Worcester Regional Transit Authority

Invitation for Bids (IFB) #2025-07

WRTA Hub Lobby Renovation

IFB Issue Date: July 18, 2025

Addendum #3

The Worcester Regional Transit Authority (WRTA) is issuing this addendum to the above-mentioned Invitation for Bids (IFB) for the purpose of answering question submitted on or before August 19, 2025 and issuing revised specifications and drawings

Questions & Clarifications

Question 1: It appears that spec section 084413, Glazed Aluminum Curtain Wall, is missing. It seems that 084113, Aluminum-Frames Entrances and Storefronts is in there twice.

Answer 1: will be included in Addendum #3

Question 2: Could you please clarify what scope of work is included in the filed sub bid for Div. 8?

Answer 2: the scope includes:

- **replace swing doors with sliding doors at south vestibule (room 106B, curtainwall replacement as needed);**
- **reduce vestibule size at north vestibule and replace swing doors with sliding doors (room 106A, curtainwall replacement as needed);**
- **add ticketing windows on Curtainwalls along south entrances(room 105);**
- **curtainwall and communication window at security room(room 110)**
- **interior ticketing window at ticketing room(room 105)**

Question 3: Spec section 000010, Construction Progress Documentation. The spec is very specific with requirements regarding scheduling. We typically utilize Microsoft Project to build and maintain our construction schedules which does not meet some of the spec requirements. Will this be an acceptable practice for this project.

Answer 3: Yes, this is acceptable.

Question 4: Spec section 000010, Project Management and Coordination, calls for the general contractor to provide a Mechanical/Electrical Coordinator. This would be a person that we would have to outsource. Is the MEC position going to be required for this project?

Answer 4: Yes, this coordinator is required for the project.

Question 5: Please provide a rough project schedule with key milestone dates and anticipated completion date, for labor estimating purposes.

Answer 5:

- **NTP: Sep 15th, 2025**
- **preconstruction: Sep 15th, 2025 – Dec 15th, 2025 (90 days)**
- **Construction mobilization: Nov 15th, 2025**
- **Sitework and Demolition: Nov 15th – Jan 15th, 2026 (60 days)**
- **New construction: Jan 15th, 2026 – April 15th, 2026 (90 days)**
- **Final Activity: April 15th, 2026 – April 22nd, 2026 (7 days)**
- **Project closeout: April 22nd, 2026 – June 2nd, 2026 (40 days)**

Question 6: Specification [000010-pg. 41; 3.18] calls out testing and commissioning of a generator. Drawing ED-601, Existing Single Line Diagram, calls out "New Natural Generator – 75 KW 208Y/120V 3-Phase".
Please confirm this is existing equipment and no associated scope, including testing or commissioning scope, is required on this project.

Answer 6: The Generator is existing and no commissioning scope is required for the project. The corrected spec number is 018100 and generator commissioning scope is removed.

Question 7: What is the make and model of the existing fire alarm system? If the existing system vendor is known, please provide this as well.

Answer 7: The make is Notifier by Honeywell. The FACP is a NFW2-100.

Question 8: What is the make and model of the existing panelboards in which new circuit breakers are to be provided?

Answer 8: The main switchboard is a Eaton Pow-R-Line. All of the existing panelboards are also Eaton Pow-R-Line as well.

Question 9: Please provide a design for the "Temporary Ticketing Office" specified in Addendum #1, providing at minimum an approximate square footage, the total required ampacity, and the number of power and data outlets required.

Answer 9: All work for the temporary ticketing office to be provided by the General Contractor. In addition to the requirements of specification 015000, the temporary ticketing office shall be at least 60 square feet with minimum R-30 batt insulation in the walls and ceiling, an 8' ceiling. Provide, three 120v duplex receptables, two data jacks and one telephone jacks, two light fixtures providing a minimum 30 foot -candles total. Provide one battery powered, emergency light fixture inside the office. Provide one smoke detector. Provide one additional 20amp circuit for heating. All work for the temporary ticketing office to be provided by the General Contractor.

Question 10: Drawing E-201, keynotes 3 and 4 call out fixtures to be provided with emergency battery drivers and test switches. Please confirm that a test switch is required for each noted fixture. Also confirm which fixtures are intended to use keynote 3, and which to use keynote 4, as both are noted as "TYP".

Answer 10: All shaded fixtures required the battery pack as noted in keynote 3. All shaded D1 fixtures require the battery pack and regressed test switch as noted in keynote 4.

Question 11: What is the basis of design for lighting controls? Drawing E-001 calls out LV switches to be "CRESTON [sic] ZUMLINK-BTN6", but occ/vac sensors as "SENSORYWORX [sic] SWX-22#-1AR, while Specification [260001-pg. 27; 2.11-F] calls out Lutron.

Answer 11: BOD control system is Lutron per the specification noted in the question. Equivalent lighting control systems will also be considered.

Question 12: What low-voltage scope is included in this bid? Drawing E-001 states "ALL DATA AND TELEPHONE CABLING SHALL BE BY OTHERS", but Drawing E-701 calls out wiring and devices for data and telephone and Specification [270001] is listed as part of ELECTRICAL WORK.

Answer 12: The note on E-001 is incorrect. The low voltage cabling, devices, enclosures, wiring connections and other equipment noted on the drawings/specs is required as part of the electrical contractor's scope. The only low voltage scope not required by the electrical contractor is providing the cameras, making the final wiring connections on the cameras, and commissioning the cameras as noted on sheet E-903.

Question 13: Drawing ED-102 indicates an existing "TELECOMMUNICATION PANEL" to be relocated. Drawing E-102 shows it in a new location, with no notation. Is this relocation part of the EC scope, or "by others" as noted above?

Answer 13: The electrical contractor is required to relocate this panel.

Question 14: There are significant discrepancies/disagreements in the plans regarding the door control/security scope. Please provide a matrix clearly delineating who will furnish, install, wire, and test/commission all door hardware/access control devices and wiring.

Answer 14: EC is responsible for all junction boxes, power wiring, and raceways. Door hardware, door openers, and other door hardware accessories will be provided by the door hardware manufacturer/contractor. Security system connections, commissioning, cabling, and programming will be provided by the security system contractor for the WRTA.

Question 15: For CCTV cameras, please indicate the required cabling to be furnished and installed by the EC.

Answer 15: Assume 4PR CAT6 for bidding purposes. The exact cable requirements should be coordinated with Galaxy during construction.

Question 16: In the specs, the Table of Contents 000010, Pg. 2 lists the Painting Filed Sub-Bid section as 090007 but that section is not included. Can this section be provided?

Answer 16: will be included in addendum #3

Question 17: Please clarify the scope of the Glass and Glazing Filed Sub Bid, as the specification summary only lists products.

Answer 17: Glass and Glazing for all Windows and Curtainwalls, except for the security ticket windows

Question 18: Per the Invitation To Bid, all bidders shall provide 5% bid deposit with their bids. The successful contractor shall provide the Town with a 100% payment bond and a 100% performance bond upon issuance of the notice of award. Does the Payment and Performance Bond pertain to the General Contractor and All Filed Sub-Bidders?

Answer 18: The payment and performance bonds are required only for the General Contractor.

Question 19: Are Electrical Permit Fees waived for this project?

Answer 19: No construction permits are waived for this project.

Question 20: Per Fire Alarm Note 1 on Drawing E-001, the existing Fire Alarm System is Simplex/Grinnell. Please confirm and provide Model Number.

Answer 20: See the response to question 7 above. The manufacturer is in fact Notifier by Honeywell.

Question 21: Reading through the door and window spec can you please clarify what scope is filed sub bid and what isn't? Why would the following not be included in the filed sub?

Answer 21:

Aluminum Frames Entrances & Storefronts - **Filed sub bid Required under Section 080001 – Metal Windows**

Automatic Entrances – Filed Sub bid not required

Glazing - **Filed sub bid Required under Section 08002 – Glass and Glazing**

Interior Glazing – **Filed sub bid Required under Section 08002 – Glass and Glazing**

Security Windows - Filed Sub bid not required

Question 22: The heading of Section 085113 indicates this Section is part of Section 080001 - Metal Windows Filed Sub-Bid. Please advise if there is a Metal Windows Filed Sub-Bid.

Answer 22: Metal window FSB is required. Metal windows FSB is included in Addendum #3.

Question 23: Please clarify the scope of work to be carried by the Glass and Glazing Filed Sub-Bid. The description of work in Section 088010 - Interior Glazing lists back-painted glass, glazing film, unframed mirrors and bullet resistant security glazing.

Answer 23: Spandrel glass are used at curtainwall. Glazing film is used for interior glasses. those are correct scope for glazing FSB

Question 24: Is there back-painted glass on this project? There is bullet resistant film on the aluminum scope, which is not part of the FSB. Is there any film work by the Glass & Glazing FSB? The security windows typically come with their own glass. Is

there bullet resistant glass we need to include in the bid? Please advise if any of the mirrors are unframed.

Answer 24:

- **Spandrel glass is included in this project. Window film is included in the scope as shown on A-301 and A-701.**
- **Bullet resistant glass at the ticket window only**

Question 25: this only notes glass and glazing on the advertisement and on the Table of Contents FSB (Section 080002) please see screen shot below

DIVISION 08 - OPENINGS

Section 080002*	Glass and Glazing (filed sub-bid)
Section 081113	Hollow Metal Doors and Frames
Section 083110	Access Doors and Frames
Section 083326	Overhead Coiling Grilles
Section 084113	Aluminum-Framed Entrances and Storefronts
Section 084229	Automatic Entrances
Section 084413	Glazed Aluminum Curtain Walls
Section 085113	Aluminum Windows
Section 085653	Security Windows
Section 087100	Door Hardware
Section 088000	Glazing
Section 088010	Interior Glazing (part of 080002 filed sub-bid)

However, page 438 on the link notes Aluminum Windows as a FSB as well (section 080001) please see screen shot below

SECTION 085113

ALUMINUM WINDOWS

(Part of Work of Section 080001 - METAL WINDOWS, Filed Sub-Bid Required)

Please advise if there are two different FSB required?

Answer 25: Metal window FSB is required and include Section 085113 Aluminum Windows. Metal windows FSB is included in Addendum #3.

Question 26: "We are a concrete contracting company interested in submitting a bid for the foundation and flatwork aspects of the project referenced above. Currently, I am aware of only one bidder. I would appreciate it if you could provide information on any other General Contractors who may be bidding on this project so that we can submit our proposal to them as well".

Answer 26: The list of contractors that attended the site walks is available in Addendum #1 and #2.

Question 27: "I will be bidding on the resinous flooring for the **WRTA Lobby Renovation.** I have the spec. is there a way you can send the print plans"?

Answer 27: Plans are available at the WRTA Business Opportunities website under IFB #2025-07. Note this single document is 834 pages and contains the drawings and technical specifications for the project.

Question 28: Will this spec section be carried under the 26 00 00 Electrical Filed sub bid? Please Confirm.

Answer 28: The specifications owned by the Electrical Contractor are 260001 – Electrical Work & 270000 – Communications Systems.

Question 29: Please confirm the trade sections that will be filed sub bids. The AFB has the filed sub bids as:

- Electrical
- Plumbing
- Fire Protection Sprinkler Systems
- HVAC
- Painting
- ~~Waterproofing, dampproofing, and caulking~~

Both sections 079200 Joint sealants and 099000 painting state within the spec section that they are Field sub bids. Also there is no waterproofing or damproofing specification. Please Confirm.

Answer 29: There is limited scope at exterior wall which is covered under curtainwall specification. No FSB for waterproofing; No FSB for 079200. Painting FSB is included in Addendum #3.

Question 30: Specification 102813 Toilet Accessories refers to all accessories to have blocking and refers to the 061000 specification which is missing. Please provide.

Answer 30: spec section 061000 will be included in Addendum #3

Question 31: On A-502 the FFE schedule has a column for Client to furnish and GC to install. want to confirm the YES means GC is only installing these items and the NO is the GC is furnishing and Installing. Please confirm.

Answer 31: Correct, YES means Client to furnish, GC to install; No means GC to furnish and install.

Question 32: Per specification 10 28 13 Toilet accessories are to be FURNISH only to 22 00 01 Plumbing Filed sub bid contractor to install. Please confirm

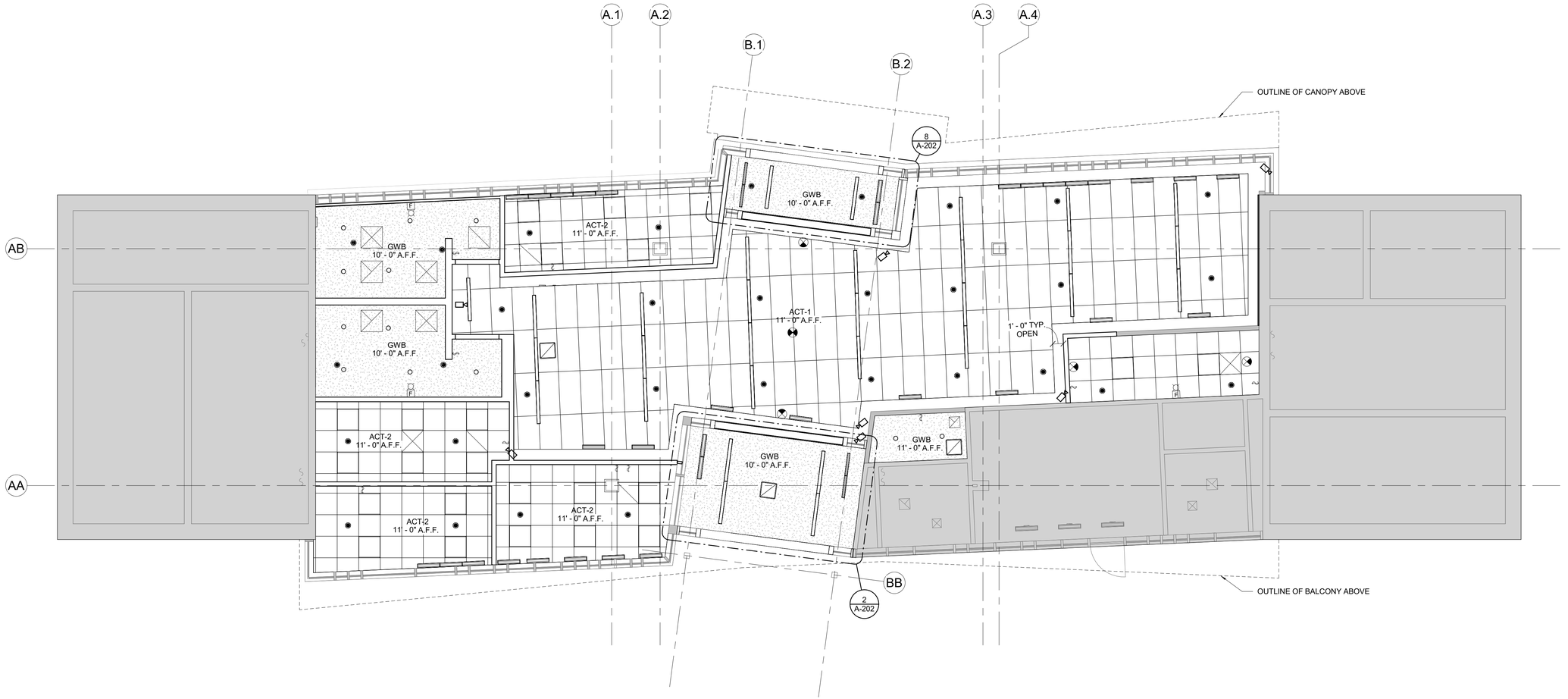
Answer 32: Confirmed.

