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The following listed documents comprise the project manual for the project listed above. Where numerical sequence of sections is interrupted, such interruptions are intentional.

The complete Project Manual for this project consists of this entire Volume 1 and 2, which must not be separated for any reason. The Architect and Owner disclaim any responsibility for any assumptions made by a contractor or subcontractor who does not receive a complete Project Manual, including all sections listed in the Table of Contents.

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bid form 00 40 00. All requests shall be in writing on the Contractor's letterhead and submitted with documented evidence of cause to Owner's Office of Procurement Diversity. Owner will review each request and may, at its sole discretion, authorize the change.

1.5.I.1 After receipt of NOA and/or NOIA letter, but Prior to Contract Execution. The Bidder may request approval of an MBE/FBE subcontractor or supplier other than one listed on Attachment B – Minority/Female Business Enterprise Program Requirements of bid form 00 40 00 provided sufficient information is supplied by the Contractor as deemed appropriate by Office of Procurement Diversity. Owner may require supporting documentation from the MBE/FBE subcontractor or supplier.

1.5.I.2 After Contract Execution. If for any reason an approved MBE/FBE subcontractor or supplier fails to meet its contractual commitment to the Bidder after an award of contract, start of construction, or during construction, the Bidder may request approval of an alternate MBE/FBE subcontractor or supplier. All requests shall be in writing on the Bidder's letterhead and submitted with documented evidence of cause to Owner's Office of Procurement Diversity. Owner may require supporting documentation from the MBE/FBE subcontractor or supplier.

2.0 CERTIFICATION OF EEO INFORMATION

The Bidder certifies that, to the best of its knowledge and belief, the workforce projection is accurate and complete and that the Bidder is not currently under suspension by the Illinois Department of Human Rights or declared ineligible by said Department to enter into a contract with the Owner.

3.0 UNUSED

4.0 RECEIPT OF ADDENDA

The Bidder acknowledges receipt of the following addenda:

#____ dated _____	#____ dated _____	#____ dated _____
#____ dated _____	#____ dated _____	#____ dated _____
#____ dated _____	#____ dated _____	#____ dated _____

5.0 EXAMINATION OF PROJECT SITE AND CONTRACT DOCUMENTS

The Bidder has visited the site and has become thoroughly familiarized with the local conditions affecting the cost of the work, the Contract Documents entitled:

CLASSROOM AND LAB - M1 STUDENTS- Peoria

dated: 09/15/16, prepared by: Lothan Van Hook DeStefano Architecture LLC

(including the agreement forms, the General Conditions, the specifications and drawings), this bid (if and as accepted by The Board of Trustees of the University of Illinois), the bidding instructions (including the Notice to Bidders and the General Instructions to Bidders) which are hereby incorporated into this bid,and all addenda thereto.

6.0 BID PRICES

The Bidder hereby bids to furnish all labor, materials, equipment, transportation, construction plant and facilities necessary to complete, in a workmanlike manner and in accordance with the Contract Documents, the Contract Division Work bid upon herein for compensation in accordance with the following prices:

NOTE: Owner will consider any Alternate bid prices left blank, marked “N/A” or “No Bid” or other indication that an additional cost is not identified by the bidder to be Zero Dollar ($0.00) bids. Alternates, if considered, will be accepted in any order as determined by the Owner. Bid alternates use a numbering scheme for identification only, not for prioritization.

6.1 01 - General Work

6.1.A Base Bid

All Division 01 - General Work Base Bid Work for the fixed sum of:

_____ Dollars ($_____).

6.1.B Alternates

Alternate #01 - Seminar Rooms A200B & A200C- complete build out

_____ Dollars ($_____).

Alternate #02 - Seminar Room A209- complete build out

_____ Dollars ($_____).

Alternate #03 - Seminar Room B216- complete build out

_____ Dollars ($_____).

Alternate #04 - Add fire rated glass wall in TBL classroom A200A, east wall in lieu of drywall partition.

_____ Dollars ($_____).

Alternate #05 - Glass markerboards in Room A200A, in lieu of porcelain steel enameled panels

_____ Dollars ($_____).

Alternate #06 - Replace existing rooftop access ladder.

_____ Dollars ($_____).

Alternate #7 - Additional telecommunication ports with cabling and termination in TBL Classroom A200A.

_____ Dollars ($_____).

6.2 03 - Heating Work

6.2.A Base Bid

All Division 03 - Heating Work Base Bid Work for the fixed sum of:

_____ Dollars ($_____).

6.2.B Alternates

Alternate #01 - Seminar Rooms A200B & A200C- complete build out

_____ Dollars ($_____).

Alternate #02 - Seminar Room A209- complete build out

_____ Dollars ($_____).

Alternate #03 - Seminar Room B216- complete build out

_____ Dollars ($_____).

Alternate #04 - Add fire rated glass wall in TBL classroom A200A, east wall in lieu of drywall partition.

_____ Dollars ($_____).

Alternate #05 - Glass markerboards in Room A200A, in lieu of porcelain steel enameled panels

_____ Dollars ($_____).

Alternate #06 - Replace existing rooftop access ladder.

_____ Dollars ($_____).

Alternate #7 - Additional telecommunication ports with cabling and termination in TBL Classroom A200A.

_____ Dollars ($_____).

6.3 04 - Ventilation Work

6.3.A Base Bid

All Division 04 - Ventilation Work Base Bid Work for the fixed sum of:

_____ Dollars ($_____).

6.3.B Alternates

Alternate #01 - Seminar Rooms A200B & A200C- complete build out

_____ Dollars ($_____).

Alternate #02 - Seminar Room A209- complete build out

_____ Dollars ($_____).

Alternate #03 - Seminar Room B216- complete build out

_____ Dollars ($_____).

Alternate #04 - Add fire rated glass wall in TBL classroom A200A, east wall in lieu of drywall partition.

_____ Dollars ($_____).

Alternate #05 - Glass markerboards in Room A200A, in lieu of porcelain steel enameled panels

_____ Dollars ($_____).

Alternate #06 - Replace existing rooftop access ladder.

_____ Dollars ($_____).

Alternate #7 - Additional telecommunication ports with cabling and termination in TBL Classroom A200A.

_____ Dollars ($_____).

6.4 05 - Electrical Work

6.4.A Base Bid

All Division 05 - Electrical Work Base Bid Work for the fixed sum of:

_____ Dollars ($_____).

6.4.B Alternates

Alternate #01 - Seminar Rooms A200B & A200C- complete build out

_____ Dollars ($_____).

Alternate #02 - Seminar Room A209- complete build out

_____ Dollars ($_____).

Alternate #03 - Seminar Room B216- complete build out

_____ Dollars ($_____).

Alternate #04 - Add fire rated glass wall in TBL classroom A200A, east wall in lieu of drywall partition.

_____ Dollars ($_____).

Alternate #05 - Glass markerboards in Room A200A, in lieu of porcelain steel enameled panels

_____ Dollars ($_____).

Alternate #06 - Replace existing rooftop access ladder.

_____ Dollars ($_____).

Alternate #7 - Additional telecommunication ports with cabling and termination in TBL Classroom A200A.

_____ Dollars ($_____).

7.0 CONTRACT TIME

7.1 Starting Date. The Bidder for Contract Division 01 - General Work hereby agrees that, if awarded a contract for the Work bid upon herein, the Bidder shall commence the Work on the date specified in a written Notice to Proceed from the Owner.

Completion Date. Time is of the essence in this contract. The Bidder agrees to achieve Substantial Completion of the Work bid upon as expeditiously as the Work will permit, in such a manner as to cause no delay to any of the other contractors employed in the Work or to the completion of the Work as a whole and, subject to adjustments as provided by the Contract Documents, no later than 150 calendar days from the date specified in the Notice to Proceed (the “Substantial Completion Date”).

The Bidder agrees to achieve Final Completion of the Work bid upon within thirty (30) days after Substantial Completion. Neither the Substantial Completion Date nor the time for Final Completion shall be changed except by Change Order issued in accordance with the terms of the Contract Documents.

7.2 Starting Date. The Bidder(s) for Contract Division(s) 03 - Heating Work, 04 - Ventilation Work, 05 - Electrical Work hereby agree(s) that, if awarded a contract for the work bid for herein, the Bidder(s) shall commence the Work on the date specified in a written Notice to Proceed from the Owner.

Completion Date. Time is of the essence in this contract. The Bidder(s) agree(s) to achieve Substantial Completion of its Work as expeditiously as the Work will permit, in such a manner as to cause no delay to any of the other contractors employed in the Work or to the completion of the Work as a whole.

8.0 ASSIGNMENT OF CONTRACTS

8.1 The Bidder for Contract Division(s) 03 - Heating Work, 04 - Ventilation Work, 05 - Electrical Work hereby agrees that, if awarded the contract by Owner for the Work bid upon herein, the Bidder's contract (including all of the Bidder's rights against, and duties

SECTION 011000

SUMMARY

GENERAL

1.1 PROJECT DESCRIPTION

A. Project Name and Address: University of Illinois College of Medicine at Peoria Interior Renovations Address: 1 Illini Drive, Peoria, IL 61605.

B. Owner: University of Illinois College of Medicine at Peoria.

C. Related Requirements: The General Conditions, Supplementary Conditions, and all Division 00 and 01 Sections are a part of each and every Section of the Project Manual Specifications, Volumes One and Two.

D. See Division 00 Bidding and contract provisions for additional information regarding multiple prime bidding requirements.

1.2 MULTIPLE PRIME BIDDING

A. Division 01- General Work includes fire protection and plumbing.

1. Interior remodeling required to support the addition of M-1 students in fall of 2017. General work to include fire protection and plumbing work. New partitions and architectural finishes to be provided in two renovated areas of existing building. In building area A, existing lecture room A200A will be enlarged to be large enough to hold 70 students for team based learning. This area of renovation will be approximately 4000 S.F. Selective demolition is included in scope of work. Plumbing to be provided for new single occupant toilet room reusing existing fixtures. In building area B, program areas to create a gross anatomy lab include: the anatomy lab, classroom, locker rooms and adjacent spaces. This suite will be approx. 4193 gsf. Plumbing scope of work includes new sinks and emergency shower in anatomy lab and lavatories in locker rooms.

i. Addendum 1- Each trade is responsible for creating penetrations required by their scope of work and patch/repair existing construction as required. Penetration Firestopping to be provided as required by code. Labor rates to be based on regular time work schedule.
ii. No trailer is required on site. Space for weekly construction meeting to be provided on site by university.
iii. Each trade is responsible for removing their waste material from the site. General contractor typically coordinates dumpster rental/ waste management between the different trades. Assumption is that one dumpster will be on site at a time.

iv. See logistic plan for service access locations and path of travel for construction. General contractor to provide floor protection at path of travel with 4'x8' sheets of masonite, taped down at edges and joints. Continuous plastic sheeting/ 'visqueen' underlayment to be placed under masonite. Floor protection is only required at the second floor. General contractor to provide daily cleaning/ maintenance in path of travel.

v. Owner does not require flood or earthquake insurance.

2. General Work- Relevant Specification Sections include the following, in addition to all Division 00 Bidding and contract provisions and Division 01 General Requirements.

024119 Selective Demolition
035416 Hydraulic Cement Underlayment
055000 Metal Fabrications
061053 Miscellaneous Rough Carpentry
064113 Wood-Veneer-Faced Architectural Cabinets
~~076200 Sheet Metal Flashing and Trim~~
078413 Penetration Firestopping
078443 Joint Firestopping
079200 Joint Sealants
079219 Acoustical Joint Sealants
081113 Hollow Metal Doors and Frames
087100 Door Hardware
088000 Glazing
088300 Mirrors
092116.23 Gypsum Board Shaft Wall Assemblies
092216 Non-Structural Metal Framing
092900 Gypsum Board
093013 Ceramic Tiling
095113 Acoustical Panel Ceilings
096513 Resilient Base and Accessories
096516 Resilient Sheet Flooring
096813 Tile Carpeting
097200 Wall Covering
099123 Interior Painting
099653 Electrostatic Metal Painting
101000 Visual Display Surfaces
101423.13 Room-Identification Signage
102113.13 Metal Toilet Compartments
102239 Folding Panel Partitions
102600 Wall and Door Protection
102800 Toilet, Bath, and Laundry Accessories
104413 Fire Protection Cabinets
104416 Fire Extinguishers
105113 Metal Lockers
~~115213 Projection Screens~~ Projection Screens provided by AV Vendor under separate contract
122413 Roller Window Shades
123213 Manufactured Wood-Veneer-Faced Casework
123616 Metal Countertops

123623.13 Plastic-Laminate-Clad Countertops
200000 General Mechanical Requirements
200529 Mechanical Supporting Devices
200553 Mechanical Systems Identification
200573 Mechanical Systems Firestopping
200700 Mechanical Systems Insulation
21 0000 General Fire Suppression Requirements
21 1314 Automatic Fire Sprinkler System
22 0000 General Plumbing Requirements
22 0533 Electrical Heat Tracing
22 1118 Water Distribution System
22 1314 Sanitary Waste and Storm Drainage Systems
22 2114 Plumbing Specialties
22 4000 Plumbing Fixtures

B. Division 03 – Heating Work

1. Temperature Controls Contractor shall integrate to existing Tridium system and shall provide building controller and software updates for the renovated building. A new controller and programing will be required for a new air handling unit and new terminal units. Controllers, programing, wiring, valves and sensors shall be provided as identified on drawings and as written in specifications.
2. Renovated building area is broken up into two areas of renovation, Area A- Team Based Learning Classroom and Area B-Gross Anatomy Lab, totaling approximately 8,193 gsf. Heating and Piping contractor to provide new hot water reheat piping to new Anatomy Lab located on the 2nd floor Area B, and new heat piping to dedicated roof mounted air handler including re-circulating in-line pump and control valves. Provide new dedicated DX split system air conditioning units to IT/AV closets B227, including new refrigerant and condensate piping, route refrigerant piping up to remote mounted air cooled condenser and condensate piping down to nearest floor drain. New hot water and chilled water tie-in points will be made in the first floor mechanical room and routed up to the second and third floors via new utility chases. The Area A- Team Based Learning Classroom: dedicated DX split system air conditioning units to IT/AV closets A217, including new refrigerant and condensate piping, route refrigerant piping up to remote mounted air cooled condenser and condensate piping down to nearest floor drain.
   i. Addendum 1- Each trade is responsible for creating penetrations required by their scope of work and patch/repair existing construction as required. Penetration Firestopping to be provided as required by code.
   ii. Labor rates to be based on regular time work schedule.
   iii. No trailer is required on site. Space for weekly construction meeting to be provided on site by university.
   iv. Each trade is responsible for removing their waste material from the site.
   v. Heating and Piping contractor to include an allowance for 40 hours of research time to trace existing temperature controls, heating and piping building services in Rooms B221 and B223. All unused wiring, conduit, hangers, etc to be removed.
   vi. Owner does not require flood or earthquake insurance.

3. Heating Work- Relevant Specification Sections include the following, in addition to all Division 00 Bidding and contract provisions and Division 01 General Requirements.

078413	Penetration Firestopping
200000	General Mechanical Requirements
200513	Motors
200529	Mechanical Supporting Devices
200553	Mechanical Systems Identification
200573	Mechanical Systems Firestopping
200700	Mechanical Systems Insulation
230000	General HVAC Requirements,
230550	Vibration Isolation
230594	Water Systems Test Adjust Balance
230901	Control Systems Integration
230902	Control Valves and Dampers
230903	Control Instrumentation
230923	Direct Digital Controllers and Networks
230924	Graphical User Interface Integration
230993	Control Sequences
232116	Pipe and Pipe Fittings
232118	Valves
232120	Piping Specialties
232123	Pumps
232314	Refrigeration Systems
237214	Heat Recovery Equipment
237328	Factory Fabricated Custom Air Handling Units (applies to Division 3 and 4, unit provided by ventilation contractor)
238123	Self-Contained air Conditioning Units
238214	Heating and Cooling Terminal Devices
238216	Coils

C. Division 04 – Ventilation Work

1. Renovated building area is broken up into two areas of renovation, Area A- Team Based Learning Classroom and Area B-Gross Anatomy Lab, totaling approximately 8,193 gsf. Ventilation contractor to provide new dedicated roof mounted air handler with heat recovery system and integral exhaust fan. Route new galvanized supply and exhaust ductwork to and from new Anatomy Lab located on the 2nd floor Area B. The Anatomy lab will consist of new Phoenix supply and exhaust air valves, high and low level exhaust and high supply air duct distribution.
2. The Area A- Team Based Learning Classroom, will utilize the existing supply and return system. Ventilation contractor to provide new supply variable air volume boxes with sound traps, new supply air duct distribution off of existing supply mains, ceiling diffusers and return grilles to plenum return ceiling.

    i. Addendum 1- Each trade is responsible for creating penetrations required by their scope of work and patch/repair existing construction as required. Penetration Firestopping to be provided as required by code.

ii. Labor rates to be based on regular time work schedule.
iii. No trailer is required on site. Space for weekly construction meeting to be provided on site by university.
iv. Each trade is responsible for removing their waste material from the site.
v. Ventilation contractor to include an allowance for 40 hours of research time to trace existing ventilation building services in Rooms B221 and B223. All unused ducts, hangers, diffusers etc to be removed.
vi. Owner does not require flood or earthquake insurance.

3. Ventilation Work- Relevant Specification Sections include the following, in addition to all Division 00 Bidding and contract provisions and Division 01 General Requirements.

075323	EPDM Roofing
076200	Sheet Metal Flashing and Trim
078413	Penetration Firestopping
200000	General Mechanical Requirements
200513	Motors
200529	Mechanical Supporting Devices
200553	Mechanical Systems Identification
200573	Mechanical Systems Firestopping
200700	Mechanical Systems Insulation
230000	General HVAC Requirements
230550	Vibration Isolation
230595	Air Systems Test Adjust Balance
233114	Ductwork
233118	Built-Up Air Handling Housings
233314	Ductwork Specialties
233400	Fans
233600	Air Terminal Devices
233713	Diffusers, Registers and Grilles
234114	Filters
237328	Factory Fabricated Custom Air Handling Units

D. Division 05 – Electrical Work

1. Renovated building area is broken up into two areas of renovation, Area A- Team Based Learning Classroom and Area B-Gross Anatomy Lab, totaling approximately 8,193 gsf. Electrical contractor to provide lighting and receptacles in renovated spaces as shown on electrical drawings. Electrical connections will be required for new rooftop air handling unit. The electrical scope of work will support power and data requirements of new audio visual system in classrooms, anatomy lab and seminar rooms. Electrical contractor to install only conduit and back boxes with pull string for A/V. Installation of audiovisual equipment, cabling, and terminations will be performed by AV vendor under separate contract.

i. Addendum 1- Each trade is responsible for creating penetrations required by their scope of work and patch/repair existing construction as required. Penetration Firestopping to be provided as required by code.
ii. Labor rates to be based on regular time work schedule.

iii. No trailer is required on site. Space for weekly construction meeting to be provided on site by university.
iv. Each trade is responsible for removing their waste material from the site.
v. Electrical contractor to include an allowance for 40 hours of research time to trace existing electrical building services in Rooms B221 and B223. All unused wiring, conduit and, hangers to be removed.
vi. Owner does not require flood or earthquake insurance.

2. Electrical Work- Relevant Specification Sections include the following, in addition to all Division 00 Bidding and contract provisions and Division 01 General Requirements.

078413	Penetration Firestopping
26 0000	General Electrical Requirements
26 0516	Owner-Furnished Equipment
26 0519	Low-Voltage Electrical Power Conductors and Cables
26 0526	Grounding and Bonding for Electrical Systems
26 0529	Hangers and Supports for Electrical Systems
26 0533	Raceway and Boxes for Electrical Systems
26 0553	Electrical Systems Identification
26 0593	Electrical Systems Firestopping
26 0923	Lighting Control Devices
26 2200	Low-Voltage Transformers
26 2416.13	Lighting and Appliance Panelboards
26 2416.16	Distribution Panelboards
26 2726	Wiring Devices
26 2813	Fuses
26 2816	Enclosed Switches and Circuit Breakers
26 5000	Lighting Systems
270000	General Communications Requirements
270526	Grounding and Bonding for Communications Systems
27 0528.29	Hangers and Supports for Communications Systems
27 0528.33	Raceway and Boxes for Communications Systems
27 0553	Communications Systems Identification
27 1500	Communications Horizontal Cabling

1.3 USE OF PREMISE

A. Use of Site: Limit use of premises to work in areas indicated. Do not disturb portions of site beyond areas in which the Work is indicated.

1. Limits: Confine constructions operations to Contract Limit Lines, Property Lines.
2. Owner Occupancy: Allow for Owner occupancy of site and use by the public.
3. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.

1.4 OCCUPANCY REQUIREMENTS

A. Partial Owner Occupancy: Owner reserves the right to occupy and to place and install equipment in completed areas of building, before Substantial Completion, provided such occupancy does not interfere with completion of the Work. Such placement of equipment and partial occupancy shall not constitute acceptance of the total Work.

1. Architect will prepare a Certificate of Substantial Completion for each specific portion of the Work to be occupied before Owner occupancy.
2. Obtain a Certificate of Occupancy from authorities having jurisdiction before Owner occupancy.
3. Before partial Owner occupancy, mechanical and electrical systems shall be fully operational, and required tests and inspections shall be successfully completed. On occupancy, Owner will provide, operate, and maintain mechanical and electrical systems serving occupied portions of building.
4. On occupancy, Owner will assume responsibility for maintenance and custodial service for occupied portions of building

PRODUCTS (Not Used)

EXECUTION (Not Used)

END OF SECTION

SECTION 012300

ALTERNATES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes administrative and procedural requirements for alternates.

1.2 DEFINITIONS

A. Alternate: An amount proposed by bidders and stated on the Bid Form for certain work defined in the Bidding Requirements that may be added to or deducted from the Base Bid amount if Owner decides to accept a corresponding change either in the amount of construction to be completed or in the products, materials, equipment, systems, or installation methods described in the Contract Documents.

1. The cost or credit for each alternate is the net addition to or deduction from the Contract Sum to incorporate alternate into the Work. No other adjustments are made to the Contract Sum.

1.3 PROCEDURES

A. Coordination: Modify or adjust affected adjacent work as necessary to completely integrate work of the alternate into Project.

1. Include as part of each alternate, miscellaneous devices, accessory objects, and similar items incidental to or required for a complete installation whether or not indicated as part of alternate.

B. Notification: Immediately following award of the Contract, notify each party involved, in writing, of the status of each alternate. Indicate if alternates have been accepted, rejected, or deferred for later consideration. Include a complete description of negotiated modifications to alternates.

C. Execute accepted alternates under the same conditions as other work of the Contract.

D. Submit a price for each of the scheduled Alternates. Alternates may require the work of more than one trade. Coordinate prices to include all costs so that no additional costs is borne by the Owner due to the acceptance of additive or deductive alternates.

E. All additional costs due to the inclusion of Alternates is to be included in the amount to be added to the Contract Sum, including, without limitation, all labor, materials, equipment, supervision, taxes, permits, fees, overhead and profit, so that no additional costs will be borne by the Owner due to the inclusion of the additive or deductive Alternates.

F. Schedule: A Schedule of Alternates is included at the end of this Section. Specification Sections referenced in schedule contain requirements for materials necessary to achieve the work described under each alternate.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SCHEDULE OF ALTERNATES

A. General Work

1. Alternate No. 1: State the amount to add to the Contract Sum for the complete build out of Seminar Rooms A200B & A200C. Alternate for room build-out to include flooring, ceiling finish, folding partition and installation of whiteboards. The base bid submission shall include corridor walls with open metal stud wall cavities to allow electrical conduit to be added to room interior for future build out except where complete wall assembly is indicated on the floor plan for required fire rating. The corridor side of the wall will be paint, finished drywall as part of the base bid.
2. Alternate No. 2: State the amount to add to the Contract Sum for the complete build out for Room 209. Alternate for room build-out to include flooring, ceiling finish, and installation of whiteboards. The base bid submission shall include corridor walls with open metal stud wall cavities to allow electrical conduit to be added to room interior for future build out. The corridor side of the wall will be paint, finished drywall as part of the base bid submission.
3. Alternate No. 3: State the amount to add to the Contract Sum for the interior build out of Seminar Room B216. Alternate for room build-out to include flooring, ceiling finish, and installation of whiteboards.
4. Alternate No. 4: State the amount to add to the Contract Sum for the installation of interior storefront with frosted glass in Rooms A200A and Room 209 as indicated on partial plan K1/A-101. See architectural plan and interior elevations for dimensions. Fire protection to be provided at A200A and corridor with closely spaced sprinklers in lieu of 1 hour rated drywall partition.
5. Alternate No. 5: State the amount to add to the Contract Sum for the installation of glass markerboards in Room A200A in lieu of porcelain steel enameled whiteboard panels.
6. Alternate No. 6: State the amount to add the Contract Sum for the replacement of the existing rooftop access ladder with OSHA compliant rooftop access ladder. See A-105 for location and specification section 055000 Metal Fabrications for additional information.
7. Alternate No. 7: Not applicable.

B. Heating Work

1. Alternates No. 1-7 are not applicable. All heating, piping and temperature controls work indicated in drawings and specifications to be priced in Contract Sum.

C. Ventilation Work

1. Alternate No. 1: State the amount to add to the Contract Sum for the ventilation system complete build out for Seminar Rooms A200B & A200C as indicated M-202. The above ceiling wall openings shall be furnished in the base bid for the Contract Sum, but the transfer duct from the Seminar rooms to the Room A200A will be part of Alternate 1.
2. Alternate No. 2: State the amount to add to the Contract Sum for the ventilation system complete build out for Room A209 as indicated M-202. Diffusers to be located in coordination with architectural reflected ceiling plan.
3. Alternate No. 3: State the amount to add to the Contract Sum for the ventilation system complete build out for Room B216 as indicated M-201. Diffusers to be located in coordination with architectural reflected ceiling plan.
4. Alternate No. 4: Not applicable.
5. Alternate No. 5: Not applicable.
6. Alternate No. 6: Not applicable.
7. Alternate No. 7: Not applicable.

D. Electrical Work

1. Alternate No. 1: State the amount to add to the Contract Sum for the complete build out of Seminar Rooms A200B & A200C. Alternate for room build-out to includes lighting, power and data at west and east walls. The Contract Sum shall include receptacles shown in south wall shared with Room A200A and corridor side of partitions. The base bid submission shall include corridor walls with open metal stud wall cavities to allow electrical conduit to be added to room interior for future build out except where complete wall assembly is indicated on the floor plan for required fire rating.
2. Alternate No. 2: State the amount to add to the Contract Sum for the complete build out for Room 209. Alternate for room build-out to include lighting, power and data as indicated on E-202. The base bid submission shall include corridor walls with open metal stud wall cavities to allow electrical conduit to be added to room interior for future build out.
3. Alternate No. 3: State the amount to add to the Contract Sum for the interior build out of Seminar Room B216. Alternate for room build-out to include lighting, power and data as indicated on E-201.
4. Alternate No. 4: Not applicable.
5. Alternate No. 5: Not applicable.
6. Alternate No. 6: Not applicable.
7. Alternate No. 7: State the amount to add to the Contract Sum for the providing additional data lines in Room A200A. See E-202 for notes and locations.

END OF SECTION

SECTION 019113
GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1. COMMISSIONING DESCRIPTION
   a. This Section 01 91 13 GENERAL COMMISSIONING REQUIREMENTS shall form the basis of the construction phase commissioning process and procedures. The Commissioning Agent shall add, modify, and refine the commissioning procedures, as approved by the Owner, to suit field conditions and actual manufacturer's equipment, incorporate test data and procedure results, and provide detailed scheduling for all commissioning tasks. Additions or modifications in refining the commissioning procedures are not a basis for a change order.
   b. Various sections of the project specifications require equipment start-up, testing, and adjusting services. Requirements for start-up, testing, and adjusting services specified in the Division 07, Division 08, Division 20, Division 21, Division 22, Division 23, Division 25, Division 26, Division 27, Division 28, and Division 31 series sections of these specifications are intended to be provided in coordination with the commissioning services and are not intended to duplicate services. The Contractor shall coordinate the work required by individual specification sections with the commissioning services requirements specified herein.
   c. Where individual testing, adjusting, or related services are required in the project specifications and not specifically required by this commissioning requirements specification, the specified services shall be provided and copies of documentation, as required by those specifications, shall be submitted to the OWNER and the Commissioning Agent to be indexed for future reference.
   d. Where training or educational services for OWNER are required and specified in the Division 7, Division 08, Division 20, Division 21, Division 22, Division 23, Division 25, Division 26, Division 27, Division 28, and Division 31 series sections of the specification, these services are intended to be provided in addition to the training and educational services specified herein.
   e. Commissioning is a systematic process of verifying that the building systems perform interactively according to the construction documents and the OWNER’s operational needs. The commissioning process shall encompass and coordinate the system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training. Commissioning during the construction, acceptance, and warranty phases is intended to achieve the following specific objectives according to the contract documents:
      1). Verify that the applicable equipment and systems are installed in accordance with the contact documents and according to the manufacturer's recommendations.
      2). Verify and document proper integrated performance of equipment and systems.
      3). Verify that O&M documentation is complete.
      4). Verify that all components requiring servicing can be accessed, serviced and removed without disturbing nearby components including ducts, piping, cabling or wiring.
      5). Verify that the OWNER’s operating personnel are adequately trained.
      6). Document the successful achievement of the commissioning objectives listed above.

f. The commissioning process does not take away from or reduce the responsibility of the Contractor to provide a finished and fully functioning product.

2. RELATED WORK
   a. Division 01 – GENERAL REQUIREMENTS
   b. Division 23 – MECHANICAL
   c. Division 26 – ELECTRICAL

3. RELATED DOCUMENTS
   a. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
   b. Owner's Project Requirements (OPR) and Basis of Design (BOD) documentation prepared by Owner and Architect contains requirements that apply to this Section.

4. SUMMARY
   a. This Section includes general requirements that apply to implementation of commissioning without regard to systems, subsystems, and equipment being commissioned.

5. DEFINITIONS
   a. Architect: Includes Architect identified in the Contract for Construction between the OWNER and Contractor, plus consultant/design professionals responsible for design of fire suppression, plumbing, HVAC, controls for HVAC systems, electrical, communications, electronic safety and security, as well as other related systems.
   b. BOD: Basis of Design – The Basis of Design is a document developed by the A/E detailing the basis at which they are designing the facility in order to meet the Owner's Project Requirements and key stakeholder goals.
   c. CxA: Commissioning Agent.
   d. Commissioning Plan: a dynamic document that describes how the commissioning process will be applied to this project. It is an overall plan that provides the structure, schedule and coordination for the commissioning process.
   e. Commissioning Issue or Deficiency: a condition in the installation or function of a component, piece of equipment or system that affects the system operations, maintenance, and/or repair.
   f. Commissioning Observation: a condition in the installation or function of a component, piece of equipment or system that may not be in compliance with the Contract Documents, or may not be in compliance with the manufacturer's installation instruction, or may not be in compliance with generally accepted industry standards.
   g. OPR: Owner's Project Requirements – The OPR is a dynamic document outlining the Owner's goals and objects for the building space functions as it relates to Mechanical, Electrical, Plumbing and Electronic Safety and Security Systems.
   h. OWNER: Includes the OWNER, or other authorized representative of the Owner.
   i. Systems Functional Performance Test: a test, or tests, of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Systems Functional Performance Testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested

interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not functional testing, in the commissioning sense of the word. TAB's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The Commissioning Agent develops the Systems Functional Test Procedures in a sequential written form, coordinates, directs and documents the actual testing. Systems Functional Testing is performed by the Contractor. Systems Functional Performance Tests are performed after Pre-functional Checklists, startups, and control systems are complete and functional, and TAB functions are complete.

j. System: A system is defined as the entire complex which must be coordinated to work together during normal operation to produce results for which the complex is designed. For example, air conditioning supply air is only one component of an entire system which provides comfort conditions for a building. Other related components are return air, exhaust air, steam supply, chilled water supply, refrigerant supply, hot water supply, controls and electrical service, etc. Another example of a complex which involves several components of different disciplines is a boiler installation. Efficient and acceptable boiler operation depends upon the coordination and proper operation of the fuel supply, combustion air, controls, steam, feed water supply, condensate return and other related components.

k. Pre-functional Checklist: a list of items provided by the Commissioning Agent to the Contractor that require inspection and elementary component tests conducted to verify proper installation of equipment. Pre-functional Checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). However, some Pre-functional Checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three-phase pump motor of a chiller system). The term "System Readiness" refers to before functional testing. Pre-functional Checklists augment and are combined with the manufacturer's start-up checklist and the Contractor's Quality Control checklists.

l. Seasonal Performance Tests Functional Performance Test: a test or tests that are deferred until the system will experience conditions closer to their design conditions.

m. TAB: Testing, Adjusting, and Balancing.

n. Warranty Period - warranty period for entire project, including equipment components. Warranty begins at Substantial Completion and extends for at least one year, unless specifically noted otherwise in the Contract Documents and accepted submittals.

6. SYSTEMS TO BE COMMISSIONED

a. Commissioning of a system or systems specified for this project is part of the construction process. Documentation and testing of these systems, as well as training of the OWNER's Operation and Maintenance personnel, is required in cooperation with the OWNER and the Commissioning Agent.

b. The systems to be commissioned as part of this project include at a minimum:

1) HVAC Systems

a. Air handling units
b. Return / exaust fans
c. Terminal reheat control upgrades (terminal, induction, booster)
d. Steam converters and associated pumps
e. Electric and water meters
f. Unit heaters
g. Isolation room pressure controls
h. RO system integration
i. Building Automation Systems
j. Exhaust fans
k. CRAC units and condensing units

7. COMMISSIONING TEAM
   a. Members Appointed by Contractor:
      1). Contractor: The designated person, company, or entity that plans, schedules and coordinates the commissioning activities for the construction team.
      2). Contractor's Commissioning Representative(s): Individual(s), each having authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated actions. The commissioning team shall consist of, but not be limited to, representatives of Contractor, including Project Superintendent and sub-contractors, installers, suppliers, and specialists deemed appropriate by the OWNER and Commissioning Agent.
   b. Members Appointed by Owner:
      1). Commissioning Agent: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. The OWNER will engage the CxA under a separate contract.
      2). Representatives of the facility user and operation and maintenance personnel.
      3). Architect and engineering design professionals.

8. OWNER'S RESPONSIBILITIES
   a. Develop and provide the Owner's Project Requirements (OPR) documentation to the design team for use in developing the Basis of Design (BOD) document and the CxA for use in reviewing the design documents (basis of design document, drawings and specifications), developing the commissioning plan, Pre-functional Checklists, and functional test procedures.
   b. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities including, but not limited to, the following:
      1). Coordination meetings.
      2). Training in operation and maintenance of systems, subsystems, and equipment.
      3). Testing meetings.

4). Witness and assist in systems functional testing.

5). Demonstration of operation of systems, subsystems, and equipment.

c. Provide the design documents, prepared by Architect and approved by OWNER, to the Commissioning Agent and for use in directing the commissioning process, developing the commissioning plan, systems manuals, and reviewing the operation and maintenance training plan.

d. Provide utility services required for the commissioning process.

9. CONTRACTOR'S COMMISSIONING RESPONSIBILITIES

a. The Contractor shall assign a Commissioning Manager to manage commissioning activities of the Contractors, subcontractors, installers and vendors.

b. The Contractor shall ensure that the commissioning responsibilities outlined in these specifications are included in all sub-contracts and that sub-contractors comply with the requirements of these specifications.

c. The Contractor shall ensure that each installing sub-contractor shall assign representatives with expertise and authority to act on behalf of the sub-contractor and schedule them to participate in and perform commissioning team activities including, but not limited to, the following:

1). Participate in construction-phase commissioning coordination meetings.

2). Conduct operation and maintenance training sessions in accordance with approved training plans.

3). Verify that Work is complete and systems are operational according to the Contract Documents, including calibration of instrumentation and controls.

4). Evaluate commissioning issues and commissioning observations identified in the Commissioning Issues Log, field reports, test reports or other commissioning documents. In collaboration with entity responsible for system and equipment installation, recommend corrective action.

5). Review and comment on commissioning documentation.

6). Participate in meetings to coordinate systems functional testing.

7). Provide schedule for operation and maintenance data submittals, equipment startup, controls checkout, test and balance, and testing to Commissioning Agent for incorporation into the commissioning plan. Update schedule on a weekly basis throughout the construction period.

8). Provide information to the Commissioning Agent for developing construction-phase commissioning plan.

9). Participate in training sessions for OWNER's operation and maintenance personnel.

10). Provide technicians who are familiar with the construction and operation of installed systems and who shall develop specific test procedures to conduct systems functional performance testing of installed systems.

11). Gather and submit operation and maintenance data for systems, subsystems, and equipment to the CxA, as specified in Division 01 Section "Operation and Maintenance Data."

12). Provide technicians who are familiar with the construction and operation of installed systems and who shall develop specific test procedures and participate in testing of installed systems, subsystems, and equipment.

10. COMMISSIONING AGENT RESPONSIBILITIES
    a. Organize and lead the commissioning team.
    b. Prepare the construction phase commissioning plan.
    c. Collaborate with the Construction Manager, each Contractor, and with subcontractors to develop test and inspection procedures.
    d. Include scheduled commissioning activities coordinated with overall Project schedule.
    e. Review and comment on selected submittals from the Contractor for general conformance with the Construction Documents. Review and comment on the ability to commission the system and/or equipment, including providing gages, controls and other components required to operate, maintain, and test the system. Review and comment on performance expectations of systems and equipment and interfaces between systems relating to the Construction Documents and Owner's Project Requirements.
    f. At the beginning of the construction phase, conduct an initial construction-phase coordination meeting for the purpose of reviewing the commissioning activities and establishing tentative schedules for operation and maintenance submittals; operation and maintenance training sessions; TAB Work; Pre-functional Checklists, Systems Functional Performance Testing; and Project completion.
    g. Convene commissioning team meetings for the purpose of coordination, communication, and conflict resolution; discuss progress of the commissioning processes. Responsibilities include arranging for facilities, preparing agenda and attendance lists, and notifying participants. The Commissioning Agent shall prepare and distribute minutes to commissioning team members and attendees within five workdays of the commissioning meeting.
    h. Observe construction and report progress, observations and issues. Observe systems and equipment installation for adequate accessibility for maintenance and component replacement or repair, and for general conformance with the Construction Documents.
    i. Prepare Project-specific Pre-functional Checklists and Systems Functional Performance Test procedures.
    j. Coordinate Systems Functional Performance testing schedule with the Contractor. Witness selected systems startups. Verify selected Pre-functional Checklists completed and submitted by the Contractor. Direct, witness, and document Systems Functional Performance testing.
    k. Compile test data, inspection reports, and certificates and include them in the systems manual and commissioning report.
    l. Review and comment on operation and maintenance (O&M) documentation and systems manual outline for compliance with the Contract Documents. Operation and maintenance documentation requirements are specified in Division 01 Section "OPERATION AND MAINTENANCE DATA."
    m. Review operation and maintenance training program developed by the Contractor. Verify training plans provide qualified instructors to conduct operation and maintenance training.
    n. Prepare commissioning reports.
    o. Return to the site at 10 months into the 12 month warranty period and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Also interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff

in developing reports, documents and requests for services to remedy outstanding problems.

p. Assemble the final commissioning documentation, including the Final Commissioning Report and Addendum to the Final Commissioning Report.

11. COMMISSIONING DOCUMENTATION

a. Commissioning Plan: A document, prepared by the Commissioning Agent, that outlines the schedule, allocation of resources, and documentation requirements of the commissioning process, and shall include, but is not limited to the following:

1). Plan for delivery and review of submittals, systems manuals, and other documents and reports. Identification of the relationship of these documents to other functions and a detailed description of submittals that are required to support the commissioning processes. Submittal dates shall include the latest date approved submittals must be received without adversely affecting commissioning plan.

2). Description of the organization, layout, and content of commissioning documentation (including systems manual) and a detailed description of documents to be provided along with identification of responsible parties.

3). Identification of systems and equipment to be commissioned.

4). Description of schedules for testing procedures along with identification of parties involved in performing and verifying tests.

5). Identification of items that must be completed before the next operation can proceed.

6). Description of responsibilities of commissioning team members.

7). Description of observations to be made.

8). Description of requirements for operation and maintenance training, including required training materials.

9). Description of expected performance for systems, sub-systems, equipment, and controls.

10). Schedule for commissioning activities with specific dates coordinated with overall construction schedule.

11). Identification of installed systems, sub-systems, and equipment, including design changes that occurred during the construction phase.

12). Process and schedule for documenting changes on a continuous basis to appear in Project Record Documents.

13). Process and schedule for completing prestart and startup checklists for systems, sub-systems, and equipment to be verified and tested.

14). Step-by-step procedures for testing systems, sub-systems, and equipment with descriptions for methods of verifying relevant data, recording the results obtained, and listing parties involved in performing and verifying tests.

b. Functional Performance Test Procedures: The Commissioning Agent will develop Systems Functional Performance Test Procedures for each system to be commissioned, including sub-systems, or equipment and interfaces or interlocks with other systems. Systems Functional Performance Test Procedures will include a separate entry, with space for comments, for each item to be tested. Preliminary Systems Functional Performance Test Procedures will be provided to the OWNER, Architect/Engineer, and Contractor for review and comment. The Systems Performance Test Procedure will include test procedures for each mode of operation and provide space to indicate whether

the mode under test responded as required. Each System Functional Performance Test procedure, regardless of system, sub-system, or equipment being tested, shall include, but not be limited to, the following:

1). Name and identification code of tested item.

2). Test number.

3). Time and date of test.

