



CITY OF HOUSTON

Sylvester Turner

Mayor



HOUSTON AIRPORT SYSTEM

George Bush Intercontinental ~ William P. Hobby ~ Ellington Airport

Mario C. Diaz
Director of Aviation

January 12, 2023

SUBJECT: Addendum No. 3

REFERENCE: Invitation To Bid (ITB) for IAH ARFF 92 AT GEORGE BUSH INTERCONTINENTAL AIRPORT; Solicitation No. HHG-ARFF92-2023-007; Project No. 668

To: All Prospective Bidders:

This Addendum is issued for the following reason:

- I. Extend** the bid due date from **January 19, 2023, to January 26, 2023, at 10:30 A.M., (CST).**
- II. Replace** the following pages with the attached documents as outlined below.
 1. Pages 3-4 Division 01 Table of Contents.
 2. Pages 300-301 Table of Contents – Volume 3.
 3. Pages 589-590 Section 00 01 10 Table of Contents – Volume 4.
 4. Pages 482-487 Section 08 80 00 Glazing.
 5. Pages 20-21 Document 00410A Bid Form – Part A
 6. Pages 22-26 Document 00410B Bid Form – Part B.
 7. Page 15 Section 01210 Cash Allowances.
- III. Add** the following pages with the attached documents as outlined below.
 1. Section 01 91 13 General Commissioning Requirements.
 2. Section 01 91 15 Building Enclosure Commissioning.
 3. Section 01 91 17 Building Enclosure Functional Performance Testing.
 4. Section 23 08 00 Commissioning of HVAC System.
 5. Section 26 08 00 Commissioning of Electrical Systems.
 6. Section 28 08 00 Commissioning of Electronic Safety and Security.
 7. Section 23 0923 Direct Digital Control System for HVAC.
 8. Section 23 8129 Variable Refrigerant Flow HVAC Systems.
 9. Section 23 7420 Packaged, Outdoor, Heating and Cooling Make-Up Air-Conditioners.
- IV. To Respond to Questions.**
 1. **Question:** Sheet CS-201 (Paving Joint Plan) - Legend refers to detail D2/CS-502 which does not exist.

Response: D2 is revised to "A3" for expansion joint details.

January 12, 2023
IAH ARFF 92 At George Bush Intercontinental Airport
Solicitation No. HHG-ARFF92-2023-007
Project No. 668

2. **Question:** Please be aware that when the Geotech is made available, there may be questions regarding that document. Could you consider extending the Q&A period?

Response: No.

3. **Question:** Please provide a specification section for the Sealed Concrete Flooring (SC-01 and SC-02) as listed on the Interior Finish Legend.

Response: Both SC-01 and SC-02 use Spec Section 03 30 00. Note the Basis of Design requirements in for VC5 Lithium Cure, Lithium Cure 2000, and HLQ-125 by SINAK. SC-01 is used in the Vehicle Bays and must have a non-slip finish for vehicles.

4. **Question:** The Interior Finish Legend on A-651 lists EPX-01 Epoxy Floor for the Apparatus Bays. However, the Room Finish Schedule shows the Apparatus Bays' floor finish as SC-01. Please advise.

Response: Finish Schedule on A-651 is correct. Apparatus Bays to be SC-01.

5. **Question:** Division 95100 paragraph 2.03.B indicates 15/16" grid with ACT1 tegular edge ceiling tile, and paragraph 2.03.C indicates bolt slot grid for AC2 square edge tile. Please verify this is correct.

Response: ACT-01 Basis of Design is ARMSTRONG; ULTIMA TEGULAR1914 - WHITE
ACT-02 Basis of Design is USG; MARS HEALTHCARE - WHITE

6. **Question:** Division 95100 paragraph 2.02.C indicates .60 -.75 for NRC and CAC .35 of ceiling tile. This cannot be met with the 5/8" tile indicated. Please clarify.

Response: ACT-01 Basis of Design is ARMSTRONG; ULTIMA TEGULAR1914 - WHITE. Use 3/4" tile thickness.

7. **Question:** A651 and A652 does not match Division 95100 for ceiling types. Please clarify what ceiling tile and grid to bid for ACT01 and ACT02?

Response: ACT-01 Basis of Design is ARMSTRONG; ULTIMA TEGULAR1914 - WHITE
ACT-02 Basis of Design is USG; MARS HEALTHCARE - WHITE

8. **Question:** Per the General Requirements, QC Managers are listed for site as well as building. Please confirm that one QC Manager is adequate for this project. In addition, please confirm that the QC Manager with the following qualification is acceptable:

a. Demonstrated experience in paving construction and quality assurance compliance equivalent in scope and complexity to work of this contract

b. Graduate Bachelor of Science degree in Civil Engineering, Civil Engineering Technology or Construction, with 3 years above experience

January 12, 2023
IAH ARFF 92 At George Bush Intercontinental Airport
Solicitation No. HHG-ARFF92-2023-007
Project No. 668

Response: A single QC Manager is acceptable. Preference is for someone with both horizontal and vertical construction experience.

9. **Question:** Per Drawing CG-006, please confirm that Note 7 relocation of equipment is by owner. Please provide anticipated duration for this relocation.

Response: Allowance to be added to project specifications for relocation of existing equipment, to be performed by the Contractor. HFD requires two weeks for equipment relocation.

10. **Question:** Please confirm the exercise equipment shown on the Equipment and Appliance Schedule (EX-1 through EX-5) is included in Allowance Item 4 - Equipment (FF&E).

Response: Exercise equipment is not included in FF&E allowance and will not be provided new in this contract.

11. **Question:** Drawings show NEMA 4 on equipment (E-130, E-100), but on the one line sheet (E-401) it states NEMA 4x. Please give clarification.

Response: NEMA 4 is required by HAS.

12. **Question:** Please confirm location of ATS. Drawings show it located in Elect Rm 105, but on one line it looks to be outside.

Response: The ATS will be in the electrical room. The one-line is schematic only.

13. **Question:** Will the FCU's be connected to some type of BAS system where they can be viewed?

Response: Yes, the controls are by the VRF manufacturer with a BACnet Interface to connect to the HAS Allerton Campus system.

14. **Question:** If so, will the controls subcontractor be working with HAS or the Contractor? There are currently no specifications for the controls. Please clarify.

Response: VRF controls by the VRF manufacturer with BacNet Interface. There will be a front in to connect to the Allerton Airport System.

15. **Question:** The refrigerant lines that serve FCU 3A, FCUs 4A, 4B, 4C, & 4D, FCUs 5A & 5B looks to me like they want to 90 up or down to go over some ductwork or something but this is the only area they do this, so I don't know if maybe it's a typo or what the case is. I have attached a of the piping that I'm referring to.

Response: There may have been something in the way. The fewer turns in the refrigerant lines, the better.

January 12, 2023
IAH ARFF 92 At George Bush Intercontinental Airport
Solicitation No. HHG-ARFF92-2023-007
Project No. 668

16. **Question:** Can you specify what's included in the FF&E allowance? The spec only state "Allowance Item 4 - Equipment (FF&E): For Furniture Fixtures & Equipment (FF&E) work for, \$475,000.00". We need to know if this allowance includes all equipment and furniture shown in the Equipment and Appliance Schedule and Furniture Schedule on sheets A661A and B.

Response: Please refer to the responses provided in Addendum #1, Question numbers 27, 28, 74 and 75.

17. **Question:** Integral Water Repellent for CMU and Mortar - Unit Masonry Spec Section 042000 calls for integral water repellent in the CMU and mortar. Structural Reinforced Concrete Unit Masonry Section 042213 does not call for integral water repellent in the CMU and mortar. Is integral water repellent required in the CMU and mortar?

Response: Waterproofing is required.

18. **Question:** On sheet T-103, in the backbone schedule notes it references an Add Alternate to install 3 cell in existing conduit. Please clarify this alternate as there are no alternates listed on the bid form.

Response: The 3 cells in existing conduit is not included in the bidding.

19. **Question:** Reference S303/15 calls for a 10' flagpole foundation. However, a typical foundation depth for a 30' flagpole is 3'. Please confirm the depth in the drawings is correct as custom flagpoles will have to be fabricated to accommodate this foundation depth.

Response: Foundation was designed due to height, local geotechnical conditions, and flag wind loadings. No material substitutions are allowable at the time of bidding. If a manufacturer recommends a different foundation for their product, the substitution request will be evaluated according to the project specifications for material substitutions.

20. **Question:** I'm interested in bidding the waterproofing for your ARFF 92 HAS project to multiple GC's. Would it be possible to receive the sign-in list?

Response: Please visit the Houston Airports solicitation website www.fly2houston.com/biz/opportunities/solicitations/2267 and look in the solicitation file. The sign in sheet is posted.

21. **Question:** Please provide clarification for which products shall be used for ACT-01 & ACT-02 for ceiling tile and ceiling grid. There is a conflict between the plan sheets and the specifications.

Response: Use the following products as the basis of design for ceilings, updated 12/09/2022.
Basis of Design:

ACT-01 Tile: Armstrong Ultima 1941 24"x24"x7/8"
ACT-01 Grid: Armstrong Prelude 15/16"
ACT-02 Tile: Armstrong Ultima Health Zone 1447 24"x24"x7/8"
ACT-02 Grid: Armstrong SS Prelude Plus XL 15/16"

January 12, 2023
IAH ARFF 92 At George Bush Intercontinental Airport
Solicitation No. HHG-ARFF92-2023-007
Project No. 668

22. **Question:** Please issue Division 23 BAS specification.

Response: [Division 23 BAS specifications is attached.](#)

When issued, Addendum shall automatically become part of the solicitation documents and shall supersede any previous specification(s) and/or provision(s) in conflict with the Addendum. Addendum will be incorporated into the Agreement as applicable. It is the responsibility of the bidder(s) to ensure that it has obtained all such letter(s). By submitting a bid on this project, bidder(s) shall be deemed to have received all Addendum and to have incorporated them into their bid.

If further clarification is needed regarding this solicitation, please contact Senior Procurement Specialists, Jorge Ardines, and David Martinez via email at jorge.ardines@houstontx.gov and david.martinez@houstontx.gov.

DocuSigned by:

Cathy Vander Plaats

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Cathy Vander Plaats
Aviation Procurement Officer
Houston Airport System

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CVP/dm

DS
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cc: Alfredo Oracion
Dallas Evans
Solicitation File

Attachments:

1. Pages 3-4 Division 01 Table of Contents.
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13. Section 28 08 00 Commissioning of Electronic Safety and Security.
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15. Section 23 7420 Packaged, Outdoor, Heating and Cooling Make-Up Air-Conditioners.
16. Section 26 08 00 Commissioning of Electrical Systems.

DIVISION 01
TABLE OF CONTENTS
(REVISED)

SPECIFICATIONS

DIVISION 1 - GENERAL REQUIREMENTS

01110	Summary of Work
01145	Contractor's Use of Premises
01210	Cash Allowances
01230	Alternates
01241	Contractor's Value Engineering
01255	Modification Procedures
01270	Measurement and Payment
01290	Payment Procedures
01292	Schedule of Values
01312	Coordination and Meetings
01321	Construction Photographs
01325	Construction Schedules
01326	Construction Sequencing
01330	Submittal Procedures
01340	Shop Drawings, Product Data and Samples
01410	TPDES Requirements (with Attachments)
01423	Reference
01450	Contractor's Quality Control
01455	City's Acceptance Testing
01457	Estimating Percentage of Product Within Specification
01505	Temporary Facilities
01506	Airport Temporary Controls
01507	Temporary Signs
01550	Public Safety and Contractor's Safety Staffing
01555	Traffic Control and Regulation
01570	Storm Water Pollution Prevention Control
01572	Erosion and Sedimentation Control
01575	Stabilized Construction Exit
01576	Waste Material Disposal
01610	Basic Product Requirements
01630	Product Options and Substitutions
01640	City-Furnished Products
01725	Field Surveying
01726	Base Facility Survey
01731	Cutting and Patching
01740	Site Restoration

TABLE OF CONTENTS

- 01761 Protection of Existing Services
- 01770 Contract Closeout
- 01782 Operations and Maintenance Data
- 01785 Project Record Documents

Addendum 2:

- 019113 General Commissioning Requirements
- 019115 Building Enclosure Commissioning
- 019117 Building Enclosure Functional Performance Testing

END OF DOCUMENT

SECTION 00 01 10
TABLE OF CONTENTS – VOLUME 3
(REVISED)

DIVISION 00 -- PROCUREMENT AND CONTRACTING REQUIREMENTS

00 01 10 - Table of Contents Atkins

DIVISION 02 -- EXISTING CONDITIONS

02 41 00 - Demolition Atkins

DIVISION 03 -- CONCRETE

03 10 00 - Concrete Forming and Accessories Henderson Rogers

03 20 00 - Concrete Reinforcing Henderson Rogers

03 30 00 - Cast-in-Place Concrete Henderson Rogers

DIVISION 04 -- MASONRY

04 20 00 - Unit Masonry Atkins

04 22 13 - Structural Reinforced Concrete Unit Masonry Henderson Rogers

DIVISION 05 -- METALS

05 12 00 - Structural Steel Framing Henderson Rogers

05 21 00 - Steel Joist Framing Henderson Rogers

05 31 00 - Steel Decking Henderson Rogers

05 40 00 - Cold-Formed Metal Framing Atkins

05 50 00 - Metal Fabrications Atkins

05 51 33 - Metal Ladders Atkins

05 53 05 - Metal Gratings and Floor Plates Atkins

05 70 00 - Decorative Metal Atkins

DIVISION 06 -- WOOD, PLASTICS, AND COMPOSITES

06 10 00 - Rough Carpentry Atkins

06 41 00 - Architectural Wood Casework Atkins

DIVISION 07 -- THERMAL AND MOISTURE PROTECTION

07 21 00 - Thermal Insulation Atkins

07 25 00 - Weather Barriers Atkins

07 42 13.23 - Metal Composite Material Wall Panels Atkins

07 54 19 - PVC Thermoplastic Single-Ply Roofing - Carlisle Atkins

07 62 00 - Sheet Metal Flashing and Trim Atkins

07 72 00 - Roof Accessories Atkins

07 84 00 - Firestopping Atkins

07 92 00 - Joint Sealants Atkins

DIVISION 08 -- OPENINGS

08 11 13 - Hollow Metal Doors and Frames Atkins

08 14 16 - Flush Wood Doors Atkins

08 31 00 - Access Doors and Panels Atkins

08 33 23 - Overhead Coiling Doors	Atkins
08 36 13 - Sectional Doors	Atkins
08 43 13 - Aluminum-Framed Storefronts	Atkins
08 51 13 - Aluminum Windows	Atkins
08 71 00 - Door Hardware	Atkins
08 80 00 – Glazing (revised 2022/11/22)	Atkins
08 83 00 - Mirrors	Atkins
08 91 00 - Louvers	Atkins
DIVISION 09 -- FINISHES	
09 21 16 - Gypsum Board Assemblies	Atkins
09 30 00 - Tiling	Atkins
09 51 00 - Acoustical Ceilings	Atkins
09 65 00 - Resilient Flooring	Atkins
09 65 66 - Resilient Athletic Flooring	Atkins
09 66 23 - Resinous Matrix Terrazzo Flooring	Atkins
09 67 00 - Fluid-Applied Flooring	Atkins
09 68 13 - Tile Carpeting	Atkins
09 72 00 - Wall Coverings	Atkins
09 91 13 - Exterior Painting	Atkins
09 91 23 - Interior Painting	Atkins
DIVISION 10 -- SPECIALTIES	
10 11 00 - Visual Display Units	Atkins
10 14 00 - Signage	Atkins
10 26 00 - Wall and Door Protection	Atkins
10 28 00 - Toilet, Bath, and Laundry Accessories	Atkins
10 43 00 - Emergency Aid Specialties	Atkins
10 44 00 - Fire Protection Specialties	Atkins
10 51 13 - Metal Lockers	Atkins
10 56 13 - Metal Storage Shelving	Atkins
10 71 13.43 - Fixed Sun Screens	Atkins
10 75 00 - Flagpoles	Atkins
DIVISION 11 -- EQUIPMENT	
11 30 13 - Residential Appliances	Atkins
DIVISION 12 -- FURNISHINGS	
12 24 00 - Window Shades	Atkins
12 36 00 - Countertops	Atkins

SECTION 00 01 10
TABLE OF CONTENTS – VOLUME 4
(REVISED)

DIVISION 21 -- FIRE SUPPRESSION

21 13 00 - Fire Suppression Sprinklers Jones

DIVISION 22 -- PLUMBING

22 05 23 - General-Duty Valves For Plumbing Piping Jones

22 05 29 - Hangers And Supports For Plumbing Piping And Equipment Jones

22 05 53 - Identification for Plumbing Piping and Equipment Jones

22 07 19 - Plumbing Piping Insulation Jones

22 11 16 - Domestic Water Piping Jones

22 11 19 - Domestic Water Piping Specialties Jones

22 13 16 - Sanitary Waste And Vent Piping Jones

22 13 19 - Sanitary Waste Piping Specialties Jones

22 30 00 - Plumbing Equipment Jones

22 40 10 - Plumbing Fixtures Jones

22 47 00 - Drinking Fountains And Water Coolers Jones

DIVISION 23 -- HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

23 02 00 - Basic Materials And Methods Jones

23 05 13 - Common Motor Requirements for HVAC Equipment Jones

23 05 26 - Variable Frequency Motor Speed Control For Hvac Equipment Jones

23 05 29 - Hangers And Support For Piping And Equipment - Hvac Jones

23 05 48 - Vibration And Seismic Controls For Hvac Piping And Equipment Jones

23 05 53 - Identification For Hvac Piping And Equipment Jones

23 05 93 - Testing, Adjusting, And Balancing Jones

23 07 13 - Duct Insulation Jones

23 07 19 - HVAC Piping Insulation Jones

23 08 00 - Commissioning of HVAC (New 2022/11/22)

23 11 23 - Facility Natural-Gas Piping Jones

23 23 00 - Refrigerant Piping Jones

23 31 00 - HVAC Ducts and Casings Jones

23 33 00 - Air Duct Accessories Jones

23 34 23 - HVAC Power Ventilators Jones

23 34 39 - High-Volume, Low-Speed Propeller Fans Jones

23 37 00 - Air Outlets and Inlets Jones

23 38 13 - Commercial-Kitchen Hoods Jones

23 41 00 - Air Filters Jones

23 74 20 - Packaged, Outdoor, Heating and Cooling Make-up Air-Conditioners Jones

23 81 26.13 - Small-Capacity Split-System Air Conditioners Jones

23 81 29 - Variable Refrigerant Flow HVAC Systems Jones

DIVISION 26 -- ELECTRICAL

26 05 00 - Common Work Results For Electrical	Jones
26 05 19 - Low-Voltage Electrical Power Conductors and Cables	Jones
26 05 26 - Grounding and Bonding for Electrical Systems	Jones
26 05 29 - Hangers and Supports for Electrical Systems	Jones
26 05 33.13 - Conduit for Electrical Systems	Jones
26 05 33.16 - Boxes for Electrical Systems	Jones
26 05 53 - Identification for Electrical Systems	Jones
26 05 73 - Power System Studies	Jones
26 08 00 Commissioning of Electrical Systems (New 2022/11/22)	
26 22 00 - Low-Voltage Transformers	Jones
26 24 16 - Panelboards	Jones
26 27 26 - Wiring Devices	Jones
26 28 16.13 - Enclosed Circuit Breakers	Jones
26 28 16.16 - Enclosed Switches	Jones
26 32 13 - Engine Generators	Jones
26 36 00 - Transfer Switches	Jones
26 41 13 - Lightning Protection for Structures	Jones
26 43 00 - Surge Protective Devices	Jones
26 51 00 - Interior Lighting	Jones

DIVISION 27 -- COMMUNICATIONS

27 05 26 - Telecommunications Grounding and Bonding	4B
27 05 28 - Interior Communication Pathways	4B
27 05 43 - Exterior Communication pathways	4B
27 05 53 - Identification and Labeling of Communication Infrastructure	4B
27 11 00 - Communications Cabinets and Equipment Rooms	4B
27 13 00 - Backbone and Riser Media Infrastructure	4B
27 15 00 - Horizontal Media Infrastructure	4B
27 40 00 - Audiovisual Systems	4B

DIVISION 28 -- ELECTRONIC SAFETY AND SECURITY

28 08 00 - Commissioning of Electronic Safety and Security (New 2022/11/22)	
28 13 00 - Access Control	4B
28 23 00 - Video Surveillance Control And Management System	4B
28 46 00 - Fire Detection and Alarm	Jones

DIVISION 31 -- EARTHWORK

31 23 00 - Excavation and Fill	Henderson Rogers
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SECTION 08 80 00
GLAZING
(REVISED)

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Insulating glass units.
- B. Glazing units.

1.02 RELATED REQUIREMENTS

- A. Section 07 25 00 - Weather Barriers.
- B. Section 07 92 00 - Joint Sealants: Sealants for other than glazing purposes.
- C. Section 08 11 13 - Hollow Metal Doors and Frames: Glazed lites in doors and borrowed lites.
- D. Section 08 14 16 - Flush Wood Doors: Glazed lites in doors.
- E. Section 08 43 13 - Aluminum-Framed Storefronts: Glazing furnished as part of storefront assembly.
- F. Section 08 51 13 - Aluminum Windows: Glazing furnished by window manufacturer.
- G. Section 08 83 00 - Mirrors.

1.03 REFERENCE STANDARDS

- A. 16 CFR 1201 - Safety Standard for Architectural Glazing Materials Current Edition.
- B. ANSI Z97.1 - American National Standard for Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test 2015.
- C. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures Most Recent Edition Cited by Referring Code or Reference Standard.
- D. ASTM C864 - Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers 2005 (Reapproved 2015).
- E. ASTM C1036 - Standard Specification for Flat Glass 2016.
- F. ASTM C1048 - Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass 2018.
- G. ASTM C1172 - Standard Specification for Laminated Architectural Flat Glass 2014.
- H. ASTM C1193 - Standard Guide for Use of Joint Sealants 2016.
- I. ASTM C1376 - Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass 2015.
- J. ASTM E1300 - Standard Practice for Determining Load Resistance of Glass in Buildings 2016.
- K. ASTM E2190 - Standard Specification for Insulating Glass Unit Performance and Evaluation 2010.
- L. GANA (GM) - GANA Glazing Manual 2008.
- M. GANA (SM) - GANA Sealant Manual 2008.
- N. GANA (LGRM) - Laminated Glazing Reference Manual 2009.
- O. IGMA TM-3000 - North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial & Residential Use 1990 (2016).
- P. NFRC 100 - Procedure for Determining Fenestration Product U-factors 2017.
- Q. NFRC 200 - Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence 2014, with Errata (2017).
- R. NFRC 300 - Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems 2017.
- S. UL 972 - Standard for Burglary Resisting Glazing Material Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Convene a preinstallation meeting one week before starting work of this section; require attendance by each of the affected installers.

1.05 SUBMITTALS

- A. See Division 01, for submittal procedures.
- B. Product Data on Insulating Glass Unit, Glazing Unit, Plastic Sheet Glazing Unit, and Plastic Film Glazing Types: Provide structural, physical and environmental characteristics, size limitations, special handling and installation requirements.
- C. Product Data on Glazing Compounds and Accessories: Provide chemical, functional, and environmental characteristics, limitations, special application requirements, and identify available colors.
- D. Samples: Submit two samples 4 by 4 inch in size of glass units.
- E. Manufacturer's Qualification Statement.
- F. Installer's Qualification Statement.
- G. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Insulating Glass Units: One of each glass size and each glass type.

