inch (12.7 mm) thick for applying interior and exterior vinyl trim, end plugs, flange and gusset gasket, and galvanized steel gusset plates.
   b. Vinyl trim color to match exposed frame colors.
   c. Fasteners: Corrosion resistant screws as recommended by manufacturer for required applications.
5. Glass Stops: Same material and color as frame, sloped for wash, factory applied.

2.03 COMPONENTS

A. Mullion: ____ inch (____ mm) wide by ____ inch (____ mm) deep profile.

B. Sills: brake formed aluminum; sloped for positive wash; fit under sash to 1/2 inch (12 mm) beyond wall face; one piece full width of opening.

C. Operable Sash Weather Stripping: Polypropylene; permanently resilient, profiled to effect weather seal.

D. Fasteners: Stainless steel.

2.04 PERFORMANCE REQUIREMENTS

A. Comply with AAMA/WDMA/CSA 101/I.S.2/A440 requirements in accordance with the following:
   1. Performance Class (PC): LC.

B. Test and Evaluation Reports: Windows comply with AAMA/WDMA/CSA 101/I.S.2/A440 performance requirements as indicated by having AAMA, WDMA, or CSA certified label, or an independent test report for indicated products itemizing compliance and acceptable by authorities having jurisdiction.

2.05 GLASS AND GLAZING MATERIALS

A. Glass and Glazing Materials:
   1. Glass in Exterior Lights: Low-E, Tinted.

2.06 HARDWARE

A. Window Opening Control Devices (WOCD): Provide operable window sash hardware that limits window opening to prevent passage of 4-inch (102 mm) diameter rigid sphere and is easily releasable to allow full window opening without use of keys, tools, or special knowledge. Comply with ASTM F2090.

B. Finish For Exposed Hardware: Match window finish.

2.07 FABRICATION

A. Factory fabricate framing, mullions and sash members with rigid corners and joints. Supplement frame sections with internal reinforcement where required for structural rigidity.

B. Form sills and stools in one piece. Slope sills for wash.

C. Fabricate components with minimum clearances and shim spacing around perimeter of window assembly, and allowing for installation and dynamic movement of perimeter seal.

D. Arrange fasteners to be concealed from view.

E. Permit internal drainage weep holes and channels to migrate moisture to exterior. Provide internal drainage of glazing spaces to exterior through weep holes.

F. Factory glaze window units.

PART 3 EXECUTION

3.01 EXAMINATION

3.02 INSTALLATION

    A.   Install composite window units in accordance with manufacturer's instructions.

    B.   Attach window frame and shims to perimeter of opening to accommodate construction tolerances and other irregularities.

    C.   Align window plumb and level, free of warp or twist. Maintain dimensional tolerances and alignment with adjacent work.

3.03 TOLERANCES

3.04 ADJUSTING

    A.   Adjust hardware for smooth operation and secure weathertight closure.

3.05 CLEANING

    A.   Remove protective material from pre-finished surfaces.

    B.   Wash surfaces by method recommended and acceptable to window manufacturer; rinse and wipe surfaces clean.

<p align="center">END OF SECTION</p>

This page intentionally left blank

SECTION 11 6623
GYMNASIUM EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section includes the following gymnasium equipment:
    1. Basketball equipment, electrically operated.

B. Products furnished, but not installed under this Section, include floor insert sleeves for inserts to be cast in concrete subfloors and footings.

1.03 DEFINITIONS:

A. FIBA: International Basketball Federation (Federation Internationale de Basketball Amateur).

B. FIVB: International Volleyball Federation (Federation Internationale de Volleyball).

C. NAGWS: National Association for Girls and Women in Sport.

D. NCAA: National Collegiate Athletic Association.

E. NFHS: National Federation of State High School Associations.

F. USAV: United States of America Volleyball (formerly, USVBA: U.S. Volleyball Association).

1.04 PERFORMANCE REQUIREMENTS:

A. Seismic Performance: Provide basketball backstops capable of withstanding the effects of earthquake motions determined according to the building code in effect for this Project or ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads," whichever is more stringent.

1.05 SUBMITTALS:

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, features, and finishes. Include details of anchors, hardware, and fastenings. If applicable, include assembly, disassembly, and storage instructions.

B. Shop Drawings: Show location and extent of fully assembled gymnasium equipment. Show location and extent of disassembled equipment and components and transport and storage accessories. Include elevations, sections, and details not shown in Product Data. Show method of field assembly, connections, installation details, mountings, floor inserts, attachments to other Work, operational clearances, and relationship to adjoining work.
    1. Blocking and Reinforcement: Show locations of blocking and reinforcement required for support of gymnasium equipment.
    2. Setting Drawings: For cast-in floor insert sleeves for post standards.
    3. Design Calculations: Upon request, submit signed and sealed design calculations by a qualified professional engineer. Calculate requirements for supporting gymnasium equipment and for seismic restraint. Verify capacity of members and connections to support loads and verify loads, point reactions, and locations for attachment of gymnasium equipment to structure with those indicated on Drawings.

C. Coordination Drawings: Court layout plans and elevations drawn to scale and coordinating oversized recesses for deferred installation of floor insert sleeves, and/or floor-insert penetrations, and game lines and markers applied to finished flooring.

D. Samples for Initial Selection: For each type of gymnasium equipment indicated.

E.   Samples for Verification: For the following products:
1.   Pad Fabric: Not less than 3 inches (80 mm) square, with specified treatments applied. Mark face of material.
2.   Volleyball Floor Insert: Full size unit, which after review and acceptance, upon request, may be picked up by the Contractor for use in the project.

F.   Product Certificates: For each type of gymnasium equipment, signed by product manufacturer.

G.   Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements. Include evidence of manufacturing experience.

H.   Qualification Data: For installer and for professional engineer.

I.   Maintenance Data: For gymnasium equipment and gymnasium equipment operator to include in maintenance manuals.

1.06 QUALITY ASSURANCE:

A.   Installer Qualifications: A qualified installer employing workers trained and approved by manufacturer.
1.   Refer to Section 01 0150 - "Special Conditions", for additional information regarding minimum experience requirements.

B.   Source Limitations: Obtain each type of gymnasium equipment through one source from a single manufacturer.

C.   Standards: Provide gymnasium equipment complying with or exceeding requirements of the Alabama High School Athletic Association, and the above referenced standards.

1.07 PROJECT CONDITIONS:

A.   Environmental Limitations: Do not install gymnasium equipment until spaces are enclosed and weatherproof, wet work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

B.   Field Measurements: Verify position and elevation of floor inserts and layout for gymnasium equipment. Verify dimensions by field measurements.

1.08 COORDINATION:

A.   Coordinate installation of floor inserts with structural floors and finish flooring installation and with court layout and game lines and markers on finish flooring.

B.   Coordinate layout and installation of overhead-supported gymnasium equipment and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.09 WARRANTY:

A.   Special Warranty: Manufacturer agrees to repair or replace components of gymnasium equipment that fail in materials or workmanship within specified warranty period.
1.   Failures include, but are not limited to, the following:
a.   Basketball backboard failures including glass breakage.
b.   Faulty operation of basketball backstops.
c.   Volleyball post standards and net tensioning system.
2.   Warranty Period:
a.   Basketball equipment: 25 years from date of substantial completion.
b.   Volleyball equipment: 10 years from date of substantial completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Basketball Equipment:
    a. AALCO.
    b. AL, Inc.; ADP Lemco, Inc.
    c. Arizona Courtlines.
    d. Basketball Products International; American Athletic, Inc.
    e. Bison Inc.
    f. Draper.
    g. Garner.
    h. Institutional Products, Inc.
    i. Jaypro Sports, Inc.
    j. Performance Sports Systems, Inc.
    k. Porter Athletic Equipment Co. (Basis of Design)
    l. Spalding.

2.02 MATERIALS, GENERAL:

A. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; mill finish or decorative, baked-enamel, powder-coat finish.
1. Extruded Bars, Profiles, and Tubes: ASTM B 221 (ASTM B 221M).
2. Cast Aluminum: ASTM B 179.

B. Steel: Comply with the following:
1. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M, hot-dip galvanized.
2. Steel Pipe: Standard-weight steel pipe complying with ASTM A 53.
3. Cold-Formed Steel Tubing: ASTM A 500, Grade A, unless another grade is required by structural loads.
4. Steel Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A 513 or steel tubing fabricated from steel complying with ASTM A 569/A 569M and complying with the dimensional tolerances in ASTM A 500.
5. Malleable-Iron Castings: ASTM A 47 (ASTM A 47M 0, grade required by structural loads.
6. Support Cable: 1/4-inch- (6-mm-) diameter, 7x19 galvanized steel aircraft cable with a breaking strength of 7000 lb (3175 kg). Provide fittings complying with cable manufacturer's written recommendations for size, number, and method of installation.
7. Support Chain: Proof coil chain, complying with ASTM A 413/A 413M, Grade 30, size and diameter as required by structural loads; plated or painted. Provide fittings complying with chain manufacturer's written recommendations for size, number, and method of installation.

C. Particleboard: ANSI A208.1.

D. Wood-Based, Structural-Use Panels: Comply with DOC PS 2; for plywood, comply with DOC PS 1.

E. Equipment Mounting Pads: Wood, transparent painted finish, size, and quantity as required to mount gymnasium equipment according to manufacturer's current written recommendations.

F. Anchors, Fasteners, Fittings and Hardware: Manufacturer's standard corrosion-resistant or noncorrodible units; concealed tamperproof, vandal and theft resistant. Provide as required for gymnasium equipment assembly, mounting, and secure attachment.

G.   Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107 with minimum strength recommended in writing by gymnasium equipment manufacturer.

2.03 BASKETBALL EQUIPMENT:

A.   General: Provide equipment complying with requirements in the Alabama High School Athletic Association's and NFHS's Basketball Rule Books. Protruding fasteners or exposed bolt heads on front face of backboards are not permitted.

B.   Overhead-Supported Backstops: Complete assembly spanning height indicated on Drawings, including primary and secondary superstructure support framing to building structure, pipe and cable bracing, adjustable hangers, clamps, cables, chains, pulleys, fittings, hardware, and fasteners. Overhead backstop support shall be compatible with Folding Type listed below.
   1.   Framing: Steel pipe, tubing, and shapes. Design framing to minimize vibration during play.
      a.   Center Mast: All welded construction with side sway bracing of pipe.
      b.   Finish: Manufacturer's standard factory-applied, baked powder-coating finish complying with finish manufacturer's written instructions for surface preparation including pretreatment, application, baking, and minimum dry film thickness; black.
   2.   Folding Type: Provide manufacturer's standard assembly for front-folding backstop where indicated, with hardware and fittings to permit folding.
      a.   Porter 90950000 - FORWARD FOLD BACKSTOP - Basis of Design
   3.   Goal Height Adjuster: Adjustable from 8 to 10 feet (2.4 to 3 m) with crank mechanism, locking in any position within adjustment range, with visible height scale and finish matching framing.
   4.   Operation: Electrically operated.

C.   Backstop/Backboard Safety Device: Designed to limit free fall if support cable, support chain, pulleys, fittings, winch, or related components fail; with mechanical automatic reset; 6000-lb (2722-kg) load capacity, unless higher capacity is recommended in writing by backstop manufacturer; Provide one per folding backstop.
      a.   3/4 HP Electric Winch
         1)   Porter 712 - ELECTRIC WINCH - Basis of Design
   2.   Retractor Device: Manufacturer's standard device designed to retract both support and safety cables, chains, and straps away from play of the basketball when backstop is in playing position; Provide one per folding backstop.

D.   Basketball Backboards: Provide predrilled holes or preset inserts for mounting goals.
      a.   Control System
         1)   Porter 02555-000 Power Touch 2.5 - Basis of Design
   2.   Description: Rectangular, 72 by 42 inches (1800 by 1050 mm) width by height, fabricated from the following:
      a.   Glass: Not less than 1/2-inch- (12-mm-) thick, transparent tempered glass. Provide glass with impact-absorbing, resilient rubber or PVC gasket around perimeter in a fully welded brushed-natural-finish, heavy extruded-aluminum frame, with steel subframe, reinforcement, and bracing, including center-strut frame reinforcement, and with mounting slots for mounting backboard frame to backstop support framing.
      b.   Direct Mount: Designed for mounting backboard frame to center mast of backstop framing to maximize relief of stresses on backboard frame and glass.
   3.   Target Area and Border Markings: Permanently etched in white color, marked in pattern and stripe width according to referenced rules.
   4.   Rim-Restraining Device: Complying with NCAA and NFHS rules and designed to ensure that basket remains attached if glass backboard breaks.

E.   Goal Mounting Assembly: Compatible with goal, backboard, and support framing.

1.   Glass Backboard Goal Mounting Assembly: Goal support framing and reinforcement designed to transmit load from goal to backboard frame and to minimize stresses on glass backboard.

2.   Direct Mount: Designed for mounting goal directly and independently to center mast of backstop support framing so no force, transmitted by ring, is directly applied to backboard and rigidity and stability of goal are maximized.

F.   Basketball Goals: Complete with flanges, braces, attachment plate, and evenly spaced loops welded around underside of ring.

1.   Single-Rim Basket Ring Competition Goal: Materials, dimensions, and fabrication complying with referenced rules.

2.   Type: Movable, breakaway design with manufacturer's standard breakaway mechanism and rebound characteristics identical to those of fixed, nonmovable ring.

3.   Mount: Rear mount.

4.   Net Attachment: No-tie loops for attaching net to rim without tying.

5.   Finish: Manufacturer's standard factory-applied, electrostatic baked powder-coating finish complying with finish manufacturer's written instructions for surface preparation including pretreatment, application, baking, and minimum dry film thickness; orange.

G.   Basketball Nets: 12-loop-mesh net, between 15 and 18 inches (400 to 450 mm long), official sized to fit rim diameter, and as follows:

1.   Competition Cord: Antiwhip, made from white nylon cord not less than 120 gm nor more than 144 gm thread.

H.   For motorized goals and other electrical equipment in this Section, Manufacturer shall coordinate junction box with switch plate in field.

PART 3 - EXECUTION

3.01 EXAMINATION:

A.   Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for play court layout, alignment of mounting substrates, installation tolerances, operational clearances, and other conditions affecting performance.

1.   Verify critical dimensions.

2.   Examine supporting structure and below finished floor for subfloors and footings.

3.   Examine wall assemblies, where reinforced to receive anchors and fasteners, to verify that locations of concealed reinforcements have been clearly marked for installers. Locate reinforcements and mark locations if not already done.

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

3.02 INSTALLATION, GENERAL:

A.   General: Comply with manufacturer's current written installation instructions and competition rules indicated for each type of gymnasium equipment. Complete equipment field assembly, where required.

B.   Unless otherwise indicated, install gymnasium equipment after other finishing operations, including painting, have been completed.

C.   Permanently Placed Gymnasium Equipment and Components: Rigid, level, plumb, square, and true; anchored securely to supporting structure; positioned at locations and elevations indicated on Shop Drawings; in proper relation to adjacent construction; and aligned with court layout.