4). Indication of whether the record is for a first test or retest following correction of a problem or issue.

5). Dated signatures of the person performing test and of the witness, if applicable.

6). Individuals present for test.

7). Observations and issues.

8). Issue number, if any, generated as the result of test.

c. Pre-functional Checklists: The Commissioning Agent will prepare Pre-functional Checklists that describe the minimum conditions necessary prior to testing. Pre-functional Checklists shall be completed and signed by the Contractor, verifying that systems, sub-systems, equipment, and associated controls are ready for testing. The Commissioning Agent will spot-check Pre-functional Checklists to verify accuracy and readiness for testing. Inaccurate Pre-functional Checklists shall be returned to the Contractor for correction and resubmission.

d. Test and Inspection Reports: The Commissioning Agent will record test data, observations, and measurements on Systems Functional Performance Test Procedure forms. Photographs, forms, and other means appropriate for the application shall be included with data. CxA shall compile test and inspection reports and test and inspection certificates and include them in systems manual and commissioning report.

e. Corrective Action Documents: The Commissioning Agent will document corrective action taken for systems and equipment that fail tests. The documentation will include any required modifications to systems and equipment and/or revisions to test procedures, if any. The Commissioning Agent will direct and document any retesting of systems and/or equipment requiring corrective action and document retest results.

f. Issues Log: The Commissioning Agent will prepare and maintain Master Commissioning Issues Log that describes Commissioning Issues and Commissioning Observations that are identified during the Commissioning process. These observations and issues include, but are not limited to, those that are at variance with the Contract Documents. The Master Commissioning Issues Log will identify and track issues as they are encountered, the party responsible for resolution, progress toward resolution, and documenting how the issue was resolved. The Master Commissioning Issues Log will also track the status of unresolved and resolved issues. The issues logs will be tracked through conventional means during design and transition to web based commissioning tool for construction issues and deficiencies.

1). Creating an Issues Log Entry:

a). Identify the issue with unique numeric or alphanumeric identifier by which the issue may be tracked.

b). Assign a descriptive title of the issue.

c). Identify date and time of the issue.

d). Identify test number of test being performed at the time of the observation, if applicable, for cross-reference.

e). Identify system, subsystem, and equipment to which the issue applies.

f). Identify location of system, subsystem, and equipment.

g). Include information that may be helpful in diagnosing or evaluating the issue.

h). Note recommended corrective action.

i). Identify commissioning team member responsible for corrective action.

j). Identify expected date of correction.

k). Identify person documenting the issue.

2). Documenting Issue Resolution:

a). Log date correction is completed or the issue is resolved.

b). Describe corrective action or resolution taken. Include description of diagnostic steps taken to determine root cause of the issue, if any.

c). Identify changes to the OPR, BoD, or Contract Documents that may require action.

d). State that correction was completed and system, subsystem, and equipment is ready for retest, if applicable.

e). Identify person(s) who corrected or resolved the issue.

f). Identify person(s) documenting the issue resolution.

g. Final Commissioning Report: The Commissioning Agent will document results of the commissioning process, including unresolved issues, and performance of systems, sub-systems, and equipment. The Commissioning Report will indicate whether systems, sub-systems, and equipment have been completed and are performing according to the Contract Documents. The commissioning report will include the following as applicable:

1). Lists and explanations of substitutions; compromises; variances with the Contract Documents; record of conditions; and, if appropriate, recommendations for resolution. This report will be used by the OWNER when determining that systems will be accepted. This report will be used to evaluate systems, sub-systems, and equipment and will serve as a future reference document during OWNER occupancy and operation. It shall describe components and performance that exceed requirements of the Contract Documents and those that do not meet requirements of the Contract Documents. It may also include a recommendation for accepting or rejecting systems, sub-systems, and equipment.

2). Owner's Project Requirements prepared by the OWNER

3). Design Narrative documentation prepared and maintained by the A/E.

4). Commissioning plan.

5). Pre-functional Checklists completed by the Contractor, with annotation of the Commissioning Agent review and spot-check.

6). Systems Functional Performance Test Procedures, with annotation of test results.

7). Commissioning Master Issues Log.

8). Listing of deferred or off-season test(s) not performed, including the schedule for their completion.

h. Addendum to Final Commissioning Report: The Commissioning Agent will prepare an Addendum to the Final Commissioning Report near the end of the Warranty Period. The Addendum will indicate whether systems, sub-systems, and equipment are complete and continue to perform according to the Contract Documents. The Addendum to the Final Commissioning Report shall include, but is not limited to, the following:

1). Documentation of deferred or off-season test(s) results.

2). Completed Systems Functional Test Procedures for off-season test(s).
3). Updated status of unresolved issues.
4). Documentation that unresolved system performance issues have been resolved.
5). Updated Commissioning Master Issues Log.
6). Identification of potential Warranty Claims to be corrected by the Contractor.

i. Systems Manual: The Commissioning Agent will gather required information and compile the Systems Manual. The Systems Manual will include, but is not limited to, the following:
1). Final version of the Owner's Project Requirements (Owner provided)
2). Final version of the Basis of Design (A/E provided)
3). System single-line diagrams (Contractor provided)
4). Retesting recommendations and blank test forms (CxA provided)
5). Recommended schedule for calibrating sensors and actuators (Contractor provided)

12. SUBMITTALS

a. Preliminary Construction Commissioning Plan Submittal: The Commissioning Agent will submit the Preliminary Construction Commissioning Plan. Delivery will be through electronic submission. Present submittal in sufficient detail to evaluate data collection and arrangement process. Review comments will be returned to the Commissioning Agent.

b. Construction Commissioning Plan Final Submittal: The Commissioning Agent will submit electronically formatted information of final commissioning plan. The final submittal must address previous review comments. The final submittal shall include a copy of the preliminary submittal review comments along with a response to each item.

c. Functional Test Procedures and Report Forms: The Commissioning Agent will submit preliminary functional test procedures and forms to the Contractor, the OWNER, and the Architect/Engineer for review and comment. The Contractor shall return review comments to the OWNER and the Commissioning Agent. The OWNER and Architect/Engineer will also return review comments to the Commissioning Agent. The Commissioning Agent will incorporate review comments into the Final Functional Test Procedures to be used in Systems Functional Performance Testing.

d. Pre-functional Checklists: The Commissioning Agent will submit Pre-functional Checklists to be completed by the Construction Manager and Contractors through a web based commissioning tool.

e. Test and Observation Reports: The Commissioning Agent will submit test and observation reports to the OWNER with copies to the Contractor and the Architect/Engineer.

f. Corrective Action Documents: The Commissioning Agent will submit corrective action documents to the OWNER with copies to the Contractor and Architect.

g. Test and Observation Reports: The Commissioning Agent will submit test and observation reports to the OWNER with copies to the Contractor and the Architect/Engineer.

h. Commissioning Report Submittal: The Commissioning Agent will submit one hard copy and two sets of electronically formatted information of the final commissioning report to the OWNER.

i. Data for Commissioning:
1). The Commissioning Agent will request from the Contractor specific information needed about each piece of commissioned equipment or system to fulfill requirements of the Commissioning Plan.

2). Typically this information will include manufacturer and model number, detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any required testing, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the OWNER to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be completed and submitted to the Commissioning Agent.

3). The Commissioning Agent may request further documentation as is necessary for the commissioning process.

4). Much of this information will also be included with the O&M manual submittals normally submitted for the project. Typically, this information is required to be used in the commissioning process prior to the formal O&M manual submittals.

13. COMMISSIONING PROCESS

a. The Commissioning Agent shall be responsible for the overall management of the commissioning process as well as the specific scheduling of all procedures.

b. Prior to the start of mechanical or electrical system installation, the Contractor shall designate a specific individual as the Commissioning Manager (CxM) to manage and lead the commissioning effort on behalf of the Contractor. The CxM shall provide a single point of contact and communications for all commissioning related services.

c. Prior to the start of mechanical or electrical system installation, the Contractor shall designate specific individuals as commissioning representatives (CxR) for each Subcontractor to be associated with commissioning work. The commissioning representatives shall participate in the commissioning process as team members providing commissioning testing services, equipment operation, adjustments, and corrections if necessary. All CR's shall be selected as individuals having sufficient authority to direct their respective staff to provide the services required, accept and provide minor changes to the work on behalf of the sub-contractors or various organizations involved, and to speak on behalf of their organizations in all commissioning related contractual matters

14. QUALITY ASSURANCE

a. Instructor Qualifications: Factory-authorized service representatives experienced in training, operation, and maintenance procedures for installed systems, subsystems, and equipment.

b. Test Equipment Calibration: Comply with test equipment manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately whenever instruments have been repaired following damage or dropping. Affix calibration tags to test instruments. Instruments shall have been calibrated within eleven months prior to use.

15. COORDINATION

a. Management: The Commissioning Agent will direct and coordinate the commissioning activities and the commissioning reports to the OWNER. All commissioning team members shall work together to fulfill their contracted responsibilities and meet the objectives of the contract documents.

b. Scheduling: The Commissioning Agent will work with the Contractor and the OWNER to schedule the commissioning activities. The Commissioning Agent will provide sufficient notice to the Contractor and the OWNER for scheduling commissioning activities. The Contractor shall integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

c. Coordinating Meetings: The Commissioning Agent will conduct periodic coordination meetings of the commissioning team to review progress on commissioning activities, to discuss scheduling conflicts, and to discuss upcoming commissioning process activities.

d. Pretesting Meetings: The Commissioning Agent will conduct pretest meetings of the commissioning team to review startup reports, Pre-functional Checklist results, Systems Functional Performance Testing procedures, testing personnel and instrumentation requirements.

e. Systems Functional Performance Testing Coordination: The Commissioning Agent will coordinate the sequence of testing activities to accommodate required quality-assurance and -control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting. The Commissioning Agent will coordinate the schedule times for tests, inspections, obtaining samples, and similar activities.

PART 2 - PRODUCTS

1. TEST EQUIPMENT
   a. The Contractor shall provide all standard and specialized testing equipment required to perform startup, initial checkout, specification defined tests, industry standards tests, and Systems Functional Performance Testing. Required test equipment for Functional Performance Testing will be identified in the detailed System Performance Test Procedure checklists prepared by the Commissioning Agent.
   b. Data logging equipment and software required to test equipment shall be provided by the Contractor.
   c. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5 C (1.0 F) and a resolution of + or - 0.1 C (0.2 F). Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

1. START-UP, PRE-FUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT
   a. The following procedures shall apply to all equipment and systems to be commissioned, according to Part 1, Systems To Be Commissioned.
      1). Pre-functional Checklists are important to ensure that the equipment and systems are hooked up and operational. These ensure that functional performance testing (in-

depth system checkout) may proceed without unnecessary delays. Each piece of equipment shall receive a full Pre-functional Checklist checkout. No sampling strategies are used. The Pre-functional Checklist for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

a. The Commissioning Agent shall develop Pre-functional Checklists and procedures after final approval of equipment submittals. These checklists indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.
b. The Contractor shall determine which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form may have more than one trade responsible for its execution.
c. The Pre-functional Checklists will be documented electronically through a web-based system. The CxA will short training session to walk the contractors through the system.

2). Start-up and Initial Checkout Plan: The Contractor shall develop detailed start-up plans for all equipment. The primary role of the Contractor in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for Pre-functional Checklists and startup shall be identified in coordination meetings and in the checklist forms.

a. The Commissioning Agent will assist the contractor in development of the full start-up plan. The Contractor shall combine the checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual data and the normally used field checkout sheets. The plan shall include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.
b. The full start-up plan shall at a minimum consist of the following items:
    a The Pre-functional Checklists.
    b The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
    c The manufacturer's normally used field checkout sheets.
    d The Contractor shall submit the full startup plan to the Commissioning Agent for review and approval.
    e The Contractor shall review and evaluate the procedures and the format for documenting them, noting any procedures that need to be revised or added.

3). Execution of Pre-functional Checklists and Startup

a. Four weeks prior to startup, the Contractor shall schedule startup and checkout with the Owner and CxA. The performance of the Pre-functional Checklists, startup and checkout shall be directed and executed by the Contractor.
b. The Commissioning Agent will observe the startup procedures for selected pieces of primary equipment.
c. The Contractor shall execute startup and provide the OWNER and Commissioning Agent with a signed and dated copy of the completed start-up, Pre-functional Checklists, and initial tests.

d. Only individuals that have direct knowledge and witnessed that a line item task on the Pre-functional Checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

2. PHASED COMMISSIONING

a. The project may require startup and initial checkout to be executed in phases. This phasing shall be planned and scheduled in a coordination meeting of the OWNER, Commissioning Agent, and the Contractor. Results will be added to the master construction schedule and the commissioning schedule.

3. INTEGRATED AUTOMATION AND TEMPERATURE CONTROLS

a. The BAS Technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the BAS Technician provided cannot perform every software task requested by the Cx agent in a timely fashion, the Contractor shall provide additional qualified personnel at the Project Site as requested by the Cx agent.

b. All setpoints, operating parameters, airflows, and outputs should be user adjustable through the operator's workstation or human machine interface.

c. Provide a wireless internet network in the building for use during controls programming, checkout, and commissioning. This network will allow project team members to more effectively program, view, manipulate and test control devices while being in the same room as the controlled device.

d. Provide web-access to the commissioning agent for remote viewing an monitoring of the automation system prior to functional performance testing.

e. Provide graphics mockups 6-weeks after submittal acceptance to the OWNER, A/E, and CxA for review.

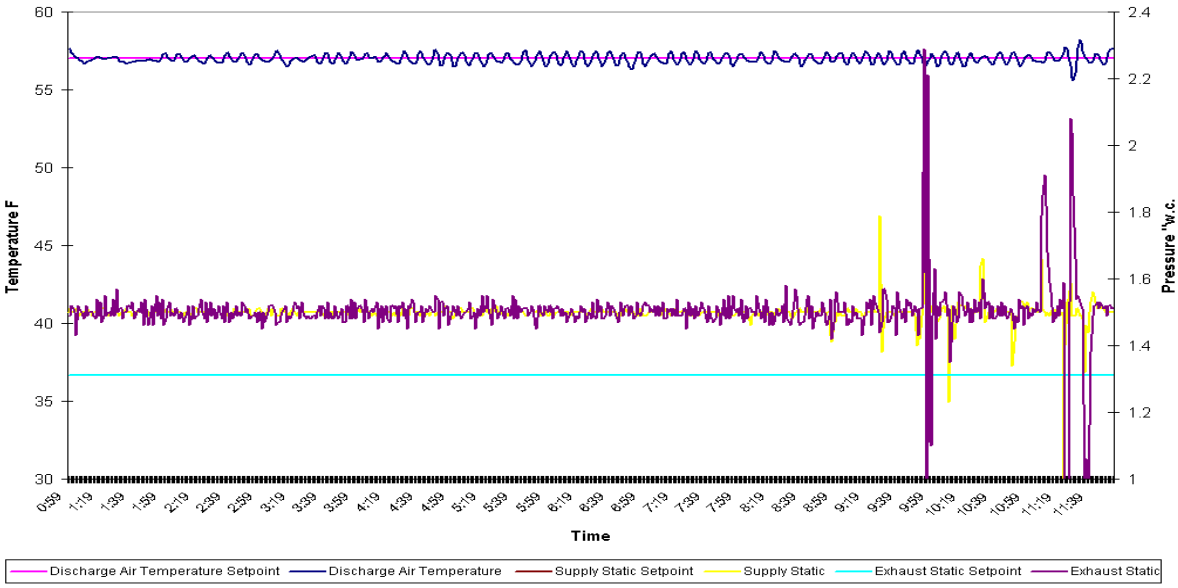
f. Provide graphical trending through the automation control system of systems being commissioned. Trending requirements will be dictated by the CxA and included within a trend plan and/or determined while execution of testing. Trending shall occur before, during and after functional testing. The Contractor shall be responsible for producing graphical representations of the trended points that show each system operating properly during steady state conditions as well as during the functional tests. These graphical reports and data backup shall be submitted to the CxA for review and analysis before, during dynamic operation, and after functional testing.

g. The graphical plots shall be provided with a dual y-axis allowing up to 15 trend points (series) plotted simultaneously with each series in distinct color. The plots will further require title, axis naming, legend etc. all dictated by the CxA. If this cannot be sufficiently accomplished directly in the automation system then it is the responsibility of the Contractor to plot these trend logs in Microsoft Excel at the direction of the CxA. The following table and graph is a reference sample similar to what will be expected for this project.

****SAMPLE FOR REFERENCE****

Trend Log #1: Temperature & Pressure	
Data Collection Frequency	1 minute
Trend Log Duration	1 week

Trend Log Start Date/Time	Minimum 1 day before test
Trend Log Stop Date/Time	Minimum 5 days after test
Point #1	Discharge Air Temperature
Point #2	Discharge Air Temperature Setpoint
Point #3	Supply Static Pressure
Point #4	Supply Static Pressure Setpoint
Point #5	Return Static Pressure
Point #6	Return Static Pressure Setpoint



h. Sensor and Actuator Calibration

1). All automation system inputs including factory calibrated and/or field calibrated devices shall be validated once field installed with test instrumentation. The test instruments shall be NIST certified within the past 12 months and record documented in the point to point validation worksheets provided at the end of this specification section.

2). All automation system outputs shall be validated after installation against the automation system and calibrated as needed by the Contractor. This shall include open, closed, and mid-point conditions for actuators, on/off for digital outputs and signal output at minimum.

3). All procedures used shall be fully documented on the forms provided at the end of this section, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.

i. Sensor and Actuator Calibration Maintenance Requirements

1). A sensor and actuator calibration table listing and referencing the location of procedures to follow in the O&M manuals, and the frequency at which calibration should be performed for all sensors/actuators, separated by system, sub-system, and type. The calibration requirements shall be submitted both in the O&M manuals and

separately in a standalone document containing all sensors for inclusion in the commissioning documentation.

2). The sensor calibration documentation used shall be fully documented on the forms provided at the end of this section, clearly referencing sensor type, frequency, and procedures to be followed specific to the location in the operations and maintenance manuals.

j. Loop Tuning Documentation

1). Loop tuning documentation and constants for each loop of the automation systems shall be submitted by system, control type (e.g. heating valve temperature control); proportional, integral and derivative constants, interval (and bias if used) for each loop.

2). The loop tuning documentation used shall be fully documented on the forms provided at the end of this section, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.

k. Performance Criteria

1). The contractor will provide control responsiveness and attributes within the following ranges unless more strigent requirements are detailed in other specification sections.

a). Steady State Setpoint Tolerances

a Zone / space temperature control: ± 0.5 ^{o}F

b Zone / space humidity control: ± 2%RH

c Zone / space static pressure control: ± 0.02 inH_20

d Supply air temperature control: ± 0.5 ^{o}F

e Supply air humidity control: ± 5%RH

f Return air humidity control: ± 2%RH

g Duct static pressure control: ± 0.05 inH_20

h Air flowrate control: ± 5% of setpoint

i Water temperature control: ± 1.0 ^{o}F

j Water differential pressure: ± 0.5 psig

k Water flowrate control: ± 2% of setpoint

b). Overshooting and Stability

a On transitions or setpoint changes the controls shall be tuned to provide both a stable output and control point generally following a quarter decay response. Overshoots shall not exceed 300% of the setpoint tolerances for supply air and duct pressure. Zone responses shall not overshoot beyond the setpoint tolerances.

l. Loop Tuning and Operational Tests

1). PID Loop tuning shall be documented for all control loops by providing a trend log graphical plot with excel data backup for all control loops in the automation system. There trend log series shall include the control input, set point, and control output. Loop output cycling under a steady load condition shall be within the tolerances defined in previous section. The maximum allowable interval sampling rate is one minute however, the most frequent available trend sample rate of the automation system shall be used.

2). The loop operational test shall be performed by the contract for all systems interfaced into the building automation system. If a piece of equipment or system has provided packaged controls it is still the responsibility to perform these tests however correction of tuning is the responsibility of the contractor providing the controls.

3). On equipment or systems of the same size where the control loops are common having the same PID constants, the contractor can perform the testing on one of the equipment or systems for demonstration as long as all are tuned the same after the test.

4). If any of the loop operational tests are deemed not acceptable by the CxA or A/E additional tuning shall occur and the testing repeated until they are satisfactory to both the CxA and A/E.

5). Successful completion and acceptance of Loop Tuning and Operational Testis is required before Functional Performance Testing can commence.

6). Provide positive and negative "bump" tests demonstrating loop stability by raising and lowering loop set points. A general sequence of events is as follows:

   a). Trend logs and the graphical plots are setup.

   b). The system is allowed to operate in steady state for 5 minutes prior to the start of the test.

   c). Provide a setpoint change to initiate a step increase “bump”.

   d). Allow the system time to respond and settle within the defined tolerance for 5 minutes. (The duration time starts when the control no longer cycles out of the defined tolerance).

   e). Provide a setpoint change to initiate a step decrease “bump”.

   f). Allow the system time to respond and settle within the defined tolerance for 5 minutes. (The duration time starts when the control no longer cycles out of the defined tolerance).

   g). Repeat steps c through f one additional time.

   h). Plot graph and save excel data for transfer to the CxA and A/E.

   i). The following plot is an example of the graph layout that will be required.

4. FUNCTIONAL PERFORMANCE TESTING

   a. This paragraph applies to commissioning Systems Functional Performance Testing of equipment and systems for all referenced specification Divisions.

   b. Objectives and Scope: The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Successful Completion of Functional Testing is a Prerequisite to Substantial Completion. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems. In general, each system shall be operated through all modes of operation where there is a specified system response. The Contractor shall verify each sequence in the sequences of operation.

   c. Development of Functional Performance Test Procedures: Before Systems Functional Performance Test procedures are written, the Contractor shall submit all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. Using the testing parameters and requirements found in the Contract Documents and approved submittals and shop drawings, the Commissioning Agent will develop specific systems functional test procedures and forms to verify and document proper operation of each piece of equipment and system to be commissioned. The Contractor shall assist the Commissioning Agent in developing the Systems Functional Performance Test procedures as requested by the Commissioning Agent i.e. by answering questions about equipment, operation, sequences, etc. Prior to execution, the Commissioning Agent will provide a copy of the Systems Functional Performance Test procedures to the OWNER, the Architect/Engineer, and the Contractor, who shall review the tests for feasibility, safety, equipment and warranty protection.

d. Purpose of Test Procedures: The purpose of each specific Systems Functional Performance Test is to verify and document compliance with the stated criteria of acceptance given on the test form. Representative test formats and examples are found in the Commissioning Plan for this project. (The Commissioning Plan is issued as a separate document and is available for review.)

e. Test Methods: Systems Functional Performance Testing shall be achieved by manual testing (i.e. persons manipulate the equipment and observe performance) and/or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data loggers. The Commissioning Agent shall determine which method is most appropriate for tests that do not have a method specified.

1). Simulated Conditions: Simulating conditions (not by an overwritten value) shall be allowed as determined by the CxA, though timing the testing to experience actual conditions is encouraged wherever practical.

2). Overwritten Values: Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed as determined by the Commissioning Agent, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair blower rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.

3). Simulated Signals: Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.

4). Altering Setpoints: Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the Air Conditioning compressor lockout initiate at an outside air temperature below 12 C (54 F), when the outside air temperature is above 12 C (54 F), temporarily change the lockout setpoint to be 2 C (4 F) above the current outside air temperature.

5). Indirect Indicators: Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification shall be completed during system readiness testing.

f. Setup: Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Contractor shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Contractor shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.

g. Sampling: No sampling is allowed in completing Pre-functional Checklists. Sampling may be allowed for functional test procedures execution. The CxA shall determine the sampling rate however the contractor should expect to test at 100%. If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CxA may stop the testing and require the Contractor to perform and document a checkout of the remaining units, prior to continuing with functionally testing

the remaining units. Costs associated with testing expanded samples and/or all equipment or systems of the specified type are the responsibility of the Contractor.

h. Cost of Expanded Sample Testing: The costs for expanded sample System Functional Performance Test shall be solely the responsibility of the Contractor. Any required expanded sample testing by the Contractor shall not be considered a justified reason for a claim of delay or for a time extension by the Contractor.

i. Coordination and Scheduling: The Contractor shall provide sufficient notice to the CxA and Owner regarding the completion schedule for the Pre-functional Checklists and startup of all equipment and systems. The CxA shall schedule functional tests through the Contractor and Owner. The CxA shall direct, witness and document the functional testing of equipment and systems. The Contractor shall execute the tests.

j. Testing Pre-Requisites: In general, functional testing shall be conducted after system readiness testing and startup has been satisfactorily completed. The control system shall be sufficiently tested and approved by the Commissioning Agent and the Owner before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing shall be completed and debugged before functional testing of air-related or water-related equipment or systems. Testing shall proceed from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems shall be checked.

k. Problem Solving: The Commissioning Agent shall recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the Contractor.

5. DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

a. Documentation: The Commissioning Agent will direct, witness, and document the results of all Systems Functional Performance Tests using the specific procedural forms developed by the Commissioning Agent for that purpose. Prior to testing, the Commissioning Agent will provide these forms to the OWNER and the Contractor for review and approval. The Contractor shall include the filled out forms with the O&M manual data.

b. Non-Conformance: The Commissioning Agent will record the results of the Systems Functional Performance Tests on the procedure or test form. All items of non-conformance issues will be noted and reported to the OWNER on Commissioning Field Reports and/or the Commissioning Master Issues Log.

1). Corrections of minor items of non-compliance identified may be made during the tests at the discretion of the Commissioning Agent. In such cases, the item of non-compliance and resolution shall be documented on the Systems Functional Test Procedure form.

2). Every effort shall be made to expedite the systems functional performance testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the Commissioning Agent will not be pressured into overlooking non-compliant work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so by direction from the OWNER.

3). As the systems functional performance tests progress and an item of non-compliance is identified, the Commissioning Agent shall discuss the issue with the Contractor and the OWNER.

4). When there is no dispute on an item of non-compliance, and the Contractor accepts responsibility to correct it:

a). The Commissioning Agent will document the item of non-compliance and the Contractor's response and/or intentions. The Systems Functional Performance Test then continues or proceeds to another test or sequence. After the day's work is complete, the Commissioning Agent will submit a Commissioning Field Report to the OWNER. The Commissioning Agent will also note items of non-compliance and the Contractor's response in the Master Commissioning Issues Log. The Contractor shall correct the item of non-compliance and report completion to the OWNER and the Commissioning Agent.

b). The need for retesting will be determined by the Commissioning Agent. If retesting is required, the Commissioning Agent and the Contractor shall reschedule the test and the test shall be repeated.

5). If there is a dispute about item of non-compliance, regarding whether it is an item of non-compliance, or who is responsible:

a). The item of non-compliance shall be documented on the test form with the Contractor's response. The item of non-compliance with the Contractor's response shall also be reported on a Commissioning Field Report and on the Master Commissioning Issues Log.

b). Resolutions shall be made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive and acceptance authority is with the OWNER.

c). The Commissioning Agent will document the resolution process.

d). Once the interpretation and resolution have been decided, the Contractor shall correct the item of non-compliance, report it to the Commissioning Agent. The requirement for retesting will be determined by the Commissioning Agent. If retesting is required, the Commissioning Agent and the Contractor shall reschedule the test. Retesting shall be repeated until satisfactory performance is achieved.

c. Cost of Retesting: The cost to retest any portion of a Functional Performance Test or to validate deficiency resolution of issues shall be solely the responsibility of the Contractor including the costs for the Commissioning Agent. Any required retesting by the Contractor shall not be considered a justified reason for a claim of delay or for a time extension by the Contractor.

d. Failure Due to Manufacturer Defect: If 10%, or three, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the Owner. In such case, the Contractor shall provide the OWNER with the following:

1). Within one week of notification from the OWNER, the Contractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the Owner within two weeks of the original notice.

2). Within two weeks of the original notification, the Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.

3). The OWNER shall determine whether a replacement of all identical units or a repair is acceptable.

4). Two examples of the proposed solution shall be installed by the Contractor and the OWNER shall be allowed to test the installations for up to one week, upon which the OWNER will decide whether to accept the solution.

5). Upon acceptance, the Contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

e. Approval: The CxA shall note each satisfactorily demonstrated function on the test form. Formal approval of the functional test shall be made later after review by the CxA and by the Owner. The CxA shall evaluate each test and report to the Owner using a standard form. The Owner shall give final approval on each test using the same form, and provide signed copies to the CxA and the Contractor.

6. DEFERRED TESTING

a. Unforeseen Deferred Functional Performance Tests: If any check or Functional Performance Test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the Owner. These tests shall be conducted in the same manner as the seasonal tests as soon as possible.

b. Seasonal Functional Performance Testing: Deferred Seasonal Systems Functional Performance Tests are those that must be deferred until weather conditions are closer to the systems design parameters. The Commissioning Agent will review systems parameters and recommend which Systems Functional Performance Tests should be deferred until weather conditions more closely match systems parameters. The Contractor shall review and comment on the proposed schedule for Deferred Seasonal Testing. The OWNER will review and approve the schedule for Deferred Seasonal Testing. Deferred Seasonal Systems Functional Performances Tests shall be directed, witnessed, and documented by the Commissioning Agent. Deferred Seasonal Systems Functional Performance Tests shall be executed by the Contractor in accordance with these specifications.

7. OPERATION AND MAINTENANCE TRAINING REQUIREMENTS

a. Training Preparation Conference: Before operation and maintenance training, the Commissioning Agent will convene a training preparation conference to include OWNER, OWNER's Operations and Maintenance personnel, and the Contractor. The purpose of this conference will be to discuss and plan for Training and Demonstration of OWNER Operations and Maintenance personnel.

b. The Contractor shall provide training and demonstration as required throughout the Contract Documents. The Training and Demonstration shall include, but is not limited to, the following:

1). Review the Contract Documents

2). Review installed systems, subsystems, and equipment.

3). Review instructor qualifications.

4). Review instructional methods and procedures.

5). Review training module outlines and contents.

6). Review course materials (including operation and maintenance manuals).

7). Inspect and discuss locations and other facilities required for instruction.

8). Review and finalize training schedule and verify availability of educational materials, instructors, audiovisual equipment, and facilities needed to avoid delays.

9). For instruction that must occur outside, review weather and forecasted weather conditions and procedures to follow if conditions are unfavorable.

c. Training Modules: The Contractor shall submit the following information to the OWNER and the Commissioning Agent:

1). Instruction Program: Submit two copies of outline of instructional program for demonstration and training, including a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module. At completion of training, submit two complete training manuals for OWNER's use.

2). Qualification Data: Submit qualifications for facilitator and/or instructor.

3). Attendance Record: For each training module, submit list of participants and length of instruction time.

4). Evaluations: For each participant and for each training module, submit results and documentation of performance-based test.

5). Demonstration and Training Video Recorded: All training modules shall be video recorded by a professional videographer hired by the Contractor and shall include post production editing for quality. Submit two copies on DVD within seven days of end of each training module. Poor quality or poor edited video will be rejected and video training required to be re-performed at the financial burden of the contractor.

a). Identification: On each copy, provide an applied label with the following information:

a Name of Project.

b Name and address of photographer

c Name of Contractor.

d Date videotape was recorded.

e Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.

6). Transcript: Prepared on 8-1/2-by-11-inch paper, punched and bound in heavy-duty, 3-ring, vinyl-covered binders. Mark appropriate identification on front and spine of each binder. Include a cover sheet with same label information as the corresponding videotape. Include name of Project and date of videotape on each page.

Quality Insurance:

1). Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.

2). Instructor Qualifications: A factory-authorized service representative, complying with requirements in Division 01 Section "Quality Requirements," experienced in operation and maintenance procedures and training.

3). Photographer Qualifications: A professional photographer who is experienced photographing construction projects.

Coordination:

1). Coordinate instruction schedule with OWNER's operations. Adjust schedule as required to minimize disrupting OWNER's operations.

2). Coordinate instructors, including providing notification of dates, times, length of instruction time, and course content.

3). Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by the OWNER.

d. Instruction Program:

1). Program Structure: Develop an instruction program that includes individual training modules for each system and equipment not part of a system, as required by individual Specification Sections, and as follows:

a). Fire-protection systems, including fire alarm, fire pumps, and fire suppression systems.

b). Intrusion detection systems.

c). Conveying systems, including elevators, wheelchair lifts, escalators, and automated materials handling systems.

d). Medical equipment, including medical gas equipment and piping.

e). Laboratory equipment, including laboratory air and vacuum equipment and piping.

f). Heat generation, including boilers, feedwater equipment, pumps, steam distribution piping, condensate return systems, heating hot water heat exchangers, and heating hot water distribution piping.

g). Refrigeration systems, including chillers, cooling towers, condensers, pumps, and distribution piping.

h). HVAC systems, including air-handling equipment, air distribution systems, and terminal equipment and devices.

i). HVAC instrumentation and controls.

j). Electrical service and distribution, including switchgear, transformers, switchboards, panelboards, uninterruptible power supplies, and motor controls.

k). Packaged engine generators, including synchronizing switchgear/switchboards, and transfer switches.

l). Lighting equipment and controls.

m). Communication systems, including intercommunication, surveillance, nurse call systems, public address, mass evacuation, voice and data, and entertainment television equipment.

n). Site utilities including lift stations, condensate pumping and return systems, and storm water pumping systems.

e. Training Modules Content: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participants are expected to master. For each module, include instruction for the following:

1). Basis of System Design, Operational Requirements, and Criteria: Include the following:

a). System, sub-system, and equipment descriptions.

b). Performance and design criteria if Contractor is delegated design responsibility.

c). Operating standards.

d). Regulatory requirements.

e). Equipment function.

f). Operating characteristics.

g). Limiting conditions.
h). Performance curves.

2). Documentation: Review the following items in detail:
a). Emergency manuals.
b). Operations manuals.
c). Maintenance manuals.
d). Project Record Documents.
e). Identification systems.
f). Warranties and bonds.
g). Maintenance service agreements and similar continuing commitments.

3). Emergencies: Include the following, as applicable:
a). Instructions on meaning of warnings, trouble indications, and error messages.
b). Instructions on stopping.
c). Shutdown instructions for each type of emergency.
d). Operating instructions for conditions outside of normal operating limits.
e). Sequences for electric or electronic systems.
f). Special operating instructions and procedures.

4). Operations: Include the following, as applicable:
a). Startup procedures.
b). Equipment or system break-in procedures.
c). Routine and normal operating instructions.
d). Regulation and control procedures.
e). Control sequences.
f). Safety procedures.
g). Instructions on stopping.
h). Normal shutdown instructions.
i). Operating procedures for emergencies.
j). Operating procedures for system, sub-system, or equipment failure.
k). Seasonal and weekend operating instructions.
l). Required sequences for electric or electronic systems.
m). Special operating instructions and procedures.

5). Adjustments: Include the following:
a). Alignments.
b). Checking adjustments.
c). Noise and vibration adjustments.
d). Economy and efficiency adjustments.

6). Troubleshooting: Include the following:
a). Diagnostic instructions.
b). Test and inspection procedures.

7). Maintenance: Include the following:
a). Inspection procedures.

b). Types of cleaning agents to be used and methods of cleaning.

c). List of cleaning agents and methods of cleaning detrimental to product.

d). Procedures for routine cleaning

e). Procedures for preventive maintenance.

f). Procedures for routine maintenance.

g). Instruction on use of special tools.

8). Repairs: Include the following:

a). Diagnosis instructions.

b). Repair instructions.

c). Disassembly; component removal, repair, and replacement; and reassembly instructions.

d). Instructions for identifying parts and components.

e). Review of spare parts needed for operation and maintenance.

f. Training Execution:

1). Preparation: Assemble educational materials necessary for instruction, including documentation and training module. Assemble training modules into a combined training manual. Set up instructional equipment at instruction location.

2). Instruction:

a). Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and OWNER for number of participants, instruction times, and location.

b). Instructor: Engage qualified instructors to instruct OWNER's personnel to adjust, operate, and maintain systems, sub-systems, and equipment not part of a system.

a The Commissioning Agent will furnish an instructor to describe basis of system design, operational requirements, criteria, and regulatory requirements.

b The OWNER will furnish an instructor to describe OWNER's operational philosophy.

c The OWNER will furnish the Contractor with names and positions of participants.

3). Scheduling: Provide instruction at mutually agreed times. For equipment that requires seasonal operation, provide similar instruction at start of each season. Schedule training with the OWNER and the Commissioning Agent with at least seven days' advance notice.

4). Evaluation: At conclusion of each training module, assess and document each participant's mastery of module by use of **an oral, or a written,** performance-based test.

5). Cleanup: Collect used and leftover educational materials and remove from Project site. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.

g. Demonstration and Training Recording:

1). General: Engage a qualified commercial photographer to record demonstration and training. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice. At

beginning of each training module, record each chart containing learning objective and lesson outline.

2). Videotape Format: Provide high-quality color DVD on standard-size DVD disks.

3). Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

4). Narration: Describe scenes on videotape by audio narration by microphone while demonstration and training is recorded. Include description of items being viewed. Describe vantage point, indicating location, direction (by compass point), and elevation or story of construction.

8. OPERATION AND MAINTENANCE MANUALS

a. Submission of Operations and Maintenance Data: Submit Operation and Maintenance (O&M) Data specifically applicable to this contract and a complete and concise depiction of the provided equipment, product, or system. Organize and present information in sufficient detail to clearly explain O&M requirements at the system, equipment, component, and subassembly level. Include an index preceding each submittal. Submit in accordance with this section and Division 01 requirements for closeout submittals, operations and maintenance data, and project record documents.

1). Package Quality: Documents must be fully legible. Poor quality copies and material with hole-punches obliterating the text or drawings will not be accepted. Documents shall be written in English language.

2). Package Content: Data package content shall be as shown in the paragraph titled "Schedule of Operation and Maintenance Data Packages." Comply with the data package requirements specified in the individual technical sections, including the content of the packages and addressing each product, component, and system designated for data package submission.

3). Changes to Submittals: Manufacturer-originated changes or revisions to submitted data shall be furnished by the Contractor if a component of an item is so affected subsequent to acceptance of the O&M Data. Changes, additions, or revisions required by the Contracting Officer for final acceptance of submitted data, shall be submitted by the Contractor within 30 calendar days of the notification of this change requirement.

b. Schedule of Operations and Maintenance Manual Packages: Furnish the O&M data packages specified in individual technical sections. The required information for each O&M data package is as follows:

1). First Submission: The first submission of O&M Manuals shall be made within 4 weeks after approval of equipment submittals. This submission shall include the Table of Contents, divider tabs, and approved submittal data arranged in accordance with the requirements provided in paragraph C above.

2). Second Submission: The second submission shall be made at least 6 weeks prior to scheduled functional performance testing and/or scheduled contractor's training, whichever is earlier. The second submission shall include all required Operations & Maintenance data as described in the specifications.

c. CxA Review and Approval: Prior to substantial completion, the CxA may review the O&M manual data, documentation and redlined as-builds for equipment and systems that were commissioned to verify compliance with the O&M documentation requirements of the specifications. The CxA shall communicate deficiencies in the manuals to the Owner. Upon a successful review of the corrections, the CxA shall recommend approval and

acceptance of these sections of the O&M manuals to the Owner. The CxA shall also review each equipment warranty and verify that all requirements to keep the warranty valid are clearly stated. This work does not supersede the normal review requirement of the O&M manual data as indicated elsewhere in the specifications.

9. MAINTENANCE AND OPERATIONS ACCEPTANCE
   a. The Commissioning Functional Performance Tests shall be successfully completed prior to Substantial Completion. However, should mechanical and electrical systems be in use prior to Substantial Completion:
      1). The Contractor shall be responsible for the operation of all systems and all adjustments necessary to successfully pass the Functional Performance Test Procedures.
      2). The Contractor shall document and respond to all concerns and questions from building occupants in a timely and professional manner.
      3). Maintenance and operational acceptance is a requirement of final completion and must be documented prior to submitting the Final Application for Payment.

PART 4 - COMMISSIONING DOCUMENTATION ATTACHMENTS

a. Training Cover Page: Training agendas shall be submitted for review and approval with this cover paged completed. See the requirements for training in this specification section for information to provide with this coversheet.
b. Static Tests and Startup Cover Page: Contractor's static test reports and startup reports shall be submitted for review with this cover page completed.
c. Sensor Calibration Record: This document shall be filled out by the contractor for all sensors. See specification requirements specific to this documentation.
d. Actuator Calibration Record: This document shall be filled out by the contractor for all actuators. See specification requirements specific to this documentation.
e. Sensor and Actuator Calibration Maintenance Report: This document shall be filled out by the contractor for all sensors and actuators. See specification requirements specific to this documentation.
f. Pre-functional Checklist and Functional Performance Tests: A preliminary PFC and FPT is attached to this section to illustrate level of rigor and general execution techniques. Additional checklists and test procedures will be incorporated during the project based on the systems being commissioned. Modifications, additions and deletions will be performed to customize these documents for the field installed equipment and systems. These incorporations will not be considered an additional service or basis for change orders nor will modifications to the preliminary checklists and test procedures which are included for the bidding contractors benefit.