1.06 QUALITY ASSURANCE

- A. Perform Work in accordance with GANA (GM), GANA (SM), GANA (LGRM), and IGMA TM-3000 for glazing installation methods. Maintain one copy on site.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years of documented experience.
- C. Installer Qualifications: Company specializing in performing work of the type specified and with at least three years documented experience.

1.07 FIELD CONDITIONS

- A. Do not install glazing when ambient temperature is less than 40 degrees F.
- B. Maintain minimum ambient temperature before, during and 24 hours after installation of glazing compounds.

1.08 WARRANTY

- A. Insulating Glass Units: Provide a five (5) year manufacturer warranty to include coverage for seal failure, interpane dusting or misting, including providing products to replace failed units.
- B. Laminated Glass: Provide a five (5) year manufacturer warranty to include coverage for delamination, including providing products to replace failed units.

PART 2 PRODUCTS

2.01 MANUFACTURERS

ADD 2

- A. Glass Fabricators:
 - 1. GGI - General Glass International: www.generalglass.com/#sle.
 - 2. Standard Bent Glass Corp: www.standardbent.com/#sle.
 - 3. Trulite Glass & Aluminum Solutions, LLC: www.trulite.com/#sle.
 - 4. Viracon, Inc: www.viracon.com/#sle.
 - 5. Substitutions: See Division 01.
- B. Float Glass Manufacturers:
 - 1. AGC Glass North America, Inc: www.agcglass.com/#sle.
 - 2. Cardinal Glass Industries: www.cardinalcorp.com/#sle.
 - 3. Pilkington North America Inc: www.pilkington.com/na/#sle.
 - 4. Substitutions: See Division 01.

ADD 2

- C. Laminated Glass Manufacturers:
 1. Cardinal Glass Industries: www.cardinalcorp.com/#sle.
 2. Goldray Industries, Inc; Colored Interlayer Laminated Glass: www.goldrayglass.com/#sle.
 3. Viracon, Architectural Glass segment of Apogee Enterprises, Inc; VE1-42: www.viracon.com/#sle.
 4. Substitutions: See Division 01.
- D. Fire-Resistance-Rated Glass: Provide products as required to achieve indicated fire-rating period.
 1. Manufacturers:
 - a. SAFTIFIRST, a division of O'Keeffe's Inc; SuperLite II-XL: www.safti.com/#sle.
 - b. Technical Glass Products; Pilkington Pyrostop: www.fireglass.com/#sle.
 - c. Vetrotech North America; Contraflam: www.vetrotechusa.com/#sle.
 - d. Substitutions: See Division 01.

2.02 PERFORMANCE REQUIREMENTS - EXTERIOR GLAZING ASSEMBLIES

- A. Provide type and thickness of exterior glazing assemblies to support assembly dead loads, and to withstand live loads caused by positive and negative wind pressure acting normal to plane of glass.
 1. Comply with ASTM E1300 for design load resistance of glass type, thickness, dimensions, and maximum lateral deflection of supported glass.
 2. Provide glass edge support system sufficiently stiff to limit the lateral deflection of supported glass edges to less than 1/175 of their lengths under specified design load.
 3. Glass thicknesses listed are minimum.
- B. Vapor Retarder and Air Barrier Seals: Provide completed assemblies that maintain continuity of building enclosure vapor retarder and air barrier.
 1. In conjunction with vapor retarder and joint sealer materials described in other sections.
- C. Thermal and Optical Performance: Provide exterior glazing products with performance properties as indicated. Performance properties are in accordance with manufacturer's published data as determined with the following procedures and/or test methods:
 1. Center of Glass U-Value: Comply with NFRC 100 using Lawrence Berkeley National Laboratory (LBNL) WINDOW 6.3 computer program.
 2. Center of Glass Solar Heat Gain Coefficient (SHGC): Comply with NFRC 200 using Lawrence Berkeley National Laboratory (LBNL) WINDOW 6.3 computer program.
 3. Solar Optical Properties: Comply with NFRC 300 test method.

2.03 GLASS MATERIALS

- A. Float Glass: Provide float glass based glazing unless otherwise indicated.
 1. Annealed Type: ASTM C1036, Type I - Transparent Flat, Class 1 - Clear, Quality - Q3.
 2. Kind HS - Heat-Strengthened Type: Complies with ASTM C1048.
 3. Kind FT - Fully Tempered Type: Complies with ASTM C1048.
 4. Fully Tempered Safety Glass: Complies with ANSI Z97.1 or 16 CFR 1201 criteria for safety glazing used in hazardous locations.
 5. Tinted Type: ASTM C1036, Class 2 - Tinted, Quality - Q3, with color and performance characteristics as indicated.
 6. Thicknesses: As indicated; provide greater thickness as required for exterior glazing wind load design.
- B. Laminated Glass: Float glass laminated in accordance with ASTM C1172.
 1. Laminated Safety Glass: Complies with ANSI Z97.1 - Class B or 16 CFR 1201 - Category I impact test requirements.
 2. Polyvinyl Butyral (PVB) Interlayer: 0.030 inch thick, minimum.

2.04 INSULATING GLASS UNITS

- A. Insulating Glass Units: Types as indicated.
 1. Durability: Certified by an independent testing agency to comply with ASTM E2190.

2. Coated Glass: Comply with requirements of ASTM C1376 for pyrolytic (hard-coat) or magnetic sputter vapor deposition (soft-coat) type coatings on flat glass; coated vision glass, Kind CV; coated overhead glass, Kind CO; or coated spandrel glass, Kind CS.
3. Metal Edge Spacers: Aluminum, bent and soldered corners.
4. Spacer Color: Black.
5. Edge Seal:
 - a. Dual-Sealed System: Provide polyisobutylene sealant as primary seal applied between spacer and glass panes, and silicone, polysulfide, or polyurethane sealant as secondary seal applied around perimeter.
 - b. Color: Black.
6. Purge interpane space with dry air, hermetically sealed.

ADD 2

- B. Type GL-01 - Insulating Glass Units: Vision glass, double glazed.
 1. Applications: Exterior glazing unless otherwise indicated.
 2. Space between lites filled with air.
 3. Outboard Lite: Laminated, 1/2 inch thick, minimum.
 - a. Tint: Clear.
 - b. Coating: Low-E (solar control type), on #2 surface.
 4. Inboard Lite: Fully tempered float glass, 1/4 inch thick.
 - a. Tint: Gray over Clear.
 5. Sound Transmission Class (STC) rating of 40, with special acoustical spacer and edge seal.
 6. Total Thickness: 1-5/16 inch.
 7. Thermal Transmittance (U-Value), Winter - Center of Glass: 34%, nominal.
 8. Visible Light Transmittance (VLT): 36 percent, minimum.
 9. Solar Heat Gain Coefficient (SHGC): .29, nominal.
 10. Glazing Method: Dry glazing method, gasket glazing.

2.05 GLAZING UNITS

- A. Type G-2 - Monolithic Interior Vision Glazing:
 1. Applications: Interior glazing unless otherwise indicated.
 2. Glass Type: Fully tempered float glass.
 3. Tint: Clear.
 4. Thickness: 1/4 inch, nominal.
- B. Type G-3 - Fire-Resistance-Rated Glazing: Type, thickness, and configuration of glazing that contains flame, smoke, and blocks radiant heat, as required to achieve indicated fire-rating period exceeding 45 minutes.
 1. Applications:
 - a. Glazing in fire-rated door assembly.
 - b. Glazing in fire-rated window assembly.
 2. Glass Type: Tempered glass outer layers filled with semi-solid fire retardant.
 3. Provide products listed by ITS (DIR) or UL (DIR) and approved by authorities having jurisdiction.
 4. Safety Glazing Certification: 16 CFR 1201 Category II.
 5. Glazing Method: As required for fire rating.
 6. Fire-Rating Period: 60 minutes.
 7. Markings for Fire-Resistance-Rated Glazing Assemblies: Provide permanent markings on fire-resistance-rated glazing in compliance with ICC (IBC), local building code, and authorities having jurisdiction.
 8. Manufacturers:
 - a. GGI - General Glass International; Pyrobel: www.generalglass.com/#sle.
 - b. SAFTIFIRST, a division of O'Keeffe's Inc; SuperLite II-XL 60: www.safti.com/#sle.
 - c. SAFTIFIRST, a division of O'Keeffe's Inc; SuperLite II-XLM 60: www.safti.com/#sle.
 - d. Substitutions: See Division 01/

2.06 ACCESSORIES

- A. Setting Blocks: Silicone, with 80 to 90 Shore A durometer hardness; ASTM C864 Option II. Length of 0.1 inch for each square foot of glazing or minimum 4 inch by width of glazing rabbet space minus 1/16 inch by height to suit glazing method and pane weight and area.
- B. Glazing Tape, Back Bedding Mastic Type: Preformed, butyl-based, 100 percent solids compound with integral resilient spacer rod applicable to application indicated; 5 to 30 cured Shore A durometer hardness; coiled on release paper; black color.
 - 1. Width: As required for application.
 - 2. Thickness: As required for application.
- C. Glazing Gaskets: Resilient silicone extruded shape to suit glazing channel retaining slot; ASTM C864 Option II; color black.

PART 3 EXECUTION

3.01 VERIFICATION OF CONDITIONS

- A. Verify that openings for glazing are correctly sized and within tolerances, including those for size, squareness, and offsets at corners.
- B. Verify that surfaces of glazing channels or recesses are clean, free of obstructions that may impede moisture movement, weeps are clear, and support framing is ready to receive glazing system.
- C. Proceed with glazing system installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Clean contact surfaces with appropriate solvent and wipe dry within maximum of 24 hours before glazing. Remove coatings that are not tightly bonded to substrates.
- B. Seal porous glazing channels or recesses with substrate compatible primer or sealer.
- C. Prime surfaces scheduled to receive sealant where required for proper sealant adhesion.

3.03 INSTALLATION, GENERAL

- A. Install glazing in compliance with written instructions of glass, gaskets, and other glazing material manufacturers, unless more stringent requirements are indicated, including those in glazing referenced standards.
- B. Install glazing sealants in accordance with ASTM C1193, GANA (SM), and manufacturer's instructions.
- C. Do not exceed edge pressures around perimeter of glass lites as stipulated by glass manufacturer.
- D. Set glass lites of system with uniform pattern, draw, bow, and similar characteristics.
- E. Set glass lites in proper orientation so that coatings face exterior or interior as indicated.
- F. Prevent glass from contact with any contaminating substances that may be the result of construction operations such as, and not limited to the following; weld splatter, fire-safing, plastering, mortar droppings, etc.

3.04 INSTALLATION - DRY GLAZING METHOD (GASKET GLAZING)

- A. Application - Exterior and/or Interior Glazed: Set glazing infills from either the exterior or the interior of the building.
- B. Place setting blocks at 1/4 points with edge block no more than 6 inch from corners.
- C. Rest glazing on setting blocks and push against fixed stop with sufficient pressure on gasket to attain full contact.
- D. Install removable stops without displacing glazing gasket; exert pressure for full continuous contact.

3.05 FIELD QUALITY CONTROL

- A. Glass and Glazing product manufacturers to provide field surveillance of the installation of their products.
- B. Monitor and report installation procedures and unacceptable conditions.

3.06 CLEANING

- A. Remove excess glazing materials from finish surfaces immediately after application using solvents or cleaners recommended by manufacturers.
- B. Remove non-permanent labels immediately after glazing installation is complete.
- C. Clean glass and adjacent surfaces after sealants are fully cured.
- D. Clean glass on both exposed surfaces not more than 4 days prior to Date of Substantial Completion in accordance with glass manufacturer's written recommendations.

3.07 PROTECTION

- A. After installation, mark pane with an 'X' by using removable plastic tape or paste; do not mark heat absorbing or reflective glass units.
- B. Remove and replace glass that is damaged during construction period prior to Date of Substantial Completion.

END OF SECTION

IAH ARFF 92
Project No. 668

REVISED

**BID FORM
PART A**

Document 00410A

BID FORM – PART A

To: **The Honorable Mayor and City Council of the City of Houston
City Hall Annex
900 Bagby Street
Houston, Texas 77002**

Project: IAH ARFF 92

Project No.: 668

Bidder: _____

(Print or type full name of business entity, such as corporation, LLC, etc)

1.0 OFFER

- A. Total Bid Price:** Having examined the Project location and all matters referred to in Bid Documents for the Project, we, the undersigned, offer to enter into a Contract to perform the Work for the Total Bid Price shown on the signature page of this Document
- B. Security Deposit:** Included with the Bid is a Security Deposit in the amount of 10 percent of the Total Bid Price subject to terms described in Document 00200 – Instructions to Bidders.
- C. Period for Bid Acceptance:** This offer is open to acceptance and is irrevocable for 180 days from Bid Date. That period may be extended by mutual written agreement of the City and Bidder.
- D. Addenda:** All Addenda have been received. Modifications to Bid Documents have been considered and all related costs are included in the Total Bid Price.
- E. Bid Supplements:** The following documents are attached:
- Security Deposit (*as defined in Document 00200 – Instructions to Bidders*)
 - Document 00450 - Bidder's Statement of MWSBE Status
 - Document 00454 - Affidavit of Non-interest
 - Document 00455 - Ownership Information Form
 - Document 00456 - Bidder's Certificate of Compliance with Buy American Program (*required for AIP funded project*)
 - Document 00457 – Conflicts of Interest Questionnaire (CIQ)
 - Document 00458 - Bidder's Certificate Regarding Foreign Trade Restriction (*required for AIP funded project*)
 - Document 00459 - Contractor's Statement Regarding Previous Contracts Subject to EEO (*required for AIP funded project*)
 - Document 00460 – Pay or Play Acknowledgement Form (POP 1-A)
 - Document 00461 – Hire Houston First Affidavit
 - Document 00470 – Bidder's MWSBE Participation Plan (*required unless no MWSBE participation goal is provided in Document 00800 (the "Goal")*).
 - Document 00470D - Bidder's DBE Participation Plan (*required for AIP funded project*)

00410-A1

REVISED 1/10/2023

IAH ARFF 92
Project No. 668

REVISED

**BID FORM
PART A**

- Document 00471 – Bidder’s Record of Good Faith Efforts (*required if the goal in Bidder’s Participation Plan–Document 00470 is lower than the Goal*).
- Document 00472 – Bidder’s Goal Deviation Request (*required if the goal in Bidder’s Participation Plan–Document 00470 is lower than the Goal*).
- Document 00480 – Form SCM-1 Reference Verification
- Document 00481 – Non-Collusion Statement
- Document 00842 – Letter of Intent
- Others as listed: _____

2.0 CONTRACT TIME

A. If offer is accepted, Contractor shall achieve Date of Substantial Completion within 300 days after Date of Commencement of the Work, subject to adjustments of Contract Time as provided in the Contract.

IAH ARFF 92
Project No. 668

REVISED

**BID FORM
PART B**

CASH ALLOWANCE TABLE:

Item No.	Spec Ref.	Cash Allowance Short Title	Cash Allowance in figures (1)
1		Building Permit	\$35,000.00
2		CenterPoint Electrical & Gas Allowance	\$300,000.00
3		Permanent Telephone & Cable Service	\$15,000.00
4		Furniture Fixtures & Equipment (FF&E)	\$475,000.00
5		Moving Allowance	\$50,000.00
<u>TOTAL CASH ALLOWANCES</u>			\$875,000.00

ADD. 2

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IAH ARFF 92
 Project No. 668

REVISED

**BID FORM
 PART B**

E. ALTERNATES TABLE:

Item No.	Spec Ref.	Alternate Short Title	Unit of Measure	Estimated Quantity	Unit Price (this column controls)	Total Price for Alternate in figures
1		N/A				
<u>TOTAL ALTERNATES</u>						\$ _____

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IAH ARFF 92
Project No. 668

REVISED

**BID FORM
PART B**

F. TOTAL BID PRICE: \$ _____
(Add Totals for Stipulated Price, Base Unit Price, Extra Unit Price, Cash Allowance, and All Alternates, if any)

2.0 SIGNATURES: By signing this Document, I agree that I have received and reviewed all Addenda and considered all costs associated with the Addenda in calculating the Total Bid Price.

Bidder: _____
(Print or type full name of your proprietorship, partnership, corporation, or joint venture.*)

****By:** _____
Signature Date

Name: _____
(Print or type name) Title

Address: _____
(Mailing)

(Street, if different)

Telephone and Fax Number: _____
(Print or type numbers)

* If Bid is a joint venture, add additional Bid Form signature sheets for each member of the joint venture.

** Bidder certifies that the only person or parties interested in this offer as principals are those named above. Bidder has not directly or indirectly entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding.

Note: This document constitutes a government record, as defined by § 37.01 of the Texas Penal Code. Submission of a false government record is punishable as provided in § 37.10 of the Texas Penal Code.

IAH ARFF 92
Project No. 668

CASH ALLOWANCES

SECTION 01210
CASH ALLOWANCES
(REVISED)

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. City's allowances allocated to the items of work listed or as directed.
- B. See Document 00700 - General Conditions, Paragraph 3.11 for costs included and excluded from cash allowance values listed in 1.02 below.
- C. Follow Section 01255 - Modification Procedures for processing allowance expenditures. Cash Allowance sums remaining at Final Completion belong to the City, creditable by Change Order.

1.02 SCHEDULE OF CASH ALLOWANCES (TOTAL \$875,000.00 VALUE)

- A. Allowance Item 1 - Building Permit: For obtaining the Building Permit from City of Houston, \$35,000.00.
- B. Allowance Item 2 - Permanent Electrical Service: For Center Point Energy work for \$300,000.00.
- C. Allowance Item 3 - Permanent Telephone Service: For Southwestern Bell Telephone work for, \$15,000.00.
- D. Allowance Item 4 – Equipment (FF&E): For Furniture Fixtures & Equipment (FF&E) work for, \$475,000.00.
- E. Allowance Item 5 – Moving Allowance: For HFD furniture and equipment relocation work for, \$50,000.00

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

CASH ALLOWANCES
REVISED 1/10/2023

IAH ARFF 92
Project No. 668

CASH ALLOWANCES

END OF SECTION

CASH ALLOWANCES
REVISED 1/10/2023

SECTION 01 91 13
GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

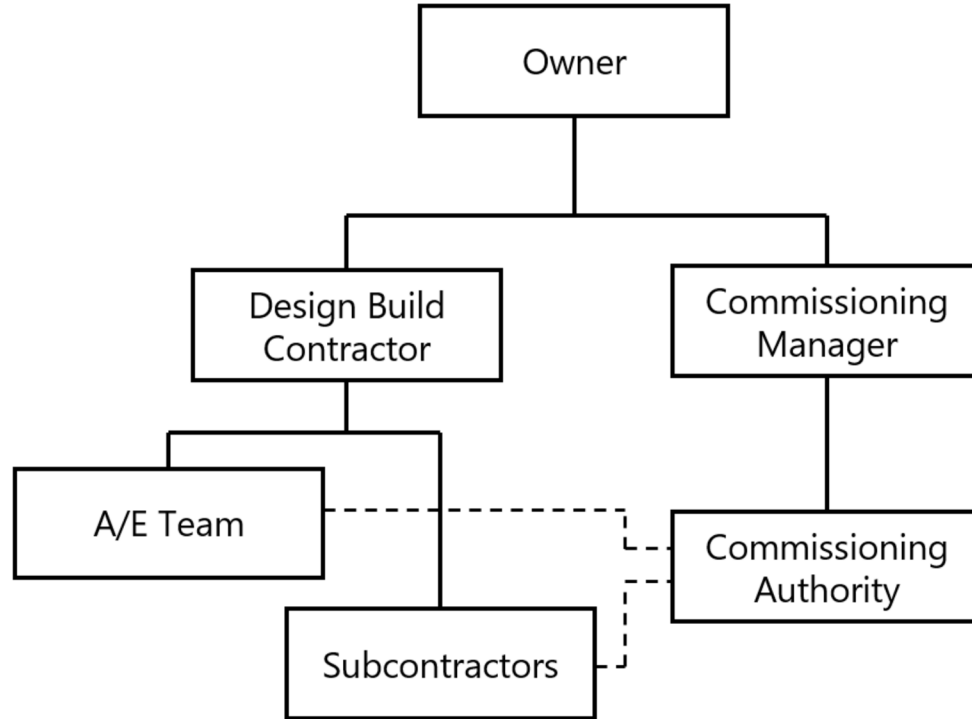
- A. Section 01 79 00 Demonstration and Training
- B. Section 23 08 00 Commissioning of HVAC Systems
- C. Section 26 08 00 Commissioning of Electrical Systems

1.2 SUMMARY

- A. The Commissioning Process (Cx) is a quality-focused process for enhancing the delivery of a project. Cx focuses on evaluating and documenting that all the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements (OPR). For the purposes of this project, the OPR is defined as the HAS Design Standards, current version as of the date of this executed contract, and the programming deliverable provided by the AE consultant.
- B. Cx roles and responsibilities for each Project Delivery Team (PDT) member involved are defined in Sections 1.9 (Cx Team), 1.10 (Contractor) and 1.11 (CxA). Special responsibilities are included in the commissioning requirements section by division, where applicable.
- C. Cx does not dilute the responsibility of the designers or installing contractors to provide a finished and fully functioning product.
- D. Systems to be commissioned are listed in Section 1.5.

1.3 COORDINATION

- A. Commissioning Authority (CxA): the CxA is the individual that is responsible for the management of actions and generation of deliverables as outlined in the Cx Plan.
- B. Commissioning Provider (CxP): the CxP may comprise several companies, including subcontractors to the CxA who act as the contract to the Owner.
- C. Management: The CxA works for the Commissioning Manager (CxM)/Owner. The CxA directs and coordinates the project Cx Activities and reports the CxM/Owner and/or the Owner's Representative (O-REP). Team members work together to fulfill their contracted responsibilities and meet the objectives of the contract documents. The organization chart in Figure 1 clarifies the roles:



D.

1.4 Figure 1. Organization Chart

1.5 COMMISSIONING PROCESS

- A. Cx activities shall begin in the design phase of the project but will initiate with the Cx Team that includes the Contractor during pre-construction with submittal reviews. The CxA shall distribute a Cx Plan that includes pre-functional and functional performance test procedures. As part of the startup procedures, the Contractor shall perform pre-functional testing and complete the web-based documentation in Facility Grid, or other designated system. The pre-verification testing will be completed by the Contractor(s) before functional performance testing begins, to ensure that ALL systems and equipment are ready for successful testing. The CxA shall witness the functional performance testing with the Contractor running each test and provide necessary support for completion of the procedures.

