STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

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September 29, 2014

Subject: Project No. 431-0006
F.A.P. No. CT-90-X523
Waterbury Bus Maintenance Facility Replacement in the Town of Watertown.

NOTICE TO CONTRACTORS:

This is to notify all concerned and especially the prospective bidders that the bid opening for the subject project is still scheduled for October 22, 2014 at 2:00 P.M. in the Conference Room of the Department of Transportation Administration Building, 2800 Berlin Turnpike, Newington, Connecticut.

Addendum No. 2 is attached and can also be obtained on the Statewide Contracting Portal at http://www.biznet.ct.gov/scp_search/BidResults.aspx?groupid=64

This addendum is necessary revise contract documents.

Bid Proposal Forms (0431-0006.EBS file and amendment file 0431-0006.00# if applicable) are available for those bidders that have received approval from the Department to bid on the subject project.

To retrieve the official Bid Proposal Forms, please download the electronic bid proposal file and amendment files, if applicable at https://www.bidx.com.

The Department has established a general mailbox to receive contractor questions. Please send all future questions to **DOTContracts@ct.gov**

Philip J. Melchionne
For: Gregory D. Straka
Contracts Manager
Division of Contracts Administration

SEPTEMBER 26, 2014
WATERBURY BUS MAINTENANCE FACILITY REPLACEMENT
FEDERAL AID PROJECT NO. CT-90-X523
STATE PROJECT NO. 431-006
TOWN OF WATERTOWN

ADDENDUM NO. 2

SPECIAL PROVISIONS
NEW SPECIAL PROVISION

The following Special Provision is hereby added to the Contract:

- NOTICE TO CONTRACTOR – SPECIALIZED WORK AND PRE-AWARD REQUIREMENTS / QUALIFICATIONS

REVISED CSI SECTIONS

The following CSI Sections are hereby deleted in their entirety and replaced with the attached like-named CSI Sections:

- DIVISION 03 – SECTION 03 36 10 - BONDED POST-TENSIONED CONCRETE
- DIVISION 23 – SECTION 23 09 93 - SEQUENCE OF OPERATION
- DIVISION 28 – SECTION 28 31 00 - VOICE COMMUNICATION FIRE ALARM AND DETECTION SYSTEMS

PLANS
REVISED PLANS

The following Plan Sheets are hereby deleted and replaced with the like-numbered Plan Sheets:

SHEET NO.	DRAWING NO.	DRAWING TITLE
02.001.A2	G-002	INDEX OF REVISIONS
08.006.A2	AS-201	SIGNAGE DETAILS
09.003.A2	S-101	GROUND FLOOR FOUNDATION PLAN – AREA A
09.007.A2	S-105	FIRST FLOOR FRAMING PLAN – AREA A
15.011.A2	D-202	DIESEL FUEL SCHEMATIC
15.012.A2	D-203	GASOLINE DISPENSING SCHEMATIC

The Bid Proposal Form is not affected by these changes.

There will be no change in the number of calendar days due to this Addendum.

The foregoing is hereby made a part of the contract.

NOTICE TO CONTRACTOR – SPECIALIZED WORK AND PRE-AWARD REQUIREMENTS/QUALIFICATIONS

The work included in this contract involves specialized work. The Waterbury Bus Maintenance Facility Replacement includes a post-tensioned slab on the first floor of the facility and requires a person experienced in this type of work. It is highly important that the Contractor (prime or subcontractor) performing the work, understand the intended construction and details for this portion of the facility. In order to ensure the successful completion of this project, the Contractor (prime or subcontractor) performing the work must meet the requirements as stipulated within specification section 033610 BONDED POST-TENSTIONED CONCRETE. The low bidder must submit written evidence of the items listed in the specifications within 7 days after bid opening, prior to award of the Contract.

SECTION 033610 - BONDED POST-TENSIONED CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General Provisions of the Contract Documents, including General and Supplementary Conditions, apply to the work specified in this Section.

B. This Section includes all labor, material, equipment and related services necessary to furnish, install, stress and grout all post-tensioning indicated on the drawings or specified herein, including, but not limited to the following:

1. Furnishing all post-tensioning materials, including prestressing steel, anchorages (bearing plates, grout caps, anchor heads, strand and duct couplers, wedges, spirals), duct, grout tubes, support bars, bar chairs, grouting materials and all accessories.
2. Performing all post-tensioning operations, including placement, stressing, grouting of tendons, and finishing of stressing recesses.

C. Related Work specified elsewhere:

1. Cast-In-Place Concrete: Section 033000
2. Div. 01, High Performance Buildings Requirements Section 018113.13 for credits 16a-38k-4(d) (9),16a-38k-4(b)4,16a-38k-4(b)5:
1. The above listed HPB credits are related to this section. Other HPB credits may apply and shall be reviewed for their potential applicability and conformed with as though listed.

1.2 QUALIFICATIONS

A. All post-tensioned concrete work shall be under the immediate control of a person experienced in this type of work. He shall exercise close check and rigid control of all operations as necessary for full compliance with the Contract Documents.

B. The post-tensioning work shall involve a Post-Tensioning Specialty Contractor (P-T Organization) which specializes in post-tensioning and has successfully performed five previous building projects with bonded tendons that are similar to the one involved in this Contract. This P-T Organization shall supply its own post-tensioning system and shall have performed work under the same business name for the past five years. The P-T Organization shall employ a Superintendent who has a minimum of five years experience and technical knowledge of the type of post-tensioning system supplied and who shall oversee all field handling, placement, stressing, and grouting operations. The superintendent's resume shall be submitted to the Engineer of Record (Engineer) and approved prior to bid. The Superintendent and/or supervisor of the grouting operation must be a certified American Segmental Bridge Institute (ASBI) grouting technician.

C. The P-T Organization shall have a minimum Errors and Omissions Insurance coverage of $1,000,000.00.

D. The post-tensioning system shall be a bonded/grouted system that conforms to all material requirements of ACI 318. The system shall be fully encapsulated – no part or length of strand may be exposed to concrete at any point. The P-T Organization shall have a qualified registered professional engineer, licensed in the state in which the project is located, oversee the production of shop drawings and associated calculations, and certify that the post-tensioning system conforms in all aspects to the requirements of ACI 318. The professional engineer shall be a full-time employee of the P-T Organization.

E. Any P-T Organization intending to bid post-tensioning work shall submit the following to the Owner/Engineer for approval :

1. List of projects described in 1.2.B above, with the following information:
   a) Consulting structural engineer, with name, address, and phone number of the individual in the company who was responsible for the project.
   b) Contractor, with name, address and phone number of the Project Manager who was responsible for the project.
   c) Value of post-tensioning subcontract.
   d) Quantity of post-tensioning strand used on the project.

2. Resume of Professional Engineer referenced in 1.2.D. and Superintendent referenced in 1.2.B.

3. Details of anchorages as described in Section 2.3.

4. Sample of slab and beam ducts (12 inch minimum length).

5. Grout mix and properties (Re: 3.6.).

6. QA/QC plan for the supply and installation of the post-tensioning system. The QA/QC plan shall include manufacturing, assembling, plant and job site storage, handling, installation inspection, stressing, grouting and finishing.

F. Notice To Contractor – Specialized Work and Pre-Award Requirements/Qualifications

1. The work included in this contract involves specialized work. The Waterbury Bus Maintenance Facility Replacement includes a post-tensioned slab on the first floor of the facility and requires a person experienced in this type of work. It is highly important that the Contractor (prime or subcontractor) performing the work, understand the intended construction and details for this portion of the facility. In order to ensure the successful completion of this project, the Contractor (prime or subcontractor) performing the work must meet the requirements as stipulated within specification section 033610 BONDED POST-TENSIONED CONCRETE. The low bidder must submit written evidence of the items listed in the specifications within 7 days after award of the contract.

G. P-T Contractors/Organizations should provide a payment and bid bond on the project. The payment and bond should cover the entire contract amount with agreed percentage.

1.3 SUMITTALS

A. Submit the following in accordance with Form 816 Article 1.20-1.05.02 and NOTICE TO CONTRACTOR-SUBMITTALS.

B. Shop Drawings

1. Complete shop drawings must be approved by the Engineer P.E. prior to starting the post-tensioning work. Once approved, shop drawings and data shall not be changed without prior, written approval of the Engineer. Post-tensioned concrete construction operations shall not commence without approved shop drawings on file at the job site.

   At a minimum, the shop drawings shall show:

   a) Overall concrete dimensions and pertinent member concrete dimensions
   b) Tendon profiles, support heights, chair types and sizes, method of support, quantity of support chairs and mild reinforcement
   c) Details as are necessary for the fabrication and accurate placement and stressing of the post-tensioning tendons
   d) Anchorage components and their assembly
   e) Requirements for local zone confinement reinforcement at anchorages
   f) Requirements for reinforcement around stressing pockets and closures
   g) Placement sequences, stressing procedures, including notes regarding jack clearances, sequencing, initial tensioning forces, gauge pressures
   h) Theoretical elongations
   i) Grouting materials and methods
   j) Identification of each tendon
   k) Openings, shafts, ramps, etc.
   l) Material summaries, including material certifications.

   The drawings shall be signed and sealed by the P-T Organization's Professional Engineer.

   Along with friction and elongation calculations, the P-T Organization shall also provide signed and sealed design calculations of local anchorage zone reinforcing that may be required in accordance with AASHTO.

C. Loss and Local Anchorage Zone Calculations

1. The P-T Organization shall furnish to the Engineer, with the shop drawings, calculations of all losses to verify that design forces are obtainable for the number of strands detailed, and local anchorage zone calculations. The loss calculations shall clearly show the assumed friction and wobble coefficients and the basis for their use. The long-term losses, including shrinkage, creep and elastic shortening, shall be quantified by calculations. The calculations shall be signed and sealed by the P-T Organization's Professional Engineer. The P-T Organization shall assist the Engineer in general anchorage zone calculations if requested.

D. Approvals

1. The Engineer's approval shall not relieve the Contractor of his responsibility for performing the work in accordance with the Contract Documents.

1.4 INSPECTION

A. The P-T Organization shall submit QA/QC plan for review.

B. A *Special Inspector* shall be employed by the Owner for checking the placement and stressing of the post-tensioning, placement of reinforcing, grouting of the tendons, and placement and testing of concrete, and other items, as may be required by Local Codes.

C. Duties of the Special Inspector shall include:

1. Check duct integrity, anchorage positioning, tendon support locations, and size and placement of reinforcing in post-tensioned areas.

2. Check that tendon profiles are within the tolerances required (refer to section 3.3).

3. Verify that no concrete be placed in post-tensioned members until placement of tendons and conventional reinforcement steel have been inspected and approved.

4. Record elongations accurately for submittal to the Engineer. The Engineer shall approve stressing records prior to removal of stressing tails. Stressing records shall show a tendon reference mark, theoretical elongation, measured elongation, actual gauge pressure, date, signature of stressing operator, signature of project inspector witnessing the operation, and serial number of stressing ram and gauge.

5. Prior to stressing, verify that calibration charts are submitted for each set of stressing equipment used on the project to the Engineer. The calibration chart shall show the calibration curve for the combination of stressing jack and gauge used.

6. Observe grouting procedures and record that each duct is completely grouted. Inspect quality and testing of grout outlined in Section 3.6 .

PART 2 - PRODUCTS

2.1 The following post-tensioning materials and design procedures specifications apply and are considered to be a part of this section.

A. ASTM A 416

B. ACI 318

C. AASHTO - “Standard Specifications for Highway Bridges” (latest edition)

D. Post-Tensioning Institute “Specification for Grouting of Post-Tensioned Structures”

2.2 Prestressing Steel

A. Prestressing steel shall be ½" diameter (As = .153 sq. in), seven-wire, low-relaxation strand for prestressed concrete manufactured in accordance with ASTM A416, Grade 270, and shall have a minimum ultimate tensile strength of 41,300 pounds.

B. Certified mill test reports on the prestressing steel shall be submitted to the Engineer upon request and shall show the heat number and identification, ultimate tensile strength, yield strength at 1% extension under load, elongation at failure, modulus of elasticity, diameter and net area of strand, and type of material. These values shall conform to the latest revisions of ASTM A416.

2.3 Anchorages

A. The post-tensioning system anchorages shall be specifically suited for bonded tendons. The anchorages shall consist of a cast-in bearing plate and a separate anchor head that is placed after concrete placement; "slap-on" anchorages shall not be permitted. All post-tensioning system anchorages must be approved in writing as per Section 1.2. Grout tubes shall not project out of the top or bottom of the slab. Anchorages shall include details that completely encapsulate the post-tensioning steel, all connections shall be mechanical and not friction-type connections.

B. The load from the anchoring device shall be uniformly distributed to the concrete by approved devices. Such approved devices shall conform to the following requirements:

1. The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 3,000 pounds per square inch.

2. Bending stresses in the plates or assemblies induced by the pull of the prestressing steel shall not cause visible distortion in the bearing plate when the ultimate strand load is applied as determined by testing.

3. Alternately, anchorages may be designed as special anchorage devices that use confinement reinforcement. Such special anchorage devices shall be subject to all testing requirements in AASHTO.

C. Information to be submitted for approval:

1. Complete description of the post-tensioning system anchorage and method proposed for use; such descriptions shall include tendon size, blockout dimensions, tendon layout and design calculations as required to fully substantiate any deviations from the method shown on the Contract Plans.

2. Certified Test Reports confirming the post-tensioning system anchorage meets or exceeds the minimum test requirements of AASHTO.

3. All post-tensioning system stressing anchorages shall be capable of lift-off, detensioning or retensioning a tendon at any time prior to removing the strand tails

D. Couplers

1. Coupling of bonded tendons shall be used only at locations specifically indicated and/or accepted by the Engineer.

2. Coupling of tendons shall not be used at points of sharp tendon curvature.

3. Tendon couplers shall be an integral part of the post-tensioning system and designed as such and they shall be subjected to similar requirements as the post-tensioning system anchorage.

4. Grout connections at couplers shall not project out of the top or bottom of the slab.

5. Lapping tendons at joints shall not be permitted as an effective tendon splice.

2.4 Tendons Ducts:

A. Duct shall be PT-Plus by VSL, Dywidag-System International USA, CCL-USA or preapproved equivalent.

B. Alternate plastic duct systems may be approved if documentation of test results indicating compliance (a letter of certification is not sufficient) with the following performance requirements is submitted to the Engineer at least 10 days prior to bid date:

1. Plastic duct shall be made of High Density Polyethylene (HDPE) according to ASTM D3350 cell classification 324420C, or Polypropylene with a specific gravity of 0.90 to 0.91.

2. Corrugation of ducts may be either spiral, concentric, or any other shape for which it has been demonstrated that the duct can be completely filled with grout.

3. Duct shall be mortar-tight and capable of transferring satisfactory bond stress. Duct shall be designed specifically for post-tensioning tendons.

4. The inside cross-sectional slab duct area shall be a minimum of five times the nominal area of the strands. Beam duct area shall conform to ACI-318 requirements.

5. The wall thickness of the duct shall be such that wearing through the wall by the strand during stressing is prevented. This requirement shall be met at specified minimum radius of curvature of the particular tendon size with a total strand movement of 3 feet and the full tendon stressed to 80% GUTS. The minimum remaining wall thickness of the duct after testing shall be at least 0.04 inches.

6. If couplers are required, ducts shall be coupled with specially designed couplers in a manner that is watertight without the use of tape.