1.   Floor Insert Locations: Coordinate location with application of game lines and markers.

2.   Floor Insert Elevations: Coordinate installed heights of floor insert with installation and field finishing of finish flooring and type of floor plate.

3. Operating Gymnasium Equipment: Verify clearances for movable components of gymnasium equipment throughout entire range of operation and for access to operating components.

D. Anchoring to In-Place Construction: Use anchors and fasteners where necessary for securing built-in and permanently placed gymnasium equipment to structural support and for properly transferring load to in-place construction.

3.03 ADJUSTING:

A. Adjust movable components of gymnasium equipment to operate safely, smoothly, easily, and quietly, free from binding, warp, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Lubricate hardware and moving parts.

3.04 CLEANING AND PROTECTION:

A. After completing gymnasium equipment installation, inspect components. Remove spots, dirt, and debris and touch up damaged shop-applied finishes according to manufacturer's written instructions.

B. Provide final protection and maintain conditions acceptable to manufacturer and Installer that ensure gymnasium equipment is without damage or deterioration at time of Substantial Completion.

C. Replace gymnasium equipment and finishes that cannot be cleaned and repaired, in a manner approved by Architect, before time of Substantial Completion.

3.05 DEMONSTRATION:

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain gymnasium equipment. Refer to Division 1 Section "Project Closeout".

END OF SECTION

SECTION 23 09 23 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1   SUMMARY

   A.   Section Includes:

      1.   Direct digital control (DDC) system equipment and components for monitoring and
            controlling of HVAC, exclusive of instrumentation and control devices.

1.2   DEFINITIONS

   A.   Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of
         well-defined rules or processes for solving a problem in a finite number of steps.

   B.   Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

   C.   BACnet Specific Definitions:

      1.   BACnet: Building Automation Control Network Protocol, ASHRAE 135. A
            communications protocol allowing devices to communicate data and services over a
            network.
      2.   BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet
            functionality that is needed to perform a particular task. BIBBs are combined to build the
            BACnet functional requirements for a device.
      3.   BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet
            messages over IP networks. A BACnet/IP network is a collection of one or more IP
            subnetworks that share the same BACnet network number.
      4.   BACnet Testing Laboratories (BTL): Organization responsible for testing products for
            compliance with ASHRAE 135, operated under direction of BACnet International.

   D.   Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a
         low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used
         interchangeably with "Binary" to indicate a two-state signal.

   E.   Controller: Generic term for any standalone, microprocessor-based, digital controller residing on
         a network, used for local or global control. Three types of controllers are indicated: network
         controllers, programmable application controllers, and application-specific controllers.

   F.   Control System Integrator: An entity that assists in expansion of existing enterprise system and
         support of additional operator interfaces to I/O being added to existing enterprise system.

   G.   COV: Changes of value.

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

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

J.   E/P: Voltage to pneumatic.

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

L.   HLC: Heavy load conditions.

M.   I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

N.   I/P: Current to pneumatic.

O.   LAN: Local area network.

P.   LNS: LonWorks Network Services.

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

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

S.   Modbus TCP/IP: An open protocol for exchange of process data.

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

U.   MTBF: Mean time between failures.

V.   Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

W.   Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

X.   Peer to Peer: Networking architecture that treats all network stations as equal partners.

Y.   POT: Portable operator's terminal.

Z.   RAM: Random access memory.

AA.   RF: Radio frequency.

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

CC.   Server: Computer used to maintain system configuration, historical and programming database.

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

EE.   UPS: Uninterruptible power supply.

FF.   USB: Universal Serial Bus.

GG.   User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

HH.   VAV: Variable air volume.

II.   WLED: White light emitting diode.

1.3   PREINSTALLATION MEETINGS

A.   Preinstallation Conference: Conduct conference at Project site .

1.4   ACTION SUBMITTALS

A.   Product Data:

1.   Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2.   Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3.   Product description with complete technical data, performance curves, and product specification sheets.
4.   Installation, operation, and maintenance instructions including factors effecting performance.
5.   Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
    a.   Workstations.
    b.   Printers.
    c.   Gateways.
    d.   Routers.
    e.   Protocol analyzers.
    f.   DDC controllers.
    g.   Enclosures.
    h.   Electrical power devices.
    i.   UPS units.
    j.   Accessories.
    k.   Instruments.
    l.   Control dampers and actuators.

m.   Control valves and actuators.
6.   When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7.   Each submitted piece of product literature to clearly cross reference specification and drawings that submittal is to cover.

B.   Software Submittal:

1.   Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2.   Description and technical data of all software provided and cross-referenced to products in which software will be installed.
3.   Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4.   Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5.   Listing and description of each engineering equation used with reference source.
6.   Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7.   Description of operator interface to alphanumeric and graphic programming.
8.   Description of each network communication protocol.
9.   Description of system database, including all data included in database, database capacity, and limitations to expand database.
10.   Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden, and system throughout.
11.   Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

C.   Shop Drawings:

1.   General Requirements:
      a.   Include cover drawing with Project name, location, Owner, Architect, Contractor, and issue date with each Shop Drawings submission.
      b.   Include a drawing index sheet listing each drawing number and title that matches information in each title block.
2.   Include plans, elevations, sections, and mounting details where applicable.
3.   Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4.   Detail means of vibration isolation and show attachments to rotating equipment.
5.   Plan Drawings indicating the following:
      a.   Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
      b.   Room names and numbers with coordinated placement to avoid interference with control products indicated.
      c.   Each desktop workstation network port, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
      d.   Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.

e.   Network communication cable and raceway routing.

f.   Proposed routing of wiring, cabling, conduit, and tubing; coordinated with building services for review before installation.

6.   Schematic drawings for each controlled HVAC system indicating the following:

a.   I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.

b.   I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.

c.   A graphic showing location of control I/O in proper relationship to HVAC system.

d.   Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.

e.   Unique identification of each I/O that to be consistently used between different drawings showing same point.

f.   Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.

g.   Narrative sequence of operation.

h.   Graphic sequence of operation, showing all inputs and output logical blocks.

7.   Control panel drawings indicating the following:

a.   Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.

b.   Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.

c.   Front, rear, and side elevations and nameplate legend.

d.   Unique drawing for each panel.

8.   DDC system network riser diagram indicating the following:

a.   Each device connected to network with unique identification for each.

b.   Interconnection of each different network in DDC system.

c.   For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.

d.   Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9.   DDC system electrical power riser diagram indicating the following:

a.   Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.

b.   Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.

c.   Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.

d.   Power wiring type and size, race type, and size for each.

10.   Monitoring and control signal diagrams indicating the following:

a.   Control signal cable and wiring between controllers and I/O.

b.   Point-to-point schematic wiring diagrams for each product.

c.   Control signal tubing to sensors, switches, and transmitters.

d.   Process signal tubing to sensors, switches, and transmitters.

11.   Color graphics indicating the following:

a.   Itemized list of color graphic displays to be provided.

b.   For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.

c.   Intended operator access between related hierarchical display screens.

D.   System Description:

      1.   Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
      2.   Complete listing and description of each report, log and trend for format and timing, and events that initiate generation.
      3.   System and product operation under each potential failure condition including, but not limited to, the following:
          a.   Loss of power.
          b.   Loss of network communication signal.
          c.   Loss of controller signals to inputs and outpoints.
          d.   Operator workstation failure.
          e.   Server failure.
          f.   Gateway failure.
          g.   Network failure.
          h.   Controller failure.
          i.   Instrument failure.
          j.   Control damper and valve actuator failure.
      4.   Complete bibliography of documentation and media to be delivered to Owner.
      5.   Description of testing plans and procedures.
      6.   Description of Owner training.

E.   Samples:

      1.   Provide sample graphics screens for all controls interfaces for owner review and approval as a part of the controls equipment submittal.

F.   Sustainable Design Submittals:

      1.   <u>ENERGY STAR:</u> Product Data for indicated products, showing compliance with requirements for ENERGY STAR product labeling.
      2.   <u>Product Data:</u> For adhesives and sealants, indicating VOC content.
      3.   <u>Laboratory Test Reports:</u> For adhesives and sealants, indicating compliance with requirements for low-emitting materials.

1.5   INFORMATIONAL SUBMITTALS

A.   Qualification Statements:

      1.   Manufacturer's qualification data.
      2.   Testing agency's qualification data.

B.   Product Certificates:

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

C.   Test and Evaluation Reports:

      1.   Product Test Reports: For each product, for tests performed by manufacturer .

D.   Field Quality-Control Submittals:

    1.   Field quality-control reports.

E.   Sample warranty.

1.6   CLOSEOUT SUBMITTALS

A.   Operation and Maintenance Data: For DDC system.

    1.   In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

       a.   Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.

       b.   Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.

       c.   As-built versions of submittal Product Data.

       d.   Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.

       e.   Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.

       f.   Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

       g.   Engineering, installation, and maintenance manuals that explain how to do the following:

          1)   Design and install new points, panels, and other hardware.

          2)   Perform preventive maintenance and calibration.

          3)   Debug hardware problems.

          4)   Repair or replace hardware.

       h.   Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

       i.   Backup copy of graphic files, programs, and databases on electronic media.

       j.   List of recommended spare parts with part numbers and suppliers.

       k.   Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

       l.   Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

       m.   Licenses, guarantees, and warranty documents.

       n.   Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

       o.   Owner training materials.

1.7   QUALITY ASSURANCE

A.   DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of 10 years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least five past projects.
4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:
   a. Product research and development.
   b. Product and application engineering.
   c. Product manufacturing, testing, and quality control.
   d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
   e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within 100 miles of Project.
3. Demonstrate past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
4. Demonstrate past experience on five projects of similar complexity, scope, and value.
5. Demonstrate pas experience with Limestone County School
6. Demonstrate past experience of each person assigned to Project.
7. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
8. Service and maintenance staff assigned to support Project during warranty period.
9. Product parts inventory to support ongoing DDC system operation for a period of not less than five years after Substantial Completion.
10. DDC system manufacturer's backing to take over execution of the Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8   WARRANTY

A. Special Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Adjust, repair, or replace failures at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
   a. Install updates only after receiving Owner's written authorization.
3. Perform warranty service during normal business hours and commence within 8 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.
   a. For Gateway: Two -year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1   DDC SYSTEM MANUFACTURERS

   A.   Manufacturers: Subject to compliance with requirements, provide products by the following:

        1.   Controls for this project shall be contracted separately by the owner.

   B.   The above list does not indicate order of preference. Inclusion on this list does not guarantee acceptance of products or installation. Control systems shall comply with the terms of this specification.

   C.   The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.

   D.   All new points of monitoring and control are to be mapped back to and integrated with the existing Limestone County Schools Automated Logic BAS / DDC Front End System. Provide software, or software upgrades to accept new controllers and graphic updates as required to fully and seamlessly integrate to the Automated Logic System as required. All integration to the campus Automated Logic System shall be contracted through Automated Logic, Raymon Jolly II - (615) 250-1915.

   E.   Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

2.2   DDC SYSTEM DESCRIPTION

   A.   Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

        1.   DDC system consisting of high-speed, peer-to-peer network of distributed DDC controllers, operator interfaces, and software.

   B.   Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3   WEB ACCESS

   A.   DDC system to be web compatible.

        1.   Web-Compatible Access to DDC System:
              a.   Workstation or server to perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
              b.   DDC system to support web browser access to building data. Operator using a standard web browser is able to access control graphics and change adjustable set points.

c.   Password-protected web access.

2.4   PERFORMANCE REQUIREMENTS

A.   ASME Compliance:

1.   DDC system for monitoring and controlling of HVAC systems.

B.   Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

C.   Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths complying with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1.   Flame-Spread Index: 25 or less.
2.   Smoke-Developed Index: 50 or less.

D.   DDC System Speed:

1.   Response Time of Connected I/O:
        a.   Update AI point values connected to DDC system at least every two seconds for use by DDC controllers. Points used globally to also comply with this requirement.
        b.   Update BI point values connected to DDC system at least every two seconds for use by DDC controllers. Points used globally to also comply with this requirement.
        c.   AO points connected to DDC system to begin to respond to controller output commands within one second(s). Global commands to also comply with this requirement.
        d.   BO point values connected to DDC system to respond to controller output commands within one second(s). Global commands to also comply with this requirement.
2.   Display of Connected I/O:
        a.   Update and display analog point COV connected to DDC system at least every five seconds for use by operator.
        b.   Update and display binary point COV connected to DDC system at least every five seconds for use by operator.
        c.   Update and display alarms of analog and digital points connected to DDC system within 30 seconds of activation or change of state.
        d.   Update graphic display refresh within four seconds.
        e.   Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations to not exceed graphic refresh rate indicated.

E.   Network Bandwidth: Design each network of DDC system to include spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions. Minimum spare bandwidth as follows:

1.   Level 1 Networks: 30 .
2.   Level 2 Networks: 30 .
3.   Level 3 Networks: 20 .

F.   DDC System Data Storage:

    1.   Include capability to archive not less than 12 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends, and other information indicated.

    2.   Local Storage:
        a.   Provide server with data storage indicated. Server(s) to use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

G.   DDC Data Access:

    1.   When logged into the system, operator able to also interact with any DDC controllers connected to DDC system as required for functional operation of DDC system.

    2.   Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

H.   Future Expandability:

    1.   DDC system size is expandable to an ultimate capacity of at least 1.5 times total I/O points indicated.

    2.   Design and install system networks to achieve ultimate capacity with only addition of DDC controllers, I/O, and associated wiring and cable. Design and install initial network infrastructure to support ultimate capacity without having to remove and replace portions of network installation.

    3.   Operator interfaces installed initially do not require hardware and software additions and revisions for system when operating at ultimate capacity.

I.   Input Point Values Displayed Accuracy: Meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

    1.   Energy:
        a.   Thermal: Within 3 percent of reading.
        b.   Electric Power: Within 1 percent of reading.
        c.   Requirements indicated on Drawings for meters not supplied by utility.
    2.   Flow:
        a.   Air: Within 5 percent of design flow rate.
        b.   Air (Terminal Units): Within 5 percent of design flow rate.
        c.   Fuel Oil: Within 2 percent of design flow rate.
        d.   Natural Gas: Within 2 percent of design flow rate.
        e.   Water: Within 2 percent of design flow rate.
        f.   Steam: Within 5 percent of design flow rate.
    3.   Gas:
        a.   Carbon Dioxide: Within 50 ppm.
        b.   Carbon Monoxide: Within 5 percent of reading.
        c.   Oxygen: Within 5 percent of reading.
        d.   Refrigerant: Within 5 percent of reading.
        e.   VOCs: Within 5 percent of reading.
    4.   Moisture (Relative Humidity):

      a.   Air: Within 5 percent RH.
      b.   Space: Within 5 percent RH.
      c.   Outdoor: Within 5 percent RH.
5.   Level: Within 5 percent of reading.
6.   Pressure:
      a.   Air, Ducts and Equipment: 1 percent of instrument range .
      b.   Space: Within 1 percent of instrument range .
      c.   Water: Within 1 percent of instrument range .
      d.   Steam: Within 1 percent of instrument range .
7.   Speed: Within 10 percent of reading.
8.   Temperature, Dew Point:
      a.   Air: Within 1 deg F .
      b.   Space: Within 1 deg F .
      c.   Outdoor: Within 3 deg F .
9.   Temperature, Dry Bulb:
      a.   Air: Within 1 deg F .
      b.   Space: Within 1 deg F .
      c.   Outdoor: Within 2 deg F .
      d.   Chilled Water: Within 1 deg F .
      e.   Condenser Water: Within 1 deg F .
      f.   Heating Hot Water: Within 1 deg F .
      g.   Energy Recovery Runaround Liquid: Within 1 deg F .
      h.   Steam: Within 2 deg F .
      i.   Temperature Difference: Within 0.1 deg F .
      j.   Other Temperatures Not Indicated: Within 1 deg F .
10.   Temperature, Wet Bulb:
      a.   Air: Within 1 deg F .
      b.   Space: Within 1 deg F .
      c.   Outdoor: Within 2 deg F .
11.   Vibration: Within 5 percent of reading.