1.6 SYSTEMS TO BE COMMISSIONED

- A. Commission the following systems and assemblies:
1. Rooftop Package Units
 2. Air Valve Terminal Units
 3. Exhaust/Ventilation Fans
 4. VRF Components
 5. Building Automation System (BAS)

6. Lighting Control Systems
7. Primary Electrical Distribution

1.7 REFERENCES

- A. The publications listed below form a part of this specification to extent referenced.
 1. AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR-CONDITIONING ENGINEERS (ASHRAE)
 - a. ASHRAE Standard 202 (2018) Commissioning Process for Buildings and Systems
 - b.
 - c. ASHRAE Guideline 1.1 (2007) HVAC&R Technical Requirements for the Commissioning Process, with errata published July 2, 2012
 2. INTERNATIONAL CODE COUNCIL
 - a. IECC – International Energy Conservation Code (2021)
 - b.
 3. BUILDING COMMISSIONING ASSOCIATION
 - a. New Construction Commissioning, Best Practices (2018)
 - b.
 4. ASTM INTERNATIONAL:
 - a. ANSI/ASTM E2947-21A (2021). Standard Guide for Building Enclosure Commissioning

1.8 DEFINITIONS

- A. OPR: Owner's Project Requirements. A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, supporting information, and operations and maintenance requirements.
- B. BoD: Basis of Design. A document that records concepts, calculations, decisions, and product selections used to meet the OPR and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.
- C. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
- D. Test Checklists: CxA shall develop test checklists for each system, subsystem, or equipment including interfaces and interlocks, and include a separate entry, with space for comments, for each item to be tested.
- F. Certificate of Readiness: Certificate of Readiness shall be signed by the General Contractor, Subcontractor(s) certifying that systems, subsystems, equipment, and

associated controls are ready for testing. Completed test checklists signed by the responsible parties shall accompany this certificate

- G. **Test and Inspection Reporting:** Subcontractors shall perform Pre-Functional Tests (provided by CxA), shall complete the Pre-Functional Test documentation (PFCs), and report all activities and progress in the cloud-based reporting tool (Facility Grid). Subcontractors shall perform Pre-Verification Testing based on Functional Test scripts provided by the CxA. The Subcontractors will then execute the Functional Performance Tests, which shall be witnessed by the CxA. The CxA shall complete the Functional Testing documentation, including observed issues, in Facility Grid.
- H. **Corrective Action Documents:** CxA shall document, in Facility Grid, ALL corrective action taken for systems and equipment that fail functional tests. Include required modifications to systems and equipment and revisions to test procedures, if any. Retest systems and equipment requiring corrective action and document retest results in Facility Grid.
- I. **Commissioning Report:** CxA shall document results of the commissioning process including unresolved issues and performance of systems, subsystems, and equipment. The commissioning report shall indicate whether systems, subsystems, and equipment have been completed and are performing according to the OPR, BOD, and Contract Documents.
- J. **Commissioning Manager (CxM):** The entity identified by the owner who ensures the commissioning process is executed by the CxA.
- K. **Commissioning Authority (CxA):** The entity identified by the owner who leads, plans, schedules, and coordinates the commissioning team to implement the commissioning process.
- L. **General Contractor:** The prime construction contractor, whether in a Bid/Build General Contractor role, a CMAR role, or a Design-Build prime role. The abbreviation GC shall denote any firm serving in the role of the construction prime contractor.
- M. **Sub-Contractors:** Contracted directly or indirectly to GC. Responsible for certain trade installations and related installation coordination with other trades.
- N. **Systems, Subsystems, Equipment, and Components:** Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.9 COMMISSIONING SOFTWARE FACILITY GRID

- A. The commissioning process relies upon tracking, documenting, and reporting of activities and milestones that have a critical impact on the project schedule. Communication between the Project Delivery Team members (Owner, CxM, Architect, Engineer, Constructor, Subs) is critical to recognizing potential issues in the commissioning

process. This section addresses the use of commissioning software to facilitate tracking and reporting of the commissioning process.

1. The CxA utilizes cloud-based software (Facility Grid) as a commissioning process management application reporting tool. As such, the CxA shall use Facility Grid to facilitate the Commissioning Process. Facility Grid will be used to manage Commissioning activities including but not limited to: Recording site observations, generating and completing PFCs and FPTs, tracking Commissioning issues and deficiencies, developing the Final Commissioning Report and the Systems Manual.
2. The Facility Grid software license will be provided by the CxA at no cost to the project participants. The CxA will provide the training at no cost to the project participants as required for effective use of the software.
3. The Contractors that have been awarded this project will be required to use Facility Grid for the purpose of completion of PFCs, PVTs, and for responding to Commissioning Issues.

1.10 COMMISSIONING TEAM

- A. Members appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated actions. The commissioning team shall consist of, but not be limited to, representatives of the General Contractor, Mechanical subcontractors, Electrical subcontractors, BAS subcontractors, suppliers, and specialists deemed appropriate by the CxA.
- B. Members appointed by Owner:
 1. CxM: The commissioning manager within the owner's organization, assigned to ensure successful completion of the commissioning process by the CxA.
 2. CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.
 3. Representatives of the facility user and operation and maintenance personnel.
 4. Architect and engineering design professionals.

1.11 CONTRACTOR'S RESPONSIBILITIES

- A. Provide utility services required for the commissioning process.
- B. Contractor shall assign representatives with expertise and authority to act on behalf of the Contractor and schedule them to participate in and perform commissioning team activities including, but not limited to, the following:
 1. Participate in construction phase coordination meetings.
 2. Participate in maintenance orientation and inspection.
 3. Develop and participate in operation and maintenance training sessions.
 4. Participate in final review at acceptance meeting.
 5. Furnish a copy of all construction documents, addenda, change orders, submittals and shop drawings related to commissioned equipment to the Cx Plan.

6. Furnish a copy of documents required to compile the Facility Requirements and Operations and Maintenance Plan including but not limited to:
 - a. Sequences of operation for the building
 - b. Building occupancy schedule
 - c. Equipment run-time schedules
 - d. Setpoints for all HVAC equipment
 - e. Lighting levels throughout the building
 - f. Minimum outside air requirements
 - g. Changes in schedules or setpoints for different seasons, days of the week, and times of day
 - h. Systems narrative describing the mechanical and electrical systems and equipment
 - i. Preventive maintenance plan for building equipment described in the systems narrative
 7. Certify that Work is complete:
 - a. Provide completed manufacturer start-up documents.
 - b. Complete pre-functional checklists, issued by the CxA.
 - c. Complete pre-verification tests, issued by the CxA.
 - d. Include calibration of instrumentation and controls.
 - e. Provide required trend data for applicable systems.
 8. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
 9. Review and accept Cx test procedures provided by the CxA.
 10. Perform Cx test procedures, witnessed by the CxA.
 11. Perform opposite season testing, witnessed by the CxA.
 12. Attend warranty walk through with Cx Team at approximately 10 months from date of substantial completion, and address any deficiencies identified that are in-Contract by the AE or the CxA.
- C. Subcontractors shall assign representatives with expertise and authority to act on behalf of subcontractors and schedule them to participate in and perform Cx Team activities including, but not limited to, the following:
1. Participate in construction phase coordination meetings.
 2. Participate in maintenance orientation and inspection.
 3. Participate in procedures meeting for testing.
 4. Participate in final review at acceptance meeting.
 5. Provide schedule for operation and maintenance data submittals, equipment startup, and testing to CxA for incorporation into the Cx Plan. Update schedule throughout the construction period.
 6. Provide information to the CxA for developing construction phase Cx Plan.
 7. Participate in training sessions for Owner's operation and maintenance personnel.
 8. Provide updated Project Record Documents to the CxA.
 9. Gather and submit operation and maintenance data for systems, subsystems, and equipment to the CxA.

10. Provide technicians who are familiar with the construction and operation of installed systems and who shall participate in testing of installed systems, subsystems, and equipment.
11. Certify in writing that Work is complete and ready for Functional Testing:
 - a. Provide completed manufacturer start-up documents.
 - b. Complete pre-functional checklists, issued by the CxA.
 - c. Complete pre-verification tests, issued by the CxA.
 - d. Include calibration of instrumentation and controls.
 - e. Provide required trend data for applicable systems.

1.12 CXA'S RESPONSIBILITIES

- A. Develop the Cx Plan.
- B. Host Cx kickoff meeting.
- C. Review select project equipment submittals concurrently with the AE to confirm conformance with the OPR, or identify where deviations exist. Utilize information in approved submittals to complete development of the PFCs, PVTs, FPTs, and ISTs.
- D. Provide Project-specific construction checklists and Cx test procedures (PFCs, PVTs, FPTs, and ISTs).
- E. Conduct periodic site visits and report site observations to ensure the installation meets project requirements.
- F. Verify the execution of Cx activities at a random selection sampling rate described in the commissioning section of each applicable system specifications. The sampling rate may vary from 1 to 100 percent, as determined by the CxM. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, the CxA will report the failure in the Issues Log. The issues created under the random sampling protocol will apply as "typical" to all of the same equipment type.
- G. Prepare and maintain the Issues Log in Facility Grid.
- H. Prepare and maintain completed construction checklist log in Facility Grid.
- I. Witness systems, assemblies, equipment, and component startup in a manner that encourages the installing contractors to follow the project's quality assurance plan.
- J. Compile third party test data, BSG inspection reports, and certificates of readiness; include them in the systems manual and Cx Report.
- K. Witness seasonal testing and lead Cx Team in end of warranty walk through.

1.13 RE-TESTING

- A. Abort Functional Performance Tests, Integrated Systems Tests, or Seasonal Tests if any deficiency prevents successful completion of the test or if any required Cx Team member is not present for the test. Re-test only after all deficiencies identified during the original tests have been corrected. Re-testing will occur at the direction of the CxM and will be paid for with a deductive change order against the responsible party's contract. The decision to abort scheduled tests will be the responsibility of the CxA and the CxM.
- B. Systems or equipment, for which 100 percent sample size are tested, fail if one or more of the test procedures results in discovery of a deficiency during the test that prevents completion of the test. Re-test to the extent necessary to confirm that the deficiencies have been corrected without negatively impacting the performance of the rest of the system. Re-testing will occur at the direction of the CxM and will be paid for with a deductive change order against the responsible party's contract. The decision to fail scheduled tests will be the responsibility of the CxA.
- C. For systems tests with a sample size less than 100 percent, if one or more of the test procedures for an item of equipment or a system results in discovery of a deficiency, regardless of whether the deficiency is corrected during the sample tests, the item of equipment or system fails the test.
1. If the system failure rate is 5 percent or less, meaning that 5 percent or less of the equipment or systems had at least one deficiency, re-test only on the items which experienced the initial failures.
 2. If the system failure rate is higher than 5 percent, meaning that more than 5 percent of equipment or systems tested had at least one deficiency, re-test the items which experienced the initial failures to the extent necessary to confirm that the deficiencies have been corrected. In addition, test another random sample of the same size as the initial sample for the first time. If the second random sample set has any failures, re-test those failed items and all remaining equipment and systems to complete 100 percent testing of that system type.
- D. If re-testing is required due to failed functional performance tests, the contractor is responsible for coordinating with necessary team members and adjusting the overall project schedule to accommodate the re-testing. The Contractor is also responsible for reimbursing any costs associated with factory representative and Cx Team members participation during re-retests. ~~Payment shall be made by contractor to Cx Team members prior to scheduling retesting site visits.~~
- E. If retesting is required, the contractor shall provide the CxA with 3 business days advanced notice for a test duration of less than 24 hours. For tests with duration of greater than 24 hours, advanced notice of 10 business days is required. The CxA shall not be held responsible for project delivery delays due to rescheduled tests to complete the Cx activities.

1.14 QUALITY ASSURANCE

- A. Instructor Qualifications: Factory-authorized service representatives experienced in training, operation, and maintenance procedures for installed systems, subsystems, and equipment.
 - 1. Test Equipment Calibration: Comply with test equipment manufacturer's calibration procedures and intervals. Provide current verification of calibration, in writing, prior to beginning and testing. Recalibrate test instruments immediately whenever instruments have been repaired following damage or dropping. Affix calibration tags to test instruments. Instruments shall have been calibrated within six months prior to use.

1.15 COORDINATION

- A. Coordinating Meetings: The Contractor shall conduct the following coordination meetings with the Cx Team.
 - 1. Cx kick-off meeting.
 - 2. Submittal review meetings, as required.
 - 3. Construction progress meetings.
 - 4. BAS trends requirements meeting.
 - 5. Pre-test meetings.
 - 6. Cx issue resolution meetings, if determined necessary by the CxA.
 - 7. Any additional meetings deemed necessary to adequately perform Cx duties and functions.
- B. Testing Coordination: The Contractor shall coordinate, with the Cx Team, the schedule of functional performance testing, as identified in the Cx plan.
 - 1. Schedule times for tests, inspections, obtaining samples, and similar activities

PART 2 - PRODUCTS

2.1 MATERIALS

- A. The contractor provides their own respective tools, instruments, and consumables required to meet the requirements of the Cx as described in this section and related sections.

PART 3 - EXECUTION

- 3.1 Special execution of the Cx activities shall be defined in the technical commissioning specification for each applicable discipline.
 - 1.

3.2 COMMISSIONING TESTS

- A. This subsection applies to Cx testing for all related divisions in ~~this section~~.
- B. The contractor shall be responsible to fully execute testing of equipment, systems, and assemblies according to the specifications.
- C. Pre-functional checklist will include requirements that Contractor:
 - 1. Provide BAS point to point report for each applicable system. The CxA requires this documentation be uploaded to Facility Grid.
 - 2. Pre-test all sequences of operation using the Pre-Verification Test on Facility Grid. The PVT is a version of the FPT completed by the Contractor.
- D. Functional performance testing can only initiate after approval by CxA that the pre-functional checklists, pre-verification testing, and Test and Balance is complete. The Contractor shall provide the CxA with a minimum of 5 business days to review the PFCs, PVTs, and trend data, as well as a walk through onsite before scheduling the FPTs. The Contractor shall notify the CxA directly that the PFCs and PVTs are complete and trend data is ready for review by the CxA.
- E. Test procedure format: A sample test form is provided in the Cx Plan. The test procedure forms developed by the CxA shall include, but not be limited to, the following information:
- F. Problem solving: The burden of problem solving is on the Contractor, Engineer and the Architect, though the CxA may recommend solutions to problems found.
- G. Functional performance test results: The CxA is responsible for determining the following results for each functional performance test they witness:
 - 1. Nonconformance
 - 2. Failure due to manufacturer defect
 - 3. Approval and acceptance
- H. Deferred testing may be required by the CxA to address seasonal conditions that may prohibit a required test, or to accommodate changes in the project schedule. All such deferred testing requirements shall be coordinated with the Construction schedule and submitted for PDT and Cx Team review and acceptance.
 - 1.

3.3 TRAINING OF OWNER'S PERSONNEL

- A. The CxA shall confirm the owner's personnel receives adequate training, administered by the appropriate contractors or manufacturer representatives, in accordance with the training requirements set in these contract documents. The contractors shall submit a training matrix to the CxA that includes proposed dates, methods of training, systems or equipment to be covered, agenda of topics to be covered, and the trainer's qualifications. The contractor should also video record each training session, as required by the owner

IAH ARFF 92
Project No. 668

GENERAL
COMMISSIONING REQUIREMENTS

in the Owner's Project Requirements. The training matrix shall be provided to the CxA no later than 30 days prior to the proposed training dates. Upon completion of each training session, a copy of the video recording shall be provided to the CxA for confirmation of completion.

IAH ARFF 92
Project No. 668

GENERAL
COMMISSIONING REQUIREMENTS

END OF SECTION

SECTION 01 91 15
BUILDING ENCLOSURE COMMISSIONING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Section 01 91 13 General Commissioning Requirements
- B. Section 01 91 17 Building Enclosure Functional Performance Testing
- C. Additionally, the following specification sections are related to the commissioning work specified in this section:
 - 1. Basic Concrete Requirements: Refer to Division 03
 - 2. Basic Masonry Requirements: Refer to Division 04
 - 3. Basic Waterproofing, Roofing, Air Barrier, Insulation Requirements: Refer to Division 07
 - 4. Basic Fenestration Systems Requirements: Refer to Division 08
 - 5. Basic Finishing Requirements: Refer to Division 09

1.2 SUMMARY

A. Section Includes:

- 1. The work under this section is subject to requirements of the Contract Documents, including the Owner's General Conditions and articles of the General Contractor's General Conditions.
- 2. This section includes the commissioning requirements for the Building Enclosure systems.
 - a. Refer to Section 019117 for Building Enclosure Functional Performance Testing.
 - b. The commissioning requirements for the building enclosure systems given in this section are in addition to, the General Commissioning Requirements specified in section 019113.
 - c. The General Contractor/Construction Manager, Contractors, Sub-contractors and Suppliers are required to participate in both commissioning processes as

BUILDING ENCLOSURE COMMISSIONING

019115-1

required by sections 019113 General Commissioning Requirements and 019115 Building Enclosure Commissioning.

- d. The 019113 Commissioning Authority and 019115 Building Enclosure Commissioning Authority will coordinate to document each commissioning process. All documents will be tracked and stored in Facility Grid.

1.3 COORDINATION

- A. Building Enclosure Commissioning Team: Members of the Building Enclosure Commissioning Team (BECT) will consist of:
 1. Architect and Engineers of Record (A/E)
 2. Building Enclosure Commissioning Authority (BECxA)
 3. Building Enclosure Testing Agency (BETA)
 4. Building Enclosure Subcontractors
 5. Commissioning Authority (CxA)
 6. Commissioning Provider (CxP)
 7. General Contractor (GC) or Construction Manager at Risk (CMAR). For the purposes of the BECT and the commissioning effort in general, the terms are interchangeable and mean the Construction Prime Contractor.
 8. Owner's Representative(s)
- B. Management: The CxA and BECxA will be the same entity, commonly known as the CxP. The BECxA will direct and coordinate commissioning activities through the CxA. All members of the Commissioning Team shall cooperate to fulfill contracted responsibilities and objectives of the Contract Documents.
- C. Scheduling: BECxA will work with the GC to establish required commissioning activities to incorporate in preliminary commissioning schedule. The GC will integrate commissioning activities into a master construction schedule. Necessary notifications are to be made in a timely manner in order to expedite the commissioning process.

1.4 BUILDING ENCLOSURE COMMISSIONING PROCESS

- A. Building Enclosure Commissioning is a systematic process of validating and verifying all building enclosure systems responsible for environmental separation perform interactively according to the Owner's Project Requirements as defined in the Contract Documents (drawings and specifications). The Building Enclosure Commissioning process is intended to achieve the following specific objectives according to the Contract Documents:
1. Verify and document installation and performance of building enclosure materials and systems.
 2. Endeavor to provide the Owner with functional Building Enclosure systems that meet the Project Requirements.
- B. Commissioning does not take away from, or reduce responsibility of, system designers or installing contractors to provide a finished and fully functioning product.
- C. This section shall in no way diminish the responsibility of Division 03, 04, 05, 07, 08, and 09 Contractors, Subcontractors, and Suppliers in performing all aspects of work and testing as outlined in the Contract Documents. Any requirements outlined in this section are in addition to or further define the requirements outlined in Division 03, 04, 05, 07, 08, and 09.

1.5 DEFINITIONS

- A. Approval: Acceptance that a material or system has been properly installed and is functioning in tested modes according to the Contract Documents.
- B. Architect/Engineer (A/E): Prime design consultant (architect) and sub-consultants who comprise the design team, generally the Architect of Record and any Design Sub-consultants.
- C. Basis of Design (BOD): Technical narrative of primary thought processes and assumptions behind design decisions made to meet design intent. Describes applications, systems, components, conditions, and methods chosen to meet the intent of the Owners Project Requirements.
- D. Building Enclosure Commissioning Authority (BECxA): Contracted to Owner through the CxA. BECxA directs and coordinates day-to-day Building Enclosure Commissioning activities in coordination with the CxA and the GC.
- E. Building Enclosure Commissioning Plan (BECx Plan): Overall plan developed after bidding that provides structure, schedule, and coordination planning for the Building Enclosure commissioning process.

- F. Building Enclosure Testing Agency (BETA): Contracted to the Owner. BETA is responsible for executing building enclosure functional performance testing under the direction of the A/E and BECxA.
- G. Building Enclosure Functional Performance Test (FPT): Test of performance of building enclosure materials and systems. Systems are tested under various simulated environmental conditions, such as air or water leakage under pressure differential. Refer to Section 01 9117.
- H. Commissioning Authority (CxA): Commissioning Authority for Building Systems; refer to Section 01 9113. Contracted to Owner. CxA directs and coordinates day-to-day Building Systems Commissioning activities, in coordination with the GC. CxA reports directly to Owner.
- I. Commissioning Provider (CxP): The CxP is the commissioning firm that provides the CxA and Cx technical specialists for the project.
- J. Commissioning Observation: Any condition identified by the BECxA that adversely affects the operability, maintainability or functionality of a system, or any equipment or component of a commissioned system. Any condition that conflicts with the project OPR, Contract Documents, contracted performance requirements, manufacturer requirements, and/or standard industry best practices of the installed systems and components will be documented and tracked. These observations will be posted in Site Observation Reports (SORs), and in the Facility Grid Issues Log, tracked until satisfactorily resolved.
- K. Owner's Project Requirements (OPR): A document developed by the Owner with input from their tenants and the design team that describes in both general and specific terms the requirements to be met in this project. Along with the contract documents, the OPR references the current HAS Design Standards. If conflict between the two exists, the more stringent requirement applies.

1.6 SUBMITTALS

- A. A/E or GC shall provide BECxA with the current set of contract documents. All building enclosure related submittals and shop drawings as required by the specifications shall be provided to the BECxA for review and comment, concurrent with the A/E team, for conformance as it relates to BECx, and so that the BECxA comments can be incorporated into the returned submittal along with the A/E's review comments.
- B. The contractor(s) shall review and address all exterior enclosure related submittal and

shop drawing review comments. Revised shop drawing details based on submittal review comments shall be clearly marked on the shop drawing resubmittal to indicate where and what changes have been made. Submittal and shop drawing review comments and responses shall be tracked by the BECxA.

- C. The BECxA review of submittals and shop drawings does not substitute for or alter the responsibility of the A/E to review submittals and/or shop drawings for compliance with the project requirements. Final approval of submittals and shop drawings rests solely with the A/E.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 SYSTEMS TO BE COMMISSIONED

A. Building Enclosure Systems to be commissioned:

1. Below Grade Systems, Roofing Systems, Opaque Wall/Cladding Systems, Fenestration Systems responsible for providing the following functions:
 - a. Air control
 - b. Vapor control
 - c. Insulation/thermal protection
 - d. Waterproofing

3.02 RESPONSIBILITIES OF COMMISSIONING TEAM MEMBERS

A. Architect/Engineer (A/E)

1. Assist in the development and documentation of the Owner's Project Requirements document.
2. Provide brief Basis of Design summary to document the design intent of building enclosure systems to the BECxA.
3. Review and incorporate Building Enclosure Commissioning specification section and Building Enclosure Functional Performance Testing specification section into the construction documents.

4. Attend BECx design review meetings and other BECx meetings.
 5. Provide construction documents electronically.
 6. Review and respond to/incorporate BECxA comments made during design reviews and submittal/shop drawings reviews.
 7. Assist in dispute resolution regarding building enclosure systems.
 8. Utilize Facility Grid, a web-based commissioning management portal to access RFIs and Issues generated by the BECxA. Facility Grid user licensing is provided at no cost to the BECT.
 9. Review BECxA reports and respond to A/E items.
- B. Building Enclosure Commissioning Authority (BECxA)
1. Develop BECx plan.
 2. Development of the BECx Requirements and Building Enclosure FPT Requirements specification sections.
 3. Conduct reviews of the architectural drawings and specifications.
 4. Review pertinent building enclosure related submittals and shop drawings.
 5. Conduct BECx kick-off meetings.
 6. Perform construction observation visits to observe and document installation of the building enclosure materials, systems, and components, and observe representative field testing.
 7. Update the BECx plan as necessary.
 8. Prepare the final BECx report and related record documents.
 9. Perform one site visit at approximately 10 months post-occupancy.
- C. General Contractor (GC)
1. Attend BECx coordination/kick-off meetings and other commissioning team meetings. The GC is responsible for all coordination items with Subcontractors.
 2. Incorporate and periodically update commissioning activities into the construction

schedule.