7. Ducts with couplers shall be able to transfer longitudinal forces as follows without effecting watertightness : for duct diameter up to 2-1/2 inches, 200 pounds, and for duct diameter exceeding 2-1/2 inches, 400 pounds.

8. Ducts with couplers shall be capable of bending to a specified minimum radius of curvature without causing damage or sharp kinks in the duct. This requirement is met if at least three full cycles of reversed bending have been applied to the duct and watertightness is not affected (Re: 2.4.2.9). A minimum radius of curvature of 3 feet shall apply for ducts in prefabricated tendon applications.

9. Ducts including couplers shall be watertight. Watertightness is provided if water loss in 40 inch long duct specimens with couplers, tested according to 2.4.2.7 and 2.4.2.8, do not exceed 1.5% of the duct volume within 5 minutes. Water shall be kept at a pressure of 7 psi during the test.

10. Irreversible deformations of the duct cross-sectional dimensions, i.e. diameter, under a point load of 150 pounds shall not exceed 1/4 inch nor 5% of the duct cross-sectional dimensions, whichever is larger, one minute after removal of the load at 70ºF ambient temperature. The point load shall be applied without impact through a #4 reinforcement bar, bearing on the duct between corrugations.

11. Friction and wobble coefficients for the particular duct shall be submitted by the P-T Organization to the Engineer Frictional losses due to vertical and horizontal intentional or non-intentional variance from a straight line trajectory shall be based on experimentally determined curvature and wobble coefficients, and experience from previous jobs.

2.5 Grout

1. Refer to Section 3.6.

PART 3 - EXECUTION

3.1 Scheduling

A. A preconstruction conference shall be held. Attendees shall include the Engineer, Contractor's representative, and the P-T Organization's Professional Engineer and Superintendent. At this time, the post-tensioning operations shall be coordinated with the General Construction schedule. The Engineer shall approve all tensioning locations, construction joints, and the acceptability of the general plan of the field post-tensioning operations.

3.2 Fabrication

A. Post-tensioning tendons shall be manufactured in accordance with detailed shop drawings approved by the Engineer.

B. Post-tensioning tendons shall be of the non-fixed length type to allow for possible form adjustments in the field.

C. Tendon fabrication and delivery should be coordinated by General Contractor so as to prevent lengthy job site storage. All prestressing steel shall be satisfactorily protected from excessive rust or other corrosion prior to placement. Sufficient protection shall also be provided for exposed prestressing steel at the ends of members to prevent deterioration by corrosion.

3.3 Placing

A. All placement shall be under the immediate control of the P-T Organization's Superintendent. He shall exercise close check and rigid control of all operations as necessary for full compliance with all requirements.

B. Placement of mild steel reinforcement shall be coordinated with placement of post-tensioning tendons. Proper tendon location takes precedence.

C. Tendons shall clear openings and drains by a minimum of 3 inches.

D. Slight deviation in horizontal spacing of the slab tendons is permitted where required to avoid openings and inserts, as detailed on the placement drawings.

E. Post-tensioning tendons shall have parabolic profiles (unless otherwise required by the design) and shall conform to the control points shown on the drawings. Support heights locating these profiles shall account for the center of gravity of the strands within the ducts. Low points of the tendons are at mid-span and high point corresponds to the center line of support, unless otherwise noted.

F. Suitable horizontal and vertical supports or chairs shall be installed as shown on the shop drawings to hold the tendons in true position. Tendons shall be tied to supports or chairs at maximum spacings as recommended by the Post-Tensioning Institute. All strands in a given pour shall be full length without splices or couplers unless called for on the approved shop drawings.

G. Post-tensioning tendons and anchorages shall be placed with a vertical tolerance of 1/4 inch in concrete dimensions less than 8 inches, 3/8 inch in concrete dimensions of 8 inches to 24 inches, and 1/2 inch in concrete dimensions of greater than 24 inches.

H. All post-tensioning tendons shall have a grout vent at all anchorages. Grout vents shall not project out of the top of the slab.

I. Post-tensioning anchorages shall be installed perpendicular to the tendon axis and have the minimum required tangent length.

J. Duct materials shall be inspected prior to concrete placement. Damaged duct shall be repaired in accordance with procedures acceptable to the engineer of record.

K. Where the end of a post-tensioning tendon will not be covered by concrete, the anchorages shall be recessed so that the ends of the prestressing steel will be at least 1-1/2 inch inside the edge of the concrete.

L. Tendons shall not be subjected to excessive temperatures, welding sparks or electric ground currents. To insure that this requirement is met, burning and welding operations shall not be conducted in the vicinity of tendons without prior approval. Stressing tails may be removed by rapid oxyacetylene burning or friction blade cutting to within 1" of the face of the anchorhead.

M. Pre-placing of strands in flat duct is mandatory prior to concrete placement. Pre-placing of strands in round duct is recommended prior to concrete placement. Placing of strand in round duct after concreting is satisfactory provided that measures are taken to prevent movement or floatation of the duct during concreting.

3.4 Concrete Placement

A. Concrete shall be placed in conformance with the requirements as outlined in Division 3, Cast-In-Place Concrete.

B. Calcium Chloride shall not be used as an admixture in post-tensioned concrete.

C. No concrete shall be placed in a particular pour until the tendons and reinforcement have been inspected and approved by the Special Inspector or the Engineer or his designated representative. The approval of the engineer of record shall not relieve the Contractor from his obligation for proper placement, and stressing of tendons, or other terms of this contract.

D. Concrete shall be placed in such a manner as to insure that the position of the post-tensioning tendons and conventional reinforcement remains unchanged. If the post-tensioning tendons move out of their designed positions, they shall be adjusted to their correct positions prior to proceeding with concrete placing operations.

E. Special provisions shall be made to insure proper consolidation of concrete in anchorage zones to prevent any voids or honeycombing.

3.5 Stressing

A. All post-tensioning shall be under the immediate control of the P-T Organization's Superintendent. He shall exercise close check and rigid control of all operations as necessary for full compliance with all requirements.

B. Before post-tensioning operations begin, all equipment shall be carefully inspected and tested by the P-T Organization. Tests shall include calibration of gauges, capacity of jacks and rams, and general condition and working order of equipment.

C. The stressing operations shall not begin until tests of the concrete cylinders, cured under jobsite conditions, verify the minimum compressive strength specified on the Contract Drawings. However, if specified on the Contract Drawings, an early partial prestress force may be applied at a concrete compressive strength less than the minimum compressive strength to help minimize plastic shrinkage cracking. The partial prestress force shall be proportionately lower than the full prestress force according to the actual concrete strength at the time the partial prestress force is applied. The full prestress shall be applied when the concrete strength reaches the minimum compressive strength specified.

D. It is intended that the stressing operation begin at the earliest possible time so as to minimize the occurrence of shrinkage and temperature cracking. To this end, it is anticipated that measures be taken (such as low water/cement ratio concrete and proper curing) in order that the early strength gain is achieved within three days, but no longer than five days, from date of concrete placement.

E. Strength of concrete members will be determined by testing standard ASTM 6" diameter test cylinders for each representative pour of 100 cu. yds, or fraction thereof, a minimum of six field-cured, and two lab-cured specimens shall be made. Lab-cured cylinders will be tested at 28 days. Field-cured cylinders shall be maintained at the site and cured under conditions identical to the in-place concrete sections represented by them. They shall be tested in sets of two, at the Contractor's discretion. Such tests shall be the basis for determining when stressing operations may commence. When field-cured cylinders have attained the designated compressive strength, stressing operations may commence. Falsework removal and reshoring may commence when stressing operations are complete and prior to injection grouting of the tendons.

F. The post-tensioning tendons shall be stressed by means of hydraulic jacks equipped with calibrated hydraulic pressure gauges to permit the stress in the prestressing steel to be computed at any time. A calibration chart shall accompany each jack-pump-gauge unit. In no case shall a jack and gauge combination be used which have not been calibrated to each other. In order to insure that proper calibration is maintained, care shall be exercised in the handling of all stressing equipment.

G. The stressing operations shall be conducted so that accurate elongation of the prestressing steel can be measured and recorded to the nearest 1/8 inch and compared with predicted elongations. An agreement within $\pm$ 7% between measured and predicted elongations shall be satisfactory. If inconsistencies exceeding $\pm$ 7% occur, the Engineer, with the assistance of the P-T Organization, shall review and determine whether any additional action is required.

H. Stressing from both ends of the prestressing steel shall be performed when there is excessive friction between the prestressing steel and the duct, depending upon the location of construction joints and construction sequencing. Stressing locations for each tendon shall be shown on the approved shop drawings.

I. The maximum temporary tensile stress (jacking stress) in the prestressing steel shall not exceed 80% of the specified guaranteed minimum ultimate tensile strength of the prestressing steel. The prestressing steel shall be anchored at stresses (initial stress) that will result in the ultimate retention of working forces of not less than those shown on the Contract Drawings

J. Records shall be kept by the Special Inspector of the elongation and force applied to each strand and this shall be submitted to the Engineer promptly upon completion of stressing of each pour.

K. Safety precautions shall be taken to prevent workers from standing over or behind the stressing jacks when tendons are being stressed. Only essential personnel shall be permitted in the area during stressing.

3.6 Grouting

A. The P-T Organization shall own and furnish all specialized equipment necessary to grout the tendons.

B. Grouting records certifying the proper grouting of each duct shall be submitted within 72 hours after grouting by the Special Inspector to the Engineer for review. Information shall include: grout materials and proportions, worker's names, date and time, ambient temperature, weather conditions, and concrete temperature, maximum pumping pressure at inlet. Additional information such as possible blockages, leaks in the system, or interruptions in the flow of grout, and procedures taken to correct the deficiency, shall be reported.

C. A trial grout mix shall be batched in advance of grouting operations to verify the grout properties and the compatibility of the cement, water and admixtures.

D. Four types of grout are available for grouting. Class C grout is prepackaged grout and may exhibit thixotropic properties.

E. Materials and Equipment:

1. Portland cement shall conform to the following:
   a) Specifications for portland cement ASTM C150 Type I, II, or I/II.
   b) Cement used for grouting shall be fresh and not contain any lumps or other indications of hydration or "pack set".

2. Water:
   a) The water used in the grout shall be potable, clean and free of injurious quantities of substances known to be harmful to or incompatible with the Portland cement, prestressing steel, or admixtures.

3. Admixtures:
   a) Admixtures shall impart the properties of low water content, good flowability, adequate open time, minimum bleed, minimum permeability and adequate compressive strength to the grout. Admixtures shall contain no substances known to be harmful to or incompatible with the Portland cement or prestressing steel. Admixtures containing chlorides, fluorides, sulfites, and nitrates shall not be used.

4. Grouting Equipment:
   a) The grouting equipment shall include a colloidal type mechanical mixer capable of continuous mixing which will produce a grout free of lumps and undispersed cement. The holding tank shall contain an agitator for the purpose of keeping the grout in continuous motion until injected into the tendon. When using thixotropic grout, the equipment shall consist of two identical charging/holding tanks.
   b) The pumping device shall be a positive displacement type capable of producing an outlet pressure at the pump of at least 145 psi.
   c) The grouting equipment shall have seals adequate to prevent the introduction of air, oil or other foreign substances into the grout.
   d) Accessory equipment which will provide for accurate solid and liquid measures of all grout components shall be provided to batch all materials.
   e) The grouting equipment shall contain a screen having clear openings of 1/8 inch maximum size to filter the grout prior to its introduction into the holding tank or immediately prior

to Being injected into the tendon. A maximum screen opening of 3/16 inch can be used for thixotropic grouts. The screen shall be easily accessible for inspection and cleaning.

f) The holding tank and/or mixing tank must be kept partially full of grout at all times during the pumping operation to prevent air from being drawn or siphoned into the grout hose or duct.

F. Grout Property Requirements:

1. The maximum water-cement ratio shall be 0.45.

2. The grout must remain pumpable for a minimum of 30 minutes. The initial flow cone efflux time of a non-thixotropic grout shall be a minimum of 11 seconds and a maximum of 30 seconds immediately after mixing. Refer to ASTM C939, Standard Test Method For Flow Of Grout. For thixotropic grouts, the efflux time shall have a minimum of 9 seconds and a maximum of 20 seconds for a 1-liter discharge. Use a modified version of ASTM C939 by filling the flow cone to the top instead of the standard level.

3. All classes of grout shall exhibit no measurable bleed after 3 hours when using a wick induced bleed test at 20°C (70°F). Refer to ASTM C940, Standard Test Method For Expansion And Bleeding Of Freshly Mixed Grouts. Class B and C grouts shall have a maximum bleed of 4 percent when using the Schupack Pressure Bleed Test with 20 psi and a vertical rise of 0 to 2 feet.

4. The minimum compressive strength of the grout at 7 days shall be 3,000 psi. The minimum compressive strength of the grout at 28 days shall be 5,000 psi. Refer to ASTM C942, Standard Test Method For Compressive Strength Of Grout.

5. The permeability of the grout shall be determined by referring to ASTM C1202, Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration. Grout at 28 days of age shall have a maximum value of 2500 Coulombs after 6 hours.

6. The volume change of grout shall be 0.0% to +0.1% at 24 hours. The volume change at 28 days shall not be greater than +0.2%. Refer to ASTM C1090, Standard Test Method for Measuring Changes in Height of Cylindrical Specimen from Hydraulic-Cement Grout.

7. The temperature of the freshly prepared grout shall not be less than 40F or greater than 100F, the optimal temperature range is 50F-70F.

8. The setting time of the grout shall be greater than 3 hours and less than 12 hours. Refer to ASTM C953, Standard Test Method

for Time of Setting of Grouts for Preplaced Aggregate Concrete in the Laboratory.

G. Mixing and Injection of the Grout:

1. It is generally desirable that tendons be grouted as soon as practical after approval of the stressing operations.

2. After a period of freezing weather conditions, grouting may be carried out only when it is certain that no ice will be trapped in the ducts.

3. Grouting may proceed when the surrounding concrete temperature is a minimum of 35F and rising. The grout temperature shall be maintained between 40F-90F before entering the duct. Grout temperature must be maintained at a minimum of 35F after entering the duct for three consecutive days after grouting or until a minimum compressive strength of 800 psi is attained as determined by job-cured 2 inch cube tests.

4. Grout fittings shall be non-metallic and not project out of the top or bottom of the slab.

5. Mixing shall be of such duration as to obtain a uniform and thoroughly blended grout, approximately 2-3 minutes.

6. Grout shall completely fill the void space within the duct under a normal pumping pressure of 75 psi. For internal flat ducts, pumping pressure shall not exceed 100 psi. For internal circular ducts, pumping pressure shall not exceed 245 psi.

7. Grout shall be injected from the lower end of the tendon in a continuous manner until it is discharged from the opposite end. The grout shall be continuously ejected from the outlet until no slugs of water or air are visible and the grout at the outlet is approximately the same viscosity as that at the inlet. Close the valve at the outlet followed by the valve at the inlet prior to relieving the pressure at the grout pump.

8. Grout injection shall be between 15ft. and 50 ft. per minute unless otherwise approved by Engineer.

9. Leaks at the grout fittings at each end of the tendon or at any intermediate locations shall not be permitted.

10. Grout fittings may be removed flush with the concrete such that there is no spalling, after the grout has set for 24 hours.

