

**Dobbs Ferry Public Library
Building Automation System & Acoustic Mitigation Project
Request for Proposal**

55 Main Sreet
Dobbs Ferry, NY

December 21, 2010

Issued For Bid

Prepared by

OLA CONSULTING ENGINEERS, PC
Hawthorne, NY

OLA Project No. NDFL0003.00



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LYNCH
ABBATTISTA**

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DIVISION 13

13 4800 ACOUSTICAL BARRIER WALL

DIVISION 23

23 0593 TESTING, ADJUSTING, AND BALANCING FOR HVAC
 23 0800 COMMISSIONING REQUIREMENTS
 23 0900 INSTRUMENTATION AND CONTROL FOR HVAC
 23 0993 SEQUENCE OF OPERATIONS FOR HVAC CONTROLS
 23 2923 VARIABLE-FREQUENCY MOTOR CONTROLLERS

DRAWINGS PROVIDED FOR REFERENCE (ORIGINAL CONSTRUCTION DRAWINGS DATED 6/20/2001)

DWG NO.	DRAWING NAME
M-1	GROUND FLOOR MECHANICAL EQUIP, DUCT & PIPING PLANS
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M-3	2ND FLOOR MECHANICAL AND MECHANICAL PIPING PLANS
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L-200	GROUND FLOOR LAYOUT AND MATERIALS PLAN
A-100	GROUND FL CONSTRUCTION PLAN
A-101	1ST FLOOR CONSTRUCTION PLAN
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SECTION I
SCOPE OF WORK

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SCOPE OF WORK

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SCOPE OF WORK

1.0 Summary:

The Village of Dobbs Ferry is hereby requesting proposals from qualified HVAC and Building Automation contractors for the design/build of a new DDC control system to resolve issues with the Library Building's HVAC and mechanical systems. In addition, this RFP requests the design/build of an acoustical mitigation system to address the excessive noise issues associated with the Library's outdoor HVAC units.

The bidder shall be designated and known as the "design/build contractor" or "contractor". The Village of Dobbs Ferry shall herein be designated and known as the "Owner" or "Village".

The contractor shall submit a proposal for the complete turnkey installation of the new Building Automation System (BAS). The contractor shall also submit a proposal for the complete turnkey installation of an acoustical barrier system for the outdoor HVAC units. The contractor shall be responsible for all work, including but not limited to the following: site survey, design, demolition, rigging, structural steel, cutting and patching, general conditions, construction permits, mobilization, labor and supervision, project management, installation of materials and equipment, controls, integration with existing systems, environmental and health and safety compliance, testing and balancing, as-built drawings, operation and maintenance (O&M) manuals, Owner training, punch-list completion, clean up and demobilization, and warranties in order to provide a complete project.

Copies of the RFP can be obtained on the main page of the Village of Dobbs Ferry's website at www.dobbsferry.com. You may also obtain copies at the Office of the Village Clerk, 112 Main Street, Dobbs Ferry, New York, 10522.

2.0 Important Dates:

A walkthrough at the project site may be arranged by the Contractor if desired by scheduling an appointment for the morning of **January 4, 2010**. Contractors shall contact the Village of Dobbs Ferry contact person to schedule the appointment. All questions should be submitted in writing to the designated point of contact no later than **January 7, 2010**. The Village of Dobbs Ferry representatives will reply to all questions within three (3) business days and will copy all bidders. In order to facilitate speedy responses to questions, all questions shall be in writing and shall be e-mailed to Village of Dobbs Ferry contact person and cc: OLA Consulting Engineers. All responses shall also be in writing and shall be sent to all proposed bidders who have picked up the RFQ/P documents. Sealed proposals and qualifications must be submitted no later than date and time indicated on the cover.

Proposal will be received in the Office of the Village Clerk until 10:00 AM, January 10, 2011.

3.0 Construction Schedule:

Village of Dobbs Ferry expects to award the contract on or about January 21, 2010.

4.0 Bid Documentation:

The Village of Dobbs Ferry shall require the following documentation to be submitted by each contractor:

- 1) Lump sum pricing for the complete turnkey installation of a new BAS as specified herein. The bid form included in this RFP shall be completed by each bidder in full and submitted with the response to this RFP.
- 2) Lump sum pricing for the complete turnkey installation of the acoustical barrier system.
- 3) Line item breakout costs for each trade and/or task as outlined in the bid form.
- 4) Timeline for the contractor's design/build schedule with milestones dates indicating significant work including but not limited to the following:
 - I) Award of contract
 - II) 75% Review Drawings
 - III) 100% Submission (Shop Drawings)
 - IV) Start of construction
 - V) Equipment and Material shop drawing submissions
- 5) Identification of all Subcontractors
- 6) Contractor Qualification Documentation as required by the attached RFQ.

Bidders shall submit three (3) hard copies, and one digital copy of their proposals.

5.0 Bid Evaluation:

Village of Dobbs Ferry will review all bid proposals for complete compliance with the RFQ/RFP documents as well as the contractor's ability to complete the construction of the Project within schedule time period. Proposals received without all required supporting documentation as stated herein may be excluded from proposal evaluation. Contractor will be selected based on the following:

- Experience with related work
- Ability to meet project schedule
- Quality of workmanship
- Pricing

6.0 Point of Contact:

Questions, inquiries, and/or requests for clarifications regarding the RFQ/P should be directed to:

Marcus Serrano
Village Administrator
914-231-8502
mserrano@dobbsferry.com

Jonathan Katz, PE, LEED AP
OLA Consulting Engineers
914-919-3132
jkatz@olace.com

Questions received after the deadline noted above may not be answered.

7.0 Background Information

The Village Library is an approximately 16,000 square foot facility constructed in 2002, located at 55 Main St., Dobbs Ferry, NY. The building's HVAC system was installed with a pneumatic temperature control system. Since the opening of the facility, the building has experienced poor temperature control of the spaces. In addition, the outdoor portion of the HVAC systems (condensing units) have been the cause of excessive noise complaints from neighbors. It is also believed that the air and water systems were never balanced during construction. The scope of this project is to provide a design/build solution from a qualified contractor to address all of these problems. The specifications contained in this document provide a basis for the minimum requirements and expectations of the new system.

8.0 General Description of Contractor's Work:

- 1) Contractor shall provide a complete turnkey installation for the new building automation system (BAS) and direct digital control (DDC) system. The specifications provide the minimum requirements for the DDC control system. Scope of work includes design, submittals, installation, commissioning, functional testing, etc.
- 2) Commissioning and functional testing of the entire building control system and HVAC equipment will be part of this scope of work. Contractor shall provide support of commissioning activities. The Village of Dobbs Ferry shall retain a Commissioning Authority who shall act as a 3rd party and direct all commissioning and functional testing activities.
- 3) The contractor shall engage the services of a qualified Testing and Balancing firm to perform TAB services as required by the specifications. The air side systems shall be balanced per the original design drawings which shall be provided for reference, or for optimal occupant comfort. Any necessary deviations shall be brought to the attention of the Village of Dobbs Ferry. Ventilation rates provided shall be in accordance NYS Mechanical Code.
- 4) The Contractor shall provide a complete turnkey installation for an acoustical mitigation system that addresses the outdoor HVAC equipment noise complaints. The scope of services shall include all layout and design of an acoustical barrier/noise mitigation system, acoustical engineering services, structural engineering services, submittals, installation, labor, and acoustical performance testing for this system. The expected solution includes the design and installation of an acoustical barrier wall to mitigate the noise per the included specifications. The design criteria for the barrier system is to achieve not more than **55 dBA** (weighted average) at the adjacent property lines.
- 5) The contractor shall submit with their proposal proposed noise reduction levels that can be achieved with the proposed mitigation strategies. The contractor may propose additional (alternate) solutions and provide expected performance and acoustical benefits for their proposed solutions. Multiple solutions may be selected by the Village

depending on cost. In no way shall the acoustical mitigation solutions compromise the ability of the HVAC system to perform its primary function for space cooling efficiently.

- 6) The contractor shall be responsible for all design calculations, equipment selections, drawings preparation, including Mechanical, Electrical, Structural, Control Drawings required for the installation of the above described projects.
- 7) The contractor shall use engineers and/or architects licensed in the State of NY of the appropriate disciplines to prepare and seal all engineering documents prepared under this proposal.
- 8) The contractor shall be responsible for obtaining all required permits as may be required for the completion of scope of the work. Including trade permits, general building permits, etc.
- 9) Contractor shall provide a complete and operational building automation systems on a design/build basis in full compliance with these documents and all local, state, and federal regulatory requirements. Contractor shall perform all work specified and all other work as is necessary to support achievement of the objectives set forth herein. It is understood and agreed that the intent of the RFP is to relieve the Village of Dobbs Ferry of the necessity of engaging in or supplying any labor, service, material or equipment required to complete the design/build project. Any scope of work items requiring clarification shall be submitted in writing as a question to the Village of Dobbs Ferry point of contact prior to submission of bid.
- 10) Contractors work shall include, but is not limited to, site survey, design, engineering, demolition, rigging, structural steel, cutting and patching, general conditions, construction permits, mobilization, labor and supervision, site safety planning and implementation, equipment storage, project management, installation of materials and equipment, automation and local controls, integration with existing systems, environmental and health and safety compliance, testing and balancing, Commissioning assistance as-built drawings, operation and maintenance (O&M) manuals, Owner training, punch-list completion, clean up and demobilization, and warranties.
- 11) The new BAS system and HVAC controls shall be commissioned under a separate contract by the Commissioning Authority. The contractor is responsible for providing all labor and materials for assistance of commissioning efforts. These efforts shall include review and response to commissioning comments of the 75% submission, furnishing of all required documents including testing and balancing reports, as-built drawings, operation and maintenance (O&M) manuals, as well as other efforts detailed in the specifications provided herein.
- 12) Contractor shall provide progress drawings for review by Village of Dobbs Ferry at the 75% (Issued for review), and the 100% (Issued for Construction) levels. The 100% drawings will be sealed by an appropriate discipline engineer or architect as applicable.

For each level of design completion, as defined below, the Contractor shall provide, at a minimum, three sets of the documents.

- 13) All work provided shall comply with the applicable requirements of the Building Code of New York State.

9.0 Shop Drawings

- 1) Contractor shall provide copies of all equipment and structural shop drawings and submittals to Owner. Contractor shall also provide copies of all equipment shop drawings and submittals to the Commissioning Authority.

10.0 Commissioning Assistance

- 1) Contractor to provide all labor, materials, documentation, and information as required to assist the commissioning agent and owners representative in the testing and commissioning of all BAS systems and HVAC controls.
- 2) Contractor shall assign representatives with the expertise and the authority to act on the behalf of the entity responsible for installation of the system to be commissioned who shall participate in and perform commissioning team activities including, but not limited to, the following:
 - A. Participate in construction phase coordination meetings and functional test performance meetings.
 - B. Provide information to the CxA for developing construction phase commissioning plan including, but not limited to:
 - i. Completion schedule as mentioned above.
 - ii. Verify in writing equipment was constructed, shipped and installed with all options specified.
 - iii. System and equipment product data submittals.
 - iv. Testing and balancing data.
 - v. Installation and operation manual submittals.
 - vi. Operation and maintenance information submittals.
 - vii. Warranty information.
 - C. Certify readiness of systems to be commissioned prior to functional performance testing.
 - D. Participate in functional performance testing of systems to be commissioned.
 - E. The Balancing Contractor (TAB) shall demonstrate airflow measurements to the Commissioning Authority for spot testing. This can occur as part of the typical balancing effort but will require coordination by the Balancer.

- F. Provide technicians who are familiar with the construction and operation of the installed systems, are trained in the use of required testing instruments and procedures to participate in testing of installed systems, subsystems and equipment.
- G. Resolving issues identified during commissioning and coordinate correction of deficiencies.
- H. Participate in training sessions for owner's operation and maintenance personnel.
- I. Participate in final review at acceptance meeting.
- J. Participate, as needed, in deferred or opposite seasonal testing of systems and equipment.
- K. Provide three (3) copies of all approved shop drawings, O&M manuals, testing and balancing data, warranty information.
- L. Document dates, times, operating conditions, and names of parties involved with any tests performed.
- M. All work must meet or exceed all applicable local, State and Federal code requirements.

11.0 General Warranty Provisions

- 1) Contractor shall be responsible for all warranty obligations for a period of one (1) year. Warrantee obligations to include labor and material for all installed equipment and systems.

12.0 Turnover Packages

- 1) Contractor shall provide three (3) hard copies and an electronic (where possible) copy of complete O&M Manuals for all contractor provided equipment prior to Substantial Completion. The manuals shall include all equipment specifications, installation requirements, maintenance requirements, and all standard documents as supplied by the equipment manufacturer.
- 2) The contractor shall provide as part of the Controls Turnover Package a separate Operator's Manual that includes all of the sequences of operation and manual tasks required for start-up, operation and shut down of every system in the building. The manual shall include at a minimum all operating parameters such as temperatures, pressures, max/min, etc., and step-by-step operating sequences, tables, charts and

diagrams for the reader to completely understand the operation of each system and subsystem in the plant.

SECTION II
INSTRUCTIONS TO BIDDERS

INSTRUCTIONS TO BIDDERS

1. Defined Terms:

Terms used in these Instructions to Bidders are defined as follows; the terms "Bidder" and/or "contractor" means one who submits a Bid directly to the Village of Dobbs Ferry, as distinct from a sub-bidder, who submits a bid to a Bidder. The term "Successful Bidder" means the most qualified, responsible and responsive Bidder to whom the Village of Dobbs Ferry (on the basis of evaluation) makes an award. The term "Bidding Documents" includes the Invitation to Bid, Instructions to Bidders, the Bid Form, and the proposed Contract Documents (including any and all Addenda issued prior to receipt of Bids).

2. Copies of Bidding Documents

- a. Complete sets of the Bidding Documents may be obtained from the Village of Dobbs Ferry Office of the Village Clerk.
- b. Complete sets of Bidding Documents must be used in preparing Bids; The Village of Dobbs Ferry will not assume any responsibility for errors or misinterpretations resulting from the use of incomplete sets of Bidding Documents.
- c. The Village of Dobbs Ferry will not pay or reimburse any costs incurred in the proposal preparation, printing or presentation of proposals.

3. Qualifications of Bidders

- a. To demonstrate qualifications to perform the work, each Bidder must be prepared to submit written evidence, such as financial data, previous experience, present commitments and other, as may be requested by the Village of Dobbs Ferry. Each bid must contain evidence of Bidder's qualification to do business in the state where the project is located.
- b. Each Bidder shall submit with the Bid references for three (3) similar projects. Reference information should include a brief description of the project, project address and name, telephone number for each reference. (References shall be provided for both BAS projects and Acoustical mitigation project).

4. Examination of contract Documents and Site

- a. Contractor is responsible for visiting the site to become familiar with local conditions that may affect cost, progress, performance or furnishing of the work.
- b. Contractor shall examine the contract documents thoroughly and consider all state and local laws and all codes and regulations that may affect cost, progress, performance or furnishing of the work.
- c. Notify the Village of Dobbs Ferry of all conflicts, errors or discrepancies in the contract documents.

5. **Interpretation of Addenda**
 - a. Requests for interpretation of the RFP documents shall be made in writing. Such interpretations will be in the form of an addendum to the RFP documents and will be on file in the Office of the Village Clerk at least two (2) business days before the day of the RFP opening. In addition, any addenda will be posted on the Village of Dobbs Ferry web-site not less than two (2) calendar days prior to the opening date unless it is to extend the opening date which can happen right up until the opening. Each respondent shall be bound by such addenda whether or not received by the respondent.

6. **Substitute or "or Equal" Items:**
 - a. The contract, if awarded, will be on the basis of materials and equipment described in the RFQ/P or specified in the attached specifications. "Or-equal" items of material or equipment may be furnished or used by contractor if acceptable to the Village of Dobbs Ferry. Refer to attached specifications for additional information.