O&M TRAINING PLAN COVER

System/Equipment Identification:	
Training Plan From (by contractor company):	
Training to be conducted by:	
Name:	Date:
Company:	Title:
Phone:	Fax:
Specification Section Reference:	
Time Required:	
List Materials Provided:	
Number of pages attached (agenda):	
Agenda Approval (by Commissioning Authority) Approved? ☐ Yes ☐ No	Agenda Approval (by O&M Representative) Approved? ☐ Yes ☐ No
Comments:	
Attendees (Owner's operations & maintenance staff)	
Name/Affiliation:	Name/Affiliation:
Acceptance of the Training	
The training has satisfactorily provided the Owner's personnel with the knowledge to operate and maintain the equipment discussed during the training session? O&M Representative ☐ Yes ☐ No Name: Date:	
Comments:	

Startup & Static Test Report

SYSTEM / EQUIPMENT IDENTIFICATION:	[SPEC SECTION / EQUIPEMENT TYPE]
CONDUCTED BY:	
Name:	Title:
Company:	Phone:
Date:	Test Duration:
Installing Contractor:	
Specification Reference:	
Number of Pages Including Cover:	
Startup or Static Testing Procedures:	
Results:	
FINAL DISTRIBUTION	
ORIGINALS TO:	**COPIES TO:**
☐ Commissioning Agent	☐ Commissioning Agent
☐ Construction Manager/ General Contractor	☐ Construction Manager/ General Contractor
☐ Owner's Project Manager	☐ Owner's Project Manager
☐ Architect/ Engineer	☐ Architect/ Engineer
☐ Installation Contractor	☐ Installation Contractor
☐ Owner's Commissioning Manager	☐ Owner's Commissioning Manager

Sensor Calibration Record

PROJECT _____ **INSTRUMENT MAN.** _____

BUILDING _____ **INSTRUMENT MODEL** _____

REFERENCE _____ **INSTRUMENT S/N** _____

SYSTEM	SENSOR	TYPE	MEASURED	READING	K-Factor	CALIBRATED

REMARKS:

TEST DATE: _____

BY: _____

Actuator Calibration Record

PROJECT _____ **INSTRUMENT MAN.** _____

BUILDING _____ **INSTRUMENT MODEL** _____

REFERENCE _____ **INSTRUMENT S/N** _____

SYSTEM	ACTUATOR	TYPE	POSITION	ACTUAL	BAS	CALIBRATED

REMARKS:

TEST DATE: _____

BY: _____

Sensor and Actuator Calibration Maintenance Requirements

SYSTEM	TYPE	FREQUENCY	PROCEDURAL STEPS (O&M Ref. Loc.)

*Note: If the O&M manuals do not have a specific procedure for the sensor or actuator referenced then a procedure will need to be written by the contractor and included or appended to this table.

SECTION 075323

EPDM ROOFING

GENERAL

1.1 SUMMARY

A. Section Includes:

1. Loosely laid and ballasted ethylene-propylene-diene-monomer (EPDM) roofing system.
2. Roof insulation.

1.2 DEFINITIONS

A. Roofing Terminology: Definitions in ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" apply to work of this Section.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Roofing Conference: Conduct conference at University of Illinois-College of Medicine Peoria

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.

C. Samples for Verification: For the following products:

1. Sheet roofing, of color required.
2. Aggregate surfacing material in gradation required.
3. Roof paver in each color and texture required.
4. Walkway pads or rolls, of color required.

1.5 INFORMATIONAL SUBMITTALS

A. Research/Evaluation Reports: For components of roofing system, from ICC-ES.

B. Sample Warranties: For manufacturer's special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roofing system to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain components including roof insulation and fasteners for roofing system from manufacturer approved by membrane roofing manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Accelerated Weathering: Roofing system shall withstand 2000 hours of exposure when tested according to ASTM G 152, ASTM G 154, or ASTM G 155.

B. Impact Resistance: Roofing system shall resist impact damage when tested according to ASTM D 3746 or ASTM D 4272.

C. Exterior Fire-Test Exposure: ASTM E 108 or UL 790, Class B; for application and roof slopes indicated; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

D. Fire-Resistance Ratings: Comply with fire-resistance-rated assembly designs indicated. Identify products with appropriate markings of applicable testing agency.

2.3 EPDM ROOFING

A. EPDM: ASTM D 4637, Type to match existing roofing membrane, uniform, flexible EPDM sheet. Contractor to confirm product is compatible with existing roof assembly.

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

i. Carlisle SynTec Incorporated.
ii. ERSystems.
iii. Firestone Building Products.
iv. GAF Materials Corporation.
v. GenFlex Roofing Systems.
vi. International Diamond Systems.
vii. Johns Manville.
viii. Lexcan Limited.
ix. Mule-Hide Products Co., Inc.
x. Roofing Products International, Inc.
xi. StaFast Building Products.
xii. Versico Incorporated.

2. Thickness: 60 mils, nominal.

3. Exposed Face Color: to match existing.

2.4 AUXILIARY ROOFING MATERIALS

A. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with roofing.

1. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.

2. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content:

i. Plastic Foam Adhesives: 50 g/L.
ii. Gypsum Board and Panel Adhesives: 50 g/L.
iii. Multipurpose Construction Adhesives: 70 g/L.
iv. Fiberglass Adhesives: 80 g/L.
v. Single-Ply Roof Membrane Adhesives: 250 g/L.
vi. Single-Ply Roof Membrane Sealants: 450 g/L.
vii. Nonmembrane Roof Sealants: 300 g/L.
viii. Sealant Primers for Nonporous Substrates: 250 g/L.
ix. Sealant Primers for Porous Substrates: 775 g/L.
x. Other Adhesives and Sealants: 250 g/L.

3. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Department of Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Sheet Flashing: 60-mil thick EPDM, partially cured or cured, according to application.

C. Protection Sheet: Epichlorohydrin or neoprene nonreinforced flexible sheet, 60 mil thick, recommended by EPDM manufacturer for resistance to hydrocarbons, non-aromatic solvents, grease, and oil.

D. Bonding Adhesive: Manufacturer's standard.

E. Seaming Material: Manufacturer's standard, synthetic-rubber polymer primer and 3-inch- (75-mm-) wide minimum, butyl splice tape with release film.

F. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Global 4470, designed for fastening membrane to substrate, and acceptable to roofing system manufacturer.

G. Miscellaneous Accessories: Provide lap sealant, water cutoff mastic, metal termination bars, metal battens, pourable sealers, preformed cone and vent sheet flashings, molded pipe boot flashings, preformed inside and outside corner sheet flashings, reinforced EPDM securement strips, T-joint covers, in-seam sealants, termination reglets, cover strips, and other accessories.

2.5 ROOF INSULATION

A. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.6-lb/cu. ft. (26-kg/cu. m)] minimum density, square edged.

B. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

2.6 INSULATION ACCESSORIES

A. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Global 4470, designed for fastening roof insulation and cover boards to substrate, and acceptable to roofing system manufacturer.

B. Insulation Adhesive: Insulation manufacturer's recommended adhesive formulated to attach roof insulation to substrate or to another insulation layer.

2.7 BALLAST

A. Aggregate Ballast: Crushed gravel or crushed stone to match existing roof ballast, that withstands weather exposure without significant deterioration and does not contribute to membrane degradation, of the following size:

1. Size: Minimum 10 lb/ft2 (48.8 kg/m2) ¾" to 1 ½" (19 to 38 mm) diameter stone, meeting ASTM D 448 size #4, ASTM C 136 test method.
2. Existing gravel may be re-used provided it is of adequate size and weight.

B. Lightweight Roof Pavers: Interlocking, lightweight concrete units; grooved back, with four-way drainage capability; beveled, doweled, or otherwise profiled; and as follows:

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

i. Hanover Architectural Products.
ii. Rapid Building Systems.
iii. Roofblok Limited.
iv. Westile Roofing Products.

2. Size: 24 x 24 nches.

3. Compressive Strength: 2500 psi, minimum.

4. Colors and Textures: match existing.

PART 3 - EXECUTION

3.1 ROOFING INSTALLATION, GENERAL

A. Install roofing system according to roofing system manufacturer's written instructions.

B. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.

C. Install roofing and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition and to not void warranty for existing roofing system.

3.2 INSULATION INSTALLATION

A. Coordinate installing roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.

B. Install tapered insulation under area of roofing to conform to slopes indicated.

C. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.

1. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.

D. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:

1. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m), and allow primer to dry.
2. Set each layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
3. Set each layer of insulation in insulation adhesive, firmly pressing and maintaining insulation in place.

E. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.

1. Fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.

F. Mechanically Fastened and Adhered Insulation: Install first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.

1. Fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
2. Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
3. Set each subsequent layer of insulation in insulation adhesive, firmly pressing and maintaining insulation in place.

G. Loosely Laid Insulation: Loosely lay insulation units over substrate.

H. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction. Loosely butt cover boards together and fasten to roof slab.

1. Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.

3.3 LOOSELY LAID AND BALLASTED MEMBRANE ROOFING INSTALLATION

A. Loosely lay roofing over area to receive roofing according to roofing system manufacturer's written instructions. Unroll roofing and allow to relax before installing.

1. Comply with requirements in SPRI RP-4 based on manufacturer’s installation and warranty criteria.

B. Accurately align roofing, without stretching, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

C. Adhesive Seam Installation: Clean both faces of splice areas, apply splicing cement, and firmly roll side and end laps of overlapping roofing according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of roofing terminations.

1. Apply a continuous bead of in-seam sealant before closing splice if required by roofing system manufacturer.

D. Tape Seam Installation: Clean and prime both faces of splice areas, apply splice tape, and firmly roll side and end laps of overlapping roofing according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of roofing terminations.

E. Leave seams uncovered until inspected by roofing system manufacturer.

F. Repair tears, voids, and lapped seams in roofing that do not comply with requirements.

G. Spread sealant or mastic bed over deck-drain flange at roof drains, and securely seal roofing in place with clamping ring.

H. Aggregate Ballast: Apply uniformly over roofing at the rate required by roofing system manufacturer, but not less than the following, spreading with care to minimize possibility of damage to roofing system. Lay ballast as roofing is installed, leaving roofing ballasted at the end of the workday.

1. Ballast Weight: Size 2 aggregate, 13 lb/sq. ft. (65 kg/sq. m), at corners and perimeter; Size 4 aggregate, 10 lb/sq. ft. (50 kg/sq. m), elsewhere.

I. Roof-Paver Ballast: Install lightweight roof-paver ballast according to manufacturer's written instructions.

J. Roof-Paver Ballast: Install rubber roof-paver ballast according to manufacturer's written instructions, in locations indicated.

1. Install perimeter paver edge securement.

K. Roof-Paver and Aggregate Ballast: Install heavyweight roof pavers according to manufacturer's written instructions on roof corners and perimeter.

1. Install Size 4 aggregate ballast elsewhere on roofing at a minimum rate of 10 lb/sq. ft. (50 kg/sq. m).
2. Install Size 2 aggregate ballast elsewhere on roofing at a minimum rate of 13 lb/sq. ft. (65 kg/sq. m).

3.4 BASE FLASHING INSTALLATION

A. Install sheet flashings and preformed flashing accessories, and adhere to substrates according to roofing system manufacturer's written instructions.

B. Apply bonding adhesive to substrate and underside of sheet flashing at required rate, and allow to partially dry. Do not apply to seam area of flashing.

C. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.

D. Clean splice areas, apply splicing cement, and firmly roll side and end laps of overlapping sheets to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of sheet flashing terminations.

E. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

3.5 WALKWAY INSTALLATION

A. Flexible Walkways: Install walkway products in locations indicated. Adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.

B. Roof-Paver Walkways: Install walkway roof pavers according to manufacturer's written instructions in locations indicated, to form walkways. Leave 3 inches (75 mm) of space between adjacent roof pavers.

3.6 PROTECTING AND CLEANING

A. Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.

B. Correct deficiencies in or remove membrane roofing system that does not comply with requirements, repair substrates, and repair or reinstall membrane roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.

C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION

SECTION 122413

ROLLER WINDOW SHADES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manually operated roller shades with single rollers.

B. Related Requirements:

1. Section 061053 "Miscellaneous Rough Carpentry" for wood blocking and grounds for mounting roller shades and accessories.
2. Section 079200 "Joint Sealants" for sealing the perimeters of installation accessories for light-blocking shades with a sealant.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, features, finishes, and operating instructions for roller shades.

B. Shop Drawings: Show fabrication and installation details for roller shades, including shadeband materials, their orientation to rollers, and their seam and batten locations.

C. Samples for Initial Selection: For each type and color of shadeband material.

1. Include Samples of accessories involving color selection.

D. Samples for Verification: For each type of roller shade.

1. Shadeband Material: Not less than 10 inches square. Mark interior face of material if applicable.
2. Roller Shade: Full-size operating unit, not less than 16 inches wide by 36 inches long for each type of roller shade indicated.
3. Installation Accessories: Full-size unit, not less than 10 inches long.

E. Product Schedule: For roller shades. Use same designations indicated on Drawings.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Certificates: For each type of shadeband material.

C. Product Test Reports: For each type of shadeband material, for tests performed by a qualified testing agency.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For roller shades to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Roller Shades: Full-size units equal to 5 percent of quantity installed for each size, color, and shadeband material indicated, but no fewer than two units.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver roller shades in factory packages, marked with manufacturer, product name, and location of installation using same designations indicated on Drawings.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Do not install roller shades until construction and finish work in spaces, including painting, is complete and dry and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

B. Field Measurements: Where roller shades are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Allow clearances for operating hardware of operable glazed units through entire operating range. Notify Architect of installation conditions that vary from Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain roller shades from single source from single manufacturer.

2.2 MANUALLY OPERATED SHADES WITH SINGLE ROLLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Lutron Electronics Co., Inc.
   2. MechoShade Systems, Inc.
   3. FlexShade XD by Draper Inc.

B. Chain-and-Clutch Operating Mechanisms: With continuous-loop bead chain and clutch that stops shade movement when bead chain is released; permanently adjusted and lubricated.

   1. Bead Chains: Stainless steel.

      a. Loop Length: Full length of roller shade.
      b. Chain-Retainer Type: As selected by Architect from manufacturer's full range.

C. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.

   1. Roller Drive-End Location: Right side of interior face of shade.
   2. Direction of Shadeband Roll: Regular, from back (exterior face) of roller.
   3. Shadeband-to-Roller Attachment: Removable spline fitting into integral channel in tube.

D. Mounting Hardware: Brackets or endcaps, corrosion resistant and compatible with roller assembly, operating mechanism, installation accessories, and mounting location and conditions indicated.

E. Roller-Coupling Assemblies: Coordinated with operating mechanism and designed to join up to three inline rollers into a multiband shade that is operated by one roller drive-end assembly.

F. Shadebands:

   1. Shadeband Material: Light-filtering fabric.
   2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.

      a. Color and Finish: As selected by Architect from manufacturer's full range.

G. Installation Accessories:

   1. Front Fascia: Aluminum extrusion that conceals front and underside of roller and operating mechanism and attaches to roller endcaps without exposed fasteners.

      a. Shape: L-shaped.

b. Height: Manufacturer's standard height required to conceal roller and shadeband assembly when shade is fully open, but not less than 4 inches.

2. Exposed Headbox: Rectangular, extruded-aluminum enclosure including front fascia, top and back covers, endcaps, and removable bottom closure.

a. Height: Manufacturer's standard height required to enclose roller and shadeband assembly when shade is fully open, but not less than 4 inches.

3. Endcap Covers: To cover exposed endcaps.
4. Recessed Shade Pocket: Rectangular, extruded-aluminum enclosure designed for recessed ceiling installation; with front, top, and back formed as one piece, end plates, and removable bottom closure panel.

a. Height: Manufacturer's standard height required to enclose roller and shadeband assembly when shade is fully open, but not less than height indicated on Drawings.
b. Provide pocket with lip at lower edge to support acoustical ceiling panel.

5. Closure Panel and Wall Clip: Removable aluminum panel designed for installation at bottom of site-constructed ceiling recess or pocket and for snap-in attachment to wall clip without fasteners.

a. Closure-Panel Width: 2 inches.

6. Installation Accessories Color and Finish: As selected from manufacturer's full range.

2.3 SHADEBAND MATERIALS

A. Shadeband Material Flame-Resistance Rating: Comply with NFPA 701. Testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

B. Light-Filtering Fabric: Woven fabric, stain and fade resistant.

1. Source: Roller shade manufacturer.
2. Weave: Mesh.
3. Orientation on Shadeband: Up the bolt.
4. Color: As selected by Architect from manufacturer's full range.

2.4 ROLLER SHADE FABRICATION

A. Product Safety Standard: Fabricate roller shades to comply with WCMA A 100.1, including requirements for flexible, chain-loop devices; lead content of components; and warning labels.

B. Unit Sizes: Fabricate units in sizes to fill window and other openings as follows, measured at 74 deg F:

1. Between (Inside) Jamb Installation: Width equal to jamb-to-jamb dimension of opening in which shade is installed less 1/4 inch per side or 1/2-inch total, plus or minus 1/8 inch. Length equal to head-to-sill or -floor dimension of opening in which shade is installed less 1/4 inch, plus or minus 1/8 inch.
2. Outside of Jamb Installation: Width and length as indicated, with terminations between shades of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.

C. Shadeband Fabrication: Fabricate shadebands without battens or seams to extent possible, except as follows:

1. Vertical Shades: Where width-to-length ratio of shadeband is equal to or greater than 1:4, provide battens and seams at uniform spacings along shadeband length to ensure shadeband tracking and alignment through its full range of movement without distortion of the material.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, operational clearances,and other conditions affecting performance of the Work.

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

3.2 ROLLER SHADE INSTALLATION

A. Install roller shades level, plumb, and aligned with adjacent units according to manufacturer's written instructions.

B. Roller Shade Locations: As indicated on Drawings.

3.3 ADJUSTING

A. Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.

3.4 CLEANING AND PROTECTION

A. Clean roller shade surfaces, after installation, according to manufacturer's written instructions.

B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that roller shades are without damage or deterioration at time of Substantial Completion.

C. Replace damaged roller shades that cannot be repaired, in a manner approved by Architect, before time of Substantial Completion.

END OF SECTION

SECTION 23 0901

CONTROL SYSTEMS INTEGRATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0513 - Motors

B. Section 23 0550 - Vibration Isolation

C. Section 23 0902 - Control Valves and Dampers

D. Section 23 0903 - Control Instrumentation

E. Section 23 0923 - Direct Digital Controllers and Networks

F. Section 23 0924 - Graphical User Interface Integration

G. Section 23 0993 - Control Sequences

H. Section 23 2118 - Valves

I. Section 23 3600 - Air Terminal Devices

J. Section 23 3614 - Laboratory Temperature and Airflow Control System

K. Section 26 0000 - General Electrical Requirements

L. Section 26 0533 - Raceway and Fittings

M. Section 26 0519 - Conductors and Cables

N. Control Sequences: Refer to Drawings

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. ASHRAE FUNDAMENTALS IP - (2013) Fundamentals Handbook, I-P Edition

C. ASHRAE 135 - (2012) BACnet - A Data Communication Protocol for Building Automation and Control Networks (ANSI Approved)

1.3 DEFINITIONS

A. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.

1. Actuator: Control device to provide motion of valve or damper in response to control signal.
2. AI: Analog Input
3. AO: Analog Output
4. Analog: Continuously variable state over stated range of values
5. Auto-Tune: Software routine used to adjust tuning parameters based on historical data.
6. BAS: Building Automation System

7.	BMS	Building Management System
8.	DDC:	Direct Digital Control
9.	DDCP:	Direct Digital Control Panel
10.	Discrete:	Binary or digital state
11.	DI:	Discrete Input (Sometimes referred to as Binary Input BI)
12.	DO:	Discrete Output (Sometimes referred to as Binary Output BO)
13.	EMCS:	Energy Management and Control System (Typically interchangeable with BAS or BMS)
14.	E/P:	Voltage to pneumatic transducer (Often solenoid valve is referred to as an E/P transducer)
15.	FA	Field Adjustable
16.	FC:	Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
17.	FMS:	Facility Management System linking two or more BAS
18.	FO:	Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
19.	I/P:	Current to pneumatic transducer
20.	Instrument:	Device used for sensing input parameters or used for actuation.
21.	Modulating:	Movement of control device through an entire range of values proportional to an infinitely variable input value.
22.	Motorized:	Control device with actuator
23.	NC:	Normally Closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
24.	NO:	Normally Open position of switch after control signal is removed or normally open position of manually operated valves or dampers.
25.	Node:	DDCP, operator workstation, or other control device connected to communications network.
26.	Operator:	Same as actuator for motorized devices. Also refers to an individual who physically "operates" facility.
27.	PC:	Personal Computer
28.	Peer-to-Peer:	Mode of communication between controllers in which each device connected to network has equal status and each share its database values with other devices connected to network.
29.	P:	Proportional control, control mode with continuous linear relationship between observed input signal and final controlled output element.
30.	PI:	Proportional - Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controlled variable (reset control).
31.	PID:	Proportional - Integral - Derivative control, control mode with continuous correction of final controlled output element versus input signal based on proportional error, its time history (reset), and rate at which its changing (derivative).
32.	Point:	Analog or discrete instrument with addressable database value.
33.	Self-Tune:	Same as Auto-Tune
34.	Solenoid:	Electric two-position actuator. (See E/P.)
35.	TCC:	Temperature Control Contractor (Same as Control Contractor)
36.	TCP:	Temperature Control Panel

1.4 ACCEPTABLE CONTROL CONTRACTORS

A. Control Contractor shall have full service office within 200 miles of project site. Full service office is defined as being home office of applications engineers, supervisors, and field technicians, having complete parts inventory, and having required test and diagnostic equipment. Control Contractors shall be factory authorized agent or dealer of controllers and control hardware as manufactured by:

1. Distech Controls

~~2. KMC Controls~~

B. Bids will be accepted only from prequalified Control Contractor per "Instruction to Bidders".

1.5 SYSTEMS DESCRIPTION

A. Control system shall be Direct Digital Control (DDC).

B. Damper and valve actuators shall be electronic type, unless otherwise noted.

C. The existing campus Building Automation System is Tridium.

D. New BAS shall seamlessly integrate with ~~existing~~ new site Tridium web server operator interface. ~~Existing~~ New web server shall be able to access and read all input, output and calculated points and issue commands to all output points in new BAS by means of a standard web browser. Contractor shall provide necessary ~~hardware and~~ software components to accomplish this interface.

E. Provide modular designed stand-alone controllers capable of future BAS architecture with peer-to-peer and/or low/medium speed communication networks. Upgrade to full BAS architecture shall not require removal of existing controllers, sensors, actuators, etc.

F. BAS network architecture shall be based on an Open implementation of BACnet using ASHRAE 135-2012 exclusively as the communications protocol for communication between DDC Hardware devices, including BAS Web Server, to allow multi-vendor interoperability.

G. Building Automation System (BAS) shall control building's HVAC components and provide interface with Lighting Control System.

H. Contractor provided BAS Ethernet Network shall be physically separate from other building Ethernet networks

I. Provide BAS architecture consisting of communication network, and modular designed controllers with all points addressable and modifiable from operator workstations or from master controller using laptop computer. BAS shall be fully expandable with addition of hardware and/or software. Expansion shall not require removal of existing controllers, sensors, actuators, or communication networks.

J. Operator workstations connected to building Ethernet network shall be able to access BAS information as determined by Graphical User Interface (GUI) software through standard web browsing software (Internet Explorer, Mozilla Firefox, Opera, or Google Chrome). GUI software shall allow transparent access to each building component/system for control and/or monitoring.

K. System intelligence shall be such that operator workstation(s) can be used for programming controls, performing analysis on filed data, generating maintenance and operation reports and providing permanent storage for programs and data.

L. Workstation PCs and printers will be furnished by Owner. Provide hardware interface card to communicate with BAS Network and required software for each workstation, as defined in this Section, to make each PC full function workstation.

M. Safety devices shall function in both auto and hand modes on starter, and on VFD in auto, hand or bypass modes.
   1. Dampers interlocked with fans shall operate in both auto and hand modes to prevent dead-head of fans.
   2. Valves interlocked with pumps shall operate in both auto and hand modes of operation to prevent dead-head of pump.
   3. All safeties shall be hardwired through starter/VFD safety circuit to prevent unsafe operation when in either auto or hand modes.

N. [Alternate Price for Automatic Bypass.]
   1. Safety devices shall function in both VFD and bypass modes Bypass).
      a. Dampers interlocked with fans shall operate in both VFD and bypass starter modes to prevent dead-head of fans.
      b. Valves interlocked with pumps shall operate in both VFD and bypass modes of operation to prevent dead-head of pump.
      c. All safeties shall be hardwired through VFD/bypass starter safety circuit to prevent unsafe operation when in either VFD or bypass modes.

1.6 SCOPE OF WORK

A. Provide all labor and materials for complete fully functioning control systems in accordance with Contract Documents including this Section plus:
   1. Section 23 0902 - Control Valves and Dampers
   2. Section 23 0903 - Control Instrumentation
   3. Section 23 0923 - Direct Digital Controllers and Networks
   4. Section 23 0924 - Graphical User Interface Integration
   5. Section 23 0993 - Control Sequences

B. Engineering services shall be performed by Factory Trained Engineers. System shall be installed either by trained mechanics directly employed by Control Contractor or by subcontractors who are under direct supervision of Control Contractor's representative. Engineer reserves right to exclude Project Managers, Engineers, Field Supervisors, or Technicians whose past experience is not sufficient to meet needs of Project.

C. Control Contractor’s Project Managers, Engineers and Digital System Programmers shall have previously performed in capacity that qualifies them to successfully engineer system of scope and magnitude similar to this Project.

D. Submit qualification of Project Managers, Engineers, Programmers, Field Supervisors, and Technicians to be assigned to this Project within 30 days after contract award. ~~Use Qualification Form attached at end of this Section.~~

E. Labor shall include, but not be limited to:
   1. Engineering services to size unscheduled valves and dampers based on design criteria specified in Section 23 0902 - Control Valves and Dampers, and confirm sizing of scheduled valves and dampers.
   2. Engineering services to produce requested submittals and working construction drawings and record drawings as specified here within.
   3. Engineering services for required software programming.
   4. Engineering services for graphics programming specified.
   5. Engineering services for mapping control points from Laboratory Temperature and Airflow Control System (Section 23 3614), if provided for the project.
   6. Engineering services for BAS Ethernet network design.

7. Project management services as single point contact to coordinate construction related activities.
8. Field mechanics for installation of control wiring and related control devices.
9. Field technicians to startup, calibrate, adjust, and tune control loops.
10. Field technicians to perform system checkout and testing, and to complete required reports.
11. Field supervisor during controls installation and startup.
12. Field technicians to assist Mechanical Contractor and Testing and Balancing (TAB) Contractor in adjusting controls and determining setpoints related to TAB work.
13. Field representatives and/or classroom instructors to provide Owner training as specified.

F. Control Contractor shall be responsible for complete installation of control devices (except as noted), wiring, and pneumatic terminations at controller locations to accomplish control sequences specified in project manual or on drawings. Control Contractor is required to provide power for air terminal controllers and other field mounted devices that require 24 VAC, 60 Hertz and shall be powered from 120 to 24 VAC transformer panels provided by Control Contractor. Control Contractor shall also be responsible for additional instrumentation described in point schedules found in Contract Documents, which may not be directly related to specified control sequences.
   1. Control contractor shall provide unique tag numbers for all devices under this specification and reference those tag numbers in control sequences and control diagrams.
   2. If Owner has tagging convention, Control contractor shall utilize it. If no tagging convention exists, Control contractor shall provide one for all devices under this specification.

G. Mechanical Contractor shall provide wells, taps, and other mechanical interfaces required for control equipment mounting into piping systems. Mechanical Contractor shall install in-line mounted devices, such as valves, dampers, flow meters, static pressure probes, etc., furnished by Control Contractor. Control Contractor shall be responsible for installation of other control devices, such as actuators, linkages, sensors, air terminal controllers, flow transducers, remote mounted control devices, control panels, control transformers, etc.

H. Electrical work required as integral part of control work is responsibility of Control Contractor. Control Contractor is responsible for providing final power connections, including conduit, wire, and/or disconnect switches, to control devices from appropriate electrical distribution panels.
   1. Electrical Contractor will provide circuit breakers required to provide electrical power to controllers.
   2. 120 to 24 VAC transformer panels shall be provided by Control Contractor and mounted adjacent to controller panels or in Electrical Rooms, Telecommunications Rooms and/or (IDF/EIDF) rooms, or as indicated on plans and powered from dedicated electrical circuit.
   3. Should any change in number of controllers or addition of other electrical equipment after Contracts are awarded, Control Contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of Control Contractor.
   4. Coordinate with Electrical Contractor for additional power requirements.

I. Fully functioning BAS Ethernet network, including all hardware (horizontal network cabling, routers, switches, firewalls, patch panels, patch cords, cabinets, etc), is responsibility of Contractor.
   1. BAS Ethernet network shall employ network/data communications security requirements per NIST Special Publication 800-53, Revision 3 – Information Security. BAS Ethernet network security plan shall be presented to Owner's IT personnel for approval prior to implementation.
   2. Contractor shall be responsible to provide all BAS data drops (from Telecommunication room patch panel to field jacks/patch panels). Coordinate final Telecommunication room patch panel connections with network installation Contractor.
   3. Contractor shall be responsible for maintaining master IP address list throughout project to be handed over to Owner upon completion.

J. Materials shall be as specified unless approved through procedures for product substitution specified in Division 01. Control Contractor shall provide components not specifically indicated or specified, but necessary to make system function within the intent of specification.

K. If during the installation period any of the factory equipment or material provided in the system is found to be defective in material or workmanship, it shall be replaced or repaired by Contractor at no additional cost to the Building owner within 24 hours from the time the problem was reported/discovered.

L. Any part/device or equipment installed as part of this contract found to be malfunctioning or defective during the warranty period shall be replaced by Contractor within 24 hours from the time the problem was reported.

M. Electrical products shall be listed and labeled by UL and comply with NEMA Standards.

N. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.

O. Provide tamper resistant screws and fasteners for equipment located in accessible and/or public areas.

P. Contractor is responsible for integration of the following independent systems into BAS:
   1. Fire Alarm System (FAS) Monitoring:
      a. FAS provider will provide contact termination points and/or addressable relays for connection to BAS for Smoke Control and Equipment Shutdown. Contractor shall supply cabling, conduit, and hardware necessary to make connections from BAS to FAS. Contractor and FAS provider are responsible for coordination of testing point connections between systems, and joint commissioning of systems. Contractor to refer to P&ID's, DDC Point Schedules and Control Sequences for programming and monitoring requirements.
   2. Lighting Control System (LCS):
      a. LCS provider will provide appropriate network termination points for connection to BAS. Contractor shall supply cabling, conduit, and gateway (if necessary) to make an interface connection from BAS to LCS point of connection. Contractor is responsible for a BAS solution to communicate data directly or through a gateway to all suppliers listed in Division 26 for LCS bidders. Contractor and LCS provider are responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems. Contractor to refer to P&ID's, DDC Point Schedules, and Division 26 for programming and monitoring requirements.
   3. Variable Frequency Drives (VFD):
      a. VFD provider will provide a termination point for a single point communication connection to the BAS utilizing BACnet MS/TP protocol. Contractor shall provide cabling and conduit to make an interface connection from the BAS to the VFD. Contractor and VFD provider responsible for translation of network protocols, testing of communications between systems, and joint commissioning of systems. Contractor to refer to P&ID's, DDC Point Schedules, and Section 20 0514 Variable Frequency Drive (VFD) System for programming and monitoring requirements.

1.7 SUBMITTALS

A. Technical Proposal:
   1. Submit, directly to Engineer on bid day, 3 copies of technical proposal. Technical proposal shall include written and/or graphic representation of proposed BAS architecture including quantity and types of controllers to be used at each location. Show or describe routing of communication networks. Include product data sheets for proposed controllers and sensors. Provide complete, detailed description of software packages to be used. Use pre-printed

shop drawing materials with technical details in lieu of sales literature whenever they are available.

2. Submit resumes of subcontractors to be used for project. List projects of similar size and scope. List shall include name and location of project, dollar value of control contract, date completed, and references. References shall include name and phone number of contact person.
3. Technical proposals shall not intentionally deviate from specification, but explain how proposed system meets or exceeds specification. Deviations and/or exceptions must be clearly stated in executive summary. Technical proposals will be evaluated based on completeness, conformance, and value (performance versus Bid price).
4. Submit control drawings including, but not limited to, the following:
   a. Front sheet index for projects with more than 10 control drawing sheets or 3 product cut sheets.
   b. Overall system/network architecture drawings: Provide block diagram showing relationship of each controller, control panel, or other network devices relative to each other. Label room location of each device. Number and indicate model number of each device. Indicate network types.
   c. Control Drawings: Including graphic representation of systems with major in-line components to properly locate all control devices. Identify controlled devices with their software designation on drawings, including unique valve and damper tag numbers.
   d. Detailed wiring and piping diagrams showing point-to-point hookup details of transducers, relays, outputs, inputs and subsystem components. Label pneumatic lines and control wires with field ID numbers/colors.
   e. Bill of material identifying actual product model number used for each control device for each schematic control drawing.
   f. Drawings showing proposed locations of sensors and flow meters in ductwork and piping systems.
   g. Sequence of operation: Provide written narrative describing each control sequence indicating method of control. Identify sensors, controllers, and actuators used with references to tag number of controlled device. Include set points of each control loop.

B. Shop Drawings:
   1. Submit manufacturer's printed product data sheets for control devices and materials listed in bill of material in Control Contractor's control drawings. Datasheets shall be submitted electronically in pdf format with bookmarks provided for each individual device and table of contents listing each device manufacturer and full model number with links to device pages. Organize sheets in order of model number, alphabetically, then numerically. When a manufacturer’s data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Data sheets shall include sufficient technical data to describe instrument parameters required as specified.
   2. Submit data concerning type of signal wiring and installation methods including raceway types and grounding methods.
      a. Submit voltage drop calculations for all low voltage DDC circuits. Voltage drop to include number of devices and wiring run lengths, calculated voltage available at each device.
   3. Submit control drawings including, but not limited to, the following:
      a. Front sheet index for projects with more than 10 control drawing sheets.
      b. Overall system/network architecture drawings: Provide block diagram showing relationship of each controller, control panel, or other network devices relative to each

other. Label room location of each device. Number and indicate model number of each device. Indicate network types.

c. Control Drawings: Including graphic representation of systems with major in-line components to properly locate all control devices. Identify controlled devices with their software designation on drawings, including unique valve and damper tag numbers.

d. Detailed wiring and piping diagrams showing point-to-point hookup details of transducers, relays, outputs, inputs and subsystem components. Label pneumatic lines and control wires with field ID numbers/colors.

e. Bill of material identifying actual product model number used for each control device for each schematic control drawing.

1). Bill of material shall be included on flow diagrams for each system and on panel layouts showing panel components.

f. Drawings showing proposed locations of sensors and flow meters in ductwork and piping systems.

g. Sequence of operation: Provide written narrative describing each control sequence indicating method of control. Identify sensors, controllers, and actuators used with references to tag number of controlled device. Include set points of each control loop.

h. BACnet Compliance Documentation: The Protocol Implementation Conformance Statement for each component.

4. Instrumentation submittals can be submitted as a separate submittal from control shop drawings but must be submitted at the same time as control shop drawings.

5. Submit a sample graphic page for each type of page described in Section 23 0924 - Graphical User Interface Integration.

C. Completion Checklist:

1. Submit with shop drawings, detailed completion checklist including written procedures for adjusting and calibrating each type of instrument and sensor. Engineer reserves the right to request modifications to any procedure, which is incomplete or not adequate to prove system performance.

2. Checklist shall include references to the following additional requirements:

a. Instruments and sensors shall be calibrated by comparison to known device, which is traceable to National Institute of Standards and Testing.

b. Each point shall be checked for calibration, connection to correct control loop, and proper setting of limit and alarm values.

c. Transducers and other output devices shall be properly zeroed and calibrated at both minimum and maximum output. Document settings for discrete instruments and set points for analog instruments shall include minimum and maximum positions for safe operating conditions where applicable (max. pump speed or max. frequency of fan drive, etc.).

d. Control loops shall be tuned to maintain controlled process variable at set point through seasonal conditions without operator intervention. Provide multiple sets of tuning parameters if necessary. Controller shall automatically use tuning parameters appropriate to existing ambient conditions. Maintain record on completion checklist, of control loops that require tuning at alternate times of year. Instruct technicians to supply default parameters that can approximate stable control until actual load conditions allow proper tuning of control loops.

e. Performance tests of analog control loops shall be performed by changing set points and verifying that sequences can come into stable control within reasonable time period appropriate for each sequence. Simulate load changes for pressure and flow control loops.

f. Performance tests of discrete control loops shall be performed by adjusting set point and verifying sequence action.

g. Alarms, including network failures, shall be tested for each controller and device connected to network. Ensure that alarms are properly acknowledged at operator's workstation.

h. Schedules for each system/device shall be verified.

i. Graphics shall be verified for functionality including password protection, floor plan displays, system displays, alarm messaging, historical trends, report generation and HVAC schedules.

j. BAS Ethernet network testing and benchmarking documentation showing network performance from switch to switch.

k. Testing of BAS to ensure cyber security. Coordinate testing requirements with Owner.

D. Control Contractor and Mechanical Contractor shall walk proposed static pressure sensor and flow meter locations and mark up drawings for review and approval by Owner and Engineer prior to installation.

1.8 WARRANTY

A. Warranty period shall begin as authorized by the Owner's representative in writing. Authorization will not be given before the following conditions are met:

1. All verified completion checklists provided to Owner.
2. Completion of all punch list items.
3. Conduction of a preliminary training session for personnel. The training shall consist of an orientation session at the job site to familiarize the personnel with the location and type of controlled equipment and controls on the project, a discussion of the control sequences, and a review of the control drawings.
4. Completion and distribution of the as-built control drawings, including correction of all items noted by Owner and Engineer after review of the documents.

B. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. A telephone number where the service supervisor can be reached at all times shall be provided. The maximum acceptable response time to provide this service at the site shall be 24 hours Monday through Friday, 48 hours on Saturday and Sunday.

D. This warranty shall apply equally to both hardware and software.

E. Service personnel shall be qualified to accomplish work promptly and satisfactorily. Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

F. Scheduled Inspections:

1. Two inspections shall be performed prior to warranty expiration and all work required shall be performed. Inspections shall be scheduled 6 months after Owner acceptance and one month prior to end of warranty period.
2. These inspections shall include:
   a. Visual checks and operational tests of equipment.
   b. Clean control system equipment including interior and exterior surfaces.
   c. Check and calibrate each field device. Check and calibrate 50 percent of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the device being calibrated. Randomly check at least 25 percent of all digital inputs and outputs

for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital inputs and outputs during the second inspection.

d. Run system software diagnostics and correct diagnosed problems.

e. Resolve any previous outstanding problems.

f. Install software upgrades, patches and fixes. Contractor to provide verification to facility personnel that all upgrades, patches and fixes to be installed have been tested in accordance with site testing and deployment procedures.

G. Scheduled work shall be performed during regular working hours, Monday through Friday, excluding holidays.

H. Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

I. Each service call request shall be recorded as received and shall include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

J. Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Owner. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions, and other documentation affected.

K. During the warranty period, the Contractor shall maintain a backup of all software installed in the system. The backup shall be updated monthly or whenever the Contractor makes a change to the software. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge.

L. At the end of the warranty period, the Contractor shall provide updated copies of the latest versions of all project record documentation as described in Paragraph 1.10, Record Documents. This includes final updated drawings, software documentation, and electronic media backups that include all changes that have been made to the system during the warranty period.

1.9 COORDINATION WITH TAB CONTRACTOR

A. Control Contractor shall allow sufficient time to provide assistance and instruction to TAB Contractor in proper use and setting of control components such as, Operator Workstation computers, static pressure controllers, "K" Factors for VAV boxes, or any other devices that may need set points changes so that TAB work can be performed.

B. Provide required hardware and software related to control system to TAB Contractor to allow testing of systems and continued operation.

1.10 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 - General Requirements.

B. Operation and Maintenance manuals shall provide descriptions of maintenance on all system components, including sensors and controlled devices. Descriptions shall include:

1. Product manuals for the key software tasks.

a. Operating the system

b. Administering the system

c. Engineering the Operator workstation
d. Application programming
e. Engineering the network
f. Setting up the web server
g. Report creation
h. Graphics creation
i. Data backup & Archiving

2. List of recommended maintenance tasks associated with the system, controllers, instruments, operator workstations, data servers, web servers, and web clients.
   a. Define the task.
   b. Recommend a frequency for the task.
   c. Reference the product manual that includes instructions on executing the task.
3. Licenses, guarantees, and warranty documents for equipment and systems.
4. System architecture diagram for components within the building annotated with specific location information.
5. As-built drawing for each control panel
6. As-built wiring design diagram for each control panel
7. As-built system flow diagram for each system
8. Sequence of control for each system
9. Binding map for the building
   a. A list of the device to device data flow. This shall not include the flow of data from devices to the presentation system.
   b. Include:
      1). Description of the variable
      2). Sending device
      3). Receiving device
10. Product data sheet for each component
11. Troubleshooting guide
12. Repair parts list
13. Calibration instructions
14. Control Contractor's completion checklist
15. Manufacturer representative's name, address, and phone number

1.11 RECORD DRAWINGS

A. Refer to Division 01 - General Requirements.

B. Submit revised shop drawings indicating changes made during Project.

C. Record drawing submittals shall be inclusive of BAS as installed and commissioned.

D. Update control diagrams to include tuning parameters and set points applicable to systems depicted as of date of system completion. This information shall be incorporated with sequence of operation for each system.

E. Include floor plans showing location of control panels and routing of BAS network cabling.

F. List of all IP addresses assigned on IFMS complete with description of device and associated vendor.

G. BACnet systems and devices:

1. Submit finished device addressing documentation.
2. Submit finished hardcopy of device binding database.

H. Provide passwords, if used, for back-up and restore functions for each controller.

I. Software (as installed and commissioned)
1. All software submittals shall be provided in a format suitable for restoration of the programming and configuration of respective digital controllers, servers, workstations and peripheral devices, etc. provided as part of the BAS.
2. Submit a copy of all software installed on the servers and workstations.
3. Submit all licensing information for all software installed on the servers and workstations.
4. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
5. Submit all licensing information for all of the software used to execute the project.
6. All software revisions shall be as installed at the time of the system acceptance.