J.   Precision of I/O Reported Values: Values reported in database and displayed to have following precision:

1.   Current:
      a.   Milliamperes: Nearest 1/100th of a milliampere.
      b.   Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
2.   Energy:
      a.   Electric Power:
         1)   Rate (Watts): Nearest 1/10th of a watt through 1000 W.
         2)   Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
         3)   Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
      b.   Fuel Oil (Usage): For gallons, nearest 1/10th of a gallon up to 100 gal.; nearest gallon for above 100 gal..
      c.   Natural Gas (Usage): Nearest 1/10th of a unit (cubic feet, MCF, therm) up to 100 units; nearest unit for above 100 units.
      d.   Thermal, Rate:
         1)   Heating: For British thermal units per hour, nearest British thermal unit per hour up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For MBh, round to nearest MBh

up to 1000 MBh; nearest 10 MBh between 1000 and 10,000 MBh; nearest 100 MBh above 10,000 MBh.

    2)   Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.

  e. Thermal, Usage:

    1)   Heating: For British thermal unit, nearest British thermal unit up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For MBtu, round to nearest MBtu up to 1000 MBtu; nearest 10 MBtu between 1000 and 10,000 MBtu; nearest 100 MBtu above 10,000 MBtu.

    2)   Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons.

3.   Flow:

  a. Air: Nearest 1/10th of a cubic feet per minute through 100 cfm; nearest cubic feet per minute between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.

  b. Fuel Oil: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm

  c. Natural Gas:Nearest 1/10th of a cubic feet per hour through 100 cfh; nearest cubic feet per hour between 100 and 1000 cfh; nearest 10 cfh between 1000 and 10,000 cfh; nearest 100 cfh above 10,000 cfh.

  d. Water: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.

  e. Steam: Nearest 1/10th of a pound per hour through 100 lb/h; nearest pound per hour between 100 and 1000 lb/h; nearest 10 lb/h above 1000 lb/h.

4.   Gas:

  a. Carbon Dioxide (ppm): Nearest ppm.

  b. Carbon Monoxide (ppm): Nearest ppm.

  c. Oxygen (Percentage): Nearest 1/10th of 1 percent.

  d. Refrigerant (ppm): Nearest ppm.

  e. Volatile Organic Compounds (ppm): Nearest ppm

5.   Moisture (Relative Humidity):

  a. Relative Humidity (Percentage): Nearest 1 percent.

6.   Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.

7.   Speed:

  a. Rotation (rpm): Nearest 1 rpm.

  b. Velocity: Nearest 1/10th of feet per minute through 100 fpm; nearest feet per minute between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.

8.   Position, Dampers and Valves (Percentage Open): Nearest 1 percent.

9.   Pressure:

  a. Air, Ducts and Equipment: Nearest 1/10th of an inch water closet.

  b. Space: Nearest 1/100th of an inch water closet.

  c. Steam: Nearest 1/10th of pounds per square inch gauge through 100 psig; nearest pounds per square inch gauge above 100 psig.

  d. Water: Nearest 1/10 of a pound per square inch gauge through 100 psig; nearest pound per square inch gauge above 100 psig.

10.   Temperature:

  a. Air, Ducts and Equipment: Nearest 1/10th of a degree.

  b. Outdoor: Nearest degree.

  c. Space: Nearest 1/10th of a degree.

          d.   Chilled Water: Nearest 1/10th of a degree.
          e.   Condenser Water: Nearest 1/10th of a degree.
          f.   Heating Hot Water: Nearest degree.
          g.   Heat Recovery Runaround: Nearest 1/10th of a degree.
          h.   Steam: Nearest degree.
    11.   Vibration: Nearest 1/10th of an inch per second.
    12.   Voltage: Nearest 1/10 V up to 100 V; nearest volt above 100 V.

K.   Control Stability: Control variables indicated within the following limits:

    1.   Flow:
          a.   Air, Ducts and Equipment, except Terminal Units: Within 2 percent of design flow rate.
          b.   Air, Terminal Units: Within 5 percent of design flow rate.
          c.   Water: Within 2 percent of design flow rate.
          d.   Steam: Within 5 percent of design flow rate.
    2.   Gas:
          a.   Carbon Dioxide: Within 50 ppm.
          b.   Carbon Monoxide: Within 5 percent of reading.
          c.   Oxygen: Within 5 percent of reading.
    3.   Moisture (Relative Humidity):
          a.   Air: Within 2 percent RH.
          b.   Space: Within 2 percent RH.
          c.   Outdoor: Within 2 percent RH.
    4.   Level: Within 2 percent of reading.
    5.   Pressure:
          a.   Air, Ducts and Equipment: 1 percent of instrument range .
          b.   Space: Within 1 percent of instrument range .
          c.   Water: Within 1 percent of instrument range .
          d.   Steam: Within 1 percent of instrument range .
    6.   Temperature, Dew Point:
          a.   Air: Within 0.5 deg F .
          b.   Space: Within 0.5 deg F .
    7.   Temperature, Dry Bulb:
          a.   Air: Within 0.5 deg F .
          b.   Space: Within 0.5 deg F .
          c.   Chilled Water: Within 0.5 deg F .
          d.   Condenser Water: Within 0.5 deg F .
          e.   Heating Hot Water: Within 0.5 deg F .
          f.   Energy Recovery Runaround Liquid: Within 0.5 deg F .
          g.   .
    8.   Temperature, Wet Bulb:
          a.   Air: Within 0.5 deg F .
          b.   Space: Within 0.5 deg F .

L.   Environmental Conditions for Controllers, Gateways, and Routers:

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

2.   Protect products with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House products not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location dictates the following NEMA 250 enclosure requirements:
a.   Indoors, Heated and Air-Conditioned: Type 1 .
b.   Mechanical Equipment Rooms:
1)   Air-Moving Equipment Rooms: Type 1 .
c.   .

M.   Environmental Conditions for Instruments and Actuators:

1.   Instruments and actuators to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
a.   If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure is internally insulated, electrically heated, and ventilated as required by instrument and application.
2.   Protect instruments, actuators, and accessories with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House instruments and actuators not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location is to dictate the following NEMA 250 enclosure requirements:
a.   Indoors, Heated and Air-conditioned: Type 1 .
b.   Mechanical Equipment Rooms:
1)   Air-Moving Equipment Rooms: Type 1 .
c.   .

N.   DDC System Reliability:

1.   Design, install, and configure DDC controllers, gateways, routers, to yield a MTBF of at least 40,000 20,000 hours, based on a confidence level of at least 90 percent. MTBF value includes any failure for any reason to any part of products indicated.
2.   If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment being controlled, operational, and under automatic control.
3.   See Drawings for critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated.

O.   Electric Power Quality:

1.   Power-Line Surges:
a.   Protect DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.1 and IEEE C62.41.2.
b.   Do not use fuses for surge protection.
c.   Test protection in the normal mode and in the common mode, using the following two waveforms:
1)   10-by-1000-microsecond waveform with a peak voltage of 1500 V and a peak current of 60 A.
2)   8-by-20-microsecond waveform with a peak voltage of 1000 V and a peak current of 500 A.
2.   Power Conditioning:

       a.   Protect DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner are as follows:

          1)   At 85 percent load, output voltage to not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.

          2)   During load changes from zero to full load, output voltage to not deviate by more than 2 percent of nominal.

          3)   Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.

          4)   Total harmonic distortion to not exceed 2 percent at full load.

    3.   Ground Fault: Protect products from ground fault by providing suitable grounding. Products to not fail due to ground fault condition.

P.   Backup Power Source:

    1.   Serve DDC system products that control HVAC systems and equipment served by a backup power source also from a backup power source.

Q.   Continuity of Operation after Electric Power Interruption:

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

2.5   SYSTEM ARCHITECTURE

A.   System architecture consisting of no more than two or three levels of LANs.

    1.   Level 2 LAN: Connect network controllers and operator workstations.
    2.   Level 1 or Level 2 LAN: Connect programmable application controllers to other programmable application controllers and to network controllers.
    3.   Level 2 or Level 3 LAN: Connect application-specific controllers to programmable application controllers and to network controllers .

B.   Minimum Data Transfer and Communication Speed:

    1.   LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.
    2.   LAN Connecting Programmable Application Controllers: 1000 kbps.
    3.   LAN Connecting Application-Specific Controllers: 115,000 bps.

C.   Provide dedicated DDC system LANs that are not shared with other building systems and tenant data and communication networks.

D.   Provide modular system architecture with inherent ability to expand to not less than 1.5 times system size indicated with no impact to performance indicated.

E.   Configure architecture to eliminate or minimize need to remove and replace existing network equipment for system expansion.

F.   Make number of LANs and associated communication transparent to operator. Configure all I/O points residing on any LAN to be capable of global sharing between all system LANs.

G.   Design system to eliminate dependence on any single device for system alarm reporting and control execution. Design each controller to operate independently by performing own control, alarm management, and historical data collection.

H.   Special Network Architecture Requirements:

1.   Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling-system air-handling unit(s). Basically, create DDC system LAN that aligns with air-handling system being controlled.

2.6   DDC SYSTEM OPERATOR INTERFACES

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

1.   Desktop and portable workstation with hardwired connection through LAN port.
2.   Remote connection through web access.

B.   Make access to system, regardless of operator means used, transparent to operator.

C.   Network Ports: For hardwired connection of desktop or portable workstation. Network port easily accessible, properly protected, clearly labeled, and installed at the following locations:

1.   Each mechanical equipment room.
2.   Each outdoor on-grade yard and elevated platform with equipment connected to DDC system.
3.   Each different roof level with roof-mounted equipment connected to DDC system.
4.   Security system command center.
5.   Fire-alarm system command center.
6.   Other locations as specified by Owner.

D.   Desktop Workstations:

1.   Able to communicate with any device located on any DDC system LAN.
2.   Can reuse existing desktop station if approved by owner.

E.   Critical Alarm Reporting:

1.   Send operator-selected critical alarms to notify operator of critical alarms that require immediate attention.
2.   Send alarm notification to multiple recipients that are assigned for each alarm.
3.   Notify recipients by any or all means, including email, text message, and prerecorded phone message to mobile and landline phone numbers.

F.   Simultaneous Operator Use: Capable of accommodating up to 10 simultaneous operators that are accessing DDC system through any of operator interfaces indicated.

2.7   NETWORKS

     A.   Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:

          1.   IP.

     B.   Acceptable networks for connecting programmable application controllers include the following:

          1.   Bacnet over ARCnet.

     C.   Acceptable networks for connecting application-specific controllers include the following:

          1.   Bacnet over ARCnet.

2.8   NETWORK COMMUNICATION PROTOCOL

     A.   Use network communication protocol(s) that are open to Owner and available to other companies for use in making future modifications to DDC system.

     B.   ASHRAE 135 Protocol:

          1.   Use ASHRAE 135 communication protocol as sole and native protocol used throughout entire DDC system.
          2.   DDC system to not require use of gateways except to integrate HVAC equipment and other building systems and equipment; not required to use ASHRAE 135 communication protocol.
          3.   If used, gateways to connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
          4.   Use operator workstations, controllers, and other network devices that are tested and listed by BTL.
          5.   System shall use the BACnet protocol for communication between the control modules and web server. Communication between the web server and the user's browser shall be HTTP or HTTPS protocol utilizing HTML5. Use of Adobe Flash technology is not acceptable.

     C.   Industry Standard Protocols:

          1.   Use one industry standard protocols for network communication while complying with other DDC system requirements indicated:
               a.   ASHRAE 135 (BacNET)
          2.   Operator workstations and network controllers are to communicate through ASHRAE 135 protocol.
          3.   Provide portions of DDC system networks using ASHRAE 135 communication protocol as an open implementation of network devices complying with ASHRAE 135. Use network devices that are tested and listed by BTL.
          4.   Use gateways to connect networks and network devices with different protocols.

     D.   Additional BACNET Requirements:

      1.   BACnet Communication.

          a.   Building Controllers (BC). Each BC shall connect to a network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol using BACnet/IP or BACnet/SC.

          b.   BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.

          c.   Each AAC shall connect to a network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol using BACnet/IP or BACnet/SC.

          d.   Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

          e.   Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

          f.   Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

    E.   Security.

      1.   Provide BACnet firewall capability, as defined in the BACnet standard.

    F.   Building Controllers (BC)

      1.   Communication

          a.   Network Connection. Controller shall support a single point ethernet connection.

          b.   Ethernet Port. Provide one (1) Gig-E port capable of full duplex communication up to 1000 Mbps

          c.   Service Port. Provide one (1) ethernet port for connection to a Portable Operator's Terminal.

          d.   Serial Port. Provide two (2) serial ports for communication to serial BACnet or serial Modbus networks.

          e.   Signal Management. BC shall have the ability to manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

          f.   Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.

          g.   Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.

      2.   Environment. Controller hardware shall be suitable for anticipated ambient conditions.

          a.   Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).

          b.   Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

      3.   Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

4.   Real-time Clock. Controller shall have a real-time clock to keep track of time in the event of a power failure for up to three (3) days.

5.   Memory
   a.   Controller memory shall support operating system, database, and programming requirements.
   b.   Each BC shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

G.   Advanced Application/Specific Controllers (AAC/ASC)

1.   Communication
   a.   Network Connection. Controller shall support a single point ethernet connection or a daisy-chained ethernet connection using the Spanning Tree Protocol (STP).
   b.   Ethernet Port. Provide two (2) 10/100 Base T ethernet ports with ethernet switching capability.
   c.   Service Port. Provide one (1) USB port for connection to a Portable Operator's Terminal or a display.
   d.   Serial Port. Provide two (2) serial ports for communication to serial BACnet or serial Modbus networks.
   e.   Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.

2.   Environment. Controller hardware shall be suitable for anticipated ambient conditions.
   a.   Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
   b.   Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

3.   Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

4.   Real-time Clock. Controller shall have a real-time clock to keep track of time in the event of a power failure for up to three (3) days.