7. **RFP Submission:**
 - a. All RFPs shall be sealed and identified on the outside by your firm's name and the RFP title, and submitted to the Office of the Village Clerk, 112 Main St., Dobbs Ferry, NY, 10522, by the time and date shown on "Cover". A "clearly marked" Original and copies of your submittals are required, if submitting hardcopy.

8. **RFP Withdrawal** – RFPs may be withdrawn by written request prior to RFP opening or after 60 days subsequent to RFP opening if no award has been made.

9. **RFI: Questions, Inquiries, and/or requests for clarifications regarding this RFP should be directed to the contacts listed in Section I.**
 - a. Content of the RFI: Include a detailed, legible description in the form of a question, of item needing information or interpretation and the following:
 1. Project name.
 2. Date.
 3. Name of Contractor.
 4. RFI number, numbered sequentially.
 5. RFI subject.
 6. Specification Section number and title and related paragraphs, as appropriate.
 7. Attachments: Include sketches, descriptions, measurements, photos, and other information necessary to fully describe items needing interpretation.

10. **Assignment of Contract**
 - a. The contractor may NOT assign all or part of the contract to another party unless after receiving written permission from the Village of Dobbs Ferry. Such assignment shall NOT release the contractor from any part of the responsibility or liability assumed under the contract.

11. **Implied Requirements**
 - a. It is the contractor's responsibility to notify the Village of Dobbs Ferry within a minimum of three (3) days of the opening date of any services or supplies not specifically mentioned in this specification but are necessary to provide the functional capabilities of the contract.
12. **Execution of Agreement**
 - a. Failure of the successful respondent to deliver to the Village a properly signed and witnessed Agreement with all required bonds and insurance policies, within ten (10) days after receipt of written Notice of award, or within such extended period as the Village may grant, shall constitute a default, to the Village, which may either award the contract to the next lowest respondent, or re-advertise for RFPs.
13. **Contract Term**
 - a. Bidders pricing must remain in effect for (120) days or otherwise indicated in the specification.
14. **Availability of Funds**
 - a. All contracts are bid with the intention of awarding a contract as a result of the Bid. Any and all awards and actual contract execution by the Village of Dobbs Ferry is contingent upon availability of appropriate funds. In the event that funding is not available at the time of award and/or execution of the contract the Village reserves the right to cancel the bid.
15. **Village of Dobbs Ferry Right & Reservations**
 - a. The Village of Dobbs Ferry reserves the right to alter or revoke this RFP at any time. The Village further reserves the right to reject any or all responses, to waive any informalities in the responses received and to accept only those responses deemed by the Village to be in the best interests of the Village. Any mention in these documents of the term "Proposal" refers to the Response; and any mention of the term "provider" refers to the Respondent.
16. **RFQ/P Review Criteria:**
 - a. Experience: Provide 3 similar projects with scope of work description, budget, and reference name and contact number.
 - b. Pricing
 - c. Qualifications
 - d. Demonstration of ability to meet schedule and dates
 - e. Demonstration of ability to meet performance expectations
 - f. Demonstration of experience with design, installation and maintenance of commercial mechanical HVAC systems.
 - g. Experience with energy conservation design and operations of buildings.
17. **Indemnification & Hold Harmless:**
 - a. The selected firm will be required to indemnify, defend and save harmless the Village and its officers, agents, and employees from and against all claims, damages, losses and expenses, including but not limited to attorney's fees arising out of or resulting directly or indirectly from the performance of services irrespective of whether the

Village has approved or supervised the production of any materials, drawings, plans or technical specifications.

18. **Agreement Term:**

- a. The Term of the agreement as a result of this RFP will be for one fiscal year.

19. **Preparation Costs:**

- a. All costs incurred in the preparation and presentation of this proposal shall be wholly absorbed by the proposer.

20. **Implied Requirements:**

- a. All services not specifically mentioned in this RFP that are necessary to provide the functional capabilities described by the vendor shall be included in the proposal. The Village does not reimburse for expenses incurred during the performance of this contract.

21. **Vendor Supplied Materials:**

- a. Any material submitted by the vendor shall become the property of the Village of Dobbs Ferry unless otherwise requested at the time of submission. Any material that is to be considered as confidential in nature must be so marked.

22. **Davis-Bacon Act**

- a. Proposals must include a conformance statement to Davis-Bacon prevailing wage requirements.

23. **Buy-American Act**

- a. Proposal must include a conformance statement to the Buy-American Act.

24. **Insurance Requirements**

- a. Refer to the following sections for insurance requirements:

1. The Contractor, prior to signing of the contract, shall provide to the Village of Dobbs Ferry, and maintain throughout the life of the contract, at his own cost and expense, proof of the following insurance by insurance companies licensed in the State of New York.
 - a. General Liability Insurance with a single limit of liability per occurrence for ~~bodily injury and property damage of \$4,000,000.~~ The Certificate of Insurance shall indicate the following coverages:
 - (1) Premises - Operations;
 - (2) Contractual as respect this contract including the indemnification set forth in section 146 - Indemnity Clause of the General Conditions.
 - (3) Any deductibles shall not be the liability of the Village of Dobbs Ferry.
 - b. ~~Owners and Contractors Protective Liability Policy - \$1,000,000~~ single limit endorsed that Village of Dobbs Ferry is not responsible for premium.
 - c. Automobile Liability Insurance with a single limit of liability per occurrence for bodily injury and per occurrence for property damage at \$1,000,000. This insurance shall include coverages for:
 - (1) Owner automobiles;
 - (2) Hired automobiles;
 - (3) Non-owned automobiles.
 - d. Compensation, Disability and Employer's Liability Insurance The Contractor shall take out and maintain during the life of this contract the statutory Workmen's Compensation, Disability, and Employer's Liability Insurance for all of his employees to be engaged in work on the project under this Contract and, in case any such work is sublet, the Contractor shall require the Subcontractor similarly to provide Workmen's Compensation, Disability, and Employer's Liability Insurance for all of the latter's employees to be engaged in such work.
 - e. Unemployment Insurance - The Contractor for the agreed consideration, promises and agrees to pay the contributions measured by the wages of his employees required by State Unemployment Insurance Laws and all amendments thereto, and to accept the account of any contribution measured by the wages as aforesaid of employees of the Contractors and his subcontractors assessed against the owner under the authority of said law.

2. All policies and certificates of Insurance of the Contractor shall state that the "Village of Dobbs Ferry is an additional Insured" under the policy.
3. The Contractor, as part of the Contract, shall agree to the following clauses for all policies and certificates of insurance:
 - a. The insurance companies issuing the policy or policies shall have no recourse against the Village of Dobbs Ferry for payment of any premiums or for assessments under any form of policy.
 - b. ~~Any and all deductibles in the above described insurance policies shall be assumed by and be for the account of, and at the sole risk of the Contractor.~~
 - c. In case of cancellation or material change in any of the policies, thirty (30) days notice shall be given to the Village of Dobbs Ferry, Village Hall, 112 Main Street, Dobbs Ferry, New York 10522, by registered mail, return receipt requested.
4. All property losses shall be made payable to and adjusted with the Village.
5. ~~All policies of insurance shall be acceptable to and approved by the Department of Law prior to the inception of any work.~~
6. Other coverages may be required by the Village of Dobbs Ferry based on specific needs.
7. I, at any time, any of the said policies shall be or become unsatisfactory to the Village, as to form or substance, or if a company issuing any such policy shall be or become unsatisfactory to the Village, the Contractor shall promptly obtain a new policy, submit the same to the Department of Law of the Village of Dobbs Ferry for approval and submit a certificate thereof as herein above provided. Upon failure of the Contractor to furnish, deliver and maintain such insurance as above provided, this contract, at the election of the Village, may be forthwith declared suspended, discontinued or terminated. Failure of the Contractor to take out and/or to maintain or the taking out and/or maintenance of any required insurance, shall not relieve the Contractor from any liability under the contract, nor shall the insurance requirements be construed to conflict with the obligations of the Contractor.
8. ~~In the event that claims in excess of these amounts are filed by reason of any operations under the contract, the amount of excess of such claims, or any portion thereof, may be withheld from payment due or to become due the Contractor until such time as the Contractor shall furnish such additional security covering such claims.~~

9. All policies and certificates of insurance of the Contractor shall contain the following clause:

The Contractor agrees to protect, defend, indemnify and hold the Village of Dobbs Ferry and its officers, employees and agents free and harmless from and against any and all losses, penalties, damages, settlements, costs, charges, professional fees or other expenses or liabilities of every kind and character arising out of or relating to any and all claims, liens, demands, obligations, actions, proceedings or causes of action of every kind and character in connection with or arising directly or indirectly out of this agreement and/or the performance hereof. Without limiting the generality of the foregoing, any and all such claims, etc., relating to personal injury, death, damage to property, defects in materials or workmanship, actual or alleged infringement of any patent, trademark, copyright (or application for any thereof) or of any other tangible or intangible personal or property right, or any actual or alleged violation of any applicable statute, ordinance, administrative order, rule or regulation, or decree of any court, shall be included in the indemnity hereunder. The Contractor further agrees to investigate, handle, respond to, provide defense for and defend any such claims, etc., at his sole expense and agrees to bear all other costs and expenses related thereto, even if it (claims, etc.) is groundless, false or fraudulent. In any case in which such indemnification would violate Section 5322.1 of the New York General Obligations Law, or any other applicable legal prohibition, the foregoing provisions concerning indemnification shall not be construed to indemnify the Village of Dobbs Ferry for damage arising out of bodily injury to persons or damage to property caused by or resulting from the sole negligence of the Village of Dobbs Ferry, or its employees.

BID FORM

Project:

Village of Dobbs Ferry Library, Building Automation System and Acoustic Mitigation Project

Submit Bid To:

Mr. Marcus Serrano
Village Administrator
914-231-8502
mserrano@dobbsferry.com

The undersigned BIDDER proposes and agrees, if this Bid is accepted, to enter into an agreement with The Village of Dobbs Ferry in the form included in the Contract Documents to perform and furnish all work as specified or indicated in the Contract Documents for the Contract Price and within the Contract Time indicated in this bid package, and in accordance with the other terms and conditions of the Contract Documents.

BIDDER accepts all of the terms and conditions of the Invitation to Bid and Instructions to Bidders, including without limitation those dealing with the disposition of Bid security.

This Bid will remain subject to acceptance for (120) one hundred twenty days after the day the bids become due. BIDDER must sign and submit the original Agreement with the Bonds (if required) and other documents required by the Bidding Requirements by the due date specified in the RFP document.

In submitting this Bid, BIDDER represents, as more fully set forth in the Agreement, that: BIDDER has examined copies of all the Bidding Documents and of the following Addenda (receipt of all which is hereby acknowledged):

Date

Addenda

Number

BIDDER has familiarized itself with the nature and extent of the Contract Documents, work, site, locality, prevailing wage rates and all local conditions and Laws and Regulations that in any manner may affect cost, progress, performance or furnishing of the Work.

BIDDER has correlated the results of all such observations, examinations, investigations, explorations, tests, reports and studies with the terms and conditions of the Contract Documents. This Bid is genuine and not made in the interest of or on behalf of any undisclosed person, firm or corporation and is not submitted in conformity with any agreement or rules of any group, associations, organization or corporation; BIDDER has not directly or indirectly induced or solicited any other Bidder to submit a false or sham Bid; BIDDER has not solicited or induced any person, firm or corporation to refrain from bidding; and BIDDER has not sought by collusion to obtain for itself any advantage over any other Bidder or over The Village of Dobbs Ferry.

Bidder: _____

Bidder agrees to furnish all labor, equipment, services, materials, installation, cartage, hoisting, supplies, insurance, equipment, scaffolding, tools, utilities, storage, safety equipment and other facilities of every kind and description required for the prompt and efficient execution of the work described herein. The following attachments are required to be completed and returned with the Bid package:

- Subcontractor Qualification Documents
- Project Cost Breakdown Sheet

Bidder represents that it has familiarized itself with all OSHA requirements / regulations for operations relative to the work of this contract and that the cost of adherence with such requirements / regulations is included in any price quoted herein.

Bidder will complete the Work for the following price.

Lump sum contract price:

(Use Words)

\$ _____

(Use Figures)

Signature: _____

Title: _____

Date: _____

Pricing Breakdown:

Contractor must fill in all line item costs. All "other" costs not specifically outlined should be identified by the contractor and the sum of all the line items must be equal to the total proposed project cost.

- 1. Building Automation System/System Balancing - Base Project: \$ _____
 - a. Add-Alternate #1: Additional DDC/BAS Scope \$ _____
 - b. Add-Alternate #2: VFD drives for AHU-2/RF-1/RF-2 \$ _____
 - c. Add-Alternate #3: DCV Controls AHU-1, 2 \$ _____

Total Controls Project with All Alternates: \$ _____

- 2. Acoustical Mitigation Project Total: \$ _____
 - a. Add-Alternate #1: (As defined by Bidder) \$ _____

- Total Project \$ _____**

Supporting Document Acknowledgement:

BIDDER agrees that the Work will be substantially complete within _____ calendar days after the date when the Contract Time commences to run, and completed and ready for final payment within _____ calendar days after the date when the Contract Time commences to run.

The following documents are attached to and made a condition of this Bid: (a) Subcontractor's Qualification Statement (b) Summary of the sequence of construction (c) Project Schedule - timeline (d) Identification of all lower tier Subcontractors (e) Proof of ability to bond to the bid level.

Communications concerning this Bid shall be addressed to the BIDDER indicated below:

Company Name: _____

Address: _____

Phone number: _____

Date submitted: _____

Signature: _____

Title: Date: _____

Section III
Standard Forms

PROPOSAL AND SCHEDULE FOR BIDS

EXECUTION OF THIS FORM IS MANDATORY UNDER STATE LAW

NON-COLLUSIVE BIDDING CERTIFICATION

Made pursuant to Section 103-d of the General Municipal Law of the State of New York, as amended by the Laws of 1966.

"(a) By submission of this Bid, each Bidder and each person signing on behalf of any Bidder certifies, and in the case of a joint bid, each party thereto certifies a to its own organization, under penalty of perjury, that to the best of his knowledge and belief:

"(1) The prices in this Bid have been arrived at without collusion, consultation, communication or agreement, for the purpose of restricting competition, as to any matter relating to such prices with any other Bidder or with any competitor;

"(2) Unless otherwise required by law, the prices which have been quoted in this bid have not been knowingly disclosed by the bidder and will not be knowingly disclosed by the Bidder prior to the opening, directly or indirectly, to any other Bidder or to any competitor;

"(3) No attempt has been made or will be made by the Bidder to induce any other person, partnership or corporation to submit or not to submit a Bid for the purpose of restricting competition.

"(b) A Bid shall not be considered for award nor shall any award be made where (a) (1), (2) and (3) above have not been complied with, provided, however, that, if in any case the Bidder cannot make the foregoing certification, the Bidder shall so state and shall furnish with the Bid a signed statement which sets forth in detail the reasons therefore. Where (a) (1), (2) and

(3) above have not been complied with, the Bid shall not be considered for award, nor shall any award be made unless the head of the purchasing unit of the political subdivision, public department, agency or official thereof to which the bid is submitted, or his designee, determines that such disclosure was not made for the purpose of restricting competition".