J. Firmware Files (as installed and commissioned)
1. All firmware files shall be provided in a format suitable for restoration of the programming and configuration of respective digital controllers, servers, workstations and peripheral devices, etc. provided in the BAS.
2. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
3. Submit control listing of firmware version for all firmware that is permanently burned on a chip at the factory.
4. Submit a copy of all application files that were created during the execution of the project.
5. Submit a copy of all graphic page files created during the execution of the project.
6. Submit a copy of all secondary graphic files such as bitmaps, jpegs, etc. that were used in the creation of the graphic pages.

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

A. Owner shall retain all rights to software for this project.

B. Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software.

C. Licensing agreement shall not preclude the use of the software by individuals under contract to the Owner for commissioning, servicing, or altering the system in the future. Use of the software by individuals under contract to the Owner shall be restricted to use on the Owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.

D. All project developed software, files and documentation shall become the property of Owner. These include but are not limited to:
1. Server and Workstation software
2. Application Programming Tools
3. Configuration Tools
4. Addressing Tools
5. Application Files
6. Configuration Files
7. Graphic Files

8. Report Files
9. Graphic Symbol Libraries
10. All Documentation.

PART 2 - PRODUCTS

2.1 CONTROL WIRING

A. Control wiring shall be in accordance with National Electrical Code and Local Electrical Codes. Final connection points at devices and panels shall be made either at terminal blocks integral to device or at separate terminal blocks mounted inside of control panel enclosures. Use of wire nuts and crimped connections are not allowed for terminating control wiring unless approved by Engineer.

B. Refer to Division 26 for specification requirements for conduits and conductors, except as noted.

C. Terminal Blocks:
   1. Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

D. Signal and Power Conductors (24 V and Under):
   1. Wires smaller than #18 AWG shall not be used, except for manufacturer supplied instrument specific wire, or where otherwise specified. Use 2-wire stranded twisted/shielded pair 24 VDC for analog and discrete input and 24 VAC/VDC output devices. For 3-lead RTD signal wiring, use #18 AWG stranded, tinned copper twisted/shielded 3-conductor. Provide isolated instrument grounding system as per manufacturer's recommendations.
   2. Conductors not concealed in raceway shall have UL Listed plenum rated Teflon insulation.
   3. Provide 250 ohm, 5 watt, 0.1% tolerance dropping resistors in 4 - 20 mA circuits as required to generate 1 to 5 volt signals in 24 VDC powered instrument loops.
   4. 24 VAC Power Conductors shall be #18 AWG 2 wire twisted pair or larger. Provide Metal Oxide Varistors (MOVs) on 24 VAC/VDC discrete outputs connected to inductive loads to reduce noise levels (i.e., solenoid valves, motor contactors, relays, damper/valve electric actuators, etc.).
   5. Stranded twisted/shielded control conductors are required with shields to be terminated within variable frequency Drive enclosures to reduce effects of noise from VFD. Follow VFD manufacturer's installation instructions for wiring control conductors to VFD.

E. Communication Cable:
   1. Cable not concealed in raceway shall have UL Listed plenum rated insulation.
   2. Floor Level Network Communication Cable (Twisted Pair): Use control system manufacturer's standard communications cable or #22 AWG to #24 AWG twisted, shielded pairs, coaxial cable, or fiber optics for communications between remote controllers/devices
   3. Interior LAN Horizontal Communication Cable:
      a. Refer to specification 27 1500 - Communications Horizontal Cabling.
      b. Horizontal copper LAN cable shall meet or exceed all requirements of Category 6 cable as specified in TIA/EIA-568-B.2.
      c. BAS Ethernet network Horizontal copper LAN cable shall be yellow.
      d. Horizontal copper LAN cable shall be terminated in an eight-position modular Jack with color to match system cable.
      e. Horizontal copper LAN cable shall be terminated in a telecommunication room that is on the same floor as the area being served in a 4-pair 100Ω twisted pair modular patch panel with color to match system cable.

f. Horizontal copper LAN cabling shall not exceed 295 ft.

g. Provide minimum of 10’ of slack at telecommunication room and 12” of slack at outlet

F. Transient Voltage Surge Suppression Devices:

1. Devices shall be designed for 120 V power conditioning devices for electronic equipment. Devices shall be designed, manufactured, tested, and installed in compliance with ANSI/IEEE C62.41 and C62.45, Federal Information Processing Standards Publication 94 (FIPS PUB 94), NEMA, NFPA 70, 75, and 78, and UL 1449 and 1283. Devices shall be labeled for UL 1449.
2. Clamping voltage for 120 V power systems shall be 400 V.
3. Provide visual indicator of when surge device has been used.

G. Uninterruptible Power Supply

1. Manufacturers: MGE UPS Systems, Eaton Powerware, Liebert PowerSure or approved equal
2. Provide UPS for backup power for Operator Workstations, Building Level Controllers, Floor Level Controllers and field panels required for control of emergency/standby powered equipment, UPS shall maintain control upon loss of normal power and until emergency/standby power supply is brought on line.
3. Select UPS for minimum of 5 minutes backup time for load connected. This will allow emergency/standby power sources to come on line and provide backup power to emergency/standby powered equipment.
4. Upon sensing loss of normal power, transfer time shall be 8 milliseconds maximum.
5. Operating Parameters:
   a. Operating Temperature: 32°F to 104°F
   b. Relative Humidity: 0 to 95% rh, non-condensing
   c. Recharge Time: 8 hours, typical
6. UPS shall have self-diagnostic capability with DO to BAS to allow remote monitoring/alarming of UPS trouble or alarm conditions.

H. Uninterruptible Power Supply (Servers):

1. Manufacturers: MGE UPS Systems, Eaton Powerware, Liebert PowerSure or approved equal
2. Provide rack mounted dual/double conversion UPS for backup power for each rack-mounted Server. UPS shall maintain power to Server upon loss of normal power and until emergency power supply is brought on line.
3. Select UPS for minimum of 20 minutes backup time for load connected. This will allow emergency power sources to come on line.
4. UPS shall be provided with power management software and communication cable for interfacing with respective Server.
5. Upon sensing loss of normal power, transfer time shall be 8 milliseconds maximum.
6. Operating Parameters:
   a. Operating Temperature: 0 to 40°C
   b. Relative Humidity: 0 to 95% rh, non-condensing
   c. Recharge Time: 8 hours, typical

2.2 LOCAL CONTROL PANELS

A. Control panels shall meet the following minimum requirements:

1. Outdoors: Control panels located outdoors shall comply with NEMA 3R or 4X requirements.
2. Mechanical Rooms: Control panels located in mechanical or electrical rooms shall comply with NEMA 4 requirements.

3. Other Locations: Control panels in other locations, including but not limited to occupied spaces, above ceilings, and plenum returns shall comply with NEMA 1 requirement.

B. Provide panels of adequate size to accommodate instruments for future expansion of approximately 25% beyond space required for this scope of work.

2.3 NETWORK HARDWARE

A. Ethernet Switches, Routers, and Bridges:
1. Network hardware shall be provided and configured to form a campus-wide Fast Ethernet (a combination of 100BASE-TX and 100BASE-BX, -FX, and –SX or higher).
2. Ethernet devices shall be IEEE Std 802.3 which shall function as the center of a distributed-star architecture and shall be "learning" type with spanning tree algorithms per IEEE Std 802.1D. All devices shall have a non-blocking architecture.
3. The switch shall support the connected media types and shall have a minimum of 150% the required ports and no fewer than 4 ports. One port shall be switch selectable as an uplink port.
4. Network hardware shall be compatible with the copper and fiber optic cabling installed by the Division 27 contractor. Refer to specifications 27 1300 and 27 1500 for media types.
5. Switch located in BAS server rack shall be managed type and shall have a minimum of two fiber optic ports.
6. Switch shall include N.O./N.C. alarm contact for monitoring by BAS.

B. Network Components:
1. Network components (Racks, enclosures, patch panels, etc.) shall comply with respective sections of specification 27 1100 – Communications Equipment Room Fittings.

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment, and wiring in neat and workmanlike manner.

B. Coordinate timely delivery of materials and supervise activities of other trade contractors to install devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, valves, dampers, and other such items furnished by Control Contractor, which are to be installed by Mechanical Contractor.

C. Install control devices in accessible location.

D. All BAS associated 120 VAC power wiring (including all input and output power supplies) shall originate from clearly-marked, BAS-dedicated circuit breakers. All input/output transducers shall be powered from the same circuit that supplies power to the associated BAS controller. All BAS equipment shall be fused in accordance with manufacturer's recommendations.

E. BAS controllers shall be labeled with the source of electrical power including panel number, circuit breaker number, and room number where electric panel is located.

F. Devices containing mercury are not allowed.

G. Coordinate mounting height and location of control devices so that NEC workspace clearances are maintained.

H. During construction, Contractor shall take necessary precautions to ensure all panels, wiring, instrumentation, etc. are kept clean and dry. Upon Project completion, control panels shall be clean of wire nuts, trash, and wire stripping. All excess material is to be turned over to Owner BAS group.

I. BAS floor level network to room/equipment controllers shall be confined to the same floor the respective building level controller is located on.

1. In applications where the floor level network must transition between floors, the transition shall be located in a clearly marked junction box on each floor of appropriate size to accommodate a screw terminal strip. Network cabling shall be labeled to indicate the previous connection prior to entering the junction box with the terminal strip. Terminal strip shall be used as a transition point from one floor to the next. Terminal strip shall be large enough to accommodate transitions to and from the floors below and above if floor transitioning is required.

3.2 CONTROL WIRING

A. Provide electrical wiring required for complete functional control systems, including power circuit to control panels, both line and low voltage, in accordance with applicable local codes, and latest version of National Electrical Code and NFPA. Refer to Paragraph 1.6.H. for definition of scope of Work.

1. Voltage drops for all low voltage circuits shall be calculated prior to installing low voltage circuits. Voltage drop calculations shall be made available to Engineer on demand.

B. Control panels serving equipment fed by emergency/standby power shall also be served by emergency/standby power. Equipment fed by emergency/standby power is so indicated on mechanical equipment schedules and electrical motor schedules. Control panels shall be powered by local UPS (Uninterruptible Power Supply) to ensure continued control of equipment powered by site standby power sources when primary power source is lost. Devices such as Operator Workstations, Floor Level and Building Level Controllers, Application Specific Controllers and fume hood controls shall be provided with UPS power.

C. Where multiple controllers reside in a single control panel, provide a separate disconnect (or fuse) for each controller.

D. Install control wiring in metal conduit or raceway system. Refer to Division 26 - Electrical for additional requirements.

E. Color-code each junction box cover plate as to signal type using 1/2" self-adhesive color dot or enamel spray paint. Use blue for low voltage signal wiring, and yellow for line voltage wiring used for signal wiring or dedicated power wiring.

F. Tag each wire termination at control panels, junction boxes, and remote control devices with unique wire ID number.

G. Low voltage wiring concealed above accessible ceilings does not require raceway. Cables not in raceway shall be routed along building structure lines using Bridal Rings, J-hooks or other mounting methods as approved by Engineer. Use of wire-ties for attaching cabling to duct brackets, piping or structure is not acceptable. Diagonal routing is not allowed. Label each cable not in raceway with unique wire ID number every 50 ft.

H. Terminate low voltage DC instrument signal cable with black terminated on positive terminal and white terminated on negative unless otherwise noted.

I. Run direct current instrument conductors separately from alternating current conductors. Where allowed by NEC wiring classification, AC-DC route crossings shall be at 90 degrees. Install special sensor to transmitter cables in accordance with manufacturer's installation drawings or in compliance with manufacturer's instructions. Extra precautions shall be taken when pulling and shortening these "vendor furnished" cables. Any extra length on these cables shall be neatly coiled into minimum 3" diameter coils and installed into junction box.

J. All wiring terminating in a control panel/enclosure shall be landed on terminal strips, with one wire per terminal. All I/O points on a DDC/BAS controller shall be wired to panel-side of terminal strip, including all spare I/O points.

K. Route intrinsic safe wiring separately from other conductors. These conductors shall not be run with, nor cross, conductors of other NEC classifications and shall require intrinsic barrier if run in the same path with wiring of other classifications.

L. **[UIC** standard cabling and color codes shall be used, if no specified cabling and color codes are available use below standards.

M. Recommended instrument and control conductor color code shall be as follows:

1. 120 VAC control signal Red
2. 120 VAC instrument line power Black
3. 120 VAC instrument line neutral White
4. 24 VAC control signal Yellow
5. 24 VAC instrument line power Brown
6. 24 VAC instrument line neutral Orange Grounds Green
7. 24 + VDC instrument signal Black
8. 24 - VDC instrument signal White or clear
9. RTD V+ Black
10. RTD V- White
11. RTD compensation Red

N. Electric Signal Cables:

1. Analog electric signal cables from electronic transmitters to controllers/receivers and from controllers to other analog devices shall be continuously shielded to reduce effects of EMI on control signals residing on those cables. Electric signal cables to discrete devices typically do not require shielding, but for better noise immunity use twisted/shielded pairs.
2. Shields shall be grounded at power source end only and floated at other end. Pay particular attention to floating shields through termination points, maintaining only one single grounding point, and insulating from ground at other points.
3. Provide 250 ohm, 5 watt, 0.1% tolerance, dropping resistors as required to generate 1 - 5 VDC signals or 500 ohm, 5 watt, 0.1% tolerance, dropping resistors as required to generate 2 - 10 VDC signals from 4 - 20 mA control loop powered by 24 VDC power supply.

O. BAS Network Communication Cable:

1. Install special cable connectors in accordance with BAS manufacturer's recommendations.
2. Typically, #22 AWG, but no smaller than #24 AWG, twisted pairs, twisted shielded pairs, coaxial cable, fiber optics or manufacturer's standard cabling for communications between remote control devices and BAS controllers.
3. BAS Network communication cable shall not be spliced.
4. Provide isolated instrument grounding system as necessary per manufacturer's recommendations.

3.3 LOCAL CONTROL PANELS

A. Provide local control panel for each system where more than one control device requires field mounting, (air handling units, exhaust fans, miscellaneous control systems including pump controls, heat exchanger controls, etc.). Single devices may be mounted on piping, wall or ductwork. Install local control panel where indicated on drawings or suitable location adjacent to system served.

B. Mount panels on wall with suitable brackets or on self-supporting stand. Mount top of panels no higher than 6 ft above floor. Install panels so front cover door can swing fully open without interference.

C. Label local control panels with respective unique ID numbers in accordance with Section 20 0553 - Mechanical Identification.

D. All control panels located in accessible areas be provided with keyed locks. Locks shall utilize a single master key. Provide 2 spare key sets to Owner.

E. Panel Layout:
   1. Locate controllers in lower half of panel first and upper half second.
   2. Locate terminal strips either horizontally in upper half of back panel or vertically. Do not locate terminal strips below 2'-0" or above 6' above finished floor.
   3. Separate 24 VDC and 120 VAC, wire, cable, and devices by 6" minimum space.
   4. Enclose wire and cable in wireways or bundle w/ wire ties and secure to back-panel. This does not apply to wire exiting wireways to terminal strips or panel mounted devices.
   5. Space controllers according to manufacturer's requirements with 3" minimum between controllers and other devices on panel and 6" between controller front and door mounted devices. Ensure adequate space is allowed for device heat dissipation.
   6. Do not place controller or control devices on enclosure sides.
   7. Do not use any control panel as wire or cable pass-through to adjacent panel.

3.4 BAS ETHERNET NETWORK TESTING AND BENCHMARKING

A. Test and document connectivity, latency, and integrity of network from each switch to each BAS controller and BAS server switch and from switch-to-switch.
   1. Latency between any ports shall be equal to or less than 1 millisecond.
   2. Packet loss shall be less than 0.5% between any ports when tested with frame sizes between 64 and 1518 frames for duration of 60 seconds.

B. Test and document all telecommunication protection/security techniques employed on system including access control into BAS Ethernet network from other building networks and access control to other building networks from BAS Ethernet network. Coordinate testing procedures with Owner.

3.5 ADJUSTMENT AND COMPLETION CHECKLIST

A. After completion of installation, follow checklist procedure defined in checklist submittal to adjust and calibrate thermostats, control valves, control actuators, controllers, sensors, and other equipment provided in this Contract. Include signed and dated, completed checklist in Operation and Maintenance Manuals.

B. Upon completion of Work but before final acceptance of systems, Engineer or Owner's representative will verify performance of control loops. Control Contractor shall immediately remedy any deficiencies found. Corrective measures may include modification or addition of equipment and devices, control strategies and/or software program. Corrective modifications made by Control Contractor during warranty period shall be incorporated and updated in Operation and Maintenance Manuals.

C. After final acceptance of system, Contractor shall work with Owner to remove all existing user names and passwords for all software and hardware used on project and create new user names and passwords as required.

3.6 OWNER TRAINING

A. Provide full time BAS operator to run system after systems have been started and are regularly used until Owner has completed on-site training specified.

B. Provide minimum of **8** hours of on-site training to Owner's representatives. Conduct training sessions during normal business hours after system start-up and acceptance by Owner.

Scheduling of training session(s) will be established by Owner. Portions of training may be performed before system is completely operational, but no sooner than one month before system is planned to be fully operational. Final training session shall be held after systems are complete including all graphics programming.

C. Course content shall include, but not be limited to, the following topics:
   1. Explanation of control sequences. Include which sensors are used and how output device operates.
   2. Explanation of control drawings and manuals, including symbols, abbreviations, and overall organization.
   3. Walk-through of Project to identify controller locations and general routing of network cabling.
   4. Review of operation and maintenance of hardware devices including air compressor, air dryers, controllers, instruments, and sensors. Include schedule for routine maintenance.
   5. Review of operation of operator's workstation; include hardware (PC's, printers, etc.).
   6. Review of operator's workstation software using specific examples of operating hardware.
   7. Review of portable operator's workstation software using specific examples of operating hardware.
   8. Any additional item(s) specifically requested by Owner.

D. Provide listing of regularly scheduled factory classroom training sessions concerning advanced topics covering proper operation and maintenance of control systems, sensing, monitoring and control equipment. Additional classes travel and lodging will be arranged and paid by Owner.

END OF SECTION

~~Qualification Form~~

~~Brief resume of key persons, specialists, and individual consultants anticipated for this project:~~

a. Name & Title:	b. Project Assignment:
c. Name of Firm with which Associated:	d. Years of Experience: With this Firm_____ Other firms_____
e. Education: Degree(s)/Year/Specialization	f. Responsibility Level Proposed for this Project:
g. Other experience and qualifications relevant to the proposed project (include training courses/certifications):	
Recent Relevant Experience (see example below) ▪ Company, Location - Name of Specific Project, Facility - Description of Work and Responsibilities	**Qualifications**

SECTION 23 0923

DIRECT DIGITAL CONTROLLERS AND NETWORKS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901 - Control Systems Integration

B. Section 23 0903 - Control Instrumentation

C. Section 23 0993 - Control Sequences

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DEFINITIONS

A. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.

1. ASC:	Application Specific Controller. A networked device or node that contains a complete, configurable application that is specific to a particular task.
2. Alarms & Events:	The exchange of data between devices related to the occurrence of a predefined condition that meets specific criteria (event).
3. BC:	Building Controller. Provide supervisory control, scheduling, trend logging & alarm handling.
4. B-OWS:	BACnet Operator Workstation
5. B-BC:	BACnet Building Controller. Same as SLC.
6. B-AAC:	BACnet Advanced Application Controller. Same as PPC.
7. B-ASC:	BACnet Application Specific Controller
8. B-SA:	BACnet Smart Actuator
9. B-SS:	BACnet Smart Sensor
10. BBMD:	BACnet Broadcast Management Device
11. BIBBS:	BACnet Interoperability Building Blocks. Specific individual function blocks for data exchange between interoperable devices.
12. Broadcasting:	The propagation of data from a device to the control network. Software objects that broadcast data to the network may include the following parameters:
13. Send on Delta:	An adjustable parameter that defines a requirement to broadcast when the data generated by the software object changes by an amount that exceeds this parameter's value. For binary data, this parameter defaults to a change of state. The broadcast of data is initiated when this criteria and the minimum send time requirement have been met. Also referred to as a "Change of Value".
14. Minimum Send Time:	An adjustable parameter that defines a mandatory time period during which no broadcasting of data will occur. Once this time period has been exceeded without a broadcast, the send on delta parameter or the maximum send time parameter shall determine when a broadcast is initiated.

15. Maximum Send Time: An adjustable parameter that defines the maximum time period between broadcasts of a software object's data to the network. Should the value of a software object remain constant over an extended period of time, the value will be rebroadcast once every maximum time period.
16. BTL: BACnet Testing Laboratory.
17. Channel: One or more segments not containing a router.
18. Domain: A logical collection of devices on one or more channels.
19. FLN: Floor Level Network. BACnet MS/TP.
20. HMI: Human-Machine Interface. Graphical operator BAS interface. Same as Graphical User Interface (GUI).
21. LAN: Local Area Network. Same as Floor Level Network.
22. Maximum Send Time: Event driven communication parameter specifying the time period for which data must not be sent more than once.
23. Minimum Send Time: Event driven communication parameter specifying the time period for which data must be sent at least once.
24. PICS: Protocol Implementation Conformance Statement. Detailed description for a given BACnet device stating its inherent BACnet capabilities.
25. Point: Group of data, which corresponds to a hardware input, output, or calculated value.
26. PPC: Programmable Process Controller. Same as Advanced Application Controller (AAC)
27. Scheduling: The exchange of data between devices related to the establishment and maintenance of dates and times at which specified output actions are to be taken.
28. Send on Delta: Event driven communication parameter specifying the amount of variable change before data is to be sent between the Minimum and Maximum send times.
29. SLC: Supervisory Level Controller. Same as Building Controller.
30. Segment: A section of uninterrupted cable where multiple devices may be installed.
31. Subnet: Logical division of a domain.
32. Trending: The accumulation of (time, value) pairs at specified rates for a specified period duration.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Submit shop drawings for each hardware device used and submit complete description of software applications used. Submit manufacturer's printed product data sheets for each device or software program used. Datasheets shall be submitted electronically in pdf format with bookmarks provided for each individual device and table of contents listing each device manufacturer and full model number with links to device pages. Organize sheets in order of model number, alphabetically, then numerically. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
   2. Submittals shall include points list of each control input and output, controlled devices, locations of devices, and symbol or label of each control point in software.

B. Operating and Maintenance Manuals: Refer to Section 23 0901 - Control Systems Integration.

C. Software Manual:

1. As part of operating and maintenance manuals, submit one software manual per workstation plus one extra copy for archive use. Software manuals shall be divided into separate parts with tabs for each part.
2. Software manual parts shall include:
   a. Complete description of operating system including all commands, configuration programs, printouts, logs, database functions and passwords. Describe general operating procedures, starting with system overview and proceeding to detailed description of each software command feature with sample printed displays and system function description for each option. Include instructions on verifying errors, status, changing passwords and initiating or disabling control programs.
   b. Complete description of programming language including all commands, configuration programs, control loop functions and testing. Describe general programming procedures, starting with system overview and proceeding to detailed description of each software command feature. Include instructions on creating or modifying any control algorithm or parameter, debugging, etc. This shall include all control functions, algorithms, mathematic equations, variables, setpoints, time periods, messages, and other information necessary to load, alter, test and execute custom or pre-written programs.
   c. Software Backup: Upon successful completion of acceptance testing, submit to Owner 2 archive copies of all accepted versions of source code and compiled code for all application programs and data files on CD ROM backup disks. All control software must be readily accessible by Owner using BAS workstation hardware and software.
   d. Web server/data historian SQL database schema (table format) for trend data and event/alarm data.
   e. Control Loop Documentation: Submit indexed summary of each control loop program. Summary shall list in tabular form, name of system, name of control loop, all I/O points used, and reference to sheet number in shop drawings to describe control sequence programmed. For each control loop submit complete printed listing of source code used, all setpoints, high/low alarm points, time event schedules, proportional gains, integrals, derivative values, and other database values.
   f. BAS Points List Summary: Provide detailed summary for each point in the system. Summary shall be cross-index listing of all points in alpha/numerical order with list of control loops which use each point. For each point, include an abbreviated point name, expanded point description, detailed description of each input instrument or output device, and detailed description of exact location of all field hardware. Location descriptions shall include room names, column numbers, elevation (above ceiling, bottom of duct, etc.).

1.5 WARRANTY

A. Provide 1 year warranty on all materials and labor.

B. Warranty requirements shall include furnishing and installing software upgrades issued by the manufacturer during the 1 year warranty period.

1.6 FCC COMPLIANCE

A. Digital equipment furnished under this contract shall be tested and made to comply with limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environments. Literature shall so note and equipment shall be so labeled to show this compliance.

PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROL (DDC) CONTROLLERS

A. General:

1. DDC controllers shall be microprocessor based, field programmable controllers, capable of performing control and energy management functions, and shall be UL listed as Signaling Systems. Each controller shall include its own microprocessor, power supply, input/output modules, and termination modules as required to perform intended function.
2. DDC controller shall receive discrete electrical and/or analog electronic field input signals, convert signals for use by controller, perform control sequences, convert controller information into output signals, and provide control output signals to actuators and field control devices. Inputs and outputs, including communication connections, shall be electrically or optically isolated from controllers.
3. All DDC controllers shall be provided by the same manufacturer.
4. DDC controller with analog input modules shall be capable of accepting any form of linear or non-linear voltage (0-5 VDC or 0-10 VDC), current (4-20 mA) or resistive input (0-1000 ohm).
5. DDC controller with discrete input modules shall be capable of accepting discrete inputs from any device with isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate input point status.
6. Provide input modules capable of interfacing with pulsed output type sensors as required.
7. DDC controller with discrete output modules shall have isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate output point status.
8. DDC controller shall have capability to scale, offset, and display proper analog value without field hardware modification. DDC controller shall convert analog input signals to digital values (A/D conversion) and convert digital values to analog outputs (D/A conversion) for modulating control purposes. Some application specific controllers may utilize tri-state or Triac outputs for floating point control of control devices. Floating point control should be limited to non-critical room temperature control and mechanical space heating and cooling.
9. Failsafe hardware shall be provided such that BAS failures result in immediate return to local control. If DDC controller uses database values from other DDC controllers and communication network fails or malfunctions, control loop outputs shall continue to function using last value received from BAS.
10. Failure of network or control devices (i.e. building level controllers, floor level controllers, application specific controllers, routers, repeaters, etc.) shall be alarmed at the Operator Workstation as a Level 3 Critical Alarm.
11. All DDC Hardware shall meet the following requirements:
    a. All DDC controllers shall be connected to an ASHRAE 135 MS/TP, BACnet over ARCNET or BACnet/IP control network and communicate via ASHRAE 135 exclusively.
    b. MS/TP controllers shall operate at a minimum baud rate of 38.4 kbps.
    c. All DDCP shall implement all required functionality of the application network interface via BACnet objects, properties, and services.
    d. All DDC controllers shall conform to the BACnet Testing Lab's Device Implementation Guidelines and be BTL Listed.
    e. Application programs and configuration settings shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings.
    f. All settings and parameters used by the application shall be fully configurable to the greatest extent possible, via properties of BACnet objects that can be written to via BACnet services or via properties of BACnet objects that can be written to via BACnet services for the following:
        1). Setpoint
        2). Alarm limit
        3). Schedule modification
        4). Trend modification
    g. All other settings and parameters that cannot be written to via BACnet services shall be fully configurable via either properties of BACnet objects that can be written to with a

configuration tool, or via hardware settings on the controller itself to support the application.

12. Each DDC panel shall have sufficient I/O capacity to perform specified control sequences and/or include points listed in point schedules. If DDC controller does not have sufficient capacity, provide additional slave I/O panels to achieve required point count.
13. Analog and critical safety discrete control loops shall have inputs and outputs into/from same DDC panel. Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control.

B. BACnet Building Controller (B-BC):
   1. BACnet Building Controllers (B-BCs) shall provide direct connection to high speed, BACnet/IP Local Area Network (LAN) and Campus Ethernet network and serve as communications router for other controllers on slower speed BACnet MS/TP or BACnet over ARCNET Floor Level Network (FLN).
      a. B-BC shall be a JACE 8000 or approved equivalent.
   2. Communication between B-BC's shall be through BACnet/IP communication.
   3. B-BC's shall have sufficient processor capabilities, hard-drive storage and RAM to implement all types of custom software applications and shall provide supervisory control, scheduling, trend logging & alarm handling functions as follows:
      a. Scheduling:
         1). Each B-BC shall support a minimum of 250 BACnet Schedule Objects and 250 BACnet Calendar Objects.
      b. Trending:
         1). Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
         2). B-BC shall periodically upload trended data to networked BAS Web Application Server for long term archiving.
         3). Archived data shall be stored in standard database format and shall be made available for use in third-party spreadsheet or database programs.
      c. Alarm Generation:
         1). Alarms may be generated within the system for any object change of value or state either real or calculated. This includes analog object value changes, binary object state changes, and various controller communication failures.
         2). B-BC shall periodically upload alarm logs to networked BAS Web Application Server for long term archiving.
   4. B-BC's shall have uninterrupted real time clocks capable of time of day, week, and year information to the system as needed to perform software functions. Clock shall be programmed to reset twice per year to allow for Daylight Savings Time. Clocks in multiple DDC Controllers shall be synchronized to automatically match designated B-BC's or Web server. Accuracy shall be within 1 second per day.
   5. Batteries shall maintain volatile memory and real time clocks for a period of at least 72 hours during power failure. Batteries shall be maintenance free and have minimum life of 2 years. When power has been restored, the following shall occur automatically:
      a. Orderly startup of controlled equipment (user defined)
      b. Continuation of control algorithms
      c. Database revision
      d. Logging of power interruption and restoration times
      e. Battery recharging
   6. Provide local visual indication and system annunciation of low battery power for each battery.
   7. Each B-BC shall include its own micro-processor, power supply, input/output modules, and termination modules as required to perform intended function.
   8. BACnet UDP port number to always be set to 47808 (BAC0).

C. BACnet Advanced Application Controllers (B-AAC):
   1. B-AACs are defined as having sufficient processor capabilities and RAM to implement all types of custom software applications.
   2. B-AACs shall be capable of communicating to BAS network via BACnet MS/TP connected to Building Controller or via BACnet/IP directly.
   3. All B-AACs controlling major mechanical equipment/systems and lab equipment monitoring shall communicate via BACnet/IP as indicated on BAS Network Architecture drawings.
   4. Provide at least one extra communication port at each B-AAC for direct connecting a notebook computer or hand-held terminal.

D. BACnet Application Specific Controllers (B-ASC):
   1. B-ASCs are defined as having standard software burned into EPROM, set points in EEPROM or RAM maintained by battery, and are designed to handle specific types of control sequences.
   2. Application specific DDC Controller shall be capable of communicating to BAS network via low/medium speed network connected to B-BC.
   3. Control outputs may be in the form of floating point control or true analog output control of end devices. Floating point control shall be limited to non-critical room temperature control or mechanical space heating and cooling.
   4. Provide communication ports integral room temperature sensors/thermostats for interface with local terminal equipment controllers or a low range wireless (Bluetooth®) Commissioning tool that provides a temporary wireless connection between the MS/TP network and the laptop computer used to commission.

E. BACnet Router
   1. BACnet MS/TP to BACnet/IP and BACnet/ARCNET to BACnet/IP Routers shall perform layer 3 routing of BACnet MS/TP or BACnet/ARCNET packets over an IP network in accordance with ASHRAE 135 Annex J. The router shall provide the appropriate connection to the IP network and connections to the BACnet MS/TP or BACnet/ARCNET network. BACnet Routers shall be capable of configuration via DHCP and Write-Broadcast-Distribution-Table messages but shall not rely on these services for configuration.
   2. One router in the IP subnetwork shall be designated as the BBMD (BACnet Broadcast Management Device) and shall be indicated as so on the Network Architecture.
   3. BACnet router functionality can also be incorporated into BACnet Building Controllers.

F. BACnet Gateways:
   1. Provide gateways to connect BACnet to non-BACnet devices, and non-BACnet DDC controlled equipment.
   2. Provide with each gateway an interoperability schedule, showing each point or event on the non-BACnet side that the BACnet "client" will read, and each parameter that the BACnet network will write to. Describe this interoperability in terms of BACnet services, or Interoperability Building Blocks (BIBBS), defined in ASHRAE 135 Annex K. Provide two-year minimum warranty for each gateway, including parts and labor.
   3. The following minimum capabilities are required:
      a. Gateways shall be able to read and view all readable object properties listed in the interoperability schedule on the non-BACnet network to the BACnet network and vice versa where applicable.
      b. Gateways shall be able to write to all writeable object properties listed in the interoperability schedule on the non-BACnet network from the BACnet network and vice versa where applicable.
      c. Gateways shall provide single-pass (only one protocol to BACnet without intermediary protocols) translation from the non-BACnet protocol to BACnet and vice versa.
      d. Gateways shall meet the requirements of Data Sharing Read Property (DS-RP-B), Data Sharing Write Property (DS-WP-B), Device Management Dynamic Device Binding-B (DM-

DDB-B), and Device Management Communication Control (DM-DCC-B) BIBBs, in accordance with ASHRAE 135.

e. Gateways shall include all hardware, software, software licenses, and configuration tools for operator-to-gateway communications. Provide backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

G. Power Supplies:

1. Power supplies shall operate on nominal 120 V, 60 Hz, single-phase power. DDC Controllers shall be provided with surge and noise protection. Power fluctuation shall not affect control system. Include surge protection on telephone line.

a. Isolation transformers shall be included when connections are being made between 2 separate buildings.

2.2 DIRECT DIGITAL CONTROL SOFTWARE

A. General:

1. DDC Controller control strategies shall be Owner definable from engineering workstations.
2. Software functions and algorithms shall be sufficient to enable implementation of control sequences as specified and shall be able to maintain continuous control as intended.
3. Control functions shall include both mathematical and logical operators. Control algorithms shall include proportional, integral and derivative control (PID). Adaptive (self-tuning) PID loop parameters, if offered by DDC Controller manufacturer, shall not be used unless adaptive limits are used to adjust limit values based on system status; or written request is submitted and approved by Engineer.
4. Allow operators to assign unique identifiers of their choice to each connected point. Identifiers shall have at least 8 alpha/numeric characters. References to these points in programs, reports and command messages shall be by these identifiers.
5. Provide access control (user defined passwords) for system operation. There shall be minimum of 3 access levels. First level shall allow system monitoring only. Second level shall allow monitoring, set point adjustment, and scheduling revision. Third level shall allow modification of control algorithms. System shall return to secured (monitoring only) mode after 5 minutes of inactive operation.
6. Each DDC Controller shall contain self-diagnostics that continuously monitor proper operation of panel.
7. If microprocessor malfunctions, control loop outputs shall continue to function using last value received from microprocessor.

B. Building Controller Software:

1. Provide DDC Controller software application program modules for performing energy management control functions such as time of day change of database values (programmed start/stop, temperature setbacks, etc.), supply air temperature reset based on space load demand, economizer control, optimum start/stop based on current indoor and outdoor psychometrics, duty cycling and client tailored programs required for special applications such as VAV fan matching and supply fan control, enthalpy control, intermediate season or "dead band" control, totalizing, and holiday programming.
2. Provide manufacturer's standard operating system for real time control of system interactions, including database information requests/transfers by system hardware or by operators. Operating system shall also have the following additional capabilities (given that operator has appropriate security access level):

a. User interface and online system configuration software embedded in Building Controller.

b. Support for Web services at the automation network level.

c. Displaying database (point) value including measured values, controlled variables, setpoints, gain factors, and any other adjustable parameters.

d. Changing or overriding any database value.

e. Error detection, correction, re-transmission of database values, arithmetic or logical faults.

f. Alarm reporting including sending alarms to remote workstations, User Interface Web Server or Data Historian on network.

g. Alarm buffer to retain alarms in order of importance without losing any alarms.

h. Creating and displaying historical trend logging of any value, limited only by available memory.

i. Creating new variable database values (soft points) based on arithmetic calculation (including summation or totalizing) on other database values.

j. Adding new hardware points without overall BAS shutdown.

C. B-ASC Controller Software:

1. Manufacturer's standard software for B-ASC's may be used only if control sequences can be implemented without modification. If control sequence cannot be accomplished with standard software, provide battery backed RAM or EEPROM DDC Controller (B-AAC) capable of being programmed for specified control sequence.

2. Provide software for portable PC units to communicate with terminal controllers at the room level network. Software shall allow access to modify, delete or create control strategies at the room sensor location.

2.3 OPERATOR'S ~~WORKSTATION~~ SERVER - HARDWARE

A. Owner will furnish **1** operator's ~~workstations~~ server for operator interface to BAS for monitoring, control, and database management. Provide network interface cards, all required cables and other associated hardware for connecting each of Owner's workstations to BAS network and other remote devices specified.

~~2.4 ENGINEERING WORKSTATION~~

~~A. Refer to Operator Workstation section for requirements.~~

~~2.5~~2.4 WEB APPLICATION SERVER

A. Refer to 25 0924 – Graphical user Interface Integration.

~~2.6 DDC ENGINEERING (PROGRAMMING) - SOFTWARE~~

~~A. Provide engineering software for **1** Engineering Workstations.~~

~~B. Software shall have the same characteristic and capabilities as DDC Controllers. In addition, operator's workstations shall have the following features.~~

~~C. User Programmability:~~

~~1. Engineering workstation software shall include field-engineering tools (software & hardware) for programming all controllers supplied.~~

~~2. All application software shall be interactive, fully prompted, and menu driven and shall provide the following functionality as a minimum:.~~

~~a. Determine control strategies, which have been defined for specific piece of equipment.~~

~~b. Add control loops to system using English language type program language equal to BASIC or other easily learned language or function block programming. (PASCAL, C, or other assembly type languages are not acceptable.)~~

~~c. Add points to system.~~

~~d. Create, modify or delete control strategies.~~

~~e. Create, modify or delete system graphics.~~

~~f. Assign sensors and/or actuators to control strategy.~~

~~g. Tune control loops through adjustment of control loop parameters.~~

~~h. Enable or disable control strategies.~~

~~i. Generate hard copy records of control strategies on printer or soft copies to files compatible with Microsoft Office applications.~~

~~j. Select points to be alarmable and define alarm state(s).~~

~~k. Select points to be trended over a period of time and initiate recording of values.~~

~~l. Override Input/Output points for each individual controller.~~

~~2.7 OPERATOR WORKSTATION - SOFTWARE~~

~~A. Custom Database Functions:~~

~~1. Operator shall be capable of generating long term historical trend logs and displaying information in tabular or graphic formats. Provide all software options for standard and custom report generators.~~

~~B. Color Graphics:~~

~~1. Provide color graphics software package compatible with manufacturer's standard software. Provide mouse or other special hardware required to operate software. Software shall be capable of user editing of text fields, graphics, alarms, and real-time variables.~~

~~2. Software shall be capable of importing files in AutoCAD format, directly or via translators.~~

~~2.8~~2.5 NETWORK HARDWARE

A. Provide network interface hardware for each device connected to network. Each device shall have sufficient performance as not to degrade specified processing speed.

B. Provide network cabling with sufficient performance as not to degrade specified communication speed. Cabling shall be compatible with proposed system and shall comply with requirements specified in Section 23 0901 - Control Systems Integration.

C. Provide other network support devices that are required for proper operation of network, such as file servers, signal repeaters, network hubs, etc.

D. Provide network diagnostic tool for measuring/confirming bandwidth usage on IP layer.

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment in neat, professional manner to satisfaction of Architect and Engineer.

B. Coordinate timely delivery of materials and supervise installation of DDC Controllers and network cabling and devices.

C. Install DDC Controllers and network control devices in accessible locations.

3.2 OVERALL BAS ARCHITECTURE

A. Provide hardware/software to update database in less than 1 second for fast-acting control loops such as pressure control, air or water flow rate control, and air handling unit temperature control, or 10 seconds or less for other control loops.

B. Control software algorithm and inputs and outputs for a single system or piece of equipment shall reside on a single controller and shall not be distributed amongst multiple controllers. If multiple pieces of equipment are to be interlocked, a single "Master" controller shall provide control for all interlocked pieces of equipment, i.e. an AHU and interlocked return fan and exhaust fans.

C. Control loop software algorithm for each analog control loop shall reside on same controller as inputs and outputs required for that specific control loop.

D. Networks that operate via polled response or other types of protocols that rely on central processors, file servers, or other such devices to maintain or manage peer-to-peer communications, shall have redundant components to maintain network in event of failure at central device. Provide automatic changeover (without operator intervention) to redundant device upon failure of any central type processor.

E. Floor Level Network (FLN) network shall be multi-drop digital transmission network utilizing BACnet MS/TP (38.4kbs) communication.

F. Each multi-drop trunk shall be within manufacturer's allowable line lengths without signal degradation. Multi-drop trunks shall be interfaced to system via standard EIA or other industry recognized interfaces so that single failure does not disrupt or halt network.

G. Communications between Building Level DDC Controllers and operator's workstations shall be peer-to-peer, allowing multiple users to access and use system simultaneously with no loss of system performance.

H. Provide levels of connected networks to connect all DDC Controllers, including terminal DDC Controller. Communications to terminal devices shall be similar to capabilities and functions of other DDC Controllers and shall be transparent to operator.

I. Quantity of nodes (devices connected) on any one FLN (MS/TP) shall not exceed 50% of maximum node capacity published by equipment manufacture and Building Controller processor usage shall not be greater than 30% nominal. Provide additional hardware to meet this requirement.

