ADDITIONS AND RENOVATIONS
HC WILCOX REGIONAL VOCATIONAL TECHNICAL SCHOOL
MERIDEN, CONNECTICUT
PROJECT: BI- RT - 843

BID OPENING	**July 7, 2010**	**July 7, 2010**
ADDENDUM NUMBER 4	**DATE OF ADDENDUM**	**JULY 23, 2010**

The following clarifications are applicable to drawings and specifications for the project referenced above.

Item 1

Section 00 11 16, Invitation to Bid, Plans & Specs Ready Date is Wednesday, July 28, 2010.

Item 2

Section 00 11 16, Invitation to Bid, the Pre-bid Conference Date is scheduled for Tuesday, August 10, 2010 at 10:00 a.m. Prospective Bidders must sign in, at or before 10:00 a.m. and must sign out at the conclusion of the Pre-bid Conference. Prospective bidders will be denied admittance to the Pre-bid Conference after 10:00 a.m.

Item 3

Section 00 11 16, Invitation to Bid, the Bid Opening Date is scheduled for Wednesday, September 15, 2010.

Item 4

In the Project Manual, Table of Contents, Division 2, ADD the following above 020900 Lead Paint Activity:

020226	Excavation Of PCB Remediation Waste Soils	9

Item 5

In the Project Manual, Table of Contents, Division 2, ADD the following below Unit Price Schedule:

028215	Abatement Of PCB Contaminated Building Materials	20

Item 6

In Section 011000, Paragraph 1.3, D.1, CHANGE the last sentence to read: "Allow two weeks."

Item 7

In Section 012000, Paragraph 1.3, ADD the following:

C. Quantity Allowances:

1. The Contractor's costs for unloading and handling, storage, insurance, overhead and profit and other expense related to the Allowance item shall be included in the Lump Sum Bid Amount and not in the Allowance unless stated otherwise in the Allowance Schedule of this section.

2. Architect/Engineer Responsibilities:
   a. Review Change Order.

3. Construction Administrator Responsibilities:
   a. Assist Architect/Engineer, Project Manager and Agency Representatives with verifying quantities.
   b. Review/Prepare Change Order.

4. Contractor Responsibilities:
   a. Arrange for and process shop drawings, product data, and samples. Arrange for delivery.
   b. If the actual quantities of an Allowance item are more or less than the specified amount, the Contract Sum will be adjusted by Change Order utilizing the quantity allocation to establish an add/deduct unit price. This unit price will be determined by dividing the allowance value by the specified number of units. The unit price established will be used for deduct changes. The unit price plus 10% will be used for add changes. The unit price must appear as a separate line item in the schedule of values.

5. Allowance Schedule: These allowances are to be used for additional work NOT identified in the Contract Documents.
   a. Allowance No. 1: Include a quantity allowance of 14,000 SF of Moisture Vapor Emission Reduction Control System For Resinous Flooring Locations.
   b. Allowance No. 2: Include a quantity allowance of 14,000 SF of Moisture Vapor Emission Reduction Control System For Non-Resinous Flooring Locations.

Item 8

In Section 012000, Paragraph 1.5, G, ADD the following:

2. Unit Price – See Division 02 "Abatement of PCB Contaminated Building Materials" for unit prices associated with PCB's.

Item 9

In Section 015000, Paragraph 3.3, K

DELETE Paragraph 3.3, K.1.

SUBSTITUTE

1. Rodent and Pest Control: Before deep foundation work or structural demolition has begun, retain a local exterminator or pest control company to recommend practices to minimize attraction and harboring of rodents, roaches, and other pests. Employ this service to perform extermination and control procedures at regular intervals so the project will be free of pests and their residues.

Item 10

In Section 017830, Paragraph 1.3, F, ADD the following:

29. Section 072600, Surface Applied Vapor Reduction Systems: Repair/replace flooring system that fails due to vapor transmission for 5-years.

Item 11

ADD Section 020226, Excavation of PCB Remediation Waste Soils

Item 12

ADD Section 028215, Abatement of PCB Contaminated Building Materials.

Item 13

DELETE Section 072600 "Surface Applied Vapor Reduction System".

SUBSTITUTE Section 072600 "Surface Applied Vapor Reduction System" dated 07/23/10.

Item 14

In Section 099419, Paragraph 2.3

DELETE: Paragraph 2.3, A.1

SUBSTITUTE:

1. Available Products: Subject to compliance with requirements, provide one of the following:
   a. Zolatone, Polomyx Airless; Master Coating Technologies.
   b. Scuffmaster; Master Coating Technologies.
   c. Roxatone Multicolored Coatings; Sky Coatings Inc;.

Item 15

In Section 210548, Paragraph 1.4

DELETE Paragraph 1.4, F

SUBSTITUTE

F. Seismic-Restraint Loading:

   1. Seismic design Category: B
   2. Site Class as Defined in the IBC: D.
   3. Building Category as Defined in the IBC: III.
   4. Seismic Use Group: II

      a. Component Importance Factor: Refer to table 9.6.3.2, ASCE 7.
      b. Component Response Modification Factor: Refer to table 9.6.3.2, ASCE 7.
      c. Component Amplification Factor: Refer to table 9.6.3.2, ASCE 7.

   5. Design Spectral Response Acceleration at Short Periods (0.2 Second): 28%
   6. Design Spectral Response Acceleration at 1-Second Period: 8.4%

Item 16

In Section 220548, Paragraph 1.4

DELETE Paragraph 1.4, B

SUBSTITUTE

B. Seismic-Restraint Loading:

   1. Seismic design Category: B
   2. Site Class as Defined in the IBC: D.
   3. Building Category as Defined in the IBC: III.
   4. Seismic Use Group: II

      a. Component Importance Factor: Refer to table 9.6.3.2, ASCE 7.
      b. Component Response Modification Factor: Refer to table 9.6.3.2, ASCE 7.

c. Component Amplification Factor: Refer to table 9.6.3.2, ASCE 7.

5. Design Spectral Response Acceleration at Short Periods (0.2 Second): 28%
6. Design Spectral Response Acceleration at 1-Second Period: 8.4%

Item 17

In Section 230548, Paragraph 1.4

DELETE Paragraph 1.4, E

SUBSTITUTE

E. Seismic-Restraint Loading:

1. Seismic design Category: B
2. Site Class as Defined in the IBC: D.
3. Building Category as Defined in the IBC: III.
4. Seismic Use Group: II

a. Component Importance Factor: Refer to table 9.6.3.2, ASCE 7.
b. Component Response Modification Factor: Refer to table 9.6.3.2, ASCE 7.
c. Component Amplification Factor: Refer to table 9.6.3.2, ASCE 7.

5. Design Spectral Response Acceleration at Short Periods (0.2 Second): 28%
6. Design Spectral Response Acceleration at 1-Second Period: 8.4%

Item 18

DELETE Section 230900 "Instrumentation and Controls for HVAC".

SUBSTITUTE Section 230900 "Instrumentation and Controls for HVAC" dated 07/23/10.

Item 19

In Section 260548, Paragraph 1.4

DELETE Paragraph 1.4, A

SUBSTITUTE

A. Seismic-Restraint Loading:

1. Seismic design Category: B
2. Site Class as Defined in the IBC: D.
3. Building Category as Defined in the IBC: III.

4. Seismic Use Group: II

   a. Component Importance Factor: Refer to table 9.6.3.2, ASCE 7.
   b. Component Response Modification Factor: Refer to table 9.6.3.2, ASCE 7.
   c. Component Amplification Factor: Refer to table 9.6.3.2, ASCE 7.

5. Design Spectral Response Acceleration at Short Periods (0.2 Second): 28%
6. Design Spectral Response Acceleration at 1-Second Period: 8.4%

Item 20

On the drawing set Cover sheet, Volume 1 of 2, ADD the following to the list of drawings after "LBP1.01. Lead Based Paint":

SOIL1.01	PCB Soil Remediation Areas
PCB1.01	First Floor Demolition Plan – Area A & C
PCB1.02	First Floor Demolition Plan – Area A
PCB1.03	First Floor Demolition Plan – Area B & C
PCB1.04	First Floor Demolition Plan – Area B & C
PCB1.05	First Floor Demolition Plan – Area C
PCB1.06	Second Floor Demolition Plan – Area A
PCB1.07	Second Floor Demolition Plan – Area A
PCB1.08	Second Floor Demolition Plan – Area C
PCB1.09	First Floor Demolition Plan Annex Building – Area D

Item 21

ADD Drawing SOIL1.01.

Item 22

ADD Drawing PCB1.01.

Item 23

ADD Drawing PCB1.02.

Item 24

ADD Drawing PCB1.03.

Item 25

ADD Drawing PCB1.04.

Item 26

ADD Drawing PCB1.05.

Item 27

ADD Drawing PCB1.06.

Item 28

ADD Drawing PCB1.07.

Item 29

ADD Drawing PCB1.08.

Item 30

ADD Drawing PCB1.09.

Item 31

CHANGE drawing D1.03, per SKA-1

Item 32

DELETE Drawing D1.04.

SUBSTITUTE Drawing D1.04, Revision date 7/23/10.

Item 33

CHANGE Drawing D1.05 per SKA-2.

Item 34

In Drawing A1.02, ADD Elevation key per SKA-3.

Item 35

In Drawing A1.02, ADD Sink and revise Elevation key per SKA-4.

Item 36

In Drawing A1.03, ADD Elevation key per SKA-5.

Item 37

DELETE Drawing A1.04.

SUBSTITUTE Drawing A1.04, Revision date 7/23/10.

Item 38

DELETE Drawing A1.05.

SUBSTITUTE Drawing A1.05, Revision date 7/23/10.

Item 39

In Drawing A1.07, ADD Elevation Keys per SKA-6.

Item 40

In Drawing A1.07, ADD Elevation Keys per SKA-7.

Item 41

DELETE Drawing A3.05.

SUBSTITUTE Drawing A3.05, Revision date 7/23/10.

Item 42

In Drawing A4.10A, CHANGE Detail 4 per SKA-8.

Item 43

In Drawing A5.01, ADD window type per SKA-9.

Item 44

In Drawing A8.07, ADD interior elevation detail per SKA-10.

Item 45

In Drawing A10.02, CHANGE schedule per SKA-11.

Item 46

In Drawing A12.08, ADD equipment per SKA-12.

Item 47

In Drawing A12.09, ADD equipment per SKA-13.

Item 48

In Drawing P1.02, ADD sink per SKP-072310-1.

Item 49

In Drawing P1.03, ADD piping per SKP-072310-2.

Item 50

In Drawing P1.09, ADD plumbing per SKP-072310-3.

Item 51

In Drawing E1.02, CHANGE receptacle locations per SKE-072310-1.

Item 52

In Drawing E1.09, ADD receptacles per SKE-072310-2.

Item 53

In Drawing E6.05, CHANGE Panel Schedule per SKE-072310-3.

Item 54

In Drawing FP1.05, ADD Piping per SKFP-072310-1

Item 55

In Drawing FP3.00, CHANGE Detail per SKFP-072310-2

Item 56

In Drawing FP2.00, CHANGE Riser Diagram per SKFP-072310-3

All questions must be in writing (not phone or e-mail) and must be forwarded to the consulting Architect/Engineer (Randall Luther, Tai Soo Kim Partners, LLC., Fax: 860-249-0695) with copies sent to the DPW Project Manager (Barbara Cosgrove, Fax: 860-713-7270).

End of Addendum Number Four

Gail Blythe

Gail Blythe, Associate Fiscal Administrative Officer
Department of Public Works

PART 1 GENERAL

1.1 APPLICABLE PUBLICATIONS

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

UNITED STATES ARMY CORPS OF ENGINEERS (COE)

EM-385-1-1 Safety and Health Requirements Manual

ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SW-846 Test Methods for Evaluating Solid Waste, Current Edition.

CODE OF FEDERAL REGULATIONS (CFR)

40 CFR Part 761 Polychlorinated Biphenyls Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions

REGULATION OF CONNECTICUT STATE AGENCIES

Sections 22a-133k-1 through 22a-133k-3, inclusive, Remediation Standard

1.2 DESCRIPTION

The project SITE encompasses sections of the H.C. Wilcox Technical High School (Wilcox Tech) located at 298 Oregon Road in Meriden, Connecticut. The SITE, which is part of the Connecticut Technical High School System, is owned by the Connecticut Department of Education (CT DOE). The Connecticut Department of Public Works (DPW) is conducting site remediation tasks at this facility prior to the performance of various site renovation and demolition activities.

Remedial action at the SITE includes excavation and off-site disposal of soil adjacent to the buildings with total PCB concentrations $\geq$1 mg/kg contaminated by PCB containing caulk and/or glazing classified as a PCB Bulk Product Waste.

This section includes requirements for excavating and handling PCB contaminated soil from the proposed surface soil remediation areas as shown on the Contract Drawings and described in the PCB Site Remedial Plan.

1.3 DEFINITIONS

1.3.1 Contaminant Zones

Contaminant zones are those areas of active excavation and the waste storage area.

1.3.2 Excavation

The removal of soil, rock, or hard material to obtain a specified depth or elevation.

1.3.3 PCB Bulk Product Wastes

PCB bulk product waste means waste derived from manufactured products containing PCBs in a non-liquid state, at any concentration where the concentration at the time of designation for disposal was ≥50 ppm PCBs.

1.3.4 PCB Remediation Waste with ≥50 ppm PCBs

PCB remediation waste means waste containing PCBs as a result of a spill, release, or other unauthorized disposal, at concentrations ≥ 50 ppm PCBs, regardless of the concentration of the original spill.

1.3.5 PCB Remediation Waste with <50 ppm PCBs

PCB remediation waste means waste containing PCBs as a result of a spill, release, or other unauthorized disposal which are currently at any concentration if the PCBs are spilled or released from a source not authorized for use under this part.

1.3.6 PCB Site Remedial Plan

"Self-Implementing Cleanup Plan, H.C. Wilcox Technical High School", Prepared by TRC, June 2010.

1.3.7 PCB Engineer

To be retained by the Owner, responsible for overseeing excavation work and for performing and evaluating verification sample data.

1.3.8 Owner

The Owner is the Connecticut Department of Public Works and shall be responsible for the Contract and the performance of all the work.

1.3.9 Remedial Action Level

Concentration to which PCB contaminated soil must be removed to verify completion of excavation work.

1.3.10 Soil

The loose surface material of the earth's crust resulting from the chemical and mechanical weathering of rock and organic material.

1.3.11 Suitable Waste Storage Container

A container in which soil is placed for storage prior to transport offsite for disposal that is water tight, lined, and equipped with a cover that prevents the infiltration of rainwater into the container.

1.3.12 Excavated Soil Stockpile

An area where excavated soil is placed following excavation and prior to loading into a waste storage container. At no time will the Contractor create and excavated soil stockpile. All excavated soil is to be placed directly into a suitable waste storage container.

1.3.13 Verification Sampling

Sampling performed to determine the completion of excavation activities as per Subpart O of 40 CFR Part 761.

1.3.14 Waste Storage Area

The secured location in which the Contractor shall store soil prior to offsite transport for disposal. The Contractor shall consult with the Owner and the PCB Engineer to identify the location of Waste Storage Areas prior to generating any wastes. This area shall be secured and signed by the Contractor.

1.4 SUBMITTALS

Prior to performing the excavation work, the Contractor shall submit:

1.4.1 Key Personnel

The Contractor shall submit a list of the key personnel of the Contractor and subcontractors (including addresses and telephone numbers) for use in the event of an emergency. As changes occur and additional information becomes available, the

Contractor shall correct and change the information contained in previous lists. The Contractor's Representative shall be identified on this list.

1.4.2 Waste Characterization Analytical Data, Waste Profiles, and Disposal Approval

The Contractor shall submit all waste characterization analytical data and waste profiles prior to submittal to any proposed waste disposal facility. The Contractor shall submit all Disposal Approvals a minimum of seven (7) days prior to performing excavation work.

1.4.3 Equipment Decontamination Plan

The Contractor shall submit a decontamination plan for all materials and equipment that shall contact PCB Remediation Wastes and that are to be removed from the site following the completion of work. The decontamination plan shall conform to the requirements of §761.79(c). The Contractor shall submit proof of decontamination to the PCB Engineer as required.

1.5 REGULATORY REQUIREMENTS

All soil is to be handled and stored in accordance with the provision of 40 CFR Part 761 Subpart D. The Contractor shall be responsible for all costs associated with investigation and remediation of any releases due to their failure to handle excavated soil in accordance with the regulatory requirements.

1.6 DELIVERY AND STORAGE

The Contractor shall deliver and store materials in a manner to prevent contamination, segregation, freezing, and other damage.

1.7 MEASUREMENT AND PAYMENT

The Contractor's cost proposal shall be based on the following criteria:

a. Measurement for payment shall be based on mass computation using the tonnage recorded by the waste disposal facility on the completed and signed manifests for each

b. No extra payment shall be made for removal of standing water, fencing, decontamination, run-on/run-off controls, dust control, site preparation, site restoration or waste disposal areas. The cost for these items shall be included in the base bid.

1.8 PROTECTION

1.8.1 Utility Location

The Contractor shall contact Connecticut's Call Before You Dig for underground utility markouts in accordance with applicable regulations, and provide a confirmation number for DPW's records. The Contractor shall verify the location of all utilities shown on the Contract Drawings or identified during utility mark-outs.

Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. The Contractor shall perform all work adjacent to utilities as indicated in accordance with procedures outlined by utility company. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, use hand or light equipment excavation. Start hand or light equipment excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation as required. The Contractor shall report damage to utility lines or subsurface construction immediately to the PCB Engineer. The Contractor shall be responsible for the repair of all damaged utilities that were previously shown on Contract Drawings or identified during utility mark-outs.

1.8.2 Overhead Utilities

If excavation or backfilling equipment (excavator arms, lifts, dump truck beds, etc.) at the site can potentially come within a 15 foot radius of the overhead electrical lines, a dedicated spotter must be used for each such piece of equipment. The spotter must be in continuous radio and line of sight communication with the equipment operator and be capable of immediately stopping the equipment operation if any portion of the equipment is in danger of penetrating the 15 foot radius overhead electrical line safety zone. The spotter shall be an experienced and qualified equipment operator.

1.8.3 Structures and Surfaces

The Contractor shall protect adjacent structures and surfaces from traffic, erosion settlement, or any other damage. The Contractor shall repair and reestablish damaged or eroded grades and slopes and restore surface construction prior to acceptance.

PART 2 PRODUCTS - NONE

PART 3 EXECUTION

3.1 SITE PREPARATION

Prior to performing soil excavations, the Contractor shall secure the excavation area with temporary fencing. The Contractor may move temporary fencing sections to allow for work progress while actively working in an excavation area. However, if no work is actively being performed in an excavation area the temporary fencing will be reinstalled.

3.1.1 Excavation Layout

The Contractor shall mark the limits of proposed initial excavations of contaminated soils prior to performing any excavations. The limits of the excavations shall correspond to those shown on the Contract Drawings.

3.1.2 Sedimentation, Erosion and Run-On Controls

The Contractor shall install in accordance with Section 02112, "Erosion and Sediment Control" and the Contract Drawings.

3.1.3 Waste Storage Areas

If the Contractor chooses to store soil onsite prior to transport offsite for disposal, the Contractor shall construct a secured Waste Storage Area at a location agreed to by the Contractor and the PCB Engineer within contract limit lines. The contract limit lines are to be secured as described elsewhere in these specifications and entry shall be limited to Contractor Personnel only. The Waste Storage Area shall enclose all Suitable Waste Storage Containers actively in use with temporary fencing. The fence shall be marked with a Large M_L mark as specified in 40 CFR Part 761 Subpart C.

3.1.4 Waste Storage

The Contractor shall not store waste onsite in a Suitable Waste Container for a period of more than 30 days. The start of the period of waste storage for each container will start on the day in which wastes are first loaded into a container and will terminate when the container is transported offsite.

The Contractor shall store waste onsite in Suitable Waste Containers. No stockpiling shall be allowed and the Contractor shall be responsible for all costs associated with investigation and remediation of any areas contaminated due to the failure of the Contractor to comply with waste storage requirements.

3.1.5 Decontamination

The Contractor shall decontaminate all moveable equipment that contact PCB Remediation Wastes in accordance with the procedures specified in §761.79(c). The Contractor shall not remove any equipment from the Contaminant Zone until it has been properly decontaminated.

Specifically, the Contractor shall employ double wash/rinse procedures as specified in 40 CFR Part 761 Subpart S or swab non-porous surfaces that have contacted PCB wastes with a solvent as specified in §761.79(c)(2)(i). The Contractor shall segregate all liquid waste streams and be responsible for characterizing these wastes for disposal purposes. Solid wastes generated during decontamination shall be stored for disposal with the other PCB wastes generated during remediation activities.

The PCB Engineer shall be responsible for ensuring that decontamination procedures are followed and that wastes are appropriately characterized and disposed of properly.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Clearing is not required for any of the excavation areas as this will be performed by others. Limited grubbing is required in the excavation to be performed on the northwest side of the A-Wing as there are some roots in place within the excavation area.

The soil removed from any root structure that has been grubbed from an excavation area must remain in the excavation or be placed directly into a Suitable Waste Container. Unless suitably decontaminated and tested as clean, all roots grubbed from an area must be considered to be PCB Remediation Wastes.

3.3 EXCAVATION AND HANDLING OF CONTAMINATED SOILS

3.3.1 Contaminant Zone Operations

Construction equipment such as excavators, front end loaders, dozers and hauling vehicles, used within a Contaminant Zone that have contacted PCB Remediation Wastes shall not be permitted to move outside of the area until they have been properly decontaminated.

All soil within the excavations shall be assumed to be PCB Remediation Wastes <50 ppm unless the Contractor is otherwise instructed by the PCB Engineer. All waste handling and storage procedures, equipment decontamination procedures, and other Contaminant Zone Operations shall conform to the requirements of 40 CFR Part 761 Subpart D.

3.3.2 Dust Control

The Contractor shall utilize an adjacent fire hydrant and appropriate hose for dust control. Water shall be applied to keep fugitive dust under control as needed and as directed by the PCB Engineer. Water will be provided by the DPW from an approved fire hydrant or other suitable source at no extra charge to the Contractor.

3.3.3 Excavation

Excavation shall be shallow and performed in lift intervals no greater than one foot unless otherwise approved by the PCB Engineer. Excavation areas shall be clearly marked with stakes and labels.

Excavation equipment shall be smooth edge blade without ripping teeth. Excavation shall be carried out in such a manner so as to minimize the mixing of soils to underlying soils. No ripping, plowing, harrowing or mixing of soils shall be permitted. Only excavation equipment that provides precise depth control will be permitted. No crane mounted clamshell or dragline excavators will be allowed.

Excavation shall be carried out so as to remove contaminated soils from the edge farthest away from the edge where hauling vehicles will approach the Contaminant Zone. Contaminated soils shall not be moved over areas excavated and tested as below action levels and ready for backfilling, unless hauling vehicles move across the clean area to the edge of the Contaminant Zone. Excavation equipment shall not overfill their buckets so as to allow spillage of soil across other contaminated or clean areas. The loose or excess soil shall be removed from the bucket within the active excavation area prior to moving the soil to the hauling vehicles. The Contractor shall be solely responsible for the cost of excavating, handling, storage, testing and disposal of soils that were previously clean and have tested as contaminated due to deficient Contractor operation practices and methods.

3.3.4 Personal Protective Equipment

The Contractor shall assume that all personnel working within a contaminant zone shall be required to be equipped with Personal Protective Equipment (PPE). The Contractor's health and safety officer will be responsible for determining the appropriate level of personal protection. That determination must be evaluated by a certified industrial hygienist and shall be based on actual laboratory data and monitoring from site operations. All personnel shall be required to go through an approved decontamination procedure. All personal protective garments shall be containerized and not reused after removal. The personal protective garments shall be disposed of as contaminated waste in an approved manner.

3.3.5 Remedial Action Levels

The remedial action level for PCB contaminated soil shall be <1.0 mg/kg as specified in the Regulations of Connecticut State Agencies Sections 22a-133k-1 through 22a-133k-3, inclusive, and the High Occupancy Standard without further restrictions in §761.61(a)(4) of 40 CFR Part 761.

3.8 EXCAVATION COMPLETION

Each excavation shall be considered complete after sufficient verification samples have been collected and analyzed and determined to meet remedial action levels. Verification samples shall be collected and analytical data reviewed by the PCB Engineer.

Following the completion of an excavation, the Contractor shall decontaminate their equipment as required and remove from the area. The Contractor may remove temporary security fencing if the excavation is deemed by the PCB Engineer not to be a site hazard.

END OF SECTION

PART 1 GENERAL

1.1 APPLICABLE PUBLICATIONS

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to this work.

"Self-Implementing Cleanup Plan, H.C. Wilcox Technical High School," prepared by TRC Environmental Corporation, June 2010. ("PCB Site Remedial Plan")

PCB Soil Abatement Specifications

40 CFR Part 761

1.2 DESCRIPTION

Work under this item shall include the abatement of: PCB-containing caulk and glazing (Federally-regulated and non-federally regulated PCB) and removal of abutting building materials (concrete, brick, metal door framing, and windows, including window framing, as identified in the Contract Plans and PCB Site Remedial Plan) that are coated with PCB-containing caulk and/or glazing ("PCB Waste").

The work shall be performed by persons who are knowledgeable, qualified, trained and licensed in the removal, treatment, handling, and disposal of PCB contaminated wastes and the subsequent cleaning of the affected environment. Where areas to be abated contain materials with PCBs and asbestos the workers should have all the required asbestos licensing/training as required in Specification Section 28213.

1.2.1 REQUIREMENTS

Federally-regulated PCB-containing caulk and/or glazing (classified as PCB Bulk Product Waste) is defined as any building material manufactured with total PCB concentrations ≥50 mg/kg by weight. All Federally-regulated caulk and glazing shall be removed by the Contractor and all associated building materials in contact with the subject caulk and glazing shall be removed by the Contractor to a depth of at least six inches (6") unless otherwise indicated by the PCB Engineer that more material requires removal. Building material abutting caulks identified as IE1 and IE2 as shown on the Contract Drawings, shall be removed to a depth of at least twelve (12) inches of building materials on either side of the caulk. Metal door frames abutting the subject caulk shall be removed and disposed of as PCB Bulk Product Waste and the associated doors shall be removed prior to abatement activities and shall not be considered PCB Waste. Windows with the subject PCB-containing glazing and associate metal frames shall be removed and disposed of as PCB Bulk Product Waste.

The Owner shall hire a PCB Engineer for the duration of the PCB abatement work. The PCB Engineer shall provide a Project Monitor to oversee the activities of the

Contractor. After removal, verification sampling shall be performed by the Project Monitor. PCB Bulk Product Wastes and abutting building materials shall be considered removed when all verification samples are <1 mg/kg total PCBs.

Non-federally regulated PCB-containing caulk and/or glazing is defined as any building material manufactured with total PCB concentrations ≥1 mg/kg and < 50 mg/kg. All non-federally regulated caulk and glazing shall be removed from the site and disposed of per these Specifications by the Contractor.

In demolition/renovation areas, building materials in contact with the non-federally regulated caulk and glazing shall be removed by the Contractor to a depth of six inches (6") and disposed of by the Contractor as PCB Bulk Product Waste.

Work in non-demolition/renovation areas, shall be scheduled during school vacations, when school is not in session. Such work shall be started and completed within such schedule. Work shall be completed at least ten (10) days prior to students returning to school. Building materials in contact with the non-federally regulated caulk and glazing shall be appropriately cleaned by the Contractor as per these Specifications. Verification samples of the remaining, cleaned building materials shall then be taken by the Project Monitor. If total PCB concentrations in the remaining building materials are ≥1 mg/kg, then an encapsulant, per these Specifications, shall be applied by the Contractor to the area where the caulk and/or glazing were in contact with building materials and new caulk or glazing shall be applied by the Contractor. If total PCB concentrations in the remaining building materials are <1 mg/kg, then the building materials shall be left in place as is.

These Specifications govern all work activities that disturb PCB-containing caulk and glazing and associated building material. All activities shall be performed in accordance with, but not limited to, OSHA Regulation 29 CFR 1926, EPA PCB Regulation 40 CFR Part 761, RCSA 22a-463 through -469 inclusive, and the PCB Site Remedial Plan where applicable.

Abatement work shall include the removal, transportation, and disposal of all PCB Wastes as identified on the Contract Documents, the PCB Site Remedial Plan, and Specifications prior to any phased or planned renovation/demolition work involving the subject PCB areas. All PCB abatement material to be disposed of, except for soil remediation as covered under separate project Specifications, shall be disposed of by the Contractor as PCB Bulk Product Waste in accordance with 40 CFR Part 761.

Deviations from these Specifications require the written approval from the Owner.

1.3 DEFINITIONS

1.3.1 Contaminant Zones

Contaminant zones are those areas of active abatement and the waste storage area.

1.3.2 Abatement

The removal of PCB contaminated building materials in the manner specified in this section.

1.3.3 Federally-Regulated PCB Bulk Product Wastes

Federally-regulated PCB Bulk Product Waste, as defined in §761.3, means waste derived from manufactured products containing PCBs in a non-liquid state, at any concentration where the concentration at the time of designation for disposal is ≥50 ppm PCBs.

1.3.4 Non-federally Regulated PCB Waste

Non-federally regulated PCB waste means waste derived from manufactured products containing PCBs in a non-liquid state, at any concentration where the concentration at the time of designation for disposal is ≥1 mg/kg and < 50 mg/kg PCBs.

1.3.5 PCB Waste

PCB waste means PCB-containing caulk and glazing (Federally-regulated and non-federally regulated PCB) and abutting building materials to the subject caulk and glazing.

1.3.6 PCB Site Remedial Plan

"Self-Implementing Cleanup Plan, H.C. Wilcox Technical High School", Prepared by TRC, June 2010.

1.3.7 Remedial Action Level

Concentration to which PCB contaminated building materials must be removed to verify completion of the abatement work.

1.3.8 PCB Contaminated Building Materials

Consists of those caulks and glazings identified as PCB Bulk Product Wastes and/or non-federally regulated materials. Also may include the building materials in which the caulks and glazings are in contact with which includes, but not limited to, window frames, window glass, brick, concrete, mortar, metal, and stone window sills.

1.3.9 Suitable Waste Storage Container

A container in which PCB wastes are placed for storage prior to transport offsite for disposal that is water tight, lined, and equipped with a cover that prevents the infiltration of rainwater into the container.

1.3.10 Verification Sampling

Sampling performed by the Project Monitor to determine the completion of abatement activities as per the PCB Site Remedial Plan.

1.3.11 Waste Storage Area

The secured location in which the Contractor shall store PCB wastes prior to offsite transport for disposal. The Contractor shall consult with the Owner and the PCB Engineer to identify the location of Waste Storage Areas prior to generating any wastes. This area shall be secured and signed by the Contractor.

1.3.12 PCB Engineer

Responsible for overseeing PCB abatement work and for performing and evaluating verification sample data on behalf of the Owner. The PCB Engineer shall be represented daily onsite by the Project Monitor.

1.3.13 Owner

The Owner is the State of Connecticut, Department of Public Works, as further defined in the General Conditions.

1.3.14 Project Monitor

The onsite representative for the PCB Engineer responsible for overseeing daily work activities. The Project Monitor shall approve all containments prior to performance of abatement work, sampling during and after abatement activities, and for verifying that abatement has been successfully performed and allowing containments to be removed.

1.4 SUBMITTALS

Prior to the performance of the work described in this section the Contractor shall submit to the Owner and Construction Administrator the following on the schedule indicated:

1.4.1 The following must be provided to the Owner, Construction Administrator, and the PCB Engineer within seven (7) days after execution of the Contract.

As related to the PCB abatement work, site-specific Health and Safety Plan including the Emergency Response Plan and provisions for decontamination and a contingency plan for unforeseen emergencies. The PCB Engineer shall review such plan only to determine if the plan meets basic regulatory requirements and the minimum requirements of these Specifications. The review will not determine the adequacy of

the plan to address all potential hazards, as that remains the sole responsibility of the Contractor.

Current certification of employee's OSHA health and safety training (HAZWOPER).

Certification of additional required health and safety training for Supervisors.

Qualifications and experience of the Site Safety Officer (SSO).