Dated _____, 20
(Seal _____ of Corporation)

Legal Name of Person, Firm or Corporation

Business Address of Person, Firm or Corporation

By _____ Title _____
Signature

Section IV

Specifications and Reference Drawings

SECTION 134800 – ACOUSTIC BARRIER WALL

PART 1 – GENERAL

1.1 SUMMARY

- A. Acoustic barriers field assembled from 4” thick pre-manufactured components. Barrier is designed to meet performance criteria specified herein as a complete assembly.
- B. Work of this section includes the layout and design of the acoustical barrier system in order to achieve a measurable reduction in noise transmittance from the Owner’s outdoor HVAC equipment to the neighboring properties.
- C. Provide design, acoustical engineering services, structural engineering services, labor, material, tools, equipment, scaffolding, transportation, inspection, certificates, and temporary protection necessary to:
 - 1. Provide an Acoustical Barrier as shown or as specified in these Specifications. Provide accessories and appurtenances required for a complete working installation.
 - 2. Connectors and flashing shall make holes in walls acoustically tight in accordance with barrier wall manufacturer’s instructions.
- D. Structural steel support frame included as part of this installation.
- E. Provide all necessary concrete work, asphalt cutting, asphalt patching for a complete installation in all respects. Provide all cutting and patching for building attachments as may be required by the design.
- F. The Contractor shall engage or provide the services of a licensed Professional Engineer (P.E.) who specializes in the field of noise control engineering and/or acoustical engineering. The PE shall provide performance testing services to benchmark the “before project” and “after project” sound emissions of the HVAC systems. The acoustical engineer shall provide a final report at the end of the project with test data stamped/signed by a licensed PE in the State of NY. Refer to par. 3.4 for additional testing procedures.
- G. The required sound performance requirement for this project shall be for the as installed sound barrier/noise mitigation system to reduce sound emissions from the building to **55 dBA** (weighted average) at the adjacent property lines. The mitigation system shall provide a measurable reduction in sound emissions from the HVAC equipment. The contractor shall be responsible for achieving the required sound levels through their design.

1.2 QUALITY ASSURANCE:

- A. Regulatory Requirements:
 - 1. Acoustical performance: Minimum NRC (Noise Reduction Coefficient) rating of 0.95 and minimum STC (Sound Transmission Class) of 42 (refer to drawings for STC requirement) after panel fabrication.

2. Structural requirements: design panels and attachment system for this installation to withstand wind loads and structural loads required by NY State Building Code.
3. Reference Standards:
 - a. ASTM E90-99 and E413-87 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.
 - b. ASTM C423-90A and ASTM E795-00, Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

1.3 SUBMITTALS:

- A. Product Data: Manufacturer's product specifications and color/finish selection chart.
- B. Shop Drawings: Complete drawings showing components including mechanical and electrical requirements.
- C. Certificate of Compliance: Certify completed assembly meets requirements specified herein.
- D. Delegated-Design Submittal: For acoustical barrier wall systems, submit all design details indicated to comply with performance requirements and design criteria, including structural analysis data signed and sealed by the qualified professional engineer in the State of New York responsible for their preparation.
 1. Design Calculations: Calculate static and dynamic loading due to equipment operation, seismic (where applicable by Building Code) and wind forces required to select acoustical wall systems, restraints, and all supports. Provide design for any required wall panel foundations and foundation anchoring systems.
 2. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with applicable NY State Building Code Requirements.
 3. Seismic and Wind Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.
- E. Acoustical Engineering Test Procedures and Reports:
 1. Submit proposed testing procedures prior to commencing with initial testing. Refer to par. 3.4 for minimum requirements for testing procedures.
 2. Provide 'before-project' test reports indicating sound levels of HVAC equipment.
 3. Provide 'after-project' test reports indicating sound levels of HVAC equipment.
 4. All engineering reports shall be stamped/signed by a Professional Engineer (PE) licensed in the State of New York.
- F. As-built Drawings: Contractor shall provide as-built drawings of the final installation for review and approval to the Owner. Submit (2) copies for review. Final as-built drawings shall be provided.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver products in sufficient quantity and time to maintain approved construction schedule.
- B. Materials shall be in original containers with seals unbroken and labels intact until time of use. Wrapped or bundled materials shall bear name of manufacturer and product. Damaged or otherwise unsuitable material, when so ascertained, shall be removed from Project site.
- C. Store products in secure, dry location, out of way of construction operations. Store products off ground and protect from elements. Wetting of elements not permitted.
- D. Prevent damage to materials, to other stored products, to existing construction, and project work.

1.5 WARRANTY

- A. Finish warranty: Furnish panel manufacturer's written warranty covering failure of the factory-applied finish on metal panels within the warranty period. This warranty shall be in addition to and not a limitation of other rights the Owner may have against the Contractor under the Contract Documents.
- B. Warranty Period: 10 years

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Available Manufacturers/Suppliers: Subject to compliance with requirements, manufacturers offering products and services that may be incorporated into the Work include, but are not limited to, the following:

- 1. NoiseBarriers, LLC.,

Representative:
Vibration Products Inc.
60 Dutch Hill Road, Suite 2
Orangeburg, NY 10962
Contact: Robert J. Buelow, Phone: (845) 365-6800 Fax: (845)365-6809
Email: rbuelow@ketchumandwalton.com

- 2. Kinetics Noise Control, LLC.,

Representative:
Vibration Products Inc.
60 Dutch Hill Road, Suite 2

Orangeburg, NY 10962
Contact: Robert J. Buelow, Phone: (845) 365-6800 Fax: (845)365-6809
Email: rbuelow@ketchumandwalton.com

3. Industrial Acoustics Company

Representative:
Quiet Star Industries
7216 Bergenline Ave.
North Bergen, NJ 07047
Contact: Bob Schmitt / Steve Dutton
Phone: 201-868-5600
Fax: 201-868-5601
Cell: 914-643-4122
E-mail: dbbob@quietstarindustries.com

4. George Koch Sons, LLC – Acoustical Enclosures/Barriers

Representative:
Mason East, Inc.
64-3 Brook Avenue
Deer Park NY 11729
Contact: Clif Perkins
Phone: (631) 254-2240
Fax: (631) 254-2199
Cell: (516) 446-4580
E-mail: cp@mason-east-inc.com

2.2 PANEL CONSTRUCTION

- A. Except as shown on Drawings or at locations described below, use 4” thick acoustical panels. Exterior surfaces are solid sheet 16-ga. Galvanized steel. Interior surfaces are 22 ga. Perforated galvanized steel.
- B. Sound-retarding and absorbing fill material shall be noncombustible, inert mildew-resistant and vermin proof.
- C. Lateral panel reinforcement shall be minimum of 18 ga. Cold rolled steel and spaced so vertical span does not exceed 2 ft. – o in.
- D. Prior to attaching face sheet, panel shall be dampened and filled with sound-retarding and absorbing elements. Fill shall be slightly larger and thicker than inside dimensions of panel. No voids will be tolerated.
- E. Weld and rivet face sheet to panel assembly to acoustically compress and hold fill materials in place. Panel assembly shall hold fill materials in place under severe conditions of vibration encountered in shipping, installation, and in operation of completed structure.
- F. Weep holes to permit water runoff shall be provided on all horizontal surfaces.

2.3 PANEL JOINING AND CONNECTORS

- A. Joint shall be a VEE grove connection in a vertical orientation as shown on the drawings
- B. Connectors shall be detailed to support loads shown on Drawings.
- C. Weep holes to permit water runoff shall be provided on all horizontal surfaces that may trap water.

2.4 FINISH

- A. Powder coated as specified and color by Owner
- B. Provide color and finish selection chart to Owner during submittal review phase.

2.5 INTERCHANGEABILITY AND REUSE

- A. Acoustic structural components having same part numbers shall be completely interchangeable.
- B. Acoustic structure shall be such that no components will be damaged upon disassembly. Design shall allow structure to be assembled, disassembled and reassembled minimum of 3 times without detracting from acoustic performance.

2.6 PANEL COMPONENT CHARACTERISTICS

- A. Submit certified laboratory test including absorption and transmission loss values for specified panel type and construction of not less than following :

		Sound Transmission Loss, dB						
OCTAVE BAND	Center Frequencies, HZ	125	250	500	1K	2K	4K	STC
	4" thick	23	31	40	49	56	62	42

		Sound Absorption Coefficients						
OCTAVE BAND	Center Frequencies, HZ	125	250	500	1K	2K	4K	NRC
	4" thick	0.68	1.06	1.12	1.08	1.03	0.98	0.95

2.7 Access Door

- A. Provide acoustically rated access doors compatible with Barrier wall.
- B. Provide access doors wherever required as necessary to access equipment concealed by Acoustical Barriers.

- C. Provide at the location as shown on approved design and submittal drawings.
- D. Provide lockable hardware per the Owner's requirements.

PART 3 - EXECUTION

3.1 PANEL SUPPORTS AND ANCHORAGE

- A. Install structural panel support members and anchorage in accordance with AISC Manual of Steel Construction "Code of Standard Practice".
- B. Install panel support members on concrete floor bolted thru base plate with inserts sized to meet wind loads.

3.2 PANEL INSTALLATION

- A. Install panels according to manufacturer's instructions and recommendations, as applicable to project conditions and supporting substrates. Anchor panels and other components of the work securely in place, with provisions for thermal and structural movement.
 - 1. Install panels with exposed fasteners pre-finished to match panel finishes.
 - 2. Any penetrations thru the barrier shall be acoustically treated by the barrier manufacturer.
- B. Accessories: Install components required for a complete acoustical barrier panel system, including trim, coping, supports and attachments, connections between panels, seam covers, sealants, fillers, closures strips and similar items.

3.3 CLEANING AND ADJUSTMENT

- A. Damaged units: Replace panels and other components of the work that have been damaged or have deteriorated beyond successful repair by means of finish touch up or similar minor repair procedures.
- B. Cleaning: Remove temporary protective coverings and strippable films (if any) as soon as each panel is installed. Upon completion of panel installation, clean finished surfaces as recommended by panel manufacturer, and maintain in a clean condition during construction.

4.4 PROCEDURES FOR SOUND-LEVEL MEASUREMENTS

- A. Provide a pre-project test to determine existing sound levels prior to start of construction. Initially take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.
- B. Provide post-project testing to determine and prove effectiveness of installed acoustical mitigation strategies. Initially take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.

- C. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.
- D. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.
- E. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm, use a windscreen on the microphone.
- F. Perform measurements when the occupant noise level from other spaces in the building and outside are at a minimum.
- G. Clear the space to be tested of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.
- H. Take sound measurements at a height approximately 48 inches above the ground and at least 36 inches from a wall, column, and other large surface capable of altering the measurements whenever possible.
- I. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.
- J. Perform sound testing at multiple locations on the Project Site. Select measurement locations that are expected to have the greatest sound level. The following list are the minimum number of locations required:
 - 1. At approximately 3' horizontally from the HVAC equipment, on each of (4) sides.
 - 2. At each of the shared property boundary lines, at a point of maximum expected sound levels.
- K. Perform above tests for both the before project and after project conditions.

END OF SECTION 134800

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Variable-air-volume systems
 - b. Fan-Powered VAV Boxes.
 - c. Exhaust fans.
 - d. Terminal heating units.
 - 2. Balancing Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Certified TAB reports.
- C. Sample report forms.
- D. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity certified by NEBB or TABB.
1. TAB Field Supervisor: Employee of the TAB contractor and certified by NEBB or TABB.
 2. TAB Technician: Employee of the TAB contractor and who is certified by NEBB or TABB as a TAB technician.
- B. TAB Conference: Meet with Owner and Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.
1. Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Coordination and cooperation of trades and subcontractors.
 - d. Coordination of documentation and communication flow.
- C. Certify TAB field data reports and perform the following:
1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- D. TAB Report Forms: Use standard TAB contractor's forms approved by Commissioning Authority.
- E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."
- F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

- A. Notice: Provide seven days advance notice for each test. Include scheduled test dates and times.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

- A. Subject to compliance with requirements, available TAB contractors that may be engaged include, but are not limited to, the following:
 - 1. DL Flowtech.

3.2 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- B. Examine the existing systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

- F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- G. Examine test reports specified in individual system and equipment Sections.
- H. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- I. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- J. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- K. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- M. Examine system pumps to ensure absence of entrained air in the suction piping.
- N. Examine operating safety interlocks and controls on HVAC equipment.
- O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system-readiness checks and prepare reports. Verify the following:
 - 1. Permanent electrical-power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic temperature-control systems are operational.
 - 4. Equipment and duct access doors are securely closed.
 - 5. Balance, smoke, and fire dampers are open.
 - 6. Isolating and balancing valves are open and control valves are operational.
 - 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 2. After testing and balancing, install test ports and duct access doors.
 3. Install and join new insulation that matches removed materials.
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal

units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

- B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 3. Measure total system airflow. Adjust to within indicated airflow.
 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 8. Record final fan-performance data.
- C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance variable-air-volume systems the same as described for constant-volume air systems.
 2. Set terminal units and supply fan at full-airflow condition.
 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 4. Readjust fan airflow for final maximum readings.
 5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
 6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.

7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
- D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
 3. Set terminal units at full-airflow condition.
 4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 5. Adjust terminal units for minimum airflow.
 6. Measure static pressure at the sensor.
 7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 1. Open all manual valves for maximum flow.
 2. Check liquid level in expansion tank.
 3. Check makeup water-station pressure gage for adequate pressure for highest vent.
 4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
 5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.

6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
 1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 - a. Monitor motor performance during procedures and do not operate motors in overload conditions.
 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 4. Report flow rates that are not within plus or minus 10 percent of design.
- B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
- C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.
- D. Set calibrated balancing valves, if installed, at calculated presettings.
- E. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 1. Determine the balancing station with the highest percentage over indicated flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.

3. Record settings and mark balancing devices.
- H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.
- J. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Efficiency rating.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.10 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.11 PROCEDURES FOR BOILERS

- A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.
- B. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

3.12 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each water coil:
 1. Entering- and leaving-water temperature.
 2. Water flow rate.

3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.13 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform testing and balancing of the entire existing system in accordance with procedures in this section.

3.14 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.

3.15 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents and the existing conditions as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend

changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

- B. Status Reports: Prepare monthly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB contractor.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB supervisor who certifies the report.
 - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 - 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 - 12. Nomenclature sheets for each item of equipment.
 - 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 - 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 - 15. Test conditions for fans and pump performance forms including the following:

- a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 3. Test Data (Indicated and Actual Values):
 - a. Total air flow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.

- e. Filter static-pressure differential in inches wg.
- f. Preheat-coil static-pressure differential in inches wg.
- g. Cooling-coil static-pressure differential in inches wg.
- h. Heating-coil static-pressure differential in inches wg.
- i. Outdoor airflow in cfm.
- j. Return airflow in cfm.
- k. Outdoor-air damper position.
- l. Return-air damper position.
- m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

- a. System identification.
- b. Location.
- c. Coil type.
- d. Number of rows.
- e. Fin spacing in fins per inch o.c.
- f. Make and model number.
- g. Face area in sq. ft..
- h. Tube size in NPS.
- i. Tube and fin materials.
- j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

- a. Air flow rate in cfm.
- b. Average face velocity in fpm.
- c. Air pressure drop in inches wg.
- d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
- e. Return-air, wet- and dry-bulb temperatures in deg F.
- f. Entering-air, wet- and dry-bulb temperatures in deg F.
- g. Leaving-air, wet- and dry-bulb temperatures in deg F.
- h. Water flow rate in gpm.
- i. Water pressure differential in feet of head or psig.
- j. Entering-water temperature in deg F.
- k. Leaving-water temperature in deg F.
- l. Refrigerant expansion valve and refrigerant types.
- m. Refrigerant suction pressure in psig.
- n. Refrigerant suction temperature in deg F.
- o. Inlet steam pressure in psig.

G. Fan Test Reports: For supply, return, exhaust fans, and terminal units, include the following:

1. Fan Data:

- a. System identification.
- b. Location.
- c. Make and type.
- d. Model number and size.

- e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave, and amount of adjustments in inches.
2. Motor Data:
- a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values):
- a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
- a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Indicated air flow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual air flow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- I. Air-Terminal-Device Reports:
1. Unit Data:
- a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.

- h. Size.
 - i. Effective area in sq. ft..
 - 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary air flow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final air flow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 - 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm.
 - g. Water pressure differential in feet of head or psig.
 - h. Required net positive suction head in feet of head or psig.
 - i. Pump rpm.
 - j. Impeller diameter in inches.
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.

- o. Full-load amperage and service factor.
 - p. Seal type.
2. Test Data (Indicated and Actual Values):
- a. Static head in feet of head or psig.
 - b. Pump shutoff pressure in feet of head or psig.
 - c. Actual impeller size in inches.
 - d. Full-open flow rate in gpm.
 - e. Full-open pressure in feet of head or psig.
 - f. Final discharge pressure in feet of head or psig.
 - g. Final suction pressure in feet of head or psig.
 - h. Final total pressure in feet of head or psig.
 - i. Final water flow rate in gpm.
 - j. Voltage at each connection.
 - k. Amperage for each phase.