J. Alarm reports from DDC Controllers shall not be impeded by use of either remote or local monitor, or control stations on network either in access mode or programming mode.

3.3 DIRECT DIGITAL CONTROLLERS

A. DDC Controller Usage:

1. Select DDC Controller to provide speed of response required for each control loop type. Pressure, flow rate, and air handling unit temperature control must be via Building Level DDC Controller. Application specific DDC Controller may be used for other control loop types.
2. Each DDC Controller shall have sufficient I/O capacity to perform specified control sequences and/or include points listed in any point schedules. If DDC Controller does not have sufficient capacity, provide additional slave panels to achieve required point count.
3. Analog and critical safety discrete control loops shall have inputs and outputs into/from same DDC Controller. Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control. Air terminal control loops may utilize floating point control from tri-state or Triac outputs from the controller, but require some type of feedback device to prove position.
4. Provide at least one Building Level DDC Controller per mechanical equipment room and, if required, at each PC workstation location.
5. For valves and dampers within 100 ft of associated DDC Controller, mount current to pneumatic (I/P) converter within DDC Controller panel or in adjacent panel. Otherwise mount I/P converters at valve or damper. Provide pressure gauges on main air, and all control output signals.

B. Point Capacity:

1. Provide point capacity required plus spare I/O point capacity in each B-AAC. Spare I/O point capacity is defined as terminal connections, which are ready to accept digital or analog inputs, dry contacts for digital outputs, and variable voltage or current terminals for analog outputs. Universal type points are acceptable for both discrete and analog type points. Spare points do not include any input or output conversion devices.
2. Spare points in each B-AAC shall be 25% of total capacity for the following point type:
   a. Digital Inputs

b. Digital Outputs
c. Analog Inputs
d. Analog Outputs

C. Building Controllers:
1. Provide one BBMD in each IP subnet.
2. BACnet UDP port number to always be set to 47808 (BAC0).

D. Gateways:
1. Gateways may be used for communication with non-BACnet control hardware subject to all of the following limitations:
a. Non-BACnet control hardware shall not be used for controlling built-up units.
b. Non-BACnet control hardware shall not perform system scheduling functions.

E. Cabinets:
1. Provide local control cabinets for DDC Controllers. DDC Controller cabinets for air terminals may be used directly if enclosures are rated for NEMA 1. All cabinets shall utilize a single master key. Provide 2 spare key sets to Owner.
2. All control cabinets shall be labeled. Labels shall be keyed to the unique identifiers shown on the As-Built drawings

F. Controller Firmware
1. Provide latest version of controller firmware. Include firmware updates for period of one year after system acceptance, coinciding with warranty period. If the upgrade of firmware causes the need to upgrade or reconfigure/reprogram related systems, controllers or software, Contractor shall notify Owner prior to upgrade and provide additional work scope in coordination with other Contractors, as required, at no cost to Owner.

~~3.4 OPERATOR/ENGINEERING WORKSTATIONS~~

~~A. Locate workstations as indicated on plans and Network Architecture.~~

~~B. Furniture is provided by others. Provide all necessary connections and extensions to integrate hardware with furniture system.~~

~~C. Security access levels for the engineering workstation software shall be setup as follows:~~
~~1. Guest (View-only) access level shall have the ability to perform the following tasks:~~
~~a. View Data~~
~~b. View Trends~~
~~2. Operator access level shall have the ability to perform the following tasks:~~
~~a. View Data~~
~~b. Acknowledge Alarms~~
~~c. View Reports~~
~~d. Override Points~~
~~e. Change Setpoints~~
~~f. View Trends~~
~~g. Edit Schedules~~
~~3. Engineer access level shall have the same access as Operator level with the ability to perform the following additional tasks:~~
~~a. Add Devices~~
~~b. Address Changes~~
~~c. Create Applications~~

~~d. Download Applications~~

~~e. Configure ASCs~~

~~f. Setup Trends~~

~~g. Setup Reports~~

~~h. Modify Alarm Settings~~

~~D. Provide security access level setup for 10 users. Coordinate user names, access levels and passwords with Government.~~

~~E. System shall provide an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for 5 minutes. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.~~

~~3.5~~3.4 DDC SOFTWARE INSTALLATION

A. Contractor shall supply, install, and ~~upgrade~~ provide~~existing~~ new Tridium software license for owner provided server. Tridium software shall be upgraded to Niagra AX 3.8U1.

B. Contractor shall install and configure all software packages required to maintain and configure all types of controllers provided as part of this project on each engineering workstation.

~~B.~~1. Contractor shall provide workbench tools to access the programming.

C. Software from panels shall be permanently stored on CD ROM and on at least one hard disk at operator's workstation or Web Application Server. Provide auto re-boot feature on power up from system failure. System failures shall not necessitate manual reprogramming to restore normal system function.

D. Provide the latest version of all standard software, including operating system and control software. Include any software updates for period of one year, coinciding with warranty period. Beta released software shall not be used.

~~3.6~~3.5 INITIAL PROGRAMMING

A. Control Contractor shall provide initial programming of controllers to accomplish sequences specified.

B. Provide back-up documentation per software manual submittals for all programs, in both written and electronic media formats.

C. Outputs, whether sequenced or not, shall have separate programmable hardware outputs. For air handling units, minimum outside air, maximum (economizer) outside air, return air, relief air, smoke dampers, heating valves, cooling valves, humidifier valves, etc., shall each have separate output.

D. BACnet Naming and Addressing

1. Every BACnet device shall have an assigned and documented MAC Address unique to its network. For Ethernet networks, document the MAC Address assigned at its creation. For MS/TP, assign from range as indicated by vendor documentation.
2. Assign unique numbers to each new network installed on the BACnet internetwork. Provide ability for changing the network number; either by device switches, network computer, or field operator interface. The BACnet internetwork (all possible connected networks) can contain up to 65,534 possible unique networks.
3. Every BACnet Building Controller (B-BC) and BACnet Router UDP port number shall be set to 47808 (BAC0).
4. Assign unique Device "Object Identifier" property numbers or device instances for each device on the BACnet internetwork. Provide for future modification of the device instance number;

either by device switches, network computer, or field interface. BACnet allows up to 4,194,302 possible unique devices per internetwork.

5. The Object Name property field shall support 32 minimum printable characters. Assign Object Name properties with plain-English names descriptive of the application. Examples include "Zone 1 Temperature" and "Fan Start/Stop".

E. Minimum BACnet Object Requirements

1. For the following points and parameters, use standard BACnet objects, where all relevant object properties can be read using BACnet's Read Property Service, and all relevant object properties can be modified using BACnet's Write Property Service: all device physical inputs and outputs, all set points, all PID tuning parameters, all calculated pressures, flow rates, and consumption values, all alarms, all trends, all schedules, and all equipment and lighting circuit operating status.
2. The Object Description property shall support 32 minimum printable characters. For each object, complete the description property field using a brief, narrative, plain English description specific to the object and project application. For example: "HW Pump 1 Proof." Document compliance, length restrictions, and whether the description is writeable in the device PICS.
3. Support and provide Description and/or Device Type text strings matching signal type and engineering units shown on the points list.
4. Support and provide Inactive Text and Active Text property descriptions matching conditions shown on the points list.
5. For devices with scheduling capability, provide at least one Calendar Object with ten-entry capacity. Enable the writeable Date List property and support all calendar entry data types.
6. Use Schedule Objects for all building system scheduling.
7. Use Loop Objects or equivalent BACnet objects in each applicable field device for PID control. Regardless of program method or object used, allow authorized operators to adjust the Update Interval, Setpoint and all constraints associated with Object, such as Proportional Constant, Integral Constant, and Derivative Constant for Loop Object, using BACnet read/write services.

F. Minimum BACnet Service Requirements

1. Use commandable BACnet objects to control machinery and systems, providing the priority levels listed below.

Priority Level	Application
1	Manual-Life Safety
2	Automatic-Life Safety
3	(User Defined)
4	(User Defined)
5	Critical Equipment Control
6	Minimum On/Off
7	(User Defined)
8	Manual Operator
9	(User Defined)
10	(User Defined)
11	Load Shedding
12	(User Defined)
13	(User Defined)
14	(User Defined)
15	(User Defined)
16	(User Defined)

G. Data Sharing:

1. Data communication from Building Controllers to Engineering Workstation and BAS web server shall be programmed to use Change of Value (COV) data sending and not continuous data polling to limit net work traffic.
2. Data communication parameters for analog values shall be operator configurable and setup as follows:
    a. Minimum Send Time: 2 seconds
    b. Maximum Send Time: 60 seconds
    c. Send on Delta (COV) :
        1). Space Temperature: ±0.5°F
        2). Process Temperature: ±0.5°F
        3). Air Pressure, AHU: ±0.05“ W.C.
        4). Relative Humidity: ±0.5%
        5). Air Flow: ±200 cfm
        6). Water Flow: ±50 gpm
        7). Water Pressure ±0.2 psi
        8). Space Pressure: ±0.01“ W.C.
3. Digital data points shall be sent whenever a state change occurs.

H. Historical Trending:
1. All inputs and analog outputs shall be trended and shall fully configured and operational. Sample time shall be one minute.
2. Program historical file for run-times and quantity of start/stops of motor driven equipment
3. Trend logs are to be stored at the building controllers and uploaded to the BAS web server or data historian when the building controller trend buffer size reaches 90% full or every 30 minutes (FA).
4. Data points indicated to as “LEED M&V” in the DDC Point Schedules shall be have a sampling time of one minute and averaged over 15 minutes.

I. Alarm/Event Management:
1. All alarm handling shall be fully configured with consistent alarm messages and priorities or category numbers to identify the system from which the alarm originates.

J. Provide programming of menus to assist new users in accessing screen displays of each point group. Point groups (user definable) shall be initially arranged by DDC Controller for major equipment and by floor and area for terminal devices. Terminal devices shall also be grouped by air handling system where applicable.

K. When adding to an existing system, groupings, tag names, descriptions, engineering units, etc. shall match the existing system. Transitions from the existing system to the new system shall be seamless in look, functionality, and operation. Controls Contractor shall verify with Owner if any standard naming conventions are being used and continue with those naming conventions when applicable.

L. Program historical file for run-times and quantity of start/stops of motor driven equipment.

M. Program maintenance alarms based on run-times and quantity of start/stops for motor driven equipment.
1. Provide the following additional alarms:
    a. Controller loss of communications for each controller.
    b. Controller battery alarm for each controller (where available)
    c. Out-of-range, bad, or missing data (fault) for each device.

N. Program alarms using the following levels:

1. Level 1 - Maintenance Alarm, requiring attention within 1 to 2 days. (Examples: 2-3°F temperature variance from set point; 15-25% relative humidity variance; etc.)
2. Level 2 - Low Level Alarm, requiring attention within 8 h, preferably during the same shift. (Examples: More than 3°F variance from set point, 30 percent relative humidity or more variance from set points; excess start/stops per day; etc.)
3. Level 3 - Critical Alarm, requiring immediate attention. (Examples: Non-operation of primary equipment; H-O-A overrides; failure of controllers, routers and repeaters.)
4. Level 1 and 2 alarms shall not interrupt current user operation, but shall be logged into alarm summary file, indicating status, acknowledgment, and by whom. Level 3 alarms shall interrupt user via audible and/or flashing warning until acknowledged, without losing any work in progress. When alarms are acknowledged, program shall display point group or appropriate graphic display. Level 3 alarms shall also be logged into alarm summary file in similar manner as Level 1 and 2 alarms.

O. Time Schedules:
1. Provide time schedules for HVAC components/systems as indicated in Control Sequences.
2. All time schedules shall be fully configured with weekly schedules and all holidays identified by the Owner.
3. Time schedules are to reside in the Building Controllers.

~~3.7~~3.6 POINT LIST

A. Provide points required to implement control sequences specified, whether or not they are listed in schedules. In addition to control points, provide additional points listed in point schedules or defined in Control Sequences.

B. All points shall be programmed with a point name and detailed description. Control contractor shall submit point naming convention to Laboratory/Engineer for approval prior to system programming.

C. Work jointly with Owner to develop point naming convention prior to start of programming.

~~3.8~~3.7 AUTO-DIAL ALARM MESSAGES

A. Program up to 30 types of prerecorded voice or text messages assigned to different alarm types. Assign up to 10 phone numbers for each message. BAS shall automatically call phone numbers without answering machines in predetermined order. If an acceptable phone response is not received after 6 rings (adjustable), system shall automatic retry 3 times (adjustable) before calling next number. Systems shall print level 3 alarm message if no phone numbers were reached.

~~3.9~~3.8 GRAPHICS PROGRAMMING

A. Graphics shall be designed to match any existing graphic displays on the existing system when new system is to fully integrate with existing system. Transition from existing graphics to new graphics shall be seamless transition for operator in look, functionality, and operation.

B. On new system, program color graphic displays for each system as described herein. Graphic displays shall consist of pictorial presentations on display monitor/workstation with text description, system schematic, or picture; alarm fields; and database fields for all associated points, including dynamic input values, output values, set points, gains, time schedules, etc. Provide single keystroke access to text file description of control sequence(s) in detail.

C. Make use of color to highlight system components. Components of similar type shall be of same color for all graphics (example: dampers shall be purple, valves yellow, etc.). Alarm fields shall be flashing white letters on red background. Affected component shall also turn red whenever alarm status is indicated. Database fields shall be white letters on black background and shall be dynamically updated and re-displayed on screen by periodically polling database points not less than once every minute.

D. Display time, date, outside temperature and humidity on displays in same location on each graphic. Display command line with English prompt in same location on each graphic. Provide command to direct specific displays without accessing main menu. Provide means of displaying directory of screens. Arrange displays by group and type.

E. Graphic displays shall be designed to be easily understood. When display screen is too cluttered due to size, limit information to important monitoring data. Provide sub-graphic(s) to display data not displayed on main display.

F. Graphics shall include, but not be limited to:
   1. Site Plans, including each building, building name, and status of all exterior points such as lighting, etc.
   2. Overall building plan of each building. Indicate location of mechanical rooms and areas served by each air handling unit.
   3. Floor plans for each area depicting locations of terminal units, areas served by terminal units, and other remotely located points. Plans shall include full height partitions, column numbers, room numbers, and room names with special functions (not offices, corridors, toilets, storage, etc.).
   4. Schematic type graphics for:
      a. Each air handling system
      b. Supply fan control loop
      c. Return fan control loop
      d. Cooling coil control loop
      e. Heating coil control loop
      f. Humidifier control loop
      g. Damper control loops
      h. All air terminal devices shown on floor plans
      i. Main chilled water system showing all components
      j. Main condenser water system showing all components
      k. Steam system showing all components
      l. Each heating hot water system showing all components
      m. Lab and fume hood exhaust system.
   5. Indicate systems to be graphically represented.
   6. Submit sample graphics (one per type) for review and approval by Owner prior to starting graphics programming.

END OF SECTION

SECTION 23 0924

GRAPHICAL USER INTERFACE INTEGRATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901 - Control Systems Integration

B. Section 23 0923 - Direct Digital Controllers and Networks

1.2 SYSTEMS DESCRIPTION

A. Building Automation System (BAS) Graphical User Interface (GUI) shall be accomplished via a web-server environment.

B. BAS web server shall communicate with individual Building Systems via BACnet/IP protocol on the Owner provided Enterprise Ethernet network.

C. Provide remote alarm paging via text message, alphanumeric message and email integral to web server software.

D. Operator workstations connected to building Ethernet network shall be able to access information as determined by Graphical User Interface (GUI) software through standard web browsing software (Internet Explorer, Mozilla Firefox or Netscape Navigator). GUI software shall allow transparent access to each connected building and building component/system for control and/or monitoring.

E. Building Campus currently has an ~~existing~~ new owner provided *Tridium* BAS Web server which provides system monitoring, alarming, scheduling, reporting and historical trend functions via graphical user interface. Contractor shall provide all Tridium software for owner provided server.

F. Contractor shall integrate the new BAS provided under Section 23 0923 to the existing BAS Web Application Server.

1.3 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with Owner and Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.4 SUBMITTALS

A. Refer to Section 23 0901 - Control Systems Integration.

1.5 OPERATION AND MAINTENANCE MANUALS

A. Refer to Section 23 0901 - Control Systems Integration.

1.6 RECORD DRAWINGS

A. Refer to Section 23 0901 - Control Systems Integration.

1.7 OWNERSHIP OF PROPRIETARY MATERIAL

A. Refer to Section 23 0901 - Control Systems Integration.

1.8 WARRANTY

A. Refer to Section 23 0901 - Control Systems Integration.

PART 2 - PRODUCTS

2.1 SERVER - HARDWARE

A. ~~Contractor~~ Owner shall provide BAS Web Application Server for operator control/monitoring of building control systems. BAS Web Application Server is ~~existing~~new.

B. System databases (data historian) may be provided on server hardware separate from graphical web interface server as necessary to provide optimum system performance and flexibility.

C. User Interface Web Application Server Hardware (server) shall be a standard unmodified digital computer of modular design currently being manufactured. Modular components of the server shall be products of a single manufacturer which advertises service in all 48 contiguous states. All desktops, laptops, and computer monitors are required to have achieved Bronze registration or higher under the Electronic Products Environmental Assessment Tool (EPEAT).

~~A. Server hardware shall meet the following minimum requirements.~~

~~1. Processor speed: Minimum 250% of the stated requirements of the software to be installed on server.~~

~~2. Random Access Memory (RAM): Minimum 250% of the stated requirements of the software to be installed on server.~~

~~3. Communications ports: One serial port, one enhanced parallel port and two USB port in addition to any ports required for the keyboard and mouse.~~

~~4. Hard Drives and Controller: Controller and Drives shall provide a minimum of 250 percent of the usable disk space required for monitoring, control and data archiving with an average seek time of 7 milliseconds or less using hardware RAID (Redundant Array of Inexpensive Disks) at level 5 (RAID-5).~~

~~5. CD/DVD-RW Drive: Combo CD-RW with 32x read, 24x write and 16x rewrite and DVD-RW with 12x read; 4x re-write; 2x write.~~

~~6. Video output card: Support at least 16 bit color at a minimum resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.~~

~~7. Network Interface Card (NIC): Two (2) Gigabit Ethernet Network Interface Cards (NICs) with automatic switchover and load sharing.~~

~~8. Monitor: 19-inch rack-mount LCD monitor w/ keyboard (mouse required if keyboard does not incorporate touchpad) with a minimum resolution of 1024 by 768 pixels, non-interlaced, a maximum dot pitch of 0.28 millimeters, and a minimum refresh rate of 70 Hz. Include cantilever shelf and all hardware required for mounting monitor drawer in two post rack. Provide rack-mountable KVM switch and associated cabling where multiple servers are housed in common rack.~~

~~9. Hot-swappable redundant power supplies~~

~~10. Redundant Fans~~

~~11. Operating system (OS) shall fully support all installed software and peripherals.~~

~~12. Virus Protection Software shall consist of the project site's standard virus protection software complete with a virus definition update subscription.~~

~~13. Latest version of Microsoft Office Professional~~

~~14. Latest version of Adobe Acrobat~~

~~15. Coordinate additional software requirements with Owner.~~

~~16. All required cables for connecting to network and other remote devices~~

2.2 USER INTERFACE WEB SERVER - SOFTWARE

A. Web server shall provide dynamic, real-time graphical control/monitoring interface for all HVAC, plumbing, lighting control and electrical systems shown on System Diagrams or included in Control Sequences. Refer Section 23 0901 - Control Systems Integration

A. Graphical displays shall also include alarm displays, scheduling displays and trending displays. Data associated with an active display shall be no more than 5 seconds out-of-date.

B. BAS web server shall be provided with all software applications and licenses required to provide web access to UIC required simultaneous clients.

C. Operator web access Graphical User Interface (GUI) shall be interactive, fully prompted, menu driven and shall provide the following functionality as a minimum:

1. HVAC Systems:
   a. GUI shall allow for hierarchical graphical navigation between individual buildings and building control systems within individual buildings, graphical representations of systems, access to real-time data for each system, ability to override points in a system, and access to all supervisory monitoring and control functions including building/equipment schedules. Each system display shall clearly distinguish between the following point data types and information: Real-time data, User-entered data, Overridden or operator-disabled points, Devices in alarm (unacknowledged), and Out-of-range, bad or missing data.
   b. Software shall allow the user to create, modify, and delete displays and graphic symbols.
   c. Operator shall be able to monitor/control all data points as listed in DDC Point Schedules and shown on flow diagrams via graphic displays.
   d. Operator shall be able to view and modify all Occupied/Unoccupied schedules.

~~2. Lighting Control System (LCS):~~
   ~~a. Operator shall be able to monitor status of all lighting control zones, private offices and conference rooms from floor graphic.~~
   ~~b. Verify lighting control layout with Owner and LCS provider prior to programming.~~
   ~~c. Operator shall be able to override lighting commands via graphical interface if logged on with the appropriate security access.~~
   ~~d. Operator shall be able to view and modify lighting control system schedule for individual rooms/zones if logged on with the appropriate security access.~~
   ~~e. Lighting control schedule shall provide the following minimum schedules: Occupied/Unoccupied, holiday, special events, Building Sweep All On & All Off (multiple sweep times)~~

~~3.~~2. Alarm and Event Management:
   a. Web interface shall provide audible, visual, and printed means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s) currently running.
   b. Web interface shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the web server. Each entry shall include a description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal time and date of alarm acknowledgment and identification of operator acknowledging alarm.
   c. Alarm Notification and Routing: Software shall be capable of performing alarm notification and routing functions. Upon receipt or generation of an alarm, software shall immediately perform alarm notification and routing according to an assigned routing for that alarm. Software shall support at least 100 alarm routes; an alarm route shall be a unique combination of any of the following activities:

1). Generate a pop-up up display on designated workstation monitors. The pop-up display shall include identification of the alarm, date and time of the alarm, alarm message, and current value/status of the alarm point. Alarms shall be capable of being acknowledged from the pop-up display by operators with sufficient permissions. Pop-up displays shall be displayed until acknowledged.

2). Dial an alphanumeric paging system and leaving an alphanumeric message. The paging system number and alphanumeric message shall be user configurable for each alarm route.

3). Send a text message to user cell phone. The text message shall contain a scripted message and all alarm data. The text message recipient and scripted message shall be user configurable for each alarm route.

4). Send an e-mail message via simple mail transfer protocol (SMTP; RFC 821). The e-mail shall contain a scripted message and all alarm data. The e-mail recipient and scripted message shall be user configurable for each alarm route.

5). Print alarms to designated alarm printers. The printed message shall be the same as the pop-up message.

~~4.~~3. Scheduling:

a. Web interface shall show all information in easy-to-read daily format including calendar of current month and next. All schedules shall show actual ON/OFF times for day based on scheduling priority.

b. Schedules shall be provided for individual HVAC system Occupied/Unoccupied operation.

c. Operator shall be able to change all information for a given schedule if logged on with the appropriate security access.

~~5.~~4. Trending & Data Archiving:

a. Trend logs are not to be server based using polling. Trend logs are to be initially stored at the BAS controller and periodically uploaded to the Web Server data historian for long-term storage.

b. Users logged into the system shall not have direct access to any of the raw trend data located in the BAS controllers or Web Server data historian.

c. Trend log files shall be appended with new sample data, allowing samples to be accumulated. Systems that write over archived data shall not be allowed, unless limited file size is specified.

d. Web interface shall provide ability to graphically view trend data using two-axis (x,y) graphs that display up to ten object types at the same time in different colors. Graphs shall show object values relative to time.

e. Operator shall be able to change trend log setup information if logged on with the appropriate security access. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged.

~~6.~~5. Report Generating:

a. Web Server Software shall be provided with commands to generate and format reports for displaying on current Workstation, printing, and storing on disk.

b. Reports shall be stored by type, date, and time. The destination of each report shall be selectable by the operator.

c. Dynamic operation of system shall not be interrupted to generate a report. The report generation mode, either automatic or requested, shall be operator assignable. The report shall contain the time and date when the samples were taken, and the time and date when the report was generated.

d. Software shall be capable of saving reports to a file. If the file format is not in a format compatible with standard Microsoft Office software, Control Contractor shall provide a means to export or convert the file to a compatible format.

e. Software shall allow for automatic or manual generation of reports. For automatic reports, the operator shall be able to specify the time the initial report is to be generated, the time

interval between reports, end of period, and the output format for the report. The operator shall be able to modify, or inhibit a periodic report.

f. Manual report generation shall allow for operator to request at any time the output of any report.

~~7.~~6. Activity Logging:

a. System shall maintain a historical file logging all activity of the system.

b. This file shall maintain, as a minimum, a record of all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications. Passwords shall not be logged.

c. Activity log shall be maintained at the web application server hardware. System shall automatically provide a mechanism for archiving the log files for long term record storage.

d. System shall maintain a minimum of 2 years of log files.

D. User Access Permissions:

1. Web Application Server Software shall manage user information and shall recognize at least 100 separate users and have at least 3 levels of user permissions. User permission levels (from most restrictive to most permissive) shall include:

a. Guest (View-only) access level shall have the ability to perform the following tasks:

1). View Data

2). View Trends

b. Operator access level shall have the ability to perform the following tasks:

1). View Data

2). Acknowledge Alarms

3). View Reports

4). Override Points

5). Change Setpoints

6). View Trends

7). Edit Schedules

c. Engineer access level shall have the same access as Operator level with the ability to perform the following additional tasks:

1). Add Devices

2). Address Changes

3). Create Applications

4). Download Applications

5). Configure ASCs

6). Setup Trends

7). Setup Reports

8). Modify Alarm Settings

9). Create and modify System Graphic Displays

2. Passwords shall not be displayed.

3. System shall provide an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for 5 minutes. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.

E. Graphics and Controls:

1. Graphics shall be configured for “point-and-click” operation to allow user to navigate through the building systems with ease. The user shall be able to define the action of control buttons configured on the graphics.

2. Building systems and equipment drawings can be created from built-in image library or may be imported from a scanner, the Internet, CAD drawing, or other files such as bitmap (.BMP), JPEGs or Icon files.
3. All symbols used by the Contractor in the creation of graphic pages shall be saved to a library file for use by the Owner. Provide additional copy of library file on CD.
4. Graphic Editor: The graphic editor shall enable the user to create, modify, and delete displays and graphic symbols. The primary use shall be for adding and modifying graphic displays, status displays, system summaries, and system directories, as new controllers, points, data, and other necessary changes are made.

2.3 DATA HISTORIAN – DATA ARCHIVING

A. Data historian software may reside on the same physical server as the BAS software or on a separate server. The data historian shall seamlessly integrate to the BAS software without the need for a 3rd party application.

A. System must provide a means to gather, archive and retrieve trend, alarm, and operator\system activity records. Archived information shall be available for the life of the system.

B. Historian shall have minimum of five (5) simultaneous user licenses.

C. Historian database shall be Microsoft SQL Server. Microsoft Access databases are not allowed.

D. System must allow archival to/from a mass storage device.

E. Historian shall homogeneously combine historical data from multiple collection intervals for a given point (e.g., 15 minute and change of value trends shall be blended into a common view).

F. System shall be able to perform exception reporting (e.g., show all values below or above a certain value).

G. System shall be able to perform advanced analysis of BAS alarms to include the following information:
   1. Number of alarms for a given period
   2. Detailed alarm information; initial alarm, alarm cleared, duration, and highest level achieved during alarm.
   3. Statistical information: longest alarm duration, average duration, and total duration.

2.4 BAS WEB APPLICATION SERVER – HARDWARE INTEGRATION INTO EXISTING SERVER

A. Provide all hardware required to integrate the BAS into the existing Campus BAS Web Application Server for operator control/monitoring of building control systems.

2.5 BAS WEB SERVER – SOFTWARE INTEGRATION INTO EXISTING SERVER

A. Provide all necessary software upgrades or additional licenses to accommodate the additional point capacity required to integrate all BAS monitoring and controls points. ~~Refer to specifications 23 0905 – DDC Point Schedule and 23 0993 – Control Sequences~~.

PART 3 - EXECUTION

3.1 GENERAL

A. Install all control equipment in neat and workmanlike manner to satisfaction of Architect and Engineer.

B. Coordinate timely delivery of materials and supervise installation of control devices.

3.2 SOFTWARE

A. Software shall be permanently stored on compact disk and on Web Application Server. Provide auto re-boot feature on power up from system failure. System failures shall not necessitate manual reprogramming to restore normal system function.

B. Provide the latest version of all standard software, including, operating system and application software. Include any software updates, and hardware updates associated with such software upgrades, for period of one year coinciding with warranty period. No beta released software shall be used.

~~3.3 OPERATOR WORKSTATIONS~~

~~A. Configure each operator workstation (coordinate with Owner) with desktop shortcut to BAS Web Server and provide all necessary additional setup required for full functioning access to BAS Web Server environment including real-time process monitoring, alarm and event management, scheduling and trending.~~

~~3.4~~3.3 BAS WEB SERVER – SOFTWARE PROGRAMMING

A. Alarm and Event Management:
   1. Web Server Software shall be programmed to receive BACnet alarm event notifications from individual controllers and manage system alarm/event notification and routing.
   2. Web Server Software shall be programmed to monitor status of each IP-based controller and provide alarms on loss of communication/status.
   3. Operator shall be able to adjust alarm limits if logged on with the appropriate security access.
   4. Alarm logs shall be maintained for a minimum of 1 year.

B. Scheduling:
   1. Web Server Software shall be programmed to provide scheduling interface for individual HVAC system Occupied/Unoccupied operation as indicated in Control Sequences.

C. Trending & Data Archiving:
   1. Web Server shall provide data archiving for all analog inputs, analog outputs, analog values, setpoints and calculated energy data.
   2. Archived data shall be maintained for a minimum of 2 years.
   3. All trend log information shall be displayed in standard engineering units.
   4. Data points indicated to as “LEED M&V” in the DDC Point Schedules shall be have a sampling time of 1 minute and averaged over 15 minutes.
   5. Configure routing for all alarms. Coordinate alarm routing with Owner.

D. Report Generating: Software shall have a report generation utility programmed for generating the following standard reports:
   1. Energy usage Report: An energy usage summary, operator selectable, for a unit and building. Report shall be divided by utility, and shall be capable of reporting on at least four separate utilities. Report shall include the following information:
      a. Beginning and ending dates and times
      b. Total energy usage for each utility for the current and previous day
      c. Total energy usage for each utility for the current and previous month
      d. Maximum 15-minute interval average rate of consumption for each utility for the current and previous day and current and previous month
      e. Average Outside air (OA) temperature and OA relative humidity (rh) for current and previous month and current and previous day
      f. Calculated degree days

2. Current Alarm Summary Report: Current alarms by building or unit, including time of occurrence.
3. Daily Alarm Summary Report: Current alarms by building or unit, including time of occurrence for a user specified day.
4. Daily Room Summary Report: Average, high & low values for temperature, humidity and air change rate for a user specified day.
5. AAALAC Report: Report indicating current temperature, humidity, supply air flow, light level, exhaust air flow and air change rate for user specified space.
6. Device Failure Report: Failed devices including instruments, points, controllers and network hardware, including time of failure, and identification of operator acknowledging failure alarm.
7. Override Report: Points overridden, including time overridden, and identification of operator overriding the point.
8. Lockout Report: Points locked-out, including time locked-out, and identification of operator locking-out the point.
9. Run Time Reports: A report totalizing the accumulated run time of individual pieces of equipment. The operator shall be able define equipment groupings and shall be able to generate reports based on these groupings.
10. LEED Measurement & Verification (M&V) Report: Full listing of all trend data points designated for M&V over a user definable one year period of time. Data shall be provided in a format compatible with Microsoft Office Excel.
11. Provide allowance for ten (10) additional Owner defined custom reports.

~~3.5~~3.4 GRAPHICS PROGRAMMING

A. Navigation Scheme: System graphic displays of HVAC, plumbing and electrical systems and points shall be hierarchical displays using a building-to-equipment point-and-click navigation scheme. Each display shall show the building/Area name and number.

B. Program color graphic displays for each system as described herein. Graphic displays shall consist of pictorial presentations with text description, system schematic, or picture; alarm fields; and database fields for associated points, including dynamic input values, output values, set points, gains, time schedules, etc.

C. Make use of color to highlight system components.
   1. Color and texture meanings shall be consistent across all displays. Components of similar type shall be of same color for graphics (example: dampers shall be purple, valves yellow, etc.). Alarm fields shall be flashing black letters on red background. Affected component shall also turn red whenever alarm status is indicated. Database fields shall be dynamically updated and re-displayed on screen by periodically polling database points not less than once every 5 seconds. Each display shall clearly distinguish between the following point data types and information:
      a. Real-time data
      b. User-entered data (setpoints)
      c. Overridden or operator-disabled points
      d. Devices in alarm (unacknowledged)
      e. Out-of-range, bad, or missing data
   2. State indication shall be determined by status indicating equipment such as current sensing switches, auxiliary contacts, or position switches. Commands to field devices shall be shown separately.

D. Graphics shall be configured to automatically update values without any action by the operator.

E. All standard graphic features, such as title block, navigation buttons, etc., shall always be located in the same general area on each Graphic. For example, the navigation buttons shall always start at

the left frame of the graphic. The Home, Charts and Alarm buttons shall always start in the upper right corner of the graphic.

F. A description of a point shall be included on the Graphic next to the object's value whenever there is any ambiguity about the value's meaning. For example, when status and command points are both shown on a Graphic, they shall both be labeled with separate identifying descriptions. If a description of a point in a point block is not adequate, then a separate note may be added to the Graphic Background near the point block clarifying function or purpose. This shall prevent any confusion about what a value represents.

G. Display all control loop and alarm setpoints on respective system graphic. Provide ability to change control loop setpoints, alarm setpoints and start/stop equipment from system graphic, provided user has appropriate access. If system graphic seems too cluttered, provide separate, text-based, System Overview page.

H. Display time, date, outside temperature and humidity on each display in same location on each graphic. Provide command to direct specific displays without accessing main menu. Provide means of displaying directory of screens. Arrange displays by group and type.

I. Graphic displays shall be designed to be easily understood. When display screen is too cluttered due to size, limit information to important monitoring data. Provide sub-graphic(s) to display data not displayed on main display.

J. Each graphic shall have a shortcut to the main menu graphic and to previous graphic.

K. Main menu graphic shall be automatically displayed when user logs on to system.

L. Graphics shall include, but not be limited to:
   1. Site Plans, including each building, building name, and status of exterior points such as lighting, etc.
   2. Overall building plan. Indicate location of mechanical rooms and areas served by each air handling unit.
      a. Provide link from building plan to individual building floors and mechanical rooms.
   3. Overall HVAC floor plan of each Area/Floor with indication of individual space temperatures, humidity, occupancy status, equipment status, equipment locations and alarm status for displayed values. Include room names and numbers for all spaces on floor plan graphics.
      a. Provide link from displayed values and equipment to associated equipment graphic.
      b. Provide link to overall building plan.
      c. Label equipment and displayed values according to mechanical floor plans and BAS program.
   4. Overall Lighting Control System floor plan of each floor with indication of individual light status and outline of lighting zones.
      a. Provide link from floor graphic to manual control graphic for each space/zone. Operator shall be able to select individual offices, conference rooms and open office zones from floor graphic and initiate manual control graphic.
      b. Manual control graphic shall provide lighting status indication and one-touch ON/OFF override control for respective room/zone.
   5. Overall Fire Alarm System floor plan of each floor with status of individual Fire Alarm/Control Zone. Zone status shall be indicated as follows:
      a. Red: Alarm
      b. Yellow: Warning
      c. Magenta: Supervisor
   6. Schematic type graphics for:
      a. Site Main Menu, with background digital picture of site, showing each building, shall have direct links to each individual building Main Menu.

b. Individual Building Main Menu, with background digital picture of building, shall have direct links to each of the following, as applicable:
    1). Overall Building Plan
    2). Chilled Water System
    3). Condenser Water System
    4). Steam System
    5). Boiler Feedwater System
    6). Fuel Oil System
    7). Emergency Generators
    8). Heating Hot Water System
    9). Reheat Hot Water System
    10). Heat Recovery System
    11). Each Air Handling Unit (AH)
    12). Power Monitoring System
    13). Each HVAC Floor Plan
    14). BAS Network Architecture
    15). Lighting Control System
c. Chilled water system showing all components and control loops
    1). Individual Chillers
d. Condenser water system showing all components and control loops
e. Steam system showing all components
    1). Individual Boilers
f. Fuel oil system showing all components
    1). Individual Fuel tanks
    2). Individual Day Tanks
g. Emergency Generators
h. Each Air Handling Unit (AH)
    1). Supply fan control loops
    2). Return fan control loops
    3). Cooling coil control loops
    4). Heating coil control loops
    5). Humidifier control loops
    6). Damper control loops
i. Fan Coil Units
j. Exhaust Air Systems
    1). Exhaust fan control loops
k. Air Terminals
l. Space Specific Control & Monitoring
m. Heating hot water system showing all components
    1). Temperature control loops
    2). Pump control loops
n. Reheat hot water system showing all components
    1). Temperature control loops
    2). Pump control loops
o. Heat Recovery system showing all components
    1). Temperature control loops

2). Pump control loops

p. Computer Room Air Conditioning Units

q. Each Plumbing System

r. Each Packaged System/Equipment

s. BAS Network Architecture indicating status of all devices/controllers

t. HVAC Schedules

u. Lighting Control System

1). Each Floor Plan

2). Lighting Schedules

v. Fire Alarm System

1). Each Floor Plan

w. HVAC Trends

7. Submit sample graphics (one per type) for review and approval by Owner prior to starting graphics programming.

~~3.6~~3.5 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

~~3.7~~3.6 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by contractor and witnessed and documented by Commissioning Authority.

END OF SECTION

SECTION 23 7328

FACTORY FABRICATED CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0513 - Motors

B. Section 20 0514 - Variable Frequency Drive (VFD) System

C. Section 20 0529 - Mechanical Supporting Devices

D. Section 20 0553 - Mechanical Systems Identification (Nameplate Markings)

E. Section 20 0700 - Mechanical Systems Insulation

F. Section 23 0550 - Vibration Isolation

G. Section 23 0901 - Control Systems Integration

H. Section 23 0902 - Control Valves and Dampers

I. Section 23 0903 - Control Instrumentation

J. Section 23 0905 - Instrument Point List

K. Section 23 0923 - Direct Digital Controllers and Networks

L. Section 23 0993 - Control Sequences

M. Section 23 2116 - Pipe and Pipe Fittings

N. Section 23 2118 - Valves

O. Section 23 2120 - Piping Specialties

P. Section 23 3314 - Ductwork Specialties

Q. Section 23 3400 - Fans

R. Section 23 4114 - Filters

S. Section 23 8216 - Coils

T. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables

U. Section 26 0533 - Raceway and Boxes for Electrical Systems

V. Section 26 2726 - Wiring Devices

W. Section 26 2816 - Enclosed Switches and Circuit Breakers

X. Section 26 2913 - Enclosed Controllers

Y. Section 26 5100 - Interior Lighting

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplemental Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

A. Shop Drawings (Product Data) for all equipment including, but not limited to, the following:
   1. Appropriate identification
   2. Complete drawings showing plans and sections including details of construction
   3. Overall unit dimensions and individual components and sections dimensions
   4. Shipping and operating weight of unit and/or sections
   5. Structural design load
   6. Details of component support
   7. Capacities/ratings
   8. Materials of construction
   9. Thermal and acoustical performance of wall, roof and floor panels
   10. Pressure ratings and leakage ratings
   11. Thermal break construction details and performance calculations or test data
   12. Each component manufacturer's name, model number and data (Refer to each component section for submittal requirements.)
   13. Air leakage rates and test data
   14. Wiring diagrams and terminal points for control panels provided with units
   15. Manufacturer’s installation instructions
   16. Air handling unit manufacturer’s local representative and phone number

1.4 DESIGN CRITERIA

A. For housings and floors operating under positive pressure (fan discharge side), maximum allowable deflection at panel midpoint shall not exceed 1/240th of any span in any direction at +10” WG.

B. For housings and floors operating under negative pressure (fan inlet side), maximum allowable deflections at panel midpoint shall not exceed 1/240th of any span in any direction at -10” WG.

C. Air handling unit manufacturer shall provide equipment as specified and install equipment furnished by others to result in complete and operational unit. Unit manufacturer shall assume single source responsibility for all air handling unit components and accessories.

D. Furnish units complete with fans, piping, valves, piping specialties, actuators, motors, coils, humidifiers, drain pans, filter sections, damper sections and interior lighting, meeting configuration and as shown on drawings, specified and as scheduled. All unit components shall meet this Section of specification and all requirements specified in each section and division listed under Related Work. Control dampers shall be provided by unit manufacturer. Control dampers actuators will be furnished by Control Contractor and shall be field-installed by Mechanical Contractor.

E. All materials shall meet NFPA 90A Flame and Smoke Generation Requirements.

F. Units shall be UL or ETL listed in accordance with UL Standard 1995.

G. Unless otherwise indicated, galvanized steel shall be G90 according to ASTM A924 (formerly ASTM A525), A653 and ASTM A-90 and aluminum sheet shall be 3003-H14 alloy, conforming ASTM B209.

H. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled total static pressure without operating into motor service factor.

I. Motor furnished with fan shall not operate into motor service factor in any cases.

J. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static pressure requirement as described in AMCA Publication 201. This Contractor shall be responsible for any motor drive and/or wiring changes required as result of duct configuration changes at fan.

K. Air handling unit static pressure to take into consideration actual static pressure loss of components furnished within unit.

L. Wire brush all welds with solvent and wipe clean all bare metal before painting.

M. Air handling unit shall be constructed for outdoor application and shall be designed for roof mounting on concrete curb provided by GC. For outdoor units, allow for snow and wind loading in accordance with the governing building Code when calculating allowable deflections.