Question 33: Specification 104400 Fire protection specialties sub section 2.4 lists stair evacuation chairs. Where are these located and how many will be required.

Answer 33: Sub section 2.4 was included in error. Stair evacuation chairs are not required.

Question 34: There will be a 1'0" gap between the wall and the edge of the new ACT ceiling in Lobby Waiting Area 106. Will any portion of the overhead deck, structure, and/or MEPs visible through this gap need to be painted and if so, for what distance from the edge?

Answer 34: to be painted black 1'-0" back from the edge. Scope defined in Sheet A-111, included in Addendum #3.



LEVEL 1 RCP

3/16" = 1'-0"

0 4' 8' 12'

REFLECTED CEILING PLAN GENERAL NOTES

1. COORDINATE ALL DEVICE LOCATIONS WITH HVAC, ELECTRICAL & FIRE PROTECTION DRAWINGS.
2. ALL FIXTURES SHALL BE CENTERED IN EACH CEILING TILE OF SUSPENDED ACT CEILING SYSTEM UNLESS OTHERWISE INDICATED.
3. ALL CEILING GRIDS SHALL BE CENTERED IN EACH DIRECTION IN ALL ROOMS UNLESS OTHERWISE INDICATED.
4. PROVIDE ACCESS PANELS, MINIMUM 24" x 24", OR OF SIZES REQUIRED, WHERE PLUMBING AND HEATING VALVES, WATER SWITCHES, VENTILATION SPLITTER DAMPERS, ETC. ARE SHOWN ON PLUMBING, HEATING, AND VENTILATION DRAWINGS. SUCH ACCESS PANELS SHALL BE INSTALLED IN THE FOLLOWING:
   A. METAL STUD OR MASONRY PARTITION
   B. SUSPENDED GYPSUM WALLBOARD CEILINGS
5. EXPOSED PIPES/DUCTWORK WITHIN THE 1'-0" GAP BTWEEN WALLS AND CEILING TO BE PAINT BLACK, 1'-0" FROM THE EDGE.

LEGEND - RCP

- XXX — SOFFIT / CEILING TYPE
- X' - Y" A.F.F. — SOFFIT / CEILING HEIGHT ABOVE FINISHED FLOOR
- GYPSUM WALLBOARD CEILING
- 2' X 2' ACT CEILING
- 2' X 4' ACT CEILING
- AREA OF WORK NOT IN SCOPE
- 2' x 2' ACCESS PANEL. FINAL LOCATION SHALL BE COORDINATED IN FIELD WITH EQUIPMENT
- SUPPLY DIFFUSER - REFER TO MECHANICAL DRAWINGS
- EXHAUST DIFFUSER - REFER TO MECHANICAL DRAWINGS
- RETURN DIFFUSER - REFER TO MECHANICAL DRAWINGS
- SUPPLY DIFFUSER WITH PLANUM - REFER TO MECHANICAL DRAWINGS
- CEILING MOUNTED SPRINKLER HEAD - REFER TO FIRE PROTECTION DRAWINGS
- F — FIRE ALARM REFER TO ELECTRICAL DRAWINGS
- LIGHT SWITCH REFER TO ELECTRICAL DRAWINGS
- CAMERA REFER TO ELECTRICAL DRAWINGS
- RECESSED LIGHT FIXTURE - REFER TO ELECTRICAL DRAWINGS
- RECESSED LINEAR LIGHT FIXTURE - REFER TO ELECTRICAL DRAWINGS
- RECESSED DOWNLIGHT - REFER TO ELECTRICAL DRAWINGS
- EXIT SIGN - SINGLE SIDED REFER TO ELECTRICAL DRAWINGS
- EXIT SIGN - DOUBLE SIDED REFER TO ELECTRICAL DRAWINGS

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CONSULTANTS

SEALS

PROJECT IDENTIFICATION

WORCESTER REGIONAL TRANSIT AUTHORITY

MAIN LOBBY RENOVATION

MARK	DATE	DESCRIPTION	BY
1	08/21/2025	ADDENDUM 3	

ISSUE BLOCK

PROJECT NO.:	4022461
DESIGNED BY:	WX
DRAWN BY:	AA
CHECKED BY:	SC
APPROVED BY:	RR
DATE:	02/10/2025

SHEET TITLE

LEVEL 1 RCP

A-111

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WORCESTER REGIONAL TRANSIT AUTHORITY

HUB LOBBY RENOVATION

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SECTION 018100

COMMISSIONING

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PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS, which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Commissioning: Commissioning is a planned, collaborative process of witnessing and testing that confirms that a new building and its systems meet the Owner's Project Requirements (OPR) and the project's Basis of Design (BOD). The OPR is a written document that details the ideas, concepts and criteria that are defined by the owner to be important to the success of the project. The BOD includes design information necessary to accomplish the OPR, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations and guidelines. Achievement of these goals begins in the Pre-Design phase, continues through the Design, Construction and Acceptance Phases and concludes in the Post-Acceptance Phase with actual verification of performance. Commissioning shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training. The commissioning process will be directed by an independent, third-party Commissioning Authority (CA) whose services will be provided by DCAMM.

1. In addition to collaborating in the development of the project's BOD and OPR, during the Pre-Design Phase the Commissioning Authority shall review the size and skill levels of the Owner's maintenance staff in relation to the requirements of the new building in order to fill any deficiencies.
2. In the Design Phase the Commissioning Authority shall complete the following tasks:
   a. Write commissioning specifications that define contractor responsibilities and provide samples of required commissioning documentation (based on the most recent industry-accepted format) to the Designer for integration into the project specifications.
   b. Develop the Commissioning Plan, detailing commissioning team organization, schedule, training and documentation requirements. Include all related testing, verification and quality control procedures.
   c. Establish the schedule for all commissioning activities, including periodic design reviews. Insure that commissioning activities do not interfere with any phase of the project.
   d. Review the design calculations and performance criteria for the project, identifying operation and maintenance problems. Provide written comments and a checklist of

required actions to be completed by the Designer prior to phase approval and recommend alternatives where appropriate.

e. Check and confirm that the BOD includes all of the elements defined in the OPR at the end of the Design Phase.

3. In the Construction Phase the Commissioning Authority shall complete the following tasks:
   a. Update the Commissioning Plan to reflect any changes in the BOD.
   b. Coordinate the commissioning process with the Project Team through project planning and scheduled meetings.
   c. Review contractor submittals in collaboration with the Project Team for conformance to project specifications and operation and maintenance requirements and report findings.
   d. Observe and document system verification checks.
   e. Observe and document equipment and system start-ups.
   f. Document testing and balancing work.
4. In the Acceptance Phase the Commissioning Authority shall complete the following tasks:
   a. Monitor and document functional performance tests on all building systems in collaboration with the Project Team.
   b. Review O&M documentation and develop O&M training plans and videos. Ensure that the Owner's staff is able to operate and maintain all building systems.
   c. Review all as-built documents and warranty information in collaboration with the Project Team. Submit warranty information and preventive maintenance schedules for all building systems in a comprehensive, five-year preventive maintenance plan. The format for this submittal shall be approved jointly by DCAMM and the Owner. This submittal shall also include list(s) of recommended spare parts, bench stock and special tools/equipment required for the first year of building operation.
   d. Convene and chair a comprehensive final debriefing with the entire Project Team (including the owner's maintenance staff) to coordinate correction of any required re-testing and identification of any training deficiencies prior to building turnover.
   e. In collaboration with the Designer, Contractor(s) and General Contractor populate all operational information, including equipment data, for each building system in the digital format specified by DCAMM.
5. In the Post-Acceptance Phase the Commissioning Authority shall complete the following tasks:
   a. Coordinate with the project team to ensure that any required "off-season" tests are completed.
   b. Ensure that any required changes are provided as written updates in the project documentation.
   c. Confirm that all equipment continues to perform as designed and alert the Owner to any warranty claims by providing a review of all system warranties prior to their one-year expiration date.
   d. Document the estimated savings generated by the commissioning process through specific examples of avoided costs collected during all project phases. The required format will be provided by DCAMM. Compare the actual tested performance of the building's completed systems with established standards.
   e. Implement a measurement and verification (M&V) plan consistent with Option D: Energy Conservation Measure Isolation as specified in the International Performance Measurement & Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction,

April, 2003. The M&V period must cover at least one year of post-construction occupancy.

6. The commissioning process does not eliminate or reduce the responsibility of the system designers and installing contractors to provide a finished and fully functioning product.

B. Commissioning Authority: The Commissioning Authority directs and approves the commissioning work.

C. Responsibility of Disciplines: The parties listed below are part of the commissioning team and will be required to participate in the commissioning process. The responsibilities relative to commissioning for each of these parties is defined in this section.

1. Designer
2. Engineer
3. Owner
4. Commissioning Authority
5. General Contractor
6. Mechanical/Electrical Coordinator
7. Test Technician
8. Mechanical Contractor
9. Plumbing Contractor
10. Fire Protection Contractor
11. Electrical Contractor
12. Controls Contractor
13. Testing, Adjusting and Balancing Contractor
14. All Subcontractors and equipment suppliers/manufacturers that are associated with the above disciplines.

D. Abbreviations:

1. The following are common abbreviations used in the Specifications and in the commissioning process. Definitions are found in Section 1.11.

A/E-	Designer and Design Engineers	EC-	Electrical Contractor
CA-	Commissioning Authority	FM-	Facility Manager
CC	Controls Contractor	FT-	Functional Performance Test
MC-	Mechanical Contractor	GC-	General Contractor (prime)
PC-	Prefunctional Checklist	Subs-	Subcontractors
Cx-	Commissioning	TAB-	Test and Balance Contractor
MEC	Mechanical/Electrical Coordinator	TT	Test Technician

1.3 COORDINATION

A. Commissioning Team. The members of the commissioning team consist of the Commissioning authority (CA), Facility Manager (FM), the designated representative of the General Contractor (GC), the Designer and design engineers (A/E), the Mechanical Contractor (MC), the Electrical Contractor (EC), the TAB representative, the Controls Contractor (CC), Mechanical/Electrical Coordinator (MEC), Test Technician (TT) and any other installing Subcontractors or suppliers

of equipment. The Owner's building or plant operator/engineer is also a member of the commissioning team.

B. Management: The CA is hired by DCAMM, directs and coordinates all commissioning activities and reports to the Owner. All Project Team members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.

C. Scheduling: The CA will work with the General Contractor according to established protocols to schedule commissioning activities. The CA will provide sufficient notice to the General Contractor and/or MEC for scheduling commissioning activities. The General Contractor will 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.

1. The CA will provide the initial schedule of primary commissioning events at the commissioning scoping meeting. As construction progresses more detailed schedules are developed by the CA and are incorporated into the project schedule by the General Contractor.

1.4 COMMISSIONING PROCESS

A. Commissioning Process. The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.

1. Commissioning during construction begins with a scoping meeting conducted by the CA wherein the commissioning process is reviewed with the commissioning team members.
2. Additional meetings scheduled by the CA will be required throughout construction, to plan, scope, coordinate, and schedule future activities and resolve problems.
3. Equipment documentation is submitted to the Engineer during normal submittals, including detailed start-up procedures. The CA will review and comment on applicable items.
4. The Subcontractors develop startup plans and startup documentation formats and provide to the CA. The CA uses this information to supplement prefunctional checklists to be completed, during the startup process.
5. The Subcontractors execute and document the prefunctional checklists and perform startup and initial checkout. The CA documents that the checklists and startup were completed according to the approved plans. This may include the CA witnessing start-up and prefunctional tests of selected equipment.
6. The CA develops specific equipment and system Functional Performance Test procedures. The Subcontractors review the procedures.
7. The procedures are executed by the Subcontractors, and witnessed and documented by the CA. The Owner's FM is also invited to witness testing.
8. Items of non-compliance in material, installation, or setup are corrected at the Sub's expense and the system in question is retested.
9. The CA reviews the O&M documentation for completeness.
10. The CA approves the training plan and audits training.
11. The CA assembles all project documentation into Systems Manuals
12. Deferred testing is conducted, as specified or required.

1.5 RELATED WORK

A. All of the following sections apply to the Work of this section. This list does not limit the work that may be required by the General Contractor under additional specification section for the completion of the Commissioning process.

1. Section 017700 - CONTRACT CLOSEOUT
2. Section 013100 - PROJECT MANAGEMENT AND COORDINATION
3. Section 140001 - ELEVATORS
4. Section 210001 - FIRE PROTECTION
5. Section 220001 - PLUMBING
6. Section 230001 - HEATING, VENTILATING AND AIR CONDITIONING
7. Section 260001 - ELECTRICAL WORK

1.6 COMMISSIONING COMPLETION

A. Prerequisites to functional completion

1. All TAB work and commissioning activities must be complete prior to Functional Completion, unless approved in writing by the CA. Exceptions to this are the planned control system training performed after occupancy and any required seasonal or approved deferred testing. This requirement covers all systems, but is not limited to:
   a. Completed and signed start-up and prefunctional checklist documentation
   b. Requested trend log data
   c. Submission of final approved TAB report
   d. Completion of all functional testing
   e. Required training of Owner maintenance personnel
   f. Submission of the approved O&M manuals
   g. All identified deficiencies have been corrected or are approved by the DCAMM Project Manager to be excepted from this milestone.