L. Instrument Calibration Reports:

1. Report Data:
- a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.17 INSPECTIONS

A. Initial Inspection:

- 1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
- 2. Check the following for each system:
 - a. Measure airflow of at least 5 percent of air outlets.
 - b. Measure water flow of at least 5 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Verify that balancing devices are marked with final balance position.
 - e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

- 1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Commissioning Authority.
- 2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.

3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
 5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.
- D. Prepare test and inspection reports.

END OF SECTION 230593

SECTION 230800 - COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

- A. Commissioning requires the participation of the mechanical contractor and subcontractors, to ensure that all systems are operating in a manner consistent with the contract documents.

1.2 SYSTEMS TO BE COMMISSIONED

- A. The following mechanical systems will be commissioned on this project:
 1. Heating systems
 2. Hot water systems
 3. Air handling units
 4. Air conditioning systems
 5. Exhaust fans
 6. Building control system
 7. Testing, adjusting and balancing work (review of TAB report)

1.3 OPERATION AND MAINTENANCE (O&M) MANUALS

- A. Compile and prepare documentation for all equipment and systems covered in the design documents and deliver to the owner for inclusion in final O&M manuals.

PART 2 - EXECUTION

2.1 PREFUNCTIONAL CHECKLISTS AND STARTUP

- A. Prefunctional tests and checklists (PFT's) are important to ensure that the equipment and systems are connected properly and are operational. PFT's ensure that functional performance testing may proceed without unnecessary delays. The contractor shall be responsible for performing prefunctional testing. Each piece of related equipment receives a full prefunctional checkout.
- B. The contractor has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting design objectives of the RFP documents. Commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to Commissioning Authority or Owner.

2.2 PREFUNCTIONAL TRENDING DATA

- A. The BAS Contractor shall setup and trend a number of data points prior to the functional testing phase. Trend data shall be submitted to the Commissioning Authority for review prior to scheduling of functional testing. Trend data may be submitted electronically or in hardcopy format. The following minimum trend data shall be submitted:
 1. Space temperatures for a sampling of spaces (5% of temperature zones, or 5 spaces, whichever is more).

2. Outside air temperature during the trending period.
3. Space temperature setpoints
4. AHU supply fan status and speed (if applicable).
5. Space VAV box CFM and damper position

- B. Trend formats shall be graphic based (line graph, with time as X-axis) with multiple points plotted on same graphic wherever possible. Data shall be provided for a 1 week period, with hourly intervals.

2.3 FUNCTIONAL PERFORMANCE TESTS

- A. Functional testing is intended to begin upon completion of the work and resolution of any open issues.
- B. Functional performance testing requirements are in addition to and do not replace any testing required by code.
- C. Functional performance testing procedures will be performed on but not be limited to the following system types and equipment. Final functional testing requirements and procedures will be developed based on approved equipment shop drawings.

1. Heating systems
 - a. Equipment:
 - 1) Air conditioning units
 - 2) VAV boxes (fan powered)
 - 3) HW circulating pumps
 - 4) Control panel and components
2. Building management system
 - a. Equipment:
 - 1) Field control panels
 - 2) Operator workstations
 - 3) File server(s)
 - 4) LAN interface equipment
 - 5) Verification of controls front end.

- D. The associated contractor shall be responsible for the correction of all commissioning issues that pertain to their trade. The contractor shall send a dated response to the commissioning team in writing that an open issue has been rectified. When the commissioning team receives the written rectification of an open issue the commissioning team will re-verify the issue to ensure issue has been rectified. The commissioning team will provide only one re-verification visit to each open item. In the case where the associated contractor provides the written rectification of an open issue and the item was never rectified. The associated contractor shall be held responsible for the commissioning team additional time needed to re-verify the open issue.

2.4 TRAINING OF OWNER PERSONNEL

- A. Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.
- B. Refer to section 230900 for detailed training scope.

END OF SECTION 230800

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including any applicable General and Supplementary Conditions and any Division 01 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 23 Section "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.2 DEFINITIONS

- A. DDC: Direct digital control.
- B. BAS: Building Automation System
- C. B-BC: Building Controller
- D. B-AAC: Advanced Application Controller
- E. B-ASC: Application Specific Controller
- F. B-OWS: Operator Workstation
- G. I/O: Input/output.
- H. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- I. MS/TP: Master slave/token passing.
- J. PC: Personal computer.
- K. PID: Proportional plus integral plus derivative.
- L. RTD: Resistance temperature detector.

1.3 SUMMARY

- A. Work Included:
 - 1. Furnish and install a BACnet internetwork and control system.

2. The Building Automation System Contractor shall coordinate the requirements of all mechanical and electrical equipment that will be controlled and shall be responsible for the coordination and interface requirements between the Control System, the Mechanical and Electrical Systems, and existing conditions.
3. The contractor shall be responsible for obtaining all necessary permits and paying all fees associated with this work including but not limited to filing with the utility company (as required), obtaining work permits, electrical work permits, from the local authority having jurisdiction.
4. The Building Automation System contractor shall be the prime contractor for this project. All other contractors shall be sub-contractors (electrical, plumbing, etc.) as determined by the BAS contractor. Provide a complete functional Building Automation System in all respects.
5. Provide all power wiring required by the Building Automation System scope.
6. Provide any testing and balancing services as required to accomplish the intended sequence of operations.
7. Contractor to field verify all existing conditions prior to the beginning of work and coordinate new work.
8. Visit site before submitting bid. Inspect and verify all conditions which may affect cost of installation. Verify exact location of all existing pipes, ducts, beams, etc., whether shown on the drawings or not, so far as these locations relate to the new work.
9. Add-Alternates:
 - a. Refer to "Sequence of Operation" for description of the Add-Alternates.

B. System Description

1. General Requirements
 - a. The Control System shall be an on-line network of distributed, communicating micro-processor based stand-alone controllers, including PC based operator workstation interfaces and programming software applications, field sensors, control devices, enclosures and interconnecting conduit and wire.
 - b. The Control System provided shall be supplied with a complete Web enabled operator interface. The Web enabled application shall operate on industry standard PC servers. Proprietary servers or "Black Boxes" will not be acceptable. Third party Web enabled applications are acceptable if they are configured to be indistinguishable from the OWS applications. The Owner at the Owner's expense shall provide connection to the Web. The LAN connection type will be information that is required to be provided to the System Contractor.
 - c. The networked components of the system shall make up a BACnet internetwork including at least a high speed and/or other LAN's interconnecting BACnet devices.

Those devices on the BACnet internetwork shall communicate utilizing the BACnet protocol on BACnet LAN types.

- d. Actuation of control devices shall be electronic. Spring return fail-safe actuation shall be provided when loss of property is possible without spring return fail-safe.
- e. Where the System Contractor has determined that existing pneumatic end-devices are considered to be operational and functional they may be re-used with the permission of the Engineer to accomplish the sequence, except where new devices are called for or required in sequence of operation.

2. Basic System Architecture

- a. The system components shall include but not be limited to:
 - 1) WEB Server with operating software
 - 2) Operator Workstation with operating software (B-OWS)
 - 3) Third Party Application Software
 - 4) Building Controllers (B-BC)
 - 5) Advanced Application Controllers (B-AAC)
 - 6) Application Specific Controllers (B-ASC)
 - 7) Enclosures
 - 8) Field Sensors
 - 9) Controlled Devices
 - 10) Interconnecting Wire & Cabling
 - 11) Service Tools
 - 12) Network LAN's & Communication Protocols
 - 13) Interfaces for Hardwire Connection to Variable Frequency Controls; chillers & lighting control
 - 14) Serial interface to other system listed below:
- b. Field Sensors and Control Devices shall connect to peer-to-peer, fully programmable B-BC, B-AAC & B-ASC as required to achieve the point monitoring and control sequences specified. All devices are to be monitored by B-OWS. Controlled devices are to be electronically actuated. Each mechanical system shall have a controller that shall be connected to all field sensors and control devices for that system. Sensors and Control devices shall be UL listed.

1.3 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
1. Graphics shall display with a minimum of 50 dynamic current data points and within 10 seconds of the request.
 2. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 10 seconds. Analog objects shall start to adjust within 10 seconds of being commanded to change.
 3. All changes of state or change of analog values shall be transmitted such that no reporting of a value is more than 15 seconds old.
 4. The maximum time from when an object goes into alarm to when it is annunciated at the B-OWS shall not exceed 20 seconds. Those points denoted as critical shall be annunciated within 2 seconds.
 5. B-BC, B-AAC, & B-ASC shall be able to execute control loops at a selectable frequency at least 5 times every second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
 6. All B-OWS on the network shall receive alarms within 5 seconds of each other.
 - a. Each controller/sensor combination shall be selected and designed to perform within the accuracy and repeatability limits specified herein.
 - b. Unless noted otherwise in these Specifications the overall combined system accuracy of sensors, controllers and readout devices shall be noted in Table 1.

Table 1 – System Accuracy	
Measured Variable	Reported Accuracy
Space temperature	+/-0.5 deg C (+/-1 deg F)
Ducted air	+/-1.0 deg C (+/-2 deg F)
Outside air	+/-1.0 deg C (+/-2 deg F)
Water temperature	+/-0.5 deg C (+/-1 deg F)
Delta-T	+/-0.15 deg C (+/-0.25 deg F)
Relative humidity	+/-3% RH 10-95% RH
Water flow	+/-2% of actual valve
Air flow (terminal)	+/-10% of actual valve (Note 1)
Air flow (measuring stations)	+/-2% for calibrated range.
Air pressure (ducts)	+/-25 Pa (+/-0.1 WG)
Air pressure (space)	+/-3 Pa (+/-0.01 WG)
Water pressure	+/-1PSI (Note 2)
Electrical Power	±2% of Range (Note 3)
Carbon Monoxide (CO)	+/-5 Percent of Reading
Carbon Dioxide (CO ²)	+/- 50 PPM
Note 1: (10% to 100% of scale) (cannot read accurately below 10%)	
Note 2: for both absolute and differential pressure	
Note 3: * not including utility supplied meters	

- c. Overall combined system repeatability of sensors, controllers and readout devices for a particular application shall be plus or minus 2 percent of full scale of the operating range. Repeatability of overall combined system of sensor, controller and readout device in a control loop application will be plus or minus 5 percent of full scale of the operating range.
 - d. Long-term electronic drift shall not exceed 0.4 percent per year.
- 7. The system to have an ultimate capacity of at least 20,000 to 30,000 points.
 - 8. All components provided as part of this system shall operate under indoor ambient environmental conditions of 35 to 122 deg F dry bulb and 10 percent to 95 percent relative humidity, non-condensing as a minimum. Outdoor conditions shall be -30°F to 150°F and 0 percent to 100 percent relative humidity. Sensors and control elements shall operate under the ambient environmental temperature, pressure, humidity, and vibration conditions encountered for the installed location. B-OWS equipment, such as CRTs and printers, shall, unless designated otherwise, operate properly under ambient environmental conditions of 45 to 90 deg F and a relative humidity of 10 percent to 90 percent.
 - 9. Networked components of the system shall be able to operate at 90-percent to 110-percent of nominal voltage rating and shall perform an orderly shutdown below 80-percent.
 - 10. All sensors and control devices exposed directly to a controlled media shall be rated to withstand 150 percent of maximum conditions found where in contact with the controlled media, and shall be constructed of material suitable for the media sensed.

1.4 SEQUENCE OF OPERATION (Refer to separate section)

1.5 SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
 - 1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 - 2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
 - 3. 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.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
 3. Wiring Diagrams: Power, signal, and control wiring.
 4. Details of control panel faces, including controls, instruments, and labeling.
 5. Written description of sequence of operation.
 6. Schedule of dampers including size, leakage, and flow characteristics.
 7. Schedule of valves including flow characteristics.
 8. DDC System Hardware:
 - a. Wiring diagrams for control units with termination numbers.
 - b. Schematic diagrams and floor plans for field sensors and control hardware.
 - c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
 9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
 10. Controlled Systems:
 - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
 - c. Written description of sequence of operation including schematic diagram.
 - d. Points list.
- C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.
- D. Samples for Initial Selection: For each color required, of each type of thermostat or sensor cover with factory-applied color finishes.
- E. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.
 5. Software license required by and installed for DDC workstations and control systems.
- F. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
- G. Qualification Data: For Installer and manufacturer.
- H. Field quality-control test reports.
- I. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.
- B. System Contractor shall be a licensed contractor specializing and experienced in control system installations for not less than 5 years and with experience in networked microprocessor based commercial HVAC and Electrical control systems installation with point counts equal to this project.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with ASHRAE 135-2001: "BACnet - Building Automation and Control Networking Protocol" for DDC system components.
- E. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. System Software: Update to latest version of software at Project completion.

1.8 COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation, and coordinate with Owner's approval.

1.9 WARRANTY, MAINTENANCE, NORMAL AND EMERGENCY SERVICE

- A. The Contractor shall warranty the Control System to be free from defects in workmanship and material under normal expected service and use for a period of one (1) year from date of final acceptance by the Owner. During this period, the Contractor shall furnish all labor to repair or replace all items or components that fail due to defects in workmanship or material at no charge or reduction in service to the owner. Provide this service within 4 hours of notice from the Owner's representative.
- B. Manufacturer shall provide a five-year warranty for all B-BC, B-AAC and B-ASC controllers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

- A. Acceptable Building Automation System Manufacturers:
 - 1. Reliable Controls Corp.
 - 2. T.A.C. – Andover Continuum
 - 3. Automated Logic Corporation
- B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 WEB SERVER HARDWARE

- A. Hardware: The WEB Server shall be a 19” rack-mount Windows 2000 server.
- B. Database: The complete database of each B-BC, B-AAC and B-ASC shall reside (at a minimum) within the respective device. The Web Server Hardware may retain and utilize a backup of the database within each device; however, the complete and original database must reside in the B-BC, B-AAC, and B-ASC.
- C. Software: Provide licensed copy of the Control System WEB Enabled Application Software described in Section 2.4. This license shall allow unlimited access to the Web Server by an unlimited number of simultaneous clients.

2.4 WEB ENABLED APPLICATION SOFTWARE

- A. The WEB Enabled Application software and system graphics is to be stored on the WEB Server hard disk drive. WEB Enabled Applications that require system graphics to be stored on the client machines will not be acceptable. The application shall support unlimited access by an unlimited number of clients using standard Web browser such as Internet Explorer.

- B. Client Web Browser applications shall run on any operating system and system configuration that is supported by the Web Browser. WEB Enabled Applications that require specific PC requirements in terms of processor speed, memory, etc. in order to allow the WEB Enabled features to operate on the Web Browser shall not be acceptable.
- C. The WEB Enabled Application shall provide the same methodology when viewing the BACnet Internetwork in terms of network architecture, system graphics, calendars, logs, etc. Systems utilizing Web Enabled Applications and Control Operator Workstation Applications of different manufacturer shall implement both applications so that the methodology is the same. Control Systems that utilize different methodology between the WEB Enabled Application and the Control System Operator Workstation Application for network architecture views, system graphic presentation or request, object, schedule or alarm interaction will not be acceptable.
- D. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
- E. Users shall have administrator defined access privileges. Depending on the access privileges assigned, the user shall be able to utilize those features described herein at different levels of interface varying between View only and Modify.
- F. HTML programming shall not be required to display system graphics or data on a Web page.
- G. The WEB Enabled Application shall support via the Web Browser client the following as it is described in the Control System Operator Workstation Application as a minimum:
 - 1. Password Protection
 - 2. Alarming and Event Notification
 - 3. Weekly and Annual Scheduling
 - 4. Trend Log Graphing
 - 5. Runtime Log Information
 - 6. Manually Overriding of Any Point
 - 7. Adjusting any Setpoint
- H. The WEB Enabled Application shall support via the Web Browser client the following in addition to what is described above:
 - 1. Color Graphics
 - a. The windowing environment shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, and/or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
 - b. All color graphic display shall be dynamic with current point data automatically updated from the BACnet internetwork to the browser without operator intervention. Manual operator intervention shall use the same methodology as on the B-OWS application.
 - c. The operator shall be able to manually adjust digital, analog or calculated values in the system, adjust values of control loops, and command points to local mode or release points to automatic mode.
- I. System Graphic screens developed for the B-OWS shall be the same screen used for the Web Browser Client. Systems, which require special translation or re-export of graphics to accommodate the web domain, will not be accepted. The Web Browser client shall support any System Graphic animation supported by the B-OWS. System Graphic screens on the Web

Browser client shall support hypertext links to other location on the Internet or on Intranet sites by specifying the Uniform Resource Locator (URL) for the desired link.