1.5 FINAL CLEANING

A. Outside and inside of each air handling unit shall be thoroughly cleaned. Use industrial grade cleaners to remove construction dust, sheet metal mill finish or grease. All proposed cleaning materials shall have contents identified and approved prior to use. Cover unit openings with sheetmetal or other proper material until ductwork is connected to maintain unit cleanliness.

1.6 MANUFACTURER QUALIFICATIONS

A. Air handling units shall be manufactured by qualified unit manufacturer that has been making custom units for at least 10 yrs, and shall carry manufacturer's nameplate. Unit manufacturer shall be held responsible for specified performance of units.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Engineered Air, ~~Ingenia, Racan~~, Ventrol, ~~York Custom~~, and MarCraft, with operating characteristics as scheduled and physical dimensions as shown on drawings and/or detailed.

2.2 UNIT BASE

A. Unit base shall be fabricated from **structural steel**.

B. Base shall be sized to provide sufficient height above floor to accommodate cooling coil drain trap height indicated on details. Additional steel base may be used as sub-base to provide the required trap height. Sub-base may be provided at factory by unit manufacturer or provided at field by Installing Contractor.

C. Weld steel solid at connection points to assure rigidity. Size perimeter steel to allow for rigging and handling.

D. Locate and size base cross supports to support internal components.

E. Provide lifting lugs to perimeter base steel. Incorporate means of attaching cable or chain into each lug.

F. Base shall be split in maximum size pieces to allow for economical shipment to jobsite and placement within building. Provide bolting structural steel on both sides of split for field joining.

G. Unit base shall be primed and finished with rust inhibiting epoxy paint.

2.3 UNIT FLOOR

A. Unit floor shall be constructed to meet the maximum allowable deflection, and constructed of no lighter than:
   1. 3/16" plate of 304 stainless steel.

B. Floor joints and seams shall be sealed to meet allowable housing leakage rate specified. Use acrylic latex sealant meeting ASTM C834-76 (1981) or polyurethane sealant, ASTM C-920, Type S, Grade NS, Class 25, USDA Approved.

C. Entire floor including base drain pans shall be insulated on underside to have same thermal and acoustical performance specified for unit housing. Insulation shall be supported by minimum 20 ga galvanized steel liner with joints sealed to provide continuous vapor barrier.
   1. Provide recessed drain pans as integral part of unit floor in pre-heating coils, outside air sections and humidifier sections.
   2. Drain pans shall be constructed from minimum 16 ga 304 SS sheet, all seams continuously welded with minimum 2" turned up.
   3. Drain pan shall be double sloped; pitched down in direction of air flow and pitched sideways to drain connection.
   4. Locate drain connections at lowest point of pan, one on either end. Connections shall extend through perimeter base channel and be continuously welded to insure air-tight seal as well as eliminate requirement for backup wrench during field piping. Provide removable cap on each drain connection.
   5. Refer to Cooling Coil Section for cooling coil drain pan requirements.

D. Service corridor shall use same construction as unit, except floor shall be constructed of 3/16" aluminum plate with diamond-tread. Width of service corridor shall be as shown, but not less than 60".

2.4 UNIT HOUSING

A. Unit housing shall be constructed of 4" thick double wall panels meeting thermal, acoustical and structural requirements specified.

B. Panels shall utilize modular panel type construction. Panels may be self-supporting with internal support structure or supported by structural frame work.

C. Panel joints and seams shall be sealed with proper gasket and caulking to meet maximum allowable housing leakage rate specified.

D. Panel system, including service corridor where used, shall incorporate thermal break design at panel frames, joining mullions, supporting base, or corners. Thermal break is defined as prevention of condensation on outside surface of unit casing with 92ºF dry bulb and 82ºF wet bulb temperature in adjacent space and 50°F dry bulb temperature inside air handling unit.

E. Unit manufacturer shall submit, as part of Shop Drawings, details of thermal break construction and calculations or test data indicating that thermal break design will prevent condensation on outside surface of unit casing with specified air temperatures at outside of unit and specified air temperature at inside of unit.

F. Outer face of panels for indoor units shall be constructed of no lighter than:
   1. 16 ga galvanized steel or 18 ga if injected foam panels are used.

G. Outer face of panels for outdoor units shall be constructed of no lighter than:
   1. 16 ga galvanized steel with 2 coats of primer having total dry film thickness of 5 mils and one finish coat of enamel. Finish color will be manufacturer's standard color.

H. Solid inner face of panels shall be constructed of no lighter than:

1. 20 ga galvanized steel
2. Unit casing shall be insulated with minimum 3 pcf density glass fiber, or 3 pcf density polyurethane foam insulation. Composite panel shall have heat transfer factor not greater than 0.12 Btu/(h·ft^2·°F). All products as applied shall meet NFPA 90A possessing flame spread rating of not over 25 and smoke developed rating of not over 50.
3. Acoustical absorptive panels shall have perforated inner face constructed of no lighter than 22 ga galvanized steel with fibrous inert core.

I. Use solid inner surface for all sections

J. Use solid inner surface for all sections except fan inlet and discharge sections where perforated inner face to be used.

K. Provide center vertical partition to divide units into modules, as detailed on drawings. Partition panels shall be same construction as housing wall panels except both faces to be constructed of no lighter than 16 ga solid galvanized steel.

L. Provide blank-off panels with proper gaskets and sealants to prevent air bypass around equipment such as filters, coils, humidifiers and sound attenuators. Blank-off panels shall be constructed of galvanized steel no lighter than 16 ga unless otherwise noted. Blank-off panels at cooling coil sections shall be insulated with 3/4" thick insulation similar to AP Armaflex SA Duct Liner Do not insulate blank-off panels between cooling coils located above drain pans.

M. Panel manufacturer shall have published literature available stating sound absorption coefficient of panel system obtained using ASTM Method of Test for Sound Absorption of Acoustical Materials in Reverberation Rooms (ASTM Designation C423-66), and sound transmission loss obtained using procedures conforming to ASTM Designation E90-70, E413-70T and other pertinent standards.
1. Sound Transmission Loss in accordance with ASTM E90 shall equal or exceed the following:

	Octave Band Center Frequency (Hz)					
	125	250	500	1000	2000	4000
Transmission Loss (dB) of 4" Panels	21	24	34	44	51	53

2. Sound performance tests must be documented by independent laboratory (ETL, Riverbank Laboratories, Kideras Labs, etc.).

N. Manufacturer shall also have published literature available describing load-carrying capabilities and thermal characteristics of the panel system.

O. Entire roof of outdoor units shall be constructed with standing seam of 1-1/2" in height and filled with sealant for water-tight joints. Roofing shall be sloped 1/4" per foot with gutter and downspout mounted on low side of unit.

2.5 ACCESS DOORS

A. Each unit section shall have 24" x 72" access door, unless shown differently on drawings.

B. Fan section access door shall be sized to allow removal of fan wheel and motor through door, but not smaller than 30" x 72". If access door needs to be wider than 36", removable access panel may be provided.

C. Access doors and door frames shall have similar thermal break construction as specified under Unit Housing.

D. Access doors shall be same construction as housing panels.

E. Access doors located downstream of cooling coils shall be true thermal break design with no metal to metal contact.

F. Access doors shall be guaranteed tight closing through use of seals around entire periphery. Provide neoprene gasket between door frame and housing for air tight seal.

G. Each access door shall contain 1/4” thick wire glass or double glazed tempered glass window minimum size of 12" x 12" or 12" round. Window shall be double paned with vapor seal construction.

H. Each access door shall be furnished with corrosion resistant metal hinges or continuous piano hinge and shall have at least 2 stainless steel or aluminum alloy handles operable from both sides.

I. Doors shall open against higher air pressure to affect seal.

2.6 ACCESS SECTIONS

A. Access sections shall allow minimum of 30” between adjoining equipment. Provide access doors as indicated on the plans.

2.7 REMOVABLE ACCESS PANELS

A. Removable access panels shall be provided as indicated on drawings and where equipment removal is not possible through access door. Removable panels shall be same construction as housing panels.

2.8 FILTER SECTIONS

A. Filters shall be provided as specified and scheduled. Holding frames shall be installed by unit manufacturer to raise filters off floor and to prevent leakage in accordance with filter manufacturer’s installation recommendation by unit manufacturer.

2.9 PREHEAT COIL SECTION

A. Provide preheat coils, piping and internal piping as specified and indicated on drawings.

B. Install coils, piping, and specialties not to block face area of coils. Terminate piping outside of unit casing for connection by Mechanical Contractor. Provide necessary pipe supports and hangers.

C. Each coil shall be supported by galvanized steel frame which is independent of unit casing. Support frame shall allow individual coil removal. Coils shall be removable through unit access doors. Blank-off panels shall be galvanized steel sheets.

2.10 HEAT RECOVERY COIL SECTION

A. Provide heat reclaim coils, piping and internal piping as specified and indicated on drawings.

B. Install coils, piping, and specialties not to block face area of coils. Terminate piping outside of unit casing for connection by Mechanical Contractor. Provide necessary pipe supports and hangers.

C. Each coil shall be supported by 304 stainless steel frame, which is independent of unit casing. Support frame shall allow individual coil removal. Coils shall be removable through unit access doors. Blank-off panels shall be 304 stainless steel sheets with insulation as specified.

2.11 COOLING COIL SECTIONS

A. Provide cooling coils, piping and piping specialties specified, and indicated on drawings.

B. Install coils, internal piping, and specialties not to block face area of coils. Terminate piping outside of unit casing for connection by Mechanical Contractor. Provide necessary pipe supports and hangers.

C. Each coil shall be supported by 304 stainless steel frame which is independent of unit casing. Support frame shall allow individual coil removal. Coils shall be removable through unit access doors or removable access panels. Blank-off panels shall be 304 stainless steel sheet with insulation as specified.

D. Each coil shall be provided with minimum 16 ga 304 stainless steel all welded condensate drain pan extending min. 6", but no more than 12" downstream of coil face. Each drain pan shall have sufficient depth to hold condensate water but not less than 2". Bottom drain pan shall extend min 18". Drain pans shall cover U bends of coil and any other pipes and components that form condensation. Drain pan shall be sloped in 2 directions (pitched down in direction of airflow and pitched sideways to drain connection) for self-drainage at minimum 1/4" per foot. Drain pan shall be individually piped down to drain pan located below, and bottom drain pan to be piped to hub drain at exterior of unit. Drain connection opening shall be flush with bottom of pan. Side pan connection located at lowest point of pan may be used only where bottom pan connection cannot be used. Drain pipes of intermediate and main drain pans shall be 304 stainless steel with sufficient size, but not less than 1-1/2"

1. Furnish drain pan with separate overflow drain connection located just below overflow rim of pan.

2.12 FAN SECTION

A. Fan and motor shall be provided as scheduled and meet requirements of appropriate Specification Sections.

B. Fan and motor shall be factory mounted on vibration isolation equipment meeting requirements of Section 23 0550 - Vibration Isolation. Vibration base shall include integral adjustable motor base. If inertia bases are required, provide required concrete in factory.

C. Unit manufacturer shall provide flexible connection between fan and discharge wall.

D. Motor Removal:

1. For motors 15 hp and larger, provide motor removal rail sized for L/400 deflection when fully extended and subjected to weight of motor at furthest extreme position.
2. Removal rail shall be mounted in fan section, directly over motor, perpendicular to side of AHU.
3. Removal rail shall be designed with roller so motor can be fully removed from unit to distance motor diameter plus minimum of 6", and lowered onto dolly with traversing arm able to freely move while carrying motor weight.
4. Motor shall be able to be removed through access door or access panel.

E. Fan Array:

1. Fan array system shall consist of multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for duty specified. Fans shall be selected to deliver scheduled airflow quantity at scheduled operating total static pressure and scheduled fan/motor speed. Fan array shall be selected to operate at system total static pressure that does not exceed 90% of scheduled fan's peak static pressure producing capability at scheduled fan/motor speed. Each fan/motor cube shall include 11 ga, A60 Galvanized steel intake wall, 14 ga spun steel fan inlet funnel, and 11 ga G90 Galvanized steel motor support plate and structure. Fan intake wall, inlet funnel, and motor support structure shall be powder coated for superior corrosion resistance. Motors shall be standard pedestal mounted type, T-frame motors selected at specified operating voltage, rpm, and efficiency as needed to meet performance requirements. Motors shall include isolated bearings or shaft grounding. Each fan/motor cartridge shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 2.5 residual unbalance.
2. Fan array shall provide uniform air flow and velocity profile across entire air way tunnel cross section. Airflow and velocity shall not exceed scheduled cooling coil and/or filter bank face velocity when measured at a point 12" from intake side of fan wall array intake plenum wall, and distance of 48" from discharge side of fan wall intake plenum wall.

3. Provide partition between fans to minimize system effect.
4. Provide structural frame to support upper fans with solid floor panel partition between fans as shown on drawings to minimize system effect.
5. Each fan/motor cube shall be equipped with metal grating fan outlet guard.
6. Each fan in array shall be provided with back flow prevention means that produces less than 0.10" of static pressure drop and/or system effect when that fan is enabled. Any such system effects and/or pressure drops shall be submitted and included as component in determining fan system total static pressure as submitted. Manufacturer's pressure drop ratings of any such equipment, developed from straight run test conditions will not be accepted.
7. Provide one variable frequency drive for fan array in AHU-1. Fan array shall be sized such that upon single fan failure, remaining fans could ramp up and provide same 100% design capacity.
8. Technology with multiple fans having individual VFDs may be considered.
9. Provide local electrical disconnect for each fan.
10. Contractor shall provide all wiring to air handling unit components that require power.

2.13 DIFFUSER SECTION

A. Provide with diffusers to distribute fan discharge air evenly over unit cross section. Diffusers shall be minimum 16 ga galvanized steel or aluminum plate with proper perforation. Maximum PD of diffuser plate shall be 0.3" WG. Reinforce and support plate adequately.

2.14 DISCHARGE AIR SECTION

A. Provide with framed discharge opening or spun bellmouth fitting conforming to size and configuration of the ductwork.

2.15 CONTROL DAMPERS

A. Refer to Section 23 0902 - Control Valves and Dampers, for control dampers.

B. Outside air dampers shall be equal to Tamco Series 9000 thermally insulated dampers.
1. Extruded aluminum (6063T5) damper frame shall not be less than 0.080" in thickness. Damper frame shall be 4" deep. Outside air dampers shall be insulated with polystyrofoam on four sides.
2. Blades shall be extruded aluminum (6063T5) profiles. Dampers shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and temperature index of 55.
3. Blade seals shall be of extruded EPDM. Frame seals shall be of extruded TPE thermoplastic. Seals shall be secured in integral slot within aluminum extrusions.
4. Bearings shall be composed of Celcon inner bearing fixed to 7/16" aluminum hexagon blade pin, rotating within polycarbonate outer bearing inserted in frame, resulting in no metal-to-metal or metal-to-plastic contact.
5. Linkage hardware shall be installed in frame side and constructed of aluminum and corrosion-resistant, zinc-plated steel, complete with cup-point trunnion screws for slip-proof grip.
6. Dampers shall be designed for operation in temperatures ranging between -40°F and 212°F.
7. Air leakage through 48" x 48" damper shall not exceed 4.12 cfm/ft^2 against 4" WG differential static pressure at standard air.
8. Pressure drop of fully open 48" x 48" damper shall not exceed .03" WG at 1000 fpm.

2.16 FLOOR OPENING PROTECTION

A. Floor openings shall have safety grates using 1" x 1/8" steel bar stock on 1-1/4" center spacing. Grates shall have same finish as floor. Provide 1-1/2" lip of galvanized steel at entire perimeter of opening.

2.17 ROOF CURB

A. Unit manufacturer shall furnish roof curb for AHU-1 unit. Roof curb shall be 18" high and constructed from minimum 12 ga galvanized steel. At each of 4 corners, curb shall be joined together with corner post that is welded to one section of curb and then field bolted to adjacent section. Wood nailer shall be attached to inside flange of curb for field attachment of flashing and roof membranes.

2.18 CONTROLS

A. All Control devices except for those that control the heat recovery system, will be furnished by Control Contractor and shall be factory installed by unit manufacturer as shown on plans and as described in control section of Specifications.

B. The heat recovery system controls will be provided by the air handler manufacturer.

2.19 TESTING

A. Owner and/or Owner's representative may elect to witness tests. Notify Owner and/or Owner's representative of test date at least 2 weeks in advance. Submit certified test data to Engineer for approval.

B. Unit manufacturer shall provide factory tests to verify casing leakage after units are assembled.

C. Unit manufacturer and installing contractor shall jointly provide field tests to verify casing leakage after units are installed at jobsite. Coordinate with Electrical Contractor for power to unit test fan.

D. Casing leakage tests shall verify that unit casing leakage is less than **1%** of design air flow at specified static pressure.
   1. Seal duct openings in positive pressure section. Connect this section to fan developing **10"** WG positive static pressure, and read air flow of this fan using approved air flow measuring device. Fan air flow measurement shall be considered casing leakage of this Section.
   2. Seal duct openings in suction side of unit. Connect this section to fan developing **10"** WG in negative static pressure, and read fan air flow of this fan using approved air flow measuring device. Fan air flow shall be considered casing leakage of this Section.
   3. Conduct casing leakage test individually for each air handling unit. Total casing leakage shall be calculated as sum of positive pressure section leakage and negative pressure sections leakage. Total casing leakage shall not exceed the allowable rate specified above.

E. Unit manufacturer shall provide factory panel deflection test. Conduct this test in conjunction with casing leakage testing.
   1. Panel deflection test for panels under positive pressure shall verify that unit casing deflection is less than 1/200 of the longest plane being measured at 1-1/2 times design static pressure or 10" WG positive, whichever is greater.
   2. Panel deflection test for panels under negative pressure shall verify that unit casing deflection is less than 1/200 of the longest plane being measured at 1-1/2 times design static pressure or 10" WG negative, whichever is more negative.
   3. Deflection shall be measured at 2 points for positive pressure sections and 2 points for negative pressure sections (total 4 points at panel seams) at mid-point of panel height.

2.20 ELECTRICAL SERVICE

A. Provide adequate lighting and switching so equipment can be observed and maintained in safe manner. Combination lighting and convenience outlet circuit is required for each section of unit. Each access section shall contain a minimum of one light fixture. Sections wider than 12 ft shall have multiple light fixtures with maximum spacing of 6 ft.
   1. Provide light switch with pilot light for each access section. Locate switch near access door.
   2. Wire all lights to single junction box with single switch with pilot light.

3. Light fixtures shall be marine type incandescent bulb type. Provide bulbs for each fixture.

B. Lights, switches, convenience outlets, wiring and conduit shall meet requirements of appropriate Specification Sections of Division 26.
   1. Provide two points of power connection, one for 3 Ph, 480 V and one for 1 Ph, 120 V power connection.

C. Seal electrical penetrations into unit air-tight.

D. For outdoor air handling units, unit manufacturer shall provide cabinet built into side of unit for mounting of VFD and temperature control panel. Unit manufacturer shall coordinate size of cabinet with equipment being furnished to ensure it is of adequate size to contain VFD and temperature control panel. Cabinet shall have weather tight access door to provide access to VFD and panel from outside of air handling unit. Cabinet shall be cooled with air supplied through dampered opening from discharge side of supply fans.

2.21 PIPED SERVICE

A. Interior piping and equipment installation shall be complete. Piping shall be installed and tested per appropriate specification section. Unit manufacturer shall be responsible for any leaks, which occur in unit during system testing which occurs before system startup.

B. Extend piping for each coil and humidifier if used through panel casing. Terminate piping with flange for pipe 2-1/2" and larger or threaded connection for pipe 2" and smaller with caps.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Units shall be assembled in unit manufacturer's plant to allow for testing of complete unit.

B. Unit manufacturer shall supervise and be responsible for all field joining of the modules, including sheet metal, electrical and piping. Local trades may provide labor for unit assembly and installation.

C. Joints in floor between modules shall be air and water tight.

D. Unit manufacturer shall provide and install all equipment within unit as specified including fans, motors, coils, humidifiers, dampers, sound attenuating devices, piping, piping specialties, ductwork specialties, lights, switches and all equipment necessary to complete air handling equipment contained within housings. Mechanical and electrical connections (i.e., piping and conduit) shall be stubbed through housing so that appropriate Contractor may provide service to air handling unit. Electrical wiring and control wiring shall terminate in junction boxes on accessible side of unit.

E. Provide structural steel sub-base as required. Refer to Unit Base in Part 2.

F. Field mounting of any equipment on housing walls or roof is not allowed without prior approval of Engineer.

G. Unit manufacturer and installing contractor shall coordinate with other trade Contractors, all necessary requirements to assure proper air handling unit installation.

3.2 INSTRUMENT TEST HOLES

A. Provide instrument test holes at air entering and air leaving side of all internal air handling unit components for static pressure differential or temperature measurements. Refer to Section 23 3314 - Ductwork Specialties, for instrument test holes.

3.3 PROTECTION OF OPENINGS

A. Protect openings on housings during construction against entry of foreign matter and construction dirt.

3.4 FIELD TESTING

A. Unit manufacturer and installing contractor shall jointly perform field casing leakage test on each completed housing assembly as previously specified and shall be responsible for repair of all leaks. Submit certified test data to Engineer for approval.

B. Temporary sealing of access doors, condensate drains, etc. is not allowed during field testing except to troubleshoot leakage points.

END OF SECTION

SECTION 27 0000

GENERAL COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

A. This section details references, standards, guidelines, requirements and conditions common to all Division 27 work.

B. Work under this Section and related sections is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.2 DESCRIPTION

A. Intent of drawings and specifications is to obtain complete systems tested, adjusted, and ready for operation.

B. Except as otherwise defined in greater detail, terms "provide", "furnish" and "install" as used in Division 27 contract documents shall have the following meanings:
   1. "Provide" or "provided" shall mean "furnish and install".
   2. "Furnish" or "furnished" does not include installation.
   3. "Install" or "installed" does not include furnishing.

C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.

E. Included in this contract are connections to equipment provided by others. Refer to Architectural, Electrical, Integrated Automation, Mechanical, Security and final shop drawings for equipment being furnished under other sections for exact locations of outlets and various connections required.

F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.

G. Where architectural features govern location of work, refer to architectural drawings.

H. All work shall be performed in "neat and workmanlike" manner as defined in ANSI/NECA 1 "Standard Practices for Good Workmanship in Electrical Contracting".

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0526 - Grounding and Bonding for Communications Systems
   2. Section 27 0528.29 - Hangers and Supports for Communications Systems
   3. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   4. Section 27 0528.36 - Cable Tray for Communications Systems
   5. Section 27 0553 - Communications Systems Identification
   6. Section 27 1100 - Communications Equipment Room Fittings
   7. Section 27 1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0593 – Electrical Systems Firestopping
   2. Also see individual technical sections identified above.

C. Continuity of Service:
   1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before work is started.
   2. When interruption of services is required, persons concerned shall be notified and shall agree upon a time.

D. Demolition:
   1. Division 1 - Selective Demolition.
      a. See other sections regarding general requirements for selective demolition.
   2. Division 2 - Building Demolition
      a. Not applicable to this Division of work.
   3. Perform demolition as required to accomplish new work.
      a. Remove abandoned wiring to source of supply.
      b. Disconnect abandoned outlets and remove devices.
      c. Remove abandoned outlets if conduit servicing them is abandoned and removed.
      d. Provide blank cover for abandoned outlets that are not removed.
      e. Disconnect communications systems in walls, floors, and ceilings scheduled for removal.
      f. Provide drawings for each floor showing locations and outlet identification of all outlets removed under project demolition.
   4. Accomplish work in neat workmanlike manner to minimize interference; annoyance or inconvenience such work might impose on Owner or other contractors.
   5. Unless otherwise noted, remove from premises materials and equipment removed in demolition work.
   6. Equipment noted to be removed and turned over to Owner shall be delivered to Owner at place and time Owner designates.
   7. Where materials are to be turned over to Owner or reused and installed by Contractor, it shall be Contractor's responsibility to maintain condition of materials and equipment equal to that existing before work began. Repair or replace damaged materials or equipment at no additional cost to Owner.
   8. Where demolition work interferes with Owner's use of premises, schedule work through Architect, Owner and with other contractors to minimize inconvenience to Owner. Architect must approve schedule before Contractor begins such work.

E. Cleaning and Repair
   1. Clean and repair existing materials and equipment that remain or is to be reused.

F. Painting:
   1. Furnish equipment with factory applied prime finish unless otherwise specified.
   2. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Engineer.
   3. Furnish one can of touch up paint for each factory finish, which will be final finished surface of product.
   4. Contractor is responsible for painting of plywood in Telecommunications Equipment Rooms. Refer to Drawings.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

A. Rules and regulations of Federal, State and local authorities and utility companies, in force at time of execution of contract shall become part of this specification.

1.5 REFERENCES AND STANDARDS

A. Design, cable and component selection, and installation practices shall conform with following:
   1. ANSI/NFPA 70 - National Electrical Code
   2. Chicago Electric Code (CEC)
   3. Country, state and local health, safety and building codes
   4. UL 444 - Communications Cables
   5. Standards identified in individual Technical Sections
   6. TIA/EIA
   7. Information Technology Construction Standards for University of Illinois at Chicago

B. Agencies or publications referenced herein refer to the following:
   1. ANSI American National Standards Institute
   2. ASME American Society of Mechanical Engineers
   3. ASTM American Society for Testing and Materials
   4. BICSI Building Industry Consulting Services International
   5. EIA Electronic Industries Alliance
   6. FIPS Federal Information Processing Standards
   7. FCC Federal Communications Commission
   8. ICEA Insulated Cable Engineers Association
   9. IEEE Institute of Electrical and Electronics Engineers
   10. NEC National Electrical Code
   11. NECA National Electrical Contractors Association
   12. NEMA National Electrical Manufacturers Association
   13. NESC National Electrical Safety Code
   14. NETA National Electrical Testing Association
   15. NFPA National Fire Protection Association
   16. NIST National Institute of Standards and Technology
   17. OSHA Occupational Safety and Health Administration
   18. TIA Telecommunications Industry Association
   19. UL Underwriters Laboratories, Inc.

C. Work shall be in accordance with latest edition of codes, standards or specifications unless noted otherwise.

1.6 DEFINITIONS

A. The following definitions are applicable to communications environments and shall apply to this document and its companion sections for clarification and direction.
   1. Intermediate Distribution Frame (IDF) – Connection point in each building for campus distribution service entrance from the central office node.
   2. Floor Distribution Frame (FDF) – Distribution source for each telecommunications information outlet.
   3. Telecommunications Information Outlet – Three separate jacks, one for voice and two for data allowing individual users to connect to the campus network.

4. Guarantee - promise or an assurance that attests to quality or durability of product or service or that task will be performed in specified manner. Used interchangeably with "Warranty" in these documents.
5. Intra-building - within single building.
6. Inter-building - between 2 or more buildings.
7. Rack Unit - standard measurement of vertical mounting space on an equipment rack. Each Rack Unit is 1.75" high.

1.7 ABBREVIATIONS AND ACRONYMS

A. The following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction.

1. AFF Above Finished Floor
2. ATM Asynchronous Transfer Mode
3. AWG American Wire Gauge
4. BAS Building Automation Systems
5. BTU British Thermal Unit
6. CATV Community Antenna Television
7. CCTV Closed-Circuit Television
8. CDDI Copper Distributed Data Interface (Cisco Systems trade name for TP-PMD)
9. CEC Chicago Electric Code
10. cm centimeters
11. °C degrees Celsius
12. °F degrees Fahrenheit
13. DTMF Dual Tone Multi Frequency
14. EIA Electronic Industries Alliance
15. EF Entrance Facility
16. ER Entrance Room
17. EIDF Equipment Intermediate Distribution Facility
18. FDDI Fiber Distributed Data Interface
19. FDF Floor Distribution Frame
20. ft feet
21. GbE Gigabit Ethernet
22. Hz Frequency in Hertz (k = kilo, M = Mega, G = Giga)
23. ID Inside Diameter
24. IDF Intermediate Distribution Frame
25. in inch
26. IPT IP Telephony
27. kg kilogram
28. lbs pounds
29. LAN Local Area Network
30. MATV Master Antenna Television
31. MC Main Cross-connect
32. m meters
33. mm millimeters
34. Mbps Megabits per second
35. µm micrometer (10^{-6} meter)
36. NEC National Electric Code

37. OD Outside Diameter
38. PBX Private Branch Exchange (Telephone Switch)
39. pF pico-Farad (10^{-12} Farad)
40. PVC Polyvinyl Chloride
41. RU Rack Unit
42. sq ft square feet (area)
43. TP-PMD Twisted Pair Physical Layer Medium
44. WAN Wide Area Network
45. WLAN Wireless Local Area Network
46. VoIP Voice over Internet Protocol

B. Refer also to technical sections for additional terminology.

1.8 LISTING

A. Refer to technical sections of this Division of work for listing requirements.

1.9 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section:
   1. Refer to Division 1 - Submittal Procedures.
   2. Note that for satisfying submittal requirements for Division 27, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 1. However, expression "Shop Drawings" is generally used throughout specification.
   3. Mark catalog sheets and drawings to indicate specific items submitted.
      a. Markings shall be reproducible (arrow, boxed, encircled, checkmark, etc.).
      b. Where sheet includes multiple product options, mark proposed option(s).
   4. Include proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
   5. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Mark and annotate submittals clearly accordingly.
   6. Group submittals by Section to include complete documentation of related systems, products and accessories. Where applicable, dimensions shall be marked in units to match those specified.
   7. Submittals shall be in electronic form or on paper per Division 1.
      a. Documents in electronic form shall be ADOBE *Acrobat* PDF.
      b. Paper documents shall be original catalog sheets or photocopies thereof.
      c. Facsimile (fax) sheets will not be accepted.
   8. Engineer's Review is to confirm compliance with performance, interoperability, physical, and other pertinent requirements of project. Review is not to confirm quantities nor that all required items have been submitted.
   9. When equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include required components.
   10. Include wiring diagrams for electrically powered or controlled equipment.
   11. Submit equipment room layouts drawn to scale, including equipment, raceways, accessories and clearance for maintenance.
   12. Where submittals cover products containing potentially hazardous non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
   13. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.

14. Submittals, which are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
15. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 27 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork, communications and/or electrical raceway layouts.
    a. Unless specifically requested in Division 27 technical sections, submittals of coordination drawings will be returned without review.

B. Certificates and Inspections:
1. Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to Owner unless otherwise directed.

C. Operation and Maintenance Manuals:
1. Refer to Division 1 - Closeout Procedures.
2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2" thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
3. Manuals shall be organized by specification section number and shall have table of contents and tabs for each piece of equipment or system.
4. Manuals shall include the following:
    a. Copies of shop drawings.
    b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment. Where manufacturer's data includes several types or models, applicable type or model shall be designated.
    c. CD ROM's of O&M data with exploded parts lists where available.
    d. Phone numbers and addresses of local parts suppliers and service companies.
    e. Internet/WEB page addresses where applicable.
    f. Wiring diagrams.
    g. Start up and shut down procedure.
    h. Factory and field test records.
    i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section.
5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
6. O&M manuals and instructions to Owner shall be provided prior to request for final payment.

D. Record Documents:
1. Refer to General Conditions of Contract, and Division 1 - Closeout Procedures. Prepare complete set of record drawings in accordance with Division 1.
2. Use designated set of prints of contract documents as prepared by Architect to mark-up for record drawing purposes.

1.10 JOB CONDITIONS

A. Building Access:
1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Cutting and Patching:
1. Refer to General Conditions of Contract, and Division 1 - Cutting and Patching.

2. Perform cutting and patching required for complete installation of systems unless otherwise noted. Patch and restore work cut or damaged, to original condition. This includes openings remaining from removal or relocation of existing system components.
3. Provide materials required for patching unless otherwise noted.
4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

C. Housekeeping and Cleanup:
1. Refer to Division 1 - Closeout Procedures.
2. Periodically as work progresses and/or as directed by Architect, remove waste materials from building and leave area of work broom clean. Upon completion of work, remove tools, scaffolding, broken and waste materials, etc. from site.

1.11 WORK BY OWNER

A. Owner will provide:
1. Active electronics for interface with building voice and data cabling systems
2. Connections from data equipment to Contractor provided patch panel.

1.12 QUALITY ASSURANCE

A. Refer to the individual technical sections for general product quality requirements, manufacturer qualifications, and contractor qualifications and certification requirements.

1.13 GUARANTEE

A. Refer to Division 1 for general Guarantee (Warranty) requirements.

B. Refer to technical sections for Guarantee requirement for each system.
1. Where no guarantee requirements are called out, guarantee for one year after acceptance by Owner equipment, materials, and workmanship to be free from defect.

C. Repair, replace or alter systems or parts of systems found defective at no extra cost to Owner.

D. In any case, wherein fulfilling requirements of any guarantee, if Contractor disturbs any work guaranteed under another contract, restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.

E. Guarantees shall include labor, material and travel time.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

A. Refer to Division 1 - Product Requirements.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify elevations and measurements prior to installation of materials.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 1.

B. Store and protect products under provisions of Division 1

C. Store in clean, dry space.

D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.

E. Handle in accordance with manufacturer's written instructions.

F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.

3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide during progress of construction sleeves and inserts that are to be built into structure.

B. Temporary sleeves, if used to form wall openings, shall be removed prior to installation of permanent materials. Permanent sleeves for wall penetrations shall be minimum 24 ga galvanized sheet metal unless otherwise noted

C. Steel sleeves, when required, shall be Schedule 40 carbon steel pipe with integral water stop.

D. For core drilled holes, size and location shall be reviewed and approved by Structural Engineer prior to execution.

E. Submit product data and installation details for penetrations of building structure. Submittal shall include schedule indicating penetrating materials, (including steel conduit, PVC conduit, cables, cable tray), sizes of each, opening sizes and sealant products intended for use.

F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Division 26.

G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls. Indicate and locate, by dimension, required openings including those sleeved, formed or core drilled. Drawings shall be approved by the structural engineer prior to preparing openings in structural member.

H. Openings for penetrations shall be minimum 1/2" larger on all sides than outside dimensions of raceways or cables. However, where fire resistant penetrations are required, size openings in accordance with recommendations of firestopping systems manufacturer.

I. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.

J. Seal non-rated wall openings with urethane caulk.

3.4 EQUIPMENT ACCESS

A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocation of raceways, or accessories as required to provide access, shall be provided at no additional cost to Owner.

B. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other equipment, which is to be installed or which is already in place.

C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 8 - Access Doors and Frames, unless otherwise indicated. Access doors shall be for purpose of providing access where equipment requiring servicing, repairs or maintenance is located in walls, chases or above inaccessible ceilings.

D. Locate communications outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.

E. Verify room door swings before installing wall-mounted communications outlets and install boxes on latch side of door unless otherwise noted

3.5 EQUIPMENT SUPPORTS

A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers.

B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.

C. Do not support equipment or cable pathways from metal roof decking.

3.6 SUPPORT PROTECTION

A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, certain equipment must be guarded to protect personnel from injury.

B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.

C. Threaded rod or bolts shall not extend beyond supporting element and shall be protected as described above.

3.7 HOUSEKEEPING PADS

A. Not applicable to this Division of work.

3.8 ACCEPTANCE TESTING

A. Prior to testing, submit to owner (or owners representative) and Engineer, proposed schedule for acceptance testing.
   1. This notification shall be minimum of 10 working days in advance to allow for participation by Owner and/or Engineer.

B. Prior to testing, submit written description of intended test procedures and submit sample test forms to Engineer.
   1. Submitted information shall include proposed file naming format to be used in identifying cable, pair or optical fiber which is subject of test record.
   2. Failure to provide above information shall be grounds for Engineer or Owner to reject any Documentation of related testing and to require repeat of affected test.

C. Conduct tests during course of construction when identifiable portion(s) of installation is complete.
   1. Alternatively, testing can be conducted after entire installation is complete if this does not delay project schedule.

D. Provide equipment and personnel necessary to conduct acceptance tests.

E. Testing shall be completed and accepted by Owner and Engineer before Owner furnished equipment and cross connects are installed.

F. Document tests.

G. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test. This shall be at no additional cost to the owner. Replacement materials shall be new.

H. This Contractor is responsible for certifying, in writing, equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.

I. Maintain copies of certified test results, including those for failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

3.9 START-UP

A. All systems and equipment shall be started, tested, adjusted and turned over to Owner ready for operation.
   1. This includes "Owner-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.

B. Follow manufacturer's pre-start-up checkout, start-up, trouble shooting and adjustment procedures.

C. Contractor shall provide services of technician/installer knowledgeable in start-up and checkout of types of systems and equipment on project.

D. Provide start-up services, by manufacturer's representative where specified or where Contractor does not have qualified personnel.

E. Coordinate start-up with trades.

3.10 DOCUMENTATION

A. Upon completion of installation, Contractor shall provide System Documentation. Documentation shall include:
   1. Acceptance Test Results
   2. Record Drawings
   3. All Approved Submittals
   4. Manufacturer’s Warranty Documents

B. Submit System Documentation in accordance with Division 1 "Project Record Documents".

C. Submit documentation within ten (10) working days of the completion of testing of each testing phase (e.g. subsystem, cable type, area, floor, etc.) or 3 weeks prior to scheduled occupancy of subject area, whichever is sooner. This is inclusive of Test Result and draft Record Drawings.
   1. Draft drawings may include mark-ups done by hand.
   2. Machine generated (final) copies of Record Drawings shall be submitted within 30 working days of completion of each testing phase.

D. Submit Acceptance Test Results in electronic form for review and distribution.
   1. Interim documentation of Test Results (if applicable) may be submitted via email or on CD-ROM.
   2. Final documentation of Test Results shall be submitted on CD-ROM.
   3. Test results shall be submitted in format(s) native to test instrument(s) used in performing testing.

4. Where unique software (other than an MS-Word® compatible Word Processor or MS-Excel® spreadsheet) is required for viewing of test results, Contractor shall provide along with above documentation, 1 licensed copy of such software. Software shall run on MICROSOFT Windows-based personal computer.

E. Acceptance Test results shall include description of sub-system tested, equipment/cable/outlet I.D., reference and test setup, test equipment type/model and serial number(s), equipment location and direction of test (if applicable), test frequencies/wavelengths, date and operator name(s).

F. Engineer or Owner may request that 10% random re-test be conducted on cable system - at no additional cost - to verify documented findings. Tests shall be a repeat of those defined above and in technical sections.
   1. Owner may also perform independent testing to verify results.
   2. If findings contradict documentation submitted by Contractor, additional testing can be requested to extent determined necessary by Engineer or Owner, including 100% re-test. This re-test shall be at no additional cost to Owner.

G. Documentation - including hard copy and electronic forms of Test Data and Record Drawings - shall become property of Owner.

H. Refer also to Technical Sections for requirements specific to covered subsystems.

3.11 CLEANING

A. After installation is complete, Contractor shall clean all systems.

B. Vacuum debris from system components, enclosures, junction boxes and pull boxes prior to testing and again prior to completion.

C. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

END OF SECTION

SECTION 27 0526

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This section includes product and execution requirements for Grounding and Bonding that are unique to communications systems and not included in Division 26 sections.

1.2 DESCRIPTION

A. Grounding and Bonding infrastructure for communications includes Cabling, Busbars and Connectors.

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   3. Section 27 0528.36 - Cable Tray for Communications Systems
   4. Section 27 0553 - Communications Systems Identification
   5. Section 27 1100 - Communications Equipment Room Fittings
   6. Section 27 1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0526 - Grounding and Bonding for Electrical Systems

1.4 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements which identifies pertinent References and Standards.

B. In addition, the following apply:
   1. IEEE/ANSI 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
   2. IEEE 837 - Standard for Qualifying Permanent Connections Used in Substation Grounding.
   3. UL 467 Electrical Grounding and Bonding Equipment
   4. ANSI TIA/EIA-607-B - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

1.5 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements which provides information on Definitions used in this and related sections.

B. Additional definitions (per referenced standards):
   1. Telecommunications Main Grounding Busbar: Busbar placed in convenient and accessible location and bonded by means of bonding conductor for telecommunications to building service equipment (power) ground.

2. Telecommunications Grounding Busbar: Interface to building telecommunications grounding system generally located in telecommunications room. Common point of connection for telecommunications system and equipment bonding to ground, and located in telecommunications room or equipment room.
3. Telecommunications Bonding Conductor: Conductor that interconnects telecommunications bonding infrastructure to building's service equipment (power) ground.
4. Telecommunications Bonding Backbone: Conductor that interconnects tele-communications main grounding busbar to telecommunications grounding busbar.
5. Grounding Equalizer: Conductor that interconnects elements of telecommunications grounding infrastructure.
6. Exothermic Weld: Method of permanently bonding two metals together by controlled heat reaction resulting in molecular bond.
7. Irreversible Compression: Permanent mechanical bond between conductors or conductor and connector using mechanical or hydraulic tool.

1.6 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements which provides information on Abbreviations and Acronyms used in this and related sections.

B. Additional abbreviations and acronyms (per referenced standards):
1. Telecommunications Main Grounding Busbar - TMGB
2. Telecommunications Grounding Busbar - TGB
3. Telecommunications Bonding Backbone - TBB
4. Grounding Equalizer - GE

1.7 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.8 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements which provides general guidelines for product or installation information to be submitted by Contractor.

1.9 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements which identifies general quality assurance requirements for the Project.