3.7 Field Testing

1. One bleed test shall be taken per day for Class B and D grouts. The test shall be taken from the mixer. The sample test shall be either a Wick Induced Bleed Test or Schupack Pressure Bleed Test.

2. Two mud balance tests shall be taken per day for all classes of grout. Mud balance tests shall be performed in addition to the two daily tests whenever an apparent change in the grout appears.

3. One strength test shall be taken during the grouting.

4. At least two flow cone tests – one at the mixer and one at the outlet, per every two hours of grouting operation for all classes of grout. The flow cone tests shall be either the ASTM C939 or the modified ASTM C939 tests.

3.8 Finishing of Stressing Recesses

1. Stressing recesses shall be properly prepared and then filled flush with a non-shrink, non-metallic, non-corrosive grout to give a satisfactory appearance per the project requirements.

END OF SECTION 033610

SECTION 23 09 93 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. The work included in this specification consists of furnishing all labor, material, accessories and equipment necessary for a complete, operational temperature control system as described herein.

B. Related Sections:

1. Division 01, High Performance Buildings Requirements Section 018113.13 for credits 16a-38k-3(l), 16a-38k-4(a)11, 16a-38k-4(b)11.

2. The above listed HPB credits are related to this section. Other HPB credits may apply and shall be reviewed for their potential applicability and conformed with as though listed. Division 23 Section 230900 Instrumentation and Control for HVAC contains requirements that relate to this Section.

C. The following specification sections contain requirements that relate to this section:

1. 260501 – Basic Electrical Materials & Methods
2. 260533 – Raceways and Boxes for Electrical Ssystems
3. 260519 – Building Wire and Cable
4. 260553 – Electrical Identification
5. 260526 – Grounding and Bonding for Electrical Systems
6. 262813 – Fuses
7. 262416 – Panelboards and Circuit Breakers

1.3 SUBMITTALS

A. Refer to Section 230900 Instrumentation and Control for HVAC for submittal requirements.

1.4 DEFINITIONS

A. Point Types:

1. Digital Input - DI
2. Digital Output - DO
3. Analog Output - AO
4. Analog Input - AI

PART 2 – PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to the Electrical Demand Monitoring and Trending Measurement and Verification Plan section for equipment energy usage trending requirements. Provide the required sensors and devices necessary to trend energy usage for the equipment listed. Coordinate provision of energy usage signals which may be standard from the equipment manufacturer, available from electric meters at panels (provided by electrical contractor), or added per this specification section.

B. All setpoints and schedules shall be adjustable by the owner through operator interface with no additional programming required. Coordinate the various levels of security and access with the Facilities Maintenance Supervisor.

C. Provide control components compatible with individual manufacturer's equipment.

D. Provide wall mount space thermostats with temperature indication, set point adjustment and override button. Indicate space temperature, set point and override status.

1. Provide space temperature sensors only in Spaces associated with RTU-7, Spaces associated with RTU-9, Lobby A201, Vestibules, Stairs, Corridors, Toilet rooms and Locker rooms.

2. Space temperature shall be monitored using RTU return air duct temperature sensors for the following areas: Bus Storage S113, Maintenance M104 & M108, Chassis Wash M103, Service Lanes S111 & Bus Wash S112.

3. Spaces served by Cabinet Unit Heaters (CUH) and Unit Heaters (UH) not shown with associated temperature sensors shall be provided with unit mounted temperature sensors in the return airstream.

E. Provide Window Operation Indicators where shown on construction drawings. Provide wall plate with red and green LEDs mounted at 6ft above finished floor, for the purpose of notifying occupants whenever outdoor temperature and humidity conditions are suitable for opening windows.

F. Upon a signal from a the fire alarm panel, HVAC air handling equipment shall be shut down and outside air dampers shall close, with the exception of vehicle exhaust systems. The controls contractor shall provide wring, conduit and all necessary devices from the fire control panel to the Building Automation System (BAS). When the fire alarm signal has cleared, each unit shall revert to its scheduled operating mode.

G. Provide data jacks for BAS laptop access in control cabinets of all RTUs and Boiler Room M130.

H. Provide starters/contactors/relays required for the control of HVAC equipment that are not provided by equipment manufacturers or electrical contractor.

I. Current transmitters shall be provided on each electrical power leg of equipment noted in points lists for the purpose of monitoring energy usage. Variable frequency drives on fan motors and pumps shall provide energy usage output. Provide all devices and components necessary for reading and trending max kWh and max kW for each piece of equipment. Refer to 'Electrical Demand Monitoring and Trending' within this specification section.

J. Current transmitters shall be provided on each electrical power leg of electrical panels serving lighting. Provide all devices and components necessary for reading and trending max kWh and max kW for each electrical panel. Refer to 'Electrical Demand Monitoring and Trending' within this specification section.

K. Note considerable distance to Guard Booth from facility building. Controls contractor shall provide all conduit and/or controls devices and components necessary for communications with the Guard Booth.

L. Provide the following general points for monitoring and use as required by individual equipment and terminal unit operating sequences.

Points List:

Point ID	Description	Type	Remarks
G-1	Outdoor Air Temperature	AI	
G-2	Outdoor Air Humidity	AI	
G-3	Outdoor Air CO2 Concentration	AI	
G-4	Fire Alarm Status	DI	
G-5	CO & NOx Sensors (See electrical plans)	AI	Separate CO & NOx inputs from multiple sensors
G-6	Gas Service Meter	AI	Gas usage
G-7	Water Meter	AI	Water usage
G-8	Electrical Panel Current Transmitters	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage – Multiple panels
G-9	Alarms to Security Systems	DO	Multiple - Coordinate alarm types with owner's representative

3.2 HEATING PLANT

A. Points List:

Point ID	Description	Type	Remarks
Boilers B-1/2/3/4	Boiler Enable/Disable	DO	
Boilers B-1/2/3/4	Boiler Status	DI	Monitor Boiler Control Panel Alarm
Boilers B-1/2/3/4	Boiler Management System		Provide (6) points for monitoring system
Boilers B-1/2/3/4	Boiler Current Sensors	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage
Boilers B-1/2/3/4	Boiler Supply Water Temperature	AI	
Boilers	Boilers Gas Usage	AI	Boiler gas meter output
Pumps BP-1/2/3/4	Boiler Pump Start / Stop	DO	
Pumps BP-1/2/3/4	Bldg Pump Flow Status	DI	Current transmitter
Pumps BP-1/2/3/4	Boiler Pump Current Transmitters	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage

Point ID	Description	Type	Remarks
Pumps P-1&2	Bldg Distribution Pump Start / Stop	DO	
Pumps P-1&2	Bldg Distribution Pump Status	DI	Current sensor
Pumps P-1&2	Bldg Distribution Pump Speed	AO	Variable Frequency Drive
Pumps P-1&2	Bldg Distribution Pump Energy Output from Variable Frequency Drive	AI	
HHW System	Distribution Loop Supply Temperature	AI	Downstream of P-1A/B
HHW System	Distribution Loop Return Temperature	AI	Upstream of Boiler take offs
HHW System	Piping System Differential Pressure	AI	
HHW SYSTEM	Piping System Flow	AI	
GLYCOL INJECTION SYSTEM	Alarm	DI	Monitor system alarm

B. Heating:

1. Coordinate sequence with boiler manufacturer's boiler management system. On boiler graphics screen show return water temperature and respective boiler's supply water temperature.

2. Whenever the OAT is below 60 degrees, the designated lead primary building distribution pump shall start and run continuously. Above 60 degrees OAT the pumps shall be off. If proof of flow is not established by the lead building distribution pump, the standby pump shall start and an alarm shall be generated. Lead and standby pump assignments shall be determined by the BAS based on overall runtime and number of starts. The lead pump speed shall vary to maintain system differential pressure setpoint; on a loss of the differential pressure signal, the lead pump shall default to 50% pump speed and an alarm shall be generated.

3. When the lead pump has proven operation for at least one minute, the boilers shall be enabled and the boiler manufacturer's control panel shall control the boilers. The boilers shall provide the discharge water temperature necessary to maintain the building distribution water supply temperature as determined by the reset schedule. Provide all necessary control devices and wiring necessary for the control panel to operate the boilers and respective boiler pumps.

   a. Each boiler's circulation pump shall prove operation for at least one minute before the boiler fires. An alarm shall be generated whenever a pump does not prove operation, and the next pump/boiler in sequence shall be brought on line.

   b. Boiler circulation pump speed shall be manually adjustable through the BAS graphic screens.

4. Provide building distribution water supply temperature reset based on ambient temperature. Also provide a manual water supply temperature setpoint schedule which overrides the reset schedule – heating plant graphics screens shall indicate manual override operation whenever it is engaged.

Ambient Air Temperature	Building Distribution Hot Water Supply Temperature
0°F	140°F

Ambient Air Temperature	Building Distribution Hot Water Supply Temperature
60°F	90°F

5. If the heating hot water supply temperature varies by more than 10°F from setpoint, an alarm shall be generated.

6. The BAS shall monitor the alarm status of each boiler's on board controller, the boiler management system and the glycol injection system, and initiate a BAS alarm.

3.3 VARIABLE AIR VOLUME H/C ROOFTOP UNITS
RTU-11/12/13

A. Points List:

Point ID	Description	Type	Remarks
RTU	Supply Fan Start/Stop	DO	
RTU	Supply Fan Status	DI	Current sensor
RTU	Supply Fan Speed	AO	Display on respective unit's graphic screen
RTU	Duct Static Pressure	AI	Locate sensors approx. 2/3 downstream of supply fan
RTU	Exhaust Fan Start/Stop	DO	
RTU	Exhaust Fan Status	DI	Current sensor
RTU	Exhaust Fan Speed	AO	Display on respective unit's graphic screen
RTU	Supply Air Temperature	AI	Ductstat
RTU	Return Air Temperature	AI	Ductstat
RTU	Mixed Air Temperature	AI	
RTU	Heating Coil Control Valve	AO	Modulating Actuator
RTU	Cooling Stages Start/Stop	DO	For each stage
RTU	Return Air Damper	AO	Modulating Actuator
RTU	Outside Air Damper	AO	Modulating Actuator
RTU	Supply Airflow – Array for each fan	AI	Display on respective unit's graphic screen
RTU	Return Airflow– Array for each fan	AI	Display on respective unit's graphic screen
RTU	Outside Airflow	AI	Display on respective unit's graphic screen
RTU	Energy Recovery Wheel Rotation	DO	
RTU	Filter Status	DI	Differential Press Switch
RTU	Duct Smoke Detectors	DI	Multiple
RTU	Space Humidity	AI	Duct humidistat. Display on respective unit's graphic screen
RTU	RTU Supply Fan Energy Output from	AI	

Point ID	Description	Type	Remarks
	Variable Frequency Drive		
RTU	RTU Exhaust Fan Energy Output from Variable Frequency Drive	AI	
RTU	RTU Compressor Current Transmitters (for each compressor)	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage
RTU	CO2 Concentration Rooms A115, A202, A212, M101, M131	AI	Monitor

B. The rooftop units shall operate in either Occupied, Unoccupied, Warmup or Cooldown modes as scheduled. Optimization programming shall determine start time of occupancy mode. The energy recovery wheel shall rotate only when the unit is in occupied mode, except the wheel shall stop whenever the unit is in economizer operation.

C. During Occupied mode, the supply and exhaust fans shall operate continuously and the outside air damper shall modulate to provide the minimum ventilation air requirement.

1. The supply fan variable frequency drive shall vary the supply fan speed to maintain the duct static pressure setpoint, which shall be automatically reset to meet zone airflow demands. The exhaust fan variable frequency drive shall modulate the exhaust fan speed to maintain building pressurization control via airflow station data.

    a. Coordinate initial balance fan speed settings with the balance contractor to determine the supply and exhaust fan speeds at maximum design supply and exhaust airflows. Note the VFD frequency settings as "MAX DESIGN AIRFLOW" for each, plainly visible, in the control cabinet adjacent to the VFD. Provide a list of RTU unit designations and the noted frequencies/airflows accessible through the controls system as a reference document.

2. The outside air damper and exhaust fan speed shall modulate to maintain building pressurization, via airflow station data, and to ensure the minimum ventilation airflow requirements are met.

3. The heating coil normally closed control valve shall modulate to maintain the discharge air temperature setpoint 55°F (adjustable).

4. The cooling stages shall cycle to maintain the discharge air temperature setpoint 55°F.

    a. Provide differential enthalpy economizer operation to modulate outside air and return air dampers from minimum outdoor air position to 100% outdoor air to maintain space temperature setpoint. Optimization control shall cycle cooling stages during economizer operation if deemed efficient to do so. The exhaust fan speed shall modulate to maintain building pressurization. Provide mixed air low limit control to prevent mixed air temperature from dropping below the discharge air temperature setpoint. During economizer operation the energy recovery wheel shall stop.

    b. Whenever an air handling unit's return air relative humidity (RH) is below setpoint 50% (adjustable), the respective unit's discharge air temperature shall be reset upward to maintain 80 to 95% airflow through the VAV box with the most cooling demand. If airflow through the most demanding VAV box drops below 80%, the discharge air temperature shall be reset to 65°F. If airflow through the most demanding VAV box rises toward 95%, the discharge air temperature shall be reset to 55°F.

D. During Unoccupied mode, the supply and exhaust fans shall stop, the outside air damper shall close and the return air damper shall fully open, unless night purge is active.

1. Whenever any space temperature drops below the unoccupied setpoint temperature 60°F, the respective unit's supply fan shall operate at full airflow and the heating coil control valve shall

fully open. The supply fan shall stop and the coil valve shall close when all spaces reach the unoccupied setpoint temperature.

a. Provide an adjustable time delay to prevent the supply fan from starting again until time delay has expired (default -15 minutes). If the number of supply fan cycles exceeds an operator adjustable maximum cycles (default - 8) during an unoccupied period, the fan shall run continuously until the end of the next scheduled occupied period.

2. Night Purge shall be enabled whenever the average of space temperatures for a respective air handling unit system is above 75 °F, the outdoor air temperature is above 50°F and the outdoor air dewpoint is below 60°F. During Night Purge the outside air and exhaust air dampers shall fully open, and the supply and exhaust fans shall operate continuously at full airflow. Night Purge shall cease whenever the average space temperature drops below 75°F, or the outdoor air temperature drops below 50°F, or the outdoor air dewpoint rises above 60°F , or the outdoor air temperature is less than 5°F cooler than the average space temperature.

3. Upon activation of the unoccupied mode override, the unit control shall revert to occupied mode operation for an operator defined interval (default – 2 hrs).

E. During Warmup, the outside air dampers shall be closed, the return air damper shall be fully open, the exhaust fan shall be off, the supply fan shall operate continuously, the heating coil control valve shall modulate to maintain a minimum 55°F supply air temperature, and the VAV box reheat coils shall operate in occupied mode. When all spaces reach their occupied space temperature setpoint, the system shall revert to occupied mode operation.

F. During Cooldown, the outside air damper shall be closed, the return air damper shall be fully open, the exhaust fan shall be off, the supply fan shall operate continuously, the cooling stages shall cycle to maintain the occupied discharge air temperature setpoint and the respective system's VAV boxes shall operate in occupied mode. When all spaces reach their occupied space temperature setpoint, the system shall revert to occupied mode operation.

G. Monitor the unit's filter differential pressure switch and generate an alarm for dirty filters (default - 0.5" wc above clean filter).