B. The General Contractor will determine the date of Functional Completion after reviewing the Commissioning Agent's recommendation for Functional Completion.

C. Commissioning activities are non-compensable and cannot be a cause for delay claims.

1.7 SYSTEMS TO BE COMMISSIONED

A. The following systems will be commissioned in this project, but this list does not limit the testing that may be required to achieve LEED certification of the project by the United States Green Building Council. Testing requirements are part of this section. Each member of the commissioning team shall review all test procedures in this section to determine if his/her presence is required for each test (for example, certain tests of mechanical equipment may require the support of electrical personnel and vice versa)

Equipment and System	Functional Test Requirements Specified In:
Plumbing System	
Plumbing Water System	3.12
HVAC System	
Hot Water Heating System (Boilers, Pumps, Distribution	3.13
Terminal Units (FCU, FPT, VAV, CUH, UH)	3.14
Packaged DX Split System Air Conditioning or Heat Pump	3.15
Exhaust Fans	3.16
Building Automation System (BAS)	3.17
Test and Balance Work (TAB)	3.18
Air Handling Units (Recirculating and 100% O.A.)	3.19
Cold Water Cooling System (Chillers, Cooling Towers, Pumps, Distribution)	TBD
Electrical System	
Emergency Lighting~~Emergency Generator(s)~~	3.21~~3.20~~
Fire Alarm System~~Emergency Lighting~~	3.22~~3.21~~
Short Circuit Trip~~Fire Alarm System~~	3.23~~3.22~~
Lighting Control System~~Short Circuit Trip~~	3.24~~3.23~~
Automatic Transfer Switch(es)~~Lighting Control System~~	3.25~~3.24~~
~~Automatic Transfer Switch(es)~~	~~3.25~~
Life Safety System	
~~Life Safety System~~	
Fire alarm system	TBD
Fire suppression/protection systems~~Fire alarm system~~	TBD~~TBD~~
Egress pressurization systems~~Fire suppression/protection systems~~	TBD~~TBD~~
~~Egress pressurization systems~~	~~TBD~~
Other	
~~Other~~	
Telecommunications System	
~~Telecommunications System~~	

1.8 RESPONSIBILITIES

A. The responsibilities of all parties in the commissioning process are provided in this section.

B. All Parties:

1. Attend commissioning scoping meeting and additional meetings, as necessary.

C. Designer (of A/E):

1. Construction Phase
   a. Attend the commissioning scoping meeting and selected commissioning team meetings.
   b. Perform normal submittal review, construction observation, as-built drawing preparation, O&M manual preparation, etc., as contracted.
   c. Provide any design narrative documentation requested by the CA.
   d. Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.
   e. Prepare and submit design intent documentation clarifications for inclusion in the O&M manuals. Review and approve the O&M manuals.
2. Post Construction Phase
   a. Coordinate resolution of design non-conformance and design deficiencies identified during warranty-period commissioning.

D. Design Engineer:

1. Construction Phase
   a. Perform normal submittal review, construction observation, as-built drawing preparation, etc., as contracted. One site observation should be completed just prior to system startup.
   b. Provide any design narrative and sequences documentation requested by the CA. The designers shall assist (along with the contractors) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation are not sufficient for writing detailed testing procedures.
   c. Participate in the resolution of system deficiencies identified during commissioning, according to the contract documents.

E. Commissioning Authority (CA): The CA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CA may assist with problem-solving, non-conformance or the resolution of deficiencies, but the ultimate responsibility resides with the General Contractor and the A/E. The primary role of the CA is to observe and document performance and confirm that systems are functioning in accordance with the Owner's Project Requirements (OPR), documented design intent (BOD) and the Contract Documents. Contractors will provide all tools and equipment to start and functionally test building equipment and systems.

1. Construction Phase
   a. Coordinate and direct the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.
   b. Submit commissioning schedule to GC, MEC, TT, and A/E to ensure that commissioning activities are being scheduled into the master schedule.

c. Plan and conduct a commissioning scoping meeting and other commissioning meetings.
d. Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures.
e. Before startup review the current control sequences and interlocks and work with contractors and design engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.
f. Review systems being commissioned for compliance with commissioning needs, concurrent with the A/E reviews.
g. Perform site visits, as necessary, to observe component and system installations. Attend selected planning and job-site meetings to obtain information on construction progress.
h. Verify systems startup by reviewing start-up reports and by selected site observation.
i. Review TAB execution plan.
j. Verify air and water systems balancing by spot testing, by reviewing completed reports and by selected site observation.
k. With necessary assistance and review from installing contractors, write the functional performance test procedures for equipment and systems. This may include energy management control system trending, stand-alone data logger monitoring or manual functional testing.
l. Analyze any functional performance trend logs and monitoring data to verify performance.
m. Coordinate, witness, and approve manual functional performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.
n. Maintain a master deficiency and resolution log and a separate testing record. Provide the GC, MEC, TT, and A/E with written progress reports and test results with recommended actions.
o. Witness performance testing of all other owner contracted tests or tests by manufacturer's personnel over which the CA may not have direct control (a smoke control system, for example). Document these tests and include results in Systems manuals.
p. Compile and maintain a commissioning record.
q. Review O&M manuals submitted by contractors.
r. Provide a final commissioning report (as described in this section).
s. Develop a systems manual.
t. Prepare a standard trend logging package of primary parameters that will provide the operations staff clear indications of system function in order to identify proper system operation and trouble shoot problems. The CA shall also provide any needed information on interpreting the trends.

2. Post Construction Phase
   a. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.
   b. Return to the site during the opposite season from when functional testing was performed (approximately 6 months into the Post Construction Phase) and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning.

F. General Contractor (GC), Mechanical/Electrical Coordinator (MEC), and or Test Technician (TT):

1. Construction Phase
   a. Facilitate the coordination of the commissioning work by the CA. The GC, TT, and MEC will ensure that commissioning activities are being entered into the master schedule.
   b. Attend a commissioning scoping meeting and other commissioning team meetings.
   c. Perform the normal review of Contractor submittals and completed commissioning test results.
   d. When necessary, observe and witness prefunctional checklists, startup, and functional testing of selected equipment.
   e. Review commissioning progress and deficiency reports.
   f. Coordinate the resolution of non-compliance and design deficiencies identified in all phases of commissioning.
   g. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training.
   h. Prepare and submit As-built documentation for inclusion in the O&M manuals.
   i. Provide written notice for the completion of the commissioning testing.
2. Post Construction Phase
   a. Assist the CA and User Agency as necessary in the seasonal or deferred testing and deficiency corrections required by the specifications.
   b. Ensure that any seasonal or deferred testing and any deficiency issues are addressed.

G. Mechanical, Controls, and TAB Contractors: The commissioning responsibilities applicable to each of the mechanical, controls, and TAB contractors under 1.05 RELATED WORK A. above is as follows (all references apply to commissioned equipment only):

1. Construction Phases
   a. Attend a commissioning scoping meeting and other meetings necessary to facilitate the Commissioning process.
   b. Subcontractors shall provide the CA with normal cut sheets and shop drawing submittals of commissioned equipment.
   c. Provide additional requested documentation (prior to normal O&M manual submittals) to the CA for development of start-up and functional testing procedures.
      1) Typically this documentation will clearly identify detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures. It will also include full details of any owner-contracted tests, 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. In addition, the installation, start-up, and checkout materials that are shipped with the equipment and the field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
      2) The Commissioning Agent may request further documentation necessary for the commissioning process.
      3) This data request may be made prior to normal submittals.

d. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CA and A/E for review and approval.
e. Subcontractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
f. Provide assistance to the CA in preparing the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety, and equipment protection and provide necessary written alarm limits to be used during the tests.
g. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CA for all commissioned equipment. Submit to CA and A/E for review and approval prior to startup.
h. During the startup and initial checkout process, execute the mechanical-related portions of the prefunctional checklists for all commissioned equipment.
i. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA and A/E.
j. Address current A/E punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
k. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.
l. Provide skilled technicians to perform functional performance testing under the direction of the CA for specified equipment. Assist the CA in interpreting the monitoring data, as necessary.
m. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA and A/E and retest the equipment.
n. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
o. During construction, maintain as-built drawings.
p. Provide training of the Owner's operating staff using expert qualified personnel, as specified. Maintain sign-in sheets and provide copies to CA.
q. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Post Construction Phase
   a. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.
   b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

H. Mechanical Contractor: The responsibilities of the HVAC mechanical contractor, during Construction Phases in addition to those listed in (A) are:

1. Provide startup for all HVAC equipment, except for the building automation control system.
2. Assist and cooperate with the TAB contractor and CA by:
   a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.

b. Including cost of sheaves and belts that may be required by TAB.
c. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.
d. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.

3. Install a P/T plug at each water sensor, which is an input point to the control system.
4. List and clearly identify on the as-built drawings the locations of all airflow stations.
5. Prepare a preliminary schedule for Division 15501 pipe and duct system testing, flushing, and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.
6. Notify the CA 48 hours prior to pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the General Contractor and CA ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CA has the scheduling information needed to efficiently execute the commissioning process.

I. Controls Contractor: The commissioning responsibilities of the controls contractor, during Construction Phases in addition to those listed in (A) are:

1. Sequences of Operation Submittals:
   a. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
      1) An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components, and function.
      2) All interactions and interlocks with other systems.
      3) Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
      4) Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
      5) Start-up sequences.
      6) Warm-up mode sequences.
      7) Normal operating mode sequences.
      8) Unoccupied mode sequences.
      9) Shutdown sequences.
      10) Capacity control sequences and equipment staging.
      11) Temperature and pressure control: setbacks, setups, resets, etc.
      12) Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
      13) Effects of power or equipment failure with all standby component functions.
      14) Sequences for all alarms and emergency shut downs.
      15) Seasonal operational differences and recommendations.
      16) Initial and recommended values for all adjustable settings, set points and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.

17) Schedules, if known.
18) To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.

2. Control Drawings Submittal:
   a. The control drawings shall have a key to all abbreviations.
   b. The control drawings shall contain graphic schematic depictions of the systems and each component.
   c. The schematics will include the system and component layout of any equipment that the control system monitors, enables, or controls, even if the equipment is primarily controlled by packaged or integral controls.
   d. Provide a full points list with at least the following included for each point:
      1) Controlled system
      2) Point abbreviation
      3) Point description
      4) Display unit
      5) Control point or set point (Yes / No)
      6) Monitoring point (Yes / No)
      7) Intermediate point (Yes / No)
      8) Calculated point (Yes / No)
   e. Key:
   f. Point Description: DB temp, airflow, etc.
   g. Control or Set point: Point that controls equipment and can have its set point changed (OSA, SAT, etc.)
   h. Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).
   i. Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
   j. Calculated Point: "Virtual" point generated from calculations of other point values.
3. The Controls Contractor shall keep the CA and A/E informed of all changes to this list during programming and setup.
4. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
5. Assist and cooperate with the TAB contractor in the following manner:
   a. Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).
   b. For a given area, have all required prefunctional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CA prior to TAB.
   c. Provide a qualified technician to operate the controls to assist the TAB contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.
6. Assist and cooperate with the CA in the following manner:
   a. Using a skilled technician who is familiar with this building, execute the functional testing of the controls system as specified for the controls contractor. Assist in the

functional testing of all equipment specified. Provide two-way radios during the testing.

b. Execute all control system trend logs specified.

7. The controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:
   a. System name.
   b. List of devices.
   c. Step-by-step procedures for testing each controller after installation, including:
      1) Process of verifying proper hardware and wiring installation.
      2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
      3) Process of performing operational checks of each controlled component.
      4) Plan and process for calibrating valve and damper actuators and all sensors.
      5) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
   d. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has "passed" and is operating within the contract parameters.
   e. A description of the instrumentation required for testing.
   f. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CA and TAB contractor for this determination.
8. Provide a signed and dated certification to the CA and A/E upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.
9. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as requested by the CA to demonstrate system operation.
10. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

J. TAB Contractor: The duties of the TAB contractor, in addition to those listed:

1. Six weeks prior to starting TAB, submit to the CA and A/E the qualifications of the site technician for the project, including the name of the contractors and facility managers of recent projects the technician on which was lead.
2. Submit the outline of the TAB plan and approach for each system and component to the CA, A/E, and the controls contractor six weeks prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system.
3. The submitted plan will include:
   a. Certification that the TAB contractor has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.
   b. An explanation of the intended use of the building control system. The controls contractor will comment on feasibility of the plan.

c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
e. Final test report forms to be used.
f. Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / submain proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the waterside.
g. List of all airflow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
h. Details of how total flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).
i. The identification and types of measurement instruments to be used and their most recent calibration date.
j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.
k. Confirmation that TAB understands the outside air ventilation criteria under all conditions.
l. Details of whether and how minimum outside air cfm will be verified and set, and for what level (total building, zone, etc.).
m. Details of how building static and exhaust fan / relief damper capacity will be checked.
n. Proposed selection points for sound measurements and sound measurement methods.
o. Details of methods for making any specified coil or other system plant capacity measurements.
p. Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.
q. Details regarding specified deferred or seasonal TAB work.
r. Details of any specified false loading of systems to complete TAB work.
s. Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
t. Details of any required interstitial cavity differential pressure measurements and calculations.
u. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
v. Plan for formal progress reports (scope and frequency).
w. Plan for formal deficiency reports (scope, frequency and distribution).

4. A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CA and General Contractor at least twice a week.

5. Communicate in writing to the controls contractor all set point and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.
6. Provide a draft TAB report within two weeks of completion. A copy will be provided to the CA and A/E. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE Standard 111.
7. Provide the CA and A/E with any requested data, gathered, but not shown on the draft reports.
8. Provide a final TAB report for the CA and A/E with details, as in the draft.
9. Conduct functional performance tests and checks on the original TAB as specified.