1.4.2 Prior to any worker accessing the site to perform the work described in this section, the Contractor shall provide documentation, typed on company letterhead and signed by the Contractor, certifying that all employees assigned to the PCB abatement work listed therein have received the following:

Medical monitoring within the previous twelve (12) months, as required in 29 CFR 1910.120;

Respirator fit testing within the previous twelve (12) months as detailed in 29 CFR 1910.134 (for all employees who must also don a tight-fitting face piece respirator).

1.4.3 At least seven (7) days prior to performing any abatement work that shall generate PCB wastes, the Contractor shall submit copies of the EPA/State-approved permits for the proposed Chemical Waste landfill and a waste profile approved by the proposed landfill indicating that the waste materials to be generated are acceptable to the facility.

1.4.4 Seven (7) days prior to the start of abatement work, material information for the proposed encapsulant indicating that these materials conform to the specifications contained within.

1.4.5 No abatement shall commence until a copy of all required submittals have been received and found acceptable to the Owner and the PCB Engineer. Those employees added to the Contractor's original list will be allowed to perform work only upon submittal, and receipt of, all the above required paperwork to the Owner and PCB Engineer.

1.4.6 Copies of all permits, licenses, certifications, including but not limited to, manifests and/or bill of lading for the removal, transport, and disposal of PCB waste material shall be submitted to the Owner and PCB Engineer no later than five (5) business days after the Contractor receives such documents.

1.4.7 Notice shall be provided to the Owner and the PCB Engineer at least five (5) business days prior to the start of work under this Specification. Such notice shall include an estimated completion date. If this work is phased over the duration of the project, then such notification requirements shall apply to each phase.

1.5 REGULATORY REQUIREMENTS

1.5.1 All abatement and decontamination wastes are to be handled and stored in accordance with the provision of 40 CFR Part 761 Subpart D. The Contractor shall be responsible for all costs associated with investigation and remediation of any releases due to their failure to handle abatement wastes in accordance with the regulatory requirements.

1.6 DELIVERY AND STORAGE

1.6.1 The Contractor shall deliver and store materials in a manner to prevent contamination, segregation, freezing, and other damage.

1.7 MEASUREMENT AND PAYMENT

The Contractor's cost proposal shall be based on the following criteria:

Measurement for payment shall be based on a lump sum price for the removal of all PCB Wastes.

No extra payment shall be made for the construction and removal of containments, any required barrier installation and removal, decontamination, dust control, site preparation, site restoration or waste disposal areas. The cost for these items shall be included in the base bid.

Contractor shall use add deduct prices provided for determining cost for additional work if required. If additional areas requiring work is found outside of an area that would already require containment, the Contractor shall use the lump sum price of the containment plus the unit prices abatement work required. If there is a reduction in the work or the requirements of the work as described in the Contract Documents, the deduct price shall be calculated using the lump sum and unit prices provided.

1.8 PROTECTION

1.8.1 Structures and Surfaces

The Contractor shall protect adjacent structures and surfaces from traffic or any other damage. The Contractor shall repair and reestablish damaged building materials that are to remain in place prior to acceptance of the work.

PART 2 PRODUCTS

2.1 All materials shall be delivered to the job site in the original packages, containers, or bundles bearing the name of the manufacturer, the brand name and product technical description.

2.2 No damaged or deteriorating materials shall be used. If material becomes contaminated with PCBs, the material shall be disposed of as PCB waste material. The cost to dispose of this material shall be at the expense of the Contractor.

2.3 Fire retardant polyethylene sheet shall be in roll size to minimize the frequency of joints, with factory label indicating four (4) or six (6) mil thickness.

2.4 Tape (or equivalent) capable of sealing joints in adjacent polyethylene sheets and for the attachment of polyethylene sheets to finished or unfinished surfaces must be capable of adhering under both dry and wet conditions.

2.5 Containers for storage, transportation and disposal of PCB-containing waste material shall be impermeable and both air and watertight.

2.6 Labels and warning signs shall conform to OSHA 29 CFR 1926, USEPA 40 CFR Part 761, and USDOT 49 CFR Part 172 as appropriate.

2.7 Any planking, bracing, shoring, barricades and/or temporary sheet piling, necessary to appropriately perform work activities shall conform to all applicable federal, state and local regulations.

2.8 Air filtration devices and vacuum units shall be equipped with HEPA filters.

PART 3 EXECUTION

3.1 General Requirements for PCB Containing Building Material Abatement.

All labor, materials, tools, equipment, services, testing, insurance, and incidentals which are necessary or required to perform the work in accordance with applicable governmental regulations, industry standards and codes, and these Specifications shall be provided by the Contractor. The Contractor shall be prepared to work all shifts and weekends throughout the course of this work.

Prior to beginning work per these Specifications, the PCB Engineer and Contractor shall perform a visual survey of each work area and review conditions at the site for safety reasons. In addition, the Contractor shall instruct all workers in all aspects of personnel protection, work procedures, emergency evacuation procedures and use of equipment including procedures unique to this work.

3.2 Prior to the performance of any abatement work, the Contractor shall perform the following tasks.

Shutdown and isolate heating, cooling, and ventilating air systems to prevent contamination to the other areas of the buildings.

Shut down and lock out electrical power, including all receptacles and light fixtures, when feasible. The use or isolation of electrical power will be coordinated with all other ongoing uses of electrical power at the site.

Coordinate all power and fire alarm isolation with the appropriate representatives.

When necessary, provide temporary power and adequate lighting and ensure safe installation of electrical equipment, including ground fault protection and power cables, in compliance with applicable electrical codes and OSHA requirements. The Contractor is responsible for proper connection and installation of electrical wiring.

3.3 If sufficient electrical service is unavailable, the Contractor may need to supply electrical power to the site by fuel operated generator(s). Electrical power supply shall be sufficient for all equipment required for this work in operation throughout the duration of the work.

3.4 Negative pressure must be maintained in each active work area, until the area achieves satisfactory reoccupancy criteria and is approved by the Project Monitor to be deregulated.

3.5 Water service may not be available at the site. Contractor shall supply sufficient water for each shift to operate the decontamination units as well as to maintain the work areas adequately wet.

3.6 Ladders and/or scaffolds shall be in compliance with OSHA requirements, and of adequate length, strength and sufficient quantity to support the scope of work. Use of ladders/scaffolds shall be in conformance with OSHA 29 CFR 1926 Subpart L and X requirements.

3.7 Work performed at heights exceeding six feet (6') shall be performed in accordance with the OSHA Fall Protection Standard 29 CFR 1926 Subpart M including the use of fall arrest systems as applicable.

3.8 Data provided regarding PCB sampling conducted throughout the structure(s) is for informational purposes only. Under no circumstances shall this information be the sole means used by the Contractor for determining the presence and location of all PCB Waste. The Contractor shall verify all field conditions affecting performance of the work as described in these Specifications in accordance with applicable OSHA, USEPA, USDOT, and CTDEP standards. Compliance with the applicable requirements is solely the responsibility of the Contractor.

3.9 The PCB Engineer will provide a Project Monitor to oversee the activities of the Contractor. No PCB abatement work shall be performed until the Project Monitor is on-site.

3.10 All interior and exterior abatement areas are to be established in the same manner.

The abatement Contractor shall establish a Control Area around each area where removal actions are being performed. Only properly trained personnel associated with the removal or abatement will be allowed within the Control Areas that will be established by placing barriers with signs indicating that access to the area is restricted. The Contractor's field inspector will maintain the Control Areas and escort unauthorized personnel from the area promptly. Only those personnel actively working on the removal, abatement, and soil excavation actions will be allowed within the Regulated/Containment Area and they shall be equipped with appropriate Personal Protective Equipment (PPE).

The Contractor shall pre-clean the work areas using HEPA filtered equipment (vacuum) and/or wet methods as appropriate, collecting and properly containing all dust and debris identified as PCB Waste. Vacuum units, of suitable size and capabilities for the project, shall have HEPA filters capable of trapping and retaining at least 99.97 percent of all monodispersed particles of three micrometers in diameter or larger. Do not use methods that raise dust, such as dry sweeping or vacuuming with equipment not equipped with HEPA filters.

After pre-cleaning, movable objects shall be removed from the work areas with the utmost care to prevent damage of any kind and relocated to a temporary storage location coordinated with the PCB Engineer. The Contractor is responsible for protecting all fixed objects that are permanent fixtures or are too large to remove and remain inside the Regulated Area. Fixed objects shall be enclosed with one layer of six (6) mil polyethylene sheeting sealed with tape.

The Contractor shall establish remote to the Regulated Area but within the Control Area, a Worker Decontamination Enclosure System consisting of Equipment Room, Shower Room and Clean Room in series.

The Shower Room shall be of sufficient capacity to accommodate the number of workers. One shower stall shall be provided for each eight (8) workers. Showers shall be equipped with hot and cold or warm running water through the use of electric hot water heaters supplied by the Contractor. No worker or other person shall leave a Regulated Area without showering. Shower water shall be collected.

The Contractor shall ensure that no personnel or equipment be permitted to leave the Control Area until proper decontamination procedures (including HEPA vacuuming, wet wiping and showering) to remove all PCB debris have occurred. No PCB-contaminated materials or persons shall enter the Clean Room.

The Contractor shall seal off all windows, doorways, skylights, ducts, grilles, diffusers, vents, light fixtures, electrical receptacles, suspended ceiling tile systems and any other openings between the Regulated Area and the uncontaminated areas outside of the Regulated Area, including the outside of the building, with critical barriers consisting of a minimum of one (1) layer of six (6) mil polyethylene sheeting

securing the edges with tape. Doorways and corridors which will not be used for passage during work and separate the regulated areas from occupied areas must be sealed with fixed critical barriers constructed of 2" x 4" wood or metal framing 16" O.C., with ½" plywood on the occupied side and two layers of six (6) mil polyethylene sheeting on the Regulated Area side to prevent unauthorized access or air flow.

A Negative Pressure Enclosure (NPE) shall be constructed by the Contractor via covering of floor and wall surfaces with polyethylene sheeting sealed with tape. Polyethylene shall be applied alternately to floors and walls. Cover floors first, with a layer of six (6) mil polyethylene sheeting, so that polyethylene extends at least twelve (12) inches up on wall. Cover wall with a layer of six (6) mil polyethylene sheeting to twelve (12) inches beyond the wall/floor intersection, thus overlapping the floor material by a minimum of twenty-four (24) inches. Repeat the process for the second layer of polyethylene. There shall be no seams at wall-to-floor joints. Contiguous to the NPE, construct a single chamber airlock from six (6) mil polyethylene sheeting for entry/exit purposes into the regulated area.

Conspicuously label and maintain emergency and fire exits from the Regulated Area satisfactory to fire officials.

The Contractor shall create a negative pressure differential in the range of 0.02 to 0.04 inches of water column between the Regulated Area and surrounding areas by the use of acceptable negative air pressure equipment. Exhaust air filtration units shall be equipped with HEPA filters capable of providing sufficient air exhaust to create a minimum pressure differential of 0.02 inches of water column, and to allow a sufficient flow of air through the area providing 4 air changes per hour. The Contractor shall provide a sufficient quantity of HEPA air filters to maintain the pressure differential throughout the duration of the project. An automatic warning system shall be incorporated into the equipment to indicate pressure drop or unit failure. Continuously monitor the pressure differential between the Regulated Area and surrounding area to ensure exhaust air filtration equipment maintains a minimum pressure differential of 0.02 inches of water column. The Contractor shall provide actual air flow measurement of filtration units while the unit is in place and calculate actual air exchange rates. No air movement system or air filtering equipment shall discharge unfiltered air outside the Regulated Area.

The Contractor shall post warning signs to deter unauthorized personnel from entry. Additional signs may require posting following construction of workplace enclosure barriers.

3.11 Personnel Protection

The Contractor shall utilize all appropriate engineering controls and safety and protective equipment while performing the work in accordance with applicable

OSHA, USEPA, USDOT, CTDEP, CTDPH regulations, and other Contract provisions.

The Contractor shall provide and require all workers to wear protective clothing in the Regulated Areas where PCB contamination exists. Protective clothing shall include impervious coveralls with elastic wrists and ankles, head covering, gloves and foot coverings.

Respiratory protection shall be provided and shall meet the requirements of OSHA as required in 29 CFR 1910.134. A formal respiratory protection program must be implemented in accordance with 29 CFR 1910.134. The Contractor shall provide respirators from among those approved as being acceptable for protection by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 30 CFR Part ll.

All other necessary personnel protective equipment (i.e. hardhat, work boots, safety glasses, hearing protection, etc.) required to perform the PCB abatement work activities shall conform to all applicable federal, state and local regulations and other applicable provisions of the Contract.

All other qualified and authorized persons by the Owner and/or Contractor entering into a Regulated Area shall be required to adhere to the requirements of personnel protection as stated in this section and all other applicable provisions of the Contract. All unqualified and unauthorized persons shall be escorted outside of the Regulated Area and if due to other provisions of the Contract, escorted outside of the project site during the PCB work.

3.12 PCB Abatement Procedures

The Site Supervisor, as the OSHA Competent Person shall be at the site at all times during the performance of abatement work.

The Contractor shall not begin abatement work until authorized by the Project Monitor, following a pre-abatement visual inspection.

All workers and authorized persons shall enter and leave the Regulated Area through the contiguous airlock, leaving contaminated protective clothing in the airlock for disposal of as PCB contaminated waste. No one shall eat, drink, smoke, chew gum or tobacco, or apply cosmetics while in a Regulated Area.

The following details the extent of each phase of operation designated for this work. Phase areas may be combined or divided at the direction of the PCB Engineer. Proceed through the sequencing of the work phases under the direction of the Engineer.

See the PCB Site Remedial Plan and other Contract Drawings provided for the site for specific locations of PCB containing caulks and glazing. The specific locations for these materials and amount of associated building materials to be removed as well are indicated on these drawings and the PCB Site Remedial Plan.

During removal, the Contractor shall spray PCB containing building material with water using airless spray equipment capable of providing a "mist" application to reduce airborne dust. Hose length shall be sufficient to reach all of the Regulated Area. Do not "flood" the area with hose type water supply equipment with the potential to create water releases from the regulated area.

The Contractor shall employ mechanical methods such as cutting, grinding, and pneumatic hammers to remove PCB contaminated wastes. The methods employed must not damage the integrity of the containment structure and shall not create a breach through which contaminated dust may escape. The Contractor shall be responsible for all costs associated with decontamination and remediation in the case of a containment breach.

In order to minimize PCB concentrations inside the Regulated Area, the Contractor shall remove the materials in manageable sections. In addition, PCB Waste materials removed from any elevated level shall be carefully lowered to the floor.

The Contractor shall promptly place the PCB Waste material in disposal containers (six (6) mil polyethylene bags/ poly-lined dumpsters, etc.) as it is removed. Large components removed intact may be wrapped in one (1) layer of six (6) mil polyethylene sheeting secured with tape. As the disposal containers are filled, the Contractor shall promptly seal the containers, apply caution labels and clean the containers before transportation to the airlock. Bags shall be securely sealed to prevent accidental opening and leakage by taping in gooseneck fashion. Small components and PCB Waste material with sharp-edged components (e.g. nails, screws, metal lath, tin sheeting) which could tear polyethylene bags and sheeting shall be placed in clean drums and sealed with locking ring tops. Drums may not be placed intact into final waste disposal containers intact and may be reused by the Contractor after the contents have been emptied. However, any drums use to handle wastes must be broken down and disposed of properly with other PCB wastes.

All waste containers shall be leak-tight. Containers shall be decontaminated by wet cleaning and HEPA vacuuming within the airlock prior to exiting the regulated area. Wet clean each container thoroughly before moving to a Waste Holding Area.

If at any time during PCB Waste removal, the Project Monitor should suspect contamination of areas outside the Regulated Area, the Contractor shall immediately stop all abatement work and take steps to decontaminate these areas and eliminate causes of such contamination. Unprotected individuals shall be prohibited from entering contaminated areas.

After completion of abatement work, all surfaces from which PCB Waste has been removed shall be wet brushed, using a nylon brush, wet wiped and sponged or cleaned by an equivalent method to remove all visible material (wire brushes are not permitted). Cleaning shall also include the use of HEPA filtered vacuum equipment.

The Contractor shall also remove and containerize all visible accumulations of PCB Waste and/or PCB contaminated debris which may have splattered or collected on the polyethylene engineering controls/barriers.

The Contractor shall clean surfaces of contaminated containers and equipment thoroughly by vacuuming with HEPA filtered equipment and wet sponging or wiping before moving such items into the airlock for final cleaning and removal to uncontaminated areas.

The Contractor shall remove contamination from the exteriors of the air filtration devices, scaffolding, ladders, extension cords, hoses and other equipment inside the Regulated Area. Cleaning may be accomplished by brushing, HEPA vacuuming and/or wet cleaning. The Contractor shall wet wipe the Regulated Area beginning at the point farthest away from the negative air filtration units using cotton rags or lint free paper towels. Rags and towels shall be disposed of after each use. Workers should avoid the use of dirty rags to insure proper cleaning of surfaces. Mop the entire floor with a clean mop head and amended water. Water shall be changed frequently

Once the Regulated Area surfaces have dried, the Project Monitor shall perform a thorough post abatement visual inspection. The Project Monitor will visually inspect the Regulated Area and the surrounding Control Area to determine that the Contractor has sufficiently decontaminated and removed any dust that might contain PCBs. All surfaces within the Regulated Area, including but not limited to ledges, beams, and hidden locations shall be inspected for visible residue. Evidence of dust contamination that would be indicative of PCB contamination identified during this inspection will necessitate further cleaning as heretofore specified. The area shall be re-cleaned at the Contractor's expense, until the standard of cleaning is achieved.

Once the area has received a satisfactory post-abatement visual inspection, any equipment, tools or materials not required for completion of the work, shall be removed by the Contractor from the Regulated Area. Negative air filtration devices shall remain in place and operating for the remainder of the clean-up operation.

3.13 Phased PCB Abatement Procedures

Should the potential exist for an unsafe condition to be produced by removing PCB contaminated building materials prior to removing clean materials, then the Contractor shall notify the Owner and the PCB Engineer and Project Monitor of such concerns and mitigate potentially unsafe conditions.

Should PCB contaminated building material need to remain to prevent an unsafe situation, the PCB Engineer shall collect the required verification samples prior to the performance of any demolition in the area. The Contractor shall then physically demark the line of clean building materials as determined by the verification sampling on the structure by painting or otherwise marking the structure so that it is clearly visible.

Once the area is marked, the Contractor may remove clean building materials as described elsewhere in the Contract Document. After the clean building materials have been removed to the marked line, PCB Contaminated building materials shall be abated according to the procedures stated in section 3.12 of this specification.

3.14 Post-Abatement Reoccupancy Procedures

The Project Monitor shall collect verification samples as per the EPA Region 1 Standard Operating Procedure for Sampling Concrete at the frequency specified in the approved PCB Site Remedial Plan. The verification samples will be analyzed for PCBs using EPA Methods 3540 and 8082. Analysis of verification samples will be expedited but the Contractor shall expect 48 to 72 hours (these hours do not include weekend and/or holiday hours) delay until analytical results are available.

Federally and Non-federally Regulated PCB Waste (demolition/renovation areas): In areas where PCB Wastes have been removed along with the associated building materials, the remedial standard to be achieved by all verification samples is <1 mg/kg total PCBs. If this standard is achieved then additional reoccupancy work will be performed. If the remedial standard is exceeded, the Contractor shall be instructed to remove additional building materials as instructed by the Project Monitor.

Non-federally Regulated PCB Waste (non-demolition areas): Work involving non-federally regulated PCB waste in non-demolition/renovation areas, shall be scheduled during school vacations, when school is not in session. Such work shall be started and completed within such schedule. Work shall be completed at least ten (10) days prior to students returning to school. In non-demolition/renovation areas, non-federally regulated PCB-containing caulks and/or glazing shall be removed and the associated building materials shall be cleaned in accordance with these Specifications and left in place. The remedial standard to be achieved by the verification samples collected from the associated building materials is <1 mg/kg total PCBs. If this standard is achieved in the building materials left in place, then additional reoccupancy work will be performed. If this standard is not achieved, then an encapsulant shall be applied by the Contractor to the area where the caulk and glazing were in contact with building materials and after the encapsulant has cured, new caulk or glazing shall be applied by the Contractor.

Following the collection and analysis of verification samples indicating that remediation goals have been achieved or the encapsulation of other materials, the Project Monitor shall collect wipe samples of surfaces within the Containment Area

to determine if the decontamination performed by the Contractor has been sufficient to remove potentially PCB containing dust. The PCB Engineer shall obtain expedited analyses of these samples from an outside laboratory, but the Contractor shall expect 48 to 72 hours (these hours do not include weekend and/or holiday hours) delay until analytical results are available. The PCB Engineer shall instruct the Contractor to perform additional decontamination if wipe sample results are ≥1.0 µg/100 cm2. Areas which do not comply shall continue to be cleaned by and at the Contractors expense, until the specified Standard of Cleaning is achieved as evidenced by results of wipe testing. When the Regulated Area passes the re-occupancy clearance, controls established by these Specifications may be removed.

Wipe sampling will not begin until after the area has received an acceptable post abatement visual inspection and verification sample results indicate compliance with remedial standards.

Analysis shall follow the requirements of EPA Methods 3540 and 8082.

Each homogeneous Regulated Area which does not meet the clearance criteria shall be thoroughly recleaned using HEPA vacuuming and/or wet cleaning, with the negative pressure ventilation system in operation. New samples shall be collected in the Regulated Area. The process shall be repeated until the Regulated Area passes the test, with the cost of repeat sampling being borne entirely by the Contractor.

For a PCB Waste abatement project with more than one homogeneous Regulated Area, the release criterion shall be applied independently to each Regulated Area.

These clearance sampling procedures shall be implemented for both interior and exterior NPE work areas.

3.15 Post Abatement Work Area Deregulation

The Contractor shall remove all remaining polyethylene, including critical barriers, and airlocks with the negative air filtration devices in operation. HEPA vacuum and/or wet wipe any visible residue which is uncovered during this process. All waste generated during this disassembly process shall be discarded as PCB Bulk Product Waste.

A final visual inspection of the work area shall be conducted by the PCB Engineer and the Project Monitor to ensure that all visible accumulations of PCB Waste materials have been removed and that no equipment or materials associated with the abatement work remain.

The Contractor shall restore all work areas and auxiliary areas utilized during work to conditions equal to or better than original. Any damage caused during the performance of the work activity shall be repaired by the Contractor at no additional expense to the Owner.

3.16 Encapsulation Procedures

The contractor shall encapsulate building materials located in areas where renovation/demolition is not being performed as indicated on the Contract Drawings and these Specifications with an elastomeric, crack bridging, anti-carbonation, protective coating to be applied as the encapsulant. Following completion of encapsulant application, including cure time, the Contractor shall reinstall caulk as per and meeting the specifications contained within Section 079200 – Joint Sealants.

The Contractor shall install materials in accordance with all safety and weather conditions required by manufacturer or as modified by applicable rules and regulations of local, state and federal authorities having jurisdiction. Consult Material Safety Data Sheets for complete handling recommendations.

All encapsulant materials shall be delivered in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers. Damaged material shall be removed from the site immediately. All materials shall be stored off the ground and protect from rain, freezing or excessive heat until ready for use.

The Contractor shall not apply material if it is raining or snowing or if such conditions appear to be imminent. Minimum application temperature are 45°F (7°C) and rising. Precautions shall be taken by the Contractor to avoid damage to any surface near the work zone due to mixing and handling of the specified material.

The encapsulant shall be Sikagard 550W (or 670W) Elastocolor, as manufactured by Sika Corporation, 1682 Marion Williamsport Road, Marion, Ohio, or equivalent. The Contractor shall provide submittals for the encapsulant to be used prior to bringing the materials onsite for use.

Elastomeric Acrylic Coating shall be one hundred percent (100%) Acrylic Emulsion with the following properties:

3.16.1 Water vapor permeable

3.16.2 Can bridge dynamically moving cracks

3.16.3 Crack bridging properties maintained at low temperatures

3.16.4 The material shall be resistant to dirt pick-up and mildew

3.16.5 Pot Life: indefinite

3.16.6 Tack Free Time 6 Hours @ 73°F, 50% Relative Humidity. Final Cure < 24 Hours

3.16.7 Carbon Dioxide Diffusion: μCO2 214,000 Carbon Dioxide Diffusion Resistance at 16 mils (400 microns)

3.16.8 SdCO2 = 299 ft. (equivalent air thickness) i.e. Approx. 9-in. of standard concrete cover.

3.16.9 Water Vapor Diffusion: μH2O 2,146 Water Vapor Diffusion Resistance at 16 mils SdH2O = 2.6 ft. (0.8m)

3.16.10 Moisture Vapor permeability (ASTM E96) 14.5 perms

3.16.11 Tensile Properties (ASTM D-412 Modified)

3.16.12 7 day-Tensile strength 190 psi (1.3 MPa) - Elongation at break 820% - 340% @ 0°F (-18°C)

3.16.13 Crack Bridging (at 16 mils = 400 microns DFT

3.16.14 Static (at –4°F/-20°C) 30 mils (0.75mm)

3.16.15 Dynamic>1000 cycles (at –4°F/-20°C) 12 mils (0.30mm)

3.16.16 Resistance to wind driven rain (TT-C-555B): No passage of water through coating

3.16.17 Weathering (ASTM G-23) 10,000 hours excellent, no chalking or cracking.

3.16.18 Solids Content: by weight – 62% by volume – 55%

3.16.19 Flame Spread and Smoke Development (ASTM E-84-94)

3.16.20 Flame Spread 5 Smoke Development 5 Class Rating A

Note: Tests above were performed with the material and curing conditions @ 71°F – 75°F and 45-55% relative humidity.

Building substrate to which the encapsulant coating is to be applied must be clean, sound, and free of surface contaminants. Remove dust, laitance, grease, oils, curing compounds, form release agents and all foreign particles by mechanical means. Substrate shall be in accordance with ICRI Guideline No. 03732 for coatings and fall within CSP1 to CSP3.

The Contractor shall stir materials to ensure uniformity using a low speed (400-600 rpm) drill and paddle. To minimize color variation, blend two batches of material. For small defects and cracks the Contractor shall apply Surface Filler by "Brush Grade" encapsulant generously over the center of the cracks. The Contractor shall feather material over a two-inch wide area and allow a minimum 24 hours to cure before overcoating. For large defects and cracks (cracks >20mils) the Contractor shall blow out the cut with oil-free compressed air and fill the crack with joint sealant conforming to specifications allowing for a small crest to remain as this will compensate for any shrinkage that might occur. The Contractor shall allow 24 hours-minimum cure before over coating with encapsulant.

For the final coating application, the Contractor shall apply by brush or roller over the entire area to be encapsulated by moving in one direction. The Contractor shall apply a minimum of two coats. Each coat should be applied at a rate not to exceed 100 sq. ft. per gallon. The total dry film thickness shall be minimum 8 - 10 dry mils per coat. Allow a minimum of 2 hours prior to re-coating. When applying the coating, never

stop the application until the entire surface has been coated. Always stop application at an edge, corner, or joint.

3.17 Waste Disposal

If the Contractor chooses to store soil onsite prior to transport offsite for disposal, the Contractor shall construct a secured Waste Storage Area at a location agreed to by the Contractor and the PCB Engineer within contract limit lines. The contract limit lines are to be secured as described elsewhere in these specifications and entry shall be limited to Contractor Personnel only. The Waste Storage Area shall enclose all Suitable Waste Storage Containers actively in use with temporary fencing. The fence shall be marked with a Large M_L mark as specified in 40 CFR Part 761 Subpart C.

Unless otherwise specified by the Owner, all removed materials and debris resulting from execution of this work shall become the responsibility of the Contractor and removed from the premises. Materials not scheduled for reuse shall be removed from the site and disposed of in accordance with all applicable Federal, State and Local requirements.

Waste removal dumpsters and cargo areas of transport vehicles shall be lined with a layer of six (6) mil polyethylene sheeting to prevent contamination from leaking or spilled containers. Floor sheeting shall be installed first, and shall be extended up sidewalls 12-inches. Wall sheeting shall overlap floor sheeting 24-inches and shall be taped into place. A single liner may be employed as long as it entirely covers the interior of the waste container.

All containers used to transport PCB Waste for disposal must be marked with a Large ML mark as specified in 40 CFR Part 761 Subpart C. The signs must be posted so that they are plainly visible.

Ensure all waste containers (bags, etc.) are properly packed, sealed and labeled with USEPA and USDOT shipping labels. For each shipment of PCB Waste, the Contractor shall complete a PCB waste shipment manifest.

Authorized representatives signing waste shipment records on behalf of the generator must have USDOT Shipper Certification training in accordance with HMR 49 CFR Parts 171-180.

Transport vehicles hauling PCB Waste shall have appropriate USDOT placards visible on all four (4) sides of the vehicle.

The Contractor shall dispose of PCB Waste at a TSCA-permitted facility.

Any PCB Waste materials which also contain other hazardous contaminants shall be disposed of in accordance with the EPA's Resource Conservation and Recovery Act (RCRA), CTDEP and ConnDOT requirements. Materials may be required to be

stored on-site and tested by the Project Monitor to determine proper waste disposal requirements.

3.18 Decontamination

The Contractor shall decontaminate all moveable equipment that contact PCB Wastes in accordance with the procedures specified in §761.79(c). The Contractor shall not remove any equipment from the Contaminant Zone until it has been properly decontaminated.

Specifically, the Contractor shall employ double wash/rinse procedures as specified in 40 CFR Part 761 Subpart S or swab non-porous surfaces that have contacted PCB wastes with a solvent as specified in §761.79(c)(2)(i). The Contractor shall segregate all liquid waste streams and be responsible for characterizing these wastes for disposal purposes. Solid wastes generated during decontamination shall be stored for disposal with the other PCB wastes generated during remediation activities.

The PCB Engineer shall be responsible for ensuring that decontamination procedures are followed and that wastes are appropriately characterized and disposed of properly.

3.19 Project Closeout Data:

Provide the Owner and PCB Engineer, within 30 days after PCB Waste has been disposed of, a compliance package; which shall include, but not be limited to, the following:

3.19.1 Site Supervisor job log;
3.19.2 Completed waste shipment records.

The Contractor shall submit the original completed waste shipment records to the PCB Engineer.

3.20 Method of Measurement:

No measurement will be made for the abatement work in this Section. The completed work shall be paid as a lump sum. The lump sum bid price for PCB abatement shall include the specialty services of the PCB Removal Contractor including: labor, materials, equipment, insurance, permits, notifications, submittals, personal air sampling, personal protection equipment, temporary enclosures, utility costs, incidentals, fees and labor incidental to the removal of PCB Wastes, including close out documentation.

Measurement for payment for waste disposal will be on a per ton basis. The unit price for PCB Bulk Product Waste Disposal shall include providing adequate containers for storage of PCB wastes until they are removed from the site and the transport and disposal of these materials at a TSCA-permitted facility. Payment for

the disposal of PCB Bulk Product Waste disposal shall be made when the Contractor submits manifests with the mass of waste disposed and signed by the receiving facility and the Certificates of Disposal provided by the waste disposal facility for each manifested load to the Engineer. Once the manifest and Certificate of Disposal has been received, the Owner shall make payment to the Contractor.

Deducts from payment for containments without negative pressure will be made on a per containment basis. The deduct cost shall account for construction of containment as described in this section without the negative pressure generating air handling units and HEPA filtration of discharge air.

Pay Item	Pay Unit
PCB Abatement	Lump Sum
PCB Waste Disposal	Per Ton

Unit Price Schedule – Additional or Reduced PCB Abatement

This schedule applies only to items beyond the scope specified in the Contract Documents or if there is a reduction in the scope of work or the requirements of the work. Costs associated with the use of unit price items is inclusive of all labor, equipment, materials, and overhead and profit.

Item	Item Description	Unit	Add/Deduct Cost
1	Containment Area – Set up of containment area (up to 400 square feet area) as described in these specifications.	EA	$1,300
2	Containment Area – Set up of containment area (up to 400 square feet area) as described in these specifications except for installation of equipment used to create and maintain negative pressure.	EA	$1,100
3	PCB Contaminated caulk abatement with removal of 6" of building materials on either side of the caulked joint.	LF	$4.73
4	PCB Contaminated caulk abatement with removal of 12" of building materials on either side of the caulked joint	LF	$8.78
5	PCB Contaminated caulk abatement with no removal of building materials	LF	$3.15
6	Removal of door and contaminated caulk	EA	$125

SECTION 072600 - SURFACE APPLIED VAPOR REDUCTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Furnish all labor, materials, tools and equipment as necessary to perform installation of a surface applied moisture mitigation system (vapor retarder) on new and existing concrete slabs free of oil contamination or previously treated with a sealer, as shown on drawings and/or as specified in this section.