H. Safety Controls:

1. The duct smoke detectors auxiliary contacts shall be hard-wired into the respective unit's fan control circuits to shut down the fans upon activation. Shut down fans and close outdoor air damper whenever the building fire alarm is activated. Restart units when the alarm signal is cleared.

3.4 AIR TERMINAL VAV BOXES AND FINNED TUBE RADIATION

A. Points List:

Point I.D.	Description	Type	Remarks
VAV	Space Temperature Sensor	AI	
VAV	Space Temperature Setpoint	AI	
VAV	Supply Airflow	AI	
VAV	Supply Airflow Damper	AO	Modulating Actuator
VAV	Supply Air Temperature	AI	
VAV	Coil Control Valve	AO	Modulating Actuator
Space	Space Temperature Sensor	AI	
Space	Space Temperature Setpoint	AI	

Space	Unoccupied Mode Override Button	DI	
Space	Open Window Signal	DI	All operable windows in areas D and G
Space	Window Operation Indicator (Green pilot light)	DO	Lit when conditions are favorable
FT	Finned Tube Control Valve Open/Close	DO	Modulating

B. The air terminals shall operate in either Occupied, Unoccupied, Warmup or Cooldown modes as scheduled. Finned tube radiation shall be enabled during occupied mode. Provide a range of outdoor air temperatures and outdoor humidity conditions within which ambient conditions are favorable for opening windows by the building occupants. Under favorable conditions the Window Operation Indicator (WO) shall be lit.

C. During Occupied mode, Warmup and Cooldown:

1. On a rise in space temperature from 75°F setpoint, the VAV box damper shall modulate from minimum damper position to maximum airflow to maintain the space setpoint temperature for cooling. The coil control valve shall be closed. When the space temperature is satisfied the damper shall be at minimum position.

2. On a drop in space temperature from 70°F setpoint, the VAV box shall be in minimum damper position and the heating coil control valve shall modulate to satisfy the space temperature setpoint for heating. For spaces with radiation heating, the radiation shall integrate with VAV box control.

   a. For each VAV box, provide a heating mode damper position, a cooling mode minimum ventilation damper position and a window open damper position. Whenever a window is open, the respective VAV box damper shall maintain the window open damper position.

3. Enable finned tube heating whenever OAT is below 65°F. Integrate finned tube radiation as primary heat source with VAV box operation. Modulate finned tube control valve to maintain space temperature occupied setpoint.

4. During occupied mode, whenever one or more windows in a space is open, the damper of the VAV air terminal serving the space shall fully close.

D. During Unoccupied mode:

1. The VAV boxes dampers shall be open for full airflow, for unoccupied heating and Night Purge operation.

3.5 CONSTANT VOLUME ROOFTOP H/C UNITS RTU-14 & 15

A. Points List:

Point ID	Description	Type	Remarks
RTU	Supply Fan Start/Stop	DO	
RTU	Supply Fan Status	AI	Current sensor
RTU	Supply Fan Speed	AO	Manual setting
RTU	Exhaust Fan Start/Stop	DO	
RTU	Exhaust Fan Status	AI	Current sensor
RTU	Exhaust Fan Speed	AO	Manual setting
RTU	Supply Air Temperature	AI	Ductstat
RTU	Return Air Temperature	AI	Ductstat
RTU	Mixed Air Temperature	AI	

RTU	Heating Coil Control Valve	AO	Modulating Actuator
RTU	Cooling Stages Start/Stop	DO	For each stage
RTU	Return Air Damper	AO	Modulating Actuator
RTU	Outside Air Damper	AO	Modulating Actuator
RTU	Supply Airflow – Array for each fan	AI	Display on respective unit's graphic screen
RTU	Return Airflow	AI	Display on respective unit's graphic screen
RTU	Outside Airflow	AI	Display on respective unit's graphic screen
RTU	Filter Status	DI	Differential Press Switch
RTU	Space Humidity	AI	Duct Humidistat. Display on respective unit's graphic screen
RTU	RTU Supply Fan Energy Output from Variable Frequency Drive	AI	
RTU	RTU Exhaust Fan Energy Output from Variable Frequency Drive	AI	
RTU	RTU Compressor Current Transmitters (for each compressor)	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage

B. The rooftop units shall operate in either Occupied, Unoccupied, Warmup or Cooldown modes as scheduled. Optimization programming shall determine start time of occupancy mode.

C. During Occupied mode, the supply and exhaust fans shall operate continuously and the outside air damper shall modulate to provide the minimum ventilation air requirement.

1. Coordinate initial balance fan speed settings with the balance contractor to determine the design supply and exhaust fan speeds. Note the VFD frequency settings as "DESIGN AIRFLOW" for each, plainly visible, in the control cabinet adjacent to the VFD. Provide a list of RTU unit designations and the noted frequencies/airflows accessible through the controls system as a reference document

2. The heating coil normally closed control valve shall modulate to maintain the discharge air temperature setpoint 55°F (adjustable).

3. The cooling stages shall cycle to maintain the discharge air temperature setpoint 55°F.

    a. Provide differential enthalpy economizer operation to modulate outside air and return air dampers from minimum outdoor air position to 100% outdoor air to maintain space temperature setpoint. Optimization control shall cycle cooling stages during economizer operation if deemed efficient to do so. The exhaust fan speed shall modulate to maintain building pressurization. Provide mixed air low limit control to prevent mixed air temperature from dropping below s the discharge air temperature setpoint.

D. During Unoccupied mode, the supply and exhaust fans shall stop, the outside air damper shall close and the return air damper shall fully open, unless night purge is active.

1. Whenever space temperature drops below the unoccupied setpoint temperature 60°F, the respective unit's supply fan shall operate at full airflow and the heating coil control valve shall fully open. The supply fan shall stop and the coil valve shall close when all spaces reach the unoccupied setpoint temperature.

    a. Provide an adjustable time delay to prevent the supply fan from starting again until time delay has expired (default -15 minutes). If the number of supply fan cycles exceeds an

operator adjustable maximum cycles (default - 8) during an unoccupied period, the fan shall run continuously until the end of the next scheduled occupied period.

2. Night Purge shall be enabled whenever the average of space temperatures for a respective air handling unit system is above 75 °F, the outdoor air temperature is above 50°F and the outdoor air dewpoint is below 60°F. During Night Purge the outside air and exhaust air dampers shall fully open, and the supply and exhaust fans shall operate continuously at full airflow. Night Purge shall cease whenever the average space temperature drops below 75°F, or the outdoor air temperature drops below 50°F, or the outdoor air dewpoint rises above 60°F , or the outdoor air temperature is less than 5°F cooler than the average space temperature.

3. Upon activation of the unoccupied mode override, the unit control shall revert to occupied mode operation for an operator defined interval (default – 2 hrs).

E. During Warmup, the outside air dampers shall be closed, the return air damper shall be fully open, the exhaust fan shall be off, the supply fan shall operate continuously, the heating coil control valve shall fully open. When the space has reached occupied space temperature setpoint, the system shall revert to occupied mode operation.

F. During Cooldown, the outside air damper shall be closed, the return air damper shall be fully open, the exhaust fan shall be off, the supply fan shall operate continuously, the cooling stages shall cycle to maintain the occupied discharge air temperature setpoint. When the space has reached occupied space temperature setpoint, the system shall revert to occupied mode operation.

G. Monitor the unit's filter differential pressure switch and generate an alarm for dirty filters (default - 0.5" wc above clean filter).

H. Safety Controls:

1. Shut down fans and close outdoor air damper whenever the building fire alarm is activated. Restart units when the alarm signal is cleared.

3.6 ENERGY RECOVERY ROOFTOP UNITS RTU-1 THRU 10

A. Points List:

Point ID	Description	Type	Remarks
RTU	Supply Fan Start/Stop	DO	
RTU	Supply Fan Status	AI	Current sensor
RTU	Supply Fan Speed	AO	Display on respective unit's graphic screen
RTU	Exhaust Fan Start/Stop	DO	
RTU	Exhaust Fan Status	AI	Current sesnor
RTU	Exhaust Fan Speed	AO	Display on respective unit's graphic screen
RTU	Supply Air Temperature	AI	Ductstat
RTU	Return Air Temperature	AI	Ductstat
RTU	Mixed Air Temperature	AI	
RTU	Heating Coil Control Valve	AO	Modulating Actuator
RTU	Bypass Air Damper	AO	Modulating Actuator
RTU	Outside Air Damper	AO	Modulating Actuator
RTU	Heat Exchanger Bypass damper	AO	

RTU	Supply Airflow – Array for each fan	AI	Display on respective unit's graphic screen
RTU	Exhaust Airflow– Array for each fan	AI	Display on respective unit's graphic screen
RTU	Outside Airflow	AI	Display on respective unit's graphic screen
RTU	Filter Status	DI	Differential Press Switch
RTU	Duct Smoke Detectors	DI	Multiple
RTU	Return Duct Temperature Sensor	AI	
RTU	Space Temperature Setpoint	AI	
RTU-7, 8 & 9	Space Temperature Sensor	AI	Multiple
RTU-7, 8 & 9	Space Temperature Setpoint	AI	Average – selectable inclusion and priority
RTU	Space CO/NOx Sensor Separate CO and NOx readings	DI	Multiple for each unit
RTU	RTU Supply Fan Energy Output from Variable Frequency Drive	AI	
RTU	RTU Exhaust Fan Energy Output from Variable Frequency Drive	AI	

B. The air handling units shall operate continuously. RTUs are provided with manufacturer's defrost controls and associated on-board dampers and devices. Provide associated startup services for defrost operation. Separate 4-20ma CO & 4-20ma NOx signals from multiple sensors shall be associated with each rooftop unit.

C. During Occupied mode, the supply and exhaust fans shall operate continuously. Provide night purge operation.

1. Coordinate initial balance fan speed settings with the balance contractor to determine the design supply and exhaust fan speeds. Note the VFD frequency settings as "DESIGN AIRFLOW" for each, plainly visible, in the control cabinet adjacent to the VFD. Provide a list of RTU unit designations and the noted frequencies/airflows accessible through the controls system as a reference document.

2. The heating coil control valve shall modulate to maintain the discharge air temperature setpoint to satisfy space temperature (Bus Storage: 55 degrees F – Maintenance Area: 68 degrees F)

   a. RTU-7, 8 & 9: Provide settings for an average space temperature to drive the system, polling the respective space temperature sensors with selectable inclusion and priority, and settings for any one of the space temperature sensors to drive the system.

   b. The unit manufacturer's on-board controls shall initiate defrost control to prevent frosting of the heat exchanger. Coordinate BAS requirements with RTU manufacturer.

3. Provide a high limit CO setpoint and a high limit NOx setpoint (PPM) and minimum ventilation airflow rate (CFM). The CO/NOx levels shall be monitored continuously. Below the high limit, the supply fan and exhaust fan shall modulate fan speed to provide the minimum ventilation airflow rate. Whenever any CO/NOx sensor exceeds the upper limit setpoint, the associated rooftop units shall provide 100% outside air and exhaust until the levels drop below the upper limit.

   a. RTU-8 & 9 shall operate at full airflow, 100% outside air and exhaust air at all times.

   b. The RTU-8 exhaust fan shall reduce airflow by 800 cfm for each hose reel fan in operation.

D. Monitor the unit's filter differential pressure switch and generate an alarm for dirty filters (default - 0.5" wc above clean filter).

E. Safety Controls:

1. The duct smoke detector auxiliary contacts shall be hard-wired into the respective unit's fan control circuits to shut down the fans upon activation. Shut down fans and close outdoor and exhaust air dampers whenever the building fire alarm is activated. Restart units when the alarm signal is cleared.

2. Provide a set of contacts to close whenever RTU-7 status indicates proper unit operation, for the purpose of enabling fuel dispensers. Provide wiring from contact to fuel dispenser control panels. Coordinate with fuel dispenser controls technician.

3.7 SPLIT SYSTEMS

A. Points List:

Point I.D.	Description	Type	Remarks
AC, HPC	Split System Enable/Disable	DO	
AC, HPC, FC	Fan Status	AI	Current transmitter
HPC	Ventilation Fan Status	AI	Current transmitter
AC& FC	Space Temperature Sensor	AI	AC: High temperature alarm
AC & FC	Space Temperature Setpoint	AI	AC: High temperature alarm
FC	Heating Coil Control Valve	AO	
ACCU	ACCU Compressor Start/Stop	DO	
ACCU	ACCU Compressor Current Transmitters	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage
AC, FC, HPC VENTILATION FAN	Fan Motor Current Transmitters	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage

B. For AC and HPC systems temperature controls are provided by the manufacturer with BAS capability to enable/disable; provide individual system schedules. In spaces with the symbol TA, a separate space temperature sensor (no adjustment) shall be provided to alarm whenever the high limit temperature setpoint is exceeded. Provide interconnecting wiring between indoor units and respective ACCUs, and between HPC and respective ventilator fans.

C. The FC-1/ACCU-16 split systems shall operate in either occupied or unoccupied mode as scheduled.

D. During occupied mode the FC-1 fan unit shall operate continuously, the ACCU-16 compressor shall cycle to maintain space temperature setpoint. The FC-1 heating coil control valve shall modulate to maintain space temperature setpoint; cooling or heating operation shall be locked out whenever the opposite mode is engaged.

E. During unoccupied mode the indoor fan unit shall be off. The unit shall cycle occupied mode operation to satisfy the unoccupied space temperature setpoint. The FC-1 fan shall cycle and the heating coil control valve shall modulate to maintain unoccupied space temperature setpoint.

F. Safety Controls:

1. Shut down units whenever the building fire alarm is activated. Restart units when the alarm signal is cleared.

3.8 UNIT VENTILATORS

A. Points List:

Point I.D.	Description	Type	Remarks
UV	Fan Start/Stop	DO	
UV	Fan Status	AI	Current transmitter
UV	Supply Air Temperature	AI	
UV	Outdoor Air Damper	DO	
UV	Face and Bypass Damper	DO	Two position
UV	Heating Coil Control Valve	AO	
UV	Space Temperature Sensor	AI	
UV	Space Temperature Setpoint	AI	
UV	UV Current Transmitters	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage

B. The unit ventilator shall operate in either occupied or unoccupied mode as scheduled.

C. During occupied mode the fan shall operate continuously, the outside air damper shall be open, the coil control valve shall open and the face & bypass dampers shall modulate to maintain the discharge air temperature setpoint to satisfy the space temperature setpoint.

D. During unoccupied mode the fan shall be off, the outside air damper shall be closed and the coil control valve shall be closed. The unit shall cycle occupied mode operation to satisfy the unoccupied space temperature setpoint.

E. Safety Controls:

1. Shut down unit ventilator and close outdoor air damper whenever the building fire alarm is activated. Restart units when the alarm signal is cleared.

3.9 OVERHEAD DOOR HEATERS

A. Points List:

Point ID	**Description**	**Type**	**Remarks**
ODH	Fan Start/Stop	DO	
ODH	Discharge Air Temperature	AI	
ODH	Discharge Air Temperature setpoint	AO	
ODH	Coil Control Valve	AO	
ODH	Overhead Door Open Signal	DI	
ODH	Outside Air Temperature Enable/Disable		Operator manual setting
ODH	Fan Time Delay ON After Door Open Signal		Operator manual setting
ODH	Fan Time Delay OFF After Door Closed		Operator manual setting
ODH	ODH Current Transmitters	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage

A. Whenever the outside air temperature is below the operator manual setting and the door signal is open, the fan shall start and the coil control valve shall modulate to maintain the discharge air temperature setpoint. When the door signals closed, the fan shall stop and the coil control valve shall close. Provide settings for fan time delay when door opens and continued operation time delay when door is closed.