3. Facilitate cooperation of Subcontractors in commissioning work.
 4. Review and respond to BECxA's submittal review comments.
 5. Utilize Facility Grid, a web-based commissioning management portal to access PFCs, FPTs and Issues generated by the BECxA. Facility Grid user licensing is provided at no cost to the BECT.
 6. Submit copies of initial submittals to A/E and BECxA for review. Provide final A/E approved submittals to BECxA for record.
 7. Verify building enclosure materials and assemblies are ready for functional performance testing. Coordinate scheduling of Building Enclosure FPT with the BECxA and BETA at least two weeks prior to testing.
 8. Ensure resolution of non-compliance and deficiencies in construction or test results. Provide written responses and documentation of completion from the appropriate subcontractors and record responses in Facility Grid.
 - 1) Documentation includes photographs of addressed items prior to concealment by other components.
 9. Provide letters of compatibility for adjacent building enclosure materials and assemblies.
 10. Facilitate all repairs and retesting of failed functional performance testing and pay for all associated costs of retesting and additional testing including costs related to testing observation and documentation by the BECxA.
 11. Following failed field testing, provide a plan of repairs to be performed to the BECT for review. A/E shall approve plan of repairs prior to implementation and retesting. All repairs performed to facilitate successful testing must be approved by the A/E and performed comprehensively throughout project.
 12. Provide all warranty documentation for all commissioned building enclosure systems, materials, and components to the BECxA.
- D. Subcontractors/Vendors
1. Review Commissioning Plan and building enclosure related specification sections.
 2. Provide project-specific submittals/shop drawings as required by the project specifications that clearly indicate how each system is interfaced with adjacent

systems. All typical and project-specific interfaces with adjacent systems must be detailed accurately.

3. Attend BECx coordination/kick-off meetings and other commissioning team meetings.
4. Address all applicable observations in Facility Grid, a web-based commissioning management portal to access RFIs and Issues generated by the BECx. Facility Grid user licensing is provided at no cost to the BECT.
- 5.
6. Provide written responses and documentation of completion of addressed items as directed by GC.
 - 1) Documentation includes photographs of addressed items prior to concealment by other components.
7. Attend all required building enclosure functional performance testing.
8. Ensure installed work is complete, is in compliance with Contract Documents, and is ready for Functional Performance Testing. Notify GC that systems are ready for Functional Performance Testing.
9. Provide all warranty documentation for all commissioned building enclosure systems, materials, and components to the GC.

E. Building Enclosure Testing Agency (BETA)

1. Attend BECx coordination/kick-off meetings.
2. Provide technicians and equipment to complete field Building Enclosure Functional Performance Testing.
3. Prepare and submit reports at the conclusion of each test.
4. Perform retesting and/or additional testing due to failed tests and prepare corresponding reports.

3.03 BUILDING ENCLOSURE COMMISSIONING (BECX) TEAM MEETINGS

- A. BECx meetings will be held periodically as determined by the BECx.
- B. Discussions held in BECx meetings shall include, but not be limited to, system/materials, field progress, scheduling, testing, documentation, deficiencies, and

problem resolution.

3.04 REPORTING

- A. The BECxA will provide monthly status reports to Owner, A/E, GC, and CxA.
- B. The BECxA shall submit non-compliance and deficiency reports Owner, A/E, GC, and CxA.
- C. The BECxA shall provide a final BECx Plan to serve as the BECx Record to Owner.

3.05 BUILDING ENCLOSURE FUNCTIONAL PERFORMANCE TESTING

3.06 Refer to Section 019117 - Building Enclosure Functional Performance Testing

3.07 DOCUMENTATION, NON-CONFORMANCE, AND RESOLUTION

A. Documentation

- 1. The BECxA shall submit observation reports Owner, A/E, GC, and CxA and log commissioning observations in Facility Grid.

B. Non-Conformance

- 1. Deficiency or non-conformance issues will be noted and reported to the GC, A/E, and Owner.
- 2. Corrections of minor deficiencies identified during site observations and testing may be documented by the BECxA.
- 3. Deficiencies are handled in the following manner:
 - a. When there is no dispute on deficiency and Subcontractor accepts responsibility for remedial action:
 - 1) BECxA documents deficiency and Subcontractor response and intentions via Facility Grid.
 - 2) Subcontractor corrects deficiency and provides response and/or documentation, in Facility Grid, that the deficiency has been addressed.
 - b. When there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:

- 1) BECxA documents deficiency and Contractor's response via Facility Grid.
- 2) GC facilitates resolution of deficiency. Other parties are brought into discussions as needed. Final interpretive authority is with A/E. Final acceptance authority is with the Owner.
- 3) GC documents resolution process.
- 4) Once interpretation and resolution has been decided, appropriate party corrects deficiency and provides response and/or documentation, in Facility Grid, that the deficiency has been addressed.

3.08 COMMISSIONING DOCUMENTATION

A. Final Report Details

1. The final BECx report will include an executive summary, overview of BECx activities, and general description of testing and verification results. Report will contain a log of design review comments and responses, a log of submittal review comments and responses, and the issues log.
2. All outstanding non-compliance items will be specifically listed.
3. Recommendations for improvement to system or operations, future actions, etc. will also be listed.

END OF SECTION

SECTION 01 91 17
BUILDING ENCLOSURE FUNCTIONAL PERFORMANCE TESTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. The work under this Section is subject to requirements of the Contract Documents including the Owner's General Conditions and articles of the General Contractor's/Design-Builder's General Conditions.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section. Division 3, 4, 7, 8 9, and 32 Specification Sections also apply to this section. Where conflicts arise regarding building envelope testing, this Section shall supersede other Sections where contradictions occur.
- C. Refer to section 019113 for General Commissioning Requirements.
- D. Refer to section 019115 for the general Building Enclosure Commissioning Requirements.

PART 2 PRODUCTS

2.1 TESTING AGENCY

- A. The Building Enclosure Testing Agency (BETA) shall be an independent third-party with a minimum five (5) years of experience performing the testing as outlined in this specification section.
- B. The building enclosure functional performance testing scope of work is outside the building enclosure commissioning agent's (BECxA) scope of work. Building enclosure Functional Performance Testing (FPT) is performed by the BETA under the direction of the GC and BECxA
- C. The testing agency is to be contracted by the Owner. The testing agency shall be responsible for the specified testing outlined herein. The General Contractor is responsible for any costs associated with retesting and additional testing, including costs related to observation and documentation of retesting and additional testing by the BECxA.

PART 3 EXECUTION

3.1 MOCK-UP TEST REQUIREMENTS

- A. The mock-up should be constructed, tested, and accepted prior to commencement of

installation of building envelope systems, assemblies, and components. Refer to Division 01, 03, 04, 07, 08 and 09 specifications and project-specific mock-up architectural drawings provided by the Architect/Engineer (A/E) for mock-up requirements, including testing.

- B. The coordination and completion of the mock-up construction should be completed by the GC. The GC shall permit observations of the mock-up to the Building Envelope Commissioning Agent (BECxA) and any member of the Building Envelope Commissioning Team throughout construction and testing as required.
- C. In the event of water leakage through the test sample either during pre-testing or final testing; additional isolation testing should be conducted to best determine the location of the water infiltration as required.
- D. Following failed mock-up testing, GC to provide a plan of repairs to be performed to the BECT for review. A/E shall approve plan of repairs prior to implementation and retesting. All repairs performed to facilitate successful testing must be approved by the A/E and performed comprehensively throughout project.
- E. Retesting shall be conducted by the BETA. All costs associated with the repair and retesting shall be the responsibility of the contractor, including costs related to observation and documentation of retesting and additional testing by the BECxA.

3.2 FIELD TEST REQUIREMENTS

- A. Field functional performance testing should focus on interfaces and transitions of building enclosure systems, materials, and assemblies. All testing will be performed prior to the installation of interior insulation, gypsum wall board, interior (supplemental) sealant joints, and finishes. Specific test locations/specimens will be further developed and identified by the project team. Construction phase functional performance testing shall be performed in general locations identified as follows:
 - 1. Air Barriers
 - a. Air Leakage Volume Testing per ASTM E783 - Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors.
 - 1) Testing to be performed at no less than three (3) unique locations to include typical penetrations through the air barrier assembly including fasteners, sub-framing and service penetrations

- b. Air Barrier Adhesion Testing per ASTM D 4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
 - 1) Air-barrier assemblies will be tested for required adhesion to substrate according to ASTM D 4541 (with industry-accepted modifications for air barrier membranes) for each 1000 sq. ft. of installed air barrier or part thereof.
 - c. Air barrier Thickness Testing per ASTM D6132 - Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Applied Organic Coatings Using an Ultrasonic Gage.
 - 1) Air-barrier assemblies will be tested for required thickness according to ASTM D6132 for each 100 sq. ft. of installed air barrier or part thereof.
2. Nozzle Water Penetration Tests
- a. AAMA 501.2 - Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts.
 - 1) Testing to be performed at 20 percent of the following locations within the glazed aluminum storefront assembly at approximately 10 percent, 35 percent and 70 percent of glazing completion.
 - a) Split mullion joints
 - b) Stack joints, where applicable
 - c) Intermediate horizontal joints
 - d) Head conditions at interface with other materials
 - e) Sill conditions at interface with other materials
 - f) Jamb conditions at interface with other materials
 - g) Expansion joints
 - 2) Testing to be performed at 20 percent of all horizontal and vertical panel joints of assembly and all jambs with adjacent materials at insulated metal panel locations,
 - 3) Testing to be performed at 20 percent of all joints within installed Fiberglass- Sandwich-Panel Assemblies
3. Air and Water Leakage Chamber Test
- a. ASTM E783 – *Standard Test Method for Field Measurement of Air Leakage*

Through Installed Exterior Windows and Doors.

- b. ASTM E1105 - Field Determination of Water Penetration of Installed Exterior Windows, , Doors, and storefront systems.
- c. Testing shall be on an area 2 bays wide and 2 bays high at feature wall, and 2 bays wide by full height at storefront systems. Tests to be completed on installed units prior to completion of the first 5 percent of curtain wall installation Test locations will be selected to provide a representative sample of the project. Field testing shall be conducted at two-thirds of the designed water penetration resistance performance criteria.
- d. Testing shall focus on assembly interfaces and transitions and will include the perimeter transition materials.

B. Sealant Adhesion Testing

1. Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
 - a. Perform 10 tests for the first 1000 feet of joint length for each kind of sealant and joint substrate.
 - b. Perform one test for each 1000 feet of joint length thereafter or one test per each floor per elevation.
 - c. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.

C. Electronic Leak Detection

1. ASTM D7877 – Electronic Leak Detection Methods for Locating Leaks in Waterproofing Membranes
2. Survey entire hot fluid-applied rubberized asphalt waterproofing and ketone ethylene ester (KEE) roofing areas for potential leaks using Electronic Leak Detection (ELD) before overlying construction is placed
3. ASTM E 1186, Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems may be used to locate and diagnose potential leaks identified during ELD.

D. Roof Infrared Thermography

1. ASTM C1153 – Standard Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging
 2. Prior to building turnover to Owner and before overlying construction is placed, survey single-ply insulated roof assemblies to identify potential areas of wet insulation.
 3. After infrared scan, locate specific areas of leaks by electrical capacitance/impedance testing or nuclear hydrogen detection tests.
 4. Confirmation of wet roof insulation indicates deficient conditions that will require repair or reinstallation where required by specification 07 54 16 and ketone ethylene ester (KEE) roofing.
- E. All field functional performance testing shall be conducted to project performance requirements as set forth in the Construction Documents and below:

Performance Test	Test Specimen	Performance Criteria
Air Infiltration/exfiltration	Storefront	< 0.06 cfm/sf @ 6.27 psf
Air Infiltration/exfiltration	Air barrier	< 0.04 cfm/sf @ 1.57 psf
Water leakage	Storefront	No water leakage @ 10.00 psf
Water leakage	Opaque wall/cladding	No water leakage @ 10.00 psf
Air barrier adhesion	Air barrier, Sheathing	> 16 lbf/sq. in
Air barrier adhesion	Air barrier, CMU	> 30 lbf/sq. in
Sealant adhesion	Joint sealant	No adhesive failure
Electronic Leak Detection	KEE roofing	No potential leaks detected
Roof infrared thermography	KEE roofing	No areas of wet insulation
Coating Thickness	Air barrier, Traffic Coating	Mfg.'s minimum requirements

- F. The water leakage requirements are as follows:
1. Water is contained and drained to the exterior
 2. There is no wetting of a surface that is visible to the building occupants
 3. There is no wetting or staining or other damage to completed building equipment, materials, or finishes
- G. The General Contractor shall notify the BETA and BECxA at least two weeks in advance of field test specimens being complete and ready for testing.

3.3 BETA REPORTING REQUIREMENTS

- A. Testing reports shall be provided by the BETA after field functional performance test.

- B. Reports shall include a description of the test method(s) and protocol used as well as all relevant testing parameters and pass/fail criteria. Any deviations from the referenced published testing standards or project documents shall be clearly identified and justification provided by the BETA.
- C. Reports shall identify specific testing locations and specimens and include photographs of the test specimens before, during, and after testing.
- D. Reports shall include testing results, including any relevant descriptions and photographs of testing failures.

3.4 TESTING FAILURES

- A. All failed testing areas are to be repaired and retested at CM's expense. Retesting shall be conducted by the BETA. All costs associated with the repair and retesting including all access, equipment, labor, and materials, as well as costs incurred by the BETA and BECxA site visits shall be the responsibility of the contractor.
- B. In addition to re-testing, failed tests may result in testing of additional specimens at locations selected by the BECxA at the cost of the contractor. Testing will be concluded only when satisfactory results are achieved. All failed test specimens shall be repaired and retested until passing results are achieved.
- C. Every effort will be made to expedite testing and minimize unnecessary delays, while not compromising integrity of tests. BECxA shall not overlook deficient work or loosen acceptance criteria to satisfy scheduling or cost issues unless directed to do so directly by the Owner.
- D. Where testing indicates that performance requirements are not met, the contractor shall provide a repair plan for review by the BECT. Once the plan of repairs is agreed upon, Subcontractor corrects deficiency and provides written response and/or documentation on the MIL that the deficiency has been addressed and verifies that material or assembly is ready to be retested. CM informs BECT of retesting schedule and reschedules retesting with BECxA and BETA. Testing and resolution process is repeated until satisfactory performance is achieved. CM shall maintain free and clear access to the test area until satisfactory performance is achieved.

END OF SECTION

**SECTION 23 0800
COMMISSIONING OF HVAC SYSTEMS**

PART 1 GENERAL

1.01 WORK OF THIS SECTION

- A. The Cx activities shall follow all requirements as defined in Section 01 91 13 GENERAL COMMISSIONING REQUIREMENTS.
- B. The section below describes unique Cx activities to the HVAC systems including the BAS. The Contractor shall follow all provisions of 01 9113 when meeting the requirements of this specification. Where conflicts may exist between the two specifications, the more restrictive requirement is to be met.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

- A. Provide all necessary test equipment to confirm proper operation of the Mechanical Systems.
- B. All testing equipment shall be properly calibrated, and documentation of such calibration shall be submitted prior to any verification testing.

PART 3 EXECUTION

3.01 PARTICIPATION IN CX

- A. The Prime Constructor shall coordinate and manage the completion of the Pre-Functional Checklists amongst the affected subcontractors, and shall coordinate and otherwise manage the Pre-Verification Testing of the Mechanical Systems under the supervision of the CxA.
 - 1. Cooling Towers
 - 2. Air Handling Units
 - 3. Condensing Units
 - 4. Exhaust/Ventilation Fans
 - 5. Building Automation System (BAS)
 - 6. 100% Outside Air Package Direct Expansion Units
 - 7. Refrigerant Leak Detection System
- B. Coordinate with the Division 26 and BAS subcontractors for performing and documenting pre-functional checks for each of the equipment items in the scope for Cx.
- C. Division 23 subcontractor and the BAS subcontractor are responsible for completing Point-to-Point testing, pre-functional testing, pre-verification testing and the execution of functional testing of the HVAC system in front of the CxA.
- D. Division 26 subcontractor and the BAS subcontractor are responsible for completing Point-to-Point testing, pre-functional testing, pre-verification testing and functional testing of electrical equipment and systems to the BAS.

3.02 DISTRIBUTION OF TREND DATA

- A. Trend data from the BAS will be utilized in the Cx activities. Contractor shall provide at least 1 full week of trend data to the Cx Team no later than 1 week before scheduling the functional performance testing. The Cx Team will analyze the trend data from the equipment and systems to be tested as part of the determination whether the testing can be scheduled.
- B. Trend data shall be recorded at intervals no greater than 15 minutes. Differential pressure transmitters shall be trended at a sampling rate of no less than every five minutes until the Functional Testing Period is complete and the installation is accepted by the CxA and the Owner. The trend data from each field controller shall be polled and stored in a central server location with capability of archiving the collected trend data for no less than 3 months of storage. The BAS shall be capable of automated distribution of the trend data configured for no less than weekly updates of the previous interval of data. Change of Value (COV) trending is not preferred and shall only be acceptable for status or binary command points.

- C. Trend data shall be saved in a non-proprietary format such as csv or txt with consistent organization of the data to include at a minimum the timestamp, BAS system trend name, value and units. The trend reports shall contain both tabular data and also represented in line graphs. With multiple points trended in each graph as requested by the CxA..
- D. Required trends by equipment type:
1. Multizone Variable Volume Dx Rooftop Unit
 - a. Unit Mode of Operation
 - b. Return Air Damper Command
 - c. Outdoor Air Damper Command
 - d. Outdoor Air Flow Setpoint
 - e. Mixed Air Temperature
 - f. UV Light Command
 - g. Cooling Coil Discharge Air Temp
 - h. Cooling Coil Discharge Air Temp Setpoint
 - i. Reheat Coil Valve Command
 - j. Supply Fan Airflow
 - k. Supply Fan VFD Start/Stop (Per Fan)
 - l. Supply Fan VFD Speed Command (Per Fan)
 - m. Supply Fan VFD HOA Status
 - n. Supply Air Flow
 - o. Discharge Air Temp
 - p. Discharge Air Temp Setpoint
 - q. CO2 Reading
 - r. Space Temperature
 - s. Space Relative Humidity
 2. Exhaust Fan
 - a. Exhaust Fan VFD Start/Stop
 - b. Exhaust Fan VFD HOA Status
 - c. Exhaust Fan VFD Speed Command
 - d. Exhaust Damper Endswitch Open
 - e. Exhaust Damper Endswitch Closed

3.03 PRE-FUNCTIONAL AND FUNCTIONAL TEST FORMS

- A. After the initial equipment submittal phase, the CxA shall prepare the pre-functional test forms and the master functional performance tests for each type of equipment as part of the CxA's scope of work. Review respective pre-functional and functional test forms for accuracy and completeness within the review period defined by the CxA, and provide comments to the General Contractor and CxA.
- B. The following is a sample pre-functional test form:

CHK-67: AHU-1-1 (OAHU-TYPE1)

Test Type: **Pre-Functional Testing**

Unit #	AHU-1-1		
Type	AIR HANDLING UNIT		
Discipline	HVAC		
Floor Name:	LEVEL 1	Floor Type:	Site
Room Name	MECH ROOM		

Equipment Verification			
Equipment / Component	Approved Submittal Data	Installed As Submitted?	Installed Data
Manufacturer			
Model number			
Serial number			
Rated supply airflow (CFM)			
Rated outside airflow (CFM)			
Rated relief airflow (CFM)			
Rated exhaust airflow (CFM)			
Cooling capacity (MBH)			
Pre-heating capacity (MBH)			
Re-heating capacity (MBH)			
Humidifier capacity (MBH)			

Equipment / Component	Approved Submittal Data	Installed As Submitted?	Installed Data
Heat wheel motor Volts/Ph/A and HP/effy			
Heat recovery pump motor Volts/Ph/A and HP/effy			
Supply fan motor Volts/Ph/A and HP/effy			
Relief fan motor Volts/Ph/A and HP/effy			
Exhaust fan motor Volts/Ph/A and HP/effy			
Outside air fan motor Volts/Ph/A and HP/effy			
Return fan motor Volts/Ph/A and HP/effy			

Questionnaire

#	Question	Answer	Details
General Installation Checks			
1	Permanent labels affixed, per specifications	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	<input type="text"/> Mechanical Contractor_____
2	Premium efficiency motors verified	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	<input type="text"/> Mechanical Contractor_____
3	Casing condition good: no dents, leaks, door gaskets installed	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	<input type="text"/> Mechanical Contractor_____
4	Access doors close tightly - no leaks	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	<input type="text"/> Mechanical Contractor_____
5	Boot between duct and unit tight and in good condition	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	<input type="text"/> Mechanical Contractor_____

#	Question	Answer	Details
6	Vibration isolation equipment installed and released from shipping locks	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
7	Maintenance access acceptable for unit and components	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
8	Thermal insulation properly installed and according to specification	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
9	Local instrumentation installed according to specification (thermometers, pressure gages, flow meters, etc.)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
10	Clean up of equipment completed per contract documents	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
11	Filters installed and replacement type and efficiency permanently affixed to housing	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
Fans and Dampers			
1	Fan and motor alignment verified	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
2	Fan belt tension and condition set	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
3	Fan protective shrouds for belts in place and secure	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
4	Fan area clean	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
5	Fan and motor properly lubricated	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____
6	Fan and motor lube lines installed and lubed	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor_____

#	Question	Answer	Details
7	Filters installed and replacement type and efficiency permanently affixed to housing—construction filters removed	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
8	Filter pressure differential measuring device installed and functional (magnahelic, inclined manometer, etc.)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
9	Smoke and fire dampers installed properly per contract docs (proper location, access doors, appropriate ratings verified)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
10	All dampers close tightly	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
11	All damper linkages have minimum play	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
12	Low limit freeze stat sensor installed per manufacturer with adequate coverage	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor _____
Ducts (Preliminary Checks)			
1	Sound attenuators installed	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
2	Duct joint sealant properly installed	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
3	No apparent severe duct restrictions	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
4	Turning vanes installed per drawings	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
5	Pressure leakage tests completed, documentation provided to CxA	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____

#	Question	Answer	Details
6	Balancing dampers installed per drawings and TAB's site visit	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	TAB Contractor_____
Electrical			
1	Pilot lights are functioning	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor_____
2	Power disconnects in place and labeled	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor_____
3	All electric connections tight	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor_____
4	Proper grounding installed for components and unit	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor_____
5	Safeties in place and operable	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor_____
6	Current overload heaters installed and correct size	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor_____
7	Appropriate Volts vs Hz curve is being used for speed signal	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor_____
Controls			
1	Sensors calibrated (refer to BAS calibration document)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor_____
2	All building control system interlocks connected with packaged controls and functional	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor_____
3	Fire and/or smoke detectors in place	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor_____
4	Enthalpy control and sensor properly installed	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor_____

#	Question	Answer	Details
5	Related thermostats are installed	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor _____
6	Building automation system hardware installed	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor _____
7	All control devices wiring complete	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor _____
Supply Fan Motor			
1	No unusual noise or vibration in supply fan	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
2	Record actual supply fan motor voltage: A-B	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
3	Record actual supply fan motor voltage: A-C	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
4	Record actual supply fan motor voltage: B-C	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
5	Calculate % supply fan motor voltage imbalance = $100 \times (\text{avg.} - \text{lowest}) / \text{avg.}$	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
6	Supply fan rotation is correct	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
7	Supply fan motor service factor	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
8	Supply fan motor running less than maximum amp rating?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
9	Record supply fan motor actual amperage: T-1	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
10	Record supply fan motor actual amperage: T-2	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____