1.10 GUARANTEE

A. Refer to Division 1, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

PART 2 - PRODUCTS

2.1 TELECOMMUNICATIONS BUSBARS

A. Material: Copper (aluminum not permitted)
1. 1/4" thick

B. Pre-drilled
   1. Hole spacing and size per ANSI Joint Standard J-STD-607-A
   2. Hole pattern shall accommodate two-hole lugs

C. Insulators and stand-off brackets shall electrically isolate busbar from wall or other mounting surface.

D. Busbars shall be listed by nationally recognized testing laboratory.

E. Size:
   1. Telecommunications Main Ground Busbar (TMGB) - 20" x 4" (minimum)
   2. Telecommunications Grounding Busbar (TGB) - 12" x 2" (minimum)

2.2 CONDUCTORS

A. Material: Stranded copper (aluminum not permitted)

B. Bonding Conductors shall be insulated.
   1. Green Jacket per CEC and NEC Requirments and UIC Standards

C. Size:
   1. Telecommunications Bonding Conductor (TMGB to Grounding Electrode): As indicated on Project Drawings

2.3 CONNECTIONS

A. Mechanical Connectors
   1. Connector Body shall:
      a. Be high-strength, high-conductivity cast copper alloy
      b. Be 2 bolt type
   2. Bolts, nuts, washers and lock-washers: Silicon Bronze
      a. Shall be supplied as part of connector body
      b. Split bolt connector types are not allowed
   3. Connector shall:
      a. Meet or exceed UL 467
      b. Be clearly marked with catalog number, conductor size and manufacturer.

B. Compression Connectors
   1. Connector Body: pure wrought copper.
      a. Conductivity shall be no less than 99% by IACS standards.
   2. Connector shall:
      a. Meet or exceed performance requirements of IEEE 837, latest revision
      b. Be factory filled with an oxide-inhibiting compound
      c. Be clearly marked with manufacturer, catalog number, conductor size and required compression tool settings
   3. Connection shall be irreversible.

C. Exothermic Weld Connections
   1. Not Allowed

PART 3 - EXECUTION

3.1 SEQUENCING AND SCHEDULING

A. Permanently attach communications grounds prior to energizing communications equipment.

3.2 TOPOLOGY

A. Refer to the project drawings.

3.3 INSTALLATION

A. Provide required elements and miscellaneous hardware necessary to establish Telecommunication Grounding infrastructure as specified.

B. Install Products in accordance with manufacturer's instructions.
   1. Install Compression Connectors with compression, tool and die system, as recommended by manufacturer of connectors.

C. Grounding connections shall be tight and shall be made with UL listed grounding devices, fittings, bushings, etc.

D. On the Telecommunications Bonding Conductor, Telecommunications Bonding Backbone (TBB) and Grounding Equalizer (GE) all connections shall be Compression or Exothermic type.

E. Locate TGBs and TMGB per drawings.

F. Telecommunications Bonding Backbone (TBB) shall be continuous and not interrupted by Telecommunications Grounding Busbars (TGB).
   1. TGBs shall be bonded to TBB via tap off of TBB.
      a. Exception is "last" TGB on TBB (e.g. furthest from TMGB).
   2. Grounding Equalizer(s) (GE) shall connect to TGBs to be interconnected.

G. Insulate Busbars from their support.

H. Connections shall be bare metal to bare metal contact.
   1. Clean surfaces of paint, dirt, oil, etc.,

I. Connections shall be exposed and visible for inspection at all times.
   1. Do not install insulation over ground connections.

J. Terminate each grounding conductor on its own terminal lug.
   1. Multiple conductors on single lug not permitted.

K. Bond each raceway serving individual jack locations to cable tray using #6 AWG insulated conductor.

L. Bond interruptions or transitions in cable tray to form a continuous ground path from the wall jack location to the TGB location with a #6 AWG green insulated conductor.

3.4 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

B. Test resistance of each TGB to ground.

1. Maximum resistance to ground shall be less than 5 Ohms.

3.5 DOCUMENTATION

A. Accurately record actual locations of grounding electrode(s), busbars and backbone grounding conductors.

END OF SECTION

SECTION 27 0528.29

HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This section includes product and execution requirements for items unique to communications systems and not included in Division 26 sections.

B. Refer to Section 27 0000 – General Communications Requirements and 26 0529 - Hangers and Supports for Electrical Systems - Part 1 for requirements for Reference Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee.

1.2 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   3. Section 27 0528.36 - Cable Tray for Communications Systems
   4. Section 27 1100 - Communications Equipment Room Fittings
   5. Section 27 1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0529 - Hangers and Supports for Electrical Systems

1.3 REFERENCES AND STANDARDS

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and section sunder Division 01 General Requirements.

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0529 - Hangers and Supports for Electrical Systems - Part 3 for:
   1. Hanger Rods
   2. Beam Clamps
   3. Wall Anchors
   4. Metal Framing

PART 3 - EXECUTION

3.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0529 - Hangers and Supports for Electrical Systems - Part 3 for all products identified in Part 1.

3.2 TELECOMMUNICATIONS SPECIFIC REQUIREMENTS

A. Support cable tray and conduit at 5’ intervals or less and within 3’ of each termination.

B. Threaded rod minimum size is 3/8”.

C. Conduit and cable tray are to be securely installed to prevent movement during cable installation.

END OF SECTION

SECTION 27 0528.33

RACEWAY AND BOXES FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This section includes product and execution requirements for items unique to communications and not included in Division 26 sections.

1.2 DESCRIPTION

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 1 for requirements for Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee for:
   1. Outlet Boxes
   2. Pull and Junction Boxes
   3. Raceways and Wireways (including sleeves, expansion fittings, penetrations and seals)
   4. Cable Supports

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 0528.29 - Hangers and Supports for Communications Systems
   4. Section 27 0528.36 - Cable Tray for Communications Systems
   5. Section 27 0553 - Communications Systems Identification
   6. Section 27 1100 - Communications Equipment Room Fittings
   7. Section 27 1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0533 - Raceway and Boxes for Electrical Systems

1.4 REFERENCES AND STANDARDS

A. The Work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 2 for Outlet Boxes for Communications, Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 1.

2.2 FLOOR BOXES

A. Divided barrier to separate power and telecommunications compartments.

B. Fire rated as indicated on plans.

C. Submit box to UIC ACCC/Telecom for approval.

PART 3 - EXECUTION

3.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 3 for Outlet Boxes for Communications, Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 1.

3.2 GENERAL COMMUNICATIONS METALLIC RACEWAYS

A. All communications cable is to be routed in EMT raceway where concealed from telecommunications device outlet to cable tray. Communications cable is allowed to be routed in cable trays where located in non-plenum ceilings where accessible.

B. Bond conduit to cable tray with green #6AWG per Section 27 0526 – Grounding and Bonding for Communications Systems.

C. Provide insulated bushing in all communications raceways at all boxes and terminations.

D. Minimum conduit size is ¾".

E. 40% Maximum conductor fill.

F. Bend radius is to be no less than 10 times cable O.D. and 12 times raceway trade size.

G. Maintain clearance between raceways and EMI sources and hazardous systems as indicated below:
   1. 5" from fluorescent lighting fixtures
   2. 12" from power distribution raceways
   3. 48" from motors and transformers
   4. 6" from flues, steam and hot water piping or other heat sources above 100F.

H. Outlet box requirements:
   1. Boxes with four or fewer outlets shall be no smaller than 4" X 4" X 2-1/8" (1900 box)
   2. All boxes used for communications systems are to be galvanized steel.

3.3 COMMUNICATIONS RACEWAYS

A. Optical Fiber Communications Cable Raceway (Innerduct):
   1. Minimum innerduct size: 1", unless otherwise noted on drawings.
   2. Extend innerduct to termination and/or storage enclosure.
   3. Install couplings designed for innerduct size and type where innerduct enters a termination and/or storage enclosure.
   4. Splice innerduct segments using couplings designed for that purpose, where not installed in a continuous length.

5. Install 200 lb nylon pull cord in empty innerduct. Leave at least 12” of slack at each end of pull wire. Cap innerduct at both ends.
6. Label innerduct with tags indicating cable type and cables contained therein.
    a. Label in each maintenance hole, pull box and communications equipment room, where exiting a conduit and at 20 ft intervals in cable tray or where otherwise exposed.

3.4 MULTI-CELL FLEXIBLE RACEWAY

A. Segment conduits to increase capacity.
    1. Provide quantity and size per project Drawings.

B. Install per manufacturers recommendations.

END OF SECTION

SECTION 27 0553

COMMUNICATIONS SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for labeling of communications cabling, termination components, pathways and spaces for Communications Systems.

1.2 DESCRIPTION

A. All components shall be clearly labeled to identify them as unique throughout the project.

B. Labeling requirements include identification of Rooms, Equipment Racks, Telecommunications Outlets, Horizontal Cabling, Termination Hardware (Patch Panels, Blocks) and Grounding.

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 1100 - Communications Equipment Room Fittings
   4. Section 27 1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. See individual technical sections identified above (if applicable).

1.4 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements which identifies pertinent References and Standards.

B. Refer to University of Illinois at Chicago Information Technology Construction Standards

C. Other applicable references and standards include:
   1. TIA/EIA-606-A - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.

1.5 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Definitions used in this and related sections.

1.6 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related sections.

1.7 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.8 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product and/or installation information to be submitted by contractor.

B. Prior to installation, provide samples of label types planned for the project.
   1. Samples shall include examples of lettering to be used and shall follow standards detailed below.

1.9 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements which identifies general quality assurance requirements for the project.

PART 2 - PRODUCTS

2.1 GENERAL

A. Labels and markings shall be physically and chemically resistant to damage that would make label unreadable.

B. Cable labels shall be self-laminating, White/Transparent Vinyl and incorporate an integrated clear lamination which, when label is wrapped around cable, covers printed part of label.
   1. Labels shall be of adequate size to accommodate circumference of cable(s) being marked and properly self-laminate over full extent of printed area of label.
   2. Labels on larger cables (e.g. Copper Backbone) may be wrapped with clear non-removable tape.

PART 3 - EXECUTION

3.1 GENERAL

A. Labeling shall be by mechanical means.
   1. Hand lettered designations are not allowed.

B. Tags shall be non-removable.
   1. Exceptions:
      a. Telecommunications Outlet labels that are placed in recessed label holders.
      b. Telecommunications Ground tags secured with cable ties.
      c. Innerduct Tags secured with cable ties.

C. Characters shall be Black Ink and printed on background of contrasting color.

D. Labels shall match hardware layout and design.

E. Labels shall be as large as practicable while fitting properly.

F. No lettering shall be smaller than 10-point.

G. Label cables with tag which is wrapped around cable sheath.

3.2 TELECOMMUNICATIONS OUTLET

A. Label each Telecommunications Outlet (TO) connector with unique identifying code.

B. Telecommunications Outlet connector numbering shall be based on - or result in - logical numbering sequence in work area.
   1. Labeling plans that results in random TO numbering in work area are not acceptable.

C. Place Faceplate labels on outside of cover.

D. Position Labels in recessed label holders on faceplate and covered with clear plastic covers.
   1. Where Communications Outlet Faceplates not incorporating recessed holders are allowed, faceplate labels shall be protected with clear laminate.

E. Identify each cable and jack as follows:
   1. X-###-TypeS
   2. X=FDF ID Letter
   3. ###=Work Area of Jack
   4. Type="V" for Voice, "D" for Data
   5. S=Unique Sequential jack # (1,2,3,etc)
   6. No duplicate cable identification numbers in the same closet.

3.3 HORIZONTAL CABLING

A. Label each horizontal cable at Telecommunications Outlet and at horizontal cross-connect with unique identifying code.

B. Cable shall be labeled at both ends within 4" of cable choke (end of jacket).

C. Horizontal labeling code shall be same as identified for Telecommunications Outlet above.

3.4 MODULAR PATCH PANEL

A. Label each patch panel and port at horizontal cross-connect with unique identifying code.

B. Patch panel labeling code shall be same as identified for Telecommunications Outlet above.

3.5 GIGA BIX TERMINATION BLOCKS

A. Label termination block ports/pairs sequentially beginning on the first row of each termination block column. Begin with "001" for the first port/pair.

B. Label termination strip pairs sequentially (left to right)

C. For Horizontal Distribution: Label termination blocks used for horizontal distribution with a single label affixed to the designation strip. The label shall be the following:
   1. (XX-###-VS)
   2. XX=FDF ID Letter
   3. XXX=Work Area
   4. V=Voice
   5. S= Unique Sequential jack # (1,2,3,etc)

3.6 WIRELESS ACCESS POINT

A. Patch panels shell be labeled as "Wireless".

B. Patch panel labels and wireless locations are to have the same label.

C. Label format is to consist of two lines.

D. Line one format:

1. WAP-####
2. ####=wireless location room number

E. Line two format:
1. X-90#
2. X=FDF ID Letter
3. #=wireless sequential number (901, 902, 903, etc.)

3.7 CONDUITS

A. Label each conduit end.

B. Identify opposite end of conduit (i.e. room name, FDF ID, pull box ID, outlet ID, etc.)

3.8 TELECOMMUNICATIONS GROUNDS:

A. Label Grounds as close as practicable to point of termination.

B. Labels shall be non-metallic and include the following:

WARNING TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!

END OF SECTION

SECTION 27 1500

COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for Horizontal (Station) Cabling subsystem for Communications Systems.

1.2 DESCRIPTION

A. Horizontal cabling subsystem is portion of communication link that connects horizontal or intermediate cross-connect (typically at Telecom Room) and Telecommunications Outlet.

B. See Part 2 for Horizontal Cable types included in project.

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27 0526 - Grounding and Bonding for Communications Systems
   3. Section 27 0528.29 - Hangers and Supports for Communications Systems
   4. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   5. Section 27 0528.36 - Cable Tray for Communications Systems
   6. Section 27 0553 - Communications Systems Identification
   7. Section 27 1000 - Structured Cabling
   8. Section 27 1100 - Communications Equipment Room Fittings

B. Related sections in other Divisions of Work:
   1. See individual technical sections identified above (if applicable).

1.4 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identifies pertinent References and Standards.

B. Other applicable references and standards include:
   1. University of Illinois at Chicago Information Technology Construction Standards

1.5 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Definitions used in this and related Sections.

B. In this section, "Telecommunications Outlet" is considered to consist of Frame / Faceplate into which Modular Jacks or other couplings snap, Modular Jacks, blanks fitted to unused jack positions, and labeling/identification components.

1.6 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related Sections.

1.7 WORK BY OWNER

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this section.

1.8 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product or installation information to be submitted by Contractor.

B. In addition, submit:
   1. Samples of each Telecommunications Outlet Faceplate type to confirm color and material.
   2. One 3 ft section of each cable type from cable reels sent to site for Engineer's final approval.
      a. Section shall have manufacturer's cable markings visible.
   3. Nominal Velocity of Propagation (NVP) for 4-pair Horizontal Copper Cable.

1.9 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify general quality assurance requirements for the Project.

1.10 GUARANTEE

A. Refer to Division 1, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

B. Refer to Section 27 1000 - Structured Cabling for particular Warranty requirements for Structured Cabling. Those requirements apply to all cable and components covered in this section.

PART 2 - PRODUCTS

2.1 GENERAL

A. Cables and Termination hardware shall be technically compliant with and installed in accordance with referenced TIA/EIA documents.

B. Cables shall be Underwriters Laboratory (UL) listed, comply with Article 800 (Communications Circuits) of National Electrical Code and shall meet specifications of NEMA (low loss), UL 444, and ICEA (where applicable).

C. Horizontal (Station) Cable and Termination Components (Jack, Patch Panel) are specified to function as System.
   1. Where required for warranty purposes, manufacturers of cabling and termination components used (if more than one) shall recognize each other in their Certification Programs.

D. Horizontal Cable types include:
   1. 4-pair Copper Unshielded Twisted Pair (UTP)

2.2 4-PAIR HORIZONTAL COPPER CABLE

A. Manufacturers: Hitachi Category 6 Riser PLUS
   1. Voice: Grey RCA00881920GA2
   2. Data: Blue RCA00881920BL2
   3. Wireless: Orange RCA00881920OR2
   4. ETU: Green RCA00881920
   5. IP CAMERA: Purple RCA00881920

B. Cables shall be suitable for installation in environment defined

C. Cabling shall be packaged to minimize tangling and kinking of cable during installation.
   1. Cable Rating: NEC Article 800 Type CMR, UL listed

D. Pairs of 4-pair cables shall be identified by banded color code in which conductor insulation is marked with dominant color and banded with contrasting color.
   1. By pair number, pair colors or dominant band are:
      a. Pair 1: Tip - White/Blue; Ring - Blue (or Blue/White)
      b. Pair 2: Tip - White/Orange; Ring - Orange (or Orange/White)
      c. Pair 3: Tip - White/Green; Ring - Green (or Green/White)
      d. Pair 4: Tip - White/Brown; Ring - Brown (or Brown/White)

2.3 TELECOMMUNICATIONS OUTLET

A. Manufacturers: Panduit NetKey Series
   1. Data: Black NK688MBL
   2. Voice: Off White NK688MIW
   3. Wireless: Orange NK688MOR
   4. ETU: Green NK688MGR
   5. Video (CCTV): Purple NK688MVL

B. Connectors modular jacks shall snap onto faceplate.
   1. In surface-mount designs (if applicable) Jacks and connectors may mount to frame onto which coverplate is mounted.
   2. Any unused jack/connector positions shall be fitted with a blank of color matching that of the faceplate.

C. Work Area Faceplate
   1. Hubbell Quick Port Series Office White Face Plate
      a. 1-Hole: Office White IFP11OW
      b. 3-Hole: Office White IFP13OW

2.4 MODULAR JACK

A. Manufacturers: See "Telecommunications Outlet" above.

B. Modular Jacks shall be:
   1. 8-position, 8-conductor (8P8C)
   2. Non-keyed

C. Jacks shall have an attached color-coded wiring instruction label as an aid to installer.

D. Interface between jack and station cable shall be insulation displacement type contact.

E. Termination components shall maintain cable's pair twists as closely as possible to point of mechanical termination.

F. Jack contacts shall have minimum of 50 micro-inches of gold plating.

G. Jacks shall be supplied with installed dust covers to protect jack opening and internal elements during installation until jack is in use.
   1. No damage to Jack pinning shall result from insertion or removal of covers.

H. Voice and Data Jack shall:
   1. Meet or exceed performance requirements of TIA Category 6.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to project Drawings for outlet locations.

B. Provide Modular Jacks in faceplates as shown on Project Documents.
   1. Provide 1 faceplate per Telecommunications Outlet symbol shown on Project Documents.

C. Maximum 4-pair Category-rated horizontal cable length shall not exceed 295 ft (90 meters) measured from horizontal cross-connect (typically at FDF) and Telecommunications Outlet.
   1. Includes slack required for installation and termination.
   2. Contractor is responsible for installing station cable to avoid unnecessarily long runs.
   3. Any area that cannot be reached within above constraints shall be identified and reported to Engineer prior to installation.

D. Follow manufacturers recommended termination practices.

3.2 CABLE INSTALLATION AND TERMINATION

A. General
   1. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling for general cable installation requirements.
   2. During installation, minimum bend radius shall be ten times outside diameter of UTP cables.

B. Horizontal Copper Twisted-Pair Cabling
   1. Provide horizontal copper twisted pair cable between horizontal cross connect (typically at FDF) and Telecommunications Outlet.
   2. At Telecommunications Outlet, terminate each 4-pair Horizontal Cable on 8P8C Modular Jack.
      a. Terminating one cable on more than one jack is not allowed.
   3. At horizontal cross-connect, terminate:
      a. Each 4-pair cable on 8P8C Modular Jack in Patch Panel.
      b. Each 4-pair cable designated as for "Voice" on Termination Block.
   4. Terminate cables using 568A wiring standard.
   5. Cable jacket shall be continuous to within 1/2" of termination.
   6. Preserve pair twists to point of termination.
   7. Refer to Section 27 1100 - Communications Equipment Room Fittings for termination instructions for Modular Patch Panel and Termination Block.

3.3 TELECOMMUNICATIONS OUTLET

A. Faceplates shall be configured to provide connectivity as required by location. Refer to drawings.

B. Mount modular jacks and connectors into faceplates and secure faceplates to outlet box, raceway or modular furniture.
   1. Use faceplate extender if required to provide adequate clearance between jack and furniture or raceway panel to maintain minimum cable bend radius.

3.4 IDENTIFICATION

A. Label cables, outlets and conduits per Section 27 0553 – Communications Systems Identification

3.5 QUALITY ASSURANCE

A. Installing contractor is to utilize BICSI certified technicians to perform the installation.

B. Installing contractor is to provide qualifications of all technicians being employed for this project prior to accepting bid.

C. Test instruments used to conduct the testing indicated in paragraph 3.6 is to be level III compliant capable of testing Category 6 cables to 250MHz in accordance with ANSI/TIA 568C standards. Test equipment must be inspected and approved by UIC ACCC/Telecom Engineering Department prior to testing. Tests conducted without prior approval of test equipment will not be accepted.

D. Installations will not be accepted without tests conforming to this specification and UIC AAAC/Telecom Engineering Standards.

3.6 FIELD TESTING

A. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for guidelines regarding testing requirements common to all Division 27 Structured Cabling sections.
   1. In addition, refer to sub-sections below for cable type under test.

B. Installer/Technician certification requirements:
   1. Contractors must provide BICSI technicians that have at least two years of experience and the ability to install, test, and troubleshoot structured cabling systems including multimode and single-mode fiber optic cable plants. These cable plants include intra-building and inter-building cabling.
      a. At least one technician must be certified by BICSI and be on-site for crews of 4 or fewer. For every four or less additional techs, one of the four must hold the Technicians Certification.
      b. The on-site technician must provide proof of a current credential.
      c. For bid jobs, the contractor must submit the technician's names and credentials for approval prior to starting work.

C. 4-Pair Horizontal Copper Cable
   1. Test from:
      a. Horizontal Cross-connect (HC) to Jack at Telecommunications Outlet (TO).
   2. Testing shall be per TIA/EIA-568 (-B1.1 through -B3.1) Permanent Link test configurations.
   3. Maximum length of station cable shall not exceed 90 meters.
   4. Cables shall be free of shorts within pairs, and be verified for Continuity, Pair Validity and Polarity, and Wire Map (Conductor Position on Modular Jack).
      a. Identify and correct defective, split or mis-positioned pairs.
   5. In addition to above, Performance Testing shall be performed on all cables. Testing of Transmission Performance shall include the following:
      a. Length
      b. Insertion Loss / Attenuation
      c. Pair-to-pair NEXT
      d. PSNEXT
      e. Pair-to-pair ELFEXT (Equal Level Far End Cross-talk)
      f. PSEFEXT
      g. Return Loss
      h. Propagation Delay
      i. Delay Skew

6. Test cables to maximum frequency of 250 MHz.
7. Perform Transmission Performance Testing using test instrument designed for testing to specified frequencies.
    a. Test records shall verify "PASS" on each cable and display specified parameters - comparing test values with standards based "templates" integral to unit. “ Marginal PASS” will not be accepted as a passing result.

3.7 DOCUMENTATION

A. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for documentation guidelines.

B. Information added by Contractor to Record Drawings relating to Horizontal Cabling shall include cable routes, outlet locations, and other detail necessary to document cable installation.

C. Test labels are to be saved in the following format:
    1. Building ## - FDF XX – Location # - D1/D2/V
        a. Building number
        b. FDF Letter
        c. Location number
        d. Data or Voice
        e. Example (607-FDF-A-012-D1)

END OF SECTION

SECTION 274116
INTEGRATED AUDIO-VIDEO SYSTEMS AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including general and supplementary conditions and division 1 specification sections, apply to this section.

B. Related sections include the following.

1. Division 26 – electrical

2. Division 11 – equipment – rigging

1.2 BIDDER QUALIFICATIONS

A. The installation of the AV systems requires the experience and skills of a specialty contractor.

1. Only bidders who have been prequalified by the consultant and client shall be permitted to bid.

2. The contractors listed below have the required qualifications and have been approved to bid:

a. IPHEC vendors

B. Only bid proposals from qualified bidders will be accepted.

C. The following outlines the criteria used to determine the qualifications of the bidder.

1. Each bidder shall be recognized in the industry as an AV systems contractor and actively engaged in the engineering, installation and maintenance of professional AV systems for medical & educational facilities.

2. Each bidder shall be capable of providing the operational, technical and financial resources required to complete a project of this size and scope.

3. Each bidder shall have at least five years of experience in the engineering, installation, testing and maintenance of audio/video presentation systems for college and professional level venues.

4. Each bidder must maintain facilities, equipment and trained technicians for fabricating, testing, rigging, installing and servicing the equipment specified herein.

5. Each bidder must hold equipment dealerships for 80% of AV design. Bidder may obtain 20% of equipment through warehouse manufacturers authorized to resell equipment to integrators. All manufacturer's warranties must be valid and able to pass to integrator and client for whole manufacturer's warranty period.

6. Each bidder must hold certifications from manufacturers requiring certification to install or program their equipment.

7. Each bidder should participate in continuing technical training and maintain memberships in the Audio Engineering Society (AES), National Systems Contractors Association (NSCA), and/or Infocomm International.

D. The qualification submittal package shall include a minimum of the following items:

1. A company overview including the markets served and the number of years in business as an AV systems contractor serving the higher education and/or medical market segment.

2. A legal description of the company including corporate name, date of incorporation, corporate officers, mailing address and shipping address.

3. List of (3) similar education facility projects completed in the last five (5) years including contract amount, and references. Include as references the client, architect, audio consultant and general contractor where applicable.

4. Description of the size and capabilities of the shop and warehousing facility.

5. A list of all full-time employees and their current title and responsibilities. Provide a résumé for each of the key individuals that would be assigned to this project including, sales, engineering, project manager, and site foreman.

6. A complete set of shop drawings from one of the reference projects submitted in response to item 3 above.

7. A list of professional affiliations and memberships.

8. A list of test equipment.

1.3 SCOPE OF SPECIFICATION

A. This specification describes the various AV systems associated with the UIC Peoria College of Medicine. The intent of the specification is for the AV systems contractor to provide a professionally installed system that is complete, tested and ready to use.

B. This project manual and drawings sets (Sheets EA100 – EA406 includes EA Devices, Device Elevations, Device Details, Signal Flows, Rack and Panel Elevations) and any addenda constitute the contract documents.

1.4 CONTRACTOR RESPONSIBILITY

A. The specification is detailed only to the extent to show design intent and signal flow. The AV contractor understands and accepts that the work described in the specification shall be complete in every detail as necessary to supply a professional working system.

B. Equipment and parts not mentioned but required to provide a professionally installed and complete working system shall be provided without the request for additional monies or services.

1.5 SYSTEM DESCRIPTION

A. Classroom A200 (Active learning)

1. Audio System

   The audio system for the active learning classroom must support speech reinforcement, and playback of AV source material. To accomplish these requirements a distributed loudspeaker system will provide even coverage throughout the classroom for enhanced voice, and playback material. Microphones for both instructor and group tables will support speech intelligibility for both general teaching and group interaction. In addition to whole room audio support we also need to provide local audio support at each group discussion table. To accommodate local audio listening each group discussion table will be provided with a local monitoring system. Local monitoring system will provide audio enhancement of local AV source material via headphone monitoring system. Our design assumes students providing their own headphones for hygiene purposes.

   Audio system design includes the following major components and features:

   a. Amplification to support playback and live voice reinforcement

   b. Distributed ceiling loudspeakers for audio support throughout the active learning area.

   c. Wireless headset, lapel, and handheld microphones for instructor voice reinforcement and high quality direct sound recording.

   d. Quantity of 2 table top push-to-talk microphones at each collaboration table for student voice reinforcement.

   e. 6 channel personal monitor mixing station to allow students to hear local source content at each collaboration table

   f. Digital signal processor to manage audio quality, mixing, and routing of all audio signals throughout the system.

2. Video System

   The video system for the active learning classroom must provide students at each collaboration table content enhancement of instructor teaching materials, and local source content. The active learning classroom must also accommodate easy visual enhance of instructional content our local collaboration table source for when students or instructor is not looking at displays mounted at each collaboration table. To accomplish these requirements, each collaboration table will have a local monitor mounted on the wall. Monitors will have the capability of showing instructional content, wireless collaboration unit behind each display, and locally plugged in video sources. In addition to the displays, large projection screens will be place on either side of the lectern teaching area, and one additional screen at opposite end of the classroom. These screens will display both instructional and student local content when desired. Having the additional large formatted screens in the room will allow the best sightlines to content material when students are not facing there local display at the collaboration table. These screens will also be used for instructor confidence monitors and allow the instructor to roam the room freely and still see their teaching content easily no mater were they are in the classroom. In addition to this room being an active learning classroom it also needs to function as a general teaching classroom. In order to provide this requirement a short throw projector and screen will provide instructor content capabilities with all student tables and chairs

oriented towards the projection screen. The instructor will use the nearest wall mounted display or projection screen to the teaching area for a confidence monitor.

Video system design includes the following major components and features:

a. Distributed LCD monitors around perimeter of space at each collaboration table.

b. (3) Ceiling mounted 16:10 format motorized projection screens with short throw projector, will provide content enhancement. Short throw projector allows the largest amount of teaching space and allows instructor to get close to screen without being in the projected image.

c. Image processing for routing and management for all video sources and displays.

d. Document camera built into portable lectern.

e. (1) HDMI Matrix Switch at each table to allow switching content from local wired input and wireless collaboration device behind each display.

f. (1) Wireless collaboration device mounted behind each display. Wireless collaboration unit will provide students the ability to connect and display their content on the screen.

g. Wireless connectivity device for instructor to connect laptop, cell phone, or tablet to video system.

h. Designated podium computer with USB connectivity

3. Control System

The control system for the active learning classroom provides both students and instructor the necessary goal of easy to use technology. Large touch panels provided at both entrance to classroom, and built in to lectern will provide instructor with all necessary simple controls to operate the entire AV system for the classroom. Simple 8 button touch pads located next to each LCD display at collaboration tables will provide students necessary control over local display.

Control system design includes the following components and features:

a. Centralized control processor for management of all touch screen and button control stations.

b. DMX to RS232 Processor

c. Large touch screen for instructors that allows the following equipment functions:

i. Whole room system power on and off

ii. Setting room in active learning classroom mode or general teaching classroom mode

iii. Audio level controls of instructor mic, table mics, and AV playback sources

iv. Video source selection of lectern inputs

v. Locking button panels near displays form being used

vi. Capability of displaying student's local input at collaboration table to all displays throughout classroom.

vii. Powering on and of classroom projectors and selecting video source to projection system

viii. Lowering and raising of motorized projection screens

ix. Preset controls of room lighting system

x. Control of LED strip light mounted above display

d. Eight button control pad next to each collaboration table allows the following equipment functions:

i. Powering on and off display

ii. Selecting video source from local input, wireless collaboration unit, or instructors feed

4. AVPs (Audio/Video Connection Panels)

Audio/video connection panels will be provided in the following locations with the following source input capabilities:

a. AVPs mounted below displays at each collaboration table will provide the following connectivity. HDMI, two XLR female jacks for table mics, two XLR male jacks for local monitoring station.

b. AVPs mounted in the floor in one location for portable lectern will provide the following connectivity. Specialized mass connector for easy plug and play of all audio video and network signals. Local power will also be provided in floor pocket. Note: coordination of house network jack in floor pocket will need to be accomplished with IT network contractor.

c. Additional infrastructure will be included for future capabilities of distance education

B. 2 Seminar Rooms (Alternate Package #1)

The AV systems for the small classrooms needs to be able to display instructor teaching materials, and video playback. To accomplish the operational and content requirements, each classroom will have a single large display with loudspeakers flanking each side of the screen. This will provide video and audio support for the classroom. Local input & wireless collaboration unit will provide audio and video connectivity to the display and loudspeaker system.

AV system design includes the following major components and features:

a. Amplification to support playback content

b. Stereo surface mounted loudspeakers

c. (2) Large 70”displays for instructional and video playback content

d. (2) Wireless collaboration units providing, wireless video connection for instructors laptop, cell phone, or tablet.

e. 10 button control panel with rotary dial and integrated control processor, for instructors that allows the following equipment functions:

i. System power on and off

ii. Audio level controls of AV playback sources

iii. Video source selection of local input, and wireless collaboration device.

f. (2) AVPs with the following connection types: HDMI, and Cat6A

g. AV technical power will be provided next to AVP panel.

C. Lounge/Conference Room (Alternate Package #2)

The AV systems for the Lounge/Conference room needs to be able to display instructor teaching materials, and video playback. To accomplish the operational and content requirements, each classroom will have a single large display with loudspeakers flanking each side of the screen. This will provide video and audio support for the room. Local input & wireless collaboration unit will provide audio and video connectivity to the display and loudspeaker system.

AV system design includes the following major components and features:

a. Amplification to support playback content

b. Stereo surface mounted loudspeakers

c. (1) Large 70”displays for instructional and video playback content

d. (1) Wireless collaboration units providing, wireless video connection for instructors laptop, cell phone, or tablet.

e. 10 button control panel with rotary dial and integrated control processor, for instructors that allows the following equipment functions:

i. System power on and off

ii. Audio level controls of AV playback sources

iii. Video source selection of local input, and wireless collaboration device.

f. (2) AVP panel with the following connection types: HDMI, and Cat-6A

g. AV technical power will be provided next to AVP panel.

D. Classroom B223 (Anatomy Lab)

The AV systems for the Anatomy Lab need to be able to display live camera feed, instructor teaching materials, and prerecorded teaching videos. To accomplish the

programming requirements a single 85" HD display will provide visual enhancement of live camera, teaching materials, and prerecorded videos. A surface mounted loudspeaker flanking each side of the 85" display, will provide audio support for AV playback content. An IPad with mounting options for the working table and tripod will be provided. The IPad will provide live magnified shots of desired content to be displayed on local LCD monitor. The camera will utilize Apple TV with Air Play to allow a cable less interface to the display system. This keeps cables out of the way reducing possible tripping or hazards that may develop in the working and teaching areas. A simple to use touch screen control system will allow instructor to control the display and audio system within the classroom. Anatomy lab will also be able to receive video signals from the Anatomage lab, and display those video signal on its local 85" display.

AV system design includes the following major components and features:

a. Amplification to support playback content

b. Stereo surface mounted loudspeakers

c. Large 85" Ultra HD display

d. IPad with mounting hardware to connect to working tables and act like a document camera. Tripod will also be provided when mount on table is not obtainable for desired content being filmed.

e. (1) Apple TV system for portable IPad. Note when using a wireless system like Apple TV to provide live feed to local LCD monitors. There will be noticeable latency from the live content to the broadcasted content.

f. Image processing for routing and management for all video sources and displays.

g. Local computer mounted behind display, and provided with wireless keyboard and mouse.

h. Wireless connectivity device for instructor to connect laptop, cell phone, or tablet to video system.

i. Large touch screen for instructors that allows the following equipment functions:

   i. Whole room system power on and off

   ii. Audio level controls of AV playback sources

   iii. Video source selection of local inputs, live camera, Anatomage Lab Sources, and prerecorded material.

j. (1) AVP with the following connection types: HDMI, VGA with 1/8" audio connection, 1 BNC, 2 RCA connections.

k. AV technical power will be provided next to AVP panel.

E. Local Displays for Each Working Table (Alternate Package #7)

As a teaching enhancement for the Anatomy lab 32" displays on articulating arms will be mounted at the end of each anatomy working table. Displays will provide students and

instructors to display images from an IPad to the display. Displays will also provide capability of displaying content from local computer, or wireless collaboration unit.

AV system design includes the following major components and features:

a. (8) 32" HD display

b. Articulation display arm capable of pulling monitor down towards working table and pushing it to the ceiling when display is in the way.

c. (2) Apple TV system for portable IPad. Note when using a wireless system like apple air play to provide live feed to local LCD monitor, there will be noticeable latency from the live content to the broadcasted content

d. Image processing for routing and management for all video sources and displays.

e. (2)IPad with mounting hardware to connect to working tables and act like a document camera. Tripod will also be provided when mount on table is not obtainable for desired content being filmed.

F. Classroom B221 (Anatomage Lab)

The AV systems for the Anatomage Lab needs to be able to display instructor teaching materials, Anatomage table images, Ultra Sound machine images, and prerecorded teaching videos. To accomplish the programming requirements a single 95" LCD display will provide video support. A multi window video processor will provide LCD display to be setup in multiple display configurations from one large screen, 4 independent screens, one ultra-wide top screen with 2 independent bottom screens, and one top ultra-wide screen and one bottom ultra-wide screen. Loudspeakers mounted on either side of the dual display will provide support for AV playback content. A simple to use touch screen control system will allow instructor to control the display and audio system within the classroom.

AV system design includes the following major components and features:

a. Amplification to support playback content

b. L/R wall mounted loudspeaker next to dual LCD displays

c. (1) Large 95" Ultra HD display

d. Image processing for routing and management for all video sources and displays.

e. Wireless connectivity device for instructor to connect laptop, cell phone, or tablet to video system.

f. (1) Apple TV System for times when live image is needed on video wall. Note: IPad is not included in budget for this room.

g. Local computer mounted behind display, and provided with wireless keyboard and mouse

h. Large touch screen for instructors that allows the following equipment functions:

i. Whole room system power on and off

ii. Audio level controls of AV playback sources

iii. Video source selection of local inputs, Ultrasound machine, and Anatomage table.

iv. Display multi window mode

i. (1) AVP with the following connection types: HDMI, VGA with 1/8th" audio connection

j. (1) AVP with the following connection types: Composite, and Cat-6A

k. AV technical power will be provided next to AVP panel.

G. Classroom B216 (Conference Room) – (Alternate Package #3)

The AV systems for the classroom need to be able to provide web conferencing, whiteboard capabilities, and have wired and wireless connections to guest computers. To meet the requirements of the room, a large display will have a local computer mounted behind it. A USB camera will provide video conferencing capabilities via software codec. L/R surface mounted loudspeakers will provide audio support for room.

AV system design includes the following major components and features:

a. Large 70" LCD Monitor

b. Wireless connectivity device for instructor to connect laptop, cell phone, or tablet to video system.

c. HD USB camera

d. Local computer mounted behind display, with wireless keyboard and mouse.

e. (1) AVP with the following connection types: USB, HDMI, VGA with 1/8th" audio connection

f. AV technical power will be provided next to AVP panel.

1.6 SCOPE OF WORK

A. Furnish all equipment, materials, cable, labor and engineering services to provide complete and professionally installed systems in working order and in accordance with good engineering practice.

B. Coordinate with other trades.

1. Coordinate with the electrical contractor to ensure correct audio & video conduit routing, audio & video back box locations, and clean power circuit locations as specified in division 26 – electrical.

2. Coordinate with other trades as required to ensure timely progress and successful integration of the AV systems.

C. Install, “pull”, and terminate all wire and cable in the conduit system provided by the electrical contractor.

D. Furnish any additional items, not specifically mentioned herein, to meet good engineering practice, without claim for additional payment. Such items may include hardware, transformers, terminal strips, connectors, resistors, capacitors and other devices for proper installation, interface, isolation or gain structure.

E. Furnish shop drawings and receive approval, prior to procurement, fabrication and installation.

F. Perform initial adjustments and verification tests and perform final adjustments.

G. Assist the consultant in the final checkout and final optimization of the systems.

H. Provide system documentation including copies of all relevant drawings and equipment manuals.

I. Provide maintenance services for the specified period from the date of acceptance.

J. Note that the work scope under this section does not include the materials or installation for the ac power system except for the fabrication required within the equipment racks and where specifically called out in the contract documents.

K. Note that the work scope under this section does not include materials or installation for the AV systems raceway and conduit systems.

1.7 SUBMITTALS

A. Bid submittals

1. Contractors shall examine, review and acknowledge receipt of all drawings, specifications and addenda prior to submitting a bid. No allowances shall be made for failure to read and understand the bid documents. In the case where a conflict exists between the written specification and the drawings the AV system contractor must seek written clarification from the consultant prior to submitting a bid. Should the contractor fail to obtain written clarification, the interpretation of the consultant will prevail.

2. Request for clarification of the specification shall be made in writing not later than five (5) days before the bid date.

3. Bid proposals shall include all work and equipment specified as well as any incidental items required in the fabrication, installation and operation of the system.

4. The bid submittals shall include the following:

a. The total contract price.

b. A detailed breakout of the total contract price including:

i. Equipment

ii. Cable

iii. Miscellaneous materials

iv. Labor

v. Insurance & bonding

5. Lump sum subsystem pricing based on the headings outlined in the equipment list.

6. The total price for each alternate.

7. An itemized list of all equipment and materials to be used in assembling the system.

8. A breakdown of labor costs estimated for:

   a. General administration/project management.

   b. Preparation of submittals, shop drawings, and as-built documentation.

   c. On-site coordination meetings and supervision.

   d. In-shop engineering, fabrication and assembly.

   e. On-site wire pull.

   f. On-site fabrication assembly and installation.

   g. On-site verification and acceptance testing.

B. Shop drawing submittals

1. Within sixty (60) days after the contract award, submit five (5) copies of the shop drawings to the architect for review and comment. Do not begin procurement, fabrication or installation without the approval of the architect and consultant.

2. Review of the shop drawings and their acceptance does not constitute final approval of the system or its function. The contractor remains subject to the requirements of the contract documents.

3. Failure of the contractor to submit shop drawings in sufficient time for evaluation shall not entitle the contractor to an extension of contract time, or additional compensation.