K. Electrical Contractors: The commissioning responsibilities applicable to the electrical contractor are as follows (all references apply to commissioned equipment only):

1. Construction Phases
   a. Include the cost of commissioning in the contract price, if not yet let.
   b. In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.
   c. Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the Commissioning process.
   d. Contractors shall provide normal cut sheets and shop drawing submittals to the CA of commissioned equipment.
   e. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up and functional testing procedures.
      1) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, 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 submitted to the Commissioning Agent.
      2) The Commissioning Agent may request further documentation necessary for the commissioning process.
      3) This data request may be made prior to normal submittals.
   f. Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review and approval.
   g. Subcontractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
   h. Provide assistance to the CA in preparation of the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
   i. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CA. Submit manufacturer's

detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CA for review.

j. During the startup and initial checkout process, execute and document the electrical-related portions of the prefunctional checklists provided by the CA for all commissioned equipment.

k. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA and A/E.

l. Address current A/E punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.

m. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

n. Perform functional performance testing under the direction of the CA for specified equipment. Assist the CA in interpreting the monitoring data, as necessary.

o. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, and A/E and retest the equipment.

p. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

q. During construction, maintain as-built drawings and prepare final as-built drawings at project completion.

r. Provide training of the Owner's operating personnel as specified.

s. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Post Construction Phase

a. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

1.9 TESTING REQUIREMENTS

A. Specific functional testing requirements are listed for each system in Part 3 of this section. From these requirements, the Commissioning Authority (CA) shall develop step-by-step procedures to be executed by the Subs as directed by the Commissioning Authority. The test requirements for each piece of equipment or system contain the following:

1. The contractors responsible to execute the tests, under the direction of the CA.
2. A list of the integral components being tested.
3. Prefunctional checklists associated with the components.
4. Functions and modes to be tested.
5. Required conditions of the test for each mode.
6. Special procedures.
7. Required methods of testing.
8. Required monitoring.
9. Acceptance criteria.
10. Sampling strategies allowed.

1.10 TESTING PREREQUISITES

A. The following applicable generic prerequisite checklist items are required to be listed on each written functional test form and be completed and checked off by CA prior to functional testing.

1. All related equipment has been started up and start-up reports and prefunctional checklists submitted and approved ready for functional testing:
2. All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final set points and schedules with debugging, loop tuning and sensor calibrations completed. Controls contractor to sign and date when ready.
3. Test and balance (TAB) complete and approved for the HVAC air and water systems.
4. All A/E punch list items for this equipment corrected.
5. These functional test procedures reviewed and approved by installing contractor.
6. Safeties and operating ranges reviewed by the CA.
7. Test requirements and sequences of operation attached.
8. Schedules and set points attached.
9. False loading equipment, system and procedures ready.
10. Sufficient clearance around equipment for servicing.

1.11 MONITORING

A. Monitoring is a method of testing as a stand-alone method or to augment manual testing.

B. All points listed in the required monitoring section of the test requirements which are control system monitored points shall be trended by the controls contractor. At the CA's request, the controls contractor shall trend up to 20% more points than listed herein at no extra charge.

C. Provide data electronically (Microsoft Excel) in 15 minute intervals for all analog hardware and software points.

1.12 DEFINITIONS

A. Acceptance Phase - phase of construction after startup and initial checkout when functional performance tests, O&M documentation review and training occurs.

B. Basis of Design - The basis of design is the documentation of the primary thought processes and assumptions behind design decisions that were made to meet the design intent. The basis of design describes the systems, components, conditions and methods chosen to meet the intent.

C. Control system - the central building energy management control system.

D. Data logging - monitoring flows, currents, status, pressures, etc. of equipment using stand-alone data loggers separate from the control system.

E. Deferred Functional Tests - FTs that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.

F. Deficiency - a condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not complying with the design intent).

G. Design Intent - a dynamic document that provides the explanation of the ideas, concepts and criteria that are considered to be very important to the owner. It is initially the outcome of the programming and conceptual design phases.

H. Design Narrative or Design Documentation - sections of either the Design Intent or Basis of Design.

I. Functional Performance Test (FT) - test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional 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 set point). 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. The commissioning authority develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is performed by the installing contractor or vendor. FTs are performed after prefunctional checklists and startup are complete.

J. Indirect Indicators - indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed.

K. Manual Test - using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").

L. Monitoring - the recording of parameters (flow, current, status, pressure, etc.) of equipment operation using data loggers or the trending capabilities of control systems.

M. Over-written Value - writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50F to 75F to verify economizer operation). See also "Simulated Signal."

N. Owner-Contracted Tests - tests paid for by the Owner outside the GC's contract and for which the CA does not oversee. These tests will not be repeated during functional tests if properly documented.

O. Prefunctional Checklist (PC) - a list of items to inspect and elementary component tests to conduct to verify proper installation of equipment, by the Sub. Prefunctional 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 prefunctional 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 word prefunctional refers to before functional testing. Prefunctional checklists augment and are combined with the manufacturer's start-up

checklist. The commissioning authority only requires that the procedures be documented in writing, and does not witness much of the prefunctional check listing, except for larger or more critical pieces of equipment.

P. Sampling - functionally testing only a fraction of the total number of identical or near identical pieces of equipment.

Q. Seasonal Performance Tests - FT that are deferred until the system(s) will experience conditions closer to their design conditions.

R. Simulated Condition - condition that is created for the purpose of testing the response of a system (e.g., applying a hair blower to a space sensor to see the response in a VAV box).

~~S. Simulated Signal - disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and DDC system to simulate a sensor value.~~

~~T.~~S. Startup - the initial starting or activating of dynamic equipment, including executing prefunctional checklists.

~~U.~~T. Subs - the Subcontractors to the General Contractor who provide and install building components and systems.

~~V.~~U. Test Procedures - the step-by-step process which must be executed to fulfill the test requirements. The test procedures are developed by the CA.

~~W.~~V. Test Requirements - requirements specifying what modes and functions, etc. shall be tested. The test requirements are not the detailed test procedures.

~~X.~~W. Trending - monitoring using the building control system.

~~Y.~~X. Post Construction Phase - Post Construction Phase 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.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. For example, the mechanical contractor of Division 15 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls system in Division 15, except for equipment specific to and used by TAB in their commissioning responsibilities. Two-way radios shall be provided by the Division Controller.

B. Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and left on site.

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.

PART 3 - EXECUTION

3.1 MEETINGS

A. Scoping Meeting: Within 30 days of commencement of construction, the CA will schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CA.

B. Miscellaneous Meetings: Other meetings will be planned and conducted by the CA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular Subs. The CA will plan these meetings and will minimize unnecessary time being spent by Subs.

3.2 REPORTING

A. The CA will provide regular reports to the Owner and A/E, with increasing frequency as construction and commissioning progresses.

B. The CA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.

C. Testing or review approvals and non-conformance and deficiency reports are made regularly with the review and testing as described in later sections.

3.3 SUBMITTALS

A. The Commissioning authority will review submittals related to the commissioned equipment for conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures.

B. The CA may request additional design narrative from the A/E and Controls Contractor, depending on the completeness of the design intent documentation and sequences provided with the Specifications.

3.4 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all equipment to be commissioned,

B. General:

1. Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

C. Start-up and Initial Checkout Plan:

1. The primary role of the CA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for prefunctional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms. Parties responsible for executing functional performance tests are identified in the testing requirements for each system.
2. The Subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will 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.
3. The full start-up plan could consist of something as simple as:
   a. 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.
   b. The manufacturer's normally used field checkout sheets.
4. The Subcontractors shall submit the full startup plan to the General Contractor who will be responsible for reviewing and stamping the submittal. The General Contractor shall be responsible for transmitting the full submittal to the CA and A/E for approval.

D. Sensor and Actuator Calibration:

1. All field-installed temperature, relative humidity, CO, CO2 and pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated using the methods described below. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated.
2. All procedures used shall be fully documented on the prefunctional checklists or other suitable forms, clearly referencing the procedures followed and written documentation of initial, intermediate and final results. All sensors shall be calibrated to the tolerances for the specific product.

E. Valve and Damper Stroke Setup and Check:

1. For all valve and damper actuator positions checked, verify the actual position against the BAS readout.

F. Execution of Prefunctional Checklists and Startup:

1. The CA shall observe, at minimum, the procedures for each type of equipment to be commissioned.

2. The Subs and vendors shall execute startup and provide the CA with a signed and dated copy of the completed start-up and prefunctional tests and checklists.
3. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

G. Deficiencies, Non-Conformance and Approval in Checklists and Startup:

1. The Sub Contractors shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CA within two days of test completion.
2. The CA reviews the report and submits either a non-compliance report or an approval form to the A/E and GC. When satisfactorily completed, the CA recommends approval of the execution of the checklists and startup of each system to the A/E using a standard form.

3.5 FUNCTIONAL PERFORMANCE TESTING

A. This sub-section applies to all commissioning functional testing for all divisions.

B. The general list of equipment to be commissioned is found in this section.

C. The parties responsible to execute each test are listed with each test.

D. Objectives and Scope:

1. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
2. In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested. Specific modes required in this project are given in Sections.

E. Development of Test Procedures:

1. Before test procedures are written, the CA shall obtain 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.
2. The CA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Sub or vendor responsible to execute a test, shall provide limited assistance to the CA in developing the procedures review (answering questions about equipment, operation, sequences, etc.). Prior to

execution, the CA shall provide a copy of the test procedures to the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection.

3. The CA shall review owner-contracted, factory testing or required owner acceptance tests which the CA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications. Redundancy of testing shall be minimized.
4. The test procedure forms developed shall include (but not be limited to) the following information:
    a. System and equipment or component name(s)
    b. Equipment location and ID number
    c. Date
    d. Project name
    e. Participating parties
    f. A copy of the specification section describing the test requirements
    g. A copy of the specific sequence of operations or other specified parameters being verified
    h. Formulas used in any calculations
    i. Required pre-test field measurements
    j. Instructions for setting up the test.
    k. Special cautions, alarm limits, etc.
    l. Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format
    m. Acceptance criteria of proper performance with a Yes / No check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
    n. A section for comments
    o. Signatures and date block for the CA
5. Sampling:
    a. The recommended sampling rates are specified with each type of equipment in the testing sections of this specification. It is noted that no sampling by Subs is allowed in prefunctional checklist execution. The following is an example of how multiple pieces of equipment that are identical may be tested.
        1) Randomly test at least 20% of each group of identical equipment. In no case test less than three units in each group. This 20%, or three, constitute the "first sample."
        2) If 10% of the units in the first sample fail the functional performance tests, test another 20% of the group (the second sample).
        3) If 10% of the units in the second sample fail, test all remaining units in the whole group.
    b. If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CA may stop the testing and require the responsible Sub to perform and document a checkout of the remaining units, prior to continuing with functionally testing the remaining units.

F. Coordination and Scheduling:

1. The Subs shall provide sufficient notice to the CA and General Contractor regarding their completion schedule for the prefunctional checklists and startup of all equipment and systems. The CA will schedule functional tests through the General Contractor and

affected Subs. The CA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.

2. In general, functional testing is conducted after prefunctional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CA before it is used for TAB or to verify performance of other components or systems.

G. Problem Solving:

1. The CA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the GC, Subs and A/E.

3.6 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

A. Documentation:

1. The CA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the General Contractor for review and approval and to the Subs for review. The CA will include the filled out forms in the Systems manuals.

B. Non-Conformance:

1. The CA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the General Contractor and A/E on a standard non-compliance form.
2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form.
3. Cost of Retesting:
   a. The cost for the Sub to retest a prefunctional or functional test, if they are responsible for the deficiency, shall be theirs.
   b. For a deficiency identified, not related to any prefunctional checklist or start-up fault, the following shall apply: The CA will direct the retesting of the equipment once at no “charge” to the Subs for their time.
   c. Any required retesting by any contractor shall not be considered a justified reason for a claim of delay or for a time extension by the General Contractor.

C. Approval:

1. The CA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CA and by the A/E. The CA recommends acceptance of each test to the A/E using a standard form. The CA gives final approval on each test using the same form, providing a signed copy to the General Contractor.

3.7 DEFERRED TESTING

A. Unforeseen Deferred Tests:

1. If any check or 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 CA. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.

B. Seasonal Testing:

1. During the Post Construction Phase, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing will be noted by the GC.

3.8 OPERATION AND MAINTENANCE MANUALS

A. Standard O&M Manuals:

1. The specific content and format requirements for the standard O&M manuals are detailed in the specific Sections.
2. CA Review:
   a. Prior to substantial completion, the CA shall review the O&M manuals, documentation to verify compliance with the Specifications. The CA will communicate deficiencies in the manuals to the A/E and GC. Upon a successful review of the corrections, the CA recommends approval and acceptance of these sections of the O&M manuals to the A/E and GC.
3. Final Report Details:
   a. The final commissioning report shall include an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope and a general description of testing and verification methods. For each piece of commissioned equipment, the report should contain the disposition of the commissioning authority regarding the adequacy of the equipment and documentation in the following areas: 1) Equipment meeting the equipment specifications, 2) Equipment installation, 3) Functional performance and efficiency, 4) Equipment documentation and design intent. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall also be listed. The functional performance and efficiency section for each piece of equipment shall include a brief description of the verification method used (manual testing, BAS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

3.9 TRAINING OF OWNER PERSONNEL

A. The General Contractor shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed.

B. The CA shall be responsible for approving the content and adequacy of the training of Owner personnel for commissioned equipment.
   1. The CA shall interview the facility manager and lead engineer to determine the special needs and areas where training will be most valuable. The Owner and CA shall decide how rigorous the training should be for each piece of commissioned equipment. The CA shall communicate the results to the Subs and vendors who have training responsibilities.
   2. In addition to these general requirements, the specific training requirements of Owner personnel by Subs and vendors is specified in the specific Sections.
   3. Each Sub and vendor responsible for training will submit a written training plan to the CA for review and approval prior to training. The plan will cover the following elements:
      a. Equipment (included in training)
      b. Intended audience
      c. Location of training
      d. Objectives
      e. Subjects covered (description, duration of discussion, special methods, etc.)
      f. Duration of training on each subject
      g. Instructor for each subject
      h. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)
      i. Instructor and qualifications
   4. For the primary HVAC equipment, the Controls Contractor shall provide a short discussion of the control of the equipment during the mechanical or electrical training conducted by others.
   5. The CA develops an overall training plan and coordinates and schedules, with the GC. The CA develops criteria for determining that the training was satisfactorily completed, including attending some of the training, etc. The CA recommends approval of the training to the A/E and General Contractor using a standard form.
   6. The design engineer shall at the first training session present the overall system design concept and the design concept of each equipment section. This presentation shall be 8 hours in length and include a review of all systems using the simplified system schematics (one-line drawings) including boiler water systems, AHU systems, heating systems, fuel gas supply systems, supply air systems, exhaust system and outside air strategies, dust collection and BAS system.