B. Repairs and preparation of concrete floors.

C. Related Sections:

1. See section 012000 Contract Considerations.
2. See section 033000 Cast-in-Place Concrete.
3. See section 096400 Wood Flooring.
4. See section 096500 Resilient Flooring.
5. See section 096723 Resinous Flooring.

1.2 REFERENCES

A. ASTM F 1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride; 1998.

B. ASTM E 1907 – Standard Practices for Determining Moisture-Related Acceptability of Concrete Floors to Receive Moisture-Sensitive Finishes; 1997.

C. ASTM E 96 - Standard Test Methods for Water Vapor Transmission of Materials; 1995.

D. ASTM D 4541 B - Pull-Off Strength of Coatings; 1995, Modified.

1.3 SUBMITTALS

A. Product Data:
1. Submit manufacturer's literature and installation instructions for each product.
2. Test data: Submit independent testing laboratory data for product, evidencing:
    a. up to 97% reduction of water vapor transmission (tested as per ASTM E 96-95).
    b. product is insensitive to alkaline environment up to pH 14 (tested as per ASTM D 1308).
3. Submit manufacturers sample warrantee.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Company specializing in manufacturing products specified in this Section with minimum 5 years documented experience.

B. Installer Qualifications:
1. Acceptable to manufacturer with documented experience on at least 3 projects of similar nature in past 5 years and/or training provided by the product manufacturer.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver and store in a dry, well ventilated area at minimum 50 deg F (10 deg C) and maximum 90 deg F (32 deg C).

B. Deliver materials in manufacturer's unopened containers fully identified with brand, type, grade, class and all other qualifying information. Provide Material Safety Data Sheets for each product.

1.6 SYSTEM REQUIREMENTS

A. Coordinate floor sealing installation with other trades.

B. Provide materials and accessories in timely manner so as not to delay Work.

1.7 PROJECT CONDITIONS

A. Maintain surfaces to be sealed and surrounding air temperature at not less than 50 deg F (10 deg C).

B. Exercise caution when temperatures exceed 90 deg F (32 deg C).

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form, in which manufacturer agrees to repair or replace components of the flooring system, including the finish floor covering, that fail in materials or workmanship due to vapor transmission for five (5) years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Products For All Locations Indicated Unless Otherwise Specified: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
a. Vaportight Coat SG-2 by Aquafin, Inc.
b. Koester VAP 1 pH by Koester American Corporation.
c. MoistureBloc Universal by Vexcon Chemicals, Inc.

B. Available Products for Resinous Flooring Locations: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
   a. Vaportight Coat SG-3 by Aquafin, Inc.
   b. Koester VAP 1 2000 by Koester American Corporation.
   c. MoistureBloc Emulsion Vapor Reduction System by Vexcon Chemicals, Inc.

2.2 MATERIALS

A. Moisture Vapor Emission Reduction Control System (concrete floor sealer) For All Locations Indicated Unless Otherwise Specified: A 100% solids, solvent free, moisture tolerant, high density, low odor, chemically enhanced epoxy based product which must reduce vapor emissions (MVER) to 3 lbs/24 hrs*1000 SF or less and be compatible with floor finishes and adhesives approved by the manufacturer. Characteristics:

1. Permeance: (ASTM E-96) <1.0 perm
2. Alkaline Resistance: (ASTM D-1308) up to pH 14

B. Moisture Vapor Emission Reduction Control System (concrete floor sealer) For Resinous Flooring Locations: A 100% solids, solvent free, moisture tolerant, high density, low odor, chemically enhanced epoxy based product which must reduce vapor emissions (MVER) to 3 lbs/24 hrs*1000 SF or less and be compatible with floor finishes and adhesives approved by the manufacturer. Characteristics:

1. Permeance: (ASTM E-96) <0.5 perm
2. Alkaline Resistance: (ASTM D-1308) up to pH 14

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine all construction substrates and conditions under which concrete floor sealer material is to be installed. Do not proceed with the concrete floor sealer installation until unsatisfactory conditions are corrected.

B. Assure that surfaces to be treated do not contain any kind of sealer or organic compounds.

C. Anhydrous Calcium Chloride Testing as per ASTM F-1869:
   1. Before installation of concrete floor sealer: use tests carried out by Architect/Engineer during study phase, and confirm by testing through installer or independent laboratory prior to installation of concrete floor sealer.

3.2 PREPARATION

A. Protect adjacent surfaces not designated to receive concrete floor sealer.

B. Substrate preparation:

1. Remove existing floor coverings, coatings and adhesives down to bare concrete, curing compounds, efflorescence, dust, grease, laitance, etc. with steel shot blasting, abrasive (sand) blasting or grinding using a diamond cup blade. Acid etching is not allowed.

2. Assure that all slabs have surface profile ICRI CSP 3 - 5 (ICRI, Des Plaines, IL, Guideline No. 03732.) for mechanical bond (i.e. medium grit sandpaper). Smooth surfaces are not acceptable, they must be shot blasted.

3. Burn off reinforcing fibers and collect and vacuum remains.

4. Repair defective areas such as honeycombs, cracks or other defects with a suitable repairing or manufacturer recommended mortar.

5. Treat saw cut and expansion joints as per manufacturer's application guideline.

6. Install cementitious underlayment, leveling mortars, flash patching, on top of surface applied concrete floor sealer.

7. Carefully rinse or pre-dampen several times all the surfaces to be treated with clean water, leave no standing water.

3.3 INSTALLATION

A. Mix concrete floor sealer material in proportions recommended by manufacturer.

B. Apply concrete floor sealer material in quantities as per manufacturer's specifications and recommendations.

   1. Apply in one coat at specified rate.

   2. Apply using non-shed synthetic roller or notched squeegee to the still moist substrate, and carefully scrub it into the pores with a long handled scrub brush. Follow with a non-shed synthetic roller to achieve a uniform coverage.

C. Where specified install leveling course as per manufacturer's specifications and recommendations.

D. Where specified install floor covering as per manufacturer's specifications and recommendations.

3.4 ACCEPTANCE

A. Remove left over materials and any foreign material resulting from the work from the site.

B. Clean adjacent surfaces and materials.

END OF SECTION 072600

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The following sections constitute related work:

1. Section 019113 - Commissioning for additional work associated with this section.
2. Section 23 – General Provisions
3. Section 23 – Meters and Gages.
4. Section 23 – Condensing Boilers
5. Section 23 – Rotary Air Cooled Screw Chillers
6. Section 23- Laboratory Airflow Controls
7. Section 23 - Air Distribution
8. Section 23 – Enclosed Controllers
9. Section 23 - Testing, Adjusting, and Balancing
10. Section 26 – Common Work Results for Electrical
11. Section 26 - Wiring Methods
12. Section 26 - Electrical Power (Uninterruptible Power Supplies,)
13. Section 26 - Low-Voltage Distribution
14. Section 26 – Lighting

1.2 DESCRIPTION

A. The control system and work shall be an extension of the existing Automated Logic DDC control system. The existing system must be maintained fully functional throughout the construction to maintain service to existing areas of the building not being renovated. Automated Logic vendor shall provide **ALL** required hardware, software, equipment, programming, wiring, power, etc for a fully functional and complete operational system.

B. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and a web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.

C. The system shall directly control HVAC equipment as specified in Sequences of Operation. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of setpoints as specified.

D. Provide for future system expansion to include monitoring of occupant card access, fire alarm, and lighting control systems. Provide general monitoring of alarms and control of respective systems under current project as specified in sequence of operations.

E. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. Schedules, setpoints, trends, and alarms specified in Section 4 Sequences of Operation shall be BACnet objects.

F. The web based system shall be accessible remotely through internet by anyone who has been granted access permission.

1.3 PRE-SUBMITTAL CONFERENCE

A. Control contractor shall arrange a meeting with the engineer and commissioning agent to review sequence of operation prior to submission to engineer to address questions and interpretations of the sequences and control specifications prior to shop drawing submission. Submissions done without prior meeting shall be returned **NOT REVIEWED**.

1.4 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.5 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 23 - Heating and cooling piping:

1. Control valves
2. Flowmeters
3. Flow switches
4. Press and temp sensor wells & sockets
5. Temp sensor wells and sockets

B. Section 23 - Duct accessories:

1. Airflow stations

2. Automated dampers

3. Terminal unit controls

1.6 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

B. None

1.7 PRODUCTS NOT FURNISHED OR INSTALLED BUT INTEGRATED WITH THE WORK OF THIS SECTION

A. General:

1. Coordination Meeting: The Installer furnishing the DDC network shall meet with the Installer(s) furnishing each of the following products to coordinate details of the interface between these products and the DDC network. The Owner or his designated representative shall be present at this meeting. Each Installer shall provide the Owner and all other Installers with details of the proposed interface including PICS for BACnet equipment, hardware and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories. The purpose of this meeting shall be to insure there are no unresolved issues regarding the integration of these products into the DDC network. Submittals for these products shall not be approved prior to the completion of this meeting.

B. Section 01 – Building Systems Commissioning 019113 for commissioning requirements that apply to this section.

C. Section 23 - Heat boilers and accessories:

1. Boiler controls: The boiler vendor shall furnish boilers with an interface to the control and monitoring points specified in Section 230993. These specified points shall be the minimum acceptable interface to the boiler. The connection to these points shall be by one of the following methods: (a) Hardwired connection such as relay, 0-10VDC, or 4-20mA. (b) BACnet/IP network connection. (c) BACnet over ARCNET network connection. (d) BACnet MS/TP network connection.

D. Section 23 - Refrigeration equipment:

1. Chiller controls: The chiller vendor shall furnish chillers with an interface to the control and monitoring points specified in Section 230993. These specified points shall be the minimum acceptable interface to the chiller. The connection to these points shall be by one of the following methods:(a) Hardwired connection such as relay, 0-10VDC, or 4-20mA. (b) BACnet/IP network connection. (c) BACnet over ARCNET network connection. (d) BACnet MS/TP network connection. (e) Lon Communication Card

E. Section 23 – Enclosed Controllers:

1. Variable frequency drives: The variable frequency drive (VFD) vendor shall furnish VFDs with an interface to the control and monitoring points specified in this section, Appendix A. These specified points shall be the minimum acceptable interface to the

VFD. The connection to these points shall be by one of the following methods: (a) Hardwired connection such as relay, 0-10VDC, or 4-20mA. (b) BACnet/IP network connection. (c) BACnet over ARCNET network connection. (d) BACnet MS/TP network connection.

F. Communications with Third Party Equipment:

1. Any additional integral control systems included with the products integrated with the work of this section shall be furnished with a BACnet interface for integration into the Direct Digital Control System described in this section.

1.8 APPROVED CONTROL SYSTEMS

A. The following are the **ONLY** approved control system suppliers, manufacturers, and product lines:

Manufacturer
Automated Logic Corporation

B. The specification as provided is written around Automated Logic.

C. Control systems shall comply with the terms of this specification.

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

1.9 QUALITY ASSURANCE

A. Installer and Manufacturer Qualifications

1. Installer shall have an established working relationship with Control System Manufacturer.

2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

1.10 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:

1. National Electric Code (NEC)

2. International Building Code (IBC)

   a. Section 719 Ducts and Air Transfer Openings
   b. Section 907 Fire Alarm and Detection Systems
   c. Section 909 Smoke Control Systems
   d. Chapter 28 Mechanical

3. International Mechanical Code (IMC)
4. ANSI/ASHRAE 135-2004: Data Communication Protocol for Building Automation and Control Systems (BACNET)

1.11 SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 15 sec.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.
9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C (±1°F)
Ducted Air	±0.5°C (±1°F)
Outside Air	±1.0°C (±2°F)
Dew Point	±1.5°C (±3°F)
Water Temperature	±0.5°C (±1°F)
Delta-T	±0.15°C (±0.25°F)

Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO_2)	±50 ppm

Note 1: Accuracy applies to 10% - 100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0-1.5 kPa (0-6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.5°C (±3°F)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1-150 psi) 0-12.5 kPa (0-50 in. w.g.) differential

1.12 SUBMITTALS

A. Product Submittal Requirements: Meet requirements of Section 01600 on Shop Drawings, Product Data, and Samples. Provide six copies of shop drawings and other submittals on hardware, software, and equipment to be installed or furnished. Begin no work until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2006 (or newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, .VSD, or comparable) and 3 prints of each drawing on 11" x 17" paper. When manufacturer's cutsheets apply to a product series rather than a specific product, clearly indicate applicable data by highlighting or by other means. Clearly reference covered specification and drawing on each submittal. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Provide submittals within 12 weeks of contract award on the following:

1. Direct Digital Control System Hardware

a. Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:

1) Direct digital controllers (controller panels)
2) Transducers and transmitters
3) Sensors (include accuracy data)
4) Actuators
5) Valves
6) Relays and switches
7) Control panels
8) Power supplies
9) Batteries
10) Operator interface equipment
11) Wiring

2. Wiring diagrams and layouts for each control panel. Show termination numbers.

a. Floor plan schematic diagrams indicating field sensor and controller locations.
b. Riser diagrams showing control network layout, communication protocol, and wire types.

3. Central System Hardware and Software

a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:

1) Central Processing Unit (CPU) or web server
2) Monitors
3) Keyboards
4) Power supplies
5) Battery backups
6) Interface equipment between CPU or server and control panels
7) Operating System software
8) Operator interface software
9) Color graphic software
10) Third-party software

c. Schematic diagrams of control, communication, and power wiring for central system installation. Show interface wiring to control system.
d. Network riser diagrams of wiring between central control unit and control panels.

4. Controlled Systems

a. Riser diagrams showing control network layout, communication protocol, and wire types.

b. Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.
c. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
d. Instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
e. Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system. List I/O points and software points specified in Section 230993. Indicate alarmed and trended points.

5. Description of process, report formats, and checklists to be used in Article 3.16 (Control System Demonstration and Acceptance).
6. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

B. Schedules

1. Schedule of work provided within one month of contract award, indicating:

a. Intended sequence of work items
b. Start date of each work item
c. Duration of each work item
d. Planned delivery dates for ordered material and equipment and expected lead times
e. Milestones indicating possible restraints on work by other trades or situations

2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

C. Project Record Documents. Submit three copies of record (as-built) documents upon completion of installation for approval prior to final completion. Submittal shall consist of:

1. Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2006 (or newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, .VSD, or comparable) and 6 prints of each drawing on 11" x 17" paper.
2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Article 3.16 (Control System Demonstration and Acceptance).
3. Operation and Maintenance (O&M) Manual. Printed, electronic, or online help documentation of the following:

a. As-built versions of submittal product data.
b. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
c. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
d. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
f. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
g. Graphic files, programs, and database on magnetic or optical media.
h. List of recommended spare parts with part numbers and suppliers.
i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
j. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
k. Licenses, guarantees, and warranty documents for equipment and systems.
l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

D. Training Materials: Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Owner's needs. Engineer will review and approve course outlines and materials at least three weeks before first class.

1.13 WARRANTY

A. Warrant work as follows:

1. Warrant labor and materials for specified control system free from defects for a period of 24 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.
2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
3. If Engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
4. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
5. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

1.14 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code
5. Documentation

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2004, BACnet.

B. Install new wiring and network devices as required to provide a complete and workable control network. Use existing Ethernet backbone for network segments marked "existing" on project drawings.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in Section 230993. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

E. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via

the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

F. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

G. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards specified by the Web Services Interoperability Organization (WS-I) Basic Profile 1.0 or higher. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.

1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
3. For read or write requests, the system shall require user name and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.
4. System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third party Web services device to read data from or write data to any object in the system which supports this service.

2.3 OPERATOR INTERFACE AND COMMUNICATIONS

A. The ATC operator interface software must operate and work be fully operated, integrated and fully accessible via the internet at the RVTS in Middletown, CT. Access and operation of the ATC must be seamless.

B. Communication. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135-2004, BACnet Annex J.

C. New BACnet router control units shall be installed in the School and communicate with the operator work station in the Board of Education Facility via Ethernet Network.

D. All digital controllers in the school shall be networked to the BACnet router control units through hardwired communications cable. Web based dynamic color graphics of all systems shall be provided at the operator station. Graphics shall include real point display and direct software communication for setpoint and program override. In addition a building graphic shall be provided with cursor blocks for access to respective systems.

E. Hardware. Each web based workstation shall consist of the following (Note this operator work station shall reside at the Board of Education and shall be provided under a separate contract):

1. Hardware Base. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified in

1.9. Hard disk shall have sufficient memory to store system software, one year of data for trended points specified in Appendix A, and a system database at least twice the size of the existing database at system acceptance. Configure computers and network connections if multiple computers are required to meet specified memory and performance. Web server or workstations shall be IBM-compatible PCs with a minimum of:

a. Intel Pentium 2.66 GHz processor
b. 2 GB RAM
c. 160 GB hard disk providing data at 100 MB/sec
d. 48x CD-ROM drive
e. Serial, parallel, and network communication ports and cables required for proper system operation

2. Laptop Computer: (Provide 1 Lab Top)
   a. Manufactures: Dell, HP or Toshiba
   b. 2.13 GHZ processor
   c. 1 GB Ram
   d. 120 GB Hard Drive
   e. 24 X CD Burner/ DVD Combo Drive
   f. Windows XP

F. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:

1. Log In and Log Out. System shall require user name and password to log in to operator interface.
2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.
4. View and Adjust Operating Schedules. Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.
5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.
6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.
8. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.
9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add

operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

G. System Software.

1. Operating System. Web server shall have an industry-standard professional-grade operating system. Acceptable systems include Microsoft Windows XP Pro, Red Hat Linux, or Sun Solaris.
2. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

    a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
    b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
    c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
    d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

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

1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
3. System Configuration. Operators shall be able to configure the system.
4. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.
5. Security. System shall require a user name and password to view, edit, add, or delete data.

    a. Operator Access. Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object. Authorized operators shall be able to vary and deny each operator's accessible functions based on equipment or geographic location.

b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).
7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Sequences of Operations. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.
8. Alarm Messages. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.
9. Alarm Reactions. Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall log, print, start programs, display messages, send e-mail, send page, and audibly annunciate. All are configurable and user selectable through central BMS station.
10. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.
11. Trend Configuration. Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in Sequences of Operation. Trends shall be BACnet trend objects.
12. Object and Property Status and Control. Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.
13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports. Furnish the following standard system reports:

    a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
    b. Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
    c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:

        1) Alarm History.
        2) Trend Data. Operator shall be able to select trends to be logged.
        3) Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

15. Graphics Generation. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.
16. Graphics Library. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.
17. Custom Application Programming. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

    a. Language. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
    b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
    c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
    d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.
    e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
    f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
    g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

        1) Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.
        2) System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

I. Portable Operator's Terminal. Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

J. BACnet. Web server or workstation shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Operator Workstation (B-OWS) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L.

2.4 CONTROLLER SOFTWARE

A. Building and energy management application software shall reside and operate in system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. System Security. See Paragraph 2.3.F.5 (Security) and Paragraph 2.3.F.15.c (Operator Activity).

C. Scheduling. See Paragraph 2.3.D.4 (View and Adjust Operating Schedules). System shall provide the following schedule options as a minimum:

1. Weekly. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
2. Exception. Operator shall be able to designate an exception schedule for each of the next 365 days. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week.
3. Holiday. Operator shall be able to define 24 special or holiday schedules of varying length on a scheduling calendar that repeats each year.

D. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

E. Binary and Analog Alarms. See Paragraph 2.3.F.7 (Alarm Processing).

F. Alarm Reporting. See Paragraph 2.3.F.9 (Alarm Reactions).

G. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

H. Duty Cycling:

1. Periodically start and stop loads based on space temperature and according to various On/Off patterns.
2. Modify off portion of cycle based on operator specified comfort parameters. Maintain total cycle time by increasing on portion of cycle by same amount that off portion is reduced.
3. Set and modify the following parameters for each individual load:

a. Minimum and maximum Off time

b. On/Off time in one minute increment.

c. Time period from beginning of interval until load can be cycled.

d. Manually override the DDC program and place a load in an On or Off state.

e. Cooling Target temperature and differential.

f. Heating Target temperature and differential.

g. Cycle off adjustment.

I. Maintenance Management. System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in Section 230993 (Sequences of Operation).

J. Sequencing. Application software shall sequence chillers, boilers, and pumps as specified in Section 230993 (Sequences of Operation).

K. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs.

L. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

M. Energy Calculations.

1. System shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data.
2. System shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

N. Anti-Short Cycling. Binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

O. On and Off Control with Differential. System shall provide direct- and reverse-acting on and off algorithms with adjustable differential to cycle a binary output based on a controlled variable and setpoint.

P. Runtime Totalization. System shall provide an algorithm that can totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in Sequence of Operations.

2.5 CONTROLLERS

A. General. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified in Article 1.9 (System Performance). Every device in

the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

B. BACnet.

1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
4. BACnet Communication.

    a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
    b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
    c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
    d. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
    e. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
    f. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication.

1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation. Each piece of equipment specified in Section 230993 shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

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

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

E. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

F. Serviceability.

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

G. Memory.

1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

H. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

I. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.6 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

C. Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

E. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs. Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

I. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.7 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

    a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
    b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering.

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

    a. Dielectric strength of 1000 V minimum
    b. Response time of 10 nanoseconds or less
    c. Transverse mode noise attenuation of 65 dB or greater
    d. Common mode noise attenuation of 150 dB or greater at 40-100 Hz

2.8 AUXILIARY CONTROL DEVICES

A. Motorized Control Dampers.

1. Type. Control dampers shall have linear flow characteristics and shall be parallel- or opposed-blade type as specified below or as scheduled on drawings.

    a. Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
    b. Other modulating dampers shall be opposed-blade.
    c. Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.

2. Frame. Damper frames shall be 16 gauge galvanized steel channel or (1/8 in. extruded aluminum with reinforced corner bracing.
3. Blades. Damper blades shall not exceed 8 in. in width or 48 in. in length. Blades shall be suitable for medium velocity (10 m/s [2000 fpm]) performance. Blades shall be not less than 16 gauge.
4. Shaft Bearings. Damper shaft bearings shall be oil impregnated sintered bronze.
5. Seals. Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 10 cfm per ft^2 at 4 in. w.g. differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 1500 fpm.
6. Sections. Damper sections shall not exceed 48 in. - 60 in.. Each section shall have at least one damper actuator.
7. Linkages and linkage bearings. Dampers shall have exposed linkages. Oil impregnated sintered bronze.

B. Electric Damper and Valve Actuators.

1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.
2. Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).
3. Signal and Range. Proportional actuators shall accept a 0-10 Vdc or a 0-20 mA control signal and shall have a 2-10 Vdc or 4-20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 2.6H.) Provide auxiliary end switch for position status as well as full potentiometer for monitoring of damper position over full range of motion for damper position indication and monitoring.
4. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
5. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 in.-lb torque capacity shall have a manual crank.

C. Control Valves.

1. Globe Valves NPS 2 and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.

2. Globe Valves NPS 2-1/2 and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.

3. Hydronic system globe valves shall have the following characteristics:

   a. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.

   b. Internal Construction: Replaceable plugs and seats of stainless steel or brass.

      1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

      2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.

   c. Sizing: 3-psig maximum pressure drop at design flow rate.

   d. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.

4. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

   a. Body Style: Lug.

   b. Disc Type: bronze.

   c. Sizing: 1-psig maximum pressure drop at design flow rate.

5. Terminal Unit Control Valves: Bronze body, bronze trim, two- or three-port as indicated, replaceable plugs and seats, union and threaded ends.

   a. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.

   b. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.

   c. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

6. Type. Provide two- or three-way control valves for two-position or modulating service as shown.

7. Water Valves.

   a. Valves providing two-position service shall be quick opening. Two-way valves shall have replaceable disc or ball.

   b. Close-off (Differential) Pressure Rating. Valve actuator and trim shall provide the following minimum close-off pressure ratings.

1) Two-way: 150% of total system (pump) head.
2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

c. Ports. Valves providing modulating service shall have equal percentage ports.
d. Sizing.

1) Two-position service: line size.
2) Two-way modulating service: select pressure drop equal to the greatest of twice the pressure drop through coil (load), 50% of the pressure difference between supply and return mains, or 35 kPa (5 psi).
3) Three-way modulating service: select pressure drop equal to the smaller of twice the pressure drop through the coil (load) or 35 kPa (5 psi).

e. Fail Position. Water valves shall fail normally open or closed as follows unless otherwise specified.

1) Water zone valves: normally open.
2) Heating coils in air handlers: normally open.
3) Chilled water control valves: normally closed.
4) Other applications: as scheduled or as required by sequences of operation.

D. Binary Temperature Devices.

1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, non mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
3. Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

E. Temperature Sensors.

1. Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.

2. Duct Sensors. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 5 ft in length per 10 ft^2 of duct cross-section.

3. Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.

4. Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port. Provide sensor only in public spaces.

5. Differential Sensors. Provide matched sensors for differential temperature measurement.

F. Humidity Sensors.

1. Duct and room sensors shall have a sensing range of 20%-80%.
2. Duct sensors shall have a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of 40°C-75°C (40°F-170°F).
4. Humidity sensors shall not drift more than 1% of full scale annually.

G. Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).

1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

H. Relays.

3. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

4. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

I. Override Timers.

1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

J. Current Transmitters.

1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

K. Current Transformers.

1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

L. Voltage Transmitters.

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.
2. Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

M. Voltage Transformers.

1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

N. Power Monitors.

1. Power monitors shall be three-phase type and shall have three-phase disconnect and shorting switch assembly, UL listed voltage transformers, and UL listed split-core current transformers.
2. Power monitors shall provide selectable output: rate pulse for kWh reading or 4-20 mA for kW reading. Power monitors shall operate with 5 A current inputs and maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

O. Current Switches.

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

P. Pressure Transducers.

1. Transducers shall have linear output signal and field-adjustable zero and span.
2. Continuous operating conditions of positive or negative pressure 50% greater than calibrated span shall not damage transducer sensing elements.
3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4-20 mA output, suitable mounting provisions, and block and bleed valves.
4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300 psi.) Transducer shall have 4-20 mA output, suitable mounting provisions, and 5-valve manifold.

Q. Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

R. Pressure-Electric (PE) Switches. PE switches shall be UL listed, pilot duty rated (125 VA minimum) or motor control rated, metal or neoprene diaphragm actuated, operating pressure rated for 0-175 kPa (0-25 psig), with calibrated scale minimum setpoint range of 14-125 kPa (2-18 psig).

1. Provide one- or two-stage switch action (SPDT, DPST, or DPDT) as required by application.
2. Switches shall be open type (panel-mounted). Exception: Switches shall be enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
3. Each pneumatic signal line to PE switches shall have permanent indicating gauge.

S. Local Control Panels.

1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.
2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.
3. Each local panel shall have a control power source power switch (on-off) with overcurrent protection.

T. Glycol Monitoring Sensor

1. MISCO M111 Inline Refractometer

U. Carbon Monoxide Detectors:

1. Single or multichannel dual level detectors using solid state sensors with three year minimum life. Temperature environment 23 to 130 degrees F.
2. Provide individual indicators and controllers for each level initially calibrated for 50 ppm and 100 ppm.
3. Maximum response time to 100 ppm CO calibration gas is 2 minutes.

V. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

W. Carbon-Dioxide Sensor and Transmitter: Single detectors, using solid-state infrared sensors, suitable over a temperature range of 23 to 130 deg F, calibrated for 0 to 2 percent, with continuous or averaged reading, 4 to 20 mA output.

2.9 AIRFLOW MONITORING STATIONS (where indicated on drawings)

A. Provide airflow/temperature measurement devices (ATMD) where indicated on the plans. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.

B. Manufactures EBTRON, Inc. Model GTx116-P and GTx116-F (basis of design Provide full 3 year warranty. Alternative manufactures Kurtz Industries or Siera Instruments.

C. Each ATMD shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

1. Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
2. Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.
3. The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.
4. The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.
5. Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.
6. Devices using chip-in-glass or diode-case chip thermistors are not acceptable.
7. Devices using less than two thermistors in each sensor assembly are not acceptable.
8. Devices using platinum wire RTDs are not acceptable.
9. Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.
10. Pitot tubes and arrays are not acceptable.
11. Vortex shedding devices are not acceptable.

D. All Sensor Probes

1. Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.
2. Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
3. Airflow accuracy shall be +/-2% of Reading over the entire operating airflow range.

    a. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
4. Temperature accuracy shall be +/-0.15° F over the entire operating temperature range of -20° F to 160° F.
5. The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
6. Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
7. Each sensor assembly shall not require matching to the transmitter in the field.
8. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.

E. Duct and Plenum Probes

1. Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.

2. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:

   a. Insertion mounted through the side or top of the duct
   b. Internally mounted inside the duct or plenum
   c. Standoff mounted inside the plenum

3. The number of sensor housings provided for each location shall be as follows:

Duct or plenum sq ft	Total # of sensors/location
<2	4
2 to < 4	6
4 to < 8	8
8 to <16	12
>=16	16

4. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

F. Fan Inlet Probes

1. Sensor assemblies shall be mounted on 304 stainless steel housings.
2. Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
3. Mounting feet shall be constructed of 304 stainless steel.
4. The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.

G. Transmitters

1. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.

2. The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.

3. The transmitter shall have a power switch and operate on 24 VAC (isolation not required).

   a. The transmitter shall use a switching power supply fused and protected from transients and power surges.

   b. The transmitter shall use "watch-dog" circuitry to assure reset after power disruption, transients and brown-outs.

4. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.

5. The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be installed at a location that is protected from weather and water.

6. The transmitter shall be capable of communicating with other devices using one of the following interface options:

   a. Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)

   b. RS-485: Field selectable BACnet-ARCNET, BACnet-MS/TP, Modbus-RTU

   c. BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.

   d. 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, Modbus-TCP and TCP/IP

   e. Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a Windows 2000 or Windows XP based PC.

   f. LonWorks Free Topology

7. The transmitter shall be capable of accepting an infra-red interface card for downloading airflow and temperature data or uploading transmitter configuration data using a handheld PDA (Palm or Microsoft Windows Mobile operating systems).

   a. Provide PDA upload/download software. Download software shall be capable of displaying and saving individual sensor airflow rates, the average airflow rate, individual sensor temperatures and the average temperature received from the transmitter. . Upload software shall be capable of displaying and saving all setup parameters that can be configured using the on-board pushbutton interface and LCD display.
   b. Provide a Microsoft Excel file capable of creating balance reports from PDA data files transferred to a Windows 98 or higher based PC.
   c. Provide a Microsoft Excel file to create configuration data files that can be transferred from a Windows 2000, Windows XP or higher based PC to a PDA for upload to one or more transmitters.

H. The ATMD shall be UL listed as an entire assembly.

I. The ATMD shall carry the CE Mark for European Union shipments.

J. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.

2.10 WIRING AND RACEWAYS

A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

2.11 FIBER OPTIC CABLE SYSTEM

A. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.

B. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Architect or Engineer for resolution before starting rough-in work.

B. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.

C. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate of this sectionand with work of others. Controls Contractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

3.2 PROTECTION

A. Controls Contractor shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.

B. Controls Contractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

A. Site.

1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Contractor shall correct conditions without extra charge.

2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Submittals. See Article 1.10 (Submittals).

C. Test and Balance.

1. Provide Test and Balance Contractor a single set of necessary tools to interface to control system for testing and balancing.
2. Train Test and Balance Contractor to use control system interface tools.
3. Provide a qualified technician to assist with testing and balancing the first 20 terminal units.
4. Test and Balance Contractor shall return tools undamaged and in working condition at completion of testing and balancing.

D. Life Safety.

1. Duct smoke detectors required for air handler shutdown are provided under Division 26. Interlock smoke detectors to air handlers for shutdown as specified in Section 230993 (Sequences of Operation).
2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in Section 230993 (Sequences of Operation).
3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 26 unless otherwise specified.

E. Coordination with Other Controls. Integrate with and coordinate controls and control devices furnished or installed by others as follows.

1. Communication media and equipment shall be provided as specified in Article 2.2 (Communication).
2. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation described in Section 230993 regardless of where within the contract documents those products are described.
3. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
4. Controls Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

3.4 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

B. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

D. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

E. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

3.5 FIELD QUALITY CONTROL

A. Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances as identified in Article 1.8 (Codes and Standards).