#	Question	Answer	Details
11	Record supply fan motor actual amperage: T-3	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
Exhaust Fan Motor			
1	No unusual noise or vibration in exhaust fan	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
2	Record actual exhaust fan motor voltage: A-B	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
3	Record actual exhaust fan motor voltage: A-C	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
4	Record actual exhaust fan motor voltage: B-C	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
5	Calculate % exhaust fan motor voltage imbalance = $100 \times (\text{avg.} - \text{lowest}) / \text{avg.}$	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
6	Exhaust fan rotation is correct	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
7	Exhaust fan motor service factor	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
8	Exhaust fan motor running less than maximum amp rating?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
9	Record exhaust fan motor actual amperage: T-1	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
10	Record exhaust fan motor actual amperage: T-2	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
11	Record exhaust fan motor actual amperage: T-3	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
TAB			

#	Question	Answer	Details
1	Installation of system and balancing devices will allow balancing to be done per specified NEBB or AABC procedures and contract docs	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 TAB Contractor _____

Final Checks

1	All dampers stroke fully without binding and spans calibrated and BAS reading site verified	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Controls Contractor _____
2	Valves stroke fully and easily and spanning is calibrated	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Controls Contractor _____
3	Valves verified to not be leaking through coils when closed at normal operating pressure	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Controls Contractor _____
4	Safeties installed and safe operating ranges for this equipment provided to the commissioning agent	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Controls Contractor _____
5	Smoke and fire dampers are open	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor _____
6	If unit is started and will be running during construction: have quality filters on RA grills, etc. to minimize dirt in the ductwork and coils and in any finished areas. Verify moisture migration is not a problem due to improper pressures between spaces.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Mechanical Contractor _____

END TEST

#	Question	Answer	Details
1	Installation of system and balancing devices will allow balancing to be done per specified NEBB or AABC procedures and contract docs	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	TAB Contractor _____
Final Checks			
1	All dampers stroke fully without binding and spans calibrated and BAS reading site verified	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor _____
2	Valves stroke fully and easily and spanning is calibrated	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor _____
3	Valves verified to not be leaking through coils when closed at normal operating pressure	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor _____
4	Safeties installed and safe operating ranges for this equipment provided to the commissioning agent	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Controls Contractor _____
5	Smoke and fire dampers are open	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____
6	If unit is started and will be running during construction: have quality filters on RA grills, etc. to minimize dirt in the ductwork and coils and in any finished areas. Verify moisture migration is not a problem due to improper pressures between spaces.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Mechanical Contractor _____

END TEST

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1. FUNCTIONAL TEST FORMS

- a. After the final issue for record of the pre-functional test forms, the CxA shall prepare the functional test forms for each system to be documented as part of the Cx. Review respective functional test forms for accuracy and completeness and provide comments to the General Contractor and CxA.
- b. The following is a sample functional test form:

FPT-2: AHU-1-1 (AHU-1-1)

Test Type: **Functional Performance Testing**

Unit #	AHU-1-1		
Type	Air Handling Unit		
Discipline	HVAC		
Floor Name:	LEVEL 1	Floor Type:	Site
Room Name	MECH ROOM		

System Description
 TYPICAL OF - AHU-1-1, AHU-6-1, AHU-7-1, AHU-8-1, AHU-9-1, AHU-10-1, AHU-11-1, AHU-12-1

Sensor Calibration

Sensor & Location	Location OK?	First Gauge or BAS Value	Instrument Measured Value	Final Gauge or BAS Value	Pass
Supply Air Temperature					
Entering Water Temperature					

Questionnaire

#	Question	Answer	Details
OCCUPIED MODE			
1	ENABLE THE UNIT - DESCRIBE METHOD IN DETAIL	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	VERIFY THAT THE SUPPLY FAN IS RUNNING AND CONTROLLING TO THE STATIC PRESSURE SETPOINT (1.5in starting setpoint before reset)	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	VERIFY THAT THE COMPRESSORS ARE STAGING TO MAINTAIN DISCHARGE AIR TEMP (55 DEG)	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

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#	Question	Answer	Details
UNOCCUPIED MODE			
1	ENABLE UNOCCUPIED MODE (ADJUST UNOCCUPIED SPACE COOLING SETPOINT - DEFAULT OF 85 DEG F)	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	VERIFY SUPPLY FAN SHUT DOWN	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	VERIFY DX COOLING IS DISABLED	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	RELEASE SETPOINT AND RETURN UNIT TO DEFAULT SETPOINTS	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
DUCT STATIC PRESSURE CONTROL			
1	ENABLE UNIT AND VERIFY THAT DUCT STATIC PRESSURE SETPOINT IS AT ITS DEFAULT SETTING OF 1.5IN	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	DECREASE ZONE DAMPERS TO ALL BE AT 50% OPEN OR LESS - RECORD RESULTS (STATIC PRESSURE SETPOINT SHOULD DECREASE TO 1.3 IN OR BELOW)	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	INCREASE ZONE DAMPERS TO BE AT 90% OR MORE - RECORD RESULTS IN DETAIL (STATIC PRESSURE SETPOINT SHOULD INCREASE TO 1.8 IN AS MAX SETPOINT)	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	INITIATE HIGH SUPPLY STATIC PRESSURE ALARM (MANUALLY COMMAND FAN SPEED TO 25% HIGHER THAN STATIC PRESSURE SETPOINT) - RECORD RESULTS IN DETAILS	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	INITIATE LOW SUPPLY STATIC PRESSURE ALARM (MANUALLY COMMAND FAN SPEED TO 25% LOWER THAN STATIC PRESSURE SETPOINT) - RECORD RESULTS IN DETAILS	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	RELEASE SETPOINTS AND RETURN UNIT TO DEFAULT SETPOINTS	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
WATERSIDE ECONOMIZER			
1	ENABLE WATERSIDE ECONOMIZER (ENTERING WATER TEMP 4 DEG BELOW MAT) - RECORD STARTING DISCHARGE TEMP IN DETAILS	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	VERIFY THAT THE CONDENSING WATER VALVE OPENS AND RECORD THE DISCHARGE AIR TEMP IN DETAILS	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	DECREASE SUPPLY AIR SETPOINT SO ECONOMIZER MODE CANNOT SATISFY ALONE - CX COOLING SHOULD BEGIN STAGING (RECORD RESULTS IN DETAILS)	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

#	Question	Answer	Details
ALARMS			
1	HIGH SUPPLY STATIC PRESSURE	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	LOW SUPPLY STATIC PRESSURE	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	SUPPLY FAN FAILURE	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	SUPPLY FAN IN HAND	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	DIRTY FILTER ALARM	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	HIGH SUPPLY AIR TEMP ALARM	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	DXCOOLING COMMAND ALARM	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

END TEST

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END OF SECTION

**SECTION 23 8129
VARIABLE REFRIGERANT FLOW HVAC SYSTEMS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Variable refrigerant volume HVAC system includes:
 - 1. Outdoor/condensing unit(s).
 - 2. Indoor/evaporator units.
 - 3. Branch selector units.
 - 4. Refrigerant piping.
 - 5. Control panels.
 - 6. Control wiring.
 - 7. Full BACnet Interface to connect with the campus Allerton BAS system.

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment 2008.
- B. ASCE 7 - Minimum Design Loads for Buildings and Other Structures 2010, with 2013 Supplements and Errata.
- C. ITS (DIR) - Directory of Listed Products current edition.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. UL 1995 - Heating and Cooling Equipment Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Division 1 for Submittal Procedures.
- B. Pre-Bid Submittals: For proposed substitute systems/products, as defined in PART 2, and alternate systems/products, as defined above, proposer shall submit all data described in this article, under the terms given for substitutions stated in PART 2.
- C. Product Data: Submit manufacturer's standard data sheets showing the following for each item of equipment, marked to correlate to equipment item markings indicated in Contract Documents:
 - 1. Outdoor/Central Units:
 - a. Refrigerant Type and Size of Charge.
 - b. Cooling Capacity: Btu/h.
 - c. Heating Capacity: Btu/h.
 - d. Cooling Input Power: Btu/h.
 - e. Heating Input Power: Btu/h.
 - f. Operating Temperature Range, Cooling and Heating.
 - g. Air Flow: Cubic feet per minute.
 - h. Fan Curves.
 - i. External Static Pressure (ESP): Inches WG.
 - j. Sound Pressure Level: dB(A).
 - k. Electrical Data:
 - 1) Maximum Circuit Amps (MCA).
 - 2) Maximum Fuse Amps (MFA).
 - 3) Maximum Starting Current (MSC).
 - 4) Full Load Amps (FLA).
 - 5) Total Over Current Amps (TOCA).
 - 6) Fan Motor: HP.
 - l. Weight and Dimensions.
 - 2. Indoor/Evaporator Units:

- a. Cooling Capacity: Btu/h.
- b. Heating Capacity: Btu/h.
- c. Cooling Input Power: Btu/h.
- d. Heating Input Power: Btu/h.
- e. Air Flow: Cubic feet per minute.
- f. Fan Curves.
- g. External Static Pressure (ESP): Inches WG.
- h. Sound Pressure level: dB(A).
- i. Electrical Data:
 - 1) Maximum Circuit Amps (MCA).
 - 2) Maximum Fuse Amps (MFA).
 - 3) Maximum Starting Current (MSC).
 - 4) Full Load Amps (FLA).
 - 5) Total Over Current Amps (TOCA).
 - 6) Fan Motor: HP.
- j. Weight and Dimensions.
- 3. Control Panels: Complete description of options, control points, zones/groups.
- D. Operating and Maintenance Data:
 - 1. Manufacturer's complete standard instructions for each unit of equipment and control panel.
 - 2. Custom-prepared system operation, troubleshooting, and maintenance instructions and recommendations.
 - 3. Identification of replaceable parts and local source of supply.
- E. Project Record Documents: Record the following:
 - 1. As-installed routing of refrigerant piping and condensate piping.
 - 2. Locations of access panels.
 - 3. Locations of control panels.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Company that has been manufacturing variable refrigerant volume heat pump equipment for at least 5 years.
- B. Installer Qualifications: Trained and approved by manufacturer of equipment.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, and handle equipment and refrigerant piping according to manufacturer's recommendations.

1.07 WARRANTY

- A. Compressors: Provide manufacturer's warranty for six (6) years from date of installation. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced at the discretion of Toshiba, Inc. according to Toshiba's terms and conditions. All warranty service work shall be preformed by a Toshiba factory trained service professional.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable Manufacturers:
 - 1. Daiken
 - 2. LG
 - 3. Mitsubishi
- B. Basis of Design: The system design shown in the contract documents is based on equipment and system designed by Toshiba.

- C. Systems designed and manufactured by other manufacturers will be considered by Owner under the terms described for substitutions with the following exceptions:
1. Substitution requests will be considered only if received at least 10 days prior to the bid date.
 2. Substitution requests will be considered only if required submittal data is complete; see article SUBMITTALS above.
 3. Contractor (not equipment supplier) shall certify that the use of the substitute system and equipment will not require changes to other work or re-design by Architect or Engineer.
 4. xxx or HVAC subcontractor shall certify that the substitute system will achieve the performance specified.
 5. Do not assume substitution has been accepted until formal written notice has been issued by Architect and/or Engineer.

2.02 HVAC SYSTEM DESIGN

- A. System Operation: Heating and cooling, simultaneously.
1. Zoning: Provide capability for temperature control for each individual indoor/evaporator unit independently of all other units.
 2. Zoning: Provide heating/cooling selection for each individual indoor/evaporator unit independently of all other units.
 - a. Exception: Where indicated, multiple indoor/evaporator units may be controlled in groups.
 3. Provide a complete functional system that achieves the specified performance based on the specified design conditions and that is designed and constructed according to the equipment manufacturer's requirements.
 4. Conditioned spaces are indicated on drawings.
 5. Outdoor/Condenser unit locations are indicated on drawings.
 6. Indoor/Evaporator unit locations are indicated on drawings.
 7. Branch selector unit locations are not indicated on drawings.
 8. Required equipment unit capacities are indicated on drawings.
 9. Connect equipment to condensate piping provided by others; condensate piping is indicated on drawings.
- B. Operating Temperature Ranges:
1. Simultaneous Heating and Cooling Operating Range: minus 4 degrees F to 60 degrees F dry bulb.
 2. Cooling Mode Operating Range: minus 4 degrees F to 110 degrees F dry bulb.
 3. Heating Mode Operating Range: 0 degrees F to 77 degrees F dry bulb; minus 4 degrees F to 60 degrees F wet bulb; without low ambient controls or auxiliary heat source.
- C. Refrigerant Piping Lengths: Provide equipment capable of serving system with following piping lengths without any oil traps:
1. Minimum Piping Length from Outdoor/Central Unit(s) to Furthest Terminal Unit: 450 feet, actual; 600 feet, equivalent.
 2. Total Combined Liquid Line Length: 3000 feet, minimum.
 3. Maximum Vertical Distance Between Outdoor/Central Unit(s) and Terminal Units: 250 feet.
 4. Minimum Piping Length Between Indoor Units: 40 feet.
- D. Control Wiring Lengths:
1. Between Outdoor/Condenser Unit and Indoor/Evaporator Unit: 6000 feet, minimum.
 2. Between Outdoor/Condenser Unit and Central Controller: 3000 feet, minimum.
 3. Between Indoor/Evaporator Unit and Remote Controller: 1600 feet.
- E. Controls: Provide the following control interfaces:
1. For Each Indoor/Evaporator Unit: One wall-mounted wired "local" controller, with temperature sensor; locate where indicated.
 2. One central remote control panel for entire system; locate where indicated.
 3. One time clock control panel for entire system; locate where indicated.

4. BACNet gateways sufficient to connect all units to building automation system by others; include wiring to gateways.
 5. The building automation system by the VRV manufacturer is not specified in this section. Consult the manufacturer for details.
 6. Building automation system by HVAC system manufacturer; provide one user stations located where indicated.
- F. Remote Temperature Sensors: In addition to temperature sensors integral with indoor/evaporator units, provide wall-mounted, wired remote temperature sensors located in the same room for the following:
1. In-ceiling mounted units.
 2. On-ceiling mounted units.
 3. Wall mounted units mounted up high.
 4. Air handling units.
 5. Concealed console units.
 6. Exposed console units.

2.03 EQUIPMENT

- A. All Units: Factory assembled, wired, and piped and factory tested for function and safety.
1. Refrigerant: R-410A.
 2. Performance Certification: AHRI Certified; www.ahrinet.org.
 3. Safety Certification: Tested to UL 1995 by UL or Intertek-ETL, listed in ITS (DIR), and bearing the certification label.
 4. Provide outdoor/condensing units capable of serving indoor unit capacity up to 200 percent of the capacity of the outdoor/condensing unit.
 5. Provide units capable of serving the zones indicated.
 6. Energy Efficiency: Report EER and COP based on tests conducted at "full load" in accordance with AHRI 210/240 or alternate test method approved by U.S. Department of Energy.
 7. Outdoor Units: Units and their supports designed and installed to resist wind pressures defined in ASCE 7.
- B. System Controls:
1. Include self diagnostic, auto-check functions to detect malfunctions and display the type and location.
 2. Provide full BACnet interface for connection with the campus Allerton System.
- C. Remote Centralized Control Panel:
- D. Time Clock Panel:
- E. Unit Controls: As required to perform input functions necessary to operate system; provided by manufacturer of units.
- F. Wiring:
1. Control Wiring: 18 AWG, 2-conductor, non-shielded, non-polarized, stranded cable.
 2. Control Wiring Configuration: Daisy chain.
- G. Refrigerant Piping:
1. Provide three-pipe refrigerant system, including high/low pressure dedicated hot gas, liquid and suction lines; two-pipe systems utilizing lower temperature mixed liquid/gas refrigerant to perform heat recovery are not permitted due to reduced heating capabilities.
 2. Refrigerant Flow Balancing: Provide refrigerant piping joints and headers specifically designed to ensure proper refrigerant balance and flow for optimum system capacity and performance; T-style joints are prohibited.
 3. Insulate each refrigerant line individually between the condensing and indoor units.

2.04 OUTDOOR/CONDENSING UNITS

- A. Outdoor/Condensing Units: Air-cooled DX refrigeration units, designed specifically for use with indoor/evaporator units; factory assembled and wired with all necessary electronic and

IAH ARF 92	23 8129 - 4	Variable Refrigerant Flow HVAC Systems
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refrigerant controls; modular design for ganging multiple units.

1. Refrigeration Circuit: Scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.
 2. Refrigerant: Factory charged.
 3. Variable Volume Control: Modulate compressor capacity automatically to maintain constant suction and condensing pressures while varying refrigerant volume to suit heating/cooling loads.
 4. Capable of being installed with wiring and piping to the left, right, rear or bottom.
 5. Capable of heating operation at low end of operating range as specified, without additional low ambient controls or auxiliary heat source; during heating operation, reverse cycle (cooling mode) oil return or defrost is not permitted, due to potential reduction in space temperature.
 6. Sound Pressure Level: As specified, measured at 3 feet from front of unit; provide night setback sound control as a standard feature; three selectable sound level steps of 55 dB, 50 dB, and 45 dB, maximum.
 7. Power Failure Mode: Automatically restart operation after power failure without loss of programmed settings.
 8. Safety Devices: High pressure sensor and switch, low pressure sensor/switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
 9. Provide refrigerant sub-cooling to ensure the liquid refrigerant does not flash when supplying to us indoor units.
 10. Oil Recovery Cycle: Automatic, occurring 2 hours after start of operation and then every 8 hours of operation; maintain continuous heating during oil return operation.
 11. Controls: Provide contacts for electrical demand shedding.
- B. Unit Cabinet: Weatherproof and corrosion resistant; rust-proofed mild steel panels coated with baked enamel finish.
1. Designed to allow side-by-side installation with minimum spacing.
- C. Fans: One or more direct-drive propeller type, vertical discharge, with multiple speed operation via DC (digitally commutating) inverter.
1. Fan Airflow: As indicated for specific equipment.
 2. Fan Motors: Factory installed; permanently lubricated bearings; inherent protection; fan guard; output as indicated for specific equipment.
- D. Condenser Coils: Copper tubes expanded into aluminum fins to form mechanical bond; waffle louver fin and rifled bore tube design to ensure high efficiency performance.
- E. Compressors: Scroll type, hermetically sealed, variable speed inverter-driven and fixed speed in combination to suit total capacity; minimum of one variable speed, inverter driven compressor per condenser unit; minimum of two compressors per condenser unit; capable of controlling capacity within range of 6 percent to 100 percent of total capacity.
1. Variable Speed Control: Capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure; high/low pressures calculated by samplings of evaporator and condenser temperatures every 20 seconds, with compressor capacity adjusted to eliminate deviation from target value by changing inverter frequency or on/off setting of fixed speed compressors.
 2. Multiple Condenser Modules: Balance total operation hours of compressors by means of duty cycling function, providing for sequential starting of each module at each start/stop cycle, completion of oil return, and completion of defrost, or every 8 hours.
 3. Failure Mode: In the event of compressor failure, operate remaining compressor(s) at proportionally reduced capacity; provide microprocessor and associated controls specifically designed to address this condition.
 4. Inverter Driven Compressors: PVM inverter driven, highly efficient reluctance DC (digitally commutating), hermetically sealed scroll "G2-type" with maximum speed of 7,980 rpm.

5. Rotors: Incorporating neodymium magnets for higher torque and efficiency; at complete stop of compressor, position rotor into optimum position for low torque start.
6. Provide each compressor with crankcase heater, high pressure safety switch, and internal thermal overload protector.
7. Provide oil separators and intelligent oil management system.
8. Provide spring mounted vibration isolators.

2.05 BRANCH SELECTOR UNITS

- A. Branch Selector Units: Concealed boxes designed specifically for this type of system to control heating/cooling mode selection of downstream units; consisting of electronic expansion valves, subcooling heat exchanger, refrigerant control piping and electronics to facilitate communications between unit and main processor and between branch unit and indoor/evaporator units.
 1. Control direction of refrigerant flow using electronic expansion valves; use of solenoid valves for changeover and pressure equalization is not permitted due to refrigerant noise; use of multi-port branch selector boxes is not permitted unless spare ports are provided for redundancy.
 2. Provide one electronic expansion valve for each downstream unit served, except multiple indoor/evaporator units may be connected, provided balancing joints are used in downstream piping and total capacity is within capacity range of the branch selector.
 3. When branch unit is simultaneously heating and cooling, energize subcooling heat exchanger.
 4. Casing: Galvanized steel sheet; with flame and heat resistant foamed polyethylene sound and thermal insulation.
 5. Refrigerant Connections: Braze type.
 6. Condensate Drainage: Provide unit that does not require condensate drainage.

2.06 INDOOR/EVAPORATOR UNITS

- A. All Indoor/Evaporator Units: Factory assembled and tested DX fan-coil units, with electronic proportional expansion valve, control circuit board, factory wiring and piping, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
 1. Refrigerant: Refrigerant circuits factory-charged with dehydrated air, for field charging.
 2. Temperature Control Mechanism: Return air thermistor and computerized Proportional-Integral-Derivative (PID) control of superheat.
 3. Dehumidification Function: In conjunction with wall-mounted wired remote controller.
 4. Coils: Direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond; waffle louver fin and high heat exchange, rifled bore tube design; factory tested.
 - a. Provide thermistor on liquid and gas lines.
 5. Fans: Direct-drive, with statically and dynamically balanced impellers; high and low speeds unless otherwise indicated; motor thermally protected.
 6. Return Air Filter: Washable long-life net filter with mildew proof resin, unless otherwise indicated.
 7. Condensate Drainage: Built-in condensate drain pan with PVC drain connection.
 8. Cabinet Insulation: Sound absorbing foamed polystyrene and polyethylene insulation.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that required electrical services have been installed and are in the proper locations prior to starting installation.
- B. Verify that condensate piping has been installed and is in the proper location prior to starting installation.
- C. Notify Architect if conditions for installation are unsatisfactory.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

IAH ARF 92	23 8129 - 6	Variable Refrigerant Flow HVAC Systems
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- B. Install refrigerant piping in accordance with equipment manufacturer's instructions.
- C. Perform wiring in accordance with NFPA 70, National Electric Code (NEC).
- D. Coordinate with installers of systems and equipment connecting to this system.

3.03 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Provide manufacturer's field representative to inspect installation prior to startup.
- C. Contractor shall perform system pressure test using nitrogen prior to initial refrigerant charge and start-up.

3.04 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform system startup.
- B. Prepare and start equipment and system in accordance with manufacturer's instructions and recommendations.
- C. Adjust equipment for proper operation within manufacturer's published tolerances.

3.05 CLEANING

- A. Clean exposed components of dirt, finger marks, and other disfigurements.

3.06 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate operation of system to Owner's personnel.
 - 1. Use operation and maintenance data as reference during demonstration.
 - 2. Conduct walking tour of project.
 - 3. Briefly describe function, operation, and maintenance of each component.
- D. Training: Train Owner's personnel on operation and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of one day of training.
 - 3. Instructor: Manufacturer's training personnel.
 - 4. Location: At project site.

3.07 PROTECTION

- A. Protect installed components from subsequent construction operations.
- B. Replace exposed components broken or otherwise damaged beyond repair.

END OF SECTION

SECTION 28 08 00 – COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 WORK OF THIS SECTION

- A. The Cx activities shall follow all requirements as defined in Section 01 91 13 GENERAL COMMISSIONING REQUIREMENTS.
- B. The section below describes unique Cx activities to the Electronic Safety and Security Systems.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Provide all necessary test equipment to confirm proper operation of the Electronic Safety and Security Systems.
- B. All testing equipment shall be properly calibrated, and documentation of such calibration shall be submitted prior to any verification testing.