PLUMBING

3.10 PLUMBING WATER SYSTEM

A. Parties Responsible to Execute Functional Test

   1. CA: witness and document testing.
   2. Plumbing Contractor to make all adjustments.

B. Integral Components or Related Equipment Being Tested

   1. This procedure applies to the following systems:
      a. Hot and Cold Domestic Water Systems
      b. Hot and Cold Non-Potable Water Systems

2. Hot water heaters (heaters, mixing valves)
3. Recirculating pumps

C. Prerequisites: The applicable prerequisite checklist items shall be checked off prior to functional testing. The commissioning agent may also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods and Seasonal Test Requirements

Function/Mode	Test Method
1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied & manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with.	Manual
2. Verify schedules and set points to be reasonable and appropriate	
3. Mixing valve operation and temperature control	Either
4. Sensor calibration checks on hot water temperature	Manual

E. Special Procedures (other equipment to test with, etc.; reference to function ID)

1. None

F. Required Monitoring

1. None

G. Acceptance Criteria (Referenced by function or mode ID)

1. For the conditions, sequences and modes tested, equipment responds to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

H. Sampling Strategy for Identical Units

1. No sampling. Test all units.

END OF PLUMBING WATER SYSTEM

MECHANICAL

3.11 HOT WATER HEATING SYSTEM (BOILERS, PUMPS, DISTRIBUTION)

A. Parties Responsible to Execute Functional Test:

1. Vendor Support Representative
2. Controls Contractor: Operate the controls, as needed
3. HVAC mechanical contractor or vendor: Assist in testing sequences
4. CA: To witness and document testing

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Boilers
2. HW pumps
3. HW pump VFDs
4. Burner and blower
5. Pressurized compression tank and air separation
6. Water treatment and water makeup systems

C. Prerequisites:

1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods and Seasonal Test Requirements.

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Function / Mode	Test Method Manual, Monitoring, Either or Both	Required Seasonal Test[1]
General 1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied & manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks with which it is associated.	Manual	
In addition to, or as part of (1) above, the following modes or tests are required:		
2. Supply pump staging, bypass valve operation, if no VFD and HWT reset. VFD operation: modulation to minimum, control system PID, proportional band of speed vs controlling parameter, verification of program settings,, alarms, etc.	Both	Heating
3. Check all alarms and safeties (high and low pressure and temperature, etc.), PRV and flow switch functions	Manual	
4. Test each possible lead boiler as lead boiler, and each pump as lead pump. Test pump lockouts.	Manual	
5. Verify boiler inlet/outlet pressures with startup report and manufacturer's recommendations.	Manual	
6. Sensor and actuator calibration checks on: HWST, HWRT, pressure sensor controlling pump speed, mixing valve and other random checks (EMS readout against hand-held calibrated instrument must be within 0.5°F for temps. or within a tolerance	Manual	

Function / Mode	Test Method Manual, Monitoring, Either or Both	Required Seasonal Test[1]
equal to 10% of the pressure set point, with a test gage).		
7. Constancy of differential pressure (pump control parameter)	Monitoring	Heating
8. Trend all temperature, pressure, speed and control points from the start of functional performance testing until Post Construction Phase is complete.	Monitoring	Both
9. Burner operation and controls, fuel gas pilot, flow and pressure, flue gases and barometric dampers outlet temperature emission controls.		
10. Water treatment, water levels, pressure and temperature safeties and alarms.		
11. Verify schedules and set points to be reasonable and appropriate		

E. Special Procedures (other equipment to test with, etc.; reference to function ID):

1. False load boiler, if necessary.
2. Testing of boiler safety valves.
3. Boiler inspector's tests.

F. Acceptance Criteria (referenced by function or mode ID):

1. For the conditions, sequences, and modes tested, the boilers, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.
2. Boiler shall maintain the supply water set point to within +/- 3.0F of set point dead band without excessive hunting.
3. Pumping system and controls shall maintain the current desired pressure set point to within an amount equal to 10% of the set point value either side of the dead band without excessive hunting.
4. Max sound: 84 dBA
5. Gas pressure: 2.5" wC, 85% efficiency
6. Max pressure: 160 PSIG
7. Emissions < 200 ppm CO, < 20 ppm NOx

G. Sampling Strategy for Identical Units: No sampling, test all.

END OF HOT WATER HEATING SYSTEM (BOILERS, PUMPS, DISTRIBUTION)

3.12 TERMINAL UNITS (FCU, FPT, VAV, CUH, UH)

A. Parties Responsible to Execute Functional Test:

1. Controls Contractor: Operate the controls to activate the equipment.
2. CA to record results.

3. Mechanical Contractor to make any adjustments.

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. VAV Boxes w/ and w/o Reheat Coils
2. Radiation
3. Unit Heaters
4. Air Handling Systems

C. Prerequisites:

1. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Function/Mode	Test Method Manual, Monitoring, Either or Both[2]	Required Seasonal Test[1]
General 1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, warm-up, shutdown, unoccupied & manual modes and power failure and restoration. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with, including all damper, valve and fan functions.	Manual	
In addition to, or as part of (1) above, the following modes or tests are required:		
2. Sensor activator calibration checks on: SAT, zone air temperature damper position and other random checks (EMS readout against visual or hand-held calibrated instrument must be within 0.5°F for temps. or within a tolerance equal to 10% of static pressure set point, with an inclined manometer)	Manual	
3. Device and actuator calibration and stroke checks for heating coil valve and dampers	Manual	
4. For the TU's tested, check the prefunctional checklist items.	Observation	
5. Verify control parameters and set points to be reasonable and appropriate by reviewing the full program of 5% of all the TU's with each other for consistency. Verify the max. and min. cfm set points of all tested TU's against the control drawing and TAB values. Verify other TU programming parameters such as K-	Observation	

Function/Mode	Test Method Manual, Monitoring, Either or Both[2]	Required Seasonal Test[1]
factors, dead bands, set points, stroke times, etc.		
6. Verify proper operation of valve in both cooling and heating modes under occupied and unoccupied conditions.	Both	Both
7. Verify no hunting or significant overshoot by valves and dampers.	Either	
8. Verify by measurement, CCV & HCV positive shutoff (no leak-thru)	Manual	
9. All alarms (fan status, low limits, etc.)	Manual	
10. Verify that TU is maintaining space set point temperatures and fans are being cycled as specified	Monitoring	Both Design
11. Trend all temperature, pressure, speed and control points from the start of functional performance testing until Post Construction Phase is complete.	Monitoring	Both

E. Special Procedures (other equipment to test with, etc.; reference to function ID): None

F. Acceptance Criteria (referenced by function or mode ID):

1. For the conditions, sequences and modes tested, the TU, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.
2. Space temperature during occupied modes shall average within +/- 1°F of set point and always remain within 1°F of the ends of the dead band without excessive hunting of the coil valve or complaints of drafts or stuffiness from occupants.

G. Sampling Strategy for Identical:

1. Units of the same type and function, but different in size, are considered identical for sampling purposes.
2. Testing:
   a. Randomly test at least 25% of each group of identical equipment (the 1st sample). In no case test less than three units in each group. If 10% of the units in the first sample fail the functional performance tests, test another 10% of the group (the 2nd sample). If 10% of the units in the 2nd sample fail, test all remaining units in the whole group, fully at the contractor's expense. This sampling applies to the testing subsections. That is, if calibration is off on more than 10% of the tested piece of equipment, then another sample shall have calibrations checked, but not all other tests need to be done on the second sample.
3. Monitoring:
   a. Twenty five percent of the total number of zones in the building, chosen by the Owner, shall be monitored. Within this 25%, shall be included a distribution of all air handlers, zones expected to have the greatest heating and cooling demand, perimeter and core zones and zones identified from the commissioning process that have exhibited potential problems.

END OF TERMINAL UNITS (FCU, FPT, VAV, CUH, UH)

3.13 PACKAGED DX SPLIT SYSTEM AIR CONDITIONING OR HEAT PUMP

A. Parties Responsible to Execute Functional Test:

1. Controls Contractor: Operate the controls to activate the equipment.
2. CA: To witness and document testing.
3. TAB Contractor to verify airflows.
4. Unit Manufacturer's Representative.

B. Integral Components or Related Equipment Being Tested:

1. Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.
   a. Unit (fans, coils, condenser, compressors, ducts, VFD)

C. Prerequisites:

1. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Function / Mode	Test Method Manual, Monitoring, Either or Both[2]	Required Seasonal Test[1]
General 1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied & manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with.	Manual	
In addition to, or as part of (1) above, the following modes or tests are required:		
2. Supply air, and reset temp. control functions	Both	
3. SF, RF and exhaust fan interlocks	Either	
4. Compressor unloading & condenser fan staging for head pressure control	Both	
5. Damper interlocks and correct modulation in all modes, including fire and smoke dampers	Manual	
6. Temperature difference across cooling coils	Manual	

Function / Mode	Test Method Manual, Monitoring, Either or Both[2]	Required Seasonal Test[1]
7. Verify TAB reported SF cfm with control system reading	Manual	
8. All alarms (low limits, high static, freezestat, etc.)	Manual	
9. Unit cooling capacity tests	Manual	Design
10. Sensor and actuator calibration checks on: SAT, RAT, and other random checks (EMS readout against hand-held calibrated instrument must be within 0.5°F for temps. or within a tolerance equal to 10% of static pressure set point, with an inclined manometer)	Manual	
11. Trend all temperature, pressure, speed and control points from the start of functional performance testing until Post Construction Phase is complete.	Monitoring	Both
12. Verify control strategies, schedules and set points to be reasonable and appropriate		

E. Special Procedures (other equipment to test with, etc.; reference to function ID): None

F. Acceptance Criteria (referenced by function or mode ID):

1. For the conditions, sequences and modes tested, the system, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

G. Sampling Strategy: Test all units.

END OF PACKAGED DX SPLIT SYSTEM AIR CONDITIONING OR HEAT PUMP

3.14 EXHAUST FANS

A. Parties Responsible to Execute Functional Test

1. Controls Contractor: Operate the controls to activate the equipment.
2. CA: To witness and document testing.
3. TAB Contractor to verify airflows.
4. Mechanical Contractor to make any adjustments.

B. Integral Components or Related Equipment Being Tested: Prefunctional checklists must be complete for all of the components listed below prior to performing this functional test.

1. Controls
2. Terminal equipment

C. Prerequisites: The applicable prerequisite checklist items shall be signed off prior to functional testing. The commissioning agent may spot-check misc. items and calibrations on the prefunctional checklists before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

Function/Mode	Test Method	Seasonal Test
General 1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied & manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with.	Manual	
2. Verify schedules and set points to be reasonable and appropriate		
3. Function at fire alarm (off, depressurization, etc.)	Manual	
4. Check TAB report record of sound power level tests and space pressures and compare to specifications	Review	
5. Sensor calibration checks on any controlling temperature or pressure sensor	Manual	

E. Special Procedures (other equipment to test with, etc.; reference to function ID)

1. None.

F. Acceptance Criteria (referenced by function or mode ID)

1. For the conditions, sequences and modes tested, the fans, integral components and related equipment respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF EXHAUST FANS

3.15 BUILDING AUTOMATION SYSTEM (BAS)

A. Parties Responsible to Execute Functional Test:

1. Controls Contractor: Operate the controls to activate the equipment.
2. CA: To witness and document testing.

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Building Automation System
2. All prefunctional checklists of controlled equipment

C. Prerequisites:

1. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. A significant part of the BAS functional testing requirements is the successful completion of the functional tests of equipment the BAS controls or interlocks with. Uncompleted equipment functional tests or outstanding deficiencies in those tests lend the required BAS functional testing incomplete.

E. Integral or stand-alone controls are functionally tested with the equipment they are attached to, including any interlocks with other equipment or systems and thus are not covered under the BAS testing requirements, except for any integrated functions or interlocks listed below.

F. In addition to the controlled equipment testing, the following tests are required for the BAS, where features have been specified. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in the specifications.

Function/Mode	Test Method Manual (demonstration), Monitoring, Either or Both
MISC. FUNCTIONS	
1. All specified functions and features are set up, debugged and fully operable	Verbal discussion of features
2. Power failure and battery backup and power-up restart functions	Demonstration
3. Specified trending and graphing features demonstration	See equipment trends
4. Global commands features	Demonstration
5. Security and access codes	Demonstration
6. Occupant over-rides (manual, telephone, key, keypad, etc.)	Demonstration
7. O&M schedules and alarms	Demonstration
8. Scheduling features fully functional and setup, including holidays	Observation in terminal screens or printouts
9. Included features not specified to be setup are installed (list)	Demonstration
10. Demonstrate functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad	Demonstration of 100% of panels and 10% of ports
11. All graphic screens and value readouts completed	Demonstration
12. Set point changing features and functions	Done during equipment testing
13. Communications to remote sites	Demonstration
14. Sensor calibrations	Sampled during equipment tests
15. Final as-builts or redlines (per spec) control drawings, final points list, program code, set points, schedules, warranties, etc. per specs, submitted for O&Ms.	Observation
16. Verify that points that are monitored only, having no control	Observation

Function/Mode	Test Method Manual (demonstration), Monitoring, Either or Both
function, are checked for proper reporting to BAS.	
17. Optional Start/Stop Routine.	
18. Final room numbers programmed into system.	
19. Worcester standard point naming conventions used.	
INTEGRATED TESTS	
20. Fire alarm interlocks and response	Demonstration
21. Demand limiting (including over-ride of limiting)	Monitoring
22. Sequential staging ON of equipment	Either
23. All control strategies and sequences not tested during controlled equipment testing	Either
24. Other integrated tests specified in the contract documents	
25. Emergency power operation and return to normal power.	
26. Fire protection and suppression systems	Demonstration

G. Special Procedures (other equipment to test with, etc.; reference to function ID): None

H. Acceptance Criteria (referenced by function or mode ID):

1. For the conditions, sequences and modes tested, the BAS, integral components and related equipment respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF BUILDING AUTOMATION SYSTEM (BAS)

3.16 TEST AND BALANCE WORK (TAB)

A. Parties Responsible to Execute Functional Test:

1. TAB Contractor: Perform checks using test instruments.
2. Controls Contractor: Operate the controls to activate the equipment.
3. CA: To witness and document testing.