3.10 CABINET UNIT HEATERS/UNIT HEATERS

A. Points List:

Point ID	Description	Type	Remarks
CUH/UH	Fan Start/Stop	DO	
CUH/UH	Fan Status	AI	Current transmitter
CUH/UH	Coil Control Valve	DO	Two position
CUH/UH	Space Temperature Sensor	AI	Unit mounted in return air path if not shown on drawings
CUH/UH	Space Temperature Setpoint	AI	
CUH/UH	CUH/UH Current Transmitters	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage

B. Units shall operate in either occupied or unoccupied mode as scheduled.

C. The fan and coil control valve shall cycle to maintain space occupied and unoccupied space temperature setpoint.

3.11 EXHAUST FANS

A. Points List:

Point ID	Description	Type	Remarks
EF	Fan Start/Stop	DO	
EF	Fan Status	AI	Current transmitter
EF	Damper	DO	Curb mounted
EF	Damper End Switch	DI	
EF-3/4/6/14	Exhaust Fan Button	DI	EXHAUST FAN on push button wall plate
GRV-2	Damper Open/Close	DO	
GRV-2	Damper End Switch	DI	
EF-1	Damper Open/Close	DO	EF and OSA
EF-1	Damper End Switch	DI	EF and OSA
EF-15	Fan Airflow Switch	DI	
EF-6	Space Temperature Sensor	AI	
EF-6	Space Temperature Setpoint	AI	
EF-17	Fan Speed	AI	
EF-17	Exhaust Fan Energy Output from Variable Frequency Drive	AI	
AIR COMPRESSOR	Air Compressor Status	DI	Current sensor

Point ID	Description	Type	Remarks
EF	Current Transmitters	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage
HOSE REEL FANS	Current Sensor	DI	Monitor fans for operation to reduce AHU-8 exhaust fan

B. The exhaust fans shall operate as scheduled and the associated damper shall open, and prove open via end switch, prior to fan start, otherwise the fans shall be off and the dampers closed. If end switch does not prove open an alarm shall be generated and the fan shall remain off.

1. EF-1 and OSA dampers shall open prior to fan start.

2. EF-3/4/6/14 in Lunch Rooms and Boiler Room shall operate from a wall push button switch. When the exhaust fan button is depressed, the fan shall run continuously for an operator defined interval (default - 60 min). Provide laminated nameplate on wall push button plate: EXHAUST FAN.

   a. EF-6 shall also operate to maintain space temperature setpoint whenever the space temperature exceeds the space temperature setpoint. EF-6 and GRV-2 dampers shall open prior to fan start.

3. EF-15 shall be scheduled to operate continuously. Provide a red warning light with audible alarm and lockable silence button within sight of the Maintenance service pit. The alarm shall activate whenever the airflow switch proves no airflow.

4. EF-17 shall vary airflow dependent on number of air compressors operating. Modulate fan to exhaust 2000 cfm for each air compressor operating, for a total of 6000 cfm. Coordinate VFD frequency settings with the air balance contractor. Add EF-17 to the reference document accessible through the controls system noting "STEPPED DESIGN AIRFLOW", with airflow and associated frequency for each step.

3.12 FINNED TUBE RADIATION BELOW 2ND FLOOR

A. Points List:

Point I.D.	Description	Type	Remarks
FT-4	Finned Tube Control Valve Open/Close	DO	Two Position
Space	Space Temperature Sensor	AI	Multiple
Space	Space Temperature Setpoint	AI	

B. Provide settings for an average space temperature to drive the system, polling the respective space temperature sensors, and settings for any one of the space temperature sensors to drive the system.

C. Cycle the finned tube control valve to satisfy the space temperature setpoint.

3.13 PAINTBOOTH

A. Points List:

Point I.D.	Description	Type	Remarks
MAU	Makeup Air Fan Status	DI	Current sensor
MAU	Supply Air Temperature	AI	
EF	Paithbooth Fan Status	DI	Current sensor

B. Provide interconnecting control wiring and all necessary devices between the makeup air unit, exhaust fan and manufactuer's control panel. Set up system operation per manufacturer's instructions.

3.15 RADIANT FLOOR HEATING SYSTEM

A. Points List:

Point ID	Description	Type	Remarks
RZ	Pump Start/Stop	DO	
RZ	Pump Status	AI	Current transmitter
RZ	Mixing Valve	AO	
RZ	Supply Water Temperature	AI	
RZ	Return Water Temperature	AI	
RZ	Mixed Water Temperature	AI	
RZ	Slab Sensor	AI	
RZ	Slab Sensor Setpoint	AI	
RZ	Pump Current Transmitters	AI	Multiple current transmitters, on each electrical power leg, for trending total electrical usage

B. The pump shall cycle to maintain the respective slab sensor setpoint. The mixing valve shall modulate to maintain the radiant supply water temperature 98°F. Provide high and low slab temperature limit settings beyond which an alarm shall be generated.

C. There shall be no electronic devices within 18" of the Maintenance floor, or within the Maintenance Pits.

3.14 PRESSURE WAHER DRAFT INDUCER (DIF-1)

A. Provide wiring between pressure washer and draft inducer, and set up system operation per manufacturer's instructions. Draft inducer shall provide proof of flow prior to burner ignition.

3.15 STORAGE & MAINTENANCE WINDOW OPEN SIGNAL

A. The BAS shall monitor open/closed window positions in Storage and Maintenance clearstories. The windows open/close in groups – (10) groups in Storage clearstory and (5) groups in Maintenance clearstory. Provide a switch for one window in each group. BAS shall monitor, provide graphics screen representation of clearstory with window positions.

3.16 ELECTRICAL DEMAND MONITORING AND TRENDING MEASUREMENT AND VERIFICATION PLAN

A. Trend electrical demand and voltage at electrical service, individual HVAC equipment current sensors, site lighting panels, interior lighting panels and gas meters.. Trending shall continue at 15 minute intervals for a minimum of one year. As a minimum throughout the first year, the contractor is responsible for a monthly all inclusive energy usage report indicating current month and previous months energy usage, as well as a Summary of Savings to Date report. Provide data equipment necessary for storage of a year's worth of trend data and reports, with each point trending at 15 minute intervals.

1. Trend domestic water usage through water meter for record.

B. Trending: Provide trending for the following categories:

1. Voltage at electrical service
2. Facility-wide electrical usage

3. Individual HVAC equipment electrical usage

   a. Space heating
   b. Pumps
   c. Fans
   d. Space Cooling

4. Site lighting electrical energy usage

5. Interior lighting electrical energy usage

   a. Conditioned Spaces
   b. Non-Conditioned Spaces

6. Natural gas usage

   a. Site Meter
   b. Boiler Service

7. Domestic water usage

C. Provide Trending of the following items for the above categories:

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Gas Meter Serving Boilers - B-1, B-2, B-3, B-4	Total MMBtu													
Space Heating Total	Total MMBtu													
Electrical Distribution Total	Total kWh Max kW													
Boiler B-1	Total kWh													
	Max kW													
Boiler B-2	Total kWh													
	Max kW													
Boiler B-3	Total kWh													
	Max kW													
Boiler B-4	Total kWh													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
	Max kW													
Space Heating Total	Total kWh													
	Max kW													
Pump P-1	Total kWh													
	Max kW													
Pump P-2	Total kWh													
	Max kW													
Pump BP-1	Total kWh													
	Max kW													
Pump BP-2	Total kWh													
	Max kW													
Pump BP-3	Total kWh													
	Max kW													
Pump BP-4	Total kWh													
	Max kW													
Radiant System RZ-1	Total kWh													
	Max kW													
Radiant System RZ-2	Total kWh													
	Max kW													
Radiant System RZ-3	Total kWh													
	Max kW													
Radiant System RZ-4	Total kWh													
	Max kW													
Radiant System RZ-5	Total kWh													
	Max kW													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Radiant System RZ-6	Total kWh													
	Max kW													
Radiant System RZ-7	Total kWh													
	Max kW													
Radiant System RZ-8	Total kWh													
	Max kW													
Radiant System RZ-9	Total kWh													
	Max kW													
Radiant System RZ-10	Total kWh													
	Max kW													
Radiant System RZ-11	Total kWh													
	Max kW													
Radiant System RZ-12	Total kWh													
	Max kW													
Pumps Total	Total kWh													
	Max kW													
Exhaust Fan EF-1	Total kWh													
	Max kW													
Exhaust Fan EF-2	Total kWh													
	Max kW													
Exhaust Fan EF-3	Total kWh													
	Max kW													
Exhaust Fan EF-4	Total kWh													
	Max kW													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Exhaust Fan EF-5	Total kWh													
	Max kW													
Exhaust Fan EF-6	Total kWh													
	Max kW													
Exhaust Fan EF-7	Total kWh													
	Max kW													
Exhaust Fan EF-8	Total kWh													
	Max kW													
Exhaust Fan EF-9	Total kWh													
	Max kW													
Exhaust Fan EF-10	Total kWh													
	Max kW													
Exhaust Fan EF-11	Total kWh													
	Max kW													
Exhaust Fan EF-12	Total kWh													
	Max kW													
Exhaust Fan EF-13	Total kWh													
	Max kW													
Exhaust Fan EF-14	Total kWh													
	Max kW													
Exhaust Fan EF-15	Total kWh													
	Max kW													
Exhaust Fan EF-16	Total kWh													
	Max kW													
Exhaust Fan EF-17	Total kWh													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
	Max kW													
Unit Heater ODH-1	Total kWh													
	Max kW													
Unit Heater ODH-2	Total kWh													
	Max kW													
Unit Heater ODH-3	Total kWh													
	Max kW													
Unit Heater ODH-4	Total kWh													
	Max kW													
Unit Heater ODH-5	Total kWh													
	Max kW													
Unit Heater ODH-6	Total kWh													
	Max kW													
Unit Heater ODH-7	Total kWh													
	Max kW													
Unit Heater ODH-8	Total kWh													
	Max kW													
Unit Heater UH-1	Total kWh													
	Max kW													
Unit Heater UH-2	Total kWh													
	Max kW													
Unit Heater UH-3	Total kWh													
	Max kW													
Unit Heater UH-4	Total kWh													
	Max kW													
Unit Heater	Total													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
UH-5	kWh													
	Max kW													
Unit Heater UH-6	Total kWh													
	Max kW													
Unit Heater UH-7	Total kWh													
	Max kW													
Unit Heater UH-8	Total kWh													
	Max kW													
Unit Heater UH-9	Total kWh													
	Max kW													
Unit Heater UH-10	Total kWh													
	Max kW													
Unit Heater UH-11	Total kWh													
	Max kW													
Unit Heater UH-12	Total kWh													
	Max kW													
Unit Heater UH-13	Total kWh													
	Max kW													
Unit Heater UH-14	Total kWh													
	Max kW													
Unit Heater UH-15	Total kWh													
	Max kW													
Unit Heater UH-16	Total kWh													
	Max kW													
Unit Heater UH-17	Total kWh													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
	Max kW													
Unit Heater UH-18	Total kWh													
	Max kW													
Unit Ventilator UV-1	Total kWh													
	Max kW													
Unit Ventilator UV-2	Total kWh													
	Max kW													
Cabinet Heater CUH-1	Total kWh													
	Max kW													
Cabinet Heater CUH-2	Total kWh													
	Max kW													
Cabinet Heater CUH-3	Total kWh													
	Max kW													
Cabinet Heater CUH-4	Total kWh													
	Max kW													
Cabinet Heater CUH-5	Total kWh													
	Max kW													
Cabinet Heater CUH-6	Total kWh													
	Max kW													
Cabinet Heater CUH-7	Total kWh													
	Max kW													
Cabinet Heater CUH-8	Total kWh													
	Max kW													
Cabinet Heater CUH-9	Total kWh													
	Max kW													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
RTU-1 Supply Fan VFD	Total kWh													
	Max kW													
RTU-1 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-2 Supply Fan VFD	Total kWh													
	Max kW													
RTU-2 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-3 Supply Fan VFD	Total kWh													
	Max kW													
RTU-3 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-4 Supply Fan VFD	Total kWh													
	Max kW													
RTU-4 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-5 Supply Fan VFD	Total kWh													
	Max kW													
RTU-5 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-6 Supply Fan VFD	Total kWh													
	Max kW													
RTU-6 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-7 Supply Fan VFD	Total kWh													
	Max													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
	kW													
RTU-7 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-8 Supply Fan VFD	Total kWh													
	Max kW													
RTU-8 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-9 Supply Fan VFD	Total kWh													
	Max kW													
RTU-9 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-10 Supply Fan VFD	Total kWh													
	Max kW													
RTU-10 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-11 Supply Fan VFD	Total kWh													
	Max kW													
RTU-11 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-12 Supply Fan VFD	Total kWh													
	Max kW													
RTU-12 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-13 Supply Fan VFD	Total kWh													
	Max kW													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
RTU-13 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-14 Supply Fan VFD	Total kWh													
	Max kW													
RTU-14 Exhaust Fan VFD	Total kWh													
	Max kW													
RTU-15 Supply Fan VFD	Total kWh													
	Max kW													
RTU-15 Exhaust Fan VFD	Total kWh													
	Max kW													
Fans Total	Total kWh													
	Max kW													
RTU-1 (subtract VFD's)	Total kWh													
	Max kW													
RTU-2 (subtract VFD's)	Total kWh													
	Max kW													
RTU-3 (subtract VFD's)	Total kWh													
	Max kW													
RTU-4 (subtract VFD's)	Total kWh													
	Max kW													
RTU-5 (subtract VFD's)	Total kWh													
	Max kW													
RTU-6 (subtract VFD's)	Total kWh													
	Max kW													
RTU-7 (subtract	Total kWh													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
VFD's)	Max kW													
RTU-8 (subtract VFD's)	Total kWh													
	Max kW													
RTU-9 (subtract VFD's)	Total kWh													
	Max kW													
RTU-10 (subtract VFD's)	Total kWh													
	Max kW													
RTU-11 (subtract VFD's)	Total kWh													
	Max kW													
RTU-12 (subtract VFD's)	Total kWh													
	Max kW													
RTU-13 (subtract VFD's)	Total kWh													
	Max kW													
RTU-14 (subtract VFD's)	Total kWh													
	Max kW													
RTU-15 (subtract VFD's)	Total kWh													
	Max kW													
Split System AC-1	Total kWh													
	Max kW													
Split System ACCU-1	Total kWh													
	Max kW													
Split System AC-2	Total kWh													
	Max kW													
Split System ACCU-2	Total kWh													
	Max kW													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Split System AC-3	Total kWh													
	Max kW													
Split System ACCU-3	Total kWh													
	Max kW													
Split System AC-4	Total kWh													
	Max kW													
Split System ACCU-4	Total kWh													
	Max kW													
Split System AC-5	Total kWh													
	Max kW													
Split System ACCU-5	Total kWh													
	Max kW													
Split System AC-6	Total kWh													
	Max kW													
Split System ACCU-6	Total kWh													
	Max kW													
Split System AC-7	Total kWh													
	Max kW													
Split System ACCU-7	Total kWh													
	Max kW													
Split System AC-8	Total kWh													
	Max kW													
Split System ACCU-8	Total kWh													
	Max kW													
Split System AC-9	Total kWh													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
	Max kW													
Split System ACCU-9	Total kWh													
	Max kW													
Split System AC-10	Total kWh													
	Max kW													
Split System ACCU-10	Total kWh													
	Max kW													
Split System AC-11	Total kWh													
	Max kW													
Split System ACCU-11	Total kWh													
	Max kW													
Split System AC-12	Total kWh													
	Max kW													
Split System ACCU-12	Total kWh													
	Max kW													
Split System AC-13	Total kWh													
	Max kW													
Split System ACCU-13	Total kWh													
	Max kW													
Split System AC-14	Total kWh													
	Max kW													
Split System ACCU-14	Total kWh													
	Max kW													
Split System AC-15	Total kWh													
	Max kW													
Split System	Total													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
ACCU-15	kWh													
	Max kW													
Split System FC-1	Total kWh													
	Max kW													
Split System ACCU-16	Total kWh													
	Max kW													
Split System HPC-1/ACHP-1	Total kWh													
	Max kW													
Split System HPC-2/ACHP-2	Total kWh													
	Max kW													
Split System HPC-3/ACHP-3	Total kWh													
	Max kW													
Split System HPC-4/ACHP-4	Total kWh													
	Max kW													
Split System HPC-5/ACHP-5	Total kWh													
	Max kW													
Space Cooling Total	Total kWh													
	Max kW													
Lighting-conditioned	Total kWh													
	Max kW													
Lighting-unconditioned	Total kWh													
	Max kW													
Lighting-Site	Total kWh													