- J. The WEB Enabled Application shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to a defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.

2.5 OPERATOR WORKSTATION (B-OWS):

- A. Hardware: PC based desktop workstation shall operate with common database and graphic files shall be stored on a PC based operators workstation designated and acting as the system server consisting of the following:
 1. 1.4 GHz Pentium IV processor
 2. 512 MB RAM
 3. 20 Gigabyte or larger hard disc drive with 12 millisecond access time
 4. Enhanced style keyboard with 101 key layout, 10 function keys, operate numeric keypad and separate cursor control pads.
 5. Tower case with at least two spare drive slots and 3 spare board slots.
 6. A 19" diagonal screen non-interlaced LCD monitor with at least 1024*768 resolution, a fully adjustable tilting base, separate control for color, contrast and brightness and non-reflective screen.
 7. SVGA video output with 32MB video RAM
 8. Two button mouse with adjustable sensitivity and desk pad.
 9. CD-RW drive
 10. Internal 56 K BPS modem
 11. All required cables
 12. At least one spare serial port
 13. A combination surge suppressor/ UPS dedicated to this server and printer.
 14. All communication ports to connect all devices here and networked communications from the control system.
 15. Provide an integral audio tone generator to activate on detection of an alarm. Audio tone shall be capable of being enabled or disabled on operator command.
- B. Control System Application Software
 - a. Provide licensed copy of Control System Application Software described in Section 2.7.
- C. Communications and Protocols
 1. B-OWS information access for the control system shall utilize the BACnet protocol and any other open protocol or proprietary protocol.
 2. B-OWS shall reside on the same LAN as B-BC's. B-OWS shall as a minimum support point-to-point (PTP) and BACnet/IP physical/data link layer protocols.
 3. The B-OWS specified here may, at the Owner's option, be located remote from the BACnet internetwork. Other than the difference in B-OWS communication speed, the system shall be capable of remote operation via BACnet LAN types with no degradation in application performance.
- D. ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

2.6 B-OWS PC SYSTEMS OPERATING SYSTEM SOFTWARE

- A. All of the PC based OWS provided as part of this contract shall be provided with the same type and version of Operating System software. The Operating System software shall be Microsoft Windows XP Pro.

2.7 CONTROL SYSTEM OPERATORS WORKSTATIONS APPLICATION SOFTWARE

- A. The Control System Application software is to be stored on the PC or if more than one B-OWS is provided on the PC Server B-OWS hard disk drive.

B. Password Protection

1. Multiple-level password access protection shall be provided.
2. Passwords shall be exactly the same for all operator devices, including portable or panel mounted network terminals.
3. A minimum of six levels of access shall be supported:
4. A minimum of 50 passwords shall be supported at each B-OWS.
5. Operators will be able to perform only those commands available for their respective passwords.
6. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

C. Alarming and Event Notification

1. B-OWS terminal shall provide audible, visual, and printed means of alarm and event notification.
2. System shall provide log of notification messages. Alarm log shall be archived to the hard disk of the system B-OWS.
3. Alarm messages shall be in user-definable text (English or other specified language) and shall be entered either at the B-OWS terminal or via remote communication.
4. An alarm summary shall be available to show all alarms whether or not they have been acknowledged.
5. System shall provide ability to prioritize and differentiate communications for at least 6 different levels of alarms
6. Alarm messages shall be fully customizable in size, content, behavior and sound.

D. Weekly and Annual Scheduling

1. Provide separate schedules for each day of the week, and provide at least two On/Off periods per day.
2. Provide the ability for the operator to designate any day of the year as an exception schedule.
3. Provide the capability for the operator to define up to special or holiday schedules.
4. There shall be a provision with proper password access to manually override each schedule.
5. Provide the capability to designate any schedule to be "Executed Once" then automatically cleared.

E. Trend Log Graphing

1. Any system point either real or calculated shall be assignable to the historical trending program by gathering historical samples of object data stored in the field equipment (global controllers, field controllers). All trend log information shall be displayable in

text and graphic format, and shall be able to be printed in black & white or color. Long-term archives shall be stored onto a dedicated machine or server.

F. Runtime Log Information

1. The system shall monitor equipment status and generate maintenance messages based upon user designated run time

G. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started; along with the time delay between starts shall be user-selectable.

H. All binary output points shall be protected from short cycling. This feature shall allow minimum on time and off-time to be selected.

I. System Configuration, Set-Up and Definition.

1. Device and network status shall be displayed for any device on the BACnet internetwork.
2. All control strategies and energy management routines shall be stored in the controller and shall be definable by the operator.
3. B-OWS shall be able to back-up and restore the programming and data for any BACnet device on the BACnet internetwork. Users shall also have the ability to manually execute downloads of any or all portions of a device database.
4. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system.
 - a. Provide the tools to create, modify and debug all application programming.

J. Color Graphics

1. Provide a color graphics package to allow the user to generate custom dynamic graphics for graphical representation of system design and system parameters. Graphic images may reside on the B-OWS or server; however, all dynamic data and attributes must reside in the controller.
 - a. A listed set of symbols and graphic slides shall be provided to allow operators to select from the graphics table to assist in graphic generation.
 - 1) All color graphic display shall be dynamic with current point data automatically updated from the BACnet internetwork to the B-OWS workstation without operator intervention.
 - 2) The operator shall be able to manually adjust digital, analog or calculated values in the system, adjust values of control loops, and command points to local mode or release points to automatic mode.
 - b. The windowing environment of the B-OWS shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, and/or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
 - c. Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays. The system shall provide libraries of pre-engineered screens and symbols depicting mechanical system components.
 - d. The contractor shall provide all graphics.
2. The system shall be provided with fully automatic diagnostic procedures for verification of field communication. In the event of communications failure, the system shall AutoDial the condition to a remote operator. AutoDial out will repeat alarms while the situation remains unacknowledged.

3. Control Summaries, Reports and Logging:
 - a. The system shall provide self-documentation reporting to summarize control strategies for any point or any user selected group of points within the Control System.
 - b. The B-OWS shall provide reporting and logging functions for user defined point value and status information.
 - c. The B-OWS reporting package shall allow the user to configure the point information display in custom format.

2.8 THIRD PARTY APPLICATION SOFTWARE

- A. Provide one copy of the latest version of Microsoft Office 2000 Professional for each Remote, Portable or on-site Operator Workstation.

2.9 SERVICE TOOLS

- A. Hardware and Operating System
 1. Provide, at a minimum, one of each proprietary hardware and/or software tools required to service the system, including all manuals and licenses. In the case of multiple type service tools, one of each type shall be provided.

2.10 LAN TYPES AND COMMUNICATIONS

- A. This Control System shall comprise a BACnet inter-network, as described in Part 1.
- B. Each BACnet device shall operate on the BACnet physical/data link protocols specified for that device. Physical/data link protocol types utilized for communications exchange throughout the system will be limited to those LAN types described in the ANSI/ASHRAE Standard 135-1995, BACnet. BACnet LAN types are the following:
 1. BACnet/IP.
 2. Ethernet (10Mps/100 Mps)(IEEE 802.3) via 10BASE-T, 10BASE-2, 10BASE-5, and 10BASE-F.
 3. Master Slave/Token Passing (MS/TP) via RS-485.
 4. Point-to-Point via RS-232 or Modem connection.
- C. The System Contractor shall provide all communication media, connectors, repeaters, modems, switches, hubs, bridges and routers and half-routers necessary for the BACnet Internetwork.

2.11 BACnet PROTOCOL VERIFICATION SOFTWARE

- A. The System contractor shall as part of this contract provide a licensed copy of Cimetrics BAS-o-matic Protocol Analyzer. This software shall be installed on at least one of the owners Ethernet connected BACnet Operator Workstations (B-OWS). Should no BACnet Protocol packets be visible on the BACnet Internetwork then the system as installed will be rejected.

2.12 BUILDING CONTROLLERS (B-BC)

A. Hardware and Operating System

1. Provide B-BC as required to meet the topology and performance requirements of the project. "Refer to Sequence of Operations" for detailed performance requirements.
2. Each B-BC shall have an on-board power switch.
3. B-BC shall provide battery-backed distributed processing and shall communicate with all B-AAC's and B-ASC's on a peer-to-peer basis.
4. B-BC shall be capable of deciding global strategies for the system based on information from any objects in the system. Control Systems that require a higher-level host processor for update, time stamps, global point data, COS transfer, on-line control instruction, or communications control between B-BC panels shall not be acceptable.
5. B-BC shall be capable of either discriminating or indiscriminately sharing global data with other B-BC and B-OWS on the BACnet internetwork.
6. Input/Output Configuration
 - a. All inputs shall be universal and configured in hardware or software. Inputs shall accept dry-contact, 4-20mA, thermistor and 0-5VDC sources. Pulse accumulation points shall accommodate a minimum frequency of 20Hz. Analogue to digital to digital conversion shall be 12 bit resolution.
 - b. All outputs shall be universal and configured as analogue or digital in hardware or software. Outputs shall provide modulating signal to industry standard 4-20 mA, 0-5v and 0-10v analog control devices and control relays. All outputs shall be capable of sourcing at least 50mA of current simultaneously. Digital to analog conversion shall be a minimum of 12 bit resolution. All outputs shall have physical hand-off-auto switched located within the control enclosure. H-O-A switch shall be hardware monitored by the B-BC for switch position.
7. B-BCs shall have sufficient memory to support its operating system, database, and programming requirements. Battery shall retain static RAM memory and clock functions for a minimum of 72 hours. B-BC operating system, field database, and application programs shall reside in on-board memory or EEPROM.
8. Provide diagnostic LEDs for power, communications and processor. The B-BC shall continually check the status of its processor and memory circuits.

B. Control System Application Software

1. Database definition shall be accomplished through the B-OWS online with the B-BC. The complete database and application program shall reside in the B-BC. The System Contractor shall configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents. The user shall be able to add, delete, or modify objects on-line as required. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary for proper sequence of control.
2. The software defined within the B-BC, in conjunction with the stand alone control loops residing within the B-AAC & B-ASC shall provide all required application programming.
3. Alarm management shall be provided. Each B-BC panel shall perform distributed, independent alarm analysis and filtering. At no time shall the B-BC panel's ability to

report alarms be affected by either operator activity at a B-OWS or local I/O device, or communications with other B-BC on the network.

- a. B-BCs shall have capability to call out alarm conditions automatically. Alarm message and site description shall be sent to off-site computer or serial printer. If desired, controller may also send encoded message to digital pager.
 - b. Alarms log shall be viewable on site or remotely shall be provided.
 - c. All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.
 - d. The user shall be able to define the specific system reaction for each point alarm and shall be able to customize reaction and filtering to minimize nuisance reporting. Each B-BC panel shall automatically inhibit the reporting of selected alarms during the standby power modes of operation, loss of power, fire alarm mode, and normal system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 - e. Alarm reports, messages, and files can be directed to a user-defined list of operator devices, or PCs used for archiving alarm information.
4. A variety of historical data collection utilities shall be provided. Minimum sampling time shall be programmable with a minimum programmable time of one second.
 - a. B-BC panels shall store point history files for all analog and binary inputs and outputs.
 - b. Measure and calculated analog and binary data shall also be assignable to user-definable trends.
 - c. Trend data shall be stored at the stand-alone B-BC panels, and uploaded to hard disk storage when archival is desired. Separate archival application software will be accepted.
 5. Stand-alone B-BC panels shall automatically accumulate and store runtime hours for binary input and output points.
 6. B-BC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.
 7. B-BC panels shall have the ability to count events on a daily, weekly, or monthly basis.
 8. Demand Limiting
 - a. System shall be capable to monitor energy demand from any type of energy source. Networked B-BC shall provide a demand-limiting routine that shall shed appropriate system objects to prevent the demand from exceeding preset limits.
 - b. Zone shed method shall be by either preventing zone heating or cooling operations, or by shifting zone heating and cooling set points.
 9. The B-BC shall meet BACnet profile for Building Controllers.
- C. Communication and Protocols
1. Each B-BC shall reside on the same BACnet LAN type as B-OWS.

2. The B-BC shall continuously scan the BACnet Internetwork and maintain a current database of field data in on board battery backed RAM or EEPROM. The B-BC shall coordinate transfer of data between B-OWS and B-BC.
3. The B-BC shall provide a communications port for connection of the Portable Operators Terminal using Point-to-Point BACnet physical data link layer protocol or a connection to the inter-network using BACnet/IP.
4. Provide all functions that will allow remote communications via modem to off-site locations. Include modem along with all cabling necessary for installation.

2.13 ADVANCED APPLICATION CONTROLLER (B-AAC)

A. Hardware & Operating System

1. Each B-AAC shall have an on-board power switch. If the device manufacturer provides no on-board switch then the System Contractor shall provide a separate dedicated transformer and switch within each enclosure for each controller present.
2. Provide a dedicated B-AAC for each major mechanical system including all primary VAV AHU's and constant volume AHU's with ducted OA and except those so noted. B-ASC will only be acceptable for those systems described in 2.14.
3. Each B-AAC operating system shall reside in FLASH EEPROM.
4. Each B-AAC to be expandable by adding Input/Output logic modules or Input/Output expansion modules.
5. The primary device for input/output connection to the field sensors, and control devices shall be a B-AAC. Each B-AAC shall acquire, process and store point input data on a real time basis for internal use and for sharing with other controllers. Each B-AAC shall also maintain and supervise digital and analog output signals to the control devices and have a real time operating system capable of time of day scheduling and other time based functions.
6. B-AAC shall provide microprocessor based self-contained stand-alone fully programmable operation of local process control loops. All local level application programs shall be installed on individual controllers in non-volatile memory. Each B-AAC shall be capable of sharing point information with other B-BC, B-AAC, or B-ASC on the BACnet internetwork.
7. Control systems that require communication between B-AAC or B-ASC and a B-OWS or B-BC for normal control functions, or which operate in a degraded mode without those level communications, or which require programmable read only memory (PROM) level application programming are not acceptable.
8. Once downloaded, a B-AAC shall not require further communication with the B-OWS except for data base changes, operator commands, and requests from the B-OWS for B-AAC data. Programming of B-AACs shall be completely modifiable in the field, over installed BACnet Internetwork or remotely via modem.
9. All wiring shall be connected to padded screw terminals.
10. Input/Output Configuration
 - a. All inputs shall be universal and configured in hardware or software. Inputs shall accept dry-contact, 4-20mA, thermistor and 0-5VDC sources. Pulse accumulation

points shall accommodate a minimum frequency of 20Hz. Analogue to digital to digital conversion shall be 8 bit resolution.

- b. All outputs shall be universal and configured as analogue or digital in hardware or software. Outputs shall provide modulating signal to industry standard 4-20 mA, 0-5v and 0-10v analog control devices and control relays. All outputs shall be capable of sourcing at least 50mA of current simultaneously. Digital to analog conversion shall be a minimum of 10 bit resolution. All outputs shall have physical hand-off-auto switched located within the B-AAC control enclosure. H-O-A switch shall be hardware monitored by the B-AAC for switch position.

11. Provide diagnostic LEDs for power, communications and processor.
12. Each B-AAC shall be provided with the ability to prevent unauthorized access to its software program.
13. Each controller shall be addressable.
14. The B-AAC shall meet BACnet profile for Advanced Application Controller.

