ADDENDUM # 001

DATE: January 15, 2020

PROJECT: University of Missouri Women’s and Children’s Hospital
          AHU 4 and AHU-11 Upgrade
          IMEG # 18004255.00

BID DUE DATE: January 21, 2020

ARCHITECT: IMEG Corp.
            15 Sunnen Drive, Suite 104
            St. Louis, Missouri 63143
            Phone: 314-645-1132
            Fax: 314-645-1132

TO: All Contract Document Holders of Record.

This Addendum forms a part of the bidding and construction documents. This Addendum supersedes and
supplements all portions of the original bidding and construction documents dated December 12, 2019
with which it conflicts. Please attach this Addendum to the Project Manual(s) in your possession.

ACKNOWLEDGE RECEIPT OF THIS ADDENDUM IN THE SPACE PROVIDED ON THE BID FORM.
FAILURE TO DO SO MAY SUBJECT BIDDER TO DISQUALIFICATION.

A. PROCUREMENT AND CONTRACTING REQUIREMENTS
   1. Division 1 - General Requirements
      a. Section 1.A - Bid for Lump Sum Contract: REVISE bid submittal address to read
         “Room L100, General Services Building, University of Missouri”.
      b. Section 1.A.3.c - Unit Prices: DELETE paragraph in its entirety.
      c. Section 1.A.3.d - Allowance: REVISE to read: “Bidder shall include in the base
         bid sum an allowance of $10,000 for patching and repairing any damaged fire
         proofing of the structural steel that is in the ceiling space above the kitchen. This
         allowance amount shall not include contractor’s overhead and profit. The
         Contractor shall include overhead and profit on the allowance amount in his bid.
      d. Section 1.A.6.a - Supplier Diversity Goals: REVISE to read “The Contractor shall
         have as a goal subcontracting with Minority Business Enterprise (MBE) of ten
         percent (10%) with Service Disabled Veteran Owned Business (SDVE) of three
         percent (3%), and with Women Business Enterprise (WBE), Disadvantage
         Business Enterprise (DBE), and/or Veteran Owned Business of ten percent
         (10%) of awarded contract price for work to be performed.”
B. SPECIFICATIONS

1. Section 23 05 48 - HVAC Vibration Isolation: ADD Paragraph 2.2.B - Mountings, Type M3 as follows:

   B. Type M3:
   1. Free standing, laterally stable spring isolators without housings and complete with 1/4" neoprene friction pads.
   2. Units shall have bolt holes but need not be bolted down unless called for or needed to prevent movement. If bolted down, prevent short circuiting with neoprene bushings and washers between bolts and isolators. Bolt holes shall not be within the springs.
   3. All mountings shall have leveling bolts.

2. Section 23 31 00 - Ductwork:
   a. DELETE Paragraph 2.5 - Rectangular Duct - Closed Cell Rigid Panel (For Exposed Duct on Roof Only)
   b. ADD new Paragraph 2.5 Rectangular Duct - Double Wall (For All Exterior Ductwork) as follows:

   2.5 Rectangular Duct - Double Wall (For All Exterior Ductwork)
   A. All applicable portions of Rectangular Duct – Single Wall shall apply.
   B. Furnish and install double-wall insulated airtight duct as shown on the drawings.

   C. Duct Construction:
   1. Galvanized steel exterior wall with solid galvanized steel interior wall.
   2. Rectangular double wall duct shall be suitable for pressures listed in the ductwork application schedule.
   3. All ductwork gauges and reinforcement shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space-consuming reinforcement.
   4. Ducts shall 2” thick and completely metal enclosed with annular space completely filled with 1-1/2# density glass fiber insulation. Insulation shall have flame spread/smoke developed ratings of less than 25/50 per ASTM E84, NFPA 255, or UL 723.
   5. Divided flow fittings may be separate fittings or factory installed taps with the following construction requirements:
      a. Airtight, continuous welds at intersection of fitting body and tap.
      b. Tap liner spot welded to inner liner with weld spacing not over 3".
      c. Insulation packed around the tap area for complete cavity filling.
      d. Carefully fit branch connections to cut-out openings in inner liner without spaces for air erosion of insulation or sharp projections for noise and airflow disturbance.
6. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.