End Use	Usage	Monthly Total												Annual Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
	Max kW													
Guard Booth	Total kWh													
	Max kW													
Balance of Site meter Consumption - Electric	Total kWh													
	Max kW													
Balance of Site meter Consumption - Gas	Total kWh													
	Max kW													

END OF SECTION 230993

SECTION 28 31 00 - VOICE COMMUNICATION FIRE ALARM AND DETECTION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

A. Extent of voice communication fire alarm and detection systems work is indicated by drawings and schedules.

B. Types of voice communication fire alarm and detection systems in this section include the following:

1. Combination, Non-Coded, Intelligent, Addressable.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of voice communication fire alarm and detection systems, of types, sizes, and electrical characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer: Qualified with at least 5 years of successful installation experience on projects with voice communication fire alarm and detection systems installation work similar to that provided for project. The contractor must be Connecticut State Licensed. .

C. NEC Compliance: Comply with NEC as applicable to installation and construction of voice communication fire alarm and detection systems components and accessories.

D. UL Compliance and Labeling: Provide voice communication fire alarm and detection systems components which are UL-listed and labeled.

1.4 ACTION SUBMITTALS

A. Submit the following in accordance with Form 816 Article 1.20-1.05.02 and NOTICE TO CONTRACTOR – SUBMITTALS.

B. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

1.5 INFORMATION SUBMITTALS

A. Qualification Data: For Installer and field testing agency.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For Addressable Fire Alarm and Detection System to include in the operation and maintenance manuals specified in Form 816 Article 1.20-1.08.14 subsection 2 and described in

NOTICE TO CONTRACTOR – CLOSEOUT DOCUMENTS.

B. Warranty: For Fire Alarm manuals specified in Form 816 Article 1.20-1.06.08 and described in NOTICE TO CONTRACTOR – CLOSEOUT DOCUMENTS.

PART 2 - PRODUCTS

2.1 VOICE COMMUNICATION FIRE ALARM AND DETECTION SYSTEMS

A. General: Noncoded, Intelligent, Addressable, microprocessor based type system with manual and automatic alarm initiation, intelligent addressable smoke detectors, and voice evacuation.

B. Functional Description: Provide a complete voice communication fire alarm & detection systems with the following functions and operating features:

1. Priority of Signals: Automatic response functions shall be accomplished by the first address initiated. Alarm functions resulting from initiation by the first address shall not be altered by subsequent alarms. An alarm signal shall be the highest priority. Supervisory or trouble signals shall have second- and third-level priority. Signals of a higher level priority shall take precedence over signals of lower priority even though the lower priority condition occurred first. Annunciate all alarm signals regardless of priority or order received.

2. Non-interfering: Provide addressable, powered, wired, and supervised system so a signal on one address does not prevent the receipt of signals from any other address. All devices shall be manually resettable from the FACP after the initiating device or devices have been restored to normal. Systems that require the use of batteries or battery backup for the programming function are not acceptable.

3. Signal Initiation: The manual or automatic operation of an alarm initiating or supervisory operating device shall cause the FACP to transmit an appropriate signal including:

a. General alarm.
b. Smoke detector alarm.
c. Door release.
d. Elevator recall.
e. System trouble.
f. Fan shutdown.

4. Equipment Monitoring: Provide monitor modules to monitor status of the following equipment:

a. Elevator disconnect (shunt trip device)
b. Generator status (position of ATS)

5. Silencing at FACP: Switches shall provide capability for acknowledgment of alarm; supervisory, trouble, and other specified signals at the FACP; and capability to silence the local audible signal and light an LED (light emitting diode). Subsequent alarms shall cause the audible signal to sound again until silenced in turn by switch operation. Restoration to normal of alarm, supervisory, and trouble conditions shall extinguish the associated LED and cause the audible signal to sound again until the restoration is acknowledged by switch operation.

6. Power Loss Indication: Sound trouble signal at the FACP upon loss of primary power at the FACP and the annunciator. Illuminate the emergency power light at both locations when the system is operating on an alternate power supply.

7. Annunciation: Annunciate manual or automatic operation of any alarm or supervisory initiating device both on the FACP and on the remote annunciator indicating the location and type device.

8. General Alarm: A system general alarm includes:

   a. Indicating the general alarm condition at the FACP and the system annunciator.

   b. Identifying the device that is the source of the alarm at the FACP and the system annunciators.

   c. Initiating audible and visible alarm signals throughout the building.

   d. Initiating automatic recall operation of elevators.

   e. Closing fire and smoke doors normally held open by magnetic door holders.

   f. Stopping supply and return fans.

   g. Closing smoke dampers on system.

   h. Initiating transmission of alarm signal to remote central station.

9. Manual station alarm operation initiates a general alarm.

10. Smoke detection initiates a general alarm.

11. Heat detection is to initiate a general alarm.

12. Sprinkler system water flow is to initiate a general alarm.

13. Sprinkler system tamper switch initiation is to initiate a trouble signal.

14. Permissible Signal Time Elapse: The maximum permissible elapsed time between the actuation of any fire alarm or fire detection system alarm initiating device and its indication at the FACP is ten seconds.

15. Circuit Supervision: Indicate circuit faults with both a zone and a trouble signal at the FACP. Provide a distinctive indicating audible tone and (LED) indicating light. The maximum elapsed time between the occurrence of the trouble condition and its indication at the FACP is 200 seconds.

16. FACP shall monitor status of stand-by generator. Elevator disconnect shall trip and shall annunciate a trouble signal from any signal from the devices.

17. System Alarm Detection and Reporting.

   a. When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:

(1) The System Alarm LED shall flash.

(2) A local Piezo-Electric signal in the control panel shall sound.

(3) The 80-character LCD display shall indicate all information associated with the fire alarm condition, including: type of alarm point, its location within the protected premises, and the time and date of that activation.

(4) If any of the available optional serially connected equipment is being used, then each of the connected peripherals will display/print the information associated with the Fire Alarm Control Panel condition, including the time/date stamping of the change of status event.

(5) All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated System Outputs (Alarm Indicating Appliances and/or relays) shall be activated. Unacknowledged alarm messages shall have priority over trouble messages, and if such an Alarm occurs during a Trouble sequence, the Alarm condition will have display priority.

18. System Trouble Detection:

a. When a trouble condition is detected and reported by one of the system initiating devices, the following functions shall immediately occur:

(1) The System Trouble LED shall flash.

(2) A local Piezo electric signal in the control panel shall sound.

(3) The 80-character LCD display shall indicate all information associated with the Fire Alarm Trouble condition, including: type of trouble point, its location within the protected premises, and the time and date of that activation.

(4) If any of the available optional serially connected equipment is being used, then each of the connected peripherals will display/print the information associated with the Fire Alarm Control Panel condition, including the time/date stamping of the change of status event.

(5) If applicable, all system output programs assigned via control-by-event equations to be activated by the particular point in trouble shall be executed, and the associated System Outputs (Trouble Indicating Appliances and/or relays) shall be activated.

(6) Unacknowledged alarm messages shall have priority over trouble messages, and if such an Alarm occurs during a Trouble sequence, the Alarm condition will have display priority.

C. System Common Control Switch Operation

1. Acknowledge (ACK/STEP) Switch.

a. Activation of the control panel Acknowledge switch in response to a single new

Alarm and/or Trouble condition shall silence the local panel Piezo electric signal and change the System Alarm or Trouble LED from flashing mode to steady-ON mode. If additional new Alarm or Trouble conditions exist or are detected and reported in the system, depression of this switch shall advance the 80-character LCD display to the next Alarm or Trouble condition.

b. In this case, the local Piezo sounder shall not silence, and the Alarm/Trouble LED's shall not transfer to their steady-ON mode, thus signaling to the operator that more Alarm/Trouble conditions are present in the system.

c. Alarm conditions shall always have display priority before Trouble conditions.

d. Depression of the Acknowledge switch shall also cause a corresponding (time-stamped) message to be displayed on all system peripheral equipment (if used).

e. Occurrence of any new Alarm or Trouble conditions in the system shall cause the Control Panel to resound the Local Piezo sounder and repeat the Alarm or Trouble sequences.

2. Signal Silence Switch:

a. Activation of the Signal Silence Switch shall cause all programmed Alarm Indicating Appliance and relays to return to the normal condition after an alarm condition. The selection of indicating circuits and relays which are silenceable by this switch shall be fully field programmable within the confines of all applicable standards.

3. System Reset Switch:

a. Activation of the System Reset Switch shall cause all electronically-latched initiating devices, appliances or software zones, as well as all associated output devices and circuits, to return to their normal condition.

b. If the alarm condition(s) still exist, or if they re-occur in the system after System Reset Switch activation, the system shall then resound the alarm conditions.

4. System Test Switch:

a. Activation of the System Test Switch shall initiate an automatic test of all Intelligent/Addressable detectors in the system. The System Test shall activate the electronics in each intelligent sensor, simulating an alarm condition and causing the transmission of the alarm condition from that sensor to the Fire Alarm Control Panel. The Fire Alarm Control Panel shall interpret the data from each sensor installed in the system. A report summarizing the results of this test shall be displayed automatically on the System Liquid Crystal Display, as well as on any CRT's or printers in the System.

5. Lamp Test Switch:

a. Activation of the Lamp Test Switch shall sequentially turn ON all LED indicators, System Liquid Crystal Display and Local Piezo-Electric Signal, and then automatically return the Fire Alarm Control Panel to the previous condition.

D. Field Programming

1. The system shall be programmable, configurable and expandable in the field without the need for special tools or electronic equipment and shall not require field replacement of electronic integrated circuits. All programming shall be accomplished through the standard common control panel keyboard or through the use of the optional CRT-1 keyboard. All field defined programs shall be stored in non-volatile memory. The programming function shall be enabled with a special 5-digit password that may be defined specifically for the system when it is installed.

2. The password may be changed to a new value at any time by the installing Distributor. In the event that the Installing Distributor may define a password that then lose or forget it, the system shall be designed so that the valid password may be determined by special procedures available through the system manufacturer.

3. The system shall provide means for automatic programming of its operation to conform with certain NFPA Standards through internal software. The following NFPA operations are to be available through this means:

   a. NFPA 72A Local Protective Signaling Systems
   b. NFPA 72B Auxiliary Protective Signaling Systems
   c. NFPA 72C Remote Station Protective Signaling Systems

E. System Operations

1. Smoke Detector Sensitivity Adjust

   a. Means shall be provided for adjusting the sensitivity of any or all analog intelligent detectors in the system from the System keypad or from the keyboard of the CRT-1.

   b. Sensitivity range shall be within the allowed UL window, and shall be a HIGH/MEDIUM/LOW selection.

2. Alarm Verification

   a. Each of the Intelligent/Addressable Smoke Detectors in the system may be independently selected and enabled to be an alarm verified detector. The Alarm Verification Function shall be from 5-50 seconds and each detector shall be able to be enabled/disabled during the field programming of the system, or anytime after system turn-ON. The alarm verification shall not require any additional hardware to be added to the Fire Alarm Control Panel.

3. System Reports

   a. The system will be able to generate and print a summary of all of the Detectors, Modules, Pull Stations, and Zones which are currently active in the System. This printout will require password protection to prevent unauthorized user access, and will automatically print the system report using "soft" (single push) keys. No computer expertise will be required to initiate the System Report sequence.

   b. The following parameters will be printed for all installed system points whenever a "System Report" is requested:

(1) Custom 20 character detector/module label
(2) Detector/module type.
(3) Detector sensitivity.
(4) Control-by-Event equation assignments.
(5) Waterflow Zone select.
(6) Supervisory Zone select.
(7) Verified Detector select.
(8) Verification Tally Counter.
(9) Silenceable Indicating Circuit.

4. Point Parameter Selections

a. The following parameters may be defined in the field for any of the system points, and will become a permanent part of the individual point identification. These data will be automatically displayed whenever the particular point is in the alarm or trouble mode, or whenever a "Point Status" or "System Report" is requested by the operator:

(1) Custom 20 character detector/module label
(2) Detector/module type.
(3) Detector sensitivity.
(4) Control-by-Event equation assignments.
(5) Waterflow Zone select.
(6) Supervisory Zone select.
(7) Verified Detector select.
(8) Verification Tally Counter.
(9) Silenceable Indicating Circuit.

5. Signal Silence Inhibit Time

a. The Fire Alarm System shall be equipped with a Signal Silence Inhibit feature which will prevent the operator from silencing any of the signals for a period of 90 seconds (1-255 seconds). The function of this Signal Silence Inhibit Timer shall be field programmable and it's limit shall be field definable, without the need for the installation of any hardware modules into the system.

6. Automatic Signal Cut-Out Time

a. The Fire Alarm System shall be equipped with a Automatic Signal Silence Cut-Out feature which will automatically silence all of the signals after a period of 600 seconds (1-2040 seconds selectable in 8 second increments). The function of this automatic signal silence cut-out timer shall be field programmable and it's limit shall be field definable, without the need for the installation of any hardware modules into the system.

7. System Point Operations

a. Device Disable

(1) Any device in the system may be Enabled or Disabled through the system keypad or CRT-1 without the need to reprogram or deprogram any of the operational parameters of the point such as Control-By-Event linkages, etc.

b. Output Point Control

(1) Any system output point may be turned ON or OFF from the system keypad or the CRT-1.