5.   Memory
   a.   Controller memory shall support operating system, database, and programming requirements.
   b.   Each AAC shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

2.9   DESKTOP WORKSTATIONS

A.   <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:

    1.   Dell Technologies Inc.
    2.   HP Inc.
    3.   Lenovo Holding Co., Inc.; Lenovo Group Ltd.

B.   Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.

C.   Location: As directed by Owner.

D.   Performance Requirements:

    1.   May dictate equipment exceeding minimum requirements indicated.
    2.   ENERGY STAR compliant.

E.   Personal Computer:

    1.   Minimum Processor Speed: 3.0 .
    2.   RAM:
        a.   Capacity: 16 GB.
        b.   Speed and Type: 1333 MHz, DDR4 .
    3.   Hard Drive:
        a.   Media: Solid state .
        b.   Number of Hard Drives: One .
        c.   Capacity: 2 Tb minimum .
    4.   Second Hard Drive:
        a.   Media: Rotating disc, nominal rotational speed of 7200 rpm .
        b.   Capacity: 3 Tb Minimum .
    5.   Optical Read and Write Drive:
        a.   Include with at least 2 MB of data buffer.
        b.   Type: Writable Bluray .
        c.   Average access time of 150 ms or less.
        d.   MTBF of at least 100,000 power-on hours.
    6.   At least four expansion slots of 64 bit.
    7.   Video Card:
        a.   Resolution: 1920 by 1200 pixels.
        b.   RAM: 8 GB .
    8.   Sound Card:
        a.   At least 128 voice wavetable synthesis.
        b.   Capable of delivering three-dimensional sound effects.
        c.   High-resolution, 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
    9.   Network Interface Card: Include card with connection, as applicable.
        a.   10-100-1000 base TX Ethernet with RJ-45 connector port.
        b.   100 base FX Ethernet with SC or ST port.

F.   Wireless Ethernet, 802.11 ac:

    1.   Optical Modem: Full duplex link for connection to optical fiber cable provided.
    2.   I/O Ports:
        a.   Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
        b.   One serial port.

   c. One parallel port.
   d. Two PS/2 ports.
   e. One RJ-45.
   f. One stereo line-in and headphone/line-out on back panel.
   g. One microphone and headphone connector on front panel.
   h. One IEEE 1394 on front and back panel with PCI-e card.
   i. One ESATA port on back panel.
  3. Battery: Life of at least three years to maintain system clock/calendar and ROM, at a minimum.

 G. Keyboard:

  1. 101 enhanced keyboard.
  2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
  3. Wireless operation within up to 72 inches in front of workstation.

 H. Pointing Device:

  1. Two- or three-button mouse.
  2. Wireless operation within up to 72 inches in front of workstation.

 I. Flat Panel Display Monitor:

  1. Display:
   a. Color display with 32" diagonal viewable area.
   b.   Digital input signal.
   c. Aspect Ratio: 16 to 9 .
   d. Antiglare display.
   e. Dynamic Contrast Ratio: 50000 to 1 .
   f. Brightness: 250 cd/sq. m .
   g. Tilt adjustable base.
   h. ENERGY STAR compliant.
   i. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
   j. Number of Displays: Two .

 J. Speakers:

  1. Two, with individual controls for volume, bass and treble.
  2. Signal to Noise Ratio: At least 65 dB.
  3. Power: At least 4 W per speaker/channel.
  4. Magnetic shielding to prevent distortion on the video monitor.

 K. I/O Cabling: Include applicable cabling to connect I/O devices.

2.10 SYSTEM SOFTWARE

 A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system capable of operating DOS and Microsoft Windows applications.
3. Database management software to manage all data on an integrated and non-redundant basis. Additions and deletions to database are to be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software to manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software to include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software to schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Make operator sign-off a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Make automatic sign-off period programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Record operator sign-on and sign-off activity and send to printer.
6. Security Access:
   a. Use password control for operator access to DDC system.
   b. Assign an alphanumeric password (field assignable) to each operator.
   c. Grant operators access to DDC system by entry of proper password.
   d. Use same operator password regardless of which computer or other operator interface means are used.
   e. Automatically update additions or changes made to passwords.
   f. Assign each operator an access level to restrict access to data and functions the operator is cable of performing.
   g. Provide software with at least five access levels.
   h. Assign each menu item an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
   i. Display menu items to operator with those capable of access highlighted. Make menu and operator access level assignments online programmable and under password control.
7. Data Segregation:
   a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
   b. Include at least 32 segregation groups.
   c. Make segregation groups selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
   d. Make points assignable to multiple segregation groups. Display and output of data to printer or monitor is to occur where there is a match of operator or peripheral segregation group assignment and point segregations.

        e.   Make alarms displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.

        f.   Assign operators and peripherals to multiple segregation groups and make all assignments online programmable and under password control.

8.   Operators able to perform commands including, but not limited to, the following:
       a.   Start or stop selected equipment.
       b.   Adjust set points.
       c.   Add, modify, and delete time programming.
       d.   Enable and disable process execution.
       e.   Lock and unlock alarm reporting for each point.
       f.   Enable and disable totalization for each point.
       g.   Enable and disable trending for each point.
       h.   Override control loop set points.
       i.   Enter temporary override schedules.
       j.   Define holiday schedules.
       k.   Change time and date.
       l.   Enter and modify analog alarm limits.
       m.   Enter and modify analog warning limits.
       n.   View limits.
       o.   Enable and disable demand limiting.
       p.   Enable and disable duty cycle.
       q.   Display logic programming for each control sequence.

9.   Reporting:
       a.   Generated automatically and manually.
       b.   Sent to displays, printers and disc files.
       c.   Types of Reporting:
            1)   General listing of points.
            2)   List points currently in alarm.
            3)   List of off-line points.
            4)   List points currently in override status.
            5)   List of disabled points.
            6)   List points currently locked out.
            7)   List of items defined in a "Follow-Up" file.
            8)   List weekly schedules.
            9)   List holiday programming.
            10)   List of limits and deadbands.
            11)   .

10.   Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C.   Graphic Interface Software:

1.   Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.

2.   Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface is to use a pointing device with pull-down or penetrating menus, color, and animation to facilitate operator understanding of system.

3.   Include at least 10 levels of graphic penetration with the hierarchy operator assignable.

4. Make descriptors for graphics, points, alarms, and such modifiable through operator's workstation under password control.
5. Make graphic displays online user definable and modifiable using the hardware and software provided.
6. Make data displayed within a graphic assignable regardless of physical hardware address, communication, or point type.
7. Make graphics online programmable and under password control.
8. Make points assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics to also contain software points.
10. Penetration within a graphic hierarchy is to display each graphic name as graphics are selected to facilitate operator understanding.
11. Provide a back-trace feature to permit operator to move upward in the hierarchy using a pointing device. Back trace to show all previous penetration levels. Include operator with option of showing each graphic full-screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Provide operator with ability to select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Display defined and linked graphic below that selection.
14. Include operator with means to directly access graphics without going through penetration path.
15. Make dynamic data assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Make colors variable for each class of points, as chosen by operator.
18. Provide dynamic points with operator adjustable update rates on a per point basis from one second to over a minute .
19. For operators with appropriate privilege, command points directly from display using pointing device.
    a. For an analog command point such as set point, display current conditions and limits so operator can position new set point using pointing device.
    b. For a digital command point such as valve position, show valve in current state such as open or closed so operator could select alternative position using pointing device.
    c. Include a keyboard equivalent for those operators with that preference.
20. Give operator ability to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot, and other information on other quadrants on screen. This feature allows real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:
    a. Online context-sensitive help utility to facilitate operator training and understanding.
    b. Bridge to further explanation of selected keywords and contain text and graphics to clarify system operation.
       1) If help feature does not have ability to bridge on keywords for more information, provide a complete set of user manuals in an indexed word-processing program, which runs concurrently with operating system software.
    c. Available for Every Menu Item:
       1) Index items for each system menu item.

22. Provide graphic generation software to allow operator ability to add, modify, or delete system graphic displays.
    a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols.
    b. Use a pointing device in conjunction with a drawing program to allow operator to perform the following:
       1) Define background screens.
       2) Define connecting lines and curves.
       3) Locate, orient, and size descriptive text.
       4) Define and display colors for all elements.
       5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
    a. Room layouts with room identification and name.
    b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
    c. Location and identification of each hardware point being controlled or monitored by DDC system.
3. Control schematic for each of following, including a graphic system schematic representation , similar to that indicated on Drawings, with point identification, set point and dynamic value indication , sequence of operation and control logic diagram.
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, .

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. At a minimum, include the following modification capability:
    a. Operator Assignment: Designation of operator passwords, access levels, point segregation, and auto sign-off.
    b. Peripheral Assignment: Assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points, and enabling and disabling of print-out of operator changes.
    c. System Configuration and Diagnostics; Communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points, and application programs and initiation of diagnostics.
    d. System Text Addition and Change: English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time, and trouble condition.

  e. Time and Schedule Change: Time and date set, time and occupancy schedules, exception and holiday schedules, and daylight-savings time schedules.

  f. Point related change capability is to include the following:

   1) System and point enable and disable.

   2) Run-time enable and disable.

   3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.

   4) Assignment of alarm and warning limits.

  g. Application program change capability is to include the following:

   1) Enable and disable of software programs.

   2) Programming changes.

   3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Provide software to allow operator ability to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Make additions and modifications online programmable using operator workstations, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, upload and record database on hard drive and disc for archived record.

5. Include high-level language programming software capability for implementation of custom DDC programs. Include a compiler, linker, and up- and down-load capability.

6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic, and relational operators for implementation of control sequences. Also include, at a minimum, the following:

  a. Proportional control (P).

  b. Proportional plus integral (PI).

  c. Proportional plus integral plus derivative (PID).

  d. Adaptive and intelligent self-learning control.

   1) Algorithm monitors loop response to output corrections and adjust loop response characteristics in accordance with time constant changes imposed.

   2) Algorithm operates in a continuous self-learning manner and retains in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.

8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.

9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.

10. Relational operators such as "Equal to," "Not Equal to," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers .

2. Include first in, first out handling of alarms in accordance with alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.

3. Make alarm handling active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.

4.   Alarms display is to include the following:
   a.   Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
   b.   "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
   c.   Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
   d.   Include extended message capability to allow assignment and printing of extended action messages. Capability is to be operator programmable and assignable on a per point basis.
5.   Direct alarms to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6.   Send email alarm messages to designated operators.
7.   Send email, page, text, and voice messages to designated operators for critical alarms.
8.   Categorize and process alarms by class.
   a.   Class 1:
      1)   Associated with fire, security, and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
      2)   Unacknowledged alarms to be placed in unacknowledged alarm buffer.
      3)   All conditions make an audible alarm sound and require individual acknowledgment to silence audible sound.
   b.   Class 2:
      1)   Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
      2)   Acknowledgement may be through a multiple alarm acknowledgment.
   c.   Class 3:
      1)   General alarms; printed, displayed, and placed in unacknowledged alarm buffer queues.
      2)   Configure so each new alarm received makes an audible alarm sound that are silenced by "acknowledging" alarm or by pressing a "silence" key.
      3)   Make acknowledgement of queued alarms either on an individual basis or through a multiple alarm acknowledgement.
      4)   Print alarms returning to normal condition without an audible alarm sound or require acknowledgment.
   d.   Class 4:
      1)   Routine maintenance or other types of warning alarms.
      2)   Alarms to be printed only, with no display, no audible sound and no acknowledgment required.
9.   Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10.   To ensure that no alarm records are lost, make it possible to assign a backup printer to accept alarms in case of failure of primary printer.

G.   Reports and Logs:

1.   Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2.   Setup each report so data content, format, interval, and date are operator definable.
3.   Sample and store report data on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation for historical reporting.
4.   Make it possible for operators to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.

5.   Store reports and logs on workstations and servers hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.

6.   Make reports and logs readily printable and set to be print either on operator command or at a specific time each day.

H.   Standard Reports: Provide standard DDC system reports with operator ability to customize reports later.

1.   All I/O: With current status and values.
2.   Alarm: All current alarms, except those in alarm lockout.
3.   Disabled I/O: All I/O points that are disabled.
4.   Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5.   Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6.   Logs:
        a.   Alarm history.
        b.   System messages.
        c.   System events.
        d.   Trends.

I.   Custom Reports: Operator able to easily define and prepare any system data into a daily, weekly, monthly, annual, or other historical report. Reports to include a title with time and date stamp.

J.   Standard Trends:

1.   Trend all I/O point present values, set points, and other parameters indicated for trending.
2.   Associate trends into groups, and setup a trend report for each group.
3.   Store trends within DDC controller and uploaded to hard drives automatically on reaching 75 percent of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4.   Preset trend intervals for each I/O point after review with Owner.
5.   Make trend intervals operator selectable from 10 seconds up to 60 minutes. Make minimum number of consecutive trend values stored at one time 100 per variable.
6.   When drive storage memory is full, overwrite oldest data with most recent data.
7.   Make archived and real-time trend data available for viewing numerically and graphically by operators.

K.   Custom Trends: Operator-definable custom trend log for any I/O point in DDC system.

1.   Include each trend with interval, start time, and stop time.
2.   Sample and store data on DDC controller, within reaching 75 percent storage limits of DDC controller, and then uploaded to archive on workstation hard drives.
3.   Make data retrievable for use in spreadsheets and standard database programs.

L.   Programming Software:

1.   Include programming software to execute sequences of operation indicated.
2.   Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3.   Programming software is to be as follows :

        a.   Graphic Based: Use a library of function blocks made from preprogrammed code designed for DDC control systems.

              1)   Assemble function blocks with interconnection lines that represent to control sequence in a flowchart.

              2)   Make programming tools viewable in real time to show present values and logical results of each function block.

    4.   Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

M.   Database Management Software:

    1.   Where a separate SQL database is used for information storage, include database management software that separates database monitoring and managing functions by supporting multiple separate windows.

    2.   Secure database access using standard SQL authentication including ability to access data for use outside of DDC system applications.

    3.   Include database management function summarizing information on trend, alarm, event, and audit for the following database management actions:

        a.   Backup.

        b.   Purge.

        c.   Restore.

    4.   Database management software supporting the following:

        a.   Statistics: Display database server information and trend, alarm, event, and audit information on database.

        b.   Maintenance: Include method of purging records from trend, alarm, event, and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.

        c.   Backup: Include means to create a database backup file and select a storage location.

        d.   Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.

    5.   Information of current database activity, including the following:

        a.   Ready.

        b.   Purging record from a database.

        c.   Action failed.

        d.   Refreshing statistics.

        e.   Restoring database.

        f.   Shrinking a database.

        g.   Backing up a database.

        h.   Resetting Internet information services.

        i.   Starting network device manager.

        j.   Shutting down the network device manager.

        k.   Action successful.

    6.   Database management software monitoring functions is to continuously read database information once operator has logged on.