PART 3 - EXECUTION

3.1 PARTICIPATION IN CX

- A. The Division 28 subcontractors shall execute the Cx activities of the following Electronic Safety and Security Systems, under the supervision and direction of the CxP:
 - 1. Addressable Fire Alarm Systems
 - 2. Access Control System
 - 3. Video Surveillance Control and Management System
- B. Fire Alarm System Functional Testing will include interface with other systems such as Emergency Power, HVAC Systems, Fire Protection Systems, Fire/Smoke Dampers, Kitchen Equipment, Doors, Security System. Fire Alarm System Functional Testing will include testing each prototypical alarm sequence in each Fire Alarm Zone along with a 20% sampling of notification devices. Fire Alarm System Functional Performance Testing will be conducted in addition to, but separate from, and prior to any required Fire Marshal, Code Official or Authority Having Jurisdiction (AHJ) testing.
- C. Coordinate with the Division 23 and BAS subcontractors for performing and documenting pre-functional checks for each of the items integrated into the electronic safety and security equipment systems in the scope for Cx. This is for the purpose of verifying the overall systems' integration works in accordance with the applicable Building Codes, and the described intent (contract drawings and specifications) of the Architect and Engineer of Record.
- D. Coordinate with the Division 26 subcontractors for performing and documenting pre-functional checks for each of the items integrated into the electronic safety and security equipment systems in the scope for Cx. This is for the purpose of verifying the overall systems' integration works in accordance with the applicable Building Codes, and the described intent (contract drawings and specifications) of the Architect and Engineer of Record.

COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY

3.2 PRE-FUNCTIONAL TEST FORMS

- A. After the initial equipment submittal phase, the CxA shall prepare the pre-functional test forms for each item of equipment as part of the Cx. Review respective pre-functional test forms for accuracy and completeness and provide comments to the General Contractor and CxA.
- B. The following is a sample prefunctional test form:

HAS ITRP

Fire Alarm (Fire Alarm)
CHK-2

CHK-2: Fire Alarm (Fire Alarm)

Test Type: **Factory Testing**

View Summary

Unit #	Fire Alarm
Discipline	

Questionnaire

#	Question	Answer	Details
GENERAL			
1	All fire alarm equipment is clean of all dirt and debris after installation.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	Dedicated branch circuit and connections are mechanically protected for each FA system component	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
3	Circuit disconnect means has a red marking, is accessible to authorized personnel only, and is identified as "Fire Alarm Circuit"	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
4	Emergency power is supplied by maintenance-free batteries requiring no water	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
5	System printer is installed, if required	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
6	For selective notification, circuits are protected for survivability	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
7	Where applicable, door hold opens are mounted to provide complete contact with magnet	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
8	Remote annunciator is provided	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
CONTROL PANEL			
1	Fire alarm panel is installed with smoke detector provided at each location	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	Display is legible through clear, lockable cabinet door	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
3	Time and date display on FACP are correct, so that events may be time and date stamped with the actual time of activation	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	

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HAS ITRP

**Fire Alarm (Fire Alarm)
CHK-2**

#	Question	Answer	Details
4	FACP is installed with LEDs for AC power	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
5	FACP is installed with remote alarm transmission bypass	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
6	FACP is installed with HVAC / smoke damper bypass	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
7	FACP is installed with door holder bypass switch	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
8	FACP is installed with elevator bypass switch	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	

INITIATING DEVICES

1	Manual pull stations are located within 5 feet of each exit doorway opening	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	Smoke / heat detectors are installed with power/ status LED's	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
3	Duct detectors are provided with remote test station with alarm and test capabilities for detector	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
4	No smoke or heat detectors are installed within 36" of any HVAC diffuser or return air opening	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	

NOTIFICATION DEVICES

1	Devices are installed such that loss of any one speaker circuit will not cause the loss of any other speaker circuits in the system	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	Visible notification appliances are located not more than 15' from the end of a corridor, with a separation not greater than 100' between appliances	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
3	An exterior audible alarm is installed above the exterior sprinkler connection	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	

END TEST

3.3 FUNCTIONAL TEST FORMS

- A. After the finalization of the pre-functional test forms, the CxA shall prepare the functional test forms for each system to be documented as part of the Cx. Review respective functional test forms for accuracy and completeness and provide comments to the General Contractor and CxA.
- B. The following is a sample functional test form:

HAS ITRP

Fire Alarm (Fire Alarm System)
FPT-2

FPT-2: Fire Alarm (Fire Alarm System)

Test Type: **Functional Performance Testing**

Asset Summary

Unit #	Fire Alarm
Discipline	

Questionnaire

#	Question	Answer	Details
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Normal Standby

The following sequence of operation is derived from 283100 1.1.H., dated 11/13/2017.

1	Screen displays SYSTEM STATUS: NORMAL with time and date. Power LED glows on steady green.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
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General Alarm Sequence

1	VERIFY by visual response that:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	Continuously operate alarm notification appliances, including voice evacuation notices.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	Identify alarm and specific initiating devices at fire alarm control unit, connect network control panels, off-premises network control panels and remote annunciators	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
4	Transmit an alarm signal to the remote alarm receiving station.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	Unlock electric door locks in designated egress paths.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	Release fire shutters, fire and smoke doors held open by magnetic door holders -- from local dedicated smoke detectors only.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	Activate voice/ alarm communication system.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
8	Switch heating, ventilating and air conditioning equipment controls to fire-alarm mode.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
9	Activate smoke-control system (smoke management) at firefighters smoke control system panel.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
10	Activate stairwell pressurization systems - from local, dedicated smoke detectors only.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

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HAS ITRP

**Fire Alarm (Fire Alarm System)
FPT-2**

#	Question	Answer	Details
11	Close smoke dampers in air ducts of designated air-conditioning duct systems.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
12	Recall elevators to primary or alternate recall floors.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
13	Activate emergency shutoffs for gas and fuel supplies	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
14	Record events in the system memory.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Manual Station Alarm Verification			
1	PROCEDURE: Activate a 20% sampling of manual pull stations	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	VERIFY by visual response that general alarm is activated on the floor in alarm, two floors above and one below.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Smoke Detector Alarm Verification			
1	PROCEDURE: Activate a 20% sampling of automatic sprinkler system water flow switches	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	VERIFY by visual response that general alarm is activated on the floor in alarm, two floors above and one below.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Auto Sprinkler System Water Flow Verification			
1	PROCEDURE: Activate a 20% sampling of automatic sprinkler system water flow switches	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	VERIFY by visual response that general alarm is activated on the floor in alarm, two floors above and one below.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Heat Detector Verification			
1	PROCEDURE: Activate a 20% sampling of heat detectors	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	VERIFY by visual response that general alarm is activated on the floor in alarm, two floors above and one below.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Notification Devices			
1	VERIFY operation of the following devices:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	Activation of alarm notification appliances, fire safety functions, HVAC, annunciation, smoke control, elevator recall, and suppression systems occurs within 10 seconds after the activation of an initiating device.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

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HAS ITRP

**Fire Alarm (Fire Alarm System)
FPT-2**

#	Question	Answer	Details
3	Strobe devices are synchronized	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	Audible alarms in area produce a sound level 5 dB above maximum sound level lasting 60 sec or 15 dB above the average ambient sound level.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

Duct Detector Alarm Sequence

The follow sequence of operation is derived from 283100 2.2.F.4.d dated 11/13/2017.

1	Continuously operate alarm notification appliances, including voice evacuation notices.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	Identify alarm and specific initiating devices at fire alarm control unit, connect network control panels, off- premises network control panels and remote annunciators	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	Transmit an alarm signal to the remote alarm receiving station.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	Unlock electric door locks in designated egress paths.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	Release fire shutters, fire and smoke doors held open by magnetic door holders -- from local dedicated smoke detectors only	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	Activate voice/ alarm communication system.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	Switch heating, ventilating and air conditioning equipment controls to fire-alarm mode.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
8	Activate smoke-control system (smoke management) at firefighters smoke control system panel.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
9	Activate stairwell pressurization systems - from local, dedicated smoke detectors only.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
10	Close smoke dampers in air ducts of designated air-conditioning duct systems	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
11	Recall elevators to primary or alternate recall floors	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
12	Activate emergency lighting control.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
13	Activate emergency shutoffs for gas and fuel supplies.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
14	Record events in the system memory.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
15	Record events by the system printer.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

AHU Duct Detector

1	PROCEDURE: Activate duct mounted smoke detectors for the indicated air handling units.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
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VERIFY alarm sequence for the following devices

HAS ITRP

**Fire Alarm (Fire Alarm System)
FPT-2**

#	Question	Answer	Details
1	H-AHU-1 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	H-AHU-1 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	H-AHU-2 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	H-AHU-2 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	H-AHU-3 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	H-AHU-3 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	H-AHU-4 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
8	H-AHU-4 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
9	H-AHU-5 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
10	H-AHU-5 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
11	H-AHU-6 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
12	H-AHU-6 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
13	H-AHU-7 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
14	H-AHU-7 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
15	H-AHU-8 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
16	H-AHU-8 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
17	C-AHU-1 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
18	C-AHU-1 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
19	C-AHU-2 Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
20	C-AHU-2 Return duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
21	C-AHU-B Supply duct mounted smoke detector	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
22		<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

General Alarm Elevator Recall

Elevator recall operation derived from ASME A17.1-2016 2.27.3.2
Phase I Emergency Recall Operation by Fire Alarm Initiating Devices.

1	VERIFY By visual response that:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	An audible alarm is followed by a voice message on the floor of the alarm, the floor above and below, and a visual signal illuminates at the main FACP in electrical room 22009.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	A visual printout appears at the system printers	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

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**Fire Alarm (Fire Alarm System)
FPT-2**

#	Question	Answer	Details
4	Building evacuation signals illuminate in the zone of alarm, floor above and below.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	Annunciation at the remote annunciator panels.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	All magnetic hold open doors in the fire area are released.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	Smoke dampers are released at smoke barriers for area in alarm (except for pull station).	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
8	Stairwell pressurization fans turn on.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
9	Annunciator at graphic workstations.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

Level G (Primary) Elevator Recall

1	PROCEDURE: Activate smoke detector in elevator lobby.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	VERIFY Device is uniquely identified.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	

VERIFY elevators recall to primary egress floor (Level 1) for the following smoke detectors

1	ELEV 12	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	ELEVs 4, 5, 6, 8, 9, 10, 11	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	VERIFY Cab firefighters lamp "hat" is SOLID.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

Level B (Alternate) Elevator Recall

1	PROCEDURE: Activate smoke detector in elevator lobby.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	VERIFY Device is uniquely identified	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

VERIFY elevators recall to alternate egress floor for the following smoke detectors:

1	ELEVs 1, 2, 12, 13, 14	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	ELEVs 4, 5, 6, 8, 9, 10, 11	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	VERIFY Cab firefighters lamp "hat" is SOLID.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

Level 1 (Primary) Elevator Recall

1	PROCEDURE: Activate smoke detector in elevator lobby.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	VERIFY Device is uniquely identified	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

VERIFY elevators recall to primary egress floor (Level 1) for the following smoke detectors:

1	ELEVs 1, 2, 12, 13, 14	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
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HAS ITRP

**Fire Alarm (Fire Alarm System)
FPT-2**

#	Question	Answer	Details
2	ELEVs 4, 5, 6, 8, 9, 10, 11	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	VERIFY Cab firefighters lamp "hat" is SOLID.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

Level 2 (Primary) Elevator Recall

1	PROCEDURE: Activate smoke detector in elevator lobby	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	VERIFY Device is uniquely identified	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

VERIFY elevators recall to primary egress floor (Level 1) for the following smoke detectors:

1	ELEVs 1, 2, 12	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	ELEVs 4, 5, 6, 8, 9, 10, 11	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	VERIFY Cab firefighters lamp "hat" is SOLID.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

Elev Equip Room (Primary) Elevator Recall

1	PROCEDURE: Activate smoke detector in elevator equipment room.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
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VERIFY elevators recall to primary egress floor (Level 1) for the following smoke detectors:

1	ELEVs 1, 2, 12	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	ELEVs 4, 5, 6, 8, 9, 10, 11, 13, 14	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	VERIFY Cab firefighters lamp "hat" is FLASHING	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

Elevator Shaft(Primary) Elevator Recall

1	PROCEDURE: Activate smoke detector at top of elevator shaft.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
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VERIFY elevators recall to primary egress floor (Level 1) for the following smoke detectors:

1	Top of elevator shaft for Elevators 1,2	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	Top of elevator shaft for Elevators 4, 5, 6	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	Top of elevator shaft for Elevators 8, 9, 10, 11	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	Top of elevator shaft for Elevators 12	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	Top of elevator shaft for Elevators 13	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	Top of elevator shaft for Elevators 14	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	VERIFY Cab firefighters lamp "hat" is FLASHING.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

Elevator Shaft (Alternate) Elevator Recall

HAS ITRP

**Fire Alarm (Fire Alarm System)
FPT-2**

#	Question	Answer	Details
1	PROCEDURE: Activate smoke detector at pit of elevator shaft.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
VERIFY elevators recall to alternate egress floor for the following smoke detectors:			
1	Pit of elevator shaft for Elevators 1, 2	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	Pit of elevator shaft for Elevators 4, 5, 6	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	Pit of elevator shaft for Elevators 8, 9, 10, 11	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	Pit of elevator shaft for Elevators 12	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	Pit of elevator shaft for Elevators 13	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	Pit of elevator shaft for Elevators 14	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	VERIFY Cab firefighters lamp "hat" is FLASHING.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

Elevator Power Shunt Trip

1	PROCEDURE: Activate indicated heat detector in elevator equipment rooms.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
VERIFY Elevator shunt trip for the following heat detectors:			
1	Heat detector in Elevator Machine Rooms: ELEVs 1, 2, 12	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	Heat detector in Elevator Machine Rooms: ELEVs 4, 5, 6, 8, 9, 10, 11, 13, 14	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	VERIFY Cab firefighters lamp "hat" is FLASHING.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

END TEST

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COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY

**SECTION 23 0923
DIRECT DIGITAL CONTROL SYSTEM FOR HVAC**

PART 1: GENERAL

1.01 WORK INCLUDED

- A. Furnish a totally native BACnet-based system. The Houston Airport System utilizes an Alerton system provided, installed and serviced by Climatec. This project shall be an add to the existing Alerton Server by Climatec. The operator's workstation (if required to provide for this project), all building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2008, BACnet. In other words, all workstations and controllers, including unitary controllers, shall be native BACnet devices. No gateways shall be used for communication to controllers installed under this section. Gateways may be used for communication to existing systems or to systems installed under other sections.
- B. Provide the latest version of the Alerton BAS system software as a result of this project
- C. Provide all necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.
- D. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.
- E. Implement the detailed design for all analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
- F. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.
- G. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.
- H. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.
- I. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.
- J. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.
- K. Provide a comprehensive operator and technician training program as described herein.
- L. Provide as-built documentation, operator's terminal software, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.
- M. Provide new sensors, dampers, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.

1.02 SYSTEM DESCRIPTION

- A. A distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2008. This system is to control all mechanical equipment, including all unitary equipment such as VAV boxes, heat pumps, fan-coils, AC units, etc., and all air handlers, boilers, chillers, and any other listed equipment using native BACnet-compliant components. Non-BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.
- B. Variable Refrigerant Flow (VRF) HVAC Systems will utilize proprietary controls for the VRF HVAC System Only. A full BACNet Interface will be provided to connect with the Allerton System.

IAH ARF 92	23 0923 - 1	DIRECT DIGITAL CONTROL SYSTEM FOR HVAC
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- C. Outside Air Roof Top Equipment will utilize the manufacturer supplied controller. The controller will have a full BACnet Interface to connect to the Allerton System.
- D. Exhaust fans and unit heaters will be controlled by the Allerton System.
- E. Kitchen Hoods including the kitchen exhaust and make-upair fans will be controlled by the hood controller and monitored by the Allerton System.
- F. Operator's workstation software shall use Microsoft Windows 7, Microsoft Windows 8, or Microsoft Windows 10 as the computer operating system. The Energy Management and Control System (EMCS) application program shall be written to communicate specifically utilizing BACnet protocols. Software functions delivered on this project shall include password protection, scheduling (including optimum start), alarming, logging of historical data, full graphics including animation, after-hours billing program, demand limiting, and a full suite of field engineering tools including graphical programming and applications. Systems using operating systems other than that described above are strictly prohibited. All software required to program application specific controllers and all field level devices and controllers will be left with the owner. All software passwords required to program and make future changes to the system will also become the property of the owner. All software required to make any program changes anywhere in the system, along with scheduling and trending applications, will be left with the owner. All software passwords required to program and make future changes to schedules, trends and related program changes will also become the property of the owner. All software required for all field engineering tools including graphical programming and applications will be left with the owner. All software passwords required to program and make future changes to field engineering tools, including graphical programming and applications will be left with the owner.
- G. Building controllers shall include complete energy management software, including scheduling building control strategies with optimum start and logging routines. All energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator's terminal. Operator's terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.

1.03 APPROVED MANUFACTURERS

- A. The base bid shall be **Allerton by Climatec**. Other manufacturers may bid based upon meeting all requirements of the specification and receiving approval from the engineer 30 days prior to bid. A paragraph-by-paragraph comparison of based bid specified system versus alternative system—along with three references of similar projects (include project name, contact, phone number, location, consultant, value of contract, and a brief description of the control system and how it operates)—shall be submitted 45 days prior to bid for review process. If approved, other manufacturers' bids shall be shown as an add or deduct on the bid form and shall not be carried as base bid.
 - 1. Approved Control Manufacturers
 - a. **Allerton by Climatec**

1.04 QUALITY ASSURANCE

- A. The Building Automation System (BAS) system shall be designed, installed, commissioned, and serviced by manufacturer authorized and trained personnel. System provider shall have an in-place support facility within 2 hours response time of the site with technical staff, spare parts inventory, and necessary test and diagnostic equipment.
 - 1. The contractor shall provide full-time, on-site, experienced project manager for this work, responsible for direct supervision of the design, installation, start-up and commissioning of the BAS system.
 - 2. The Bidder shall be regularly engaged in the design, installation and maintenance of BAS systems and shall have demonstrated technical expertise and experience in the design, installation and maintenance of BAS systems similar in size and complexity to this project. Bidders shall provide a list of at least 10 projects, similar in size and scope to this project

IAH ARF 92	23 0923 - 2	DIRECT DIGITAL CONTROL SYSTEM FOR HVAC
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completed within the past 3 years.

- B. Materials and equipment shall be manufacturer's latest standard design that complies with the specification requirements.
- C. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.
- D. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
- E. Control system shall be engineered, programmed and supported completely by representative's local office that must be within 100 miles of project site.

1.05 REFERENCE STANDARDS

- A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
 - a. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
 - b. ANSI/ASHRAE Standard 135-2008, BACnet.
 - c. Uniform Building Code (UBC), including local amendments.
 - d. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
 - e. National Electrical Code (NEC).
 - f. FCC Part 15, Subpart J, Class A.
 - g. UL-864 UUKL listing for Smoke Controls for equipment used for smoke control. (if applicable to the project)
- B. City, county, state, and federal regulations and codes in effect as of contract date.
- C. Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work, and arrange for necessary approvals by the governing authorities.

1.06 SUBMITTALS

- A. Drawings
 - a. The system supplier shall submit engineered drawings, control sequence, and bill of materials for approval.
 - b. Drawings shall be submitted in the following standard sizes: 11" x 17" (ANSI B).
 - c. Four complete sets (copies) or one electronic set of submittal drawings shall be provided.
 - d. Drawings shall be available on CD-ROM.
- B. System Documentation
 - 1. Include the following in submittal package:
 - a. System configuration diagrams in simplified block format.
 - b. All input/output object listings and an alarm point summary listing.
 - c. Complete bill of materials, valve schedule and damper schedule.
 - d. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
 - e. For all system elements—operator's workstation(s), building controller(s), application controllers, routers, and repeaters—provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2001.
 - f. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.
 - g. A list of all functions available and a sample of function block programming that shall be part of delivered system.
 - h. Upon completion and acceptance of the DDC control system, this contractor shall provide overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions, along with as-built drawings.

C. Project Management

- a. The contractor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents, and shall indicate timing and dates for system installation, debugging, and commissioning.

1.07 WARRANTY

- A. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one (1) year from completion of system acceptance.
- B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours, Monday through Friday and 48 hours on Saturday and Sunday.
- C. This warranty shall apply equally to both hardware and software.

1.08 RELATED WORK IN OTHER SECTIONS

- A. Refer to Division 0 and Division 1 for related contractual requirements.
- B. Refer to Section 23 00 00 for General Mechanical Provisions.
- C. Refer to Section 26 00 00 for General Electrical Provisions.

PART 2: PRODUCTS

2.01 ADVANCED WORKSTATION

- A. General structure of workstation interaction shall be a standard client/server relationship. Server shall be used to archive data and store system database. Thick and web clients shall access server for all archived data.
- B. BACnet Conformance
 1. Operator workstation shall be approved by the BTL as meeting the BACnet Advanced Work Station (AWS) requirements.
 2. Please refer to Section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 3. Standard BACnet object types accessed by the AWS shall include as a minimum: Analog Value, Analog Input, Analog Output, Binary Value, Binary Input, Binary Output, Calendar, Device, Event Enrollment, File, Notification Class, Program, and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 4. The AWS shall comply with Annex J of the BACnet specification for IP connections. Must support remote connection to server using a thick client application. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs). AWS shall support Foreign Device Registration to allow temporary workstation connection to IP network.
- C. Data Displays
 1. Data displays shall render all data associated with project as called out on drawings and/or object type list supplied. Graphic files shall be created using digital, full color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings, and wiring diagrams from as-built drawings.
 2. Data displays shall render data using iconic graphic representations of all mechanical equipment. System shall be capable of displaying graphic file, text, trendlog, and dynamic object data together on each display and shall include animation. Information shall be

- labeled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user.
3. Data display frame shall allow user to change all field-resident AWS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc., from any screen, no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.
 4. Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual graphic items on the display screen as an overlay to the system graphic.
 5. All displays and programming shall be generated and customized by the local use energy management and control system (EMCS) supplier and installer. Systems requiring factory development of graphics or programming of DDC logic are specifically prohibited.
 6. AWS shall be supplied with a library of standard graphics, which may be used unaltered or modified by the operator. AWS shall include a library of equipment graphic components to assemble custom graphics. Systems that do not allow customization or creation of new graphic objects by the operator (or with third-party software) shall not be allowed.
 7. Data display frame shall include customizable and persistent tree navigation for building, equipment and system diagnostic centric display organization
 8. Each display may be protected from viewing unless operator credentials have the appropriate access level. An access level may be assigned to each display and system object. The menu label shall not appear on the graphic if the operator does not have the appropriate security level.
 9. Data displays shall have the ability to link to content outside of the EMCS system. Such content shall include, but is not limited to launching external files in their native applications (for example, a Microsoft Word document) and launching a web browser resolving to a specified web address
 10. The AWS shall have the ability to support 20 concurrent web clients.
 11. Summary Page display shall support:
 - a. A minimum of 1,024 points on the Summary Page
 - b. Updating 10 data points from 20 different controllers in under 8 seconds with fresh live data
 - c. Sortable columns
 - d. Multi-point selection and edit for commanded points within the same column
 - e. Supports a graphic image that is user collapsible for point reference
 12. Data displays shall support:
 - a. Graphic items with custom geometry that offer both color gradient shading and variable opacity in scale to system variables and range setpoints
 - b. Clear and custom geometry navigation buttons to provide intuitive navigation.
 - c. Graphic files in JPG, PNG, and GIF file types.
 - d. Viewing of 1,024 system data points in a single screen
- D. Password Protection
1. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator's assigned functions when user is logged on. This includes displays as outlined above.
 2. AWS shall provide security for a minimum of 200 users. Each user shall have an individual User ID, User Name, and Password. Entries are alphanumeric characters only and are case sensitive (except for User ID). User ID, User Name, and Password shall be shall support a minimum of 40 characters. All user information and passwords shall be stored in an encrypted form.
 - a. Each user shall be allowed individual assignment of only those control functions, menu items, navigation tree, and user-specific system start display, as well as restricted access to discrete BACnet devices to which that user requires access.
 - b. All passwords, user names, and access assignments shall be adjustable via Server and Thick client. Password shall be adjustable via the web client.