8. Point Read

a. The system shall be able to perform the following point status diagnostic functions without the need for peripheral equipment to make the readings. Each point will be annunciated for the parameters listed:

Detectors:
Device Status
Device Type
Custom Device Label (20 character minimum)
Software Zone Label (20 character minimum)
Time and Date
Device Address
SLC Loop Number

Control Modules:
Device Status
Device Type
Custom Device Label (20 character minimum)
Software Zone Label (20 character minimum)
Time and Date
Device Address
SLC Loop Number

Monitor Modules:
Device Status
Device Type
Custom Device Label (20 character minimum)
Software Zone Label (20 character minimum)
Time and Date
Device Address
SLC Loop Number

Software Zones:
Software Zone Status
Software Zone Type
Software Zone Label (20 character minimum)
Time and Date

Annunciator Points:
Device Status
Device Type
Custom Device Label (20 character minimum)
Software Zone Label (20 character minimum)
Time and Date
Device Address
SLC Loop Number

9. System Alarm Point Display

a. Upon the receipt of an alarm condition from any point in the system, the following information shall be displayed and (optionally) printed.

Modules: Module Type

Custom Module Label (20 character minimum)
Software Zone Label (20 character minimum)
Time and Date
Module Address
SLC Loop Number

Detectors: Detector Type
Custom Device Label (20 character minimum)
Software Zone Label (20 character minimum)
Time and Date
Detector Address
SLC Loop Number

10. System Trouble Point Display

a. Upon the receipt of a trouble condition from any point in the system, the following information shall be displayed and (optionally) printed.

Modules:
Type of Trouble Condition: Invalid Reply
Open Circuit
Short Circuit
Point Trouble
Sprinkler Trouble

Device Type: Custom Module Label (20 character minimum)
Software Zone Label (20 character minimum)
Time and Date
Device Address
SLC Loop Number

Detectors:
Type of Trouble Condition: Invalid Reply
Maintenance Required
Low Chamber Value

Device Type: Custom Module Label (20 character minimum)
Software Zone Label (20 character minimum)
Time and Date
Device Address
SLC Loop Number

11. System Trouble Display (Global)

a. Upon the receipt of a Global, or System-Wide trouble condition the following information shall be displayed and (optionally) printed.

Device Status
Specific Trouble Message
Time and Date of Trouble Condition
Trouble Index Code

12. System Annunciator Trouble Display

a. Upon the receipt of a trouble condition from any annunciator in the system, the following information shall be displayed and (optionally) printed.

(1) Device Status
(2) Annunciator Module Identification
(3) Specific Trouble Message
(4) Time and Date of Trouble Condition
(5) Trouble Index Code

13. System Status Reports

a. Upon command from a password-authorized operator of the system, the following reports will be generated, and (optionally) printed:

b. System Configuration Report: A System Configuration Report will show:

(1) The number of SLC Loops in the system.
(2) The Operating Style of each installed Loop.
(3) The Alarm Verification Time for the System.
(4) The Signal Silence Inhibit Time for the system.
(5) The Automatic Signal Silence Time
(6) The Supervisory Status of the CRT
(7) CRT status line function
(8) Local Piezo signal function
(9) Local Mode Module and Detector functionality.
(10) Installed Annunciators List

c. Point Status Report: Upon command from a password-authorized operator of the system, a report will be generated which details each and every installed detector, module, zone, and annunciator, as well as any and all field programmed parameters which have been assigned to these points, and (optionally), printed:

14. System History Recording and Reporting

a. The Fire Alarm Control Panel shall contain a History Buffer which will be capable of storing up to 400 system output/input/control activations. Each of these activations will be stored and time and date stamped with the actual time of the activation, until a password authorized operator requests that the contents be either displayed, or printed.

b. The contents of the History Buffer may be manually reviewed, one event at a time, and the actual number of activations may also be displayed and or printed.

c. History Buffer Reports (whether Displayed or Printed), will be instantly distinguishable from all other displayed or printed system reports through the use of a semicolon in the time/date stamp of the data.

15. Automatic Detector Maintenance Alert

a. The Fire Alarm Control Panel shall automatically interrogate each Intelligent System Detector and shall analyze the detector responses over a period of time.

b. If any Intelligent Detector in the system responds with a reading which is below

20% of normal limits (for 5 out of 6 polls), or above 80% of normal limits for a period of 26 hours, then the system will enter the Trouble Mode, and the particular Intelligent Detector will be annunciated on the System Display, and printed on the optional System Printer.

c. This feature shall in no way inhibit the receipt of Alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.

F. Extra Materials:

1. General: Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels clearly describing contents.

2. Lamps for Strobe Units: Furnish quantity equal to 10 percent of the number of units installed, but not less than one.

3. Smoke Detectors and Heat Detectors: Furnish quantity equal to 10 percent of the number of units of each type installed but not less than one of each type.

4. Detector Bases: Furnish quantity equal to 2 percent of the number of units of each type installed but not less than one of each type.

5. Speakers: Furnish quantity equal to 2 percent of the number of units installed.

G. Available Manufacturers:

1. Siemens (Cerberus Division).
2. Simplex Time Recorder Co.
3. Notifier

2.2 MATERIALS AND EQUIPMENT

A. Alarm Initiating Devices

1. Manual Pull Stations

a. General: Double-action type, fabricated of metal or polycarbonate, and finished in red with molded raised letter operating instructions of contrasting color. Stations requiring the breaking of glass are not acceptable.

b. Reset: Key-or wrench-operated reset station switch, double pole, double throw, and rated for the voltage and current at which they operate. Provide stations with screw terminals for connections.

c. Addressability: Provide pull stations with a communication transmitter and receiver having a unique identification and status reporting capability to the FACP.

d. Provide on each manual pull station a clear cover with built in annunciator similar to STI #STI-1100, for flush mounted pull stations and STI #STI-1130 for surface mounted pull stations.

2. Smoke Detectors

a. General: Comply with UL 268, "Smoke Detectors for Fire Protective Signalling Systems." Provide the following features:

b. Factory Nameplate: With serial number and type identification.

c. Operating Voltage: 24-V d.c., nominal.

d. Self-Restoring: Provide detectors that do not require resetting or readjustment after actuation to restore them to normal operation.

e. Plug-in Arrangement: Detector and associated encapsulated electronic components mounted in a module that connects to a fixed base with a twist-locking plug connection. The plug connection shall require no springs for secure mounting and contact maintenance. Provide terminals in the fixed base for building wiring.

f. Visual Indicator: Connected to indicate detector has operated.

g. Addressability: Provide detectors with a communication transmitter and receiver having a unique identification and status reporting capability to the FACP.

h. Photoelectric Smoke Detectors: Include the following features and characteristics:

(1) Detector Sensitivity: 1.6 percent per foot smoke obscuration when tested in accordance with UL 268.

(2) Sensor: Infrared detector light source with matching silicon cell receiver.

3. Addressable Thermal Detector: Rate compensated / fixed temperature type with plug-in base and alarm indication lamp. Provide detectors with a communication transmitter and receiver complete having a unique identification and status-reporting capability to the FACP.

4. Addressable Duct Detectors: Provide Detectors which are of the intelligent photoelectric type in a duct housing with sampling tubes, and provide continuous analog monitoring of the unit's sensitivity and alarm verification from the FACP. Detectors shall be UL 268A listed, 24 VDC, rated for air velocities from 300 to 4000 feet per minute, having two Form-C auxiliary contacts, and have powered outputs for remote LED indicators.

B. Materials and Equipment

a. Carbon Monoxide & Nitrogen Dioxide Sensors.

b. Each detector shall contain an electro-chemical carbon monoxide (CO) sensor with temperature compensation circuits and en electro-chemical nitrogen dioxide (NO2) sensor contained in a NEMA 1 enclosure with (4) pre-punched conduit openings and screened openings to allow proper sensing. The detector shall be protected against static discharge and excessive electrical noise, and shall include factory-installed wiring that exits the enclosure and allows for installation without the detector being opened. ETL listed, conforming to UL 3111-1 standard.

c. The detector shall have a 1/2" minimum height, liquid crystal display (LCD) that will continually display the current nitrogen dioxide (NO2) and carbon monoxide (CO) level, in parts per million. The detector shall have a green "power" LED, a yellow "sensor-active" LED, a red "low-alert" LED, a red "high-alert" LED and a red "alarm" LED. An external push button on the front of the enclosure shall be provided to silence the 106 dB internal alarm. The alarm circuit shall become active again, once the detector is no longer at alarm levels.

d. The detector shall provide separate proportional 4-20 ma DC signals in direct relationship to the nitrogen dioxide (NO2) and carbon monoxide (CO) gas concentrations. The signals shall be compatible with Building Automation System specified in specification section 230900.

e. Output relays providing a normally closed set of contacts for the low-alert and for alarm shall be provided. These relays shall be suitable for the connection of 24 VAC, 24 VA inductive circuits.

f. Switches shall be provided for field adjustment of the gas detection level for the low-alert, and of the on/off time delay for the low-alert and high-alert. Selectable CO detection levels shall range from 20 to 55 ppm and the NO2 detection levels shall range from 0.3 to 4.0 ppm. Selectable time delays shall range from 0 to 7 minutes, in 1 minute increments.

g. The detector shall contain a power supply fuse rated for 0.400 amp at 250 VAC/24 VAC. Each output relay shall have a fuse rated for 5 amp at 250 VAC. Fuses shall be of the time-lag type.

C. Alarm Indicating Devices

1. General: Equip alarm indicating devices for mounting as indicated. Provide terminal blocks for system connections.

2. Addressable Interface Units: Unit designed to monitor system component not equipped for multiplex communication with FACP and transmit identification and status to that terminal. Provide units with a communication transmitter and receiver complete having a unique identification and status-reporting capability to the FACP.

3. Fire Alarm Speakers: 25-VRMS, flush mounted, 7 - 3/8" white round speaker with field selectable power taps of 1/4 W, 1/2 w, 1 W, and 2 Watts, and a uniform frequency response range from 400 - 4000 Hz.

   a. Ceiling Speakers shall be: White.
   b. Wall Mounted Speakers shall be: Red.

4. Visual Alarm Signals: 24-V d.c. strobe lights utilizing high-intensity, white or clear, optic lens, and xenon flash tube. Provide the word "FIRE" engraved in minimum 1 inch high letters displayed on the unit. Provide units with field selectable candela output of 15, 15/75, 30, 75, 110 candela via unit mounted dip switches. Units are to have a constant 1 Hz flash rate regardless of input voltage. Comply with strobe intensity and location regulations per CABO/ANSI A117.1-1992.

   a. Red - System Sensor No. S1224MC, or equal.
   b. Weatherproof – Similar to System Sensor No. S1224MCK, or equal.

5. Combination Signals: Provide factory-combined audible and visible alarm units in a single mounting unit where indicated.

D. Magnetic Door Holders

1. General: Magnetic door holders will be provided by the G.C. E.C. to wire per "Fire Alarm Riser Diagram" on the drawings.

E. Fire Alarm Control Panel (FACP)

1. General: Comply with UL 864, "Control Units for Fire Protective Signaling Systems."

2. Cabinet: The control panel shall be housed in a cabinet designed for mounting directly to a wall or vertical surface. The back box and door shall be constructed of .060 steel with provisions for electrical conduit connections into the sides and top. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators. The cabinet shall be approximately 5 inches deep and 24 inches wide. Height shall be approximately 46 inches. The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.

3. System Capacity and General Operation: The control panel shall provide or be capable of expansion to the following capacities:

a.	Intelligent/Addressable Loops	10
b.	Intelligent Detectors per Loop	99
c.	Addressable Modules per Loop	99
d.	Total Intelligent Detectors	990
e.	Total Addressable Monitor or Control Modules	990
f.	Total Intelligent/Addressable devices per system	1980
g.	Peripheral Devices and Appliances:	
(1)	Remote Annunciators per System	32
(2)	Points per Annunciator	64
(3)	Total Annunciator Points per system	1048
(4)	Remote Printers per System	6
(5)	Remote CRT's per System	24

4. The Fire Alarm Control Panel shall include a full featured operator interface control and annunciation panel which shall include a backlit 80 character liquid crystal display, 5 individual, color coded system status LED's, and an alpha-numeric keypad for the Field Programming and Control of the Fire Alarm System. All programming or editing of the existing program in the system may be achieved without special equipment and without interrupting the alarm monitoring functions of the Fire Alarm Control Panel.

5. Loop Interface Board: One Loop Interface Board shall be provided to monitor and control each of the Signaling Line Circuit (SLC) Loops in the system. The Loop Interface Board shall contain its own microprocessor, and shall be capable of operation in Local Mode in the case of a failure in the main CPU of the Control Panel. The Loop Interface Board shall not require any jumper cuts or address switch settings to initialize SLC Loop operations, or to differentiate the discreet Loop Interface Boards within the Control Panel. This operation will allow the Control Panel to self address and configure all Loop Interface boards within the system environment.

6. The Loop Interface Board shall provide power to, and communicate with, all of the Intelligent/Addressable Detectors and Addressable Modules connected to its SLC Loop

over a single pair of wires. The SLC Loop shall be capable of operation as either a Style 4, Style 6, or as a Style 7 SLC Loop. When using a Style 4 SLC Loop, each SLC Loop shall be a shielded, twisted pair cable of up to 10,000 feet in length, and the Loop Interface Board-200 shall be able to drive 2 channels of these SLC Loops, each up to 10,000 feet in length, for an effective Loop span of 20,000 feet.

7. The Loop Interface Board shall receive analog information from all Intelligent Detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for the particular detector. The analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.

8. The Loop Interface Board shall communicate with each Intelligent/Addressable Detector and Addressable Module on its SLC Loop and verify proper device function and status. Communication with up to 198 Intelligent/Addressable devices shall be performed every 6 seconds or less. Average time to detect an alarm shall be 3 seconds (longer for detectors which utilize alarm verification).

9. Central Processing Unit: The Central Processing Unit shall communicate with, monitor, and control all other modules within the control panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the System Common Control Annunciator by the Central Processing Unit. The Central Processing Unit shall contain and execute all control-by-event programs for specific action to be taken if an alarm condition is detected by the system. Such control by event programs shall be held in non-volatile programmable memory (NVRAM), and shall not be lost even if system primary and secondary power failure occurs.

10. The Central processing Unit shall also provide a real-time clock for time annotation of all system displays. The Time-Of-Day and Date shall not be lost if system primary and secondary power supplies fail. The Central Processing Unit shall provide a single Form C General Alarm Contact, and a single Form C General Trouble Contact, rated at 5A (30VDC) minimum.

11. Display Interface Assembly: The System Display shall be the system common control/annunciator, and shall provide all the controls and indicators used by the system operator and may also be used to program all system operational parameters. The Display Interface Assembly shall contain, and display as required, the custom alphanumeric label for all Intelligent Detectors and Addressable Modules. Such label information shall be stored in programmable nonvolatile memory (NVRAM).

12. The System Display shall provide an 80-character alphanumeric Liquid Crystal Display (LCD). It shall also provide 5 Light Emitting-Diodes (LED's), which will indicate the status of the following system parameters:

    a. AC POWER; Green LED
    b. SYSTEM ALARM; Red LED
    c. SYSTEM TROUBLE; Yellow LED
    d. DISPLAY TROUBLE; Yellow LED
    e. SIGNAL SILENCE Yellow LED

13. The System Display shall provide a 25-key touch key-pad with control capabilities to command all system functions, entry of any alphabetic or numeric information, and field

programming. Two different password levels will be accessible through the Display Interface Assembly to prevent unauthorized System control or programming.

14. The System Display shall include the following operator control switch:

    a. SIGNAL SILENCE
    b. LAMP TEST
    c. RESET
    d. SYSTEM TEST
    e. ACKNOWLEDGE

15. Graphic Panel: Provide 24" x 36" floor plan drawing of entire building both floors, mounted in vandal resistant frame drawing shall indicate information necessary to locate all fire alarm devices quickly in conjunction with fire alarm annunciator.