    7.   Include operator notification through on-screen pop-up display and email message when database value has exceeded a warning or alarm limit.

    8.   Monitoring settings window with the following Sections:

        a.   Allow operator to set and review scan intervals and start times.

        b.   Email: Allow operator to create and review email and phone text messages to be delivered when a warning or an alarm is generated.

     c.   Warning: Allow operator to define warning limit parameters, set reminder frequency, and link email message.

     d.   Alarm: Allow operator to define alarm limit parameters, set reminder frequency, and link email message.

     e.   Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event, and audit databases as well as operator proper security access to restore a database.

9.   Monitoring settings taskbar with following informational icons:

     a.   Normal: Indicates by color and size, or other easily identifiable means, that all databases are within their limits.

     b.   Warning: Indicates by color and size, or other easily identifiable means, that one or more databases have exceeded their warning limit.

     c.   Alarm: Indicates by color and size, or other easily identifiable means, that one or more databases have exceeded their alarm limit.

N.   Additional software requirements:

1.   The BMS system shall allow an unlimited number of concurrent users.

2.   The BMS manufacturer shall provide all software and tools necessary to provide the following capabilities:

     a.   Create and/or edit any programming used in controllers

     b.   Create and/or edit any graphics used in the system

     c.   Software shall not be subscription based and be given to owner at time of turnover. If software is subscription based, manufacturer shall include 10 years of subscription service.

     d.   The owner shall have the ability to install software on a minimum of five (5) additional owner furnished computers without additional licenses or fees.

3.   System Graphics. The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

     a.   Minimum graphics resolution shall be 1920 x 1080 for display of detailed system graphics.

     b.   Floor Plan Graphics. Floor plan graphics shall be capable of allowing the floor plan graphic to dynamically size relative to the end user's monitor resolution.

     c.   Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.

     d.   Animation. Graphics shall be able to animate by displaying different image files for changed object status.

     e.   Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.

     f.   Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, GIF, or SVG. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in or shall only require widely available no-cost plug-ins.

4.   Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system used to create and modify graphics that are saved in the same formats as are used for system graphics.

5. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

O. System Applications. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on a standard PC type personal computer with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.

2. Manual Controller Memory Download. Operators shall be able to download memory from the system database to each controller.

3. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password.

4. Logic Page. System shall allow operator to view all application software in real time for all controllers furnished and installed by BMS manufacturer.

5. Environmental Index. System shall monitor all occupied zones and compile an index that provides a numerical indication of the environmental comfort within the zone. As a minimum, this indication shall be based upon the deviation of the zone temperature from the heating or cooling setpoint. If humidity is being measured within the zone then the environmental index shall be adjusted to reflect a lower comfort level for high or low humidity levels. Similarly, if carbon dioxide levels are being measured as an indication of ventilation effectiveness then the environmental index shall be adjusted to indicate degraded comfort at high carbon dioxide levels. Other adjustments may be made to the environmental index based upon additional measurements. The system shall maintain a trend of the environmental index for each zone in the trend log. The system shall also compute an average comfort index for every building included in this contract and maintain trendlogs of these building environmental indices. Similarly, the system shall compute the percentage of occupied time that comfortable conditions were maintained within the zones. Through the UI the user shall be able to add a weighting factor to adjust the contribution of each zone to the average index based upon the floor area of the zone, importance of the zone, or other static criteria.

6. Time Span Graphic Replay. Operator shall be able to "replay" any graphic in the system to see how key values changed over an operator-selected period of time. Operator shall be able to select the starting date/time for this display and the end date/time or the display period. System shall then display the graphic as it would have looked at the beginning of that period, displaying key data, dynamic colors, etc. based upon values recorded at the start time. When the operator starts the replay the graphics and key values shall dynamically change to produce the effect of "fast forwarding" through the designated period of time. Once the system has been operational for at least 30 days, the contractor shall demonstrate that up to 24 hours of data from within the last 30 days can be replayed on any graphic page. Owner's representative shall choose the graphic pages for this demonstration at the time of the demonstration.

7. Semantic Tagging. The BMS system shall include a semantic tagging engine that uses the Project Haystack library of descriptive tagging for building equipment and systems

used in the BMS. The Project Haystack naming tags used by the BMS shall be a library that includes a comprehensive list of standard tag names to address common equipment, building systems, and device types. The library of tag names shall include at a minimum the tag names listed in ASHRAE Standard 223P.

8. VAV Auto-Commissioning. The BMS system shall provide an auto-commissioning tool to commission single duct, dual duct, parallel and series flow fan powered VAV terminal units with or without hot water reheat.

    a. This tool shall be available for use during the construction phase of the project.
    b. The auto-commissioning tool shall run a set of functional tests to automatically exercise dampers and reheat valves in the VAV system.
    c. The user shall be able to schedule when the functional testing of a VAV system is to be done.
    d. The auto-commissioning tool shall be capable of detecting the following faults:
        1) Obstruction
        2) Over-Stroking
        3) Under Stroking
        4) Leakage
        5) Stuck
        6) Sensor Issue
        7) Reverse Stroking
        8) AHU Pressure Error
        9) Data Inconsistent
        10) Actuation Range Insufficient
        11) Data Insufficient
        12) Data Unavailable
        13) Expert Diagnosis Required
        14) Maximum Airflow Error
        15) Minimum Airflow Error
    e. The tool shall be capable of exporting an excel file or printing a file in PDF format that provides a detailed report.
    f. A baseline commissioning report shall be provided for all VAV systems at the completion of the project.

9. Weather Data. The BMS system shall retrieve current weather conditions from a data source such as AccuWeather. This weather information shall be displayed on a graphic page and be capable for use in control logic.

10. Open ADR (add-on). Open Automated Demand Response interface shall be provided that allows electricity providers to communicate DR signals directly to the BMS. Software shall fully support the OpenADR 2.0a and 2.0b and does not require any additional specialized hardware.

11. Trend Export (add-on). The BMS shall allow user to specify, manage, and export trend source data to a .CSV file. User can export the files on-demand at any time or at scheduled intervals allowing user to process or analyze trend data outside of the building automation system. Up to two years of trend data can be exported.

12. Fault Detection and Diagnostics (FDD). The system shall follow NIST and ASHRAE standards for enhanced monitoring and alarming. The FDD shall reside in the controller and be integral to the programming. Overlay software for primary FDD reporting is not acceptable. FDD capabilities shall include diagnostics for: Simultaneous Heating and Cooling; Continuous Operation; Fraction of Outdoor Air; Analog Output Cycling; Discrete Output Cycling; Sensor Failures; and Run Requests Analytics. These FDD alarms must be fully programmed, configured and active within the system. It is not acceptable for the system to have simply have the capability for FDD alarming, the alarming must be fully functional. The alarms shall be categorized and displayed on the BMS system. The FDD alarms shall categorized into one of the following four categories:

       a.   FDD Comfort
       b.   FDD Critical
       c.   FDD Energy
       d.   FDD Maintenance

2.11   ASHRAE 135 GATEWAYS

A.   Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.

B.   Include gateways to connect BACnet to legacy systems where indicated, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment.

C.   Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D.   Gateway Minimum Requirements:

    1.   Read and view all readable object properties on non-BACnet network to BACnet network, and vice versa, where applicable.
    2.   Write to all writable object properties on non-BACnet network from BACnet network, and vice versa, where applicable.
    3.   Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet, and vice versa.
    4.   Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs in accordance with ASHRAE 135.
    5.   Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
    6.   Backup programming and parameters on CD media with ability to modify, download, backup, and restore gateway configuration.

2.12   DDC CONTROLLERS

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

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

C.   DDC controllers are to use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

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

E.   Environment Requirements:

1. Controller hardware suitable for anticipated ambient conditions.
2. Controllers located in conditioned space rated for operation at 32 to 120 deg F .
3. Controllers located outdoors rated for operation at 40 to 150 deg F .

F. Power and Noise Immunity:

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

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
   a. Network Controllers: 50 percent.
   b. Programmable Application Controllers: Not less than 60 percent.
   c. Application-Specific Controllers: Not less than 70 percent.
2. Memory for DDC controller's operating system and database are to include the following:
   a. Monitoring and control.
   b. Energy management, operation, and optimization applications.
   c. Alarm management.
   d. Historical trend data of all connected I/O points.
   e. Maintenance applications.
   f. Operator interfaces.
   g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:
   a. 20 percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: Two .
      2) AOs: Two .
      3) BIs: Three .
      4) BOs: Three .
      5) Option to provide universal I/O to meet spare requirements.
2. Programmable Application Controllers:
   a. 20 percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: Two .
      2) AOs: Two .
      3) BIs: Three .
      4) BOs: Three .
      5) Option to provide universal I/O to meet spare requirements.
3. Application-Specific Controllers:
   a. 10 percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: One .
      2) AOs: One .
      3) BIs: One .
      4) BOs: One .

I.   Maintenance and Support: Include the following features to facilitate maintenance and support:

    1.   Mount microprocessor components on circuit cards for ease of removal and replacement.
    2.   Means to quickly and easily disconnect controller from network.
    3.   Means to quickly and easily access connect to field test equipment.
    4.   Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J.   I/O Point Interface:

    1.   Connect hardwired I/O points to network, programmable application, and application-specific controllers.
    2.   Protect I/O points so shorting of point to itself, to another point, or to ground will not damage controller.
    3.   Protect I/O points from voltage up to 24 V of any duration so that contact will not damage controller.
    4.   AIs:
        a.   Include monitoring of low-voltage (0 to 10 V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
        b.   Compatible with, and field configurable to, sensor and transmitters installed.
        c.   Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
        d.   Signal conditioning including transient rejection for each AI.
        e.   Capable of being individually calibrated for zero and span.
        f.   Incorporate common-mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
        g.   External conversion resistors are not permitted.
    5.   AOs:
        a.   Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
        b.   Output signals range of 4 to 20 mA dc or 0 to 10 V dc as required to include proper control of output device.
        c.   Capable of being individually calibrated for zero and span.
        d.   Drift is to be not greater than 0.4 percent of range per year.
        e.   External conversion resistors are not permitted.
    6.   BIs:
        a.   Accept contact closures and ignore transients of less than 5 ms duration.
        b.   Isolate and protect against an applied steady-state voltage of up to 180 V ac peak.
        c.   Include a wetting current of at least 12 mA to be compatible with commonly available control devices and protected against effects of contact bounce and noise.
        d.   Sense "dry contact" closure without external power (other than that provided by controller) being applied.
        e.   Pulse accumulation input points complying with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Include buffer to totalize pulses. Pulse accumulator is to accept rates of at least 20 pulses per second. Reset the totalized value to zero on operator's command.
    7.   BOs:
        a.   Include relay contact closures or triac outputs for momentary and maintained operation of output devices.
            1)   Relay contact closures to have a minimum duration of 0.1 second and at least 180 V of isolation.

         2)   Include electromagnetic interference suppression on all output lines to limit transients to non-damaging levels.

         3)   Minimum contact rating to be 1 A at 24 V ac.

         4)   Triac outputs to have at least 180 V of isolation and minimum contact rating of 1 A at 24 V ac.

    b.   Include BOs with two-state operation or a pulsed low-voltage signal for pulse-width modulation control.

    c.   BOs to be selectable for either normally open or normally closed operation.

    d.   Include tristate outputs (two coordinated BOs) for control of three-point, floating-type electronic actuators without feedback.

    e.   Limit use of three-point floating devices to VAV terminal unit control applications . Control algorithms to operate actuator to one end of its stroke once every 12 hours for verification of operator tracking.

2.13   NETWORK CONTROLLERS

  A.   General:

    1.   Include adequate number of controllers to achieve performance indicated.

    2.   Provide one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.

    3.   Include enough memory to support its operating system, database, and programming requirements with spare memory indicated.

    4.   Share data between networked controllers and other network devices.

    5.   Operating system of controller to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.

    6.   Include network controllers with a real-time clock.

    7.   Controller to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller is to assume a predetermined failure mode and generate an alarm notification.

    8.   Make controllers fully programmable.

  B.   Communication:

    1.   Network controllers communicate with other devices on DDC system Level 1 network.

    2.   Network controller to also perform routing if connected to network of programmable application controllers and application-specific controllers.

  C.   Operator Interface:

    1.   Equip controllers with a service communications port for connection to desktop operator's workstation .

    2.   Local Keypad and Display:
        a.   Equip controller with local keypad and digital display for interrogating and editing data.
        b.   Use of keypad and display requires a security password.

  D.   Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain Basic Input Output System (BIOS) and programming information in event of power loss for at least 72 hours.

2.14   PROGRAMMABLE APPLICATION CONTROLLERS

A.   General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide enough memory to support its operating system, database, and programming requirements with spare memory indicated.
3. Share data between networked controllers and other network devices.
4. Include controller with operating system to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Include controllers with a real-time clock.
6. Controller is to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller assumes a predetermined failure mode and generates an alarm notification.
7. Fully programmable.

B.   Communication:

1. Programmable application controllers are to communicate with other devices on network.

C.   Operator Interface:

1. Equip controllers with a service communications port for connection to desktop operator's workstation .
2. Local Keypad and Display:
   a.   Equip controller with local keypad and digital display for interrogating and editing data.
   b.   Protect use of keypad and display by security password.

D.   Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain BIOS and programming information in event of power loss for at least 72 hours.

2.15   APPLICATION-SPECIFIC CONTROLLERS

A.   Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment or system. Controllers are not fully user-

programmable but are configurable and customizable for operation of equipment they are designed to control.

    1.   Capable of standalone operation and continued control functions without being connected to network.

    2.   Share data between networked controllers and other network devices.

B.   Communication: Application-specific controllers are to communicate with other application-specific controllers and devices on network, and to programmable application controllers and network controllers.

C.   Operator Interface: Equip controllers with a service communications port for connection to desktop workstation .

D.   Serviceability:

    1.   Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.

    2.   Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

    3.   Use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.16   CONTROLLER SOFTWARE

A.   General:

    1.   Software applications are to reside and operate in controllers. Edit applications through operator workstations.

    2.   Identify I/O points by up to 30 -character point name and up to 16 -character point descriptor. Use same names throughout, including at operator workstations.

    3.   Execute control functions within controllers using DDC algorithms.

    4.   Configure controllers to use stored default values to ensure fail-safe operation. Use default values when there is a failure of a connected input instrument or loss of communication of a global point value.

B.   Security:

    1.   Secure operator access using individual security passwords and user names.

    2.   Passwords restrict operator to points, applications, and system functions as assigned by system manager.

    3.   Record operator log-on and log-off attempts.

    4.   Protect from unauthorized use by automatically logging off after last keystroke. Make the delay time operator-definable.