B. Control System Application Software:

1. The B-AAC application software shall be the same as and indistinguishable from the B-BC application software in paragraph 2.15 B.
2. The controller software shall reside in a real time, multi-tasking, networking operating environment. Database definition shall be accomplished through the B-OWS online with the B-AAC. The complete database and application program shall reside in the B-BC. The System Contractor shall configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents. The user shall be able to add, delete, or objects on-line as required. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary for proper sequence of control.

C. Communications and Protocols

1. Each B-AAC shall include a local port for direct connection utilizing BACnet LAN type P-T-P.
2. Each B-AAC shall have local communication port for expansion.
3. Each B-AAC shall reside on MS/TP LAN types.

2.14 APPLICATION SPECIFIC CONTROLLER (B-ASC)

A. Hardware

1. Dedicated B-ASC for Individual Fans and terminal equipment may be provided at the discretion of the System Contractor.
2. B-ASC hardware shall be the same as B-AAC and indistinguishable with the exception that there is no requirement to have expansion I/O modules an on-board power switch or H-O-A overrides on outputs and the communication capabilities are different as described below.

B. Control System Application Software

1. Shall be the same as B-BC with the exception that BACnet profile is changed to B-ASC instead of B-AAC, and B-ASC may have firmware specifically dedicated to control a specific piece of mechanical equipment.

- C. Communication and Protocols
 - 1. Shall be MS/TP LAN types.

2.15 NETWORKED DDC SPACE SENSOR (THERMOSTAT)

- A. The unit shall include an integral temperature and humidity sensor.
- B. A local keypad and display shall be provided. Keypad shall be provided for interrogating and editing data. The display shall be able to display setpoint and or actual temperature as well as other data associated with the local B-ASC. An optional system security password shall be available to prevent unauthorized use of the keypad and display.
- C. The wall-mounted unit shall include a point of connection to the BACnet Internetwork. The network components manufacturer shall manufacture the unit. Sensors with a communication jack stub wired to the Internetwork will not be acceptable.
- D. The owner shall reserve the right to review and approve all thermostat locations.
- E. The networked space sensors shall be fully programmable to perform a range of user interface and control functions including but not limited to:
 - 1. Indexing zones to unoccupied/occupied override.
 - 2. Adjust temperature setpoints (when allowed by BAS system).
 - 3. View space humidity
 - 4. Display date, time
 - 5. Integrated CO₂ sensor (where needed for sequence)
- F. In retrofit applications, provide all sensor wiring connections in concealed locations. Where approved by the Owner/Engineer, the use of surface mounted raceways may be accepted. Contractor to obtain approval prior to proceeding with any surface mounted raceway applications.

2.16 CONTROL ENCLOSURES & SUB-PANELS

- A. Provide wall mounted local control enclosures to house all control components associated with each area, system or mechanical equipment room. The enclosures shall be minimum 16 gage steel or aluminum bonded on both sides to a plywood core, totally enclosed on all sides and painted with a baked enamel finish. Provide a continuous piano hinged door, keyed locking latch and removable sub-panel. A single key shall be common to all control enclosures. Enclosures shall be the same NEMA classification as all other enclosures located in the same environment, except if location requires additional protection due to potential vandalism or environmental conditions. At a minimum enclosures located in dry indoor conditions shall conform to NEMA 1 standards. Enclosures located in wet indoor conditions such as garages or located outdoors shall be fully gasketed and shall conform to NEMA 4X standards, and enclosures located outside for cooling tower condenser water controls shall be constructed of stainless steel.
- B. Where approved by the Owner/Engineer, existing control enclosures may be reused by the System Contractor as part of renovation projects.

- C. Provide laminated nameplates for all control system components. Nameplates shall be 1/8 inch (.32cm) thick, black, with white-center core, and shall be minimum 1 inch by 3 inches [2.5 cm X 7.5 cm], with minimum ¼ inch high block lettering. Nameplates for devices smaller than 1 inch by 3 inches [2.5 cm X 7.5 cm] shall be attached to adjacent surface.
- D. Provide each DDC panel with a surge suppressor, electrical disconnect, control fuse, and control transformer. All sized and provided by the control system contractor.
- E. All new control enclosures shall be located in concealed areas. Obtain prior approval from owner for all proposed enclosure locations.

2.17 GENERAL FIELD DEVICES

- A. All control relays shall be UL listed plug-in type with dust cover and with contacts and coils rated for the application.
 - 1. Relays used for in-line control start/stop of line voltage motors and shall have a current rating at least 1.5 times full load amps.
- B. Control transformers shall be CSA and US listed. Primary and secondary sides shall be fused in accordance with the NEC or shall be class 2 current limiting type.
- C. Voltage/Current to Pneumatic Transducer shall be non-bleed type 0-5V or 0-10V input and output pressure to match spring range of controlled device.
- D. Emergency shut-off switches shall be heavy duty, two-position push-pull, maintained contact, illuminated 1-3/8 inch in diameter mushroom style push button switch. Provide hinged easy open protective clear cover to prevent accidental operation of switch.

2.18 INTERCONNECTING WIRE & CABLE

- A. Wire & cable for power, interlock, communications, sensor, and control device wiring shall be as specified in the National Electric Code, Network Standards, control system manufacturer recommendations, and applicable local codes.
- B. All control wiring shall be installed in a protective conduit approved by the Engineer.
- C. Contractor shall obtain prior approval from owner for ALL wiring and routing methods that may result in exposed conduits.

2.19 ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
- B. Thermistor Temperature Sensors and Transmitters:
 - 1. Available Manufacturers:
 - a. BEC Controls Corporation.

- b. Ebtron, Inc.
 - c. I.T.M. Instruments Inc.
 - d. MAMAC Systems, Inc.
 - e. RDF Corporation.
2. Accuracy: Plus or minus 0.5 deg F at calibration point.
 3. Wire: Twisted, shielded-pair cable.
 4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
 5. Averaging Elements in Ducts: 18 inches long, rigid; use where prone to temperature stratification or where ducts are larger than 10 sq. ft..
 6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
 7. Space temperature sensor shall consist of an element within a ventilated cover. Sensors located in plenums, lobbies, or other public spaces shall be simple sensor with no setpoint adjustment.
 8. Terminal Unit space temperature sensor shall be as described in 2.13 A 6 with the requirement that all options are provided. All sensors not located in public spaces and associated with B-ASC or B-AAC that is located in normally inaccessible locations shall be the same. Sensors accuracy shall be unaffected by wiring up to 250'
 9. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - a. Thermometer: Concealed.
 - b. Color: TBD
 10. Outside air temperature sensor shall consist of a single device sensor, ventilated non-metallic sun shield, utility box for terminations, and watertight gasket to prevent water seepage.
 11. Wet Bulb temperature and humidity station shall be suitable for duct or outside mounting and consist of sensors, ventilated non-metallic sun shield, utility box for terminations, and watertight gasket to prevent water seepage
- C. RTDs and Transmitters:
1. Available Manufacturers:
 - a. BEC Controls Corporation.
 - b. MAMAC Systems, Inc.
 - c. RDF Corporation.
 2. Accuracy: Plus or minus 0.2 percent at calibration point.
 3. Wire: Twisted, shielded-pair cable.
 4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
 5. Averaging Elements in Ducts: 18 inches long, rigid; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.
 6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
- D. Humidity Sensors: Bulk polymer sensor element.
1. Available Manufacturers:

- a. BEC Controls Corporation.
 - b. General Eastern Instruments.
 - c. MAMAC Systems, Inc.
 - d. ROTRONIC Instrument Corp.
 - e. TCS/Basys Controls.
 - f. Vaisala.
2. Accuracy: 5 percent full range with linear output.
 3. Room Sensor Range: 10 to 90 percent relative humidity.
 4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - a. Color: TBD
 5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
 6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 22 to plus 185 deg F.
 7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Pressure Transmitters/Transducers:

1. Available Manufacturers:
 - a. BEC Controls Corporation.
 - b. General Eastern Instruments.
 - c. MAMAC Systems, Inc.
 - d. ROTRONIC Instrument Corp.
 - e. TCS/Basys Controls.
 - f. Vaisala.
2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA or linear voltage signal
 - c. Building Static-Pressure Range: 0- to 0.25-inch wg.
 - d. Duct Static-Pressure Range: 0- to 5-inch wg.
3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA or suitable voltage signal

2.20 STATUS SENSORS

- A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.
- B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.
- C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
- E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
- F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
- H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.
 - 1. Available Manufacturers:
 - a. BEC Controls Corporation.
 - b. I.T.M. Instruments Inc.

2.21 THERMOSTATS

- A. Available Manufacturers:
 - 1. Erie Controls.
 - 2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
 - 3. Sauter Controls Corporation.
 - 4. Theben AG - Lumilite Control Technology, Inc.
- B. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.
- C. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
 2. Selector Switch: Integral, manual on-off-auto.
- D. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
- E. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.
- F. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.
1. Bulb Length: Minimum 20 feet.
 2. Quantity: One thermostat for every 20 sq. ft. of coil surface.
- G. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.
1. Bulb Length: Minimum 20 feet.
 2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

2.22 HUMIDISTATS

- A. Available Manufacturers:
1. MAMAC Systems, Inc.
 2. ROTRONIC Instrument Corp.
- B. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

2.23 CONTROL VALVES

- A. Available Manufacturers:
1. Belimo
 2. Danfoss Inc.; Air Conditioning & Refrigeration Div.
 3. Erie Controls.
 4. Hayward Industrial Products, Inc.
 5. Magnatrol Valve Corporation.
 6. Neles-Jamesbury.
 7. Parker Hannifin Corporation; Skinner Valve Division.
 8. Pneuline Controls.
 9. Sauter Controls Corporation.

- B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- C. Hydronic system globe valves shall have the following characteristics:
1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
 2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
 3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
 - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
 - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
 4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:
 - a. Two Position: Line size.
 - b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
 - c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
 5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
 6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
- D. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
 2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
 3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.24 AIR SUPPLY

- A. For renovation projects, the existing air supply system shall be used where needed to maintain control over pneumatic end devices including dampers.
- B. Control and Instrumentation Tubing: Copper tubing complying with ASTM B 88, Type K or ASTM B 280 Type ACR.

1. Fittings: Cast-bronze solder fittings complying with ASME B16.18; or wrought-copper solder fittings complying with ASME B16.22, except forged-brass compression-type fittings at connections to equipment.
2. Joining Method: Soldered or brazed.

PART 3 - EXECUTION

3.1 GENERAL

- A. Control System component locations are the responsibility of the System Contractor. All control system components shall be installed in locations as required to properly sense the controlled medium and shall be easily accessible for adjustment and service. All components shall be installed in accordance with the component manufacturers recommendations.
- B. The system shall be installed such that all wiring, communication, analog or digital, input or output shall be capable of sharing single conduit runs without affecting signal performance.
- C. The Contractor shall protect all work and material from damage by his/her work or workers, and shall be liable for all damage thus caused.
- D. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested and accepted. The Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed.
- E. After completion of installation, calibrate and commission all components provided as part of the Control System and demonstrate proper sequence of operation in compliance with Section 1.6. Equipment not operating correctly shall be field corrected or replaced.
- F. Verify that power supply is available to control units and operator workstation.

3.2 DIRECT AND WEB ENABLED CONTROL SYSTEM APPLICATION SOFTWARE

- A. At time of acceptance all operating system, Third party and Control System Application software shall be at least the latest version available.
- B. Software programs are described to their general intent. It is recognized that Networked System manufacturer's software differ; however, the Application software provided shall incorporate the feature described fully implemented and optimized to provide the sequences described, minimize energy consumption and prolong equipment life.
- C. The following naming convention shall be standards for the naming of BACnet Devices on the BACnet internetwork. The convention for object names viewed by B-OWS shall consist of a string made up of components indicating, as appropriate, the building location, the building, the system, the subsystem, and point function of the object.
- D. When programming the system BACnet addressing rules will be strictly adhered to. All addressing strategies will have to be approved by the Owners representative prior to terminating any LAN types.

- E. All analog and binary values shall be programmed with appropriate alarms.
 - F. Except as specified otherwise, throttling ranges, proportional bands, and cycle differentials be centered on the associated set point.
 - G. All set points unless otherwise indicated are adjustable and shall be programmed for all control loops.
 - H. Each control loop or interlock for all mechanical system including terminal unit systems shall be programmed with a control loop specific graphical trend to trend all values associated with each specific control loop or system interlock.
 - I. Where any sequence or occupancy schedule calls for more that one motorized unit to start simultaneously, the system shall start commands shall be staggered by 60-second (adj.) intervals to minimize inrush current.
 - J. Scheduling shall be developed for each mechanical system. Coordinate schedule programming with the Owner for each specific area and piece of equipment. Refer to Sequence of Operation for additional details.
 - K. Trend log/ historical data shall be implemented for every point on the system. Point trends shall be grouped into logically interrelated points for individual mechanical and PMCS systems. Initial set-up shall be to log values once every 5 minutes.
 - L. B-OWS Graphics
 - 1. All sensors, control devices and set points shall be visible on a B-OWS in graphical form.
 - 2. All mechanical systems shall have a programmed real time color graphic for primary graphical user interface. The only exception allowed will be unit heaters or finned tube, which require a tabular summary for the points associated with these systems.
 - 3. Individual floor plan graphics will be programmed for each floor or area of the building. All space sensors will be visible on floor plan graphics and system graphic.
 - M. The system shall observe the following command priorities (from highest to lowest):
 - 1. Manual Operator Command
 - 2. Energy Management
 - 3. Automatic Control
- 3.3 DIRECT AND WEB ENABLED SERVER, (B-OWS) HARDWARE (Provide for each PC B-OWS)
- A. Assemble server components in a configuration that allows easy operator access to all necessary components from one position. Locate components as required by the owner but at a minimum in a clean air-conditioned space separate from any mechanical equipment spaces.
 - B. Connect to LAN as required. If LAN/WAN is not dedicated to the BACnet internetwork the develop LAN/WAN System Architecture diagram denoting server B-OWS relative to other nodes on its segment of the LAN/WAN.
 - C. Provide sufficient permanent and removable storage drives for 25 percent free memory after provision for all operating system, Third party and Control System Application software, all

fully configured point databases, storage/back-up of all B-BC, B-AAC and B-ASC application programming, all graphic files, all user-defined reports and a three year archive of all trend and historical data described in this specification.

- D. Provide sufficient RAM to meet system performance requirements.

3.4 OPERATORS WORKSTATION, REMOTE AND PORTABLE OPERATORS WORKSTATIONS (B-OWS) HARDWARE

- A. Assemble PC components in a configuration that allows easy operator access to all necessary components from one position. Locate components as required by the owner but at a minimum in a clean air-conditioned space separate from any mechanical equipment spaces.
- B. Connect to LAN as required. If LAN/WAN is not dedicated to the BACnet internetwork the develop LAN/WAN System Architecture diagram denoting server B-OWS relative to other nodes on its segment of the LAN/WAN.
- C. Provide sufficient RAM to met system performance requirements.

3.5 CONTROL ENCLOSURES & SUB-PANELS

- A. All system components not designed for or required to be field installed shall be mounted in a control enclosure. Those components shall be sub panel mounted except components that are mounted on the panel face. Provide on/off power switch with over-current protection for control power sources in each local enclosure.
- B. All control enclosures shall be located so visual observation and adjustment can be accomplished while standing flatfooted on the floor in a convenient location adjacent to the equipment served. Install all equipment in readily accessible location as defined by Chapter1 Article 100 Part A of the NEC.
- C. Label all control system components.
- D. A copy of the “As-built” application engineering for the system served shall be laminated in clear plastic; be legible and suspended within enclosure.
- E. All B-BC, B-AAC and B-ASC shall be mounted in an enclosure.

3.6 INTERCONNECTING WIRE AND CABLE

- A. General
 1. It shall be the System Contractor's responsibility to provide all wiring required for a complete Control System.
 2. Control system wiring and cabling installed for this project shall include but may not be limited to the following:
 - a. Include all required power wiring required weather indicated on plans or not indicated.
 - b. Power to all actuators and, where required, sensors.