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. TAB water-side
2. TAB air-side
3. TAB equipment and systems
4. TAB electrical

C. Prerequisites

1. The applicable prerequisite checklist items listed in the beginning of this Section shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Purpose:

1. The purpose of this test is to spot check the TAB work to verify that it was done in accordance with the contract documents and acceptable practice and that the TAB report is accurate.

E. The following tests and checks will be conducted. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Test or Check	Test Method	Required Seasonal Test[3]
1. A random sample of up to 5 % the TAB report data shall be selected for verification (air velocity, air or water flow rate, pressure differential, electrical or sound measurement, etc.). The original TAB contractor will execute the checks, witnessed by the commissioning authority. The TAB contractor will use the same test instruments as used in the original TAB work. A failure[1] of more than 10% of the selected items of a given system[2] shall result in the failure of acceptance of the system TAB report and the TAB contractor shall be responsible to rebalance the system, provide a new system TAB report and repeat random verifications of the new TAB report. The random testing will include the verification of minimum outdoor air intake flows at minimum, maximum and intermediate total airflow rates for 100% of the air handlers. Other selected data to be verified will be made known upon day of testing.	Demonstration	
2. Verify that final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked by the TAB Contractor.	Demonstration	
3. Verification that the air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity. This shall include a review of TAB methods, control set points established by TAB and a physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all TUs taking off downstream of the static pressure sensor, the TU on the critical leg has its damper 90% or more open.	Demonstration	

Test or Check	Test Method	Required Seasonal Test[3]
4. Verification that the water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity. This shall include a review of TAB methods, control set points established by TAB and a physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90% or more open.	Demonstration	

[1]Failure of an item is defined as follows:
For airflow of supply and return: a deviation of more than 10% of instrument reading
For minimum outside airflow: 20% of instrument reading (30% for reading at intermediate supply flow for inlet vane or VFD OSA compensation system using linear proportional control)
For temperatures: a deviation of more than 1°F
For air and water pressures: a deviation of more than 10% of full scale of test instrument reading
For sound pressures: a deviation of more than 3 decibels. (Variations in background noise must be considered)

[2]Examples of a "system" are: the air distribution system served by one air handler or the hydronic hot water supply system served by a boiler. Systems can be defined smaller if inaccuracies in TAB work within the smaller defined system will have little or no impact on connected systems.

[3]Cooling season, Heating season or Both. "Design" means within 5°of season design (ASHRAE 2 1/2%), or 95% of loading design. A blank cell denotes no special seasonal test is required and that test can be executed during any season, if condition simulation is appropriate.

F. Special Procedures (other equipment to test with, etc.; reference to function ID): None

G. Required Monitoring: None

H. Acceptance Criteria (referenced by function or mode ID): Provided in footnote to test table above.

I. Sampling Strategy for Identical Units: Described in test table above.

END OF TEST AND BALANCE WORK (TAB)

3.17 AIR HANDLING UNITS (RECIRCULATING AND 100% O.A.)

A. Parties Responsible to Execute Functional Test

1. Controls Contractor: Operate the controls to activate the equipment.
2. CA: To witness and document testing.
3. TAB Contractor to verify air and water flows.
4. Mechanical Contractor to fix any problems.
5. Unit Manufacturer's Representative.

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Chilled Water System to cooling section
2. Hot water heating system or gas to unit heating section

C. Prerequisites:

1. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods :

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Function / Mode	Test Method Manual, Monitoring, Either or Both[2]	Required Seasonal Test[1]
General 1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied & manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with.	Manual	
In addition to, or as part of (1) above, the following modes or tests are required:		
2. Hot water coil and face and bypass dampers temperature control functions	Both	Heating
3. Economizer functions	Both	Cooling
4. SF, RF and exhaust fan interlocks	Either	
5. Damper interlocks and correct modulation in all modes, including fire and smoke dampers and CO_2 control	Manual	
6. Temperature difference across heating and cooling coils	Manual	Both
7. Smoke detectors and smoke evac control from fire alarm control panel.	Manual	
8. Verify TAB reported SF and RF cfm with control system reading	Manual	
9. All alarms (low limits, high static, freezestat, etc.)	Manual	
10. Supply and return fans static pressure and volume matching control	Monitoring	Design
11. Sensor and actuator calibration checks on: SAT, MAT, OSAT, CO_2, economizer and RA dampers and other random checks (EMS readout against hand-held calibrated instrument must be within 0.5°F for temps. or within a tolerance equal to 10% of static pressure set point, with an inclined manometer)	Manual	
12. Trend all temperature, pressure, speed and control points from the	Monitoring	Both

Function / Mode	Test Method Manual, Monitoring, Either or Both[2]	Required Seasonal Test[1]
start of functional performance testing until Acceptance Phase is complete. Provide CA with all requested data until approved.		
13. Verify control strategies, schedules and set points to be reasonable and appropriate		

E. Special Procedures (other equipment to test with, etc.; reference to function ID): None

F. Acceptance Criteria (referenced by function or mode ID):

1. For the conditions, sequences and modes tested, the system, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

G. Sampling Strategy: Test all units.

END OF AIR HANDLING UNITS (RECIRCULATING AND 100% O.A.)

ELECTRICAL ((SAMPLE: to be modified by Designer to suit project conditions))

~~3.18 EMERGENCY GENERATOR~~

~~. Parties Responsible to Execute Functional Test~~

~~0. Vendor Support Representative~~
~~0. Electrical Contractor~~
~~0. CA: To witness and document testing~~

~~. Integral Components or Related Equipment Being Tested: Prefunctional Test Complete?~~

~~0. Generator Motor~~
~~0. Generator Cooling System~~
~~0. Generator Fuel System~~
~~0. Phase Rotation~~

~~. Prerequisites:~~

~~0. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.~~

~~. Functions/Modes Required To Be Tested, Test Methods:~~

0. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Function/Mode	Test Method Manual, Monitoring, Either or Both	Required Seasonal Test[1]
General 1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, remote annunciation. Test functionality of this piece of equipment or system in all control strategies or interlocks with which it is associated.	Manual	Both
2. Stimulate power outage and subsequent automatic transfer switch operation(s)	Manual	
3. Generator start capability upon signal from ATS upon loss of utility power	Manual	
4. Check all alarms and annunciators local and remote and remote	Manual	
5. Demonstrate interior of enclosure operational, i.e., lighting, battery chargers, etc.	Manual	
6. Demonstrate proper functioning of governor and regulator	Manual	
7. Verify operation of all mechanical equipment elevators and fire pump from generator power and restart upon re-energizing normal power.		

[1]Cooling season, Heating season or Both. "Design" means within 5°of season design (ASHRAE 2 1/2%), or 95% of loading design. A blank cell denotes no special seasonal test is required and that test can be executed during any season, if condition simulation is appropriate.

. Acceptance Criteria (referenced by function or mode ID):

0. For the conditions, sequences and modes tested, the generator, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF EMERGENCY GENERATOR

3.813.18 EMERGENCY LIGHTING

A. Parties Responsible to Execute Functional Test:

1. Electrical Contractor
2. CA: To witness and document testing

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Emergency Lighting Fixtures
2. Emergency Bypass Relays

C. Prerequisites:

1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Function / Mode	Test Method Manual, Monitoring, Either or Both	Required Seasonal Test
General 1. Test all manual controls individually.	Manual	
2. Demonstrate all automatic functions using manual control overrides.		
3. Demonstrate all interlocking functions, i.e., security/fire alarm.		

E. Acceptance Criteria

1. Acceptance is achieved when all functions of the specified system have been demonstrated.

F. Sample strategy for identical units: No sampling, test all.

END OF EMERGENCY LIGHTING

~~3.82~~3.19 SHORT CIRCUIT TRIP

A. Parties Responsible to Execute Functional Test:

1. Electrical Contractor
2. CA: To witness and document testing

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Breaker trip settings for all adjustable trip type breakers

C. Prerequisites:

1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the

prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Function/Mode	Test Method Manual, Monitoring, Either or Both	Required Seasonal Test
General 1. Review breaker settings per the short circuit protection study.	Manual	

E. Acceptance Criteria (referenced by function or mode ID):

1. System is in compliance when trip settings are observed to be coordinated with report recommendations.

F. Sampling strategy for identical units: No sampling, test all.

END OF SHORT CIRCUIT TRIP

~~3.83~~3.20 LIGHTING CONTROL SYSTEM

A. Parties Responsible to Execute Functional Test:

1. Vendor Support Representative
2. Electrical Contractor
3. CA: To witness and document testing

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Head end system (PC)
2. Relay panels
3. Occupancy sensors
4. Low voltage switches
5. Daylight switches and override
6. System software

C. Prerequisites:

1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Function/Mode	Test Method Manual, Monitoring, Either or Both	Required Seasonal Test
General 1. Demonstrate all functions of the lighting control/low voltage switching system and head end equipment.	Manual	

E. Acceptance Criteria (referenced by function or mode ID):

1. Acceptance is achieved when all lighting functions are successfully demonstrated.

F. Sampling Strategy for Identical Units: No sampling, test all.

END OF LIGHTING CONTROL SYSTEM

~~3.84~~3.21 AUTOMATIC TRANSFER SWITCH(ES)

A. Parties Responsible to Execute Functional Test:

1. Vendor Support Representative
2. Electrical Contractor
3. Building Inspector
4. CA: To witness and document testing
5. Balancing Contractor to verify flows

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Manual and automatic operation
2. Function annunciation

C. Prerequisites:

1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

Function/Mode	Test Method Manual, Monitoring, Either or Both	Required Seasonal Test
General 1. Verify installation of switch.	Manual	
2. Demonstrate compliance with electrical sequence of operation.		

E. Acceptance Criteria

1. Acceptance is achieved when all functions of the specified system have been demonstrated.

F. Sample strategy for identical units: No sampling, test all.

END OF AUTOMATIC TRANSFER SWITCH(ES)

END OF SECTION

SECTION 061000

ROUGH CARPENTRY

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Wood blocking, cants, and nailers.
2. Plywood backing panels.

B. Alternates: Not Applicable.

C. Items To Be Installed Only: Not Applicable.

D. Items To Be Furnished Only: Furnish the following items for installation by the designated Sections

1. Section 042000 - UNIT MASONRY:
   a. Wood nailers and blocking built into masonry.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 092116 – GYPSUM BOARD ASSEMBLIES for sheet metal backing

   Section 102813 – TOLIET ACCESSORIES for wall mounted accessories installation

1.3 SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used, net amount of preservative retained, and chemical treatment manufacturer's written instructions for handling, storing, installing, and finishing treated material.

2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials, both before and after exposure to elevated temperatures when tested according to ASTM D 5516 and ASTM D 5664.
3. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
4. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

B. Shop Drawings: Submit Shop Drawings of field erection details, including materials and methods of fastening nailers in conformance with Factory Mutual wind uplift rated systems specified in other Sections of these specifications.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing agency providing classification marking for fire-retardant treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.

B. Lumber: Mark each piece of framing and board lumber or each bundle of small pieces of lumber with the grade mark of a recognized association or independent inspection agency. Such association or agency shall be certified by the Board of Review, American Lumber Standards Committee, to grade the species used. Surfaces that are to be exposed to view shall not bear grademarks, stamps, or any type of identifying mark.

C. Plywood: Mark each sheet with the mark of a recognized association or independent inspection agency that maintains continuing control over the quality of the plywood. The mark shall identify the plywood by species group or span rating, exposure durability classification, grade, and compliance with APA L870.Surfaces that are to be exposed to view shall not bear grademarks or other types of identifying marks.

D. Preservative Treated Lumber and Plywood: The Contractor shall be responsible for the quality of treated wood products. Each treated piece shall be inspected in accordance with AWPA M2 and permanently marked or branded, by the producer, in accordance with AWPA M6. The Contractor shall provide inspection report of an approved independent inspection agency that offered products comply with applicable AWPA Standards. The appropriate Quality Mark on each piece will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

E. Fire Retardant Treated Lumber: Mark each piece in accordance with AWPA M6, except pieces that are to be natural or transparent finished. Exterior fire-retardant lumber shall be distinguished by a permanent penetrating blue stain. Labels of a nationally recognized independent testing agency will be accepted as evidence of conformance to the fire-retardant requirements of AWPA M6.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products in the manufacturer's original containers, dry, undamaged, and with seals and labels intact.

B. Stack lumber, plywood, and other panels; place spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings. Store products in a weather-protected environment, clear of ground and moisture.

C. Protect all existing and new wood stored on site to prevent moisture absorption. Stacked materials should be covered with tarps (top, sides, and bottom) and stacked to provide sufficient slope to shed water.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS, GENERAL

A. Lumber: DOC PS 20 and applicable rules of lumber grading agencies certified by the American Lumber Standards Committee Board of Review.

1. Factory mark each piece of lumber with grade stamp of grading agency.
2. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.
3. Provide dressed lumber, S4S, unless otherwise indicated.
4. Provide dry lumber with 15 percent by weight on a dry weight basis maximum moisture content at time of dressing for 2-inch nominal thickness or less, unless otherwise indicated.

B. Plywood Panels:

1. Plywood: Either DOC PS 1 or DOC PS 2, unless otherwise indicated.
2. Thickness: As needed to comply with requirements specified but not less than thickness indicated.
3. Factory mark panels according to indicated standard.