C.   Scheduling: Include capability to schedule each point or group of points in system. Each schedule is to consist of the following:

    1.   Weekly Schedule:
        a.   Include separate schedules for each day of week.

       b.   Each schedule should include capability for start, stop, optimal start, optimal stop, and night economizer.

       c.   Each schedule may consist of up to 10 events.

       d.   When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

    2.   Exception Schedules:

       a.   Include ability for operator to designate any day of the year as an exception schedule.

       b.   Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

    3.   Holiday Schedules:

       a.   Include capability for operator to define up to 99 special or holiday schedules.

       b.   Place schedules on scheduling calendar with ability to repeated each year.

       c.   Operator able to define length of each holiday period.

   D.   System Coordination:

    1.   Include standard application for proper coordination of equipment.

    2.   Include operator with a method of grouping together equipment based on function and location.

    3.   Include groups that may be for use in scheduling and other applications.

   E.   Binary Alarms:

    1.   Set each binary point to alarm based on operator-specified state.

    2.   Include capability to automatically and manually disable alarming.

   F.   Analog Alarms:

    1.   Provide each analog object with both high and low alarm limits.

    2.   Include capability to automatically and manually disable alarming.

   G.   Alarm Reporting:

    1.   Include ability for operators to determine action to be taken in event of an alarm.

    2.   Route alarms to appropriate operator workstations based on time and other conditions.

    3.   Include ability for alarms to start programs, print, be logged in event logs, generate custom messages, and display graphics.

   H.   Remote Communication:

    1.   Include ability for system to notify operators by phone message, text message, and email in event of an alarm.

   I.   Electric Power Demand Limiting:

    1.   Monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.

    2.   Predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand

limit will not be exceeded, action will be taken to restore loads in a predetermined manner.

3.   Accomplish demand reduction by the following means:
    a.   Reset air-handling-unit supply temperature set points.
    b.   Reset space temperature set points.
    c.   De-energize equipment based on priority.

4.   Base demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables on the means by which electric power service provider computes demand charges.

5.   Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.

6.   Include means operator to make the following changes online:
    a.   Addition and deletion of loads controlled.
    b.   Changes in demand intervals.
    c.   Changes in demand limit for meter(s).
    d.   Maximum shutoff time for equipment.
    e.   Minimum shutoff time for equipment.
    f.   Select rotational or sequential shedding and restoring.
    g.   Shed and restore priority.

7.   Include the following information and reports, to be available on an hourly, daily, weekly, monthly, and annual basis:
    a.   Total electric consumption.
    b.   Peak demand.
    c.   Date and time of peak demand.
    d.   Daily peak demand.

J.   Maintenance Management: Monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

K.   Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

L.   Control Loops:

1.   Support any of the following control loops, as applicable to control required:
    a.   Two-position (on/off, open/close, slow/fast) control.
    b.   Proportional control.
    c.   Proportional plus integral (PI) control.
    d.   Proportional plus integral plus derivative (PID) control.
        1)   Include PID algorithms with direct or reverse action and anti-windup.
        2)   Algorithm to calculate a time-varying analog value used to position an output or stage a series of outputs.
        3)   Make controlled variable, set point, and PID gains operator-selectable.
    e.   Adaptive (automatic tuning).

M.   Staggered Start: Prevent all controlled equipment from simultaneously restarting after a power outage. Make the order which equipment (or groups of equipment) is started, along with the time delay between starts, operator-selectable.

N.   Energy Calculations:

    1.   Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.

    2.   Include algorithm that calculates a sliding-window average (rolling average). Make algorithm flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).

    3.   Include algorithm that calculates a fixed-window average. Use a digital input signal to define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

  O.   Anti-Short Cycling:

    1.   Protect BO points from short cycling.
    2.   Feature to allow minimum on-time and off-time to be selected.

  P.   On and Off Control with Differential:

    1.   Include algorithm that allows BO to be cycled based on a controlled variable and set point.
    2.   Use direct- or reverse-acting algorithm and incorporate an adjustable differential.

  Q.   Run-Time Totalization:

    1.   Include software to totalize run-times for all BI and BO points.
    2.   Assign a high run-time alarm, if required, by operator.

2.17   ENCLOSURES

  A.   General:

    1.   House each controller and associated control accessories in enclosure. Enclosure is to serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies, and transformers.
    2.   Do not house more than one controller in single enclosure.
    3.   Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
    4.   Individual, wall-mounted, single-door enclosures maximum of 36 inches wide and 60 inches high.
    5.   Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
    6.   Supply each enclosure with complete set of as-built schematics, tubing, and wiring diagrams and product literature located in pocket on inside of door.

  B.   Internal Arrangement:

    1.   Arrange internal layout of enclosure to group and protect electric, and electronic components associated with controller, but not an integral part of controller.
    2.   Arrange layout to group similar products together.
    3.   Include a barrier between line-voltage and low-voltage electrical and electronic products.
    4.   Factory or shop install products, tubing, cabling, and wiring complying with requirements and standards indicated.
    5.   Terminate field cable and wire using heavy-duty terminal blocks.

6.   Include spare terminals, equal to not less than 10 percent of used terminals.
7.   Include spade lugs for stranded cable and wire.
8.   Install maximum of two wires on each side of terminal.
9.   Include enclosure field electric power supply with toggle-type switch located at entrance inside enclosure to disconnect power.
10.   Include enclosure with line-voltage nominal 20 A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with 5 A circuit breaker.
11.   Mount products within enclosure on removable internal panel(s).
12.   Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). Nameplates are to have at least 1/4-inch- high lettering.
13.   Route tubing cable and wire located inside enclosure within a raceway with continuous removable cover.
14.   Label each end of cable, wire, and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15.   Size enclosure internal panel to include at least 15 percent spare area on face of panel.

C.   Environmental Requirements:

1.   Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2.   Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction, and wind) on enclosure.
3.   Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4.   Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5.   Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6.   Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D.   Wall-Mounted, NEMA 250, Type 1:

1.   <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:
       a.   Cooper B-line; brand of Eaton, Electrical Sector.
       b.   Hammond Mfg. Co. Inc.
       c.   Hoffman; brand of nVent Electrical plc.
       d.   Saginaw Control and Engineering.
2.   NRTL listed in accordance with UL 50 or UL 50E.
3.   Construct enclosure of steel, not less than the following:
       a.   Enclosure Size Less Than 24 Inches: 0.053 inch thick.
       b.   Enclosure Size 24 Inches and Larger: 0.067 inch thick.
4.   Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior Color: Manufacturer's standard .

    b. Interior Color: Manufacturer's standard.

  5. Hinged door full size of front face of enclosure and supported using the following:

    a. Enclosures Sizes Less Than 36 Inches Tall: Multiple butt hinges.

    b. Enclosures Sizes 36 Inches Tall and Larger: Continuous piano hinges.

  6. Removable internal panel with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size Less Than 24 Inches: Solid steel, 0.053 inch thick.

    b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.

  7. Internal panel mounting hardware, grounding hardware, and sealing washers.

  8. Grounding stud on enclosure body.

  9. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall-Mounted, NEMA 250, Types 4 and 12:

  1. <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:

    a. Cooper B-line; brand of Eaton, Electrical Sector.

    b. Hammond Mfg. Co. Inc.

    c. Hoffman; brand of nVent Electrical plc.

    d. Saginaw Control and Engineering.

  2. NRTL listed in accordance with UL 508A.

  3. Seam and joints are continuously welded and ground smooth.

  4. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.

  5. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.

  6. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.

  7. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.

  8. Construct enclosure of steel, not less than the following:

    a. Size Less Than 24 Inches: 0.053 inch thick.

    b. Size 24 Inches and Larger: 0.067 inch thick.

  9. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior Color: Manufacturer's standard .

    b. Interior Color: Manufacturer's standard.

  10. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

    a. Sizes through 24 Inches Tall: Two hinges.

    b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.

    c. Sizes Larger Than 48 Inches Tall: Four hinges.

  11. Double-door enclosures with overlapping door design to include unobstructed full-width access.

    a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

  12. Removable internal panel with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size Less Than 24 Inches: Solid steel, 0.053 inch thick.

    b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.

  13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.

  14. Grounding stud on enclosure body.

  15. Thermoplastic pocket on inside of door for record Drawings and Product Data.

2.18   RELAYS

    A.   General-Purpose Relays:

        1.   Manufacturers: Subject to compliance with requirements, provide products by one of the following:
           a.   Allen Bradley; by Rockwell Automation.
           b.   Eaton.
           c.   IDEC Corporation.
           d.   Omron Americas.
           e.   Siemens Industry, Inc., Building Technologies Division.
           f.   Square D; Schneider Electric USA.
        2.   NRTL listed.
        3.   Heavy-duty, electromechanical type; rated for at least 10 A at 250 V ac and 60 Hz.
        4.   SPDT, DPDT, or three-pole double-throw, as required by control application.
        5.   Plug-in-style relay with 8-pin octal or multiblade plug for DPDT relays and 11-pin octal or multiblade plug for three-pole double-throw relays.
        6.   Construct contacts of silver, silver alloy, or gold.
        7.   Enclose relay in a polycarbonate dust-tight cover.
        8.   Include LED indication.
        9.   Performance:
           a.   Mechanical Life: At least 10 million cycles.
           b.   Electrical Life: At least 100,000 cycles at rated load.
           c.   Pickup Time: 15 ms or less.
           d.   Dropout Time: 10 ms or less.
           e.   Pull-in Voltage: 85 percent of rated voltage.
           f.   Dropout Voltage: 50 percent of nominal rated voltage.
           g.   Power Consumption: 2 VA or less.
           h.   Ambient Operating Temperatures: Minus 40 to 115 deg F.
        10.   Equip relays with coil transient suppression to limit transients to non-damaging levels.
        11.   Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
        12.   Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

    B.   Multifunction Time-Delay Relays:

        1.   Manufacturers: Subject to compliance with requirements, provide products by one of the following:
           a.   Allen Bradley; by Rockwell Automation.
           b.   Eaton.
           c.   IDEC Corporation.
           d.   Omron Americas.
           e.   Siemens Industry, Inc., Building Technologies Division.
           f.   Square D; Schneider Electric USA.
        2.   NRTL listed.
        3.   Continuous-duty type, rated for at least 10 A at 240 V ac and 60 Hz.
        4.   Relay with up to 4 programmable functions to provide on/off delay, interval, and recycle timing functions.
        5.   Plug-in-style relay with either multi-pin or blade plug.
        6.   Construct contacts of silver, silver alloy, or gold.
        7.   Enclose relay in a dust-tight cover.
        8.   Include knob and dial scale for alternative digital interface for setting delay time.

9. Visual Status Indication: Power "On" status.
10. Performance:
    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
    d. Repeatability: Within 2 percent.
    e. Recycle Time: 45 ms.
    f. Minimum Pulse-Width Control: 50 ms.
    g. Power Consumption: 5 VA or less.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
11. Equip relays with transient suppression to limit transients to non-damaging levels.
12. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
13. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

C. Latching Relays:

1. <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:
    a. Allen Bradley; by Rockwell Automation.
    b. Eaton.
    c. IDEC Corporation.
    d. Omron Americas.
    e. Siemens Industry, Inc., Building Technologies Division.
    f. Square D; Schneider Electric USA.
2. NRTL listed.
3. Continuous-duty type, rated for at least 10 A at 250 V ac and 60 Hz.
4. SPDT, DPDT, or three-pole double-throw, as required by control application.
5. Plug-in-style relay with either multi-pin or blade plug.
6. Construct contacts of silver, silver alloy, or gold.
7. Enclose relay in a clear transparent polycarbonate dust-tight cover.
8. Performance:
    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA or less.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

D. Current Sensing Relays:

1. <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:
    a. Eaton.
    b. Functional Devices Inc.

      c.   NK Technologies.

      d.   Square D; Schneider Electric USA.

2. NRTL listed.
3. Monitors ac current.
4. Independent adjustable controls for pickup and dropout current.
5. Energized when supply voltage is present and current is above pickup setting.
6. De-energizes when monitored current is below dropout current.
7. Dropout current is adjustable from 50 to 95 percent of pickup current.
8. Visual indication of contact status.
9. Include current transformer, if required for application.
10. House current sensing relay and current transformer if required in its own enclosure. Use NEMA 250, Type 1 enclosure for indoors applications and NEMA 250, Type 4 for outdoor applications.

E. Combination On-Off Status Sensor and On-Off Control Relays:

1. <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:
   a. Functional Devices Inc.
   b. Veris Industries.
2. Description:
   a. On-off control and on-off status indication in a single device.
   b. LED status indication of activated relay and current trigger.
   c. Closed-Open-Auto override switch located on the load side of relay.
3. Performance:
   a. Ambient Temperature: Minus 30 to 140 deg F.
   b. Voltage Rating: Single-phase loads rated for 300 V ac. Three-phase loads rated for 600 V ac.
4. Status Indication:
   a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
   b. Current Sensor Range: As required by application.
   c. Current Set Point: Fixed or adjustable, as required by application.
   d. Current Sensor Output:
      1) Solid-state, SPDT contact rated for 30 V ac and dc and for 0.4 A.
      2) Solid-state, SPDT contact rated for 120 V ac and 1.0 A.
      3) Analog, 0 to 5 or 10 V dc.
      4) Analog, 4 to 20 mA, loop powered.
5. Relay: SPDT, continuous-duty coil; rated for 10-million mechanical cycles.
6. Enclosure: NEMA 250, Type 1 enclosure for indoor applications; NEMA 250, Type 4 enclosure for outdoor applications.

2.19   ELECTRICAL POWER DEVICES

A. Control Transformers:

1. Sizing Criteria: Size control transformers for total connected load, plus additional 25 percent of connected load for future spare capacity.
2. Transformer Minimum Capacity: 40 VA.
3. Protection: Provide transformers with both primary and secondary fuses.
4. Enclosure: House control transformers in NEMA 250 enclosures, type as indicated in "Performance Requirements" Article for application.

B.   Power-Line Conditioners:

1.   <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:
a.   Controlled Power Company; an Emerson company.
b.   Eaton.
c.   Emerson Electric Co.
2.   General Power-Line Conditioner Requirements:
a.   Design to ensure maximum reliability, serviceability, and performance.
b.   Overall function of power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. Power-line conditioner is to provide isolated, regulated, transient, and noise-free sinusoidal power to loads served.
3.   Standards: NRTL listed per UL 1012.
4.   Performance:
a.   Single phase, continuous, 100 percent duty rated kVA/kW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
b.   Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.
1)   At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
2)   At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
3)   At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.
c.   With input voltage distortion of up to 40 percent, limit the output voltage sine wave to maximum harmonic content of 5 percent.
d.   Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero to 100 to zero percent.
e.   Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when output is taken from no load to full-resistive load, or vice versa. Recovery from partial resistive load changes is corrected in a shorter period.
f.   K Factor: 30 , designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
g.   Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
h.   Attenuate load-generated odd current harmonics 23 dB at the input.
i.   Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
j.   Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.1 and IEEE C62.41.2.
k.   Common-mode noise attenuation of 140 dB.
l.   Transverse-mode noise attenuation of 120 dB.
m.   With loss of input power for up to 16.6 ms, output sine wave remains at usable ac voltage levels.
n.   Reliability of 200,000 hours' MTBF.

o.   At full load, when measured at 1 m distance, audible noise is not to exceed 54 dB.
p.   Approximately 92 percent efficient at full load.