B. Continually monitor field installation for code compliance and workmanship quality.

C. Contractor shall arrange for work inspection by local or state authorities having jurisdiction over the work.

3.6 WIRING

A. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26, and manufacturer's recommendations. Where the requirements of this section differ from Division 26, This section shall take precedence.

B. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC and Division 26.

C. Low-voltage wiring shall meet NEC Class 2 requirements. Subfuse low-voltage power circuits as required to meet Class 2 current limit.

D. NEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.

E. Install wiring in raceway where subject to mechanical damage and at levels below 3 m (10ft) in mechanical, electrical, or service rooms.

F. Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

G. Do not install wiring in raceway containing tubing.

H. Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 3 m (10 ft) intervals.

I. Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

J. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

K. Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

L. Include one pull string in each raceway 2.5 cm (1 in.) or larger.

M. Use color-coded conductors throughout.

N. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

O. Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 15 cm (6 in.) between raceway and high-temperature equipment such as steam pipes or flues.

P. Adhere to requirements in Division 26 where raceway crosses building expansion joints.

Q. Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

R. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

S. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.

T. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

3.7 COMMUNICATION WIRING

A. Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 3.7 (Wiring).

B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

C. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

D. Verify entire network's integrity following cable installation using appropriate tests for each cable.

E. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

F. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

G. Label communication wiring to indicate origination and destination.

H. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.8 FIBER OPTIC CABLE

A. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.

B. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

3.9 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

D. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

E. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

F. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 3 m (1 ft) of sensing element for each 1 m^2 (1 ft^2) of coil area.

G. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall at designated location with sun shield.

I. Differential Air Static Pressure.

1. Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
3. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.

4. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.
5. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.
6. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

J. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.10 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer's instructions.

3.11 ACTUATORS

A. General. Mount actuators and adapters according to manufacturer's recommendations.

B. Electric and Electronic Damper Actuators. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation. Link actuators according to manufacturer's recommendations.

1. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
2. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, then tighten linkage.
3. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
4. Provide necessary mounting hardware and linkages for actuator installation.

C. Valve Actuators. Connect actuators to valves with adapters approved by actuator manufacturer.

3.12 WARNING LABELS

A. Affix permanent warning labels to equipment that can be automatically started by the control system.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

C A U T I O N
This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

B. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

CAUTION
This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.13 IDENTIFICATION OF HARDWARE AND WIRING

A. Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 5 cm (2 in.) of termination.

B. Label pneumatic tubing at each end within 5 cm (2 in.) of termination with a descriptive identifier.

C. Permanently label or code each point of field terminal strips to show instrument or item served.

D. Label control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

E. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.

F. Label room sensors related to terminal boxes or valves with nameplates.

G. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

H. Label identifiers shall match record documents.

3.14 PROGRAMMING

A. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. See Sequences of Operation. If character limitations or space restrictions make it advisable to shorten the name, the abbreviations given in Appendix C may be used. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

B. Software Programming. Programming shall provide actions for each possible situation. Graphic- or parameter-based programs shall be documented. Text-based programs shall be modular, structured, and commented to clearly describe each section of the program.

1. Application Programming. Provide application programming that adheres to sequences of operation specified in Section 230993. Program documentation or comment statements shall reflect language used in sequences of operation.
2. System Programming. Provide system programming necessary for system operation.

C. Operator Interface.

1. Standard Graphics. Provide graphics as specified in Article 2.3 Paragraph E.2 (System Graphics). Show on each equipment graphic input and output points and relevant calculated points such as indicated on the applicable Points List in Section 230993. Point information on graphics shall dynamically update.
2. Install, initialize, start up, and troubleshoot operator interface software and functions (including operating system software, operator interface database, and third-party software installation and integration required for successful operator interface operation) as described in Section this section.

3.15 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing.

1. Calibrate and prepare for service each instrument, control, and accessory equipment furnished under this section.
2. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
3. Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
4. Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
5. Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
6. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.
7. Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
8. Alarms and Interlocks.

    a. Check each alarm with an appropriate signal at a value that will trip the alarm.
    b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
    c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

3.16 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration. Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified in Article 3.17 (Control System Checkout and Testing). Provide Engineer with log documenting completion of startup tests.

1. Engineer will be present to observe and review system demonstration. Notify Engineer at least 10 days before system demonstration begins.

2. Demonstration shall follow process submitted and approved under Article 1.10 (Submittals). Complete approved checklists and forms for each system as part of system demonstration.
3. Demonstrate actual field operation of each sequence of operation as specified. Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
4. Demonstrate compliance with Part 1 (System Performance).
5. Demonstrate compliance with sequences of operation through each operational mode.
6. Demonstrate complete operation of operator interface.
7. Demonstrate each of the following.

    a. DDC loop response. Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
    b. Building fire alarm system interface.
    c. Trend logs for each system. Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs as specified in Article 2.3 Paragraph E.11 (Trend Configuration).

8. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

B. Acceptance.

1. After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.
2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required in Article 1.10 (Submittals).

3.17 CLEANING

A. Each day clean up debris resulting from work. Remove packaging material as soon as its contents have been removed. Collect waste and place in designated location.

B. On completion of work in each area, clean work debris and equipment. Keep areas free from dust, dirt, and debris.

C. On completion of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

3.18 TRAINING

A. Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods. Provide a total of 40 hours of training and additional adjustments. The 40 hours includes the three 4 hour class schedules. Additional class schedules if needed may be scheduled within the 40 hour training time if necessary.

B. Training shall enable students to accomplish the following objectives.

1. Proficiently operate system
2. Understand control system architecture and configuration
3. Understand DDC system components
4. Understand system operation, including DDC system control and optimizing routines (algorithms)
5. Operate workstation and peripherals
6. Log on and off system
7. Access graphics, point reports, and logs
8. Adjust and change system setpoints, time schedules, and holiday schedules
9. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
10. Understand system drawings and Operation and Maintenance manual
11. Understand job layout and location of control components
12. Access data from DDC controllers
13. Operate portable operator's terminals
14. Create and change system graphics
15. Create, delete, and modify alarms, including configuring alarm reactions
16. Create, delete, and modify point trend logs (graphs) and multi-point trend graphs
17. Configure and run reports
18. Add, remove, and modify system's physical points
19. Create, modify, and delete application programming
20. Add operator interface stations
21. Add a new controller to system
22. Download firmware and advanced applications programming to a controller
23. Configure and calibrate I/O points
24. Maintain software and prepare backups
25. Interface with job-specific, third-party operator software
26. Add new users and understand password security procedures

C. Divide presentation of objectives into three 4 hour sessions (1-13, 14-23, and 24-26). Participants will attend one or more of sessions, depending on knowledge level required.

1. Day-to-day Operators (objectives 1-13)
2. Advanced Operators (objectives 1-13 and 14-23)
3. System Managers and Administrators (objectives 1-13 and 24-26)

D. Provide course outline and materials according to Article 1.10 (Submittals). Provide one copy of training material per student.

E. Instructors shall be factory-trained and experienced in presenting this material.

F. Perform classroom training using a network of working controllers representative of installed hardware.

3.19 WORK RELATING TO CONTROLS AND INSTRUMENTS

A. Under Sections 230900 as applicable, provide control wiring for the following:

1. All circuits actuated by a temperature control system component.
2. All circuits which actuate a temperature control component.
3. All control panel wiring to terminal strips and field wiring from terminal strips to field mounted devices.
4. All wiring from the "AUTO" side of hand-off-auto switches on units being controlled by Sections 230900.
5. Wiring of electro-mechanical devices required to be located on or in temperature control panels.
6. Wiring of DDC trunk, communication, and sensor cable wiring.
7. Wiring shall comply with material and workmanship standards of Division 26.
8. Wiring of damper and valve actuators, VAV box actuators, relays, transformers, PE switches and all other control apparatus.
9. All 120 volt power wiring to vav boxes, damper actuators, line voltage thermostats, valve actuators, relay's, etc. not powered by 24 volt power is work of this division. Wiring shall comply with material and workmanship standards of Division 26. Obtain 120 volt from local electrical panels or junction box. Coordinate with Division 26 contractor.
10. Wiring of line voltage fan isolation dampers located within fan curbs regardless of voltage in order to achieve specified sequence of operations.
11. Smoke detectors installed at transfer ducts to close associated dampers.

B. Under Division 26, perform the following work under supervision of Sections 230900:

1. Wiring of all devices and circuits carrying voltages greater than 110 volts unless otherwise noted.
2. Wiring of line and load power feeds to all disconnects, starters, and electric motors.
3. Wiring of 115 volt power feeds to all temperature control panels.
4. Power wiring to all motors 110 volt to 480 volt unless otherwise noted.
5. Furnish smoke detectors for mounting in ducts used for shutting down of air handling equipment. Smoke detectors installed at transfer ducts shall be provided by temperature control contractor.
6. Specific power feeds shown or specified in Div 26 documents.

PART 4 - SEQUENCE OF OPERATIONS

4.1 SEQUENCE OF OPERATIONS – GENERAL

A. General: Provide all required control devices, hardware and software to achieve the specified sequences of operation as outlined in these specifications and as detailed on drawings whether

indicated and/or implied. Refer to drawing for general I/O points. All points may not be listed and are indicated for general description.

B. BAS shall monitor and report all control function alarm points.

C. BAS shall monitor and report status of all equipment for use in sequence of operations, trending, verification. BAS shall also monitor valves and damper position as indicated.

D. All safeties shall operate whether the starters or VFD's are in the hand or automatic mode.

4.2 SEQUENCE OF OPERATIONS – SAFETIES

A. Supply and/or return duct mounted smoke detectors upon sensing products of combustion or a signal received from central fire alarm system shall shut down the air handling systems above 2000 cfm. Reset of smoke detector initiation shall be manual. Initiate an alarm upon shut down via duct smoke detector.

B. Upon building wide shutdown of air handling units from central fire alarm system, after the fire alarm is reset to normal mode, BAS shall automatically stage the re-start up of air handling units to eliminate simultaneous starting .

C. Freeze protection sensor element (Provide not less than one sensor for each 8 sq. ft. of coil face) located on the leaving side of the heating hot water coil shall de-energize the air handling unit, open HWS valve to control to setback casing temperure control and initiate an alarm if temperature on the leaving side of the coil drops below 38 deg. F. Reset shall be manual.

D. During unoccupied periods sensor located downstream of hot water coil or missed air sensor upstream of coil if sensor not located downstream shall modulate hot water control valve to maintain unit casing temperature above 40°F.

E. Duct mounted smoke dampers or combination fire smoke dampers shall only close upon activation of a duct mounted smoke detector or signal from central fire alarm panel to BAS. Dampers shall be reopened after a fire alarm system is reset to normal mode by BAS. Provide end switch to verify damper position. Provide and alarm if damper position is not in the open position while building fire alarm system is in normal safe mode.

F. Supply and return duct mounted high limit pressure sensors shall shut down both supply and return fans if discharge or inlet static pressures exceed pressure classification ratings of the ductwork or fans and an alarm generated at the BAS.

4.3 SEQUENCE OF OPERATIONS – CONTROL OF OUTSIDE AIR GENERAL

A. Outside air is controlled to satisfy whichever of the following predominates:

1. A minimum of 10% of rated total air volume. (Note 10% value is absolute minimum and shall be adjusted accordingly to ensure building maintains a slight positive pressure. Low end value shall not allow building to go neutral pressure).
2. The outside air volume required to satisfy the economizer cycle.
3. The outside air volume required to MAINTAIN a CO2 differential as described below.
4. OA intake will be limited to a maximum of the "design OA cfm" which is shown in the Schedule of Air Handling Units. This limit is not applicable to the economizer cycle.
5. Global outside CO2 sensor is required.

6. Outside air shall be measured by either airflow station or calculated using percent outside air routine utilizing supply, return airflow stations.

4.4 SEQUENCE OF OPERATIONS – OPTIMUM START

A. Each air handling system start up sequence shall include an optimal start routine. BAS shall trend time frame, based on outdoor and indoor conditions, it takes respective systems to achieve warmup/cooldown temperature setpoints. BAS shall automatically adjust startup schedules to achieve warmup/cooldown setpoints based on trended data.

4.5 SEQUENCE OF OPERATIONS – NIGHT SETBACK

A. BAS shall reset all space temperature during occupied area to the following schedule:

1. All spaces except telecommunication closets and elevator machine rooms: 55˚F (adj)
2. If any space shall drop below setback temperature respective systems shall energize and remain in operation until space temperature rises 3˚F (adj) above setback setpoint.

4.6 SEQUENCE OF OPERATION – CARBON DIOXIDE CONTROL GENERAL

A. BAS shall monitor return air CO2 sensor and modulate outside air dampers from units 10% minimum to maximum minimum scheduled. CO2 control shall be overridden during economizer.

B. Initially set the return CO2 sensors for 350 ppm above outside ambient readings.

C. If BAS fail to read a signal from the CO2 sensors or the sensor fails then the units outside air dampers shall open to scheduled minimum and an alarm shall be generated.

4.7 SEQUENCE OF OPERATION – ENTHALPY ECONOMIZER

A. Provide each air handling unit with an enthalpy controlled economizer unless otherwise noted. When outside air enthalpy is less than return air enthalpy outside air shall dampers shall be full open, return air closed and relief dampers open. Sequence chilled water valve as necessary to maintain discharge air setpoint or space setpoint.

4.8 SEQUENCE OF OPERATION – VFD STATUS

A. BAS system shall monitor all VFD alarms, associated motor speeds and report alarms.

4.9 SEQUENCE OF OPERATIONS – COMBUSTION AIR (SAF-1)

A. Upon call for the any boiler to start the combustion air fan motorized damper shall open and after proven open (SAF-1) shall be energized through manufacturers variable speed controller/panel to maintain a slight positive pressure. Refer to spec section 235113.14 for additional requirements. After flow has been proven then either appliance shall be enabled to start. If flow is not proven an alarm shall be generated and the heating appliances shall be locked out and an alarm generated.

4.10 SEQUENCE OF OPERATIONS – DOMESTIC HOT WATER COMBUSTION AIR (IP-3)

A. Upon a call for either domestic hot water heater to operate, open high and low combustion air dampers and after verification enable water heaters to fire. If damper status is not proven an alarm shall be generated and the heating appliances shall be locked out and an alarm generated

B. If temperatures in boiler room exceed setpoint open both high and low dampers to allow room gravity ventilation. If space setpoint satisfied then dampers shall be closed and under control on domestic hot water heater combustion air command.

4.11 SEQUENCE OF OPERATIONS – HEATING SYSTEM (B-1, B-2 AND B-3)

A. Heat Timer Multi Mod Modulation Panel shall control boiler operation. Refer to Specification section 235223 "Cast Iron Boilers". BMS will monitor alarms and initiate systems to start. BAS contractor to provide all integrated control wiring.

B. BAS shall initiate the heating system operation based on outside air temperature dropping below 60°F temperature (adjustable) and at least one floor space sensor calling for heating. Upon call for heating system to start, BAS shall start lead secondary system pump, start combustion air fans and after fan verified, primary hot water pump HWP-1, 2 or 3 shall start and the lead boiler B-1, B-2 or B-3 shall be initiated through the Heat Timer panel to fire. Lead boiler shall fire only after combustion air operation is proven. If combustion air system is not proven then an alarm shall be generated and boiler shall be unable to fire.

C. Prior to firing of either boiler, corresponding primary pump shall start with 3-way modulating valve open to boiler and bypassing secondary piping. Boiler HWR sensor shall modulate 3-way valve to maintain a minimum of 140 deg F HWR temp to the boiler at all times. If HWR temp is satisfied, boiler controller shall sequence firing rates to maintain secondary HWS temp based on reset schedule.

D. After shutdown of lead or lag boiler, corresponding primary pump shall continue to run with 3-way valve under control of return sensor. If outside temperature rises above 60 deg f, shutdown boiler and allow primary pump to run for an adjustable time period (5 minutes initially) to dissipate heat in boiler prior to pump shut down.

E. If either secondary pump or lead boiler does not energize the stand-by pump or lag boiler shall be initiated on and an alarm generated. If load is less than one boiler the lag boiler and primary pump shall be off.

F. Hot water pump VFD shall slowly ramp up the primary pump until system pressure set point is satisfied with pressure differential bypass valves open. The pressure differential by-pass control valves shall modulate to maintain loop pressure and minimum of 20% flow as verified by common supply pipe flow meter. As loop pressure decreases the bypass valve shall modulate closed prior to increasing pump speed while maintaining minimum flow. Further decrease in system pressure when bypass valve is approx 90 % closed increase hot water pump speed. Reverse order upon system pressure increase.

G. Hot water supply temperature shall be reset by the following schedule: 180 degree F HWS @ 10 degree F outside temperature and 140 degree F HWS @ 65 degree outside temperature. Boiler hot water setpoint shall remain constant at 180 degree F.

H. Based on a user defined schedule the lead/lag boilers and secondary/stand by pump shall be rotated to equalize run time.

I. Lead boiler shall start at low fire. Heat Timer Controller will modulate boiler based on system hot water temperature. When lead boiler reaches 80% load, initiate lag boiler to start sequence. Both boilers shall modulate at same load to meet hot water supply temperature setpoint. Upon decrease in load and each boiler load has modulated to 30% or less, de-energize lag boiler. Lead boiler will modulate to satisfy load.

J. In the event of an emergency, boilers shall be shut down through wall mounted breakglass stations.

4.12 SEQUENCE OF OPERATIONS – BOILER FUEL OIL PUMP

A. Boilers normally operate on natural gas. Fuel oil pumps shall be turned manually when required to switch to oil from gas. BAS to monitor runtimes and alarms.

4.13 SEQUENCE OF OPERATIONS – BOILER ROOM CO CONTROL

A. Space mounted CO sensor shall shut down boilers and domestic hot water heaters and start local exhaust fan (GX-18) if levels of CO rise above acceptable levels and a visual and audible alarm generated. Locate alarms in the corridor above the boiler room door.

4.14 SEQUENCE OF OPERATIONS – CHILLED WATER SYSTEM

A. Chilled water system shall be enabled on through the BAS system when the outside temperature rises above 55 degree F, at least one space calling for cooling and the air handling units are not operating in the dry bulb economizer mode. BAS shall monitor and report chiller alarms.

B. The system is configured with a variable primary pump and one standby pump configuration. Upon a call for the chilled water system to start, pressure differential bypass valve shall open, after position verified the lead pump (CHP-1 or CHP-2) shall be started and remain under control of pump variable frequency controller to maintain system pressure setpoint. VFD shall slowly ramp up pump speed to satisfy the higher of two differential pressure sensor setpoint in piping. The chiller (CH-1) shall be enabled after chilled water flow is verified by chilled water flow switch and shall operate under own controls to maintain CHS temperature (44°F adj.). BAS system shall monitor status. If either the pumps or chiller fail to start, an alarm shall be generated. Switching to the standby pump shall be automatic.

C. The pressure differential by-pass control valves shall modulate to maintain loop pressure and minimum flow of 560 gpm as verified by common supply pipe flow meter with chiller operating. As loop pressure decreases the bypass valve shall modulate closed prior to increasing pump speed while maintaining minimum chiller flow. Further decrease in system pressure when bypass valve is approx 90 % close increase chilled water pump speed. Reverse order upon system pressure increase.

D. CH-1 packaged heat trace controls shall maintain chiller evaporator at temperatures to prevent freezing. BAS shall monitor current to control circuit and report an alarm on loss of current if temperatures outside are below 35˚F.

E. Outside temperature below 15 degrees F shall turn on lead chilled water pump to circulate chilled water at minimum flow for additional freeze protection. Pump shall be off above 15 degrees if not required to run under normal conditions.

F. Upon system shutdown of all air handling units based on occupancy schedule, delay closing of chilled water valve to allow differential system to stabilize prior to shutting down chiller and pumps.

4.15 SEQUENCE OF OPERATIONS – VARIABLE AIR VOLUME AIR HANDLING UNITS (AHU-1, 4, 6A, 6B, 7, 8, 9, 10)

A. When supply fan is shut down, relief fan is shut down, the outside and relief/spill dampers are shut tight, heating coil valve is controlled by air sensors immediately downstream of coil. (Provide not less than one sensor for each 8 sq. ft. of coil face). Upon a signal from the BAS system to start the return damper shall open with relief and outside air damper at full closed, start supply air fans. Fans shall be controlled under specific mode of operation.

B. Hours of operation will be set at the building's central panel. Modes of operation will be:

1. Unoccupied cooling.
2. Unoccupied heating.
3. Cooldown or Warmup.
4. Occupied summer.
5. Occupied winter.

C. Unoccupied cooling (ambient temperature above 55 F)

1. Outdoor air dampers are closed, fans are stopped. Cooling and heating coil valves are shut.

D. Unoccupied heating (ambient temperature below 55 F)

1. Outside air dampers are closed. Fans are off. Cooling coil valves are shut. Heating coil valves are under control of sensors immediately downstream of coils shall modulate to maintain minimum inside casing temperature of 45 degrees F. When room temperature drops to 55 degrees F, radiant panels shall be first stage for heating and if further drop in space temp initiate warmup cycle (as described below) is actuated. When space temperature rises to 65 degrees F, warmup terminates and fan stops.

E. Cooldown or Warmup (Optimal schedule)

1. Prior to occupied operation (adjustable lead time), the supply fan starts, relief fan is off, and run with outside dampers shut, and under duct pressure control. After a 3 minute run time, the system reverts to a cooldown or warmup mode, depending upon temperature of return air.
2. If return air temperature is above 80, cooldown commences. OA dampers are shut. Exhaust fans are off. Chilled water valve is modulated under control of return air temperature. Normal occupied cooling resumes after average room air temperature comes down to 75 degrees F.
3. If return air temperature is below 68 F, warmup commences. Return air sensor and/or average space temperature modulates the hot water control valve, subject to a high limit of 85 F discharge air temp. Warmup terminates when average space temperature has remained above 72 deg F for a preset time period (try 30 minutes initially). Adjust the time delay as needed to allow for thermal capacitance of building construction materials.
4. After cooldown or warmup is complete, open outside air damper to specified position. Relief fan shall be under control s described below.

F. Occupied Summer (ambient temperature above 55 degrees)

1. Temperature sensor immediately downstream of chilled water coil, as reset by a return air sensor and remote zone calling, through its controller (vav air handling units), shall control sequencing of chilled water coil control valve, (occupied mode) in response to air handling unit discharge temperature. Controller shall employ a dynamic self tuning algorithm.

G. Occupied Winter (ambient temperature below 55 degrees F)

1. The fan discharge sensor modulates variable outside air dampers and heating coil control valve in sequence (with dead band between). Provide independent low limit controllers immediately downstream of heating coils, set at 45 degrees.

H. Occupied Heating or Cooling

1. Associated exhaust fans per HV unit shall be energized to run through the BAS system only when the building is in the occupied mode per the following schedule:

AIR HANDLING UNIT	EXHAUST FANS
AHU-1	TX-3, 4
AHU-4	TX-3
AHU-6A,	TX-2
AHU-6B	TX-1
AHU-7	TX-10, 11
AHU-8	TX-5, 6, 8, 9
AHU-9	TX-8
AHU-10	TX-19, 20

I. VAV Zone Control

1. A room temperature sensor sequences the radiation or radiant panel control valve (if exists), the reheat coil, and the air valve.
2. VAV air volume controller will have a maximum CFM and minimum CFM adjustment. Adjust maximum and minimum CFM to the cfm shown on the drawings.
3. For each reheat coil, provide a HW control valve and modulate it in sequence with the VAV damper.
4. During warmup, position VAV damper to maximum CFM with reheat valve closed.
5. Room temperature set points, operating temperature, air volume and status will be monitored at the central panel. Set points will be remotely adjustable.
6. Refer to additional vav/radiant control below.

J. Provide Freezestat controls in each unit, as described in the general descriptions.

K. Supply Fan volume control.

1. A static pressure pickup sensor in the supply duct, referenced to outside air, located approximately two thirds down the main supply duct will, through a controller with P-I-D control algorithm, modulate a variable frequency fan speed controller, to maintain the static pressure setting. Provide a high limit pressure sensor with two setpoints. One setpoint to alarm above-normal pressures, the second setpoint, set higher, to shut the fan down.
2. BAS shall monitor return fan airflow to verify cfm offset as described above.

L. Control of air dampers and relief:

1. Interconnect the outside air (OA) and return air (RA) dampers so that when OA damper opens, the RA damper closes. Control these dampers in the manner described, to regulate outside air intake.
2. Control the relief damper and fan independently via a static pressure sensor to maintain a slight building positive pressure with in the respective building zone. Upon a rise in building pressure vary speed of relief fan to maintain setpoint. Relief fan shall be off when not needed to maintain building pressure. Do not hold at minimum speed.
3. BAS system shall monitor position of duct mounted smoke dampers and indicate an alarm if damper fails to open or close.

M. HRU-1 AND HRU-2 shall be interlocked to operate with respective AHU's under occupied schedules.

4.16 SEQUENCE OF OPERATIONS – VARIABLE TEMPERATURE CONSTANT VOLUME AIR HANDLING UNITS (FAN COIL UNITS FC-9 through 16 and AHU-2)

A. This unit controls a single zone by varying supply air temperature.

B. When supply fan is shut down, outside dampers are shut tight, heating coil valve is controlled by air sensors immediately downstream of coil. (Provide a sensor for each coil section).

C. Hours of operation will be set at the building central panel. Modes of operation will be:

1. Unoccupied cooling.
2. Unoccupied heating.
3. Cooldown.
4. Warmup.
5. Occupied summer.
6. Occupied winter.

D. Unoccupied cooling (ambient temperature above 55 degrees F):

1. Outdoor air dampers are closed, fan is stopped. Cooling and heating coil valves are closed.

E. Unoccupied heating (ambient temperature below 55 degrees F)

1. Outside air dampers are closed. Fan is off. Cooling coil valves are shut. Heating coil valves remain under control of sensors immediately downstream of coils. When room temperature drops to 55 degrees F, warmup cycle (as described below) is actuated. When space temperature rises 10 degrees F, warmup terminates and fan stops.

F. Cooldown or Warmup Modes (Optimal start schedule)

1. Upon startup, the AH unit first goes through a cooldown or warmup mode. The supply fan shall start and run with outside dampers shut. After a 3 minute time delay, the system goes into a cooldown or warmup mode, depending upon temperature of return air.
2. Return air temperature above 80 degrees F, cooldown commences. Chilled water valve modulates under control of room air temperature. Normal occupied cooling resumes after room air temperature comes down to 75 degrees F.
3. Return air temperature below 68 degrees F warmup commences. Air discharge temperature is controlled by room temperature, subject to a maximum of 85 degrees F. Warmup terminates when room temperature has increased to 72 degrees F, subject to time delay as described below, before reverting to normal operation.
4. Provide an adjustable time delay to hold the system in warmup after reaching 72 F, for a preset time, before reverting to normal occupied mode. Adjust this delay based on observed need for thermal stability.

G. Occupied Summer (ambient temperature above 55 degrees F)

1. A space temperature signal will modulate the cooling coil valve to maintain space setpoint. Discharge temperature sensor will prevent supply air temperature from dropping below preset miminum. Controller shall have P-I-D control algorithm.
2. Outside dampers shall be as item 4 above subject to a maximum limit OA cfm shown in the AHU schedule under "OA." Relief air dampers will be controlled by gravity weighted damper.

H. Occupied Winter (ambient temperature below 55 degrees F)

1. Space sensor shall sequence heating coil control valve and outside air dampers to maintain space temperature. Outside dampers shall be as item 4 above subject to a maximum limit OA cfm shown in the AHU schedule under "OA." Relief air dampers will be controlled by gravity weighted damper.
2. Provide independent low limit controllers immediately downstream of heating coils, set at 45 degrees.

I. Provide Freezestat controls in each unit, as described in the general descriptions.

J. When FCU-9 to 16 are in economizer mode, gravity damper connected to relief outlet on return duct shall open to direct relief air into the main shop areas.

K. FCU-10 is in economizer mode sequence outside air, return air and relief air dampers to maintain a slight negative in electronics with respect to ambient.

L. Units with condensate pumps shall be connected into condensate pump safety switch to deenergize fan coil and close chilled water valve upon high condensate level in condensate pump.

M. When AHU-2 is in economizer mode, gravity damper connected to relief outlet on return duct shall open to direct relief air to exterior of building.

4.17 SEQUENCE OF OPERATIONS – VARIABLE TEMPERATURE/VARIABLE FLOW AIR HANDLING UNITS (HV-6A, 6B)

A. This unit controls a single zone by varying supply air temperature and varying outside air to maintain minimum pressure differential between space and corridor of -.03 in.wc. Units can operate independently or if operating at same time shall sequence together to maintain static pressure offset..

B. When supply fan is shut down, exhaust fan is de-energized, outside and relief dampers are shut tight, heating coil valve is controlled by air sensors immediately downstream of coil. (Provide a sensor for each coil section).

C. Supply fan shall be variable based on maintaining space pressure differential offset.

D. Hours of operation will be set at the building central panel. Modes of operation will be:

1. Unoccupied heating.
2. Occupied summer.
3. Occupied winter.

E. Unoccupied heating (ambient temperature below 55 degrees F)

1. Outside air dampers and exhaust dampers closed and fans are off. Heating coils valves operate as described above. Heating coil valves remain under control of sensors immediately downstream of coils.

2. When room temperature drops to 55 degrees F, and space unit heaters shall cycle to maintain space temperature. When space temperature rises 10 degrees F, unit haters shall be off.

F. Occupied Summer (ambient temperature above 70 degrees F)

1. Outside air damper shall open, heat exchanger bypass damper closed and supply fan shall start at 50% speed after outside air damper proven open. Exhaust fan shall be energized on after exhaust damper opens and speed shall vary to maintain space pressure differential offset.

2. As additional exhaust fans or units are energized unit exhaust fan shall reduce speed and eventually shut down. If space static cannot be maintained, is in excess of setpoint or space temperature continues to rise increase supply fan incrementally to 100% speed to allow more outside air.

3. As static pressure varies depending on space exhaust and space temperature is still above setpoint stage on unit exhaust fan to maintain setpoint.

4. Whenever associated exhaust fan GX-51 is running, respective units outside air dampers shall go full open to maintain while still under control of space pressure differential offset.

5. If outside air temperature is above return air temperature, close outside air to heat recovery coil and open bypass damper.

G. Occupied Winter (ambient temperature below 70 degrees F)

1. Outside air damper shall open, heat exchanger bypass damper closed and supply fan shall start at 50% speed after outside air damper proven open. Exhaust fan shall be energized on after exhaust damper opens and speed shall vary to maintain space pressure differential offset.

2. As additional exhaust fans or units are energized unit exhaust fan shall reduce speed and eventually shut down. If space static cannot be maintained, is in excess of setpoint or space temperature continues to rise increase supply fan incrementally to 100% speed to allow more outside air.

3. As static pressure varies depending on space exhausts stage on unit exhaust fan to maintain setpoint.

4. Drop in space sensor below setpoint shall sequence heating coil control valve, to maintain space temperature.

5. Outside air bypass dampers shall modulate based on heat exchanger exhaust air temperature to ensure unit leaving exhaust temp stays above 34 degrees F to prevent heat exchanger frosting if exhaust fan is operating.

6. Cold start up with outside air temperature below freeze stat setting of 38 degrees F, prior to starting of unit open hot water valve to flow water in coil to prevent nuisance freeze stat tripping while slowly ramping up speed of fan. Once system stabilize return hot water coil control to normal.

H. Provide Freezestat controls in each unit, as described in the general descriptions.

I. Fan speed control

1. Supply fans shall start at low speed and shall operate as described above unless space CO rises above 25 ppm. Upon rise in CO above setpoint, supply fan shall go to 100% fan speed and exhaust fan shall control to maintain static pressure if required to operate. Hot water coil shall operate as on occupied heating mode.

J. Occupied Heating or Cooling

1. Associated exhaust fans per HV unit shall be energized to run through the BAS system only when the building is in the occupied mode per the following schedule:

AIR HANDLING UNIT	EXHAUST FANS
HV6A, 6B	GX-13, 15, 16, TX-17

4.18 SEQUENCE OF OPERATIONS – VARIABLE TEMPERATURE/VARIABLE FLOW AIR HANDLING UNITS (HV-7A, 7B)

A. This unit controls a single zone by varying supply air temperature and varying outside air to maintain minimum pressure differential between space and corridor of -.03 in.wc. Both units shall operate together.