4. The shop drawing submittal shall be submitted as one package and include the following items: (prerelease of individual items is acceptable for informal pre-submittal discussions).

   a. Table of contents

   b. Itemized list of all equipment, cable, and materials used to assemble the system. This list should include the manufacturer, model number, description of item, and quantity.

   c. Detailed one-line signal diagrams of all systems showing point-to-point wiring connections (detailing the wire type, and wire identification numbers) for all equipment.

   d. Field coordinated AV systems conduit riser.

   e. Detailed 3-wire schematic diagrams for all modified or custom circuitry.

f. Detailed 3-wire schematic diagrams for typical connections between audio lines, patch bays and rack mounted equipment.

g. Detailed mechanical drawings of all custom fabricated plates and panels.

h. Detailed mechanical drawings for all modified or custom fabricated devices.

i. Full size drawings of patch bay layouts and labeling.

j. Detailed equipment rack plans, sections and elevations.

k. Control and equipment room device layout drawings.

l. Detailed mounting drawings for all loudspeakers, emitters, antennas, and microphones, etc. Showing rigging details and interface to the adjacent structure and architecture (structural engineer stamped).

m. Detailed dimensioned mounting drawings for all screens, displays, projectors, cameras, and video walls showing rigging details and interface to the adjacent structure and architecture (structural engineer stamped).

n. Control system page layouts showing user operational steps. Control page layouts may be submitted one month prior to system commissioning.

o. DSP - standalone processor and amp based system starting files. DSP and amp files may be submitted one month prior to system commissioning.

5. All drawings must be produced using a professional CAD program. Reproductions of the bid documents are not acceptable.

C. Substitution submittals

1. Substitutions will be considered only after the contract award. Bidding contractors shall base their bid on the listed equipment.

2. Substitutions require the written approval of the consultant.

3. The proposed substitutions must be equivalent to the specified products in quality, performance, construction, function, warranty and conformance to the design intent.

4. It is the responsibility of the contractor to prove to the satisfaction of the consultant and owner that the proposed substitution is equal to the specified product. The following shall be the minimal information required for consideration of the substitution:

a. List of advantages to the owner.

b. Cost savings to the owner.

c. Printed specification sheets.

d. Statement of previous field performance, reliability and experience.

e. A/B evaluation of the specified device and the proposed substitution.

f. The contractor shall list the unit price of each item proposed for substitution and each specified item that is deleted.

D. Samples

1. Submit samples of proposed substitute equipment to the consultant as required to prove equivalency to the items specified.

2. Submit samples of custom work, finishes or other materials as required by the architect or consultant to verify quality and appearance.

3. Shipping costs associated with the samples shall be the responsibility of the contractor.

E. Verification test report

1. Submit three (3) copies of a written report detailing the results of the verification testing. Refer to paragraph 3.8 for details regarding the requirements of the verification testing.

2. This report must be completed and submitted to the consultant five (5) days prior to acceptance testing and final tuning.

3. Submission of the verification test report certifies that the installation conforms to the bid specifications, is complete, and ready for the acceptance testing by the consultant.

4. The consultant will visit the site once, to perform the acceptance testing. Should the system not be ready upon the consultant's arrival for acceptance testing and final tuning, the contractor shall bear full responsibility for all expenses and professional fees associated with a return trip by the consultant. Current rates are $150 per hour plus expenses.

F. As-built drawings

1. Within thirty (30) days of the acceptance testing, prepare and submit three (3) copies of the as-built documentation in PDF and CAD format.

2. The as-built documentation will consist of the shop drawing submittal updated, corrected and reflecting all field modifications and changes.

3. One-line signal flows shall be updated with all cable runs and patch points identified by alphanumeric characters.

4. A laminated copy of the one-line signal flows shall be provided in the back of each bay of permanent racks.

5. Attached to the inside back door of each permanent rack shall be an AC power circuit schedule listing the circuits and associated panel board.

G. Owner's manuals

1. Within thirty (30) days of the completion of the acceptance testing, prepare and submit three (3) copies of the operation and maintenance manuals to the owner. These copies are in addition to the one copy provided to the consultant during the acceptance testing.

2. The manual is to include:

a. Table of contents.

b. Warranty statement.

c. Emergency contact information.

d. Rigging information (documentation on any dynamic rigging systems operation and maintenance).

e. Basic power on/off operational procedures.

f. All available manufacturer's operational and service manuals for each piece of equipment identified in the equipment list.

g. A copy of the verification test report.

h. A copy of the final tuning settings as provided by the consultant.

i. Network information (a copy of AV network settings listing all static IPs, and login information per device, along with router and WAP default setup files.)

j. Audio system files (a copy of any default system starting files for mixers, DSPs, and amps.)

k. Video system files (a copy of any default system starting files for video matrix routers, switchers, robotic cameras, servers, and playback or recording equipment).

l. Calibration files (a copy of all calibrated setup files for projectors, displays, and cameras).

m. Control systems (a copy of any control system files per job closeout).

H. Training

1. The contractor shall provide the following AV system training:

a. Provide 1 day basic training on all equipment and system operation. Please schedule with client to have training class right after system commissioning.

2. First use & additional event support

a. Provide 1 technician for first system use. Technician must be capable of operating all AV equipment on site and make necessary changes to system programming or tuning aspects.

b. Provide 1 technician for 1 additional events chosen by client. Technician must be capable of operating all AV equipment on site and make necessary changes to system programming or tuning aspects.

1.8 JOB CONDITIONS

A. The contractor shall:

1. Review the conduit system and within thirty (30) days of contract award shall notify the consultant, the architect and the electrical contractor of any deficiencies or inadequacies in the conduit system design.

2. Keep the job adequately staffed at all times. The contractor shall keep the same individual in charge of the project from start until finish, unless loss of personnel, sickness or other circumstances beyond their control

3. Cooperate with all parties in order to achieve coordinated progress throughout the construction schedule and successful integration of the AV systems.

4. Watch for conflicts with other trades on the project and execute, without claim for additional compensation, moderate moves or changes as are necessary to accommodate other equipment or to preserve acoustic performance, symmetry, function and aesthetics.

5. Immediately report to the architect and consultant, any design or installation irregularities that may obstruct or interfere with the intended coverage patterns of loudspeakers or infrared emitters.

6. Do all cutting, patching, and painting for proper and finished installation of the AV systems in coordination with the other trades.

7. Repair any damage to work by others caused by the installation of the AV systems.

8. Leave the job site and all equipment and materials clean and free from marks and blemishes.

B. Quality assurance

1. All supplied equipment must meet the manufacturer's specifications.

2. All equipment, parts and materials supplied shall be new and free from manufacturing defects.

3. All equipment, parts and materials must conform to applicable provisions of Underwriters Laboratories and the American Standards Association.

4. The contractor shall obtain and incur all costs for all required permits, licenses and inspections and conform to any requirements stipulated therein.

5. The contractor shall comply with federal, state, and local labor regulations including any applicable union agreement.

6. The AV systems installation shall conform to latest federal, state, and local electrical and safety codes. Where conflicts exist, the most stringent code or regulation shall apply.

1.9 GUARANTEE AND SERVICE

A. The contractor shall for a period of one year, after final acceptance of the system, repair or replace all defective equipment or workmanship at no cost to the owner.

1. Provide the owner with written documentation detailing which AV components are supported under manufacturer's warranty (in addition to the AV contractor's warranty) and which will be warrantied solely by the contractor.

B. All equipment supplied under this specification shall be warranted for parts and labor for the full period of the manufacturer's standard warranty, or one year, whichever is longer.

C. The contractor shall repair or replace the defective item within forty-eight (48) hours following notification by the owner.

D. The contractor shall be available on call and on eight (8) hour notice during the first month following the acceptance of the system, to assist the owner with any problems that may arise during the initial period of operation.

E. Should any device demonstrate repeated failure during the warranty period the contractor shall supply and install a new component.

F. The contractor shall provide a minimum of four (4) service visits to the site for inspection and adjustment of equipment during the warranty period. During the last month of the warranty period the contractor shall contact the owner to inquire as to the condition of the system and schedule a final warranty visit. During the visit the contractor shall evaluate the systems' working condition and repair any problems or defects that may exist.

1.10 INSURANCE

A. The contractor shall fully insure all materials and equipment against loss or damage until acceptance of the system by owner.

B. The contractor shall refer to the general conditions section of the specification for other project insurance requirements including but not limited to liability, workers compensation, coverage limits, and bonding requirements.

1.11 EXISTING CONDITIONS

A. The contractor shall visit the site and review the architectural drawings prior to submitting a bid. No allowance or claim for additional services or fees will be allowed for failing to observe or verify conditions that may affect the installation of the AV systems.

B. The contractor shall report in writing to the architect and consultant any discrepancies between the specification and existing conditions prior to submitting a bid.

PART 2 EQUIPMENT

2.1 GENERAL EQUIPMENT

A. Where the specification calls out a manufacturer and model number it is for the purpose of establishing a standard of quality, performance, and function.

B. All equipment shall operate at the required line voltage.

C. The contractor shall provide quantities as indicated in the equipment list, detail drawings, location drawings, termination schedule, and as required for a complete, professionally installed system.

D. Audio & video wire and cable:

1. All cable must meet or exceed all local, state, or federal ordinances, codes, or regulations. Where a conflict exists between these regulations the most stringent shall apply.

2. All wire numbers listed in the specification are West Penn Wire and are listed for the purpose of establishing a standard of quality, performance and function.

3. Should the contractor desire to use cable other than the specified West Penn cable:

    a. They shall submit to the consultant a cross-reference list specifying the substituted cable part number with the associated West Penn number.

    b. Verify and revise the conduit system sizing as needed to accommodate the potential differences in cable size between manufacturers.

    c. Incur any additional costs associated with increasing the conduit sizes due to the substitution.

4. Other approved cable manufacturers are:

    a. Belden CDT Inc

    b. Lake Cable, Bensenville, IL

E. Electrical wire and cable

1. All cable must meet or exceed all local, state or federal ordinances, codes, or regulations. Where a conflict exists between these regulations the most stringent shall apply.

2. Cable shall be stranded THHN or as required by code.

F. Wiring devices

1. All wiring devices must meet or exceed all local, state or federal ordinances, codes or regulations. Where a conflict exists between these regulations the most stringent shall apply.

G. Electrical plates and panels

1. Rack mount panels shall be 1/8" thick black anodized aluminum or black powder-coated 16-guage steel with white filled engraved nomenclature.

2. Termination panels shall be 1/8" thick black anodized aluminum with white filled engraved nomenclature.

3. Approved manufacturers:

    a. Proco

    b. Whirlwind

    c. Entertainment metals

    d. Wireworks

    e. Approved equal

H. Audio transformers

1. Audio transformers not specifically called out by part number shall be manufactured by Jensen transformers and shall be selected to meet the specific requirements of the design application.

I. Audio connectors

1. All cable-mount and panel-mount connectors shall be manufactured by Neutrik unless otherwise noted.

2. All HDMI runs should be continuous with no barrels or splicing. Only barrels allowed are at plate connection points.

J. Video connectors

1. All cable mount BNC connectors shall be 3 piece crimp (no compression crimp allowed).

   a. Approved manufacturers:

      i. ADC (Tyco)

      ii. Kings

2. All cable mount F connectors shall be compression crimp. No overall body crimp allowed.

   a. Approved manufacturers:

      i. ICM

      ii. Belden

      iii. Digicon

3. All cable mount Triax connectors shall be multi piece crimp.

   a. Approved manufacturers:

      i. ADC (Tyco)

      ii. Kings

4. All panel mount Triax connectors shall be multi piece crimp.

   a. Approved manufacturers:

      i. ADC (Tyco)

      ii. Kings

K. Network connectors

1. All panel mount connectors shall be punch down (no barrel connectors allowed unless otherwise noted).

a. Approved manufacturers:

i. ADC (Tyco)

ii. Neutrik

iii. Legrand

iv. Hubbell

v. Signamax

vi. Belden

2. All cable-mount connectors shall be cable guided inserts with crimp (no pass-through cut & crimp allowed).

a. Approved manufacturers:

i. ADC (Tyco)

ii. Legrand

iii. Hubbell

iv. Signamax

v. Belden

L. Fiber connectors

1. All cable mount connectors shall be terminated per manufacturer specifications.

a. Approved manufacturers:

i. ADC (Tyco)

ii. Belden

iii. Neutrik

2. All panel mount connectors shall be terminated per manufacturer specifications.

a. Approved manufacturers

i. ADC (Tyco)

ii. Neutrik

iii. Belden

M. Terminal blocks

1. All mic, line level, and intercom splicing shall be done on insulation displacement type terminal blocks using din rail mounting methods.

a. Approved manufacturers:

i. Phoenix contact

ii. Entrelec

iii. Omega

N. All speaker level splicing shall be done on spring loaded conductor connection type terminal blocks using din rail mounting methods.

1. Approved manufacturers:

a. Phoenix contact

b. Entrelec

c. Omega

2.2 MAJOR EQUIPMENT

A. The contractor shall provide the equipment specified below or approved substitute (see paragraph 1.7.C).

B. Base bid: please reference downloaded informational package for equipment list.

ITEM	MFR	MODEL	QTY
A. **A217 AV Equipment Room**			
1. Audio Processing			
a. Digital Signal Processor	QSC	Core 110F	2
2. AV Control System			
a. Control Systems	AMX	SC-N8002	1
b. Control Systems	Crestron	CP3N	1
c. Control Systems	Engineering Solutions	DecaBox	1
3. AV Equipment Racks			
a. Equipment Racks	Middle Atlantic	D3	1
b. Equipment Racks	Middle Atlantic	HCM-1DV	1
c. Equipment Racks	Middle Atlantic	MPR-3A	1
d. Equipment Racks	Middle Atlantic	SR-24-32	1
e. Equipment Racks	Middle Atlantic	SS	1
f. Equipment Racks	Middle Atlantic	UFA-14.5	1

g.	Power and Protection	Middle Atlantic	M-2X20IGA	3
h.	Power and Protection	Middle Atlantic	UPS-1000R-8IP	1
i.	Wire and Cable	Middle Atlantic	J-12X6	1

4. AV Network

a.	AV Connectivity	Hewlett Packard	JL074A	2
b.	AV Connectivity	Hewlett Packard	JL079A	2
c.	AV Connectivity	Hewlett Packard	JL083A	1
d.	AV Connectivity	Hewlett Packard	JL084A	1
e.	Computers	Dell	Dell Laptop	1

5. AV Patchbays & Patch Cables

a.	Network	Belden	AX104564	2
b.	Plates	Belden	AX104562	96
c.	Wire and Cable	Belden	CAF1100004	24
d.	Wire and Cable	Belden	CAF1106004	24
e.	Wire and Cable	Belden	CAF1108004	24
f.	Wire and Cable	Belden	CAF1109004	24

6. Loudspeaker Ceiling

a.	Amplifiers	QSC	SPA4-60	1

7. Microphones

a.	Adapter	Shure	UA221	2

8. Video Engineering Monitors

a.	Display	Samsung	LH22DBDPSGC/GO	1
b.	Mounts	Chief	K1W110B	1

9. Video Processing

a.	Conferencing	Mersive	Solstice Pod Unlimited	1
b.	Switchers	TVone	1T-SX-644	1

10. Video Transport

a.	Video Transport	AMX	NMX-DEC-N1222	1
b.	Video Transport	AMX	NMX-ENC-N1122	1

B. **Active Learning Classroom**

1. Audio Monitoring System				
a.	Distributed Audio	RDL	EZ-HDA6	10
b.	Wire and Cable	ProCo	BPBQXF-10	24
2. AV Control System				
a.	Control Systems	Crestron	CNX-B8B	10
b.	Control Systems	Crestron	TSW-1050-B-S	1
3. AV Custom Plates & Panels				
a.	Plates	Custom	Room AVP'S Floor Pocket	1
b.	Plates	Custom	Room AVP'S Wall	10
4. AV Power Distribution				
a.	Power and Protection	Tripp-Lite	ISOBAR8ULTRA	10
5. Loudspeaker Ceiling				
a.	Speakers	JBL Pro	CONTROL 47C/T	15
6. Microphones				
a.	Audio Sources	Shure	MX412D/C	20
b.	Audio Sources	Shure	QLXD2/BETA58A	1
c.	Microphone	Shure	QLXD14/83	2
d.	Plates	Custom	Antenna Plug Box	2
e.	Power and Protection	Shure	SB900	4
f.	Power and Protection	Shure	SBC200	1
7. Video Processing				
a.	Conferencing	Mersive	Solstice Pod Unlimited	10
b.	Video Switchers	TV-One	1T-SX-632	10
8. Video Projectors & Screens				
a.	Display Devices	Custom	Projector Rigging	3
b.	Display Devices	Panasonic	PT-CW330U	3
c.	Mounts	Chief	SYSAUW	3
d.	Plates	Custom	Projector Plug Box (Wall)	3
e.	Power and Protection	Middle Atlantic	PD-28-SP	3
f.	Screens	Custom	Projection Screen Rigging	3

g.	Screens	Da-Lite	21803LS	3

9. Video Room Displays

a.	Display	Samsung	LH55DCEPLGA/GO	10
b.	Display Devices	Custom	Display Rigging	10
c.	Mounts	Chief	LTMU	10
d.	Plates	Custom	Display Plug Box	13
e.	Power and Protection	Middle Atlantic	PD-28-SP	10

10. Video Transport

a.	Video Transport	AMX	NMX-DEC-N1222	13
b.	Video Transport	AMX	NMX-ENC-N1122	10

C. **Active Learning Classroom: Podium**

1. AV Control System

a.	Control Systems	Crestron	TSW-1050-B-S	1

2. AV Equipment Racks

a.	Cable Assemblies	LinkUSA	LKG 32/6E	2
b.	Equipment Racks	Middle Atlantic	UFA-14.5	2
c.	Network	Middle Atlantic	UPS-IPCARD	1
d.	Power and Protection	Middle Atlantic	UPS-S1500R	1

3. Camera

a.	Display	Epson	DC-21	1

4. Video Room Displays

a.	Computers & Tablets	Dell	Dell OptiPlex 9020M	1

5. Video Transport

a.	Video Transport	AMX	NMX-ENC-N1115-WP	1
b.	Video Transport	AMX	NMX-ENC-N1122	2

D. **B221 Anatomage**

1. AV Control System

a.	Control Systems	Crestron	TSW-1050-B-S	1

2. AV Custom Plates & Panels

a.	Plates	Custom	Room AVP'S Wall	3
3.	AV Network			
a.	Computers	Dell	Dell OptiPlex 9020M	1
4.	Loudspeaker Wall			
a.	Speakers	QSC	AD-S6T	2
5.	Video Processing			
a.	Conferencing	Mersive	Solstice Pod Unlimited	1
b.	Video Processing	Tripp-Lite	B156-002-HDMI	2
6.	Video Room Displays			
a.	Display	Samsung	LH95MECPLBA/ZA	1
b.	Display Devices	Custom	Display Rigging	1
c.	Plates	Custom	Display Plug Box	1
d.	Rigging & Mounting	Samsung	WMN9500SD/ZA	1
7.	Video Transport			
a.	Video Transport	AMX	NMX-DEC-N1222	1
b.	Video Transport	AMX	NMX-ENC-N1115-WP	2

E. **B223 Anatomy**

1.	AV Control System			
a.	Control Systems	Crestron	TSW-1050-B-S	1
2.	AV Custom Plates & Panels			
a.	Plates	Custom	Room AVP'S Wall	2
3.	AV Network			
a.	Computers	Dell	Dell OptiPlex 9020M	1
4.	Loudspeaker Wall			
a.	Speakers	QSC	AD-S6T	2
5.	Video Camera			
a.	Camera	Padcaster	Wide Lens	1
b.	Enclosures	Padcaster	Padcaster Case (Air 2)	1

c.	Mounts	Padcaster	3 Piece Clamp System	1
d.	Mounts	Padcaster	VT-16 Fluid Head Tripod	1

6. Video Processing

a.	Conferencing	Mersive	Solstice Pod Unlimited	1

7. Video Recording & Playback

a.	Computers	Apple	iPad	1

8. Video Room Displays

a.	Display	Custom	Display Rigging	1
b.	Display	Samsung	LH85QMDPLGC/ZA	1
c.	Mounts	Samsung	WMN-5770D	1
d.	Plates	Custom	Display Plug Box	2

9. Video Transport

a.	Video Transport	AMX	NMX-DEC-N1222	1
b.	Video Transport	AMX	NMX-ENC-N1115-WP	1

F. **B321A AV Equipment Room**

1. Audio Processing

a.	Audio Processing	AMX	NMX-ATC-N4321	2

2. AV Control System

a.	Control Systems	Crestron	CP3N	1

3. AV Equipment Racks

a.	Equipment Racks	Middle Atlantic	D3	1
b.	Equipment Racks	Middle Atlantic	HCM-1DV	1
c.	Equipment Racks	Middle Atlantic	MPR-3A	1
d.	Equipment Racks	Middle Atlantic	MRK-2431	1
e.	Equipment Racks	Middle Atlantic	MW-10FT-FC	1
f.	Equipment Racks	Middle Atlantic	UFA-14.5	2
g.	Network	Belden	AX104564	1
h.	Plates	Belden	AX104562	48
i.	Power and Protection	Middle Atlantic	M-2X20IGA	3
j.	Power and Protection	Middle Atlantic	UPS-1000R-8IP	1

k.	Wire and Cable	Belden	CAF1100004	12
l.	Wire and Cable	Belden	CAF1106004	12
m.	Wire and Cable	Belden	CAF1108004	12
n.	Wire and Cable	Belden	CAF1109004	12

4. AV Network

a.	AV Connectivity	Hewlett Packard	JL074A	1
b.	AV Connectivity	Hewlett Packard	JL084A	1

5. Video Processing

a.	Video Processing	TV-One	1T-VS-622	1

G. **B321A AV Equipment Room: Anatomage**

1. Loudspeaker Wall

a.	Amplifiers	QSC	SPA2-60	1
b.	Video Processing			
c.	Video Processing	AMX	NMX-WP-N1512	1

2. Video Recording & Playback

a.	Video Sources	Apple	Apple TV	1

3. Video Transport

a.	Video Transport	AMX	NMX-ENC-N1122	2

H. **B321A AV Equipment Room: Anatomy**

1. Loudspeaker Wall

a.	Amplifiers	QSC	SPA2-60	1

2. Video Recording & Playback

a.	Video Sources	Apple	Apple TV	1

3. Video Transport

a.	Video Transport	AMX	NMX-ENC-N1122	1

I. **Alternate #1 Seminar Room 1**

1. AV Control System

a.	Conferencing	Mersive	Solstice Pod Unlimited	1

b.	Control Systems	Crestron	MPC-M10	1

2. AV Custom Plates & Panels

a.	Plates	Custom	Room AVP'S Wall	1

3. AV Network

a.	Cable Assemblies	FSR	DR-PCB-H10M	1

4. Loudspeaker Wall

a.	Amplifiers	Stewart Audio	AV25-2	1
b.	Amplifiers	Stewart Audio	AV-BRACKET	1
c.	Speakers	QSC	AD-S4T	2

5. Video Room Displays

a.	Display	Samsung	LH75EDEPLGC/GO	1
b.	Display Devices	Custom	Display Rigging	1
c.	Mounts	Chief	LTMU	1
d.	Plates	Custom	Display Plug Box	1
e.	Power and Protection	Middle Atlantic	PD-28-SP	1

J. **Alternate #1 Seminar Room 2**

1. AV Control System

a.	Conferencing	Mersive	Solstice Pod Unlimited	1
b.	Control Systems	Crestron	MPC-M10	1

2. AV Custom Plates & Panels

a.	Plates	Custom	Room AVP'S Wall	1

3. AV Network

a.	Cable Assemblies	FSR	DR-PCB-H10M	1

4. Loudspeaker Wall

a.	Amplifiers	Stewart Audio	AV25-2	1
b.	Amplifiers	Stewart Audio	AV-BRACKET	1
c.	Speakers	QSC	AD-S4T	2

5. Video Room Displays

a.	Display	Samsung	LH75EDEPLGC/GO	1

b.	Display Devices	Custom	Display Rigging	1
c.	Mounts	Chief	LTMU	1
d.	Plates	Custom	Display Plug Box	1
e.	Power and Protection	Middle Atlantic	PD-28-SP	1

K. **Alternate #2 Lounge/Conference Room**

1. AV Control System

a.	Conferencing	Mersive	Solstice Pod Unlimited	1
b.	Control Systems	Crestron	MPC-M10	1

2. AV Custom Plates & Panels

a.	Plates	Custom	Room AVP'S Wall	1

3. AV Network

a.	Cable Assemblies	FSR	DR-PCB-H10M	1

4. Loudspeaker Wall

a.	Amplifiers	Stewart Audio	AV25-2	1
b.	Amplifiers	Stewart Audio	AV-BRACKET	1
c.	Speakers	QSC	AD-S4T	2

5. Video Room Displays

a.	Display	Samsung	LH75EDEPLGC/GO	1
b.	Display Devices	Custom	Display Rigging	1
c.	Mounts	Chief	LTMU	1
d.	Plates	Custom	Display Plug Box	1
e.	Power and Protection	Middle Atlantic	PD-28-SP	1

L. **Alternate #3 B216 Conference**

1. Audio Loose Inventory

a.	Wire and Cable	C2G	28104	1

2. AV Custom Plates & Panels

a.	Plates	Custom	Room AVP'S Wall	1

3. Loudspeaker Wall

a.	Amplifiers	Stewart Audio	AV25-2	1

b.	Amplifiers	Stewart Audio	AV-BRACKET	1
c.	Speakers	QSC	AD-S4T	2

4. Microphones

a.	Audio Sources	Beyerdynamic	MPC 70 USB	1

5. Video Camera

a.	Camera	Vaddio	999-9990-000	1

6. Video Processing

a.	Conferencing	Mersive	Solstice Pod Unlimited	1

7. Video Room Displays

a.	Computers	Dell	Dell OptiPlex 9020M	1
b.	Display	Samsung	LH75EDEPLGC/GO	1
c.	Display Devices	Custom	Display Rigging	1
d.	Mounts	Chief	LTMU	1
e.	Plates	Custom	Display Plug Box	1

M. **Alternate #7 Anatomy LCD Table Displays**

1. Video Camera

a.	Camera	Padcaster	Wide Lens	3
b.	Computers	Apple	iPad	3
c.	Enclosures	Padcaster	Padcaster Case (Air 2)	3
d.	Mounts	Padcaster	3 Piece Clamp System	3
e.	Mounts	Padcaster	VT-16 Fluid Head Tripod	3

2. Video Processing

a.	Video Accessories	Apple	Apple TV	3

3. Video Room Displays

a.	Display	Custom	Display Rigging	8
b.	Display	Samsung	LH32DCEPLGA/GO	8
c.	Mounts	Lucinda	LUC-T2-CM-5"	8
d.	Plates	Custom	Display Plug Box	8

4. Video Transport

a.	Video Transport	AMX	NMX-DEC-N1222	8

b.	Video Transport	AMX	NMX-ENC-N1115-WP	3

PART 3 EXECUTION

3.1 GENERAL

A. The contractor shall install all systems specified herein utilizing the highest standards of craftsmanship and in accordance with good engineering practice.

B. The contractor shall install all equipment in accordance to this specification and the manufacturer's recommendations.

C. All equipment and devices shall be installed neatly, plumb, square and with respect to the aesthetic of the project.

D. The standard reference manual for the installation and implementation of the audio systems design specified herein shall be: *Audio Systems Design and Installation* by Philip Giddings, Focal Press, Boston, MA.

3.2 CONDUIT

A. The contractor shall review the conduit riser issued as part of the specification and field coordinate with the electrical contractor to ensure proper sizing, routing, separation, and operation of the AV systems.

B. All the AV system cabling must be housed in a continuously grounded ferrous metallic AV systems raceway (ASR), including all conduit installed or encased in concrete. PVC or aluminum conduit is only acceptable below ground.

C. The contractor shall coordinate with the general contractor (or construction manager) and visit the construction site frequently to inspect the installation of the AV system raceway (ASR) during construction. Visits shall be scheduled prior to pouring of concrete or other construction that would cover or encapsulate the ASR. The consultant and architect shall be notified immediately regarding construction methods inconsistent with the requirements identified in the contract documents.

3.3 ELECTRICAL POWER

A. The contractor shall review and coordinate the installation of the clean technical power system with the electrical contractor to ensure proper system implementation.

B. The contractor shall verify that all circuits designated on the plans have been installed, correctly wired and labeled. Any discrepancies shall be reported to the consultant in writing for corrective action.

C. The contractor shall be responsible for power distribution in all portable and permanent AV equipment racks.

1. Plug strips are not acceptable.

2. Permanent audio & video equipment racks shall be hardwired and terminated directly to the panel board.

3. The electrical contractor shall be responsible for delivering and terminating the specified CTP circuits to the equipment racks.

4. Portable racks shall have a ten (10) foot so-type extension cable for connection to the CTP receptacles.

5. Each permanent rack shall have a minimum of one (1) unused receptacle per circuit.

6. Each portable rack shall have a minimum of two (2) unused receptacles.

3.4 GROUNDING

A. The contractor shall review and coordinate the installation of the isolated technical grounding system with the electrical contractor to ensure proper system implementation.

B. The contractor shall verify that the isolated technical grounding shown on the electrical plans have been installed, correctly wired and labeled. Any discrepancies shall be reported to the consultant in writing for corrective action.

C. A single point star grounding system shall be used in the implementation of the AV systems. Reference for this type of system can be found in: *audio systems design and installation* by Philip Giddings, Focal Press, Boston, MA and *Fundamentals of Grounding, Shielding, and Interconnection*, Kenneth R. Fause, Journal of the Audio Engineering Society, vol. 43, #6, June, 1995.

D. All audio signal paths shall be connected using balanced lines and/or utilizing appropriate transformer isolation as required. No unbalanced signal paths shall be connected to the patch bay.

E. Audio shields between active pieces of equipment shall be connected to ground at one end only.

1. The basis for reference for this methodology shall be chapter 10 of *Audio Systems Design and Installation* by Philip Giddings, Focal Press, Boston, MA

2. The contractor shall submit as part of the shop drawing package the typical interconnection methodology they choose to adhere to as part this project.

3. The contractor shall be responsible for the successful implementation of this scheme based on the general technical grounding outlined above and delivering a professional system free of buzz, hum and noise.

3.5 RIGGING

A. The AV systems contractor shall be responsible for the installation and mounting of all equipment specified herein.

B. The AV systems contractor shall coordinate with all applicable trades for proper installation and performance of the specified equipment.

C. The AV systems contractor shall provide detailed mounting drawings for all devices that will attach to building structure, such as, but not limited to loudspeakers, video monitors, projectors, and wall mount equipment racks.

D. The minimum safety factor for all mounting and rigging shall be the USA industry established 5:1. Always defer to structural engineer on project, as higher standards may need to be held for the project as whole or specific areas in the project.

1. The AV systems contractor shall be responsible for the safe and proper installation of all devices specified herein and shall adhere to all applicable federal, state, and local codes, regulations and standards.

2. A reference for the rigging and suspension of loudspeakers, projectors, video walls, screens, truss, and linesets. Shall be *Entertainment Rigging for the 21st Century*, by Bill Sapsis. *Entertainment Rigging*, by Harry Donovan. *Stage Rigging Handbook*, by Jay O. Glerum

E. The installation of mounting brackets or supports shall not weaken or overload the building structure. Coordinate as necessary with the project's structural engineer or secure the services of a structural engineer licensed in the state of the project for any unique or questionable structural matters.

F. All AV equipment mounting hardware and systems shall not share or utilize fixtures, devices, or supports intended for other trades or systems.

G. The AV systems contractor shall coordinate with GC any backing or wall reinforcement needed for displays.

H. Projectors should be rigged with no keystoning or horizontal lens shift needing to be applied in order to align projection image, unless directed by consultant.

I. The AV systems contractor shall not cut, drill, weld or otherwise alter any structural member without the written authorization of the architect.

3.6 WIRING

A. All AV wiring or cabling shall be installed with respect to proper routing, types, quantities, lengths, identification, and separation.

B. Splicing of cables is not permitted between points of termination.

C. All wires and cables shall be permanently and uniquely labeled and accurately documented on the as-built drawings.

1. Approved cable id labels are following:

a. Brady jet-30 type

b. Phoenix contact adhesive wrap labels

D. Pull all wire and cable in accordance to the manufacturer's requirements regarding lubricant, pulling tensions, bend radius and temperature. Protect the cable and wiring from abrasion, kinks, and excessive tension during installation.

E. All cable ends shall be wrapped with shrink tubing and each shield or drain wire sheathed in clear tubing.

F. All cabling and wiring shall be grouped, neatly bundled and labeled according to signal level in all enclosures and racks utilizing tie wraps of the appropriate size.

G. Service loops should be provided at all panel and equipment terminations allowing ease of dismounting for installation, service and inspection.

H. All devices shall be installed and wired with respect for proper polarity. Absolute polarity shall be maintained throughout the entire audio chain.

1. Polarity for XLR type connectors shall be: pin 2 hot, pin 3 cold, and pin 1 shield.

2. Polarity for ¼"-trs type connectors shall be: tip hot, ring cold, and sleeve shield.

3. Connector polarity shall be maintained throughout the system except for terminations at equipment manufactured to other standards. Should this case exist the connector shall be flagged with a label noting the variance.

3.7 EQUIPMENT RACKS

A. All equipment racks shall be considered custom assemblies and shall be fabricated and tested at the contractor's facility prior to installation at the site.

B. Equipment racks shall not be brought to the site until the rooms they are to be set in are painted, cleaned, dust free and ready for occupancy.

C. All equipment racks shall be installed level and square allowing both front and rear access per code. Submit drawings detailing the placement of the racks coordinated with all other furniture, fixtures, and equipment prior to installation.

D. All equipment racks shall be electrically isolated from the floor with a rubber isolation pad.

E. All equipment racks shall be electrically isolated from the conduit system as detailed in the electrical plans and specifications.

F. All equipment shown in the rack elevation drawings is placed for proper operator convenience. Submit any changes for consultant approval with the shop drawing submittal.

G. All wiring and cable shall be formed into harnesses, neatly grouped, tie wrapped and supported by vertical and horizontal lacing bars.

H. All wire, cable, terminals, and equipment shall be clearly labeled as to their function, circuit, or system.

I. All non-user-controlled equipment shall be supplied with security covers to avoid tampering of preset levels.

J. All equipment shall be placed in the rack with regards to logical signal flow, EMI, proper ventilation and operator convenience. Submit any changes to the bid specification rack elevations for approval as part of the shop drawing submittal.

3.8 VERIFICATION TESTS

A. The AV systems contractor shall provide the initial adjustment and testing of the AV systems to ensure that the systems are properly installed, operational and ready for acceptance testing.

B. The AV systems contractor shall perform the following tests, adjustments and verifications and include the results as part of the verification test report prior to system commissioning.

1. Each AV systems clean technical power outlet shall be tested to verify proper polarity, grounding and voltage.

2. All wires and cables shall be checked to ensure that each is uniquely marked, labeled at both ends, clearly visible and documented on the as-built drawings.

3. Each and every microphone, tie, intercom, video, control, and speaker line shall be tested and documented confirming:

a. Each circuit appears at its proper point of termination.

b. The continuity of each conductor.

c. The absolute polarity of each circuit.

d. The absence of shorts between conductors.

e. The absence of shorts between conductors and the conduit system.

4. Each and every AES/EBU line shall be tested and documented confirming:

a. Each circuit appears at its proper point of termination

b. The continuity of each conductor

c. Holding sample rates of 192 kHz

d. The absence of shorts between conductors

e. The absence of shorts between conductors and conduit system.

5. Each and every category cable shall be tested and documented confirming minimum performance parameters set forth by ANSI/NECA/BICSI-568-2006 standards including:

a. Wire map (continuity) including shield when applicable.

b. Length

c. Propagation delay & delay skew

d. Attenuation (insertion loss)

e. Return loss

f. Near-end crosstalk (next) loss

g. Equal level far-end crosstalk (ELFEXT)

h. Power sum crosstalk

6. Each and every HDMI cable shall be tested and documented confirming:

   a. Wire map (continuity)

   b. 5v signal presence

   c. Resolution passage of 3840 x 2160

7. Each and every time code cable shall be tested and documented confirming:

   a. The continuity of each conductor.

   b. The absolute polarity of each circuit

   c. Each circuit appears at its proper point of termination

8. Each and every blackburst cable shall be tested and documented confirming:

   a. The continuity of each conductor

   b. Each circuit appears at its proper point of termination

   c. Cable will hold sync up to 1080p

9. Each and every fiber optic line shall be tested and documented confirming minimum performance parameters set forth by ANSI/TIA/EIA-568-b standards including:

   a. For interbuilding backbones

      i. End-to-end attenuation testing for all connectorized fibers at both 850 nm. And 1300 nm. For multimode fiber or 1310 nm. And 1550 nm. For single mode (if any fibers are to be left unterminated, use an OTDR to test end-to-end attenuation).

      ii. OTDR signature trace documentation

   b. For intrabuilding backbones

      i. End-to-end attenuation testing for all connectorized fibers at both 850 nm. And 1300 nm. For multimode fiber or 1310 nm. And 1550 nm. For single mode (if any fibers are to be left unterminated, use an OTDR to test end-to-end attenuation).

      ii. OTDR signature trace documentation if the attenuation testing indicates questionable results.

   c. For horizontal and centralized cabling

      i. End-to-end attenuation testing for all connectorized fibers at both 850 nm. And 1300 nm. For multimode fiber or 1310 nm. And 1550 nm. For single mode (if

any fibers are to be left unterminated, use an OTDR to test end-to-end attenuation).

ii. OTDR signature trace documentation is not necessary unless the end-to-end readings are high.

10. Provide both impedance and resistance to ground measurements for each permanently installed loudspeaker line.

    a. Impedance data shall be in graph form showing impedance versus frequency for the entire frequency range of the driver under test.

    b. Resistance to ground data shall be in ohms.

11. All permanently mounted loudspeakers and their mountings shall be tested to ensure the absence of buzzes and rattles. Test using a swept sign wave at one half the device's rated power.

12. All devices during the verification test shall be adjusted according to the manufacturer's recommendations and optimized for unity gain.

13. All systems shall be tested to confirm:

    a. All outputs are free from spurious signals including oscillations and radio frequency signals.

    b. All outputs are free from audible clicks, pops, hum, buzz, and when controls are operated or when at idle.

    c. Absolute polarity is maintained throughout the entire system.

    d. All devices and controls are in proper working order and all functions are fully operational.

14. All digital video cable runs shall be shall be verified to pass signals conforming to the SMPTE 259m (SDI 270mbit) and SMPTE 424m (HD-SDI 2.970 gbit) standards.

15. All imaging devices shall be confirmed to have no inoperative pixels.

16. All display devices shall be confirmed to have no inoperative pixels.

17. Verify that each system is operating within the design intent, "passing signal"; requires no further termination, installation, troubleshooting or repair and is ready for acceptance testing and final tuning.

18. For projection systems, provide confirmation that brightness, contrast, color uniformity, color calibration, DMD alignment/convergence.

19. All video projectors and displays shall be calibrated using SMPTE standards.

20. All RF cabling shall be tested and documented confirming:

    a. The continuity of each conductor.

b. Each circuit appears at its proper point of termination

c. dB signal loss

21. All RF distribution systems should be balanced out referencing standards in blonder tongue broadband reference guide.

22. All wireless microphone systems shall have the following verified:

a. Wireless spectrum scanned and open frequencies identified.

b. Appropriate wireless groups and frequencies set on all transmitters & receivers

c. Gain structure set on all transmitting & receiving devices

d. RF signal strength mapping applied to teaching area or user usage area.

3.9 ACCEPTANCE TESTING

A. The acceptance testing shall be scheduled subsequent to the receipt and acceptance of the verification test report.

B. The consultant will perform the acceptance testing during a period scheduled by the architect. The minimum expected time is two (2) working days of dedicated quiet.

C. The contractor shall coordinate this time period with the architect, general contractor and all applicable parties to ensure:

1. A quiet testing environment.

2. Complete access to all areas, equipment, devices and loudspeakers.

3. Adequate work lighting.

4. Availability of electrical power.

D. The contractor shall furnish a minimum of two (2) technicians for the duration of the acceptance testing.

E. At the time of acceptance testing the contractor shall have available all approved shop drawings noting any field changes, modifications and corrections and a copy of the operation maintenance manual for use during the testing and final tuning of the systems.

F. The contractor shall provide the following test equipment for the duration of the acceptance testing.

1. General tools

a. High impedance multi-meter

b. Laptop preloaded & connected with all software needed to communicate with equipment onsite.

2. Audio tools

a. Frequency counter

b. Sine wave generator

c. THD and noise analyzer

d. Pink noise generator for both analog and digital signals

e. Measurement microphone's (minimum of 4 on site)

f. Handheld 1/3 octave real time analyzer

g. Smaart or Systune

h. Loudspeaker impedance measurement system

i. Portable audio monitor with analog & AES inputs.

j. Level 3 digital cable analyzer

k. RF spectrum analyzer

3. Video tools

a. HDMI signal generator

b. HDMI EDID reader

c. VGA signal generator

d. VGA EDID reader

e. Portable ENG monitor with SDI, component, composite, HDMI, DVI, and VGA capabilities.

f. HDMI audio embedder and de-embedder both analog and digital audio signals

4. Network tools

a. Fluke one touch network assistant with all adaptors for fiber connections, and cat connections.

b. Optical loss test set

c. Optical time domain reflectometer (OTDR)

G. The contractor shall be prepared to verify all tests performed as part of the verification test report and assist in the balancing, adjustment and tuning of all systems.

H. The contractor shall be prepared to make additional modifications to the systems within the scope of the bid specification and deemed necessary by the consultant to meet the design and performance intent of the systems. These may include realignment of loudspeakers, changes to interconnections including grounding, isolation and filtering and changes to gain structure.

I. During the course of the acceptance testing and final tuning a punch list will be developed and shall serve as the written acceptance of the contractor's substantial completion.

J. Final acceptance shall be contingent on the satisfactory completion of the items documented in the punch list and completion and delivery of the as-built documentation and owner's manuals.

END OF SECTION