2.2 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment by Pressure Process: AWPA U1; Use Category UC2 for interior construction not in contact with the ground, Use Category UC3b for exterior construction not in contact with the ground, and Use Category UC4a for items in contact with the ground.

1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium. Do not use inorganic boron (SBX) for sill plates.
2. For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not require incising, contain colorants, bleed through, or otherwise adversely affect finishes.

B. Kiln-dry material after treatment to a maximum moisture content of 19 percent for lumber and 15 percent for plywood. Do not use material that is warped or does not comply with requirements for untreated material.

C. Mark each treated item with the treatment quality mark of an inspection agency approved by the American Lumber Standards Committee Board of Review.

D. Application: Treat items indicated on Drawings, and the following:

1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
2. Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete in exterior walls.

2.3 FIRE-RETARDANT-TREATED MATERIALS

A. General: For fire-rated exterior walls and for all interior use materials, provide materials that are fire-retardant treated and comply with performance requirements in AWPA C20 (lumber) and AWPA C27 (plywood). Identify fire-retardant-treated wood with appropriate classification marking of UL, U.S. Testing, Timber Products Inspection, or another testing and inspecting agency acceptable to authorities having jurisdiction.

1. Use treatment for which chemical manufacturer publishes physical properties of treated wood after exposure to elevated temperatures, when tested by a qualified independent testing agency according to ASTM D 5664, for lumber and ASTM D 5516, for plywood.
2. Use treatment that does not promote corrosion of metal fasteners.

2.4 MISCELLANEOUS LUMBER

A. General: Provide lumber for support or attachment of other construction, including the following: Rooftop equipment bases and support curbs, blocking, cants, nailers, furring, grounds.

B. For items of dimension lumber size, provide Construction, Stud, or No. 2 grade lumber with 15 percent maximum moisture content.

2.5 PANEL PRODUCTS

A. Miscellaneous Concealed Plywood: Exposure 1 sheathing, span rating to suit framing in each location, and thickness as indicated but not less than 1/2 inch.

B. Telephone and Electrical Equipment Backing Panels: DOC PS 1, Exposure 1, C-D Plugged, fire-retardant treated, in thickness indicated or, if not indicated, not less than 1/2 inch thick.

2.6 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.

1. Where carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners of Type 304 stainless steel.
2. The fasteners shall be of sufficient length to penetrate the receiving member a minimum of 1-1/4 inch minimum for wood or plywood into wood, full depth into plywood, and 5/8 inch minimum for wood into steel deck or metal stud framing.

B. Nails, Wire, Brads, and Staples: ASTM F 1667.

C. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

D. Wood Screws: ASME B18.6.1.

E. Screws for Fastening to Cold-Formed Metal Framing: ASTM C 954, except with wafer heads and reamer wings, length as recommended by screw manufacturer for material being fastened.

F. Lag Screws and Lag Bolts: ASME B18.2.1.

G. Bolts: Steel bolts complying with ASTM A 307, Grade A with ASTM A 563 hex nuts and, where indicated, flat washers.

H. Bolts, Nuts, Studs, and Rivets: ASME B18.2.1, ASME B18.5.2.1M, ASME B18.5.2.2M and ASME B18.2.2.

I. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing and inspecting agency.

1. Material: Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5; except provide stainless steel complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2, where in contact with pressure-preservative treated wood or when exposed to exterior conditions.

2.7 MISCELLANEOUS MATERIALS

A. Adhesive, Including Gluing Furring and Sleepers to Concrete or Masonry: Formulation complying with ASTM D 3498 that is approved for use indicated by adhesive manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Discard units of material with defects that impair quality of carpentry and that are too small to use with minimum number of joints or optimum joint arrangement. Stagger joints layer to layer. Prepared surfaces must be clean and dry. Fill, chip, or grind as required to provide a smooth, uniform surface.

B. Set carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit carpentry to other construction; scribe and cope as needed for accurate fit. Locate furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.

C. Apply field treatment complying with AWPA M4 to cut surfaces of preservative-treated lumber and plywood.

D. Securely attach carpentry work as indicated and according to applicable codes and the following:

1. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code (IBC).
2. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.
3. ICC-ES evaluation report for fastener.

E. Countersink fastener heads on exposed carpentry work and fill holes with wood filler.

F. Use fasteners of appropriate type and length. Predrill members when necessary to avoid splitting wood.

3.2 WOOD BLOCKING, AND NAILER INSTALLATION

A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.

B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces, unless otherwise indicated.

3.3 REMOVAL OF WOOD BLOCKING

A. During removal and replacement of woodwork, report any area of deck, existing wood blocking, or other wood components that is designated to remain, but is found to be deteriorated or otherwise unsuitable for use. Provide temporary protection to the materials until such time as the materials can be reviewed.

3.4 ROOF PERIMETER BLOCKING

A. Provide 6 inch wide nailers at the perimeter of the roof, around openings through the roof, and where roofs abut walls, curbs, and other vertical surfaces, except where indicated otherwise. The nailers shall be minimum 6 inches wide nominal and the same thickness as the insulation. Anchor nailers securely to underlying construction. Anchor perimeter nailers in accordance with FM 4435 for the substrate which they are being secured to. Unless designated otherwise, the spacing of the fasteners shall be halved within eight feet of the corners of the roof.

3.5 FIELD QUALITY CONTROL

A. Independent Testing Agency: Cooperate with the Independent Testing Agency engaged by DCAMM for field quality control activities for the Work of this Section. Refer also to Section 014325 - TESTING AGENCY SERVICES.

B. Commissioning Authority: Cooperate with the Commissioning Authority engaged by DCAMM for field quality control activities for the Work of this Section. Refer also to Section 019115 - FACILITY EXTERIOR ENCLOSURE COMMISSIONING.

C. Cooperate with field quality control personnel. Allow inspectors access to scaffolding and work areas, as needed to perform inspections.

D. Additional inspections and retesting of materials which fail to comply with specified material and installation requirements shall be performed at Contractor's expense.

END OF SECTION

STANDARD SPECIFICATIONS

DCAMM Standard Specifications are intended for use only on projects of the Division of Capital Asset Management and Maintenance in the Commonwealth of Massachusetts. Each section will require editing by a registered architect or engineer before issue. Refer to the User's Guide for additional requirements.

NOTES TO THE DESIGNER

Guarantees and Warranties – When specifying guarantees and/or warranties for work, products, materials and/or equipment, the Designer must account for DCAMM's requirement that guarantees and warranties start at the date of Certificate of Agency Use and Occupancy. Guarantees or warranties that start at the date of shipment from the factory, or from the completion date of an individual portion of the project, are not acceptable.

Filed Sub-Bids MGL Chapter 149: For sections listed in the table of contents with an asterisk (*), the threshold amount for requiring a filed sub-bid is $ 25,000. If the cost estimate for the scope of the work of that filed sub-bid is below $ 25,000, then delete the requirement for the filed sub-bid for that section.

END

SECTION 080001

METAL WINDOWS

(Filed Sub-Bid Required)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Time, Manner and Requirements for Submitting Sub-Bids:

1. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Division of Capital Asset Management and Maintenance at a time and place as stipulated in the "NOTICE TO CONTRACTORS".

The following should appear on the upper left hand corner of the envelope:

NAME OF SUB-BIDDER: (Insert name of sub-bidder)

MASS. STATE PROJECT: ((Insert project number from top of page))

SUB-BID FOR SECTION: 080001 – METAL WINDOWS

2. Each sub-bid submitted for work under this Section shall be on forms furnished by the Division of Capital Asset Management and Maintenance as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-bid forms may be obtained at the office of the Division of Capital Asset Management and Maintenance, or may be obtained by written or telephone request; telephone (617) 727-4003.

3. Sub-bids filed with the Division of Capital Asset Management and Maintenance shall be accompanied by BID BOND or CASH or CERTIFIED CHECK or TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company payable to the Commonwealth of Massachusetts in the amount of five percent of the sub-bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

C. Sub Sub-Bid Requirements: (None required under this Section.)

D. Reference Drawings: The Work of this Filed Sub-Bid is shown on the following Contract Drawings: ((always insert accurate list of sheet numbers of applicable Drawings)).

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

1. All Work of Section 085113 - ALUMINUM WINDOWS.

2. All Work of Section 084413 – GLAZED ALUMINUM CURTAIN WALLS

3. All Work of Section 084113 – ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS

~~1.~~4.

B. Alternates: Not Applicable.

END OF SECTION

SECTION 080002

GLASS AND GLAZING

(Filed Sub-Bid Required)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Time, Manner and Requirements for Submitting Sub-Bids:

1. Sub-bids for work under this Section shall be for the complete work and shall be submitted through WRTA's E-Bid Room as stipulated in the WRTA Instructions to Bidders.

2. Sub-bids filed with the Division of Capital Asset Management and Maintenance shall be accompanied by BID BOND or CASH or CERTIFIED CHECK or TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company payable to the Commonwealth of Massachusetts in the amount of five percent of the sub-bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

C. Sub Sub-Bid Requirements: (None required under this Section.)

D. Reference Drawings: The Work of this Trade Bid is shown on the following Contract Drawings: ((When issuing for bidding, insert a list of the drawings applicable to the work of this section, including drawing number and title.))

NUMBER	SHEET NAME
A-101	LEVEL1 FLOOR PLAN
A-201	INTERIOR ELEVATIONS @ WAITING AREA
A-202	ENLARGED VESTIBULE PLAN & ELEVATIONS
A-301	WALL SECTIONS AND ENLARGED ELEVATIONS
A-402	PLAN DETAILS
A-403	SECTION DETAILS - PART 1 OF 2
A-404	SECTION DETAILS - PART 2 OF 2
A-601	DOOR, WINDOW SCHEDULE AND DETAILS
A-701	ROOM FINISH SCHEDULE AND DETAILS

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

1. All Work of Section 088010 - INTERIOR GLAZING.

2. All Work of Section 088000 - GLAZING

B. Alternates: Not Applicable.

END OF SECTION

SECTION 084413

GLAZED ALUMINUM CURTAIN WALLS

PART 1 - (Part of Work of Section 080001 - METAL WINDOWS, Filed Sub-Bid Required)

PART 2 - GENERAL

2.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

2.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Glazed aluminum-framed curtain wall systems and accessories.
2. Glass and glazing for the work of this Section, as specified in Section 088000 - GLAZING.

B. Alternates: Not Applicable.

C. Items To Be Installed Only:

1. Section 085113 - ALUMINUM WINDOWS for windows installed with glazed aluminum curtain-wall system only.

D. Items To Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 079200 - JOINT SEALANTS for joint sealant systems between curtain walls and adjacent construction.

F. Related Requirements: Refer to the following Sections for technical requirements relating to Work of this Section:

1. Section 079200 - JOINT SEALANTS for sealant requirements to the extent not specified in this Section.
2. Section 088000 - GLAZING for glazing requirements to the extent not specified in this Section.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design glazed curtain wall, including comprehensive engineering analysis by a qualified professional engineer licensed in the Commonwealth of Massachusetts, using performance requirements and design criteria indicated.

B. General: Provide glazed aluminum curtain-wall systems, including anchorage, capable of withstanding, without failure, the effects of the following:

1. Structural loads.
2. Thermal movements.
3. Movements of supporting structure indicated on Drawings including, but not limited to, story drift, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.
4. Dimensional tolerances of building frame and other adjacent construction.
5. Failure includes the following:

    a. Deflection exceeding specified limits.
    b. Thermal stresses transferred to building structure.
    c. Framing members transferring stresses, including those caused by thermal and structural movements, to glazing.
    d. Noise or vibration created by wind, thermal or structural movements.
    e. Loosening or weakening of fasteners, attachments, and other components.
    f. Sealant failure.

C. Structural Loads: Wind loads as indicated on the Structural Drawings, but not less than that required by Code.

D. Structural-Test Performance: Provide glazed aluminum curtain-wall systems tested according to ASTM E 330 as follows:

1. When tested at positive and negative wind-load design pressures, systems do not evidence deflection exceeding specified limits.
2. When tested at 150 percent of positive and negative wind-load design pressures, systems, including anchorage, do not evidence material failures, structural distress, and permanent deformation of main framing members exceeding 0.2 percent of span.
3. Test Duration: As required by design wind velocity but not less than 10 seconds.

E. Deflection of Framing Members:

1. Deflection Normal to Wall Plane: Limited to 1/175 of clear span for spans up to 13 feet 6 inches, and to 1/240 of clear span plus 1/4 inch for spans greater than 13 feet 6 inches or an amount that restricts edge deflection of individual glazing lites to 3/4 inch, whichever is less.
2. Deflection Parallel to Glazing Plane: Limited to 1/360 of clear span or 1/8 inch, whichever is smaller, amount not exceeding that which reduces glazing bite to less than 75 percent of design dimension and which reduces edge clearance between framing members and glazing or other fixed components to less than 1/8 inch.

F. Interstory Drift: Provide glazed aluminum curtain-wall systems that accommodate design displacement of adjacent stories indicated.

1. Design Displacement: As indicated on Drawings.
2. Test Performance: Complying with criteria for passing based on building occupancy type when tested according to AAMA 501.4 at design displacement [and 1.5 times the design displacement].

G. Seismic Performance: Provide glazed aluminum curtain walls and components capable of withstanding the effects of earthquake motions determined according to Code.

1. Seismic Drift Causing Glass Fallout: Complying with criteria for passing based on building occupancy type when tested according to AAMA 501.6 at design displacement[and 1.5 times the design displacement].
2. Vertical Interstory Movement: Complying with criteria for passing based on building occupancy type when tested according to AAMA 501.7 at design displacement[and 1.5 times the design displacement].

H. Thermal Movements: Provide glazed aluminum curtain-wall systems that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 degrees F, ambient; 180 degrees F, material surfaces.

I. Air Infiltration: Provide glazed aluminum curtain-wall systems with maximum air leakage of 0.06 cfm/sq. ft. of fixed wall area when tested according to ASTM E 283 at a minimum static-air-pressure differential of 6.24 lbf/sq. ft.

J. Water Penetration Under Static Pressure: Provide aluminum glazed curtain-wall systems that do not evidence water penetration when tested according to ASTM E 331 at a minimum differential static pressure of 20 percent of positive design wind load, but not less than 12 lbf/sq. ft.