16. Serial Interface Boards

    a. Model Number SIB-64 - The SIB-64 shall be an optional system accessory, and shall provide the following interfaces:

        (1) One port for the operation of up to (2) two PRN-2 Printers. This port may be used for the operation of the Color Graphics Annunciation System (CGAS). One port for the operation of one CRT-1, and up to 24 additional CRT-1 units used as slave monitors.

    1) The use of the SIB-64 shall not in any way decrease any of the capacities of the system.

17. Visual signal module: Provide visual signal synchronization module(s) in the FACP to synchronize all strobes.

F. Voice Alarm Multiplex System

1. General: The Audio Subsystem shall include, but not limited to: control panel electronics, alarm indicating peripheral devices, conduit, wire and accessories required to provide a complete and operational system. Comply with UL 864, "Control Units for Fire Protective Signaling Systems", NFPA 72, and NFPA 72F, "Emergency Voice/Alarm Communications Systems".

2. Mechanical Design: The Audio Subsystem shall be housed in the same cabinet as the intelligent addressable fire alarm system. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators. The cabinet shall be approximately 5 inches deep and 24 inches wide. Height shall be approximately 46 inches. The control unit shall be modular in structure for ease of installation maintenance, and future expansion.

3. Audio Amplifier: The Audio Amplifier will provide up to 120 Watts of Audio Power (25 volts RMS) each, for distribution to the speaker circuits.

4. Multiple Audio Amplifiers will be mounted in the Main Fire Alarm Control Panel, either to supply incremental audio power, or to function as an automatically switched backup amplifier(s). The Audio Amplifier shall include an integral power supply, and shall provide the following controls and indicators:

a. Normal Audio Level LED
b. Incorrect Audio Level LED
c. Brownout LED
d. Battery Trouble LED
e. Amplifier Trouble LED

5. Audio Amplifier Gain Adjust - Normally Open Trouble Contacts (to annunciate one of the following conditions):

a. Loss of Audio
b. Battery Trouble
c. A.C. Loss/Brownout
d. Style D Circuit Fault

6. Adjustment of the correct Audio Level for the Amplifier shall not require any special tools or test equipment. All terminal blocks for the connection of field wiring shall be removable plug and socket type to allow for ease of field wire installation and troubleshooting.

7. Audio Message Generator: The Audio Message Generator will provide a recorded audio evacuation message for use with the Transponder. The Audio Message Generator shall have the capacity to record a custom message for this evacuation message, and will record this message in Electrically Programmable Read Only Memory (EPROM), or in Non-Volatile Random Access Memory (NVRAM), without the use of moving parts.

8. The Audio Tone Generator (ATG-2) provides user-selected tones for single-or dual-channel output. The ATG-2 shall generate either a slow whoop, H/LO or steady tone on the primary (EVAC) channel. In dual-channel operation, the ATG-2 shall generate either a chime or a 20 pulses-per-minute tone on the secondary (alert) channel. The ATG-2 shall include a built-in microphone with a Page Select switch which allows for paging through speaker circuits on either or both channels. If employed with an optional Fire Fighters Telephone (FFT-7), the Audio Tone Generator shall provide a system paging capability from telephones installed throughout the installation.

9. The ATG-2 shall also serve as a remote paging microphone. Under this configuration the ATG-2 shall relay the audio message (or tone) received from an AMG-1 or another ATG-2 while allowing override paging capabilities from the ATG-2 microphone. Up to 50 AA-30 or AA-120 Audio Amplifiers may be driven directly by the ATG-2. Unless configured for remote paging microphone operation, all communication is accomplished through a Bell Circuit connection with the system.

10. Voice Telephone Command Center: The voice telephone command center shall provide the fire alarm control panel with a fire fighters telephone subsystem.

11. A Fire-Fighters master handset and telephone system master control will provide an on-line "Common talk" capability of up to 7 handsets, and will provide LEDs to annunciate the telephone subsystem status, including PAGE MODE, ON LINE, PHONE TROUBLE, LINE TROUBLE conditions. The Fire-Fighters master handset and telephone system master control will allow page by phone operation for any connected speaker zone within the protected premises.

12. The Voice Telephone Command Center will include an Audio Message Generator with a

hand-held microphone, which will provide the system with a recorded audio evacuation message for use with the Transponder. The Audio Message Generator shall have the capacity to digitally record up to 4 custom messages, or play back up to 4 previously recorded messages, for the emergency evacuation of the protected premisses. These pre-recorded emergency messages will be recorded in Non-Volatile RAM memory, without the use of moving parts.

13. The Audio Message Generator shall provide up to 4 digitally recorded voice messages and not require moving parts such as motors, solenoids, belts, or capstans to allow the playback of the pre-recorded emergency message.

14. Up to 2 Emergency messages may be recorded in the field using either the rebuilt in microphone, or a Standard audio cassette tape recorder as a source.

15. If, for any reason, the pre-recorded message fails, the Audio Message Generator will automatically switch to a primary evacuation tone, and generate a system trouble sequence.

16. The Audio Message Generator shall provide a variety of field selectable pre-announce tones, including slow whoop.

17. The Audio Message Generator shall provide a built-in microphone for operator initiated paging through the speaker circuits in the protected premises.

18. The Audio Message Generator shall have the following controls and indicators to allow for proper operator understanding and control of the audio subsystem in an emergency situation:

    a. Audio Level Normal LED
    b. All Call LED
    c. On-Line LED
    d. Amplified Trouble LED
    e. Speaker Trouble LED
    f. All Call Switch
    g. Local Speaker Volume Control

19. Audio Subsystem Operations: Each Audio Subsystem shall be powered from a local 120 VAC source, and shall provide all power necessary for its own operation, including battery charging and backup circuits. The Audio Subsystem shall be capable of providing up to 4 channels of Fire Alarm evacuation signals. The alarm evacuation signals may be made through a microphone or through a pre-recorded message panel.

20. Field Programming

    a. The system shall be programmable, configurable and expandable in the field without the need for special tools or PROM programmers and shall not require replacement of memory ICs. All programming may be accomplished through the standard control panel keyboard or through the use of the optional CRT-1 keyboard. All programs shall be stored in non-volatile memory.

    b. The programming function shall be entered with a special password that may be selected when the system is installed. The password may be changed in the field to a new value at any time by entering the old password and requesting a

password change. In the event that the programmer may enter a password and then lose or forget it, the system shall be designed such that the password may be determined by special procedures available through the system manufacturer.

G. System Power Supplies

1. The Main Power Supply for the Fire Alarm Control Panel shall be integral to the control panel itself, and shall provide all control panel and peripheral device power needs, as well as 3 amperes of regulated 24 VDC power for Audio-Visual alarm indicating devices. Provisions will be made to allow the Audio-Visual power to be increased as required by adding modular expansion Audio-Visual power supplies. The Power Supplies shall be designed to meet UL and NFPA requirements for power-limited operation on all indicating and initiating circuits. Positive-temperature-coefficient thermistors, circuit breakers, or other over-current protection shall be provided on all power output. Input power shall be 120 VAC, 60 HZ. The power supply shall provide an integral Dual-Rate Battery Charger for use with batteries up to 23 AH. This integral Battery Charger will automatically inhibit the deep discharge of the system standby batteries, and shall be protected against the accidental reverse polarity connection of the standby batteries. The Main Power Supply may also be used with external battery and charger systems.

2. Battery back-up power capacity shall be provided for 24 hours of system operation and capable of operating the system for 15 minutes at full load.

3. The Main Power Supply shall continuously monitor all field wires for Earth Ground conditions, and shall have the following LED indications:

   a. Negative Ground Fault LED
   b. Positive Ground Fault LED
   c. Battery Fail LED
   d. AC Power Fail LED

H. Audio Visual Power Supply

1. The Audio Visual Power Supply for the Fire Alarm Control Panel shall be integral to the control panel itself, and shall provide 3 amperes of unrelated 24 VDC power for Audio-Visual alarm indicating devices. Provisions will be made to allow the Audio-Visual power to be increased as required by the addition of more Audio-Visual power supplies. All power supplies shall be designed to meet UL and NFPA requirements for power-limited operations on all external circuits.

2. Positive-temperature-coefficient thermistors, circuit breakers, or other over-current protection shall be provided on all power outputs. Input power shall be 120 VAC, 60 HZ. The power supply shall be capable of being backed up with a standby battery, or may be used with external battery and charger systems. Battery arrangement may be configured in the field. All standby power connections shall be supervised.

I. Printer

1. The Printer shall provide hard-copy printout of all changes in status of the system and shall time stamp such printouts with the current time-of day and date. The printer shall be standard carriage with 80- characters per line and shall be standard pin-feed paper. The printer shall be enclosed in a separate cabinet suitable for placement on a desk top or table. The printer shall communicate with the control panel using an interface complying

with Electrical Industries Association standard EIA-232D. Power to the printer shall be 120 VAC 60 HZ.

J. Auto-Dialer

1. Provide a fire control communicator which is two zone, digital, UL listed for NFPA 71 and 72C applications, dual telephone lines, primary and alternate telephone lines, communicates using BFSK or pulsed single-round fast format, automatic test reports every 24 hours, two sockets for optional additional relays, phone trouble LED, phone trouble buzzer.

2. Digital Auto Dialer: Provide an automatic programmable speech dialer with two alarm inputs designed for verbal reporting of two separate events. Each event shall be reportable to four different remote telephones. Dialer shall have a dual function, built-in microphone for recording verbal messages and for listen-in purposes.

3. Monitoring agency shall be FM approved.

2.3 WIRING METHODS

A. Conduit and Conductors: Provide complete wiring and conduit between all equipment. Unless otherwise specified within the Installation Manual of the specific equipment being used, all field wiring shall be minimum #16 (solid) or #14 (stranded) copper conductors, installed in separate conduit, maximum 40% full, and shall be approved for use as Fire Alarm cable. All notification appliance circuits (NAC) shall be loaded no greater than 70% of full load. The maximum voltage drop allowable for NAC circuit calculation is 10%. Audible and Visible signals shall be wired on separate circuits. Conduit of proper size shall be installed from the Control Panel Equipment to field devices.

B. All field devices shall be mounted upon U.L. Listed Electrical junction boxes.

C. All splices in field wiring shall be made in U.L. Listed Electrical junction boxes.

D. All Electrical junction boxes shall be labeled as "Fire Alarm System" with decal or other approved markings. The Fire Alarm/Life Safety Installation shall comply fully with all local, State and National Codes, and the Local Authority having Jurisdiction (AHJ).

E. Conduit shall enter into the Fire Alarm control panel backbox only at those areas of the backbox which have factory conduit knockouts.

F. All field wiring shall be completely supervised, In the event of a primary power failure, disconnect standby battery, removal of any internal modules, or any open circuits in the field wiring; an audible and visual trouble signal will be activated until the system and its associate field wiring are restored to normal condition.

G. Open cable shall be allowed above ceilings and in other areas allowing surface wiring if so approved by the Local Authority Having Jurisdiction. All cable shall be protected where entering or leaving a junction box or device box with a portable cord straight grip connector such as Bridgeport #770-4, or equal.

H. Cable shall be the type listed for Fire Alarm/Life Safety use and shall be installed per NEC Article 760.

I. Cable must be separated from any open conductors of power, or class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, as per NEC Article 760-29.

J. All exposed cable below 84 inches from the surface of the finished floor, or to other locations where the cable may become exposed and/or damaged, must be within a steel conduit.

K. Conduits must also be provided in elevator shafts and hoistways. Cables within ducts or plenums must conform with the specifications of NEC Article 300-22.

L. Riser and wiring diagrams prepared by Engineer are not intended as final installation drawings but only as a guide for bidding. Install system based on final wiring diagrams prepared by the manufacturer of the system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install voice communication fire alarm & detection systems as indicated, in accordance with equipment manufacturer's written instruction, and complying with applicable portions of NEC, and NECA's "Standard of Installation".

B. Manual Pull Stations: Unless otherwise indicated mount semi-flush in recessed back boxes with operating handles 48" above finished floor.

C. Smoke Detectors: Install detectors indicated to be ceiling mounted not less than 4 inches from a side wall to the near edge. Install detectors located on the wall at least 4 inches but not more than 12 inches below the ceiling. For exposed solid joist construction, mount detectors on the bottoms of the joists. On smooth ceilings, install detectors not over 30 ft. apart in any direction. Install detectors no closer than 5 ft. from air registers.

D. Audible Alarm Indicating Devices: Install not more than 96" above the finished floor nor less than 6" below the ceiling. Unless otherwise indicated, install horns on flush mounted back boxes with the device operating mechanism concealed behind a grille. Combine audible and visible alarms at the same location into a single unit.

E. Visual Alarm Indicating Devices: Install adjacent to each alarm bell or alarm horn. Install not more than 96" above the finished floor and at least 6" below the ceiling.

F. Fire Alarm Control Panel (FACP): Surface mount with tops of cabinets not more than 6 ft. above the finished floor.

G. Wire Guards: Provide wire guards on smoke detectors, heat detectors, and horn/strobe units in all garage spaces.

3.2 INSTALLATION OF BASIC IDENTIFICATION

A. Install electrical identification in accordance with Section 260040, "Identification".

3.3 INSTALLATION OF BASIC WIRING SYSTEM MATERIALS

A. Install wiring, raceways, and electrical boxes and fittings in accordance with Division-26 Basic

Materials and Methods sections "Raceways", "Wires and Cables", and "Electrical Boxes and Fittings".

B. Install fire-stopping products for all open cables runs through fire-rated construction as specified in specification Section 260010 “Basic Electrical Requirements”.

3.4 FIELD QUALITY CONTROL

A. Inspect relays and signals for malfunctioning, and where necessary, adjust units for proper operation to fulfill project requirements.

B. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of voice communication fire alarm & detection systems equipment.

C. Provide three service organization inspections for each system at four-month intervals during the year following final acceptance. Correct defects found in the systems at the time of these inspections.

D. The contractor must retain the services of the fire alarm system manufacturer for the following minimum requirements:

1. To perform and assist the electrical contractor in the installation of the fire alarm system.

2. Perform testing of all devices (pull stations, smoke and heat detectors and A/V units, etc.) for alarm, supervision and trouble conditions.

3. Provide two (2) - 4 hour training sessions (separate days) dedicated to training the owner in the complete operation and maintenance of all system components and control panel.

4. Provide testing reports indicating each device tested and consistent with NFPA 72.

5. Perform acceptance testing with the authority having jurisdiction.

6. And any other functions deemed necessary.

E. The contractor shall provide full testing of the system with the authority having jurisdiction (AHJ) present, including the following:

1. The testing of the system shall be in accordance with the procedures outlined in NFPA 72, including section 7-1.6, System Reacceptance Testing, for existing software functions and devices. Testing of smoke detectors shall be with smoke or listed aerosol approved by the detector manufacturer.

2. Retest the system until all deficiencies have been rectified.

3. The contractor shall submit a written test report signed by the manufacturers representative indicating that the fire alarm system has been 100% tested and approved prior to the acceptance test.

4. The contractor shall conduct an acceptance test of every component required in the presence of the owner, owners representatives and the authority having jurisdiction.

5. Rectify all deficiencies identified at the acceptance test at no cost to the owner and reschedule a retest of the system

END OF SECTION 283100