5.   Transformer Construction:
a.   Ferroresonant, dry type, convection cooled, 600 V class. Transformer windings of Class H (220 deg C) insulated copper.
b.   Use Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40 deg C ambient temperature.
c.   Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
d.   Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
e.   Configure transformer secondary in 240/120 V split with 208 V tap or straight 120 V, depending on power output size.
f.   Electrically isolate the transformer secondary windings from primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
g.   Include interface terminals for output power hot, neutral, and ground conductors.
h.   Label leads, wires, and terminals to correspond with circuit wiring diagram.
i.   Vacuum impregnate transformer with epoxy resin.

6.   Cabinet Construction:
a.   Design for panel or floor mounting.
b.   NEMA 250, Type 1 enclosure for indoor applications. NEMA 250, Type 3R for outdoor applications.
c.   Manufacture the cabinet from heavy gauge steel complying with UL 50 or UL 508A.
d.   Include textured baked-on paint finish.

C.   DC Power Supplies:

1.   <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:
a.   Acopian Technical Company.
b.   Emerson Electric Co.
c.   IDEC Corporation.
d.   Omron Americas.
2.   Description: Linear or switched, regulated power supplies with ac input to one or multiple dc output(s).
a.   Include both line and load regulation to ensure stable output.
b.   To protect both power supply and load, include power supply with an automatic current limiting circuit.
3.   Features:
a.   Connection: Plug-in style suitable for mating with standard 8-pin octal socket. Include power supply with mating mounting socket.
b.   Housing: Enclose circuitry in a housing.
c.   Local Adjustment: Include screw adjustment on exterior of housing for dc voltage output.
d.   Mounting: DIN rail.
e.   Visual status indicator.
f.   .
4.   Performance:
a.   Input Voltage: Nominally 120 V ac, 60 Hz.
b.   Output Voltage: Nominally 24 V dc with plus or minus 1 V dc adjustment.
c.   Output Current: Minimum 100 mA.
d.   Load Regulation: Within 0.1 percent.

      e.   Line Regulation: Within 0.05 percent.
      f.   Stability: Within 0.1 percent of rated volts after warmup period.
      g.   Ripple: 1 mV rms.

2.20   CONTROL WIRE AND CABLE

A.   Wire: Single conductor control wiring above 24 V.

      1.   Wire Size: Minimum 18 AWG.
      2.   Conductors: 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
      3.   Conductor Insulation: 600 V, Type THWN or Type THHN, and 90 deg C in accordance with UL 83.
      4.   Conductor Insulation Colors: Black (hot), white (neutral), and green (ground).
      5.   Furnish on spools.

B.   Single, Twisted-Shielded, Instrumentation Cable above 24 V:

      1.   Wire Size: Minimum 18 AWG.
      2.   Conductors: Twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
      3.   Conductor Insulation: Type THHN/THWN or Type TFN rating.
      4.   Conductor Insulation Colors:
          a.   Twisted Pair: Black and white.
          b.   Twisted Triad: Black, red, and white.
      5.   Shielding: 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
      6.   Outer Jacket Insulation: 600 V, 90 deg C rating, and Type TC cable.
      7.   Furnish on spools.

C.   Single, Twisted-Shielded, Instrumentation Cable 24 V and Less:

      1.   Wire Size: Minimum 18 AWG.
      2.   Conductors: Twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
      3.   Conductor Insulation: Nominal 15-mil thickness, constructed from flame-retardant PVC.
      4.   Conductor Insulation Colors:
          a.   Twisted Pair: Black and white.
          b.   Twisted Triad: Black, red, and white.
      5.   Shielding: 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
      6.   Outer Jacket Insulation: 300 V, 105 deg C rating, and Type PLTC cable.
      7.   Furnish on spools.

D.   LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

      1.   Comply with following requirements for balanced twisted pair cable described in Section 26 05 23 "Control-Voltage Electrical Power Cables."
          a.   Plenum rated.
          b.   Unique color that is different from other cables used on Project.

2.21   RACEWAYS

   A.   Comply with requirements in Section 26 05 33 "Raceway and Boxes for Electrical Systems" for electrical power raceways and boxes.

   B.   Comply with requirements in Section 27 05 28 "Pathways for Communications Systems" for raceways for balanced twisted pair cables and optical fiber cables.

2.22   IDENTIFICATION

   A.   Control Equipment, Instruments, and Control Devices:

      1.   Laminated acrylic or melamine plastic sign bearing unique identification.
         a.   Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
      2.   Letter size as follows:
         a.   DDC Controllers: Minimum of 0.5 inch high.
         b.   Gateways: Minimum of 0.5 inch high.
         c.   Repeaters: Minimum of 0.5 inch high.
         d.   Enclosures: Minimum of 0.5 inch high.
         e.   Electrical Power Devices: Minimum of 0.25 inch high.
         f.   UPS units: Minimum of 0.5 inch high.
         g.   Accessories: Minimum of 0.25 inch high.
         h.   Instruments: Minimum of 0.25 inch high.
         i.   Control Damper and Valve Actuators: Minimum of 0.25 inch high.
      3.   Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded black with contrasting white center exposed by engraving through outer layer.
      4.   Fastened with drive pins.
      5.   Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

   B.   Equipment Warning Labels:

      1.   Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
      2.   Lettering size at least 14-point type with white lettering on red background.
      3.   Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
      4.   Lettering to be enclosed in a white line border. Edge of label is to extend at least 0.25 inch beyond white border.

2.23   SOURCE QUALITY CONTROL

   A.   Testing Agency: Engage a qualified testing agency to evaluate the following in accordance with industry standards for each product, and to verify DDC system reliability specified in performance requirements:

      1.   DDC controllers.

      2.   Gateways.

      3.   Routers.

B.   Product(s) will be considered defective if they do not pass tests and inspections.

C.   Prepare test and inspection reports.

PART 3 - EXECUTION

3.1   EXAMINATION

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

      1.   Verify compatibility with and suitability of substrates.

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

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

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

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

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

3.2   DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A.   Communication Interface to Equipment with Integral Controls:

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

      2.   Equipment to Be Connected:

           a.   Domestic water booster pumps specified in Section 22 11 23.13 "Domestic-Water Packaged Booster Pumps."

           b.   Air-compressors and air driers specified in Section 22 15 19 "General-Service Packaged Air Compressors and Receivers" and Section 22 61 19 "Compressed-Air Equipment for Laboratory and Healthcare Facilities."

           c.   Domestic water heaters specified in Section 22 33 00 "Electric, Domestic-Water Heaters" and Section 22 34 00 "Fuel-Fired, Domestic-Water Heaters."

           d.   Kitchen hoods specified in Section 23 38 13 "Commercial-Kitchen Hoods."

           e.   Heating and ventilating units specified in Section 23 73 39 "Indoor, Direct-Fired Heating and Ventilating Units."

           f.   Roof-top units specified in Section 23 74 16.11 "Packaged, Small-Capacity, Rooftop Air-Conditioning Units."

g.   Roof-top units specified in Section 23 74 16.13 "Packaged, Large-Capacity, Rooftop Air-Conditioning Units."

h.   Make-up air units specified in Section 23 74 23.13 "Packaged, Direct-Fired, Outdoor, Heating-Only Makeup-Air Units."

i.   Packaged terminal air-conditioners specified in Section 23 81 13.11 "Packaged Terminal Air-Conditioners, Through-Wall Units."

j.   Variable-frequency controllers specified in Section 26 29 23 "Variable-Frequency Motor Controllers."

k.   Split System air conditioning units specified in Section 23 81 26 " Split System Air Conditioners"

l.   Walll and Ceiling Heaters specified in Section 23 82 39.19 " Wall and Ceiling Unit Heaters".

B.   Communication Interface to Other Building Systems:

1.   DDC system communicates with systems having communication interface.

C.   Communications with Third Party Equipment:

1.   General: The BMS shall be capable of integrating to any third party equipment using any of the following standard open protocols:
a.   BACnet (IP, SC, Arcnet, or MS/TP)
b.   Modbus (MSTP or IP)

2.   The third party equipment provider shall provide the details of the proposed interface including PICS for BACnet equipment, hardware and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories.

3.   The third party equipment provider is responsible for furnishing and installing their interface pre-programmed and configured with the correct parameters to integrate with the BMS. These parameters include, but are not limited to the following:
a.   Communication protocol
b.   Correct communication protocol baud rate
c.   Points required to be viewed through the BMS. This includes ensuring the points are "in service" and visible to the BMS.
d.   Addressing of controller/interface. The BMS provider shall furnish the address.

4.   The third party equipment manufacturer shall include a minimum of 16 hours of onsite technical support for integration into the BMS.

3.3   PREINSTALLATION INTEGRATION TESTING

A.   Perform the following pretesting of other systems and equipment integration with DDC system before field installation:

1.   Test all communications in a controlled environment to ensure connectivity.

2.   Load software and demonstrate functional compliance with each control sequence of operation indicated.

3.   Using simulation, demonstrate compliance with sequences of operation and other requirements indicated including, but not limited to, the following:
a.   HVAC equipment controlled through DDC system, such as boilers, chillers, pumps, and air-handling units.
b.   Equipment faults and system recovery with fault annunciation.

   c. Analog and Boolean value alarming and annunciation.
  4. Develop a method for testing interfaces before deployment.
  5. Submit documentation supporting compliance upon request.

3.4 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

 A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

3.5 GENERAL INSTALLATION REQUIREMENTS

 A. Install products to satisfy more stringent of all requirements indicated.

 B. Install products level, plumb, parallel, and perpendicular with building construction.

 C. Support products, tubing, piping wiring, and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to force.

 D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

 E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

 F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 07 84 13 "Penetration Firestopping."

 G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 07 92 00 "Joint Sealants."

 H. Welding Requirements:

  1. Restrict welding and burning to supports and bracing.
  2. No equipment is cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
  3. Welding, where approved, is to be by inert-gas electric arc process and is to be performed by qualified welders in accordance with applicable welding codes.
  4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

 I. Fastening Hardware:

  1. Wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
  2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
  3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

J.   If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.6   INSTALLATION OF WORKSTATIONS

A.   Desktop Workstation Installation:

1.   Install workstation(s) at location(s) indicated on Drawings.
2.   Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex, electrical power receptacle.
3.   Install DDC system software on workstation(s) and verify that software functions properly.
4.   Develop Project-specific graphics, trends, reports, logs, and historical database.
5.   Power workstation through a UPS unit. Locate UPS adjacent to workstation.

B.   Portable Workstation Installation:

1.   Install DDC system software on workstation(s) and verify that software functions properly.

C.   Color Graphics Application:

1.   Use system schematics indicated on Drawings as starting point to create graphics.
2.   Develop Project-specific library of symbols for representing system equipment and products.
3.   Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4.   Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
5.   Seek Owner input in graphics development once using graphics software.
6.   Make final editing on-site with Owner's and Architect's review and feedback.
7.   Refine graphics as necessary for Owner acceptance.
8.   On receiving Owner acceptance, print a PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.7   INSTALLATION OF PRINTERS

A.   Install applicable printer software on workstations and verify that software functions properly.

3.8   INSTALLATION OF GATEWAYS

A.   Install gateways if required for DDC system communication interface requirements indicated.

1.   Install gateway(s) required to suit indicated requirements.

B.   Test gateways to verify that communication interface functions properly.

3.9   INSTALLATION OF ROUTERS

A.   Install routers if required for DDC system communication interface requirements indicated.

    1.   Install router(s) required to suit indicated requirements.

B.   Test routers to verify that communication interface functions properly.

3.10   INSTALLATION OF CONTROLLERS

A.   Install controllers in enclosures to comply with indicated requirements.

B.   Connect controllers to field power supply.

C.   Install controllers with latest version of applicable software and configure to execute requirements indicated.

D.   Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E.   Installation of Network Controllers:

    1.   DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.
    2.   Install controllers in a protected location that is easily accessible by operators.
    3.   Locate top of controller within 72 inches 84 inches of finished floor.

F.   Installation of Programmable Application Controllers:

    1.   DDC system provider and DDC system manufacturer to determine quantity and location of programmable application controllers to satisfy requirements indicated.
    2.   Install controllers in a protected location that is easily accessible by operators.
    3.   Locate top of controller within 72 inches of finished floor, except where dedicated controllers are installed at terminal units.

G.   Application-Specific Controllers:

    1.   DDC system provider and DDC system manufacturer to determine quantity and location of application-specific controllers to satisfy requirements indicated.
    2.   For controllers not mounted directly on equipment being controlled, install controllers in a location that is easily accessible by operators.

3.11   INSTALLATION OF ENCLOSURES

A.   Install the following items in enclosures, to comply with indicated requirements:

    1.   Gateways.
    2.   Routers.
    3.   Controllers.
    4.   Electrical power devices.

5.   UPS units.
6.   Relays.
7.   Accessories.
8.   Instruments.
9.   Actuators.

B.   Attach wall-mounted enclosures to wall using the following types of steel struts:

1.   For NEMA 250, Type 1 Enclosures: Use painted steel strut and hardware.
2.   For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless steel strut and hardware.
3.   Install plastic caps on exposed cut edges of strut.

C.   Align top or bottom of adjacent enclosures.

D.   Install floor-mounted enclosures located on concrete housekeeping pads. Attach enclosure legs using galvanized-steel or stainless steel anchors.

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

3.12   ELECTRIC POWER CONNECTIONS

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

B.   Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade to provide a fully functioning DDC system. Work is to comply with NFPA 70 and other requirements indicated.

C.   Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D.   Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E.   Comply with requirements in Section 26 05 33 "Raceway and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.13   INSTALLATION OF IDENTIFICATION

A.   Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems" for identification products and installation.

B.   Install laminated acrylic or melamine plastic signs with unique identification on face for each of the following:

1.   Server.
2.   Gateway.

     3.   Router.
     4.   Protocol analyzer.
     5.   DDC controller.
     6.   Enclosure.
     7.   Electrical power device.
     8.   UPS unit.
     9.   Accessory.

C.   Install unique instrument identification for each instrument connected to DDC controller.

D.   Install unique identification for each control damper and valve actuator connected to DDC controller.

E.   Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F.   Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G.   Warning Labels and Signs:

     1.   Permanently attach to equipment that can be automatically started by DDC control system.
     2.   Locate where highly visible near power service entry points.

3.14   INSTALLATION OF NETWORKS

A.   Install optical fiber cable when connecting between the following network devices and when located in different buildings on campus, or when distance between devices exceeds :

     1.   Operator workstations.
     2.   Operator workstations and network controllers.
     3.   Network controllers.

B.   Install balanced twisted pair cable when connecting between the following network devices:

     1.   Operator workstations.
     2.   Operator workstations and network controllers.
     3.   Network controllers.

C.   Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:

     1.   Gateways.
     2.   Gateways and network controllers or programmable application controllers.
     3.   Routers.
     4.   Routers and network controllers or programmable application controllers.
     5.   Network controllers and programmable application controllers.
     6.   Programmable application controllers.
     7.   Programmable application controllers and application-specific controllers.
     8.   Application-specific controllers.