- c. Users shall also have a set access level, which defines access to displays and individual objects the user may control. System shall include 10 separate and distinct access levels for assignment to users.
 - 3. The AWS and Thick Client shall include an Auto Logout feature that shall automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.
 - 4. The system shall permit the assignment of an effective date range, as well as an effective time of day, that the User IDs are permitted to authenticate.
 - a. Shall support Active Directory Integration using LDAP for remote User Access control
 - b. Enforce Minimum password length
 - c. Enforce combination of 3
 - 1) Upper Case letters
 - 2) Lower Case letters
 - 3) Base 10 digits (0-9)
 - 4) Non-alphanumeric characters
 - 5) Password expiration
 - 6) User lockout after "x" failed attempts, where "x" is adjustable by the administrator
- E. Operator Activity Log
 - 1. An Operator Activity Log that tracks all operator changes and activities shall be included with AWS. System shall track what is changed in the system, who performed this change, date and time of system activity, and value of the change before and after operator activity. Operator shall be able to display all activity, sort the changes by user and also by operation. Operator shall be able to print the Operator Activity Log display.
 - 2. Log shall be gathered and archived to a hard drive on AWS as needed. Operator shall be able to export data for display and sorting in a spreadsheet.
 - 3. System shall have the option to require user comment recording in the Operator Activity Log upon any system point change.
 - a. Operator Activity log shall be accessible via the Web Client for viewing, sorting, filtering, and Printing.
- F. Scheduling
 - a. AWS, Thick Client and Web Client shall show all information in easy-to-read daily format including calendar of this month and next. All schedules shall show actual ON/OFF times for day based on scheduling priority. Priority for scheduling shall be events, holidays and daily, with events being the highest.
 - 2. Holiday and special event schedules shall display data in calendar format. Operator shall be able to schedule holidays and special events directly from these calendars.
 - a. Operator shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate access privileges.
 - b. AWS and Thick Client shall include a Schedule Wizard for set up of schedules. Wizard shall walk user through all steps necessary for schedule generation. Wizard shall have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting Schedule.
 - 3. Scheduling shall include optimum start based on outside air temperature, current heating/cooling setpoints, indoor temperature and history of previous starts. Each and every individual zone shall have optimum start time independently calculated based on all parameters listed. User shall input schedules to set time that occupied setpoint is to be attained. Optimum start feature shall calculate the startup time needed to match zone temperature to setpoint. User shall be able to set a limit for the maximum startup time allowed.
 - 4. Schedule list shall show all schedules currently defined. This list shall include all standard, holiday and event schedules. In addition, user shall be able to select a list that shows all scheduled points and zones.

- a. Display of all three schedules must show all ON times for standard, holiday and event schedules in different colors on a given day. In addition, OFF times for each must also be shown in additional colors. User shall be able to select from standard calendar what days are to be scheduled and same display shall show all points and zones affected. User shall be able to set time for one day and select all days of the week that shall be affected as a recurrence of that same schedule for that given day.
 - b. Any displayed data that is changeable by the operator may be selected using the right mouse button and the schedule shall then be selectable on the screen. Selection of the schedule using this method shall allow the viewing of the assigned schedule allow the point to be scheduled.
5. Schedule editor shall support drag-n-drop events and holidays onto the schedule calendar.
 - a. Schedule editor shall support drag-n-drop events default to a two-hour period, which can then be adjusted by the user.
 6. Schedule editor shall support drag-n-drop holidays default for OFF all day and can be edited for multiple-day holidays.
 - a. Schedule editor shall support the view of affected zones when adding or editing timed events of a schedule.
 7. The web client shall have the ability to search a list of all scheduled points and zones to access the schedule calendar.
 8. Schedule time blocks shall present schedule detail via mouse-over information.
- G. Alarm Indication and Handling
1. AWS shall provide visual, printed, and email means of alarm indication. Printout of alarms shall be sent to the assigned network printer if applicable. Alarm notification can be filtered based on the User ID's authorization level.
 2. Alarm Manager shall provide log of alarm messages. History of alarm occurrences shall be archived to the data storage of the AWS or a SQL data base. Each entry shall include a description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal, time and date of alarm acknowledgment, identification of operator acknowledging alarm, a comment from the operator who acknowledged the alarm, and the number of alarm occurrences
 - a. Alarm Manager shall provide a means to filter all alarms that have been configured in the system for alarm description, current alarm state, default and customer date range, disabled/enabled, and priority level
 - b. Alarm Manager shall provide a means to disable alarms for the purpose of performing maintenance without creating concern with unneeded alarm notifications
 - c. Alarm messages shall be in user-definable text (English or other specified language) and shall be delivered either to the AWS user interface or through remote communication using email (Authenticated SMTP supported)
 - d. Alarm Manager shall provide the permissioned ability to Clear alarms occurrences from the Alarm Manager table while retaining the alarm in the AWS database for reporting purposes
 - e. Alarm Manager shall provide the permissioned ability to Purge alarm occurrences from the both the Alarm Manager table and the AWS database
 - f. Alarm Manager shall provide a user customizable navigation link from the Alarm message to the data display or template to the equipment associated with the alarm
 3. Alarm Manager shall provide a context menu that will allow for navigation to Schedule, Trendlog, Object Property display, or System (user) Activity from the Alarm points live data value
 4. AWS shall include an Alarm Wizard for set up of alarms. Wizard shall walk user through all steps necessary for alarm generation. Wizard shall have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting alarm setup
 - a. User can silence audible annunciation for the current session

- b. User can disable auto-refresh of alarm annunciation for current session
 - c. Any displayed data that is changeable by the operator may be selected using the right mouse button and the alarm shall then be selectable on the screen. Selection of the alarm using this method shall allow the viewing of the alarm history or allow the creation of a new alarm
5. Alarm Priority Levels (0-127) shall be definable in number and name. Alarms can be assigned to any of the priority levels defined
 6. The following Alarm data shall be displayed in the Alarm Management User Interface:
 - a. Number of times the alarm has occurred
 - b. Average alarm duration for the following transitions
 - c. Active to Normal
 - d. Active to Acknowledgement
 - e. Acknowledgement to Normal
 - f. Live data point of point alarmed
 - g. Navigation link to a user-selected display or URL
 7. User Comment text can be input upon acknowledgement of an Alarm. The comment history is stored in the system data base and a user cannot edit or delete a comment after it has been submitted in the system.
 8. Alarm Performance: An alarm annunciation shall appear on the AWS user interface within 8 seconds, and appear in the Alarm manager and data base within 10 seconds of a triggered alarm
- H. Trendlog Information
1. AWS shall periodically gather historically recorded data stored in the building controllers and store the information in the system database. Stored records shall be appended with new sample data, allowing records to be accumulated. Systems that write over stored records shall not be allowed unless limited file size is specified. System database shall be capable of storing up to 50 million records before needing to archive data. Samples may be viewed at the web client. All trendlog records shall be displayed in standard engineering units.
 - a. AWS shall be capable of trending on an interval determined by a polling rate, or change-of-value.
 - b. AWS, Thick client, or Web Client shall be able to add and edit trendlogs and the setup information. This includes the information to be logged as well as the interval at which it is to be logged. All operations shall be password protected. Viewing may be accessed directly from any and all graphics on which a trended object is displayed.
 - c. AWS and Thick Client shall include a Trendlog Wizard for setup of multiple trend logs simultaneously. Wizard shall walk user through all necessary steps. Wizard shall have its own pull-down selection for startup, or may be started by right-clicking on value displayed on graphic, and then selecting Trendlogs from the displayed menu.
 - d. AWS shall be capable of using Microsoft SQL as the system database.
 2. Any displayed data that is changeable by the operator may be selected using the right mouse button and the trendlog shall then be selectable from a menu on the screen. Selection of the trendlog using this method shall allow the viewing of the trendlog data in the DataViewer.
 3. Trendlog viewer shall provide:
 - a. Software that is capable of graphing the trend-logged object data shall be included.
 - b. Access and ability to create, edit and view are restricted to users by user account credentials
 - c. Specific and repeatable URL defines the trendlog(s) that comprise the view.
 - d. Call out of trendlog value at intersection of trend line and mouse-over vertical axis.
 - e. Trendlog and companion logs can be configured to display on one of two independent vertical scales.
 - f. Click zoom for control of data set viewed along either graph axis.
 - g. User-specifiable start and end dates as well as a fast scroll features that supports click zoom of macro scale view of the data for quickly finding data set based on visual

- signature.
 - h. User export of the viewed data set to MS Excel.
 - i. Web browser-based help.
 - j. Optional min/max ranges (Upper Control Limits, Lower Control Limits) for each value
- I. H. Energy Log Information
- a. AWS shall be capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files shall be appended with new data, allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified. Display all energy log information in standard engineering units.
 - b. All data shall be stored in database file format for direct use by third-party programs. Operation of system shall stay completely online during all graphing operations.
 - c. AWS operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. System shall support using flow and temperature sensors for BTU monitoring.
 - d. AWS shall display data in tabular format form for both consumption and peak values. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format, the user shall be able to select a specific period of data to view.
 - e. Web client shall display data in tabular format and graphical format. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format, the user shall be able to select a specific period of data to view.
- J. Reports
- 1. AWS shall be capable of periodically producing reports of trendlogs, alarm history, tenant activities, device summary, energy logs, and override points. The frequency, content, and delivery are to be user adjustable.
 - 2. All reports shall be capable of being delivered in multiple formats including text- and comma-separated value (CSV) and PDF files. The files can be printed, emailed, or saved to a folder, either on the server hard drive or on any network drive location.
 - 3. 3. SQL Server Reporting Services can be used to create custom report templates
- K. Configuration/Setup
- a. Provide means for operator to display and change system configuration. This shall include, but not be limited to system time, day of the week, date of daylight savings set forward/set back, printer termination, port addresses, modem port and speed, etc. Items shall be modified using understandable terminology with simple mouse/cursor key movements.
 - b. The building management system (BMS) shall operate the user interface in any region and support varying languages and locale settings, without the addition of special software. Localization tools shall be commonly available open sourced or purchased products, No BMS manufacturer specific software will be acceptable.
 - c. The following localization capabilities shall be supported:
 - 1) Locale settings related to date, time and number formats
 - 2) Multiple left-to-right languages supported including Cyrillic languages
 - 3) On the fly locale change using browser language settings (multiple language and locale setting change)
 - 4) Default character encoding shall be UTF-8
 - 5) Each localized BMS element can be localized independently and operate autonomously
- L. Field Engineering Tools
- a. AWS shall include field engineering tools for programming all controllers supplied. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from other types of blocks. Graphical programming that uses simple rectangles and

squares is not acceptable.

- b. User shall be able to select a graphical function block from menu and place on screen. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.
- c. Programming tools shall include a real-time operation mode. Function blocks shall display real-time data and be animated to show status of data inputs and outputs when in real-time operation. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.
- d. Field engineering tools shall also include a database manager of applications that include logic files for controllers and associated graphics. Operator shall be able to select unit type, input/output configuration and other items that define unit to be controlled. Supply minimum of 250 applications as part of workstation software.
- e. Field engineering tool shall include Device Manager for detection of devices connected anywhere on the BACnet network by scanning the entire network. This function shall display device instance, network identification, model number, and description of connected devices. It shall record and display software file loaded into each controller. A copy of each file shall be stored on the computer's hard drive. If needed, this file shall be downloaded to the appropriate controller using the mouse.
- f. AWS shall automatically notify the user when a device that is not in the database is added to the network.
- g. AWS shall include backup/restore function that will back up entire system to selected medium and then restore system from that medium. The system shall be capable of creating a backup for the purpose of instantiating a new client PC.
- h. The system shall provide a means to scan, detect, interrogate, and edit third-party BACnet devices and BACnet objects within those devices.

M. Workstation Hardware

- a. Provide operator's workstation(s) at location(s) noted on the plans.
- b. AWS Server Minimum Requirements
- c. 64-bit OS
- d. Windows 7, Windows 8.1, Windows 10, Windows Server 2008R2, or Windows Server 2012R2
- e. 3 GHz (or better), dual-core or quad-core processors
- f. 8 GB RAM or higher
- g. 3 GB of hard drive space required for base installation without application data
- h. Network interface card (10/100/1000 Mbps)

N. Software

- a. At the conclusion of the project, contractor shall leave with owner a electronic copy that includes the complete software operation system and project graphics, setpoints, system parameters, etc. This backup shall allow the owner to completely restore the system in the case of a computer malfunction.

O. Web Client

- a. EMCS supplier shall provide an HTML5-based browser access to the AWS as part of standard installation. User must be able to access all displays of real-time data that are part of the AWS using a standard web browser. Web browser shall tie into the network through owner-supplied Ethernet network connection. The web client shall support a minimum of 200 users with a single license.
- b. Browser shall be standard version of Microsoft Internet Explorer v10.0 or later, Firefox v19.0 or later, Chrome v24.0 or later, and Safari v7.1.1 or later. No special vendor-supplied software shall be needed on computers running browser. Data shall be displayed in real-time and update automatically without user interaction.
- c. Web pages shall be automatically generated using HTML5 from the data display files that reside on the AWS. Any system that requires use of an HTML editor for generation of web pages shall not be considered.
- d. Access through web client or thick client shall utilize the same hierarchical security scheme as the AWS. User shall be asked to log on once the client makes connection

to the AWS. Once the user logs on, any and all changes that are made shall be tracked by the AWS. The user shall be able to change only those items he or she has authority to change. A user activity report shall show any and all activity of the users who have logged on to the system, regardless of whether those changes were made using a web client, thick client or through the AWS.

- e. Shall provide User Session Management including the ability to view all connected user sessions to the web client, see how long they have been active/inactive for each unique session, and force log-out for any or all sessions.
- f. Shall provide menu-style navigation access to primary features, i.e. alarm history, DataViewer, Search scheduled points and Zones, System Activity, User Session Management, and Top Display
- g. Web client shall, at a minimum, support the following tablets:
- h. Android platform:
 - i. Google Nexus
 - j. Samsung Galaxy Note
 - k. Apple platform
 - l. Ipad
 - m. Apple Ipad Mini

2.02 BUILDING CONTROLLER

A. General Requirements

- a. BACnet Conformance
- b. Building Controller shall be approved by the BTL as meeting the BACnet Building Controller requirements.
- c. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- d. Building controller shall be of scalable design such that the number of trunks and protocols may be selected to fit the specific requirements of a given project.
- e. The controller shall be capable of panel-mounted on DIN rail and/or mounting screws.
- f. The controller shall be capable of providing global control strategies for the system based on information from any objects in the system, regardless if the object is directly monitored by the building controller module or by another controller.
- g. The controller shall be capable of running up to six (6) independent control strategies simultaneously. The modification of one control strategy does not interrupt the function or runtime others.
- h. The software program implementing the DDC strategies shall be completely flexible and user-definable. All software tools necessary for programming shall be provided as part of project software. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site, using a wide area network (WAN) or downloaded through remote communications are not acceptable. Changing global strategies using firmware changes is also unacceptable.
- i. Programming shall be object-oriented using control function blocks and support DDC functions. All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be supplied and be resident on workstation. The same tool shall be used for all controllers.
- j. The programming tool shall provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed using the operator's workstation or field computer.
- k. Controller shall have 6,000 Analog Values and 6,000 Binary Values.
- l. Controller IP configuration can be done via a direct USB connect with an operator's workstation or field computer.
- m. Controller shall have at a minimum a Quad Core 996Ghz processor to ensure fast processing speeds.

- n. Global control algorithms and automated control functions shall execute using a 64-bit processor.
 - o. Controller shall have a minimum of 1 GB of DDR3 SDRAM on a 533Mhz bus to ensure high speed data recording, large data storage capacity and reliability.
 - p. Controller shall support two (2) on-board EIA-485 ports capable of supporting various EIA-485 protocols including, but not limited to BACnet MS/TP and Modbus.
 - q. Ports are capable of supporting various EIA-485 protocols including, but not limited to BACnet MS/TP and Modbus.
 - r. Controller shall support two (2) ports—each of gigabit speed—Ethernet (10/100/1000) ports.
 - s. Ports are capable of supporting various Ethernet protocols including, but not limited to BACnet IP, FOX, and Modbus.
 - t. All ports shall be capable of having protocol(s) assigned to utilize the port's physical connection.
 - u. The controller shall have at a minimum four (4) onboard inputs, two (2) universal inputs and two (2) binary inputs.
 - v. Schedules
 - w. Building controller modules shall provide normal seven-day scheduling, holiday scheduling and event scheduling.
 - x. Each building controller shall support a minimum of 380 BACnet Schedule Objects and 380 BACnet Calendar Objects.
 - y. Logging Capabilities
 - z. Each building controller shall log as minimum 2,000 objects at 15-minute intervals. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
 - aa. Logs may be viewed both on-site or off-site using WAN or remote communication.
 - bb. Building controller shall periodically upload trended data to networked operator's workstation for long-term archiving if desired.
 - cc. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
2. Alarm Generation
- a. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
 - b. Each alarm may be dialed out as noted elsewhere.
 - c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
 - d. Controller must be able to handle up to 2,000 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.
3. Demand Limiting
- a. Demand limiting of energy shall be a built-in, user-configurable function. Each controller module shall support shedding of up to 1,200 loads using a minimum of two types of shed programs.
 - b. Load shedding programs in building controller modules shall operate as defined in section 2.1.J of this specification.
4. Tenant Activity Logging
- a. Tenant Activity logging shall be supported by a building controller module. Each independent module shall support a minimum of 380 zones.
 - b. Tenant Activity logging shall function as defined in section 2.1.K of this specification.
- B. BACnet MS/TP
- 1. BACnet MS/TP LAN must be software-configurable from 9.6 to 115.4Kbps
 - a. Each BACnet MS/TP LAN shall support 64 BACnet devices at a minimum.
 - b. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. BACnet IP

1. The building controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the local area network (LAN).
2. Must support interoperability on WANs and campus area networks (CANs), and function as a BACnet Broadcast Management Device (BBMD).
3. Each controller shall support at a minimum 128 BBMD entries.
4. BBMD management architecture shall support 3,000 subnets at a minimum.
5. Shall support BACnet Network Address Translation.
6. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

D. Expansion Ports

1. Controller shall support two (2) expansion ports.
 - a. Combining the two on-board EIA-458 ports with fully loaded expansion ports, the controller shall support six (6) EIA-485 trunks simultaneously.
2. Expansion cards that mate to the expansion ports shall include:
 - a. Dual port EIA-485 card.
 - b. LON network card.

E. Niagara Framework

1. Controller shall be capable of utilizing the Tridium Niagara Framework.
 - a. Niagara Framework shall be version 3.8 or newer.
 - b. All Niagara licensing shall be stored on a removable MicroSD card for fast in-field replacement of controller.
2. The Niagara License for the controllers shall be an open license.
 - a. The controller shall be programmable via Niagara Workplace programming tool.
 - b. The controller shall be programmable via an Niagara embedded Workplace programming tool.

F. Power Supply

1. Input for power shall accept between 17 and 30VAC, 47 and 63Hz.
2. Optional rechargeable battery for shutdown of controller including storage of all data in flash memory.
3. On-board capacitor will ensure continuous operation of real-time clocks for minimum of 14 days.

G. Controller shall be in compliance with the following:

1. UL 916 for open energy management
2. FCC Class B
3. ROHS
4. IEC 60703
5. C-Tick Listed

H. Controller shall operate in the following environmental conditions:

1. -4 to 149 °F (-20 to 65 °C) without optional battery, or 32 to 122 °F (0 to 50 °C) with optional battery.
2. 0 to 95% relative humidity (RH), non-condensing.
3. Controller shall support a minimum of 50 trendlogs. Any object in the controller (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.

2.03 UNIT APPLICATION CONTROLLERS (HEAT PUMPS, AHU'S, FAN-COILS, UNIT VENTILATOR)

- A. Provide one native BACnet application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall

be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

B. BACnet Conformance

1. Application controllers shall, as a minimum, support MS/TP BACnet LAN types. They shall communicate directly using this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements and support all BACnet services necessary to provide the following BACnet functional groups:
2. Files Functional Group
3. Reinitialize Functional Group
4. Device Communications Functional Group
5. Please refer to Section 22.2, BACnet Functional Groups in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
6. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

- C.** Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.
- D.** All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.
- E.** Application controller shall include support for intelligent room sensor (see Section 2.10.B.) Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

AUXILIARY CONTROL DEVICES

A. TEMPERATURE:

1. All temperature sensors to be solid state electronic thermistor or RTD, factory-calibrated to within 0.5°F, totally interchangeable with housing appropriate for application. Sensors shall be 10,000 ohm thermistor @ 77 F (type II) with temperature curve rated for the application. Sensor wiring terminations shall be in a galvanized box (not plastic).
2. Outside air temperature sensor: Sensors shall be installed in weather proof enclosure with ventilated PVC sun-shield.
3. Duct mounted temperature sensor shall be averaging type for supply air, mixed air and low temperature applications for air handling units. Duct probe temperature sensor shall be acceptable for terminal units and fan coil units.
4. Thermowell temperature sensor: Sensors shall be stainless steel probe of length that is equivalent to a minimum of 20% of the pipe diameter. End-to-end accuracy shall be ± 0.36 deg. F. Connection box shall be moisture/water proof with conduit fitting. Furnish the

stainless steel thermowell to the mechanical contractor for installation. A thermal conducting grease shall be installed in the thermowell to provide uniform temperature sensing.