- c. Provide all wiring and cabling for network communications except for owner provided LAN's/WAN's.
 - d. All sensor and control device input and output wiring.
 - e. All interconnecting cabling between and amongst network devices, PCs printers, modems, etc.
 - f. Interlock wiring between devices, and between motor starters.
 - g. All other necessary wiring for fully complete and functional system as specified.
3. Install piping, wiring/cabling parallel to building lines.
 4. Maximum allowable voltage for control wiring shall be 120-volts.
 5. All wiring shall be installed as continuous links, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.
 6. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
 7. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- B. Power Wiring and Cabling
1. All power wiring for the entire control system shall be from circuits on emergency power panels if available.
 2. Power wiring for all enclosures and equipment, including branch circuit wiring from circuit breaker panels shall be the responsibility of the System Contractor.
 3. All B-OWS equipment shall be served from isolated ground receptacles via UPS by dedicated branch circuits.
 4. All other enclosures, sensor and control devices shall be fed from separate circuits in the electrical distribution panels and shall not be served from the typical floor receptacle or lighting circuits.
- C. Network Wiring and Cabling
1. Network installation shall conform to standards for the LAN types and cabling types selected. Specific network rules inherent to the ANSI/AHRAE Standard 135-1995, BACnet will be followed. Those include but are not limited to:
 - a. Only one path can exist from any BACnet device to another.
 - b. Each BACnet device connected to an internetwork LAN must have a unique device instance (0-4,194,303).
 - c. Each internetwork LAN must have a unique Network Number (1-65,545).
 2. Primary LAN Network wire and cable shall be run in metallic conduit separately from all other wiring.
 3. Other LAN Network wire and cabling shall be installed separate from any wiring over thirty (30) volts.
 4. All communications shielding shall be grounded as per Networked System manufacturer's recommendations.
 5. Contractor may elect to run unshielded cable if noise immunity is ensured by other means. Contractor will be fully responsible for noise immunity and rewire with shielded cable if electrical or RF noise affects performance.
- D. Installation
1. Except in mechanical and electrical spaces where other conduits or piping is exposed, conceal wiring and cabling as much as possible and install as follows:
 - a. All exposed areas: in raceway or conduit as approved by Owner/Engineer

3.7 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

B. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check installation of air supply for each instrument.
5. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
6. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
7. Check temperature instruments and material and length of sensing elements.
8. Check control valves. Verify that they are in correct direction.
9. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
10. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.

C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.8 ADJUSTING

A. Calibrating and Commissioning:

1. Commission the control system. Document the commissioning and submit documentation prior to acceptance testing. Commissioning shall include the following:
2. Verify that each control panel has been installed according to the shop drawings and test, calibrate, and bring on-line each control device.
3. Each control program shall be put on-line and commissioned.

4. Verify the overall networked system performs as specified.
 5. Subsystems not controlled electronically shall also be tested and commissioned.

 6. Calibrate instruments.
 7. Make three-point calibration test for both linearity and accuracy for each analog instrument.
 8. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
 9. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milliamper meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

 10. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.

 11. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
 12. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
 13. Provide diagnostic and test instruments for calibration and adjustment of system.
 14. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Adjust initial temperature and humidity set points to owner's requirements.
- C. Set-up system schedules according to owner's requirements
- D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to six (6) visits to Project during normal occupancy hours for this purpose.

3.9 DEMONSTRATION AND ACCEPTANCE TESTING

- A. Using the documented calibration and commissioning test data the Owner and /or his representative shall select, at random, results to be demonstrated. At least 95 percent of the results demonstrated must perform as specified and documented on commissioning data sheets or the system must be re-calibrated and re-commissioned before being re-tested.

- B. Refer to specification section "Commissioning Requirements" for detailed acceptance testing and functional testing requirements.

3.10 TRAINING

A. Operational Training Program

1. The System Contractor shall furnish the services of competent instructors who will give instruction on the adjustment, and operation and maintenance of the control system provided. The System Contractor shall provide all equipment and material required for classroom training for maximum of 5 trainees.
2. This Contractor shall conduct a 16-hour operational training program for the facility operating staff, which shall be exclusive of travel time. The owner shall schedule the training times and dates with the contractor.
3. The on-site training shall cover the complete system and components. Schedule within one month of system acceptance. Training shall be done on the owners Control System and shall include:
 - a. General equipment layout.
 - b. Sequences of operation.
 - 1) Explanation of sequences
 - 2) Adjustment of Operating Schedules
 - 3) Adjustment of Setpoints
 - c. Use of OWS software
 - d. Use of OWS software for data collection
 - e. Maintenance and repair.
 - f. Troubleshooting.
 - g. Preventative maintenance.
 - h. Sensor calibration.
 - i. Proper use of service material, and tools.

- B. The instructor shall provide one copy of training material per student. Training sessions shall be videotaped at the discretion of the Owner's Representative for future use by the building staff.

C. Ongoing Support

1. In addition to the initial 16 hours of operator and supervisor training, the Contractor shall provide an additional 24 hours training during the first year of operation when requested by the owner's representative.

END OF SECTION 230900

SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including any applicable General and Supplementary Conditions and any Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

Sequence of operation:

1. Summer/Winter Change Over
2. Hot Water Boiler
3. Heating System Pumps
4. Split System AC Units
5. Cabinet Unit Heaters/Baseboard Fintube Radiation
6. Fan Powered VAV Boxes w/ Hot Water Reheat Coils
7. Kitchen Exhaust Fan
8. Elevator Machine Room Exhaust Fan
9. Toilet Exhaust Fans

- B. Related Sections include the following:

Division 23 Section "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.

- C. The points lists contained in this sections shall be construed as the *minimum* requirements for DDC system data points, alarms and field sensors/devices. The contractor shall provide for all points required to achieve the desired sequence of operation as defined in this section, and shall provide a complete operating automatic temperature control system. Points specifically listed in this section shall be interpreted that a new end device or sensor is to be provided, unless otherwise noted.

1.3 DEFINITIONS

- A. DDC: Direct digital control.
- B. VAV: Variable air volume.
- C. AI / AO: Analog Input/Output
- D. BI/BO: Binary Input/Outut

- The BMS shall provide lead/lag pump control over pumps such that if the lead pump fails, the lag pump is automatically started, and an alarm is generated.
- The BMS shall prove pump flow status before allowing the burner to fire by use of an appropriate differential pressure switch.
- The existing boiler/burner control panel safety limits shall remain.
- The BAS shall provide alarms for high hot water temperature (200 °F) and low hot water temperature (130 °F).
- BAS shall monitor and alarm the boiler safety circuit for alarm status.
- BAS shall monitor and alarm for flame failure from the existing combustion controls.
- Provide modulating control over the burner firing rate to maintain the hot water supply temperature setpoint. The supply water temperature setpoint shall be linearly reset by outdoor air temperature according to the following reset schedule. All parameters shall be adjustable from BAS interface.
 - OA: 35 °F HWST: 180 °F
 - OA: 65 °F HWST: 160 °F

B. Points List:

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Boiler B-1 Enable/Disable				X				X		X
Boiler B-1 Flame Failure Alarm			X						X	X
Boiler B-1 Safety Circuit status			X						x	x
Boiler Burner Modulation signal		x						x		x
Hot Water Return Temp	X							X		X
Hot Water Supply Temp	X							X		X
Hot Water Pumps (2) Start/Stop				X				X		X
Hot Water Pumps (2) status			X						X	X
Hot Water Pumps Lead/Lag operation						X				X
Hot Water Pumps (2) Failure									X	
High Hot Water Supply Temp									X	
Low Hot Water Supply Temp									X	

3.3 SPLIT SYSTEM AIR HANDLING UNITS (AHU-1,2), CONDENSING UNITS CCU-1,2, RETURN FANS RF-1,2

A. DDC Equipment: (For each AHU system):

- Provide all new temperature sensors as listed in the points list.
- Provide all new humidity sensors as listed in the points list.
- The following existing pneumatic actuators may be reused if found to be functional:
 - a. hot water coil control valve actuators
 - b. outside air, return air, mixed air dampers
 - c. inlet vane dampers (AHU-2, RF-2)
 - d. Control/position signals shall be generated from the DDC control panel and appropriate E/P devices may be used.
- Provide new electric freezestat interlocked with the supply fans.
- Provide new duct static pressure sensor located approximately 75% downstream of the total distance (duct length) from the first to the most remote terminal unit.

B. Sequence:

- The air handling unit shall operate as programmed by the building automation system and shall be indexed to either the occupied or unoccupied mode according to a programmed schedule. Coordinate with Owner for final Occupied hours. Expected Occupied hours shall be as follows:

Monday 10:00 am-8:00 pm
Tuesday 10:00 am-6:00 pm
Wednesday 10:00 am.-8:00 pm
Thursday 10:00 am-6:00 pm
Friday 10:00 am.-5:00 pm
Saturday 10:00 am-5:00 pm
Sunday 1:00 pm-5:00 pm (Oct. to April
only, unoccupied rest of year)

Occupied Mode:

- The unit supply fan shall have automatic start/stop control according to the occupied/unoccupied schedule.
- Return Fans RF-1,2 shall be enabled/disabled and interlocked with the associated air handler supply fan.

Supply Fan Control: AHU-1(Children's Library Unit)

- The supply fan shall be controlled to maintain the duct static pressure setpoint (as determined by the balancer) by modulating the existing VFD drive. Provide BMS interface to the existing VFD for supply fan speed control.

Supply Fan Control: AHU-2(Main Library Unit)

- The supply fan shall be controlled to maintain the duct static pressure setpoint (as determined by the balancer) by modulating the existing Variable Inlet Vanes.
- The BAS shall index the AHUs to either the cooling or heating mode depending on the outside air temperature (refer to par. 3.1).

Cooling Mode:

- Upon start up, the supply and return fans shall run continuously.
- The outside air, return and exhaust dampers shall open to minimum position.
- A temperature sensor in the AHU discharge duct shall be arranged to maintain a constant discharge temperature of 58 °F (adj.) by cycling the mechanical refrigeration compressors in stages. CCU-1 has (2) stages of cooling ; CCU-2 has (4) stages of cooling. (Contractor shall verify this in the field). The BAS shall enable the minimum number of stages to maintain a constant supply air temperature. Provide all
- During this cycle the hot water heating coil control valve shall be closed to the HW coil.
- Fan powered VAV boxes shall all operate in the cooling mode.
- The supply air temperature set point shall be further reset by the return air temperature. Control action shall be that a drop in return air temperature shall raise the discharge temperature setpoint proportionately. On a rise in return air temperature, the reverse shall take place.
- Provide economizer damper control over the existing dampers based on comparison of return air and outdoor air enthalpy. Whenever the outdoor air conditions permit, the unit shall operate in an economizer (free cooling) cycle. Provide new enthalpy controls arranged to modulate the outdoor air, exhaust air, and mixed air dampers in sequence to maintain the discharge air setpoint during the economizer mode.

- Above 75 °F (adj.) outdoor air dry bulb temperature, the economizer cycle shall be locked out.

Heating Mode:

- Units shall operate in a similar manner to the cooling cycle except DX cooling shall be disabled and the hot water pre-heat coil discharge temperature shall be maintained at 65°F (adjustable).
- VAV boxes shall operate in the heating mode in conjunction with re-heat coils

Morning Warm-up Operation:

- On initial daily startup, when the average space temperatures are below the occupied set-points by more than 3 °F, the unit shall start and operate for a predetermined period in warm-up mode as programmed into the BAS. During this cycle outside air intake and exhaust air dampers shall remain closed, and return air damper shall remain open. The heating valve shall modulate to maintain a discharge air temperature set point of 85°F (adj.).
- The VAV boxes shall operate in full open position.
- When all the connected VAV zone temperatures come to within 2°F of occupied set point, the unit shall revert to the occupied mode.

Morning Cool-Down Operation:

- On initial daily startup, when the average space temperatures are more than the occupied set-points by more than 3 °F, the unit shall start and operate for a predetermined period in cool-down mode as programmed into the BAS. (The unit shall operate in economizer mode should outdoor air conditions allow). During this cycle outside intake and exhaust air dampers shall remain closed, and return air damper shall remain open. The cooling control valve shall modulate to maintain discharge air temperature set point.
- When the zone temperature comes within 2 °F of set point the unit shall revert to the occupied mode.

Freeze-stat:

- Provide each air handling unit with a new, electric, manual reset type freeze-stat at the heating coil, arranged to shut down the unit and generate an alarm at the BMS operator station should the set point be reached (35 °F). The freeze-stat shall be capable of sensing the entire coil area. The freeze-stat element shall be the capillary type with lowest point temperature sensing.

Un-Occupied Mode:

- When the AHU is indexed to unoccupied mode by the BMS, the supply fan and return fan shall be off. The outside air, and exhaust air dampers shall be closed.

Smoke detector:

- Provide interlock with the existing smoke detectors and fire alarm shutdown relays. Upon detection of smoke, the AHU and return fan shall be shutdown.

C. Points List: (For Each air handling unit)

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
AHU-1,2 Remote Start/Stop				X				X	X	X
AHU-1,2 Run Status Indication			X					X		X
Supply Fan VFD Speed (AHU-2)		X						X		X
Supply Fan VIV (AHU-1)		X						X		X
EA Damper Control		X						X		X

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
OA Damper Control		X						X		X
MA Damper Control		X						X		X
Supply Air Duct Static Pressure	X							X	X	X
SA temperature	X							X		X
RA temperature	X							X		X
RA enthalpy / humidity	X				X			X		X
MA temperature	X							X		X
Heating Coil Valve		X						X		X
Freezestat			X					X	X	X
RF-1,2 Remote Start/Stop				X				X		X
RF-1,2 Status Indication			X					X		X
RF, variable inlet vanes		X						X		X
CCU-1,2 Enable/Disable				X				X		X
CCU Stages Enable 1,2,3,& 4				X				X		X
CCU-1,2 Run Status Indication			X					X	X	X
CCU condenser fan status			X					X	X	X

3.4 FAN POWERED VAV BOXES w/ HOT WATER REHEAT COILS

- A. DDC Equipment: (For each VAV box; approximately (17) total).
- For each VAV box, provide a BACnet listed DDC application specific controller, designed for VAV box applications.
 - Provide new motorized primary air damper integral with the DDC controller.
 - Provide pressure-independent control of primary supply air flowrate, using the existing flow sensors in the VAV boxes.
 - Provide an new electric 3-way hot water reheat control valve.
 - Provide a networked DDC room sensor for each VAV box/zone.

B. Sequence:

- Each VAV zone shall be indexed to either occupied/unoccupied mode coinciding with the respected AHU usage schedule.

Occupied Mode:

- The terminal unit fan shall operate continuously during occupied mode, to provide a constant flow of air to the diffusers.
- The cooling temperature setpoint shall be set at 75 °F (adj.). An increase in space temperature above the setpoint will cause the cooling airflow setpoint to increase proportionately to maximum cooling airflow. The primary air damper shall modulate open to increase the supply air flow. When space temperature is below the cooling setpoint, the primary airflow shall be set to its minimum value (default to 30% of design air flow).
- The heating setpoint shall be set at 70°F (adj.). The controls shall be arranged to maintain a fixed deadband of 5°F between the cooling/heating setpoints.
- On a decrease in space temperature below the heating setpoint, the hot water reheat valve shall modulate open to control the space temperature. (The flow of primary air shall be at minimum). When the space heating setpoint is satisfied, the hot water reheat valve shall be closed.

Unoccupied Mode:

- During unoccupied mode, the primary air damper shall be fully closed, and the terminal unit fan shall be kept off.
- The space temperature heating and cooling setpoints shall be reset to their unoccupied values (55 °F for heating). Cooling shall be unavailable in this mode.
- On a call for heating from space sensor, the associated terminal unit fan shall cycle on, and the hot water reheat valve shall be modulated to maintain the space temperature. The primary air damper shall remain closed (and the AHU shall remain off).

C. Special Sequence for “Periodicals Area” (3) VAV boxes w/Reheat and Fintube Radiation.

- Provide the same equipment as for all other VAV zones.
- Provide an electric actuated, modulating 2-way hot water valve to control the fin tube radiation in this zone.
- Provide a single networked DDC space sensor to control the (3) VAV boxes, and the fin tube radiation control valve in this zone.
- Provide a separate DDC space sensor for the lobby/entryway VAV zone.