D. Install cable in continuous raceway.

     1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.15 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

     1. MAC Address:
         a. Assign and document a MAC address unique to its network for every network device.
         b. Ethernet Networks: Document MAC address assigned at its creation.
         c. MS/TP Networks: Assign from 00 to 64.
     2. Network Numbering:
         a. Assign unique numbers to each new network.
         b. Provide ability for changing network number through device switches or operator interface.
         c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.
     3. Device Object Identifier Property Number:
         a. Assign unique device object identifier property numbers or device instances for each device network.
         b. Provide for future modification of device instance number by device switches or operator interface.
         c. LAN is to support up to 4,194,302 unique devices.
     4. Device Object Name Property Text:
         a. Device object name property field to support 32 minimum printable characters.
         b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.
             1) Example 1: Device object name for device controlling heating water boiler plant at Building 1000 would be "Heating Water System Bldg. 1000."
             2) Example 2: Device object name for VAV terminal unit controller could be "VAV Unit 102."
     5. Object Name Property Text for Other Than Device Objects:
         a. Object name property field is to support 32 minimum printable characters.
         b. Assign object name properties with plain-English names descriptive of application.
             1) Example 1: "Zone 1 Temperature."
             2) Example 2 "Fan Start and Stop."
     6. Object Identifier Property Number for Other Than Device Objects:
         a. Assign object identifier property numbers according to Drawings indicated.
         b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented, and be unique for like object types within device.

3.16 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

A. Comply with NECA 1.

   B.   Wire and Cable Installation:

       1.   Comply with installation requirements in Section 26 05 23 "Control-Voltage Electrical Power Cables."
       2.   Comply with installation requirements in Section 27 13 13 "Communications Copper Backbone Cabling."
       3.   Comply with installation requirements in Section 27 15 13 "Communications Copper Horizontal Cabling."
       4.   Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
           a.   Provide shielding to prevent interference and distortion from adjacent cables and equipment.
       5.   Terminate wiring in a junction box.
           a.   Clamp cable over jacket in a junction box.
           b.   Individual conductors in the stripped section of cable is to be slack between the clamping point and terminal block.
       6.   Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
       7.   Install signal transmission components in accordance with IEEE C2, REA Form 511a, NFPA 70, and as indicated.
       8.   Use shielded cable to transmitters.
       9.   Use shielded cable to temperature sensors.
     10.   Perform continuity and meager testing on wire and cable after installation.

   C.   Conduit Installation:

       1.   Comply with Section 26 05 33 "Raceway and Boxes for Electrical Systems" for control-voltage conductors.
       2.   Comply with Section 27 05 28 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.17   FIELD QUALITY CONTROL

   A.   Testing Agency: Engage a qualified testing agency to perform tests and inspections.

   B.   Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

   C.   Perform the following tests and inspections:

       1.   Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
       2.   Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.18   DDC SYSTEM I/O CHECKOUT PROCEDURES

   A.   Check installed products before continuity tests, leak tests, and calibration.

B.   Check instruments for proper location and accessibility.

C.   Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D.   Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

E.   Control Damper Checkout:

1.   For pneumatic control dampers, verify that pressure gauges are provided in each air line connected to the damper actuator and positioner.
2.   Verify that control dampers are installed correctly for flow direction.
3.   Verify that proper blade alignment, either parallel or opposed, has been provided.
4.   Verify that damper frame attachment is properly secured and sealed.
5.   Verify that damper actuator and linkage attachment are secure.
6.   Verify that actuator wiring is complete, enclosed, and connected to correct power source.
7.   Verify that damper blade travel is unobstructed.

F.   Control Valve Checkout:

1.   Verify that control valves are installed correctly for flow direction.
2.   Verify that valve body attachment is properly secured and sealed.
3.   Verify that valve actuator and linkage attachment are secure.
4.   Verify that actuator wiring is complete, enclosed, and connected to correct power source.
5.   Verify that valve ball, disc, or plug travel is unobstructed.
6.   After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace valve if leaks persist.

G.   Instrument Checkout:

1.   Verify that instrument is correctly installed for location, orientation, direction, and operating clearances.
2.   Verify that attachment is properly secured and sealed.
3.   Verify that conduit connections are properly secured and sealed.
4.   Verify that wiring is properly labeled with unique identification, correct type, and size and is securely attached to proper terminals.
5.   Inspect instrument tag against approved submittal.
6.   For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7.   For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8.   For temperature instruments, verify the following:
        a.   Sensing element type and proper material.
        b.   Length and insertion.

3.19   DDC SYSTEM I/O ADJUSTMENT, CALIBRATION, AND TESTING

A.   Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B.   Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C.   For each analog instrument, make three-point test of calibration for both linearity and accuracy.

D.   Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.

E.   Provide diagnostic and test equipment for calibration and adjustment.

1.   Use field testing and diagnostic instruments and equipment with an accuracy at least twice the instrument accuracy of instrument to be calibrated. For example, test and calibrate an installed instrument with accuracy of 1 percent using field testing and diagnostic instrument with accuracy of 0.5 percent or better.

F.   Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.

G.   If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.

H.   Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.

I.   Analog Signals:

1.   Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2.   Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3.   Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

J.   Digital Signals:

1.   Check digital signals using a jumper wire.
2.   Check digital signals using an ohmmeter to test for contact making or breaking.

K.   Control Dampers:

1.   Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2.   Check and document open and close cycle times for applications with cycle time less than 30 seconds.
3.   For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

L.   Control Valves:

1.   Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

  2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.

  3. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Meters: Check meters at zero, 50, and 100 percent of Project design values.

N. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

O. Switches: Calibrate switches to make or break contact at set points indicated.

P. Transmitters:

  1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.

  2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.20 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

  1. Verify voltage, phase, and hertz.
  2. Verify that protection from power surges is installed and functioning.
  3. Verify that ground fault protection is installed.
  4. If applicable, verify if connected to UPS unit.
  5. If applicable, verify if connected to backup power source.
  6. If applicable, verify that power conditioning units are installed.

B. Verify that wire and cabling are properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.21 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

  1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
  2. Test every I/O point throughout its full operating range.
  3. Test every control loop to verify that operation is stable and accurate.
  4. Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
  5. Test and adjust every control loop for proper operation according to sequence of operation.
  6. Test software and hardware interlocks for proper operation. Correct deficiencies.
  7. Operate each analog point at the following:
   a. Upper quarter of range.

      b.   Lower quarter of range.

      c.   At midpoint of range.

8.   Exercise each binary point.

9.   For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller, and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller, and at field instrument must match.

10.   Prepare and submit report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.22   DDC SYSTEM VALIDATION TESTS

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

B.   After approval of Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.

C.   After testing is complete, submit completed Pretest Checklist.

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

1.   Detailed explanation for any items that are not completed or verified.

2.   Required mechanical installation work is successfully completed and HVAC equipment is working correctly.

3.   HVAC equipment motors operate below full-load amperage ratings.

4.   Required DDC system components, wiring, and accessories are installed.

5.   Installed DDC system architecture matches approved Drawings.

6.   Control electric power circuits operate at proper voltage and are free from faults.

7.   Required surge protection is installed.

8.   DDC system network communications function properly, including uploading and downloading programming changes.

9.   Each controller's programming is backed up.

10.   Equipment, products, tubing, wiring cable, and conduits are properly labeled.

11.   All I/O points are programmed into controllers.

12.   Testing, adjusting, and balancing work affecting controls is complete.

13.   Dampers and actuators zero and span adjustments are set properly.

14.   Each control damper and actuator goes to failed position on loss of power and loss of signal.

15.   Valves and actuators zero and span adjustments are set properly.

16.   Each control valve and actuator goes to failed position on loss of power and loss of signal.

17.   Meter, sensor, and transmitter readings are accurate and calibrated.

18.   Control loops are tuned for smooth and stable operation.

19.   View trend data where applicable.

20.   Each controller works properly in standalone mode.

21.   Safety controls and devices function properly.

22.   Interfaces with fire-alarm system function properly.

23.   Electrical interlocks function properly.

24.   Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.

25.   Record Drawings are completed.

E.   Test Plan:

1.   Prepare and submit validation Test Plan including test procedures for performance validation tests.
2.   Address all specified functions of DDC system and sequences of operation in Test Plan.
3.   Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4.   Explain method for simulating necessary conditions of operation used to demonstrate performance.
5.   Include Test Checklist to be used to check and initial that each test has been successfully completed.
6.   Submit Test Plan documentation 10 business days before start of tests.

F.   Validation Test:

1.   Verify operating performance of each I/O point in DDC system.
       a.   Verify analog I/O points at operating value.
       b.   Make adjustments to out-of-tolerance I/O points.
              1)   Identify I/O points for future reference.
              2)   Simulate abnormal conditions to demonstrate proper function of safety devices.
              3)   Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2.   Simulate conditions to demonstrate proper sequence of control.
3.   Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4.   24 hours after initial validation test, do as follows:
       a.   Re-check I/O points that required corrections during initial test.
       b.   Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
5.   24 Hours after second validation test, do as follows:
       a.   Re-check I/O points that required corrections during second test.
       b.   Continue validation testing until I/O point is normal on two consecutive tests.
6.   Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7.   After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

3.23   FINAL REVIEW

A.   Submit written request to Architect and Owner when DDC system is ready for final review. State the following:

1.   DDC system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.

2.   DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.

3.   DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.

4.   DDC system is complete and ready for final review.

5.   .

B.   Upon receipt of written request for final review, ArchitectandOwner and to start review within reasonable period and upon completion issue field report(s) documenting observations and deficiencies.

C.   Take prompt action to remedy deficiencies indicated in reviewer's field report(s) and submit second written request after all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D.   Prepare and submit closeout submittals when no deficiencies are reported.

E.   Part of DDC system final review shall to include demonstration to parties participating in final review.

1.   Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.

2.   Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.

3.24   ADJUSTING

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

3.25   MAINTENANCE SERVICE

A.   Beginning at Substantial Completion, verify that maintenance service includes 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration, and adjusting as required for proper operation. Use only manufacturer's authorized replacement parts and supplies.

3.26   SOFTWARE SERVICE AGREEMENT

A.   Technical Support: Beginning at Substantial Completion, verify that service agreement includes software support for two year(s).

B.   Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.

1.   Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.27   DEMONSTRATION

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

B.   Extent of Training:

1.   Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2.   Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3.   Minimum Training Requirements:
     a.   Provide not less than five days of training total.
     b.   Stagger training over multiple training classes to accommodate Owner's requirements. All training to occur before end of warranty period.
     c.   Break down total days of training into not more than two separate training classes.
     d.   Schedule training so each training class is not less than one consecutive day(s).

C.   Training Schedule:

1.   Schedule training with Owner 20 business days before expected Substantial Completion.
2.   Schedule training to provide Owner with at least 10 business days of notice in advance of training.
3.   Training to occur within normal business hours at mutually agreed on time. Unless otherwise agreed to, training to occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session to be split in half with 15 -minute break between sessions. Morning and afternoon sessions to be separated by 30 -minute lunch period. Training, including breaks and excluding lunch period, are not to exceed eight hours per day.
4.   Provide staggered training schedule as requested by Owner.

D.   Training Attendee List and Sign-in Sheet:

1.   Request from Owner in advance of training a proposed attendee list with name, phone number, and email address.
2.   Provide preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3.   Include preprinted sign-in sheet with training session number, date and time, instructor name, phone number, email address, and brief description of content to be covered during session. List attendees with columns for name, phone number, and email address and a column for attendee signature or initials.
4.   Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5.   At end of each training day, send Owner an email with attachment of scanned copy (PDF) of circulated sign-in sheet for each session..

E.   Training Attendee Headcount:

1.   Plan in advance of training for three attendees.
2.   Make allowance for Owner to add up to two attendee(s) at time of training.
3.   Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

F.   Training Attendee Prior Knowledge: For guidance in planning required training and instruction, assume attendees have the following:

1.   High school and technical school education and degree.
2.   Intermediate user knowledge of computers and office applications.
3.   Intermediate knowledge of HVAC systems.
4.   Intermediate knowledge of DDC systems.
5.   Intermediate knowledge of DDC system and products installed.

G.   Attendee Training Manuals:

1.   Provide each attendee with color hard copy of all training materials and visual presentations.
2.   Organize hard-copy materials in three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3.   In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes DVD or flash drive with PDF copy of all hard-copy materials.

H.   Instructor Requirements:

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

I.   Organization of Training Sessions:

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

J.   Training Outline:

1.   Submit training outline for Owner review at least 10 business day before scheduling training.

    2.   Include in outline a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session, and synopses for each lesson planned.

K.   On-Site Training:

    1.   Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
    2.   Provide training materials, projector, and other audiovisual equipment used in training.
    3.   Provide as much of training located on-site as deemed feasible and practical by Owner.
    4.   Include on-site training with regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
    5.   Use operator workstation that is to be used with DDC system in the training. If operator workstations are unavailable, provide temporary workstation to convey training content.

L.   Off-Site Training:

    1.   Provide conditioned training rooms and workspace with ample tables desks or tables, chairs, power, and data connectivity for each attendee.
    2.   Provide capability to remotely access to Project DDC system for use in training.
    3.   Provide operator workstation for use by each attendee.

M.   Training Content for Daily Operators:

    1.   Basic operation of system.
    2.   Understanding DDC system architecture and configuration.
    3.   Understanding each unique product type installed including performance and service requirements for each.
    4.   Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm, and each unique optimization routine.
    5.   Operating operator workstations, printers, and other peripherals.
    6.   Logging on and off system.
    7.   Accessing graphics, reports, and alarms.
    8.   Adjusting and changing set points and time schedules.
    9.   Recognizing DDC system malfunctions.
    10.   Understanding content of operation and maintenance manuals including control drawings.
    11.   Understanding physical location and placement of DDC controllers and I/O hardware.
    12.   Accessing data from DDC controllers.
    13.   Operating portable operator workstations.
    14.   Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
    15.   Running each specified report and log.
    16.   Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
    17.   Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
    18.   Executing digital and analog commands in graphic mode.
    19.   Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
    20.   Demonstrating DDC system performance through trend logs and command tracing.

21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
    a. Operation of HVAC equipment in normal-off, normal-on, and failed conditions while observing individual equipment, dampers, and valves for correct position under each condition.
    b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
    c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles, and other modes of operation indicated.
    d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
    e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
    f. Each control loop responds to set-point adjustment and stabilizes within time period indicated.
    g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

N. Training Content for System Managers and Administrators:

1. DDC system software maintenance and backups.
2. Uploading, downloading, and offline archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification.

O. Video of Training Sessions:

1. Provide digital video and audio recording of each training session. Create separate recording file for each session.
2. Stamp each recording file with training session number, session name, and date.
3. Provide Owner with two copies of digital files on cloud and flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION 23 09 23