5. CARBON DIOXIDE SENSOR:
6. The CO₂ sensor shall be capable of monitoring CO₂ concentration with an accuracy of +/- 30 parts per million (PPM). The CO₂ sensor shall produce a linear 0-10 VDC or 4-20 ma signal over the range of 0 to 2000 PPM. The CO₂ sensor shall measure using non-dispersed infrared (NDIR) technology to measure carbon dioxide gas and shall have
7. Wall mounted carbon dioxide sensors shall be Veris CWE series.
8. Duct Mounted Carbon Dioxide Sensor: CO₂ sensors for duct mounted applications shall be installed in the return air path. Duct mounted carbon dioxide sensors shall be Veris CDE series.
9. The BCS contractor shall utilize the required calibration devices to properly commission and calibrate the CO₂ sensors per the manufacturer's recommendations.
10. RELATIVE HUMIDITY SENSORS:
11. All relative humidity sensors shall be a two wire type, 4-20 mA or 3-wire 0-5V, 0-10V output proportional to the relative humidity range of 0-100%. The accuracy of the sensors shall be +3% over a range of 5-95% r.h. The sensor shall be replaceable. Sensor wiring terminations shall be in a galvanized box (not plastic). Veris HO series or approved equal.
12. Outdoor air relative humidity sensors: provide non-corroding outdoor shield to minimize wind effects and solar heating. Install wall-mount weather proof enclosure with conduit fitting.
13. Interior air relative humidity sensor: wall mounted humidity sensors shall be installed in a wall mounted enclosure with white or off-white cover to match the wall temperature sensors.
14. Duct mounted relative humidity sensor: Duct mounted relative humidity sensors shall be provided with a moister resistant enclosure with conduit fitting. The probe length shall be 8" minimum.
 - a. DIFFERENTIAL PRESSURE SENSORS:
15. Duct static pressure sensor: The differential pressure sensors shall have an input range compatible with the medium being measured. The proportional output signal shall be 0-10 Vdc or 4-20 mA. Accuracy of the sensor shall be +5% over an operating range of 0-2.0 inches w.g.
16. Water differential pressure sensors: The water differential pressure sensor shall be provided with a cast aluminum NEMA-1 enclosure with an operating range of 0-30 psig and an accuracy of +2% of full scale reading. Sensor shall be installed with a valved piping bypass by the mechanical contractor. See details on the drawings.
 - a. FREEZESTAT:
17. Provide freezestats for all chilled water air handling systems that receive more than 10% untreated outside air. Freezestats shall provide vapor tension elements, which shall serpentine the inlet face on all coils. Provide additional sensors, wired in series, to provide one linear foot per square foot of coil surface area. Freezestat shall be manually reset at the switch. Interlock to the associated fan so that fan will shut down when HOA switch is in hand or auto position.
 - a. AIR DIFFERENTIAL PRESSURE SWITCH:
18. For fan shutdown provide air differential pressure switches for all fans controlled by a variable frequency drive (VFD) to shut down the associated fan in the event of sensing high differential pressure. Air differential pressure switches shall have an adjustable setpoint with a range of 0-10 inches w.g. with manual reset at the switch. Provide ¼ inch copper tubing with compression fittings to mount to the side of the duct.
 - a. MOMENTARY CONTROL RELAYS:
19. Provide momentary control relays as indicated. . Relays shall have coil ratings of 120 VAC, 50 mA or 10-30 VAC/VDC, 40 mA as suitable for the application. Contact ratings shall be 10 amp. Provide complete isolation between the control circuit and the digital output. Relays shall be located in the UC or other local enclosures and have pin-type terminals. Relays shall have LED indication of status.

- a. CURRENT SENSING RELAY:
- 20. Current sensing relays shall be rated for the applicable load. The output relay shall have an accessible trip adjustment over its complete operating range. Enclosure shall have an LED to indicate relay status.

AUTOMATIC DAMPERS

ACTUATORS

PART 3 – EXECUTION

6.01 PRE-CONSTRUCTION

INSPECTION DURING INSTALLATION

INSTALLATION OF COMPONENTS

COMMISSIONING REQUIREMENTS

COLORGRAPHICS

CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

DEMONSTRATION AND OWNER TRAINING

END OF SECTION

SECTION 23 7420
PACKAGED, OUTDOOR, HEATING AND COOLING MAKE-UP AIR-CONDOTIONERS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes cooling and heating rooftop replacement-air units.

1.03 DEFINITIONS

- A. DDC: Direct-digital controls.

1.04 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:
- C. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
- D. Wiring Diagrams: Power, signal, and control wiring.
1. Coordination Drawings: Rooftop replacement-air units to roof-curb mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
- E. Startup service reports.
- F. Operation and Maintenance Data: For rooftop replacement-air units to include in emergency, operation, and maintenance manuals.
- G. Warranty: Special warranty specified in this Section.

1.05 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of rooftop replacement-air units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.06 COORDINATION

- A. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
- B. Coordinate size, location, and installation of rooftop replacement-air unit manufacturer's roof curbs and equipment supports with roof Installer.
- C. Coordinate installation of restrained vibration isolation roof-curb rails, which are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1.07 WARRANTY

IAH ARF 92	23 7420 - 1	Packaged, Outdoor, Heating and Cooling Make-up Air-Conditioners
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- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below that fail in materials or workmanship within specified warranty period.
- B. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
- C. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

1.08 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Fan Belts: One set for each belt-driven fan.
- C. Filters: One set for each unit.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Aaon, Inc.
- C. Greenheck
- D. Daikin
- E. Trane

2.02 CABINET

- A. Construction: Single wall.
- B. Exterior Casing: Galvanized steel with baked-enamel paint finish and with lifting lugs and knockouts for electrical and piping connections.
- C. Interior Casing: Galvanized steel.
- D. Base Rails: Galvanized-steel rails for mounting on roof curb.
- E. Service Doors: Hinged access doors with neoprene gaskets.
- F. Internal Insulation: Fibrous-glass duct lining complying with ASTM C 1071, Type II.
- G. Thickness: 2 inches.
- H. Insulation Adhesive: Comply with ASTM C 916, Type I.
- I. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.
 - 1. Condensate Drain Pans: Formed sections of stainless-steel sheet designed for self-drainage. Fabricate pans and drain connection to comply with ASHRAE 62.1-2004.
 - 2. Roof Curb: Full-perimeter curb of sheet metal, minimum 12 inches high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
 - 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

2.03 SUPPLY-AIR FAN

- A. Fan: Forward-curved centrifugal; statically and dynamically balanced, galvanized steel, mounted on solid-steel shaft with pillow-block bearings rated L50 for 200,000 hours and having external grease fittings.
- B. Motor: Open dripproof, single-speed motor.
- C. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly with minimum 1.4 service factor.

IAH ARF 92	23 7420 - 2	Packaged, Outdoor, Heating and Cooling Make-up Air-Conditioners
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- D. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with spring isolators.

2.04 REFRIGERATION SYSTEM

- A. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
- B. Compressors: Reciprocating or scroll compressors with integral vibration isolators, internal overcurrent and overtemperature protection, internal pressure relief, and crankcase heater.
- C. Minimum Efficiency: As defined by ASHRAE/IESNA 90.1-2004, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- D. Refrigerant: R-410A.
- E. Refrigeration System Specialties:
- F. Expansion valve with replaceable thermostatic element.
- G. Refrigerant dryer.
- H. High-pressure switch.
- I. Low-pressure switch.
- J. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
- K. Brass service valves installed in discharge and liquid lines.
- L. Operating charge of refrigerant.
 1. Capacity Control: Hot-gas bypass refrigerant control for capacity control with continuous dehumidification on a single compressor.
 2. Capacity Control: Single compressor with evaporator and condenser coil within the refrigerant section to provide initial precooling and reheat for humidity control.
 3. Refrigerant Coils: Evaporator, condenser, and reheat condenser coils shall be designed, tested, fabricated, and rated according to ARI 410 and ASHRAE 33. Coils shall be leak tested under water with air at 315 psig.
- M. Capacity Reduction: Circuit coils for face control.
- N. Tubes: Copper.
- O. Fins: Aluminum with minimum fin spacing of 0.071 inch.
- P. Fin and Tube Joint: Mechanical bond.
- Q. Suction and Distributor: Seamless copper tube with brazed joints.
- R. Source Quality Control: Test to 450 psig, and to 300 psig underwater.
 1. Condenser Fan: Propeller type, directly driven by motor.
 2. Safety Controls:
- S. Compressor motor and outside-coil fan motor low ambient lockout.
- T. Overcurrent protection for compressor motor and outside-coil fan motors.

2.05 ELECTRIC-RESISTANCE HEATING

- A. Electric-Resistance Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
- B. Electric-Resistance Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
- C. Heating Capacity: Low density 35 W per sq. in., factory wired for single-point wiring connection; with time delay for element staging, and overcurrent and overheat protective devices.
- D. Safety Controls:

IAH ARF 92	23 7420 - 3	Packaged, Outdoor, Heating and Cooling Make-up Air-Conditioners
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1. Blower-motor interlock, air-pressure switch.
2. Quiet mercury contactors.
3. Time delay between steps.
4. Integral, nonfused power disconnect switch.

2.06 OUTDOOR-AIR INTAKE AND DAMPERS

- A. Dampers: Leakage rate, according to AMCA 500, shall not exceed 2 percent of air quantity at face velocity of 2000 fpm through damper and pressure differential of 4-inch wg.
- B. Damper Operators: Electric.
- C. Mixing Boxes: Parallel-blade, galvanized-steel dampers mechanically fastened to steel operating rod inside cabinet. Connect operating rods with common interconnecting linkages so dampers operate simultaneously.
- D. Outdoor-Air Intake Hoods: Galvanized steel, with bird screen complying with ASHRAE 62.1-2004 and finish to match cabinet.

2.07 FILTERS

- A. Comply with NFPA 90A.
- B. Cleanable Filters: 2-inch- thick, cleanable metal mesh.
- C. Disposable Panel Filters: 2-inch- thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1.
- D. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
- E. Frame: Galvanized steel.

2.08 CONTROLS

- A. Control equipment and sequence of operation are specified in Division 23 Section "Instrumentation and Control for HVAC." The manufacturer provided unit controller for this equipment shall be utilized. A Full BACNet Interface shall be provided and installed to connect to the Main Allerton BAS System.
- B. Factory-wire connection for controls' power supply.
- C. Control devices, including sensors, transmitters, relays, switches, thermostats, humidistats, detectors, operators, actuators, and valves, shall be manufacturer's standard items to accomplish indicated control functions.
- D. Unit Controls: Solid-state control board and components with field-adjustable control parameters.
- E. Supply-Fan Control – Signal from BAS system.
- F. Unit -Mounted Status Panel:
- G. Cooling/Off/Heating Controls: Control operational mode.
- H. Damper Position: Indicates position of outdoor-air dampers in terms of percentage of outdoor air.
- I. Status Lights:
 1. Filter dirty.
 2. Fan operating.
 3. Cooling operating.
 4. Heating operating.
 - a. Refrigeration System Controls:
- J. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb of dry air or outdoor-air temperature is less than 60 deg F.
- K. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than 60 deg F.

IAH ARF 92	23 7420 - 4	Packaged, Outdoor, Heating and Cooling Make-up Air-Conditioners
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- L. Wall-mounting, relative-humidity sensor energizes dehumidifier operation when relative humidity is more than 60 percent.
 - 1. Electric-Resistance Heating Controls: Wall-mounting thermostat controls SCR.
 - 2. Damper Controls:
- M. Wall-mounting pressure sensor modulates outdoor- and return-air dampers to maintain a positive pressure in space served by rooftop replacement-air unit at minimum 0.05-inch wg.
- N. When exhaust fans stop, set outdoor- and return-air damper to 25 percent outdoor air. When exhaust fans start, close return-air damper and fully open outdoor-air damper.
 - 1. Integral Smoke Alarm: Smoke detector installed in supply air.
 - 2. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation of rooftop replacement-air units.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Examine roof curbs and equipment supports for suitable conditions where rooftop replacement-air units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install roof curb on roof structure. Install and secure rooftop replacement-air units on curbs and coordinate roof penetrations and flashing with roof construction.
- B. Install wall- and duct-mounting sensors, thermostats, and humidistats furnished by manufacturers for field installation. Install control wiring and make final connections to control devices and unit control panel.

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Gas Burner Connections: Comply with requirements in Division 23 Section "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
- D. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to rooftop replacement-air units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."
- E. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.
- F. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.04 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
- C. Inspect for visible damage to furnace combustion chamber.

IAH ARF 92	23 7420 - 5	Packaged, Outdoor, Heating and Cooling Make-up Air-Conditioners
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- D. Inspect for visible damage to compressor, air-cooled outside coil, and fans.
- E. Inspect casing insulation for integrity, moisture content, and adhesion.
- F. Verify that clearances have been provided for servicing.
- G. Verify that controls are connected and operable.
- H. Verify that filters are installed.
- I. Clean outside coil and inspect for construction debris.
- J. Clean furnace flue and inspect for construction debris.
- K. Inspect operation of power vents.
- L. Purge gas line.
- M. Inspect and adjust vibration isolators and seismic restraints.
- N. Verify bearing lubrication.
- O. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
- P. Adjust fan belts to proper alignment and tension.
- Q. Start unit.
- R. Start refrigeration system when outdoor-air temperature is within normal operating limits.
- S. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
- T. Operate unit for run-in period.
- U. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
 - 1. Measure gas pressure at manifold.
 - 2. Measure combustion-air temperature at inlet to combustion chamber.
 - 3. Measure flue-gas temperature at furnace discharge.
 - 4. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - 5. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
- V. Calibrate thermostats.
- W. Adjust and inspect high-temperature limits.
- X. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
- Y. Start refrigeration system and measure and record the following:
 - 1. Coil leaving-air, dry- and wet-bulb temperatures.
 - 2. Coil entering-air, dry- and wet-bulb temperatures.
 - 3. Outdoor-air, dry-bulb temperature.
 - 4. Outdoor-air-coil, discharge-air, dry-bulb temperature.
- Z. Verify operational sequence of controls.
- AA. Measure and record the following airflows. Plot fan volumes on fan curve.
 - 1. Supply-air volume.
 - 2. Return-air volume.
 - 3. Outdoor-air intake volume.
- BB. Simulate maximum cooling demand and inspect the following:
 - 1. Compressor refrigerant suction and hot-gas pressures.
 - 2. Short circuiting of air through outside coil or from outside coil to outdoor-air intake.
- CC. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

IAH ARF 92	23 7420 - 6	Packaged, Outdoor, Heating and Cooling Make-up Air-Conditioners
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1. High-limit heat exchanger.
2. Alarms.
 - a. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
 - b. Remove and replace components that do not pass tests and inspections and retest as specified above.
 - c. Prepare written report of the results of startup services.

3.05 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain rooftop replacement-air units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238120

IAH ARF 92	23 7420 - 7	Packaged, Outdoor, Heating and Cooling Make-up Air-Conditioners
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**SECTION 26 0800
COMMISSIONING OF ELECTRICAL SYSTEMS**

PART 1 GENERAL

1.01 WORK OF THIS SECTION

- A. The Cx activities shall follow all requirements as defined in Section 01 91 13 GENERAL COMMISSIONING REQUIREMENTS.
- B. The section below describes unique Cx activities to the Electrical Systems and the electrical portions of the mechanical systems.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

- A. Provide all necessary test equipment to confirm proper operation of the Electrical Systems.
- B. All testing equipment shall be properly calibrated, and documentation of such calibration shall be submitted prior to any verification testing.
- C. Division 26 subcontractor shall provide full capacity Load Banks for Uninterruptible Power Supply (UPS) Systems functional testing. Full capacity Load Banks may be required during separate testing periods (two or more) depending on construction completion and equipment readiness for testing. Provide full capacity inductive/resistive Load Banks for a minimum of one week for commissioning functional testing to allow for potential weather events delaying testing.

PART 3 EXECUTION

3.01 PARTICIPATION IN CX

- A. The Division 26 subcontractor shall take the lead in Cx of the following Electrical Systems:
 - 1. Lighting Control Systems
 - 2. Energy Power Monitoring System
 - 3. Switchgear
 - 4. Motor Control Centers
 - 5. Transformers
- B. The Division 26 subcontractor and Lighting Control System Vendor/Authorized Manufacturer Representative shall demonstrate complete operation of Lighting Control Systems indicated separate from and in addition to any other required Owner Demonstrations or Owner Training (i.e., Lighting Control System Vendor/Authorized Manufacturer Representative shall include separate site visit trips for Cx functional testing and lighting level measurements).
- C. Division 26 subcontractor shall fully support after-hours (night-time) testing such as "black-site" testing as directed by the Prime Constructor under the supervision of the CxA. Additional afterhours testing may be required if initial tests fail to pass.
- D. Coordinate with the Division 23 and BAS subcontractors for performing and documenting pre-functional checks for each of the equipment items in the scope for Cx.
- E. Division 26 subcontractor and the Division 23 BAS subcontractor are responsible for completing Point-to-Point testing, pre-functional testing, pre-verification testing and functional testing of the BAS interface to the specified Electrical Systems.
- F. Coordinate with the Division 28 Fire Alarm System subcontractors for performing and documenting pre-functional checks for each of the equipment items in the scope for Cx.
- G. Coordinate with the Division 28 Access Control and Video Surveillance subcontractors for performing and documenting pre-functional checks for each of the equipment items in the scope for Cx.

3.02 DISTRIBUTION OF TREND DATA

- A. Trend data from the BAS will be utilized in the Cx activities. Contractor shall provide at least 1 full week of trend data to the Cx Team no later than 1 week before scheduling the functional

IAH ARFF 92	26 0800 - 1	COMMISSIONING OF ELECTRICAL SYSTEMS
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performance testing. The Cx Team will analyze the trend data from the equipment and systems to be tested as part of the determination whether the testing can be scheduled.

- B. Trend data shall be recorded at intervals no greater than 15 minutes. The trend data from each field controller shall be polled and stored in a central location with capability of archiving the collected trend data for no less than 3 months of storage. The BAS shall be capable of automated distribution of the trend data configured for no greater than weekly updates of the previous interval of data. Change of Value (COV) trending is not preferred and shall only be acceptable for status or binary command points.
- C. Trend data shall be saved in a non-proprietary format such as csv or txt with consistent organization of the data to include at a minimum the timestamp, BAS system trend name, value and units. Trend reports shall contain both data represented in tabular format as well as line charting.
- D. Required trends by equipment type:
 - 1. Energy Power Monitoring System
 - a. kW
 - b. Voltage
 - c. Amps
 - d. Hz
 - e. Any other points required to be monitored by the BAS
 - 2. Exterior Lighting Photovoltaic System
 - a. kW
 - b. Voltage
 - c. Amps
 - d. Hz
 - e. Any other points required to be monitored by the BAS

3.03 PRE-FUNCTIONAL TEST FORMS

- A. After the initial equipment submittal phase, the CxA shall prepare the pre-functional test forms for each item of equipment as part of the Cx. Review respective pre-functional test forms for accuracy and completeness and provide comments to the General Contractor and CxA.
- B. The following is a sample prefunctional test form:

CHK-1: Automatic Transfer Switch (ATS)

Test Type: **Pre-Functional Testing**

Unit #	Automatic Transfer Switch (ATS)
Discipline	

Equipment Verification			
Equipment / Component	Approved Submittal Data	Installed As Submitted?	Installed Data
Manufacturer			
Model number			
Serial number			
Operating voltage			
Current rating			
Ampacity			
Neutral Configuration			
Transition Type			
Priority			
Close and Withstand Rating			
Software version			

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Questionnaire			
#	Question	Answer	Details
Installation			
1	Bypass/ isolation switch is installed	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____
2	Equipment interiors are complete and clean	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____
3	Equipment is secured to concrete housekeeping pad	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____
4	Working clearance: 277/480V - 42" to grounded surface; 48" to exposed live parts	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____
5	Switch provided with test switch to simulate failure of normal source	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____
6	Switch provided with pilot lights to indicate normal and emergency position of transfer switch	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____
7	Switch provided with pilot lights to indicate availability of normal and emergency sources	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____
8	Switch provided with terminal blocks labeling all external connections	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____
9	Transfer switch provided with transfer override switch to cause switch to remain connected to emergency source regardless of condition of normal source	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____
10	Transfer switch provided with a retransfer switch to bypass retransfer time delay	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	_____ Electrical Contractor _____

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#	Question	Answer	Details
11	Remote annunciation is provided and wired to the transfer switch (annunciator panel, BAS)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	 Elevator Contractor _____
Instrumentation			
1	Verify metering provided as specified	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
2	Display and control unit are mounted flush or semiflush in instrument compartment door	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Electrical Contractor _____
Identification			
1	Verify label installed as specified	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Commissioning Authority _____
2	Bypass/isolation operating instructions are provided on the front of the unit	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Commissioning Authority _____
3	Verify additional labeling is complete	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Commissioning Authority _____
4	Verify conductors are properly color coded	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	Commissioning Authority _____

END TEST

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3.04 FUNCTIONAL TEST FORMS

- A. After the finalization of the pre-functional test forms, the CxA shall prepare the functional test forms for each system to be documented as part of the Cx. Review respective functional test forms for accuracy and completeness and provide comments to the General Contractor and CxA.
- B. The following is a sample functional test form:

FPT-1: Automatic Transfer Switch (ATS)

Test Type: **Functional Performance Testing**

Unit #	Automatic Transfer Switch (ATS)
Discipline	

Questionnaire			
#	Question	Answer	Details
Auto Start			
1	PROCEDURE: Open the normal power breaker serving the ATS	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	VERIFY by visual response that:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
3	ATS LED "Normal Power Available" indicator is off.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	Time delay (2 seconds) occurs prior to start signal being sent to generator system	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	The generator receives start signal following time delay to verify loss of utility power.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	Generator is up to speed and voltage within (~6) seconds of receipt of start signal.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	ATS LED indicates "Emergency Power Available".	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
8	ATS does not transfer to emergency power due to presence of time delay inhibit signal (5 seconds).	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

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#	Question	Answer	Details
9	ATS transfers to neutral position for scheduled delay per 263623.2.2.N.2	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
10	At conclusion of time delay, ATS transfers to the emergency source.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Bypass			
1	TEST PROCEDURE: Place transfer switch in bypass(E)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	EXPECTED RESPONSE: Switch bypasses to the emergency source.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	EXPECTED RESPONSE: Bypass is a closed transition process	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Isolate from Emergency Bypass			
1	TEST PROCEDURE: Move isolation handle to "Isolate"	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	EXPECTED RESPONSE: Transfer switch base is released (for inspection, maintenance, etc.)	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	EXPECTED RESPONSE: Switch base is capable of being replaced into ATS and taken out of Bypass	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Auto Stop			
1	PROCEDURE: Close the normal power breaker serving the ATS.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	The ATS indicates normal power is available.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	Time delay begins to verify stability of normal power (These time delays for Priority 2 ATS's are staggered to provide delays between loads adding from generators to utility - See 263623.2.2.N.2).	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	At end of time delay, ATS transfers to neutral position for scheduled delay per 263623.2.2.N.2	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	At conclusion of time delay, ATS transfers load to normal power	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	ATS indicates both normal and emergency power available.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	The generator begins cool down cycle.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
8	The generator automatically stops.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
9	ATS LED "Emergency Power Available" indicator off.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

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#	Question	Answer	Details
Bypass (Normal)			
1	TEST PROCEDURE: Place transfer switch in bypass(N)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	EXPECTED RESPONSE: Switch bypasses to the normal source.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	EXPECTED RESPONSE: Switch base is capable of being replaced into ATS and taken out of Bypass	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Test Start			
1	Prior to generator shutdown, Test Start is initiated.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	PROCEDURE: Activate test switch in face of ATS.	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
3	VERIFY by visual response that:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
4	ATS initiates start signal to generator.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	Generator is up to speed and voltage within (~6) seconds of receipt of start signal.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	The ATS verifies synchronization of normal and emergency sources and transfers the load to emergency power (momentary closed transition).	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	The ATS indicates that both normal and emergency power are available.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
Test Stop			
1	PROCEDURE: Restore test switch to normal in face of ATS, if applicable	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
2	VERIFY by visual response that:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A	
3	Time delay begins to verify stability of normal power.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	At conclusion of time delay, ATS verifies synchronization of normal and emergency sources and transfers load to normal power (momentary closed transition).	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	ATS indicates both normal and emergency power available.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
6	The generator goes begins cool down cycle.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
7	The generator automatically stops	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
8	ATS LED "Emergency Power Available" indicator off.	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

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#	Question	Answer	Details
Metering Communication			
The following metered data shall be communicated to the BMCS System:			
1	Phase to neutral voltages	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	Phase currents	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	Power Factor	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	Peak KW Demand	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
The following ATS status parameters are communicated to the BMCS System:			
1	Generator status	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
2	ATS Switch Position / Source Connection Status	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
3	Source 1 Status	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
4	Source 2 Status	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	
5	ATS Alarm	<input type="checkbox"/> Pass <input type="checkbox"/> Fail <input type="checkbox"/> N/A	

END TEST

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END OF SECTION