Occupied Mode:

- The sequence shall be the same as for other VAV zones, except that the (3) VAV boxes primary air dampes shall modulate together (in parallel) to control the space temperature on a space temperature rise above setpoint.
- Similarly, on a drop in space temperature below heating setpoint, the (3) reheat valves and the fin tube radiation valve shall modulate together (in parallel) to control the space temperature in the zone.

Unoccupied Mode:

- The sequence shall be the same as for other VAV zones, except that the fin tube radiation (FTR) valve shall be the first stage of heating. The terminal unit fans shall be kept off until the FTR valve is at 100% open.
- Once FTR valve is at 100% open, a further drop in space temperature shall cycle on one (1) of the terminal unit fans. Additional terminal unit fans will be cycled on only as needed to maintain space temperature at unoccupied setpoint.
- Primary air dampers shall remain closed during unoccupied mode.

Local Unoccupied Override:

- Space sensors shall have an override button programmed on the keypad which will force that zone to go into occupied mode for a set period (2 hrs. default). This will force the associated AHU to go into occupied mode for the same period.

D. Points List: (For Each Fan Powered VAV box)

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Zone Temp	X							X		X
Supply Air Temp	X							X		X
Airflow	X							X		X
Primary Air Damper		X						X		X
Zone Override						X		X		X

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Fan Start/Stop				X				X		X
Fan Status			X					X	X	X
Fan Failure									X	
HW Reheat Valve		X						X		X
HW Radiation Valve (where applicable)		X						X		X
Airflow Setpoint					X			X		X
Heating/Cooling Mode						X		X		
Schedule							X			
Heating Setpoint					X			X		X
Cooling Setpoint					X			X		X
High Zone Temp									X	
Low Zone Temp									X	

3.5 CABINET UNIT HEATERS/UNIT HEATERS: CUH-1,2,3,4/UH-1 AND MISCELLANEOUS FINNTUBE RADIATION

A. Sequence:

Finned Tube Radiation:

- Existing FTR elements shall be controlled by the existing self-contained radiator valves, unless otherwise noted.

Cabinet Heaters and Unit Heaters: (Approximately (10) locations)

- Existing unit heaters shall be controlled by the existing return air sensors, and pneumatic hot water valves.

3.6 PANTRY EXHAUST FAN – KIT

A. Sequence:

- The exhaust fan shall be controlled by the existing manual motor starter (toggle switch). No additional DDC controls are required.

3.7 ELEVATOR MACHINE ROOM EXHAUST FAN, EV-EX-1

A. Sequence:

- The machine room exhaust fan shall be controlled by the existing pneumatic thermostat mounted in the machine room. When the room temperature exceeds the setpoint of 85 °F (adj.) the exhaust fan shall be started, the intake damper shall open, and the exhaust damper shall open.
- When the fan is off, the intake and exhaust dampers shall be closed.
 - Existing pneumatic exhaust air damper actuators may be reused if functional.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Fan Status			X					X		X
Fan Start/Stop				X				X		X
Remote On/Off switch			X							X
Exhaust Damper				x						X
Fan Failure									X	X

D. Toilet Exhaust Fans TX-1, TX-2

- All pneumatic actuators for exhaust air shall be replaced with new electric actuators tied into the new BAS.

E. Elevator Machine Room Exhaust Fan, EV-EX-1

- Provide a DDC space sensor to control EV-EX-1 in lieu of using the existing pneumatic thermostat.
- Replace the pneumatic actuator on the intake and exhaust dampers with new electric actuator.
- Points list:

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Fan Status			X					X		X
Fan Start/Stop				X				X		X
Exhaust Damper				X						X
Intake Damper				X						x
Fan Failure									X	X

F. Fin Tube Radiation (Approximately (9) locations)

- Replace all existing self-contained radiation valves with 2-way, 2-position electric actuated control valves.
- Provide a wall mounted DDC space sensor/thermostat for each location.
- Sequence:
 - On a call for heat, the FTR valve shall open to maintain the space temperature at heating setpoint of 65 °F (adj.) when building is in Occupied mode.
 - When building is in unoccupied mode, the heating setpoint shall be reset to 55 °F (adj.).
- Points list: (For Each unit)

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Zone Temp	x							x		x
Zone Setpoint Adjust	x									x
Heating Valve		x						x		x
Zone Override			x					x		x
Schedule							x			
Heating Setpoint								x		x
High Zone Temp									x	
Low Zone Temp									x	

- G. Cabinet Unit Heaters/Unit Heaters: CUH-1,2,3,4/UH-1, (Approximately (10) locations)
- Provide a DDC space sensor/thermostat located in the return air or wall mounted.
 - Provide a new 2-way, 2-position electric actuated hot water control valve.
 - Sequence:
 - a. When building is in Occupied mode, heating setpoint shall be 65°F (adj.). Upon drop in space temperature below setpoint the unit fan shall cycle on and the hot water valve shall open. On a rise in space temperature the reverse shall take place.
 - b. When building is in Unoccupied mode, heating setpoint shall be reset to 55 °F (adj.).
 - c. When building is in cooling mode, DDC controls shall prevent fan from cycling on.
 - Points List: (For Each unit)

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Zone Temp	x							x		x
Zone Setpoint Adjust	x									x
Heating Valve		x						x		x
Zone Override			x					x		x
Schedule							x			X
Heating Setpoint								x		x
Fan Start/Stop				x				x		X
Fan Status			x					x		x
Fan Failure									X	X
High Zone Temp									x	X
Low Zone Temp									x	X

3.10 ADD-ALTERNATE #2: (VFDS FOR AHU-2, RF-1, RF-2)

- A. In lieu of using the existing Variable Inlet Vanes (VIV) for capacity control of AHU-2 and RF-2, provide a Variable Frequency Drive (VFD) to modulate the speed and capacity of AHU-2 supply fan.
- B. Provide all removals, power wiring, mounting of equipment, design services, control wiring, accessories, conduit, and appurtenances necessary for a complete system. Installation shall comply with NEC and all local applicable Codes.
- C. Provide submittals of all VFD equipment to Owner for review and approval prior to purchasing.
- D. Remove the existing variable inlet vanes from each fan to maximum extent possible. Provide all ductwork connections and disconnections required to remove VIVs and put fan back into service.
- E. Sequence:
 - Supply fan shall modulate speed to maintain the duct static pressure setpoint as determined by the balancer.
 - Return fans shall track the associated supply fans with a fixed offset to allow for fixed exhaust and building pressurization. Contractor shall coordinate this with their balancer.

F. Points List: For Each VFD and fan, provide the following additional points.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Fan VFD Speed		X						X		X
VFD Fault status			x						x	x

3.11 ADD-ALTERNATE #3: DEMAND CONTROLLED VENTILATION FOR AHU-1, 2

A. DDC equipment:

- Provide carbon dioxide (CO₂) sensors throughout the Library to measure CO₂ levels. Each VAV zone that is isolated from other zones by walls and a door shall have its own CO₂ sensor. Approximately (6) sensors are required. CO₂ sensors shall be integrated with the DDC space sensor/thermostat or stand alone wall mounted type.
- Provide an Outdoor Air CO₂ sensor.

B. Sequence:

- The BAS shall control the outdoor air, exhaust air and return air dampers in sequence to control and maintain a maximum differential (outdoor – inoor) CO₂ concentration in each space to below a maximum setpoint. The differential setpoint shall be 700 ppm (adj.).
- On a rise above the setpoint of any one space, the outdoor air and exhaust air dampers shall modulate open, and the return damper shall modulate closed in sequence.
- The outside air and exhaust air dampers shall not close below an amount determined by the balancer to maintain ventilation rates at the minimum flow required for fixed exhaust rates AND the minimum ventilation rate determined using ASHRAE 62.1-2004 Ventilation Rate Procedure.
- Provide a limit sequence to detect sensor failure and alert operators. If OA CO₂ sensor failure is detected, the OA CO₂ value shall be defaulted to 400 ppm (adj.), and the sensor shall be ignored until reset by the Operator.

C. Points List:

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Space CO ₂	x							X	X	X
Outside Air CO ₂	x							x	x	x

END OF SECTION 230993

SECTION 232923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes basic requirements for motor starters and variable frequency drive motor controls.

1.3 SUBMITTALS

- A. Product Data:

- 1. Motor Controllers: Catalog sheets, specifications, and installation instructions. Submit product data for motor controllers simultaneously with product data required for motors.
 - a. Identify each controller for use with corresponding motor.
 - b. Describe overload devices being supplied with each motor controller (include equipment manufacturer's recommendations).
 - c. Enumerate and describe all accessories being supplied with each motor controller.any parts from the device when subjected to the seismic forces specified."

- B. Qualification Data: For testing agency.

- C. Source quality-control test reports.

- D. Field quality-control test reports.

- E. Operation and Maintenance Data: For field-installed motors to include in emergency, operation, and maintenance manuals.

- F. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

- G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain field-installed motors through one source from a single manufacturer.
- B. Product Options for Field-Installed Motors: Drawings indicate size, profiles, and dimensional requirements of motors and are based on the specific system indicated. Refer to 01 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate features of motors & motor controllers/VFD's, installed units, and accessory devices and features that comply with the following:
 - 1. Compatible with the following:
 - a. Magnetic controllers.
 - b. Multispeed controllers.
 - c. Reduced-voltage controllers.
 - d. Variable Speed Drives
 - 2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
 - 3. Matched to torque and horsepower requirements of the load.
 - 4. Matched to ratings and characteristics of supply circuit and required control sequence.
- B. Electrical Service: All motors shall be 60 Hertz unless otherwise noted. Refer to Electrical Specifications for required electrical characteristics.
- C. Visible Nameplate: Indicating manufacturer's name and model number, motor horsepower, RPM, frame size, voltage, phase, cycles, full load amps, insulation system class, service factor, maximum ambient temperature, temperature rise at rated horsepower, minimum efficiency, power factor.
- D. Suitable starting and controlling equipment and devices shall be furnished and installed as specified hereinafter and as shown on the Drawings. The starting equipment shall be arranged, generally, in control groups, or in certain cases, as isolated combination starters as specified or indicated. The Heating Ventilating and Air Conditioning Sequences of Operation, drawings and specifications shall be referred to for the manner of control, operation and monitoring of motors and the electrically operated equipment.
- E. A starter shall be provided for each motor and each electrically operated piece of equipment except where complete starters and controls are furnished by the manufacturer of the motor or piece of equipment. Starters shall be internally wired to provide the required control operation

and monitoring. All control devices such as push buttons, break-glass stations, alternators, relays, pilot lights, etc., shall be provided as required for operation of mechanical equipment.

- F. Starting equipment and devices furnished under this Section shall be installed by the Contractor. The Contractor shall also do all wiring necessary to supply power to the electric motors provided under this Section, including connections from the starters to the motors as required.
- G. This Contractor shall furnish and install all wiring between control devices and controlled equipment furnished under this Section, including interlock control wiring between motor starters, and all automatic temperature control wiring. All wiring shall be installed in conformance with applicable NEC codes and the applicable provisions of the Building Code of New York State.
- H. The Contractor shall furnish a 120 volt power source to temperature control panels and equipment requiring a separate 120 volt control power source. Power for control circuits for all devices connecting to motor starters shall be obtained from 120-volt control transformers provided in each starter operating at other than 120 volts. Provide transformers for all low voltage control systems as required.
- I. Furnish detailed composite wiring diagrams and such other information necessary to assure the proper connection, operation and control of motorized equipment, including interlocks, automatic controls, safety controls and all auxiliary circuits.
- J. All control units shall be furnished with a nameplate indicating which device or equipment it controls, the voltage. Additional nameplates on each push button, selector switch and pilot light indicating their functions shall be provided. Nameplates shall be laminated phenolic with white letters on black background.

1.6 WARRANTY:

- A. Standard Warranty – Provide manufacturer’s standard form warranty of not less than one year from date of acceptance by owner covering replacement or repair of materials found to be defective in workmanship or quality.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY CONTROLLERS (VFD’S)

- A. Manufacturers/Suppliers: Subject to compliance with requirements, manufacturers offering products and services that may be incorporated into the Work include the following:
 - 1. Allen-Bradley, Rockwell Automation
 - 2. Square D/Schneider Electric
 - 3. ABB
- B. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.

1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.
- C. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- D. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.
- E. Unit Operating Requirements:
1. Input ac voltage tolerance of 380 to 500 V, plus or minus 10 percent. Except noted on drawings.
 2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
 3. Minimum Efficiency: 96 percent at 60 Hz, full load.
 4. Minimum Displacement Primary-Side Power Factor: 96 percent.
 5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
 6. Starting Torque: 100 percent of rated torque or as indicated.
 7. Speed Regulation: Plus or minus 1 percent.
- F. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
1. Electrical Signal: 4 to 20 mA at 24 V.
- G. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 2 to a minimum of 22 seconds.
 4. Deceleration: 2 to a minimum of 22 seconds.
 5. Current Limit: 50 to a minimum of 110 percent of maximum rating.
- H. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
 2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 10 performance.
 4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 5. Instantaneous line-to-line and line-to-ground overcurrent trips.
 6. Loss-of-phase protection.
 7. Reverse-phase protection.
 8. Short-circuit protection.
 9. Motor overtemperature fault.
- I. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

- J. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
- K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
- L. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- M. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- N. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
 - 1. Power on.
 - 2. Run.
 - 3. Overvoltage.
 - 4. Line fault.
 - 5. Overcurrent.
 - 6. External fault.
- O. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
- P. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
 - 1. Output frequency (Hz).
 - 2. Motor speed (rpm).
 - 3. Motor status (running, stop, fault).
 - 4. Motor current (amperes).
 - 5. Motor torque (percent).
 - 6. Fault or alarming status (code).
 - 7. PID feedback signal (percent).
 - 8. DC-link voltage (VDC).
 - 9. Set-point frequency (Hz).
 - 10. Motor output voltage (V).
- Q. Control Signal Interface:
 - 1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
 - 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
 - a. 0 to 10-V dc.
 - b. 0-20 or 4-20 mA.

- c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 - e. RS485.
 - f. Keypad display for local hand operation.
3. Output Signal Interface:
- a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).
 - 3) DC-link voltage (VDC).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set-point frequency (Hz).
4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
- a. Motor running.
 - b. Set-point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- R. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- S. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.
- T. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.
- U. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
- 2.2 ENCLOSURES
- A. Enclosures shall be NEMA-1 rated unless otherwise noted.
- 2.3 ACCESSORIES
- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
 - B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Standard Displays:
 - 1. Output frequency (Hz).
 - 2. Set-point frequency (Hz).
 - 3. Motor current (amperes).
 - 4. DC-link voltage (VDC).
 - 5. Motor torque (percent).
 - 6. Motor speed (rpm).
 - 7. Motor output voltage (V).
- F. Historical Logging Information and Displays:
 - 1. Real-time clock with current time and date.
 - 2. Running log of total power versus time.
 - 3. Total run time.
 - 4. Fault log, maintaining last four faults with time and date stamp for each.
- G. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.4 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFCs before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances and clearances from other equipment, access and other conditions affecting performance and maintenance.
- B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before motor installation.
- C. Proceed with installation only after any and all unsatisfactory conditions have been corrected.

3.2 FIELD-INSTALLED MOTOR & CONTROLLER/VFD INSTALLATION

- A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.
- B. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

3.3 FIELD QUALITY CONTROL FOR FIELD-INSTALLED MOTORS

- A. Prepare for acceptance tests.
 - 1. Align motors, bases, shafts, pulleys, and belts. Tension belts according to manufacturer's written instructions.
 - 2. Verify bearing lubrication.
 - 3. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
 - 4. Test interlocks and control and safety features for proper operation.
 - 5. Verify that current and voltage for each phase comply with nameplate rating and NEMA MG 1 tolerances.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

3.4 FIELD-INSTALLED MOTOR DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain field-installed motors & controllers/VFDs.

END OF SECTION 232923