1. Maximum Water Leakage: No uncontrolled water penetrating systems or appearing on systems' normally exposed interior surfaces from sources other than condensation. Water controlled by flashing and gutters that is drained to exterior and cannot damage adjacent materials or finishes is not considered water leakage.

K. Condensation Resistance: Provide glazed aluminum curtain-wall systems with condensation-resistance factor (CRF) of not less than 55 when tested according to AAMA 1503.

L. Solar Heat-Gain Coefficient: Provide units with a whole-unit SHGC maximum as required by Code, determined according to NFRC 200 procedures. Submit proof of compliance with submittals as specified.

M. Thermal Transmittance: Provide window units that have a U-value as required by Code rated in BTU/hour/sq. ft./degrees F at 15-mph exterior wind velocity, when tested in accordance with AAMA 1503.1. Submit proof of compliance with submittals as specified.

2.4 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of product indicated.

B. Shop Drawings: Prepared by or under the supervision of a qualified professional engineer licensed in the Commonwealth of Massachusetts detailing fabrication and assembly of glazed aluminum curtain-wall systems.

1. Include structural analysis data signed and sealed by the qualified professional engineer licensed in the Commonwealth of Massachusetts responsible for their preparation.
2. Include structural analysis of story drift and deflection from anticipated live loads, and determination whether head receptors are required.
3. All costs for professional engineering shall be included in the bid price for the Work of this Section..

C. Delegated-Design Submittal: For glazed curtain wall system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer licensed in the Commonwealth of Massachusetts responsible for their preparation.

D. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.

E. Fabrication Sample: Of each vertical-to-horizontal intersection of systems, made from 12-inch lengths of full-size components and showing details of the following:

1. Joinery.
2. Anchorage.
3. Expansion provisions.
4. Glazing.
5. Flashing and drainage.

F. Performance Reports: Based on systems, components and glazing methods proposed for use on this Project, proof that units as glazed for this Project meet or exceed Code requirements for the following:

1. U-value.
2. Solar heat-gain coefficient.

G. Compatibility Test Reports: Test reports by glazing and/or sealant manufacturers that show chemical compatibility and adhesion (if required) between all non-aluminum components including, but not limited, to:

1. Gaskets
2. Insulated glass edge seals
3. Setting blocks
4. Anti-walk blocks
5. End dams
6. Sealants
7. Silicone sheet membrane flashing

H. Welding certificates.

I. Qualification data for Installer.

J. Field quality-control test reports.

K. Warranties: Special warranties specified in this Section.

2.5 QUALITY ASSURANCE

A. Installer Qualifications: Capable of assuming engineering responsibility and performing Work of this Section and who is acceptable to manufacturer.

B. Engineering Responsibility: Preparation of Shop Drawings, design calculations, and other structural data by a qualified professional engineer licensed in the Commonwealth of Massachusetts.

C. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the Commonwealth of Massachusetts and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of glazed curtain wall system that are similar to those indicated for this Project in material, design, and extent.

D. Installer Qualifications: Capable of assuming engineering responsibility and performing Work of this Section and who is acceptable to manufacturer.

E. Product Options: Information on Drawings and in Specifications establishes requirements for systems' aesthetic effects and performance characteristics. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction. Performance characteristics are indicated by criteria subject to verification by one or more methods including preconstruction testing, field-testing, and in-service performance.

F. Welding: Qualify procedures and personnel according to AWS D1.2, "Structural Welding Code--Aluminum."

G. Installation Sequence Conference: Conduct conference at Project site to review sequence of installation of curtain wall systems, including installation of joint sealants, flashing, and glass. Conference shall be attended by all installers of applicable components.

H. Mockups: Build mockups to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Build mockup of typical wall area as indicated on Drawings.
2. Build mockup in sequence recommended by manufacturer including installation of joint sealants, flashing and glass.
3. The construction of the mockup shall be observed by all tradesmen constructing the curtain wall system.

I. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01. Review methods and procedures related to glazed aluminum curtain-wall systems including, but not limited to, the following:

1. Review structural load limitations.
2. Review installation sequence, including installation of sealants, flashing, and glass.
3. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review required testing, inspecting, and certifying procedures.

2.6 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of structural supports for glazed aluminum curtain-wall systems by field measurements before fabrication and indicate measurements on Shop Drawings.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating glazed aluminum curtain-wall systems without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions.

2.7 WARRANTY

A. Special Assembly Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of glazed aluminum curtain-wall systems that do not comply with requirements or that deteriorate as defined in this Section within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including, but not limited to, excessive deflection.
b. Noise or vibration caused by thermal movements.
c. Deterioration of metals and other materials beyond normal weathering.
d. Water leakage.
e. Failure of operating components to function normally.

2. Warranty Period: 10 years from from the date of Certificate of Agency Use and Occupancy. Guarantees or warranties that start at the date of shipment from the factory, or from the completion date of an individual portion of the project, are not acceptable.

B. Special Finish Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components on which finishes fail within specified warranty period. Warranty does not include normal weathering.

1. Warranty Period: 10 years from the date of Certificate of Agency Use and Occupancy. Guarantees or warranties that start at the date of shipment from the factory, or from the completion date of an individual portion of the project, are not acceptable.

PART 3 - PRODUCTS

3.1 MANUFACTURERS

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

1. EFCO, a Pella Company
2. Kawneer North America
3. United States Aluminum
4. Oldcastle BuildingEnvelope™.
5. Fremarq Innovations.
6. YKK AP America Inc

3.2 FRAMING SYSTEMS

A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.

1. Sheet and Plate: ASTM B 209
2. Extruded Bars, Rods, Shapes, and Tubes: ASTM B 221
3. Extruded Structural Pipe and Tubes: ASTM B 429.

B. Steel Reinforcement: With manufacturer's standard corrosion-resistant primer complying with SSPC-PS Guide No. 12.00 applied immediately after surface preparation and pretreatment. Select surface preparation methods according to recommendations in SSPC-SP COM and prepare surfaces according to applicable SSPC standard.

1. Structural Shapes, Plates, and Bars: ASTM A 36/A 36M.
2. Cold-Rolled Sheet and Strip: ASTM A 611.
3. Hot-Rolled Sheet and Strip: ASTM A 570/A 570M.

C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

D. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

1. Where fasteners are subject to loosening or turn out from thermal and structural movements, wind loads, or vibration, use self-locking devices.
2. Reinforce members as required to receive fastener threads.
3. Where acceptable, use exposed fasteners with countersunk Phillips screw heads.
4. Finish exposed portions to match framing system.
5. At movement joints, use slip-joint linings, spacers, and sleeves of material and type recommended by manufacturer.

E. Anchors: Three-way adjustable anchors that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.

1. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A 123/A 123M or ASTM A 153/A 153M requirements.

F. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials.

G. Framing System Gaskets and Sealants: Manufacturer's standard recommended by manufacturer for joint type.

3.3 GLAZING SYSTEMS

A. Glazing: Provide insulating-glass units in accordance with requirements in Section 088000 - GLAZING.

B. Glazing Gaskets: Manufacturer's standard compression types, replaceable, molded or extruded, that maintain uniform pressure and watertight seal.

C. Spacers and Setting Blocks: Manufacturer's standard elastomeric types.

3.4 INSULATED SPANDREL PANELS

A. Insulated Spandrel Panels: Laminated, metal-faced flat panels with no deviations in plane exceeding 0.8 percent of panel dimension in width or length.

1. Overall Panel Thickness: 1 inch.
2. Exterior and Interior Skin: Aluminum.

a. Thickness: Manufacturer's standard for finish and texture indicated.
b. Finish: Matching framing system.
c. Texture: Smooth.
d. Backing Sheet: Manufacturer's standard.
e. Thermal Insulation Core: Manufacturer's standard..

3.5 ACCESSORY MATERIALS

A. Insulating Materials: Specified in Section 072100 - THERMAL INSULATION.

B. Bituminous Paint (Isolation Coating): Cold-applied asphalt-mastic paint complying with ASTM D 1187 requirements except containing no asbestos, formulated for 30-mil thickness per coat.

3.6 FABRICATION

A. Form aluminum shapes before finishing.

B. Fabricate components that, when assembled, have the following characteristics:

1. Sharp profiles, straight and free of defects or deformations.

2. Accurately fitted joints with ends coped or mitered.
3. Internal guttering systems or other means to drain water passing joints, condensation occurring within framing members, and moisture migrating within the system to exterior.
4. Physical and thermal isolation of glazing from framing members.
5. Accommodations for thermal and mechanical movements of glazing and framing to prevent glazing-to-glazing contact and to maintain required glazing edge clearances.

C. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

D. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

3.7 ALUMINUM FINISHES

A. General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

C. High-Performance Organic Finish (3-Coat Fluoropolymer): AA-C12C40R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: conversion coating; Organic Coating: manufacturer's standard 3-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color coat, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with AAMA 2605 and with coating and resin manufacturers' written instructions.

1. Color and Gloss: As selected by Designer from manufacturer's full range, including metallics.

PART 4 - EXECUTION

4.1 EXAMINATION

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of work.

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

4.2 INSTALLATION

A. General:

1. Comply with manufacturer's written instructions.

2. Do not install damaged components.
3. Fit joints to produce hairline joints free of burrs and distortion.
4. Rigidly secure nonmovement joints.
5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
6. Seal joints watertight, unless otherwise indicated.

B. Metal Protection:

1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape or installing nonconductive spacers as recommended by manufacturer for this purpose.
2. Where aluminum will contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within the system to exterior.

D. Install components plumb and true in alignment with established lines and grades.

E. Install glazing as specified in Section 088000 - GLAZING.

F. Coordinate with sealants and installation of perimeter sealants which is specified in Section 079200 - JOINT SEALANTS.

G. Coordinate with insulation and installation of insulation which is specified in Section 072100 - THERMAL INSULATION.

H. Coordinate with materials and installation for perimeter fire-containment systems (safing insulation) which is specified in Section 078443 - JOINT FIRESTOPPING.

I. Erection Tolerances: Install glazed aluminum curtain-wall systems to comply with the following maximum tolerances:

1. Plumb: 1/8 inch in 10 feet; 1/4 inch in 40 feet.
2. Level: 1/8 inch in 20 feet; 1/4 inch in 40 feet.
3. Alignment:

    a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch wide, limit offset from true alignment to 1/16 inch.
    b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch wide, limit offset from true alignment to 1/8 inch.
    c. Where surfaces are separated by reveal or protruding element of 1 inch wide or greater, limit offset from true alignment to 1/4 inch.

4. Location: Limit variation from plane to 1/8 inch in 12 feet; 1/2 inch over total length.

4.3 FIELD QUALITY CONTROL

A. Independent Testing Agency: Cooperate with the Independent Testing Agency engaged by WRTA for field quality control activities for the Work of this Section. Refer also to Section 014325 - TESTING AGENCY SERVICES.

B. Commissioning Authority: Cooperate with the Commissioning Authority engaged by WRTA for field quality control activities for the Work of this Section. Refer also to Section 019115 - FACILITY EXTERIOR ENCLOSURE COMMISSIONING.

C. Cooperate with field quality control personnel. Allow inspectors access to scaffolding and work areas, as needed to perform inspections.

D. Additional inspections and retesting of materials which fail to comply with specified material and installation requirements shall be performed at Contractor's expense.

E. Testing Services: Testing and inspecting of representative areas to determine compliance of installed system with specified requirements shall take place as follows and in successive stages as indicated on Drawings. Do not proceed with installation of the next area until test results for previously completed areas show compliance with requirements.

1. Air Infiltration: Areas shall be tested for air leakage of 1.5 times the rate specified under Part 1 "Performance Requirements" Article, but not more than 0.09 cfm/sq. ft. of fixed wall area when tested according to ASTM E 783 at a minimum static-air-pressure differential of 6.24 lbf/sq. ft.
2. Water Penetration: Areas shall be tested according to ASTM E 1105 at minimum cyclic static-air-pressure difference of 0.67 times the pressure specified under Part 1 "Performance Requirements" Article, but not less than 6.24 lbf/sq. ft. and shall not evidence water penetration.
3. Water Spray Test: After the installation of minimum area of 75-feet-by-2-story glazed aluminum curtain-wall system has been completed but before installation of interior finishes has begun, a 2-bay area of system designated by Designer shall be tested according to AAMA 501.2 and shall not evidence water penetration.

F. Repair or remove work where test results and inspections indicate that it does not comply with specified requirements.

G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

END OF SECTION

SECTION 090007

PAINTING

(Filed Sub-Bid Required)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Time, Manner and Requirements for Submitting Sub-Bids:

1. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Division of Capital Asset Management and Maintenance at a time and place as stipulated in the "NOTICE TO CONTRACTORS".

The following should appear on the upper left hand corner of the envelope:

NAME OF SUB-BIDDER: (Insert name of sub-bidder)

MASS. STATE PROJECT: ((Insert project number from top of page))

SUB-BID FOR SECTION: 090001 – PAINTING

2. Each sub-bid submitted for work under this Section shall be on forms furnished by the Division of Capital Asset Management and Maintenance as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-bid forms may be obtained at the office of the Division of Capital Asset Management and Maintenance, or may be obtained by written or telephone request; telephone (617) 727-4003.

3. Sub-bids filed with the Division of Capital Asset Management and Maintenance shall be accompanied by BID BOND or CASH or CERTIFIED CHECK or TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company payable to the Commonwealth of Massachusetts in the amount of five percent of the sub-bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

C. Sub Sub-Bid Requirements: (None required under this Section.)

D. Reference Drawings: The Work of this Filed Sub-Bid is shown on the following Contract Drawings: ((always insert accurate list of sheet numbers of applicable Drawings)).

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

1. All Work of Section 099000 - PAINTING AND COATING.

B. Alternates: Not Applicable.

END OF SECTION

STANDARD SPECIFICATIONS

DCAMM Standard Specifications are intended for use only on projects of the Division of Capital Asset Management and Maintenance in the Commonwealth of Massachusetts. The specifications are intended to assist the Designer with incorporating DCAMM and MGL Chapter 149 filed sub-bid requirements in documents used for bidding and construction. Each section will require editing by a registered architect or engineer before issue.

NOTES TO THE DESIGNER

None for this section

RESOURCES

None for this Section

END