B. When supply fan is shut down, exhaust fan is de-energized, outside and relief dampers are shut tight, heating coil valve is controlled by air sensors immediately downstream of coil. (Provide a sensor for each coil section).

C. Supply fan shall be variable based on maintaining space pressure differential offset.

D. Hours of operation will be set at the building central panel. Modes of operation will be:

1. Unoccupied heating.
2. Occupied summer.
3. Occupied winter.

E. Unoccupied heating (ambient temperature below 55 degrees F)

1. Outside air dampers and exhaust dampers closed and fans are off. Heating coils valves operate as described above. Heating coil valves remain under control of sensors immediately downstream of coils.

2. When room temperature drops to 55 degrees F, and space unit heaters shall cycle to maintain space temperature. When space temperature rises 10 degrees F, unit haters shall be off.

F. Occupied Summer (ambient temperature above 70 degrees F)

1. Outside air damper shall open, heat exchanger bypass damper closed and supply fan shall start at 50% speed after outside air damper proven open. Exhaust fan shall be energized on after exhaust damper opens and speed shall vary to maintain space pressure differential offset.

2. As additional exhaust fans or units are energized unit exhaust fan shall reduce speed and eventually shut down. If space static cannot be maintained, is in excess of setpoint or space temperature continues to rise increase supply fan incrementally to 100% speed to allow more outside air.

3. As static pressure varies depending on space exhaust and space temperature is still above setpoint stage on unit exhaust fan to maintain setpoint.

4. Whenever associated exhaust fan GX-52 is running, respective units outside air dampers shall go full open to maintain while still under control of space pressure differential offset.

5. If outside air temperature is above return air temperature, close outside air to heat recovery coil and open bypass damper.

G. Occupied Winter (ambient temperature below 70 degrees F)

1. Outside air damper shall open, heat exchanger bypass damper closed and supply fan shall start at 50% speed after outside air damper proven open. Exhaust fan shall be energized on after exhaust damper opens and speed shall vary to maintain space pressure differential offset.

2. As additional exhaust fans or units are energized unit exhaust fan shall reduce speed and eventually shut down. If space static cannot be maintained, is in excess of setpoint or space temperature continues to rise increase supply fan incrementally to 100% speed to allow more outside air.

3. As static pressure varies depending on space exhausts stage on unit exhaust fan to maintain setpoint.

4. Drop in space sensor below setpoint shall sequence heating coil control valve to maintain space temperature.

5. Outside air bypass dampers shall modulate based on heat exchanger exhaust air temperature to ensure unit leaving exhaust temp stays above 34 degrees F to prevent heat exchanger frosting if exhaust fan is operating.

6. Cold start up with outside air temperature below freeze stat setting of 38 degrees F, prior to starting of unit open hot water valve to flow water in coil to prevent nuisance freeze stat tripping while slowly ramping up speed of fan. Once system stabilize return hot water coil control to normal.

H. Provide Freezestat controls in each unit, as described in the general descriptions.

I. Fan speed control

1. Supply fans shall start at low speed and shall operate as described above unless space CO rises above 25 ppm. Upon rise in CO above setpoint, supply fan shall go to 100% fan speed and exhaust fan shall control to maintain static pressure if required to operate. Hot water coil shall operate as on occupied heating mode.

J. Occupied Heating or Cooling

1. Associated exhaust fans per HV unit shall be energized to run through the BAS system only when the building is in the occupied mode per the following schedule:

AIR HANDLING UNIT	EXHAUST FANS
HV7A,7B	GX-13, 15, TX-16

4.19 SEQUENCE OF OPERATIONS – VARIABLE TEMPERATURE/VARIABLE FLOW AIR HANDLING UNITS (HV-8)

A. This unit controls a single zone by varying supply air temperature and varying outside air to maintain minimum pressure differential between space and atmosphere of -.03 in.wc.

B. When supply fan is shut down, exhaust fan is de-energized, outside and relief dampers are shut tight, heating coil valve is controlled by air sensors immediately downstream of coil. (Provide a sensor for each coil section).

C. Supply fan shall be variable based on maintaining space pressure differential offset.

D. Hours of operation will be set at the building central panel. Modes of operation will be:

1. Unoccupied heating.
2. Occupied summer.
3. Occupied winter.

E. Unoccupied heating (ambient temperature below 55 degrees F)

1. Outside air dampers and exhaust dampers closed and fans are off. Heating coils valves operate as described above. Heating coil valves remain under control of sensors immediately downstream of coils.

2. When room temperature drops to 55 degrees F, and space unit heaters shall cycle to maintain space temperature. When space temperature rises 10 degrees F, unit haters shall be off.

F. Occupied Summer (ambient temperature above 70 degrees F)

1. Outside air damper shall open, heat exchanger bypass damper closed and supply fan shall start at 25% speed after outside air damper proven open. Exhaust fan shall be energized on after exhaust damper opens and speed shall vary to maintain space pressure differential offset.

2. As additional exhaust fans or units are energized unit exhaust fan shall reduce speed and eventually shut down. If space static cannot be maintained, is in excess of setpoint or space temperature continues to rise increase supply fan incrementally to 100% speed to allow more outside air.

3. As static pressure varies depending on space exhaust and space temperature is still above setpoint stage on unit exhaust fan to maintain setpoint.

4. If outside air temperature is above return air temperature, close outside air to heat recovery coil and open bypass damper.

G. Occupied Winter (ambient temperature below 70 degrees F)

1. Outside air damper shall open, heat exchanger bypass damper closed and supply fan shall start at 25% speed after outside air damper proven open. Exhaust fan shall be energized on after exhaust damper opens and speed shall vary to maintain space pressure differential offset.

2. As additional exhaust fans or units are energized unit exhaust fan shall reduce speed and eventually shut down. If space static cannot be maintained, is in excess of setpoint or space temperature continues to rise increase supply fan incrementally to 100% speed to allow more outside air.

3. As static pressure varies depending on space exhausts stage on unit exhaust fan to maintain setpoint.

4. Drop in space sensor below setpoint shall sequence heating coil control valve to maintain space temperature.

5. Outside air bypass dampers shall modulate based on heat exchanger exhaust air temperature to ensure unit leaving exhaust temp stays above 34 degrees F to prevent heat exchanger frosting if exhaust fan is operating.

6. Cold start up with outside air temperature below freeze stat setting of 38 degrees F, prior to starting of unit open hot water valve to flow water in coil to prevent nuisance freeze stat tripping while slowly ramping up speed of fan. Once system stabilize return hot water coil control to normal.

H. Provide Freezestat controls in each unit, as described in the general descriptions.

I. Fan speed control

1. Supply fans shall start at low speed and shall operate as described above unless space CO rises above 25 ppm. Upon rise in CO above setpoint, supply fan shall go to 100% fan speed and exhaust fan shall control to maintain static pressure if required to operate. Hot water coil shall operate as on occupied heating mode.

J. Occupied Heating or Cooling

1. Associated exhaust fans per HV unit shall be energized to run through the BAS system only when the building is in the occupied mode per the following schedule:

AIR HANDLING UNIT	EXHAUST FANS
HV8	TX-21

4.20 SEQUENCE OF OPERATIONS – VARIABLE TEMPERATURE CONSTANT VOLUME AIR HANDLING UNITS (RTU-1)

A. This unit controls a single zone by varying supply air temperature.

B. When supply fan is shut down, exhaust fan is off, outside air and relief dampers are shut tight, heating coil valve is controlled by air sensors immediately downstream of coil. (Provide a sensor for each coil section).

C. Hours of operation will be set at the building central panel. Modes of operation will be:

1. Unoccupied cooling.
2. Unoccupied heating.
3. Cooldown.
4. Warmup.
5. Occupied summer.
6. Occupied winter.

D. Unoccupied cooling (ambient temperature above 55 degrees F):

1. Outdoor air and relief dampers are closed, fans are stopped. Cooling and heating coil valves are closed.

E. Unoccupied heating (ambient temperature below 55 degrees F)

1. Outside air and relief dampers are closed. Fans are off. Cooling coil valves are shut. Heating coil valves remain under control of sensors immediately downstream of coils. When room temperature drops to 55 degrees F, warmup cycle (as described below) is actuated. When space temperature rises 10 degrees F, warmup terminates and fan stops.

F. Cooldown or Warmup Modes (Optimal start schedule)

1. Upon startup, the AH unit first goes through a cooldown or warmup mode. The supply fan shall start, exhaust fan off, and run with outside air and relief dampers shut. After a 3 minute time delay, the system goes into a cooldown or warmup mode, depending upon temperature of return air.
2. Return air temperature above 80 degrees F, cooldown commences. Chilled water valve modulates under control of room air temperature. Normal occupied cooling resumes after room air temperature comes down to 75 degrees F.
3. Return air temperature below 68 degrees F warmup commences. Air discharge temperature is controlled by room temperature, subject to a maximum of 85 degrees F. Warmup terminates when room temperature has increased to 72 degrees F, subject to time delay as described below, before reverting to normal operation.
4. Provide an adjustable time delay to hold the system in warmup after reaching 72 F, for a preset time, before reverting to normal occupied mode. Adjust this delay based on observed need for thermal stability.

G. Occupied Summer (ambient temperature above 55 degrees F)

1. A space temperature signal will modulate the cooling coil valve to maintain space setpoint. Discharge temperature sensor will prevent supply air temperature from dropping below preset minimum. Controller shall have P-I-D control algorithm.

H. Occupied Winter (ambient temperature below 55 degrees F)

1. Space sensor shall sequence heating coil control valve to maintain space temperature. Respective exhaust fan(s) shall run when unit is in occupied mode.
2. RTU fan speed shall be varied as described above subject to a 100°F maximum discharge supply temperature.
3. Provide Freezestat controls in each unit, as described in the general descriptions.

I. Exhaust fan control

1. Unit exhaust fan shall be controlled to maintain a slight negative pressure (-0.03) in the space as reference to atmosphere.

J. Control of air dampers:

1. Interconnect the outside air (OA) and return air (RA) dampers so that when OA damper opens, the RA damper closes. Control these dampers in the manner described, to regulate outside air intake.

K. Occupied Heating or Cooling

1. Associated exhaust fans per unit shall be energized to run through the BAS system only when the building is in the occupied mode per the following schedule:

AIR HANDLING UNIT	EXHAUST FANS
RTU-1	TX-7

4.21 SEQUENCE OF OPERATIONS – VARIABLE TEMPERATURE CONSTANT VOLUME HEATING AND VENTILATION AIR HANDLING UNITS (HV-1, 2, 3, 4 & 5)

A. This unit controls a single zone by varying supply air temperature and varying outside air to maintain minimum pressure differential between space and corridor of -.03 in.wc.

B. When supply fan is shut down, outside dampers are shut tight, heating coil valve is controlled by air sensors immediately downstream of coil. (Provide a sensor for each coil section).

C. Hours of operation will be set at the building central panel. Modes of operation will be:

1. Unoccupied heating.
2. Warmup.
3. Occupied summer.
4. Occupied winter.

D. Unoccupied heating (ambient temperature below 55 degrees F)

1. Outside air dampers are closed. Fan is off. Heating coil valves remain under control of sensors immediately downstream of coils. When room temperature drops to 55 degrees F, exterior unit heaters shall cycle to maintain space setback temperature. If space temperature continues to drop, warmup cycle (as described below) is actuated. When space temperature rises 10 degrees F, warmup terminates and fan stops.
2. Units with face and bypass dampers: face damper open, bypass damper closed. Heating coils valves operate as described below.

E. Warmup Modes (Optimal start schedule)

1. Upon startup, the AH unit first goes through a warmup mode. The supply fan shall start and run with outside dampers shut. After a 3 minute time delay, the system goes into a warmup mode depending on space temperature.
2. Space temperature below 68 degrees F warmup commences. Air discharge temperature is controlled by room temperature, subject to a maximum of 100 degrees F. Warmup terminates when room temperature has increased to 72 degrees F, subject to time delay as described below, before reverting to normal operation.
3. Provide an adjustable time delay to hold the system in warmup after reaching 72 F, for a preset time, before reverting to normal occupied mode. Adjust this delay based on observed need for thermal stability.

F. Occupied Summer (ambient temperature above 70 degrees F)

1. Outside and return air dampers shall modulate from a minimum of 20% outside air to maximum minimum value scheduled to maintain offset pressure differential.
2. Whenever associated exhaust fans GX-46, 47, 48, 49 or 50 are running, respective units outside air dampers shall go full open to maintain while still under control of space pressure differential offset.

G. Occupied Winter (ambient temperature below 70 degrees F)

1. Units without face and bypass dampers: Space sensor shall sequence heating coil control valve to maintain space temperature. Outside air and return air damper are under control of space pressurization offset.
2. Units with face and bypass dampers: Space sensor shall sequence heating coil control valve, face and bypass dampers and outside air dampers to maintain space temperature. Outside air and return air damper are under control of space pressurization offset.
3. Mixed air temperature above 35 degrees F: Face damper open, bypass damper closed and heating coil control valve modulates to maintain space setpoint. Mixed air temperature below 35 degrees F: Hot water valve goes to full open and face and bypass damper modulate to maintain space setpoint.

H. Provide Freezestat controls in each unit, as described in the general descriptions.

I. Occupied Heating or Cooling

1. Associated exhaust fans per HV unit shall be energized to run through the BAS system only when the building is in the occupied mode per the following schedule:

AIR HANDLING UNIT	EXHAUST FANS
HV-1	TX-12, GX-3
HV-2	TX-14, GX-6
HV-3	TX-15, GX-31
HV-4	TX-20, GX-12, 14
HV-5	TX-13, GX-13, 25

4.22 SEQUENCE OF OPERATIONS – HEAT RECOVERY UNITS (HRU1 and HRU2)

A. HRU units shall provide minimum ventilation air to respective AHU's served. If HRU value is not sufficient to maintain minimum then modulate main outside air damper to supplement.

B. Occupied Summer (ambient temperature above 70 degrees F)

1. Outside air damper shall open, heat exchanger bypass damper closed and exhaust and supply fan shall start after outside air damper proven open. Exhaust fan speed shall vary based on maintaining a negative offset as indicated on drawing in reference to totalized supply vav boxes of spaces served. Supply fan shall track exhaust fan to maintain scheduled offset.

2. If outside air temperature is above return air temperature, close outside air to heat recovery coil and open bypass damper.

C. Occupied Winter (ambient temperature below 70 degrees F)

1. Outside air damper shall open, heat exchanger bypass damper closed and exhaust and supply fan shall start after outside air damper proven open. Exhaust fan speed shall vary based on maintaining a negative offset as indicated on drawing in reference to totalized

supply vav boxes of spaces served. Supply fan shall track exhaust fan to maintain scheduled offset.

2. Outside air bypass dampers shall modulate based on heat exchanger exhaust air temperature to ensure unit leaving exhaust temp stays above 34 degrees F to prevent heat exchanger frosting if exhaust fan is operating.

3. Cold start up with outside air temperature below freeze stat setting of 38 degrees F, prior to starting of unit open hot water valve to flow water in coil to prevent nuisance freeze stat tripping while slowly ramping up speed of fan. Once system stabilize return hot water coil control to normal.

4. Preheat coil valve to modulate to maintain discharge temp of 50 deg F (adj).

D. HRU1 shall be interlocked with AHU1. Unit shall provide required exhaust to art classrooms.

E. HRU2 shall be interlocked with AHU4. Unit shall provide required exhaust to science classrooms.

F. BAS shall monitor supply air and exhaust air at units

4.23 SEQUENCE OF OPERATIONS – VARIABLE AIR VOLUME AIR HANDLING UNITS WITH ENERGY RECOVERY (AHU-3 and AHU-5)

A. When supply fan is shut down, relief fan is shut down, the outside and relief/spill dampers are shut tight, heating coil valve is controlled by air sensors immediately downstream of coil. (Provide not less than one sensor for each 8 sq. ft. of coil face). Upon a signal from the BAS system to start the outside air and relief air dampers shall open and start supply and exhaust air fans. Fans shall be controlled under specific mode of operation.

B. Hours of operation will be set at the building's central panel. Modes of operation will be:

1. Unoccupied cooling.
2. Unoccupied heating.
3. Cooldown or Warmup.
4. Occupied summer.
5. Occupied winter.

C. Unoccupied cooling (ambient temperature above 55 F)

1. Outdoor air dampers are closed, fans are stopped. Cooling and heating coil valves are shut.

D. Unoccupied heating (ambient temperature below 55 F)

1. Outside air dampers are closed. Fans are off. Cooling coil valves are shut. Heating coil valves are under control of sensors immediately downstream of coils shall modulate to maintain minimum inside casing temperature of 45 degrees F. When room temperature drops to 55 degrees F, radiant panels shall be first stage for heating and if further drop in space temp initiate warmup cycle (as described below) is actuated. When space temperature rises to 65 degrees F, warmup terminates and fan stops.

E. Cooldown or Warmup (Optimal schedule)

1. Prior to occupied operation (adjustable lead time), the supply and exhaust fan starts, outside and relief dampers open. After a 3 minute run time, the system reverts to a cooldown or warmup mode, depending upon temperature of return air.
2. If return air temperature is above 80, cooldown commences. Chilled water valve is modulated under control of return air temperature. Normal occupied cooling resumes after average room air temperature comes down to 75 degrees F.
3. If return air temperature is below 68 F, warmup commences. Return air sensor and/or average space temperature modulates the hot water control valve, subject to a high limit of 85 F discharge air temp. Warmup terminates when average space temperature has remained above 72 deg F for a preset time period (try 30 minutes initially). Adjust the time delay as needed to allow for thermal capacitance of building construction materials.

F. Unit shall operate with 100 % outside air and will not utilize CO2 control.

G. Occupied Summer (ambient temperature above 55 degrees F)

1. Temperature sensor immediately downstream of chilled water coil, as reset by a return air sensor and remote zone calling, through its controller (vav air handling units), shall control sequencing of chilled water coil control valve, (occupied mode) in response to air handling unit discharge temperature. Controller shall employ a dynamic self tuning algorithm.

2. Outside air damper shall open, heat exchanger bypass damper closed and supply fan and exhaust fan shall start under static pressure control (static pressure control for AHU-5 relief fan only. AHU-3 relief fan described below) after outside air and relief damper proven open.

3. As additional exhaust fans or units are energized unit exhaust fan shall reduce speed and eventually shut down. If space static cannot be maintained, is in excess of setpoint or space temperature continues to rise increase supply fan incrementally to 100% speed to allow more outside air.

4. If outside air temperature is above return air temperature, close outside air to heat recovery coil and open bypass damper.

H. Occupied Winter (ambient temperature below 70 degrees F)

1. The fan discharge sensor modulates variable outside air dampers, heat exchanger bypass dampers and heating coil control valve in sequence (with dead band between). Provide independent low limit controllers immediately downstream of heating coils, set at 45 degrees.

2. Outside air bypass dampers shall modulate based on heat exchanger exhaust air temperature to ensure unit leaving exhaust temp stays above 34 degrees F to prevent heat exchanger frosting if exhaust fan is operating.

3. Cold start up with outside air temperature below freeze stat setting of 38 degrees F, prior to starting of unit open hot water valve to flow water in coil to prevent nuisance freeze stat tripping while slowly ramping up speed of fan. Once system stabilize return hot water coil control to normal.

I. Provide Freezestat controls in each unit, as described in the general descriptions.

J. Occupied Heating or Cooling

1. Associated exhaust fans per AC unit shall be energized to run through the BAS system only when the building is in the occupied mode per the following schedule:

AIR HANDLING UNIT	EXHAUST FANS
AHU-3	GX-7, 10, TX-19

K. Supply and Relief Fan volume control.

1. A static pressure pickup sensor in the supply duct, referenced to outside air, located approximately two thirds down the main supply duct will, through a controller with P-I-D control algorithm, modulate a variable frequency fan speed controller, to maintain the static pressure setting. Provide a high limit pressure sensor with two setpoints. One setpoint to alarm above-normal pressures, the second setpoint, set higher, to shut the fan down.
2. AHU-5: control relief fan speed based on duct static pressure.
3. AHU-3 exhaust fan speed shall vary to maintain space pressure differential offset between supply to maintain space negative pressure with respect to ambient.
4. BAS shall monitor both fan airflow to verify cfm offset.

L. AHU-3 VAV Zone Control

1. A room temperature sensor sequences the radiation or radiant panel control valve (if exists), the reheat coil, and the air valve.
2. VAV air volume controller will have a maximum CFM and minimum CFM adjustment. Adjust maximum and minimum CFM to the cfm shown on the drawings.
3. For each reheat coil, provide a HW control valve and modulate it in sequence with the VAV damper.
4. During warmup, position VAV damper to maximum CFM with reheat valve closed.
5. Room temperature set points, operating temperature, air volume and status will be monitored at the central panel. Set points will be remotely adjustable.
6. Refer to additional vav/radiant control below.

M. AHU-5 VAV zone control

1. Refer to LX-1 control sequence below.
2. A room temperature sensor sequences the radiation or radiant panel control valve (if exists), the reheat coil, and the air valve.
3. VAV boxes with electric duct coils shall work in similar manner and shall only operate when the hot water system is not in service. When hot water is available the electric duct coils are locked out.

4.24 SEQUENCE OF OPERATIONS – RADIANT PANELS

A. Space sensor shall modulate radiant panel control valve based on occupancy schedule to maintain space setpoint.

B. Where radiant panel and VAV box(es) with heating coil(s) are controlled by same space sensor, space sensor shall first initiate radiant panel heating on and then upon further drop in space temperature and after VAV is at minimum flow, VAV heating coil control valve shall modulate to maintain space temperature.

C. If space temperature continues to drop sequence VAV box to 75% of max cooling flow (adj) ands modulate control valve.

4.25 SEQUENCE OF OPERATIONS – VARIABLE TEMPERATURE CONSTANT VOLUME AIR HANDLING UNITS (FAN COIL UNITS FC-8)

A. This unit is 100% outside air and controls a single zone by varying supply air temperature. Respective existing exhaust fan.

B. When supply fan is shut down, outside dampers are shut tight, freeze pumps are off, heating coil valve is controlled by air sensors immediately downstream of coil. (Provide a sensor for each coil section).

C. Hours of operation will be set at the building central panel. Modes of operation will be:

1. Unoccupied cooling.
2. Unoccupied heating.
3. Occupied summer.
4. Occupied winter.

D. Unoccupied cooling (ambient temperature above 55 degrees F):

1. Outdoor air dampers are closed, fan is stopped. Cooling and heating coil valves are closed.

E. Unoccupied heating (ambient temperature below 55 degrees F)

1. Outside air dampers are closed. Fan is off. Cooling coil valves are shut. Heating coil valves remain under control of sensors immediately downstream of coils.

F. Occupied Summer (ambient temperature above 55 degrees F)

1. A space temperature signal will modulate the cooling coil valve to maintain space setpoint. Discharge temperature sensor will prevent supply air temperature from dropping below preset miminum. Controller shall have P-I-D control algorithm.
2. Outside dampers full open.

G. Occupied Winter (ambient temperature below 55 degrees F)

1. Space sensor shall sequence heating coil control valve.
2. Provide independent low limit controllers immediately downstream of heating coils, set at 40 degrees to start hot water and chilled water freeze pump for freeze protection.

H. Provide Freezestat controls in each unit, as described in the general descriptions.

4.26 SEQUENCE OF OPERATIONS – CABINET UNIT AND UNIT HEATERS

A. Provide a room sensor for each unit heater to open 2 position control valve and cycle the unit fan to maintain the desired space temperature (setting range 45 - 75 F). Provide a strap-on thermostat to stop the fan whenever the hot water supply temperature drops below 120 degrees F. Submit an alarm if space temperature drops 5 deg. F below unoccupied set point.

4.27 SEQUENCE OF OPERATION – EXHAUST FANS GENERAL REQUIREMENTS

A. Each exhaust fan is to be started and stopped by the automatic control system, as shown on the drawings, as described herein, as directed by the Engineer. Upon startup exhaust fans respective motorized inlet and make up damper shall open. BAS shall monitor run times of fans whenever they are in operation.

B. Exhaust fans will be started and stopped either by interlocking to run with or in response to a signal from another unit, or by signal from the BAS control system, or by a room thermostat to limit space temperature rise, as appropriate.

C. Status shall be monitored by the BAS system and an alarm generated if the fan does not operate when initiated on or shuts down.

D. Associated transfer duct smoke dampers shall be interlocked to open when exhaust fans is started. If damper fails to open an alarm shall be generated.

E. For all manually controlled fans located within shops, BMS shall provide a permissive to allow fan to operate based on user defined occupancy schedules. Fan shall be turned off through BMS if left on during after hours.

4.28 SEQUENCE OF OPERATIONS – HVAC SHOP CHIMNEY AUTOMATION SYSTEM (GX-38)

A. A call for heat from one of the appliances will activate the chimney fan and releases the burner once an adequate, pre-set draft has been established. Fan shall modulate based on XTP sensor signal and fan controller.

4.29 SEQUENCE OF OPERATIONS – CHEMICAL STORAGE (GX-36, 5, 45)

A. Fan shall be started through BAS and run continuously. Initiate an alarm upon failure both at the BAS and an audible and visual alarm above chemical storage room door.

4.30 SEQUENCE OF OPERATIONS – ANNEX GENERAL STOARGE EXHAUST (GX-19, 20, 21 and 22)

A. Exhaust fans shall be started based on rise in space temperature above setpoint. Fans shall sequence on one at time in a cross ventilation fashion and respective inlet motorized damper shall open. De-energize fan, close damper and inlet damper after space setpoint satisfied.

4.31 SEQUENCE OF OPERATIONS – ELEVATOR MACHINE ROOM EXHAUST (GX-1 and GX-30)

A. Exhaust fans shall be started based on rise in space temperature above setpoint.

4.32 SEQUENCE OF OPERATIONS – ELECTRIC ROOM EXHAUST (GX-2, 4, 29, 39, 40)

A. Exhaust fans shall be started based on rise in space temperature above setpoint.

B. Fans with multiple sensors in fans serving more than a single space shall operate to satisfy each space sensor.

4.33 SEQUENCE OF OPERATIONS - TELECOM CLOSET AIR CONDITIONING

A. Space air conditioning units shall be started locally through unit supplied thermostats and controls to maintain space setpoint. Units controls shall sequence evaporator fan and refrigeration cycle to maintain space setpoint.

B. BAS shall monitor space temperature of all Telecommunications Closets and MDF room. Report an alarm if space temperature rises 2˚F above setpoint (72˚F adj).

4.34 SEQUENCE OF OPERATIONS – SHOP VENTILATION EXHAUST FANS (GX-46, GX-47, GX-48, GX-49, GX-50, GX-51, GX-52)

A. Fans shall operate based on rise in space setpoint (75˚F initially, adj.) automatically or if set into the hand position. When fan is called to run, open fan motorized damper and ceiling mounted make up air damper, start fan via inlet damper end switch.

B. GX-51 and/or GX-52 shall also be started if levels of carbon monoxide as measured by sensors located at 12" above finish floor sense levels on CO above 25 ppm. If temperature outside is below 35˚F, GX-51 and/or GX-52 make up air dampers shall remain closed and HV-6A, 6B and/or 7A, 7B shall go to high speed and 100% outside air for make up.

4.35 SEQUENCE OF OPERATIONS – HVAC PLASMA CUTTER (GX-27)

A. Exhaust fan shall be started/stopped via manual starter. Provide permissive to operate fan only during user specified occupancy schedule. If fan is run after specified times it will be commanded off by BAS unless extended schedule is implemented.

4.36 SEQUENCE OF OPERATIONS – SHOP WELDING EXHAUSTS (GX-9, GX-44, GX-32)

A. Exhaust fan shall be started/stopped via manual starter.

4.37 SEQUENCE OF OPERATIONS – AUTOBODY MIXING BOOTH

A. Exhaust fan shall be started/stopped through control interlock from spray booth mixing room with mixing room supply fan. Coordinate interface with booth supplier.

4.38 SEQUENCE OF OPERATIONS – SMALL PAINT SPRAY BOOTH

A. Exhaust fan shall be started/stopped via manual starter mounted on booth enclosure. Coordinate spray operation lockout with booth supplier. Interlock compressed air solenoid valve (supplied by others) with exhaust fan. Solenoid valve shall be closed when fan is off. Provide a local audible alarm with silence switch if fan fails when called to operate. Provide permissive to operate fan only during user specified occupancy schedule. If fan is run after specified times it will be commanded off by BAS unless extended schedule is implemented.

4.39 SEQUENCE OF OPERATIONS – AUTOMOTIVE VEHICLE EXHAUST (GX -35, GX-34 and GX-24)

A. Exhaust fan shall be started/stopped via manual starter. BMS shall provide relay to shut down fan if fan is left on after normal occupied hours.

4.40 SEQUENCE OF OPERATIONS – SCIENCE HOOD EXHAUST (LX-1 and LX-2)

A. Exhaust fans shall be started/stopped via remote start/stop buttons located on Lab Hood.

B. BAS to provide and monitor local lab hood airflow alarm and initiate a local and remote alarm upon loss of hood airflow when fan is commanded on. Provide sign indicating if "FAN STATUS LIGHT IS OFF DO NOT USE HOOD"

4.41 SEQUENCE OF OPERATIONS – PREP ROOM EXHAUST (GX-37A/B)

A. GX-37A/B shall operate when main air system AHU 5 is off. When AHU 5 is operating, GX-37A/B inlet damper shall be closed allowing 100% exhaust through main air system. When AHU 5 is off, EV-2 damper shall be closed allowing 100% exhaust through GX-37A/B.

B. EV-2 shall track supply VAV box to maintain a negative pressure with a 150cfm offset.

4.42 SEQUENCE OF OPERATIONS – SCIENCE ROOM PRESSURIZATION CONTROL (LX-1 & LX-2, AHU-5)

A. LX-1 and 2 are manually turned on as described above. AHU5 VFD's shall modulate fan speed in response to duct static pressure.

B. Supply and exhaust vav boxes shall track to maintain minimum airflow offsets in the Science Lab A228 A226 A225 A223 and Prep Rooms A227 and A224. For each space, provide a static pressure sensor to verify a negative offset with respect to corridor is achieved and adjust vav box airflows as required. Whenever the respective lab hood exhaust fans , LX-1 or 2, are on, the associated exhaust vav box airflow shall be reduced 770 cfm to match hood exhaust flow.

4.43 SEQUENCE OF OPERATIONS – CARPENTRY DUST COLLECTOR

A. Unit shall be started/stopped via manual start stop station located in carpentry office through manufacturer's remote control panel. BAS to allow permissive to operate dust collector based on programmed occupancy schedule. BAS contractor to provide ALL interconnecting control wiring to and from controller to dust collector. This shall include but not limited to filter differential monitoring, pulse blow down control, alarms, fan failure and as required to satisfy sequence of operations.

B. Provide manual summer/winter switch located inside building in office to set position of dust collector discharge dampers. Under most conditions, dampers shall be set to recirculate air. Provide spark arrestor sensor on the dust collector discharge to override switch that changes the position of the discharge bypass dampers to 100% exhaust no recirculation and initiate an alarm both inside of building and at BAS.

C. Provide differential pressure monitoring across filters to signal dirty filters.

4.44 SEQUENCE OF OPERATIONS – SANDING VACUUM SYSTEM (AEROVAC)

A. Unit shall be started manually at unit provided starter.

4.45 SEQUENCE OF OPERATIONS – LARGE SPRAY BOOTH

A. Start and stop on both booth exhaust fan and gas fired makeup air unit by manufacturers controls. BAS shall monitor run times.

4.46 SEQUENCE OF OPERATIONS – PREP BOOTH

A. Start and stop on booth exhaust fan by manufacturers controls. BAS shall monitor run times.

4.47 SEQUENCE OF OPERATIONS – PLUMBING SOLDERING EXHAUST (GX -23)

A. Exhaust fan shall be started/stopped via manual starter.

4.48 SEQUENCE OF OPERATIONS – FUEL OIL TANK (HVAC And Boiler)

A. BAS shall monitor output alarms generated by fuel oil monitoring panel.

4.49 SEQUENCE OF OPERATIONS – WASTE OIL TANK

A. BAS shall monitor output alarms generated by waste fuel oil monitoring panel.

4.50 SEQUENCE OF OPERATIONS – FUEL OIL TRANSFER PUMP (FOP-1)

A. Fuel oil pump shall be started remotely through building temperature control system based on occupancy schedule or manually through unit mounted HOA switch on unit control panel and operate continuously during school hours. BAS shall coordinate with shop emergency shut down controls provided under Division 26. Provide a 120 solenoid valve (normally closed) for each shop to close when respective emergency shut off is energized. BAS to monitor status of each emergency shut off panel through a set of NO or NC contacts to allow or deenergize fuel oil pumps. One or both of the panels shall be in a normal state to allow pumps to operate. If both panels are in off state pumps shall be locked out.

B. When the fuel oil pump operation fails to operate outside a normal shut down, generate a local audible alarm in both HVAC and Plumbing shops as well as an alarm to the BAS.

C. BAS shall monitor run times of each pump.

D. Upon failure of lead fuel oil pump BAS shall rotate to the lag pump. BAS to rotate pumps to equalize pun times.

4.51 SEQUENCE OF OPERATIONS – EMERGENCY GENERATOR

A. BAS to monitor status and alarms.

4.52 SEQUENCE OF OPERATIONS – CORRIDOR LIGHTING CONTROL

A. BAS shall control corridor lighting circuits, on/off, based on user defined occupancy schedules. Extend control from nine lighting control panels. Refer to Electrical drawings for locations. Each corridor shall be controlled independently.

B. Lighting panels include RP08, LP05, LP06, LP07, LP08, LP09, LP10 and LP11.

4.53 SEQUENCE OF OPERATIONS – SITE LIGHTING CONTROL

A. BAS shall control normal site lighting circuits, on/off, based on exterior photocell (provided by BMS contractor) for turning on and user defined occupancy schedules to turn off. Extend control from site lighting control panels or contactors. Refer to Electrical drawings for locations.

B. Electrical panels include LP05, LP06, ELP11 and LP10.

4.54 SEQUENCE OF OPERATIONS – SHOP AIR COMPRESSORS (Typical of 3)

A. System is configured with and intake penthouse with damper, an exhaust penthouse with set of right angle dampers and space sensor.

B. When compressor is off and space temp is satisfied, right angle dampers are closed to exterior, open to room and make up closed.

C. Dampers shall always be positioned to room with makeup air damper closed when space setpoint is satisfied. Rise in space temperature above setpoint, BMS shall modulate right angle dampers to maintain space temperatures and open make up air damper.

4.55 SEQUENCE OF OPERATIONS – HC-1

A. Connect HC-1 hot water valve to existing controls on existing RTU. This coil replaces the existing steam coil.

4.56 SEQUENCE OF OPERATIONS – EJECTOR PUMPS (SE-1 (boiler room) and SE-2 (plumbing shop pit)

A. BAS to monitor status and alarms.

END OF SECTION 230900

DEMOLITION KEYNOTES

22 REMOVE EXISTING SLAB

4

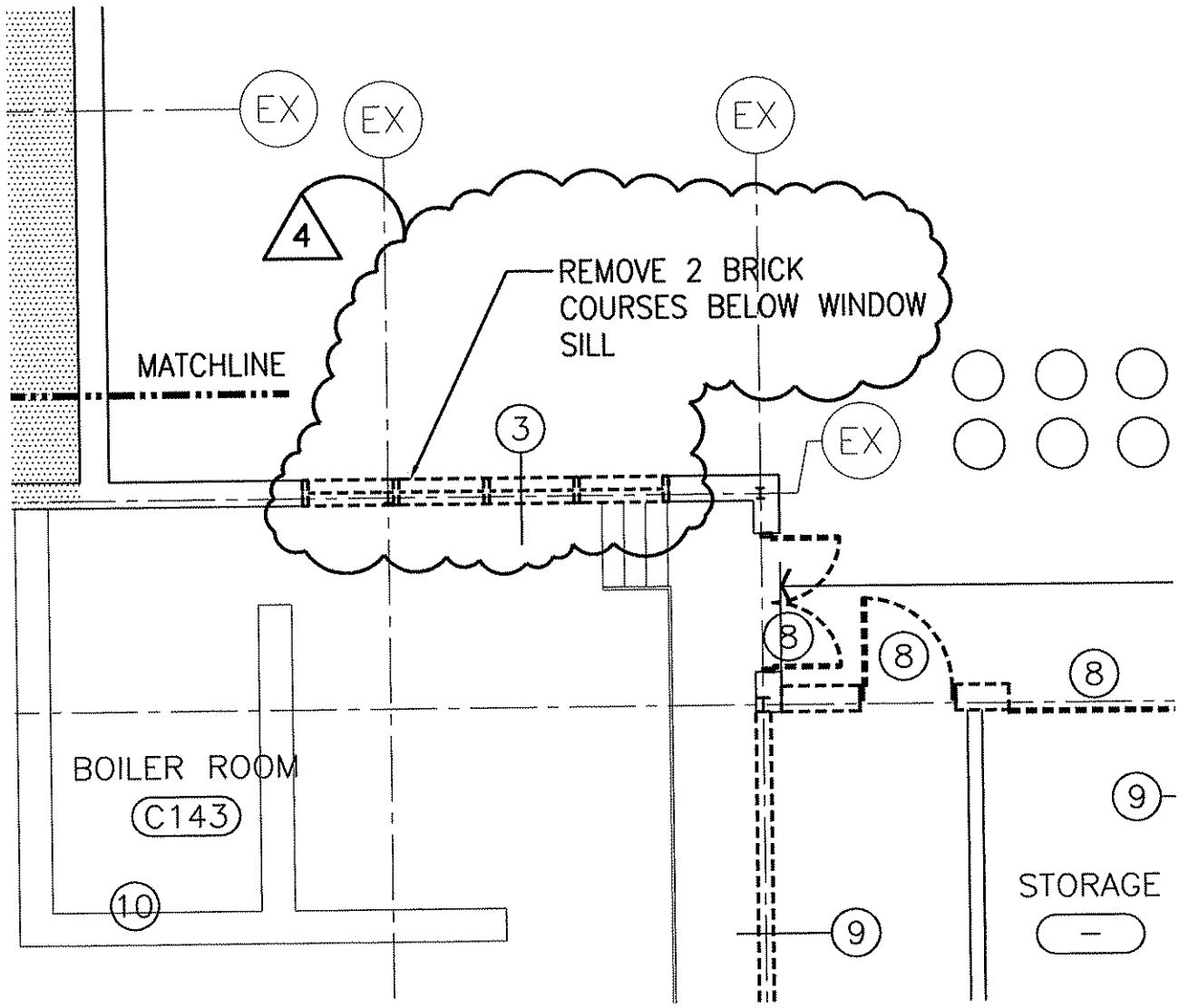
REFERENCE SHEET: D1.03
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS
TAI SOO KIM
146 Wyllys Street
Hartford, Connecticut
Tel: (860) 547-1970
Fax: (860) 249-0695

JOB NAME/NUMBER: H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843
SCALE: 1/8" = 1'-0"
DATE: 7/23/2010

TITLE: FIRST FLOOR DEMOLITION PLAN - AREA B & C

DRAWING NO.: SKA-1



REFERENCE SHEET: D1.05
REFERENCE ADDENDUM: #4

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TAI SOO KIM
146 Wyllys Street
Hartford, Connecticut
Tel: (860) 547-1970
Fax: (860) 249-0695

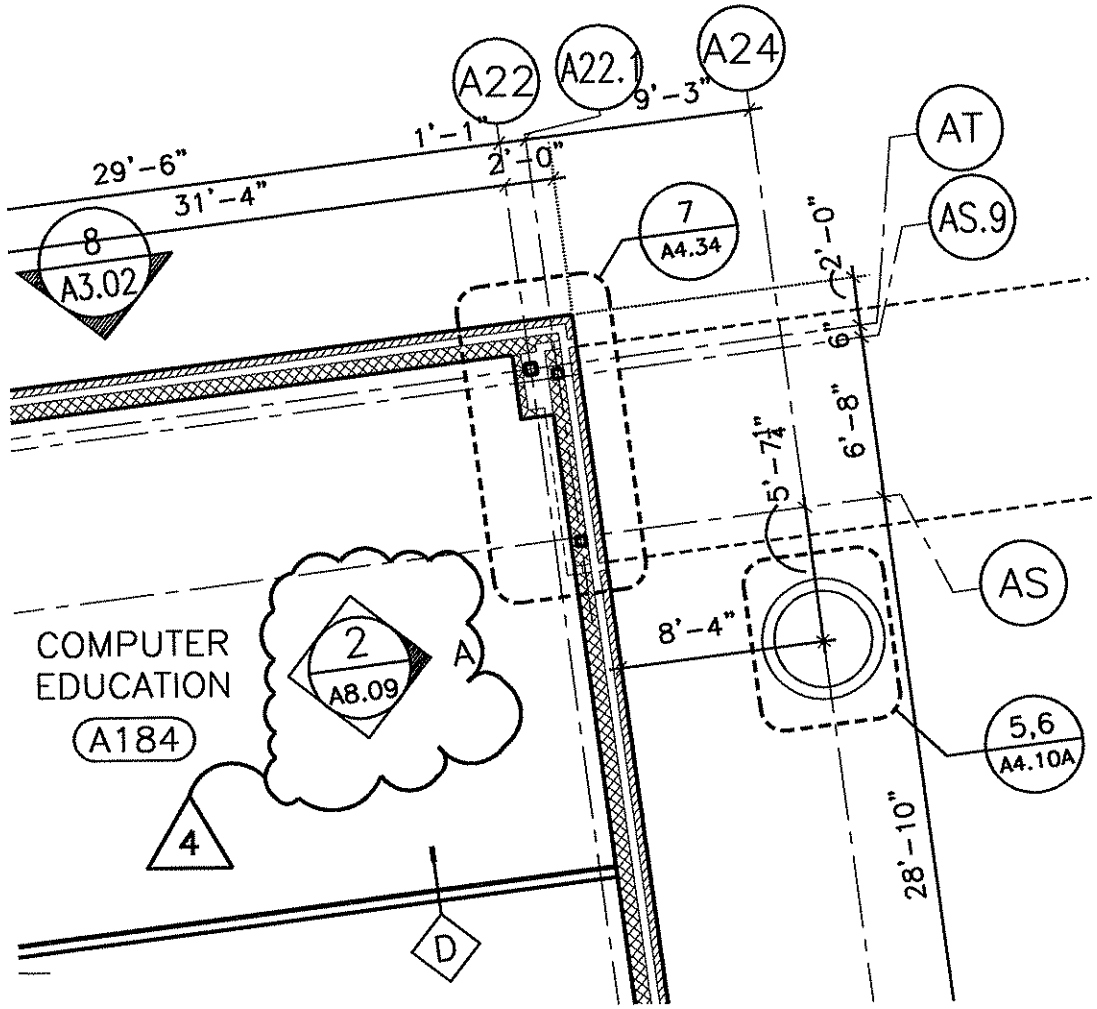
JOB NAME/NUMBER
H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843

SCALE:
1/8" = 1'-0"

DATE:
7/23/2010

TITLE
FIRST FLOOR DEMOLITION PLAN - AREA C

DRAWING NO.
SKA-2



REFERENCE SHEET: A1.02
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS
TAI SOO KIM
146 Wyllys Street
Hartford, Connecticut
Tel: (860) 547-1970
Fax: (860) 249-0695

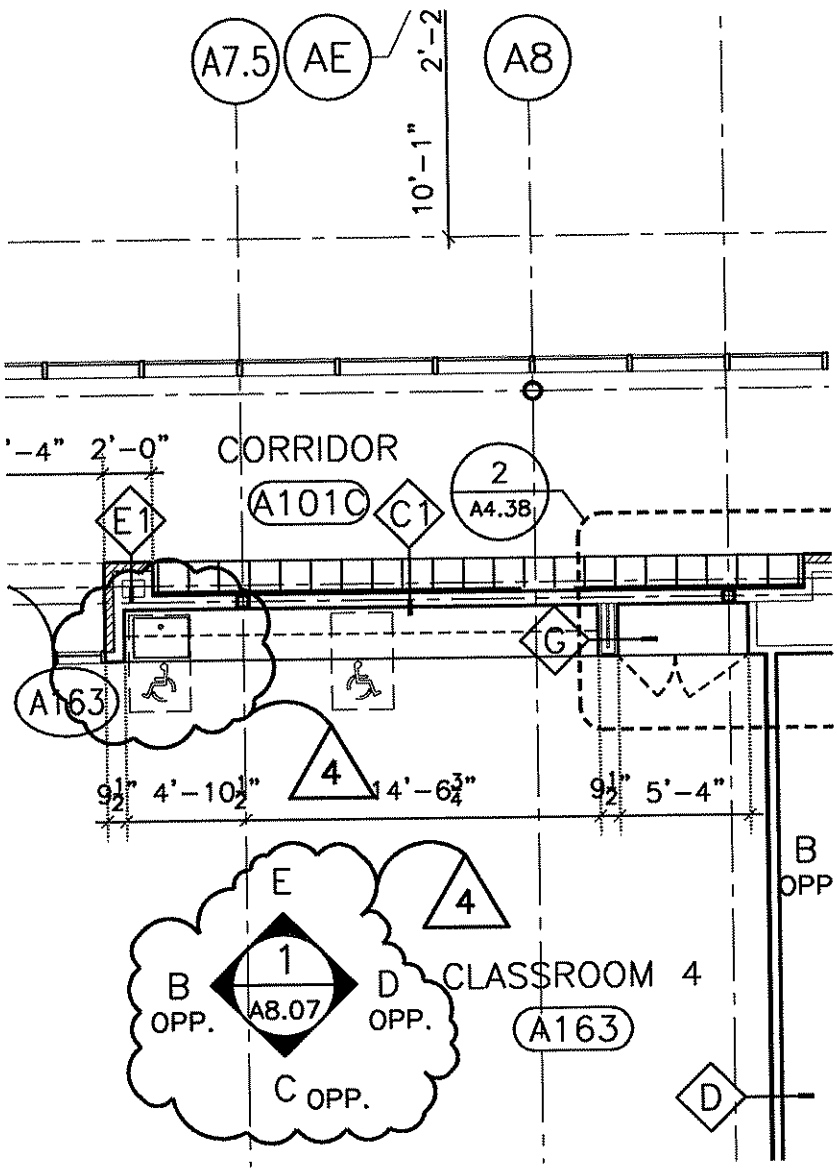
JOB NAME/NUMBER
H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843

SCALE:
1/8" = 1'-0"

DATE:
7/23/2010

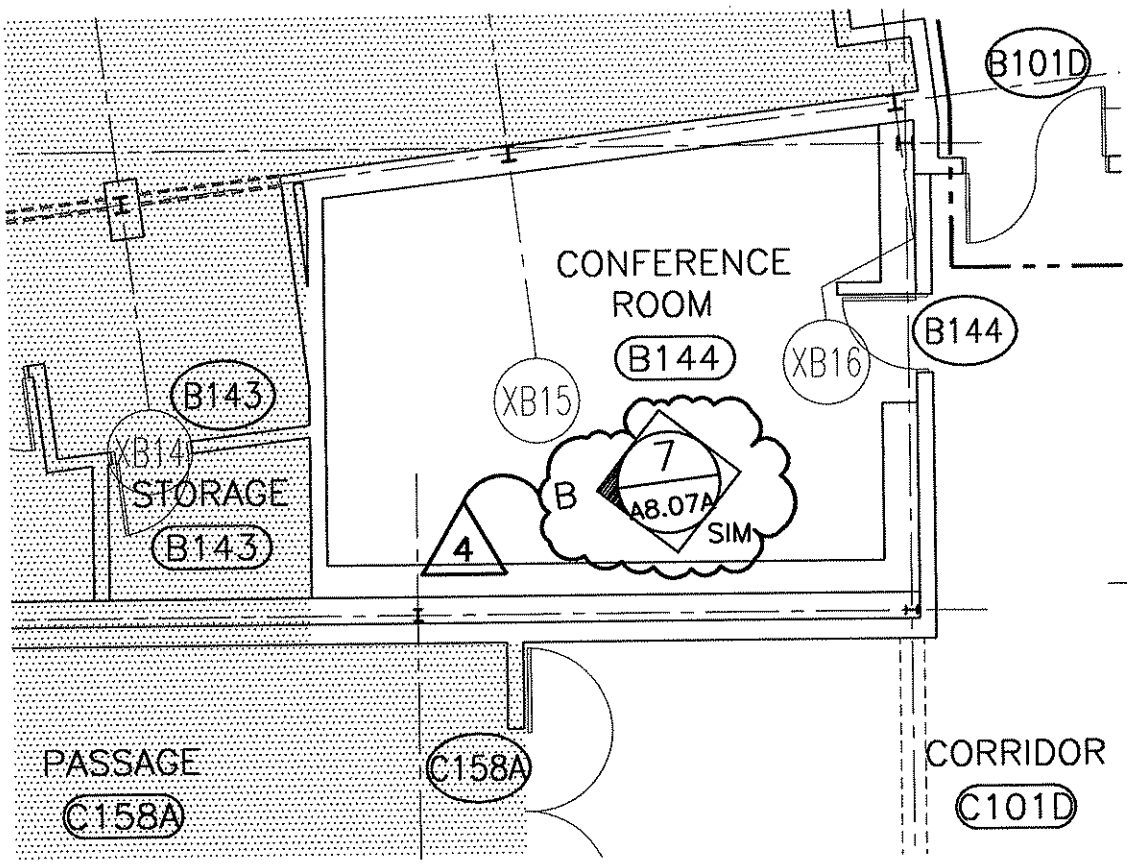
TITLE
FIRST FLOOR PLAN
AREA A

DRAWING NO.
SKA-3



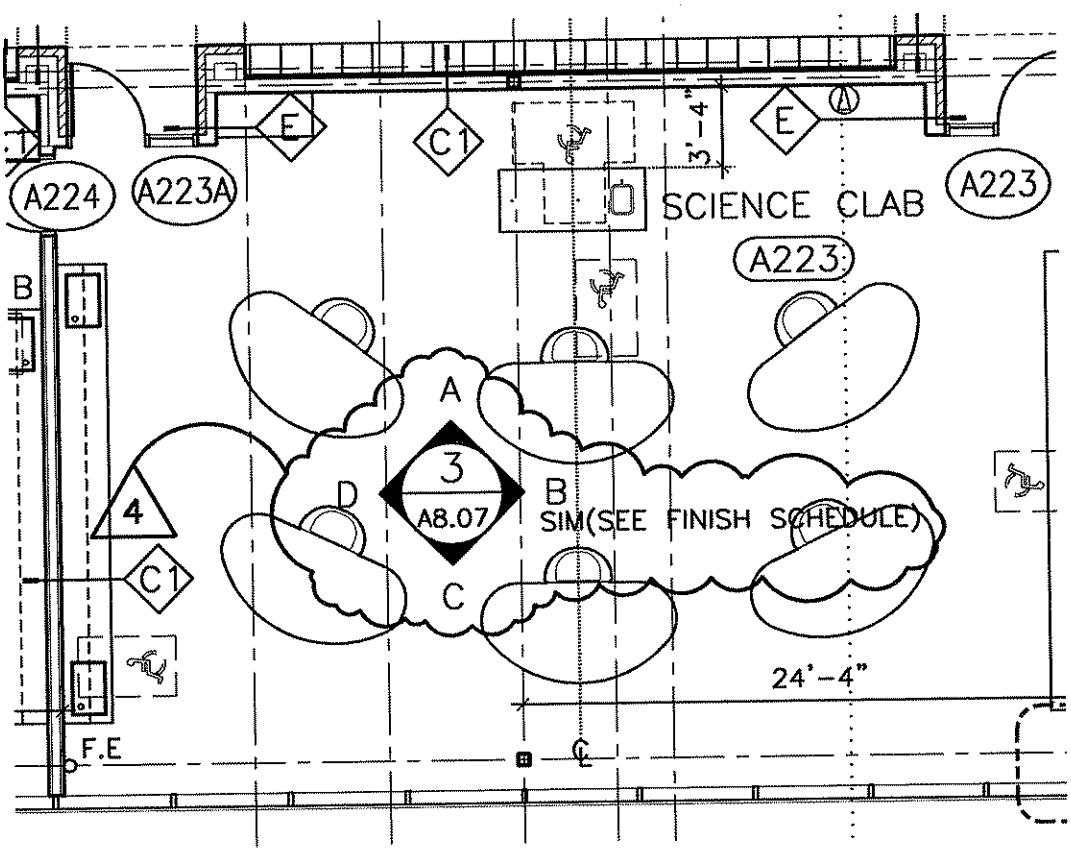
REFERENCE SHEET: A1.02
REFERENCE ADDENDUM: #4

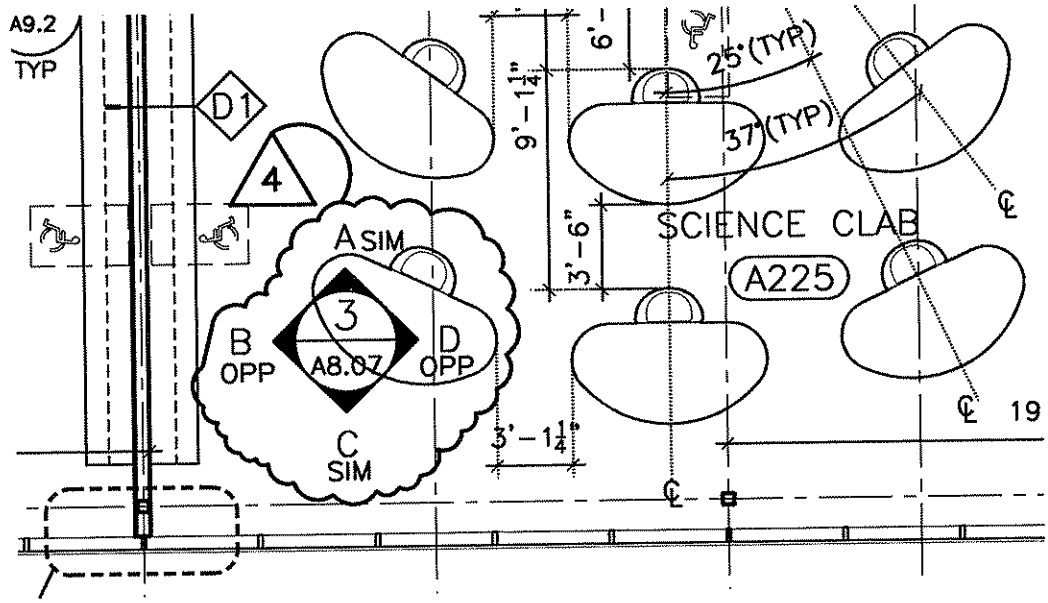
TAI SOO KIM PARTNERS TAI SOO KIM 146 Wyllys Street Hartford, Connecticut Tel: (860) 547-1970 Fax: (860) 249-0695	JOB NAME/NUMBER H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843 SCALE: 1/8" = 1'-0" DATE: 7/23/2010	TITLE FIRST FLOOR PLAN AREA A	DRAWING NO. SKA-4



REFERENCE SHEET: A1.03
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS TAI SOO KIM 146 Wyllys Street Hartford, Connecticut Tel: (860) 547-1970 Fax: (860) 249-0695	JOB NAME/NUMBER H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843 SCALE: 1/8" = 1'-0" DATE: 7/23/2010	TITLE FIRST FLOOR PLAN AREA B & C	DRAWING NO. SKA-5





REFERENCE SHEET: A1.07
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS
TAI SOO KIM
146 Wyllys Street
Hartford, Connecticut
Tel: (860) 547-1970
Fax: (860) 249-0695

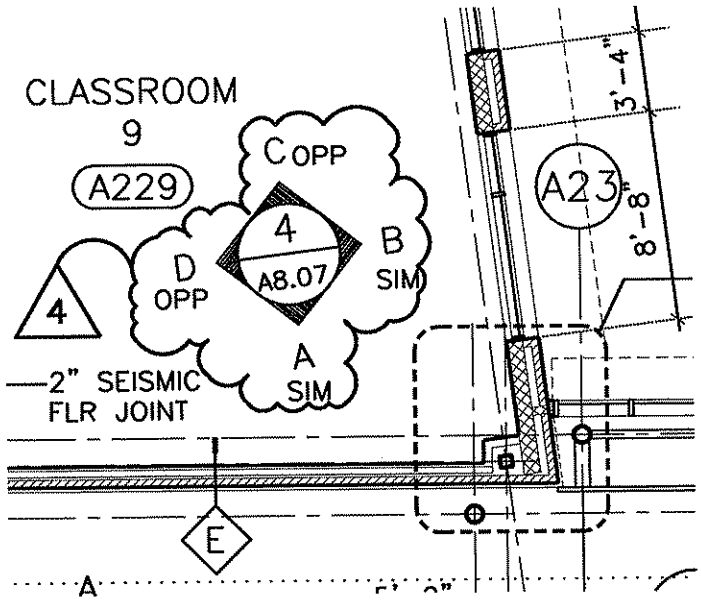
JOB NAME/NUMBER
H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843

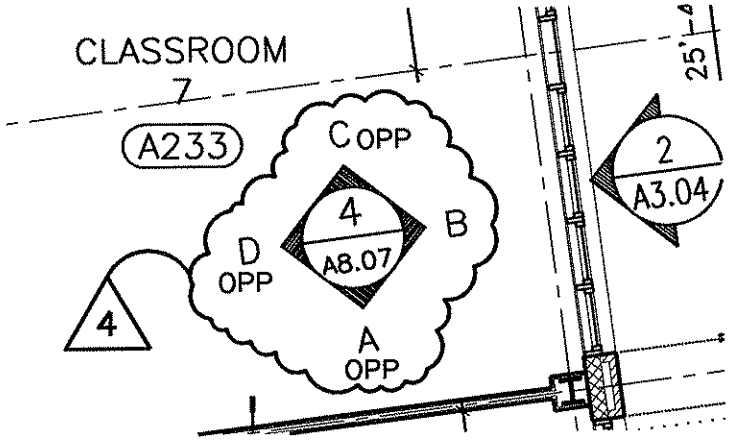
SCALE:
1/8" = 1'-0"

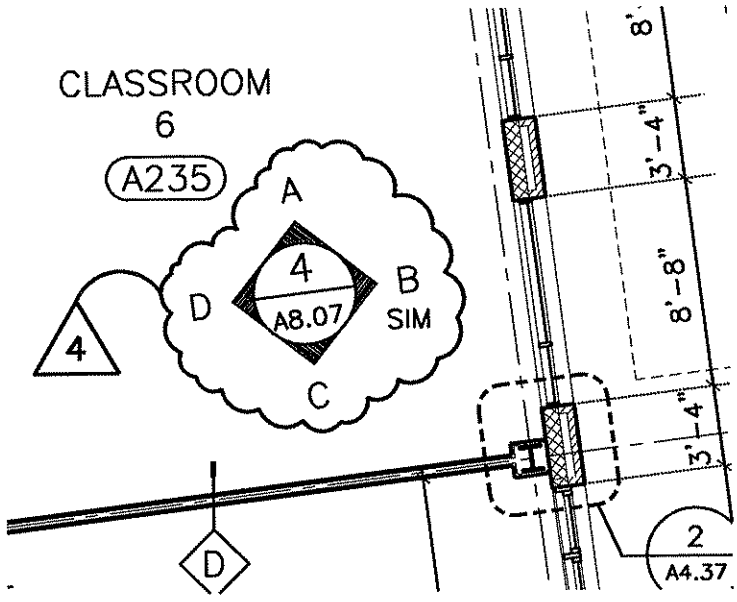
DATE:
7/23/2010

TITLE
SECOND FLOOR PLAN
AREA A

DRAWING NO.
SKA-6

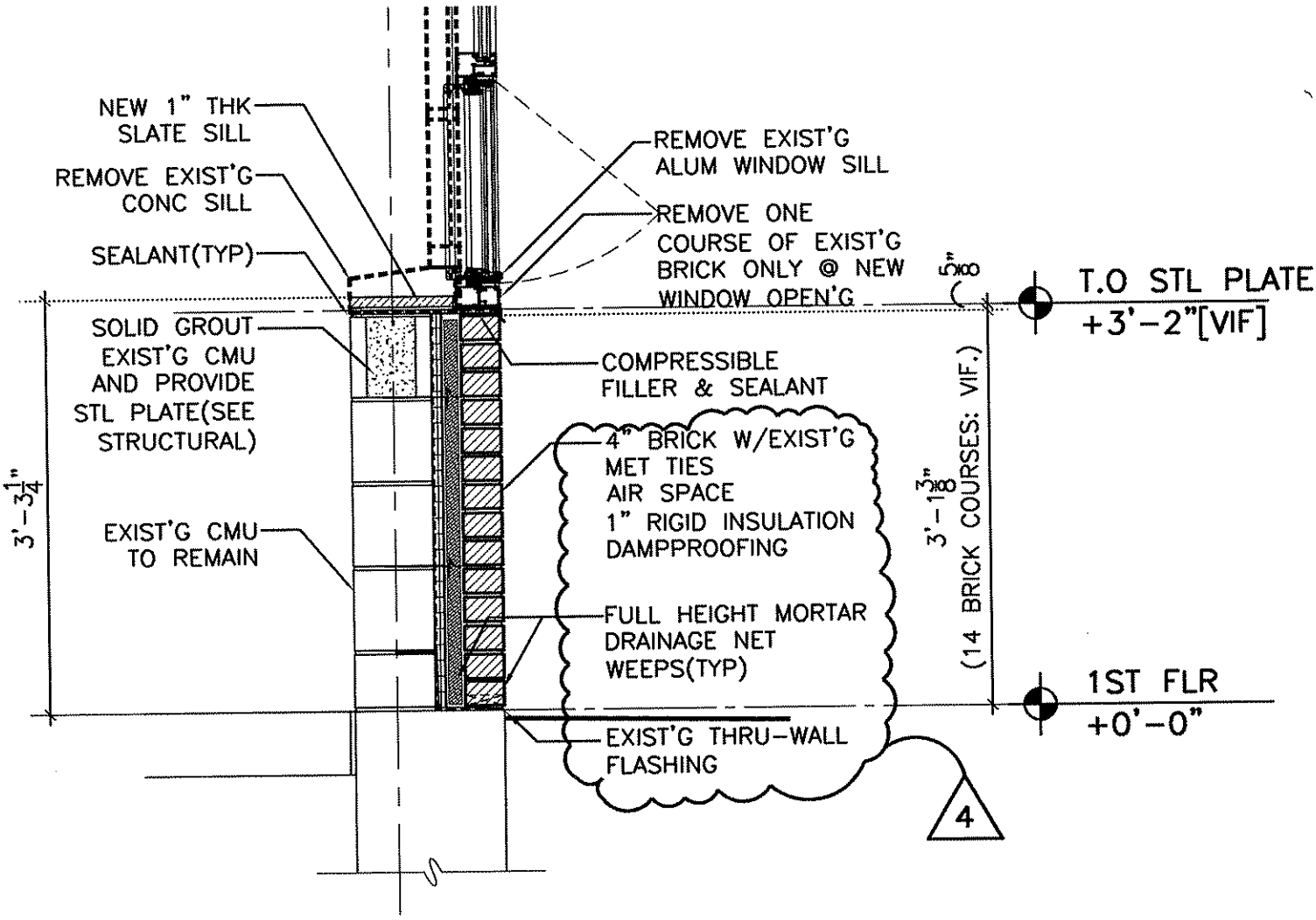






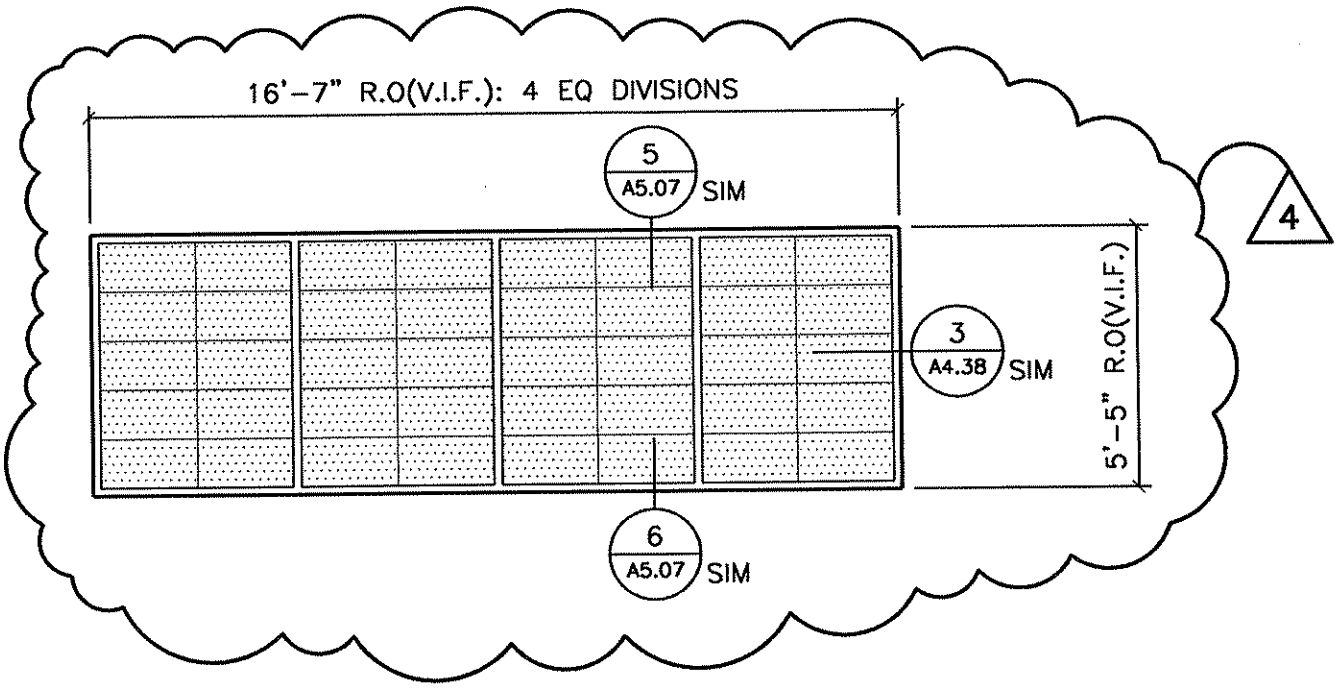
REFERENCE SHEET: A1.07
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS TAI SOO KIM 146 Wyllys Street Hartford, Connecticut Tel: (860) 547-1970 Fax: (860) 249-6695	JOB NAME/NUMBER H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843 SCALE: 1/8" = 1'-0" DATE: 7/23/2010	TITLE SECOND FLOOR PLAN AREA A	DRAWING NO. SKA-7



REFERENCE SHEET: 4/A4.10A
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS TAI SOO KIM 146 Wyllys Street Hartford, Connecticut Tel: (860) 547-1970 Fax: (860) 249-0695	JOB NAME/NUMBER H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843 SCALE: 3/4" = 1'-0" DATE: 7/23/2010	TITLE WALL SECTIONS	DRAWING NO. SKA-8

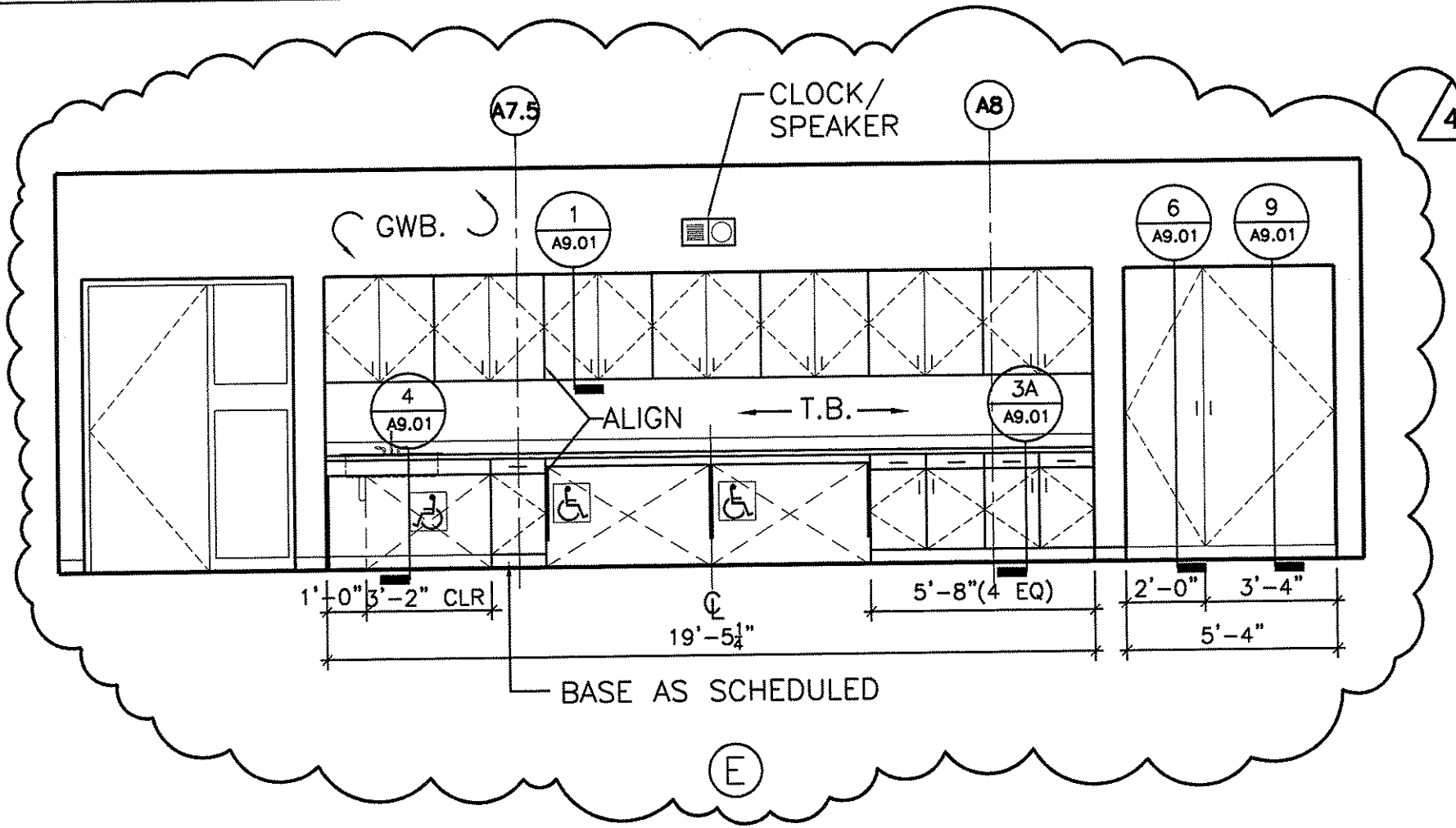


W9A SANDWICH WALL PANEL

REFERENCE SHEET: A5.01
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS
TAI SOO KIM
146 Wyllys Street
Hartford, Connecticut
Tel: (860) 547-1970
Fax: (860) 249-0695

JOB NAME/NUMBER: H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843
SCALE: 1/4" = 1'-0"
DATE: 7/23/2010
TITLE: WINDOW TYPES
DRAWING NO.: SKA-9



1 INTERIOR ELEVATIONS @ TYPICAL CLASSROOM(A163)

SCALE: 1/4"=1'-0"

REFERENCE SHEET: A8.07
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS
TAI SOO KIM
146 Wyllys Street
Hartford, Connecticut
Tel: (860) 547-1970
Fax: (860) 249-0695

JOB NAME/NUMBER
H.C. WILCOX TECHNICAL HIGH SCHOOL/B-RT-843

SCALE:
1/4" = 1'-0"

DATE:
7/23/2010

TITLE
INTERIOR ELEVATIONS
-CLASSROOMS

DRAWING NO.
SKA-10

ROOM FINISH SCHEDULE

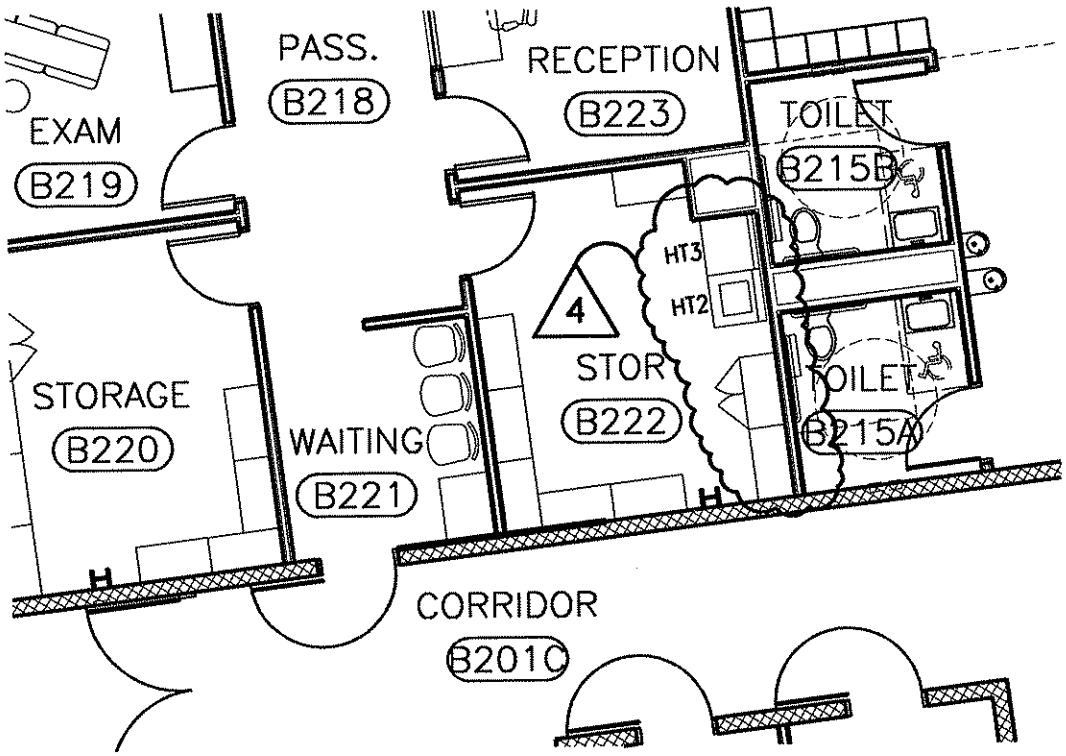
RM. NO.	ROOM NAME	FLOOR	BASE			
			NORTH	EAST	SOUTH	WEST
B133	STORAGE	VCT	VINYL	VINYL	VINYL	VINYL
B170	COMPRESS ROOM	EXTG	–	–	–	–

4

REFERENCE SHEET: A10.02
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS
TAI SOO KIM
146 Wyllys Street
Hartford, Connecticut
Tel: (860) 547-1970
Fax: (860) 249-0695

JOB NAME/NUMBER: H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843
SCALE: N/A
DATE: 7/23/2010
TITLE: ROOM FINISH SCHEDULE
DRAWING NO.: SKA-11



REFERENCE SHEET: A12.08
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS
TAI SOO KIM
146 Wyllys Street
Hartford, Connecticut
Tel: (860) 547-1970
Fax: (860) 249-0695

JOB NAME/NUMBER
H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843

SCALE:
1/8" = 1'-0"

DATE:
7/23/2010

TITLE
SECOND FLOOR
FURNITURE PLAN-AREA B

DRAWING NO.
SKA-12

EQUIPMENT SCHEDULE

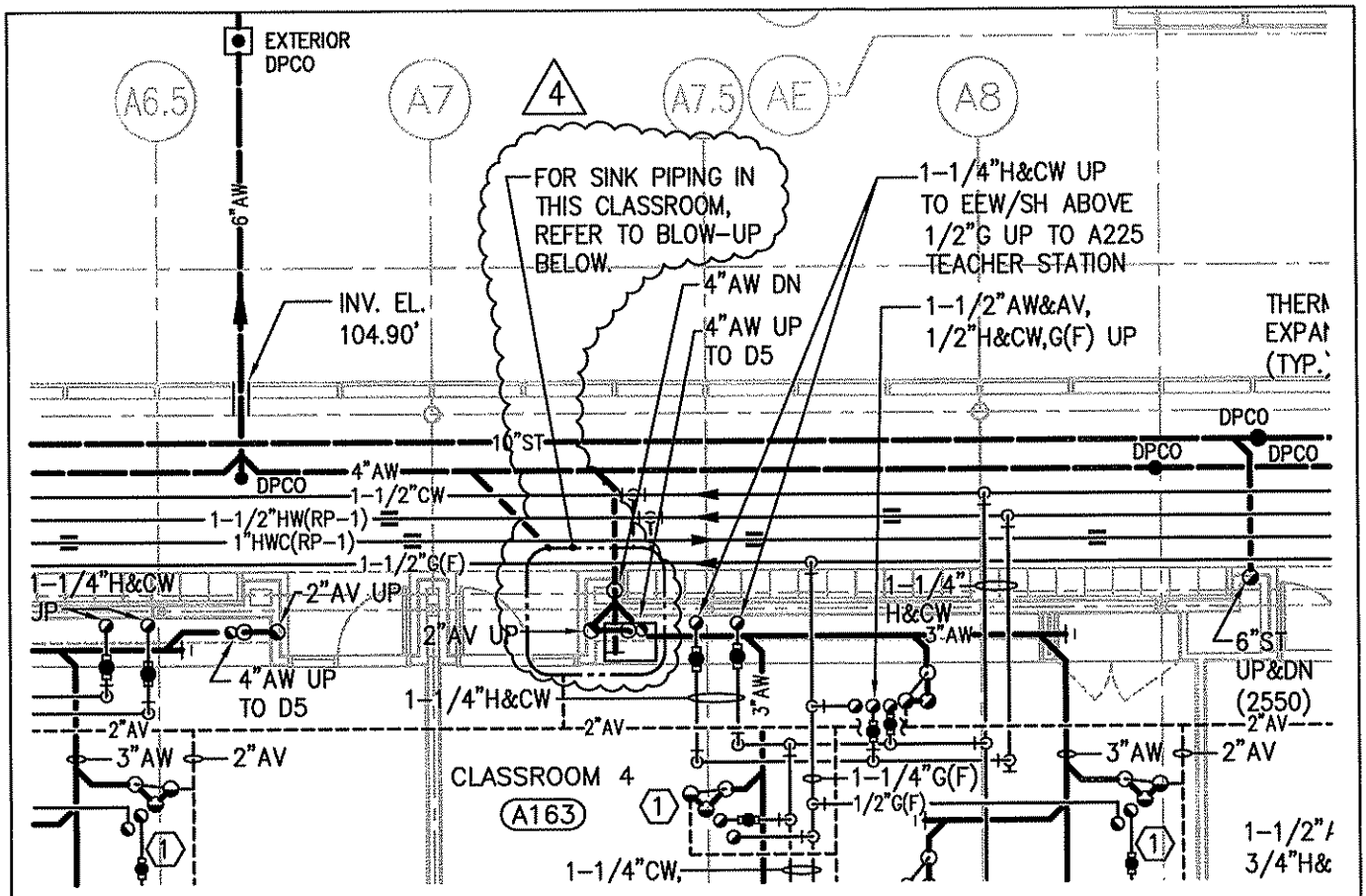
LOCATION	ITEM	NUMBER	QUANTITY	FURNISH		INSTALL		UTILITIES					POWER						HORSEPOWER	PHASE	REMARKS	CATALOG NUMBER
				G.C.	OWNER	G.C.	OWNER	H. W.	C. W.	AIR	GAS	OTHER	120 V	125 V	208 V	480 V	460 V	AMPS				
	HEALTH TECHNOLOGY (B216)																					
	MODULAR HEADWALL HT-1	HT1	4		X	X								X				20			PROVIDE POWER ONLY	
	WASHER	HT2	1		X		X	X	X				X					12				
	DRYER	HT3	1		X		X					X			X			22				

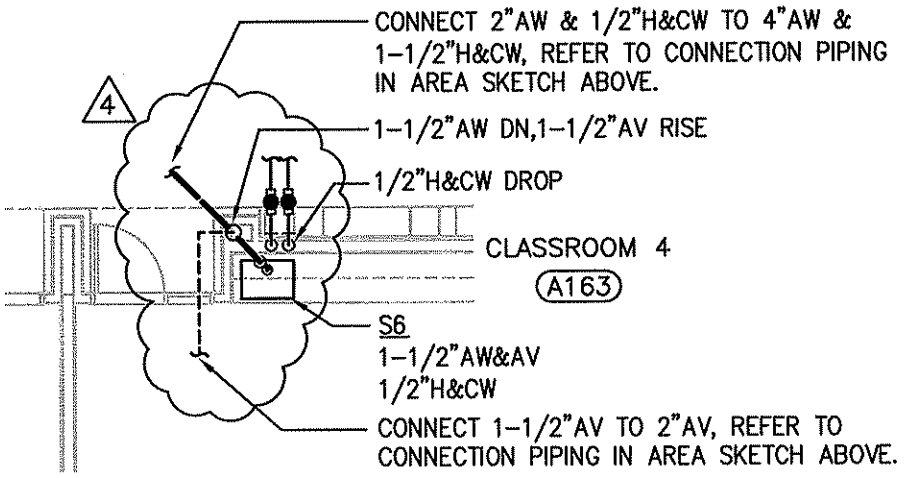
4

REFERENCE SHEET: A12.09
REFERENCE ADDENDUM: #4

TAI SOO KIM PARTNERS
TAI SOO KIM
146 Wyllys Street
Hartford, Connecticut
Tel: (860) 547-1970
Fax: (860) 249-0695

JOB NAME/NUMBER: H.C. WILCOX TECHNICAL HIGH SCHOOL/BI-RT-843
SCALE: N/A
DATE: 7/23/2010
TITLE: EQUIPMENT SCHEDULE
DRAWING NO.: SKA-13





CLASSROOM 4 #163 CLASSROOM SINK PIPING

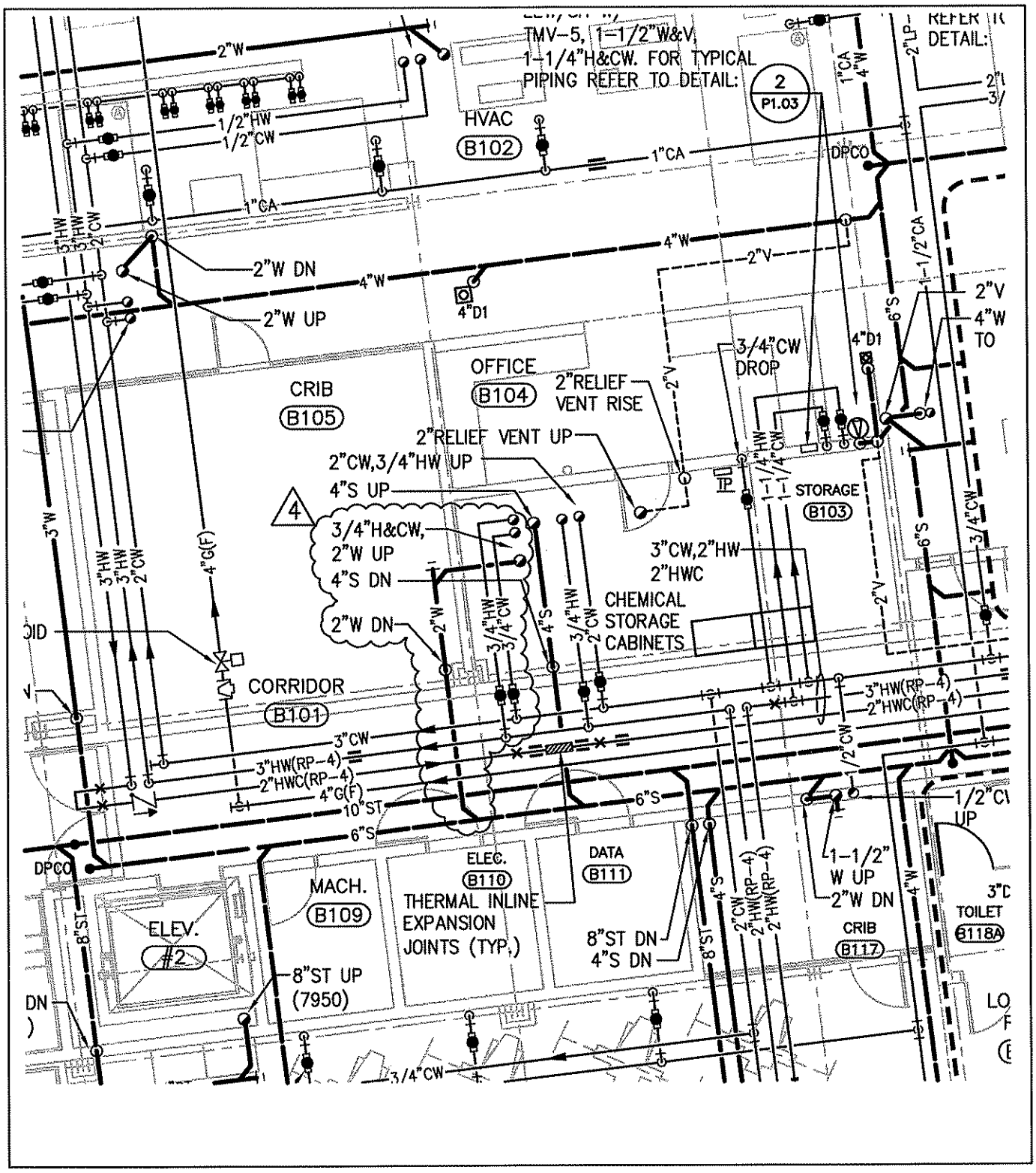
SCALE: 1/8" = 1'-0"

KOHLER RONAN, LLC
CONSULTING ENGINEERS
301 Main Street, Danbury, CT 06810
203.778.1017 F 203.778.1018
1370 Broadway, New York, NY 10018
212.695.2422 F 212.695.2423
www.kohlerronan.com
E-mail krce@kohlerronan.com

4 07/23/10 – ADDENDUM #4

PROJECT HC WILCOX/BI-RT-843 SKETCH NUMBER SKP-072310-1

PROJECT NUMBER 0532 DATE 07/23/10 REVISION TO SHEET NUMBER P1.02



KOHLER RONAN, LLC
CONSULTING ENGINEERS

301 Main Street, Danbury, CT 06810
203.778.1017 F 203.778.1018

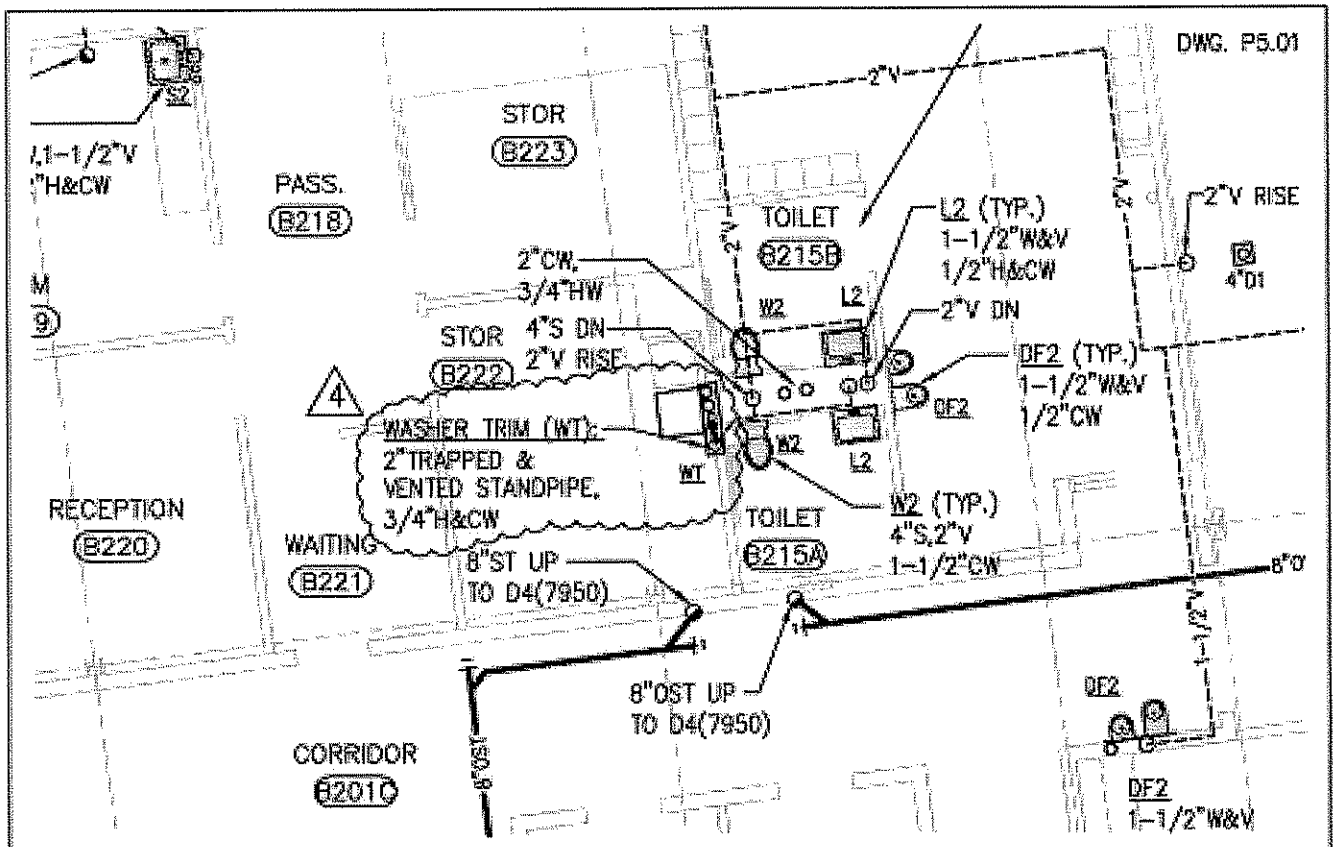
1370 Broadway, New York, NY 10018
212.695.2422 F 212.695.2423

www.kohlerronan.com
E-mail krce@kohlerronan.com

4 07/23/10 – ADDENDUM #4

PROJECT HC WILCOX/BI-RT-843 SKETCH NUMBER SKP-072310-2

PROJECT NUMBER 0532 DATE 7/23/10 REVISION TO SHEET NUMBER P1.03



PLUMBING FIXTURE SCHEDULE

FIXTURE TAG	FIXTURE TYPE	FIXTURE MANUFACTURER MODEL, MODEL NO.	DESCRIPTION
WT	WASHER TRIM	SYMMONS W-602-X PPP INC. MM-500 MLB	RECESSED EQUIPMENT WITH ½" SUPPLY CONNECTIONS, 2" DRAIN CONNECTION AND VALVE.

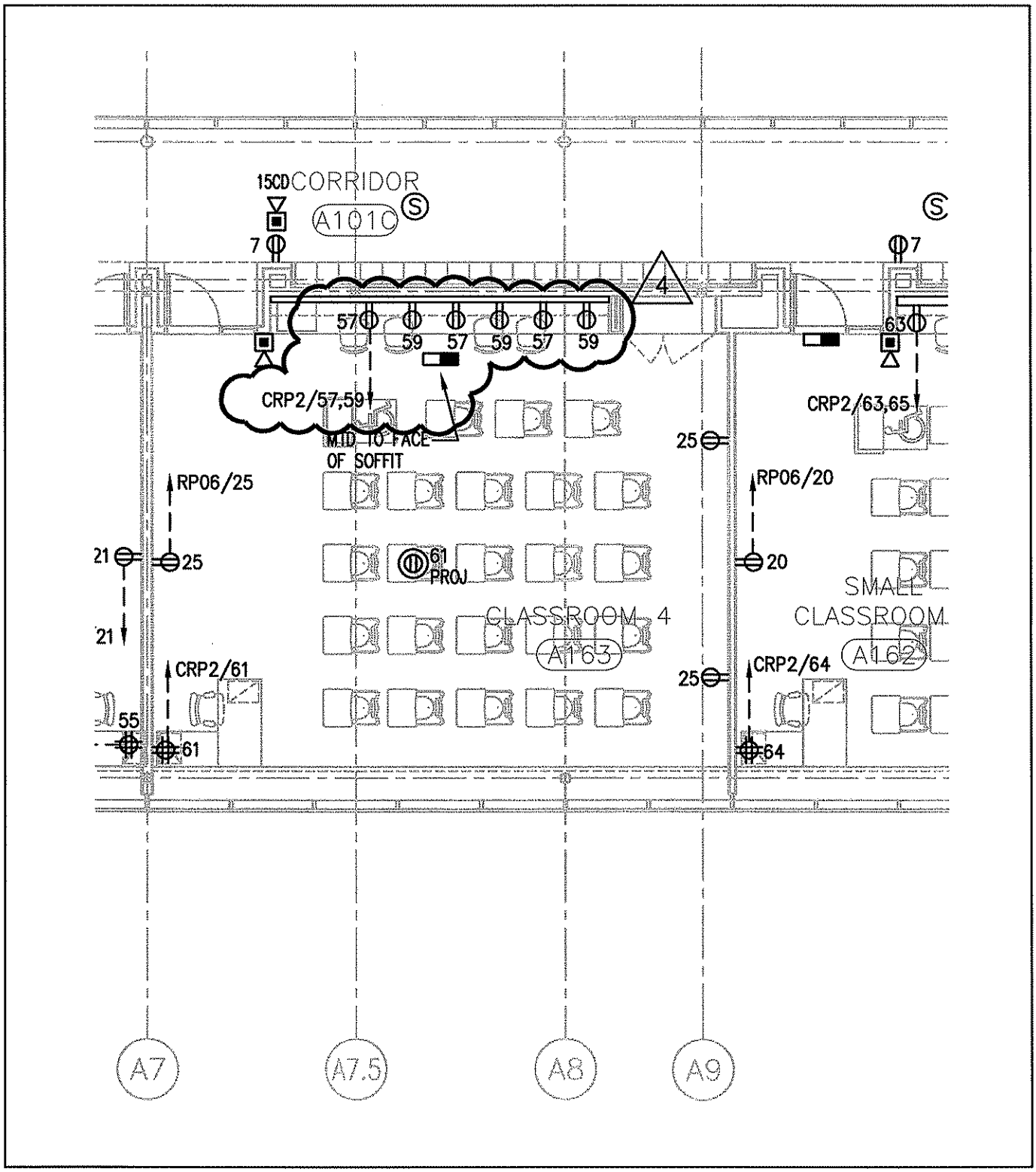
		MINIMUM BRANCH SIZES				
SUPPLY SIZE	TRAP SIZE	WASTE/ SANITARY	VENT	COLD WATER	HOT WATER	REMARKS
1/2	—	2"	—	3/4"	3/4"	CONTRACTOR TO COORDINATE INSTALLATION OF WASHER TRIM BOX WITH WALL CONDITIONS & ARCHITECT

KOHLER RONAN, LLC
921 Main Street, Danbury, CT 06810
203.778.1017 F 203.778.1018
1372 Broadway, New York, NY 10018
212.685.3422 F 212.685.3423
www.kohlerronan.com
E-mail kran@kohlerronan.com

4 07/23/10 – ADDENDUM #4

PROJECT HC WILCOX/BI-RT-843 SKETCH NUMBER SKP-072310-3

PROJECT NUMBER 0532 DATE 07/23/10 REVISION TO SHEET NUMBER P1.09



KOHLER RONAN, LLC
CONSULTING ENGINEERS

301 Main Street, Danbury, CT 06810
203.778.1017 F 203.778.1018

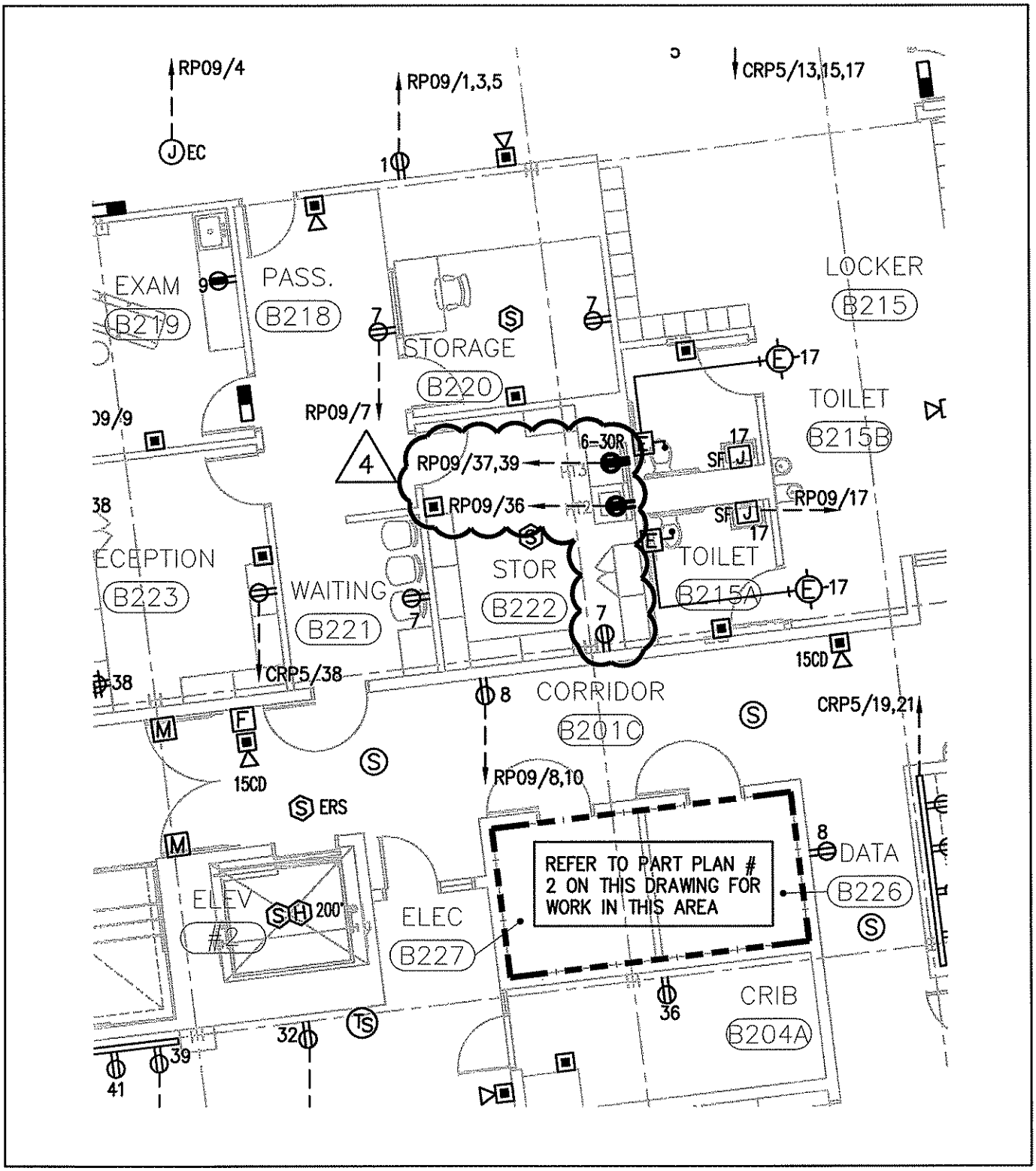
1370 Broadway, New York, NY 10018
212.695.2422 F 212.695.2423

www.kohlerronan.com
E-mail krca@kohlerronan.com

4 07/23/10 – ADDENDUM #4

PROJECT HC WILCOX/BI-RT-843 SKETCH NUMBER SKE-072310-1

PROJECT NUMBER 0532 DATE 7/23/10 REVISION TO SHEET NUMBER E1.02



KOHLER RONAN, LLC
CONSULTING ENGINEERS
301 Main Street, Danbury, CT 06810
203.778.1017 F 203.778.1018
1370 Broadway, New York, NY 10018
212.695.2422 F 212.695.2423
www.kohlerronan.com
E-mail krce@kohlerronan.com

4 07/23/10 – ADDENDUM #4

PROJECT HC WILCOX/BI-RT-843 SKETCH NUMBER SKE-072310-2

PROJECT NUMBER 0532 DATE 7/23/10 REVISION TO SHEET NUMBER E1.09

120/208V, 3 PHASE, 4 WIRE
22,000 A.I.C.

RP09

1 — 150A MCB, 225A BUS

	LOAD SERVED	WIRE & CONDUIT	TRIP	POLE	LOAD IN WATTS φA	LOAD IN WATTS φB	LOAD IN WATTS φC	POLE	TRIP	WIRE & CONDUIT	LOAD SERVED	
1	RECEPT. #B216	2 #12+G -3/4"C.	20	1	540	720		1	20	2 #12+G -3/4"C.	RECEPT. #B216	2
3	RECEPT. #B216	2 #12+G -3/4"C.	20	1		540	300	1	20	2 #12+G -3/4"C.	J.B.(EC) #B216	4
5	RECEPT. #B216	2 #12+G -3/4"C.	20	1			540 300	1	20	2 #12+G -3/4"C.	J.B.(EC) #B225	6
7	RECEPT. #B218	2 #12+G -3/4"C.	20	1	760	720		1	20	2 #12+G -3/4"C.	RECEPT. #B201C	8
9	RECEPT. #B219	2 #12+G -3/4"C.	20	1		540	720	1	20	2 #12+G -3/4"C.	RECEPT. #B201C	10
11	CALL FOR AID #B202B	2 #12+G -3/4"C.	20	1			400 500	1	20	2 #12+G -3/4"C.	CALL FOR AID #B201B	12
13	J.B.(EC) #B205A	2 #12+G -3/4"C.	20	1	300	324		1	20	2 #12+G -3/4"C.	AC-1 & RPT.	14
15	MODULAR HEADWALL	2 #12+G -3/4"C.	20	1		1080	720	1	20	2 #12+G -3/4"C.	RECEPTACLES (ROOF)	16
17	CALL FOR AID #B215A	2 #12+G -3/4"C.	20	1			400 720	1	20	2 #12+G -3/4"C.	RECEPTACLES (ROOF)	18
19	RECEPT #B214	2 #12+G -3/4"C.	20	1	720	1680		1	20	2 #12+G -3/4"C.	ACCU-1	20
21	TCP #B214	2 #12+G -3/4"C.	20	1		250	380	1	20	2 #12+G -3/4"C.	LIGHTS #STAIR B1	22
23	TX-10, TX-11	2 #12+G -3/4"C.	20	1			1176 1680	1	20	2 #12+G -3/4"C.	ACCU-1	24
25	RECEPT. #B217	2 #12+G -3/4"C.	20	1	720	540		1	20	2 #12+G -3/4"C.	RECEPT. #B203	26
27	RECEPT. #B211	2 #12+G -3/4"C.	20	1		720	540	1	20	2 #12+G -3/4"C.	RECEPT. #B212	28
29	J.B.(EC) #B212	2 #12+G -3/4"C.	20	1			300 720	1	20	2 #12+G -3/4"C.	RECEPT. #B213	30
31	RECEPT. #B202	2 #12+G -3/4"C.	20	1	540	540		1	20	2 #12+G -3/4"C.	RECEPT. #B202A	32
33	MODULAR HEADWALL	2 #12+G -3/4"C.	20	1		1080	1080	1	20	2 #12+G -3/4"C.	MODULAR HEADWALL	34
35	MODULAR HEADWALL	2 #12+G -3/4"C.	20	1			1080 1720	1	20	2 #12+G -3/4"C.	RECEPT. & TP #B214	36
37	DRYER #B222	2 #10+G -3/4"C.	30	2	2400	–		1	20	–	–	38
39						2400	–	1	20	–	–	40
41	–	–	20	1			– –	1	20	–	–	42
	LOAD PER PHASE				10504	10350	9536					
	(SURFACE MTD)	TOTAL =			30,390							

4

NO.	DATE	REVISION
1	07/23/10	ADDENDUM #1

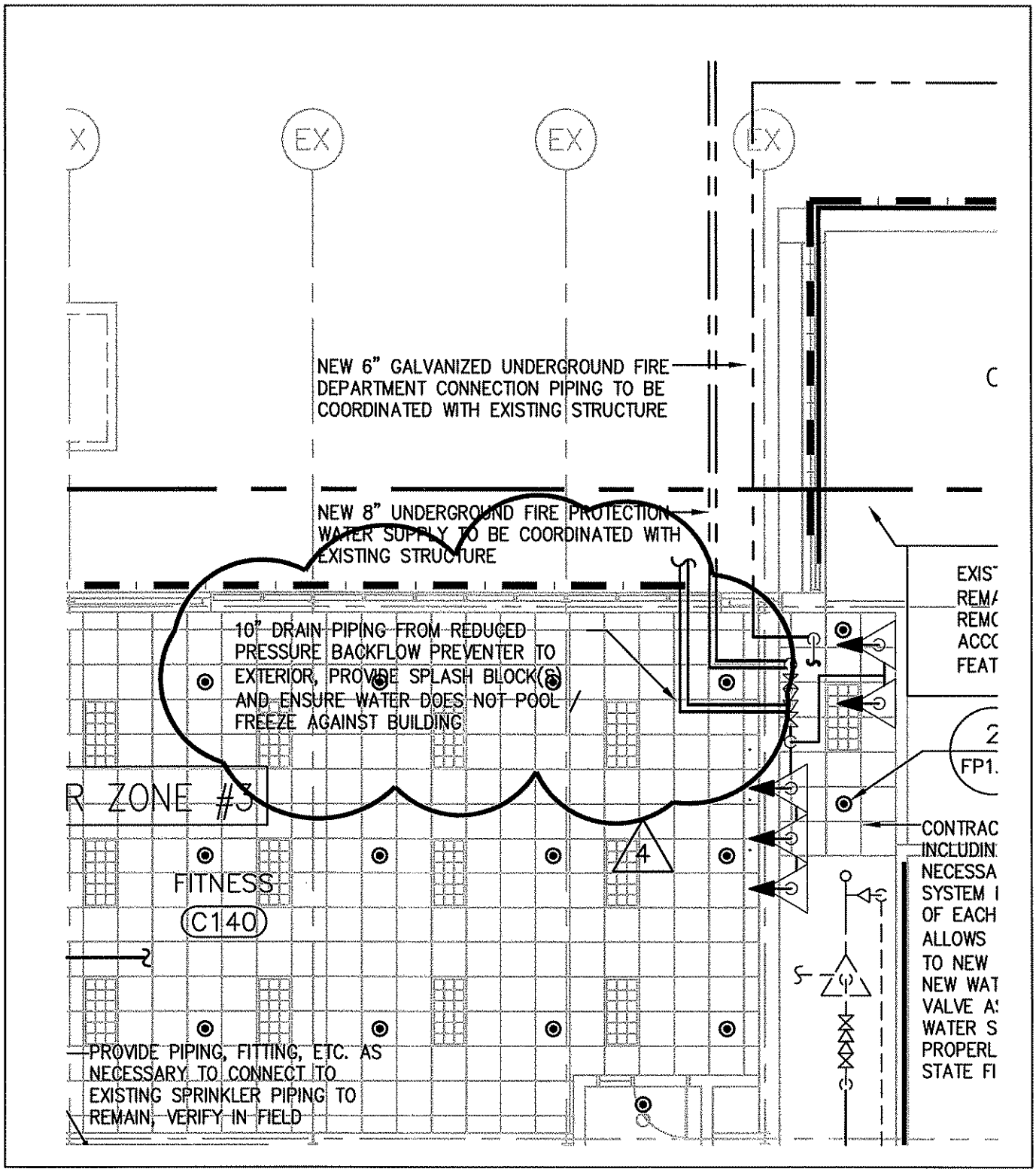
CLIENT
State of Connecticut Department of Public Works

PROJECT
H.C. Wilcox Technical High School

TITLE
SCHEDULES - ELECTRICAL

DRAWN BY: BEC | DRAWING
REV. TO DWG.: BEC
SCALE: NONE | SKE-072310-3
DATE: 07/23/10

Addendum #4

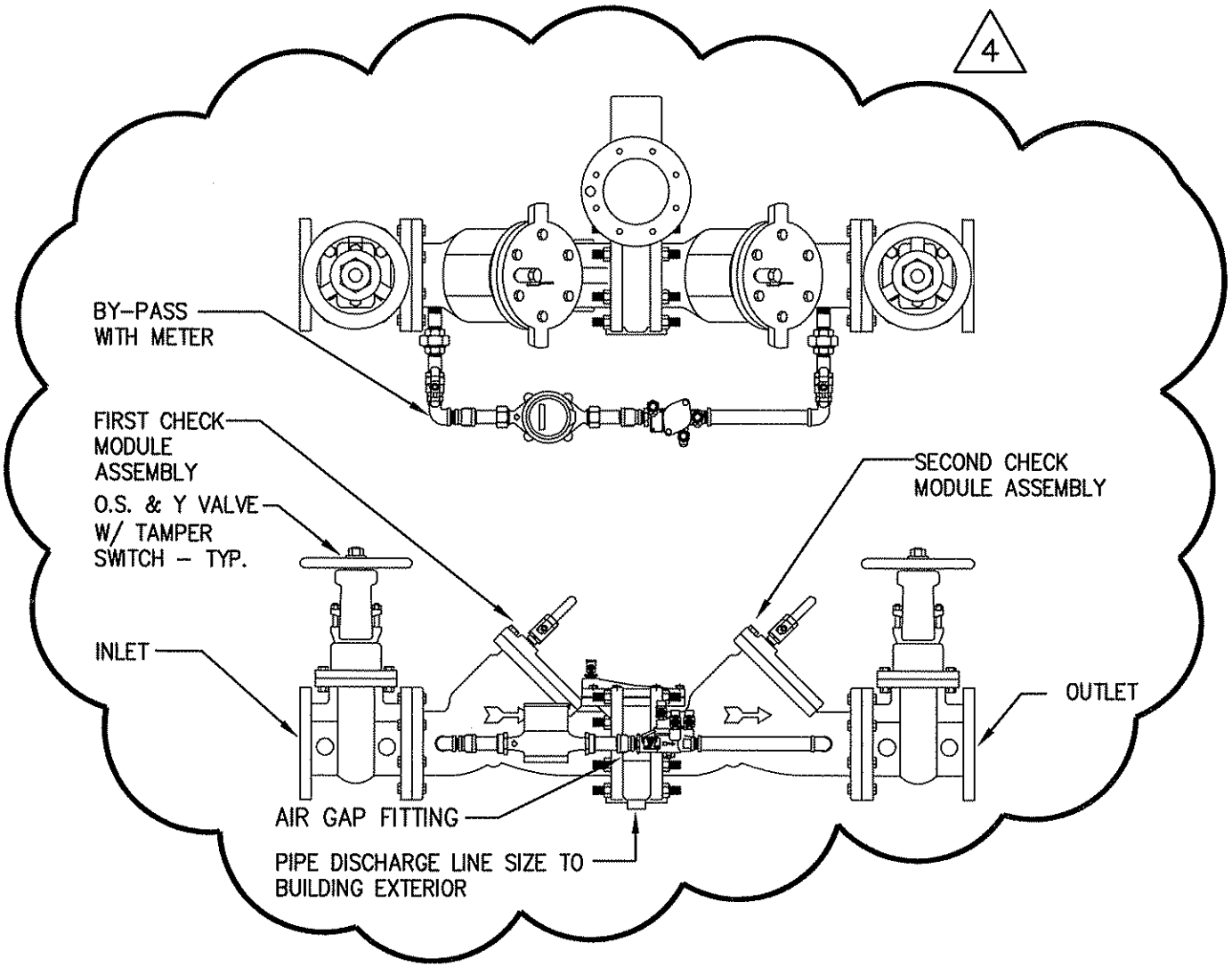


KOHLER RONAN, LLC
CONSULTING ENGINEERS
301 Main Street, Danbury, CT 06810
203.778.1017 F 203.778.1018
1370 Broadway, New York, NY 10018
212.695.2422 F 212.695.2423
www.kohlerronan.com
E-mail krce@kohlerronan.com

4 07/23/10 – ADDENDUM #4

PROJECT HC WILCOX/BI-RT-843 SKETCH NUMBER SKFP-072310-1

PROJECT NUMBER 0532 DATE 7/23/10 REVISION TO SHEET NUMBER FP1.05



3 HORIZONTAL REDUCED PRESSURE BACKFLOW ASSEMBLY

FP3.00 NOT TO SCALE

KOHLER RONAN, LLC
CONSULTING ENGINEERS

301 Main Street, Danbury, CT 06810
203.778.1017 F 203.778.1018

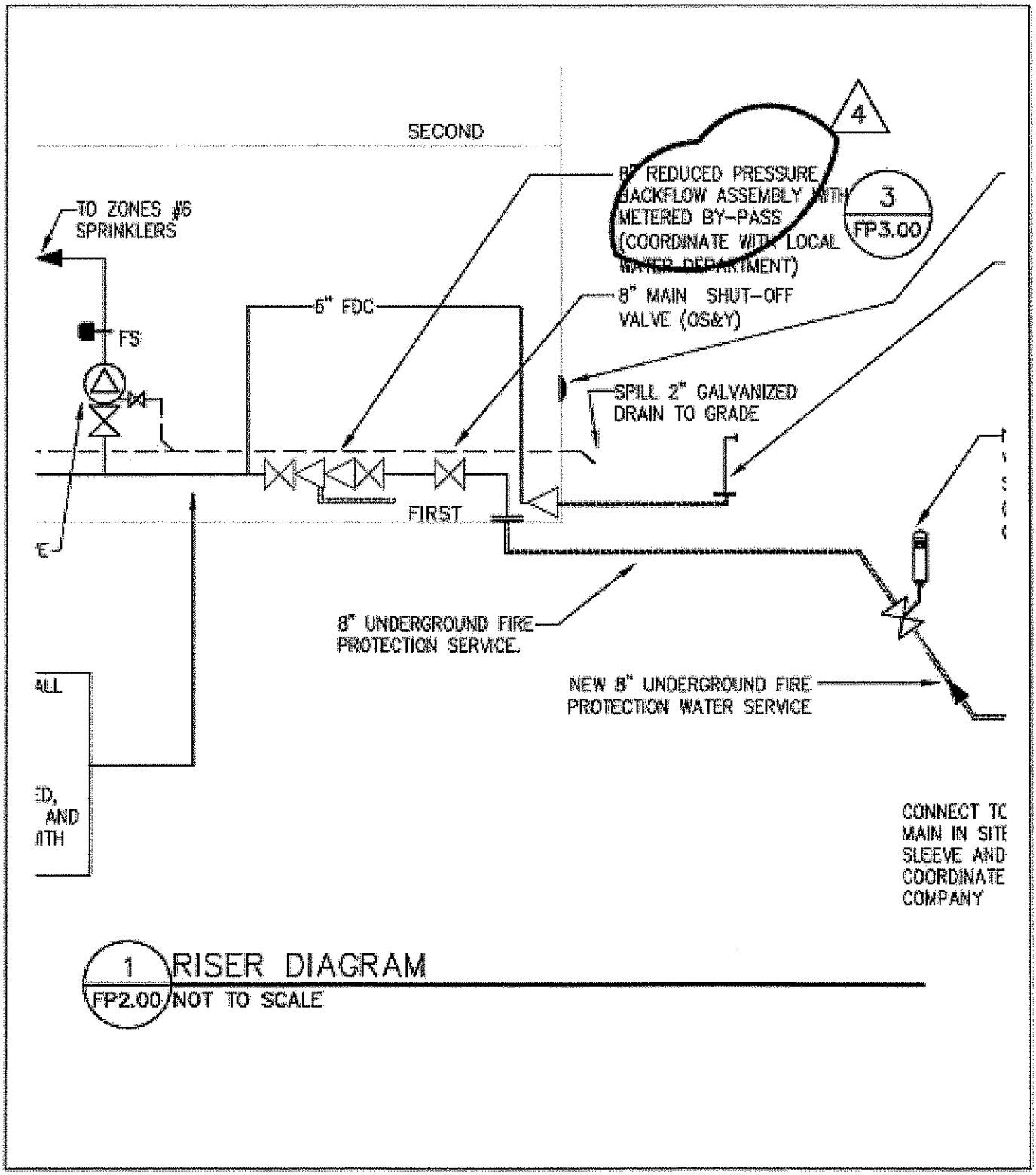
1370 Broadway, New York, NY 10018
212.695.2422 F 212.695.2423

www.kohlerronan.com
E-mail krce@kohlerronan.com

4 07/23/10 - ADDENDUM #4

PROJECT HC WILCOX/BI-RT-843 SKETCH NUMBER SKFP-072310-2

PROJECT NUMBER 0532 DATE 7/23/10 REVISION TO SHEET NUMBER FP3.00



KOHLER KONAN, LLC

4 07/23/10 – ADDENDUM #4

PROJECT HC WILCOX/BI-RT-843 SKETCH NUMBER SKFP-072310-3

PROJECT NUMBER 0532 DATE 7/23/10 REVISION TO SHEET NUMBER FP2.00

ADDITIONS AND RENOVATIONS
HC WILCOX REGIONAL VOCATIONAL TECHNICAL SCHOOL
MERIDEN, CONNECTICUT
PROJECT: BI-RT- 843

BID OPENING	**1:00 P.M.**	**July 7, 2010**
ADDENDUM NUMBER 3	**DATE OF ADDENDUM**	**June 4, 2010**

The following clarifications are applicable to drawings and specifications for the project referenced above.

Item 1

Section 00 11 16, Invitation to Bid, the Pre-bid Conference Date has been postponed. The Pre-bid Conference Date will be determined at a later date and in a subsequent addendum.

Item 2

Section 00 11 16, Invitation to Bid, the Bid Opening Date has been postponed. The Bid Opening Date will be determined at a later date and in a subsequent addendum.

All questions must be in writing (not phone or e-mail) and must be forwarded to the consulting Architect/Engineer (Tia Soo Kim Partner, LLC - 860-249-0695) with copies sent to the DPW Project Manager (Barbara Cosgrove - 860-713-7264).

End of Addendum Number THREE

Gail Blythe

Gail Blythe, Associate Fiscal Administrative Officer
Department of Public Works

ADDITIONS AND RENOVATIONS
HC WILCOX REGIONAL VOCATIONAL TECHNICAL SCHOOL
MERIDEN, CONNECTICUT
PROJECT: BI-RT- 843

BID OPENING	**1:00 P.M.**	**JULY 7, 2010**
ADDENDUM NUMBER 2	**DATE OF ADDENDUM**	**May 25, 2010**

The following clarifications are applicable to drawings and specifications for the project referenced above.

Item 1

Section 00 11 16, Invitation to Bid, the Plans and Specifications Ready Date has been postponed at this time, the status of distribution will be determined at a later date and in a subsequent addendum.

All questions must be in writing (not phone or e-mail) and must be forwarded to the consulting Architect/Engineer (Tia Soo Kim Partner, LLC - 860-249-0695) with copies sent to the DPW Project Manager (Barbara Cosgrove - 860-713-7264).

End of Addendum Number TWO

Barbara Bergeron, Associate Fiscal Administrative Officer
Department of Public Works

ADDITIONS AND RENOVATIONS
HC WILCOX REGIONAL VOCATIONAL TECHNICAL SCHOOL
MERIDEN, CONNECTICUT
PROJECT: BI-RT- 843

BID OPENING	**1:00 P.M.**	**JULY 7, 2010**
ADDENDUM NUMBER 1	**DATE OF ADDENDUM**	**MAY21, 2010**

The following clarifications are applicable to drawings and specifications for the project referenced above.

Item 1

Section 00 11 16, Invitation to Bid, the **Pre-Bid Conference** date is inaccurately stated in this Section, the correct date is Thursday, June 10, 2010.

End of Addendum Number One

Barbara Bergeron, Associate Fiscal Administrative officer
Department of Public Works

INVITATION TO BID

THRESHOLD BUILDING

FOR PROJECTS ESTIMATED TO COST MORE THAN $500,000.00

ADV. NO.: 10-28 ADV. DATE: May 21, 2010

SEALED BIDS **FROM CONTRACTORS WHO HAVE BEEN PREQUALIFIED IN THE DAS CLASSIFICATION NOTED BELOW** SHALL BE ADDRESSED TO THE DEPARTMENT OF PUBLIC WORKS - STATE OF CONNECTICUT FOR:

Project Title:	Additions and Renovations HC Wilcox Regional Vocational Technical School 298 Oregon Road Meriden, Connecticut
Project Number:	**BI-RT-843**
DAS Classification:	Group B General Building Classification
Special Requirement:	N/A
Cost Estimate Range:	$50,000,000. – $52,000,000.
Plans & Specs Ready Date:	May 26, 2010
A NON-REFUNDABLE FEE OF PER SET IS REQUIRED	$ 415.00 **Checks** should be made payable to "**Treasurer, State Of Connecticut**" and must include the prospective bidder's correct mailing address, telephone and fax numbers of where **addendum**(a) should be submitted. **USE A SEPARATE CHECK FOR EACH PROJECT**.
Examination or Purchase of Plans & Specs	Plans and specifications are available during the hours of 8:00 A.M. to 5:00 PM (Monday – Friday) and must be ordered from **Joseph Merritt, 650 Franklin Avenue, Hartford, CT 06114. Please phone Joseph Merritt when planning to purchase a complete set at 860-296-2500 on or after March 31, 2010.** Checks should be made payable to **"TREASURER, STATE of CONNECTICUT"** and must include the prospective bidder's correct mailing address, telephone and fax numbers of where addendum(a) should be submitted. **USE A SEPARATE CHECK FOR EACH PROJECT.**
Pre-Bid Conference:	All prospective bidders are required to attend a **MANDATORY** Pre-Bid Conference
Pre-Bid Conference **Time**	to be held AT 9:30 AM
Pre-Bid Conference **Date**	ON Thursday June 8, 2010
Pre-Bid Conference **Location**	AT Wilcox Technical High School, 298 Oregon Road, Meriden, CT, Tiered Lecture Hall
Pre-Bid Conference **Registration**	All prospective bidders are required to *properly* register. *Proper* registration means that the attendee has *signed* his or her name to

	the **official roster** and *listed* the name and address of the company he or she represents on the official roster no later than the designated **start time** of the pre-bid conference. **No** attendee will be allowed to register *after* the advertised start time of the pre-bid conference. **Bids** submitted by contractors who have *not properly* registered and attended the pre-bid conference shall be *rejected* as **non-responsive**.
Pre-Bid Conference **Contact**	Joe Glorioso 203-238-6260 x5272
BID OPENING DATE:	**July 7, 2010**
Receipt of Bid Package	Bids will be received at the **State Office Building, 165 Capitol Avenue, Hartford**, **CT, 06106** in **Room No. G-36** UNTIL **1:00** P.M. on the date shown **above** and thereafter publicly opened and read aloud in **Room No. G-32.**
Bid Results:	Bid results are posted on the **DPW Website** in approximately two (2) days after the bid opening date.
Set-Aside Participation	25%
Including MBE/WBE	6.25%
Gift And Campaign Contribution Certification	If awarded the subject contract and the contract has a value of **$50,000** or more the contractor will be required to sign and submit, at the time of contract execution, a **Gift And Campaign Contribution Certification**. See the DPW home page, **http://www.ct.gov/dpw**, click on **Affidavits**. For the purposes of signing the Certification, the "date DPW began planning" the subject project or services is such date noted below.
Date DPW Began Planning the Subject Project:	9/23/04
Summary and Affidavit Regarding State Ethics	Any one seeking a contract with a value of more than $500,000 shall provide with their **bid** an **Ethics Affidavit** *located* at CT **DPW Website** (**www.ct.gov/dpw**). Failure to provide this affidavit with the bid proposal shall result in rejection of the bid.
Bid Security	As **security**, *each* bid must be accompanied by a CERTIFIED CHECK made payable to "**Treasurer, State of Connecticut**," or the bid must be accompanied by a BID BOND, in the form required by the awarding authority and having surety thereto such Surety Company or Companies as are authorized to do business in this State and/or accepted by the Commissioner of the Department of Public Works for an amount not less than **10%** of the bid.
Bidders are advised that ***both*** the DEPARTMENT OF ADMINISTRATIVE SERVICES PREQUALIFICATION **CERTIFICATE** and **UPDATE STATEMENT must** accompany the ***bid*** proposal for projects *estimated* to *exceed* Five Hundred Thousand Dollars ($500,000.00) (C.G.S. 4b-91 as amended). ***Failure to supply them with the bid will result in rejection of the bid***	
Department of Administrative Services (DAS) **Contractor Prequalification Program: http://www.das.state.ct.us/busopp.asp**	
To access Executive Orders: http://www.ct.gov/governorrell/cwp/browse.asp?a=1719&bc=0&c=18433	

To access the Department of Public Works Web Site: http://www.ct.gov/dpw

Performance and **Labor and Material Bonds** to be furnished by the bidder awarded the contract shall be an amount not less than 100% of the contract price.

The Commissioner reserves the right to do any of the following without liability, including but not limited to: (a) waive technical defects in the bid proposal as he or she deems best for the interest of the State; (b) negotiate with a contractor in accordance with Connecticut General Statutes Section 4b-91;(c) reject any or all bids; (d) cancel the award or execution of any contract prior to the issuance of the "Notice To Proceed;" and, (e) advertise for new bids.

Nonresident contractors: At the time of contract signing a certificate from the Commissioner of Revenue Services must be provided which evidences that C.G.S. 12-430 for non-resident contractors has been met. For details call the Department of Revenue Services at (860) 541-3280, ext. 7.

EXECUTIVE ORDERS:

The Contract is subject to the provisions of Executive Order No. Three of Governor Thomas J. Meskill, promulgated June 16, 1971, concerning labor employment practices, Executive Order No. Seventeen of Governor Thomas J. Meskill, promulgated February 15, 1973, concerning the listing of employment openings and Executive Order No. Sixteen of Governor John G. Rowland promulgated August 4, 1999, concerning violence in the workplace, all of which are incorporated into and are made a part of the Contract as if they had been fully set forth in it. At the Contractor's request, the Client Agency shall provide a copy of these orders to the Contractor. The Contract may also be subject to Executive Order No. 7C of Governor M. Jodi Rell, promulgated July 13, 2006, concerning contracting reforms and Executive Order No. 14 of Governor M. Jodi Rell, promulgated April 17, 2006, concerning procurement of cleaning products and services, in accordance with their respective terms and conditions.

This contract is subject to the provisions of the Department of Public Works **Sexual Harassment Policy** ("Policy") and, as such, the contract may be canceled, terminated, or suspended by DPW for violation of or noncompliance with said Policy. Said document is hereby incorporated herein by reference and made a part hereof as though fully set forth herein. This policy may be found at the Department of Public Works Website at **http://www.ct.gov/dpw**, under **Publications**.

All **technical** questions must be in writing (not phoned or emailed) and faxed to the **Architect/Enginee**r with a **copy** to the **DPW Project Manager** listed below.

Architect/Engineer/ Consultant:	Tia Soo Kim Partners, LLC	Fax No:	860-249-0695
Construction Administrator	Downes Construction	Fax No:	860-225-3617
DPW Project Manager:	Barbara Cosgrove	Fax No:	860-713-7264

All **bid** questions should be addressed to the **Officer** listed below.

Associates Fiscal Administrative Officer:	Gail Blythe	Fax No:	(860) 713-7395

Contract Time Allowed: 1125 Calendar Days

Liquidated Damages: $ 4,432.00 Per Calendar Day beyond Substantial Completion

$ 3,430.00 Per Calendar Day beyond ninety (90) days after Substantial Completion

Prevailing Wage Rates: Prevailing wages are required on this project, in accordance with the schedule provided in the bid documents, pursuant to Connecticut General Statutes Section 31-53 (a) through (h), as amended.

Each contractor who is awarded a contract on or after October 1, 2002 shall be subject to provisions of the Connecticut General Statutes, Section 31-55a concerning **annual adjustments** to prevailing wages.

Wage Rates will be posted each **July** 1st on the **Department of Labor website**: **www.ctdol.state.ct.us** . Such prevailing wage adjustment shall not be considered a matter for any contract amendment.

The wages paid on an hourly basis to any mechanic, laborer or workman employed upon the work herein contracted to be done and the amount of payment or contribution paid or payable on behalf of each such employee to any employee welfare fund, as defined in subsection (h) of section 31-53 of the Connecticut General Statutes, shall be at a rate equal to the rate customary or prevailing for the same work in the same trade or occupation in the town in which such public works project is being constructed. Any contractor who is not obligated by agreement to make payment or contribution on behalf of such employees to any such employee welfare fund shall pay to each employee as part of his wages the amount of payment or contribution for his classification on each pay day.

Procurement
Department of Public Works