7. Support inner liner of ducts and fittings with metal spacers welded to maintain spacing and concentricity.

8. Formed-on flanged transverse joint systems are acceptable if they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.
   a. Apply sealant to all inside corners. Holes at corners are not acceptable.
   b. Flanges shall be 24-gauge minimum (not 26 gauge).
   c. Acceptable Manufacturers: Lockformer TDC, TDF, United McGill, or Sheet Metal Connectors. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer’s approval before any fabrication begins.
   c. REVISE Ductwork Application Schedule as follows (in bold):

<table>
<thead>
<tr>
<th>USAGE</th>
<th>MATERIAL</th>
<th>PRESSURE CLASS</th>
<th>SEAL CLASS†</th>
<th>INSULATION (Refer to Section 23 07 13 for insulation types)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior Supply Duct from Fan to</td>
<td>Galvanized Sheet Metal</td>
<td>+3&quot;</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Terminal Air Boxes – Double Wall</td>
<td>Rectangular</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Exterior Supply Duct from Fan to</td>
<td>Galvanized Sheet Metal</td>
<td>+3&quot;</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Terminal Air Boxes – Single Wall with</td>
<td>Rectangular</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Aluminum Jacket</td>
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<td></td>
</tr>
<tr>
<td>Exterior Return Duct - Double Wall</td>
<td>Galvanized Sheet Metal</td>
<td>-2”</td>
<td>A</td>
<td></td>
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<tr>
<td></td>
<td>Rectangular</td>
<td></td>
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</tbody>
</table>

C. ACCEPTABLE MANUFACTURERS
The following manufacturers are approved for this project, provided the materials and systems meet the requirements of these Contract Documents. This approval does not waive any requirements or conditions of the Contract Documents for any material, system or manufacturer.

<table>
<thead>
<tr>
<th>Section No.</th>
<th>Product</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 36 00</td>
<td>Air Terminal Units</td>
<td>Siemens</td>
</tr>
</tbody>
</table>

D. DRAWINGS
1. Drawing A-101 – LEVEL 01 – ARCHITECTURAL – PHASE 1: **EXTEND** crosshatch to wall between Kitchen 1084 and Elec 1084A.
2. Drawing A-101.1 – LEVEL 01 – ARCHITECTURAL – INFECTION CONTROL
   a. DELETE northernmost rigid infection control barrier and associated note.
   b. ADD rigid infection control barriers at wall between Elec 1084A and Kitchen 1084 and at wall between Dishwash Room 1083 and Kitchen 1084.
   c. ADD work platform/tunnel at north end of Kitchen.
   d. ADD flexible barriers at north double doors from Kitchen 1084 to Corridor 1080.
   e. ADD rigid infection control barrier west of south double doors from Kitchen 1084 to Corridor 1080.
   f. ADD notes describing when each of the NEW rigid infection control barriers should be constructed and in use.
   g. ADD numbers preceding all notes indicating the order in which barriers are to be constructed.

3. Drawing A-101.2 – LEVEL 01 – ARCHITECTURAL – ALTERNATE 1
   a. EXTEND 2’x’2 lay in grid ceiling to north wall between Elec 1084A and Kitchen 1084.
   b. MOVE one reference to Detail 8/A-501.
   c. ADD one reference to Detail 8/A-501 to new northern edges of grid ceiling.

   a. EXTEND 2’x’2 lay in grid ceiling to north wall between Elec 1084A and Kitchen 1084.
   b. MOVE one reference to Detail 8/A-501.
   c. ADD one reference to Detail 8/A-501 to new northern edges of grid ceiling.


7. Drawing M-000 - MECHANICAL COVER SHEET: REVISE mechanical phasing notes.

8. Drawing MD-101A.1- LEVEL 01 - MECHANICAL DEMOLITION - AHU4 - PHASE 1
   a. REVISE note regarding dish room area.
   b. ADD general note regarding negative pressure within the construction area.


10. Drawing M-102A.1 - ROOF - MECHANICAL - AHU4 - PHASE 1
    a. REVISE routing of return and outside air duct.
    b. REVISE existing conditions on the roof.

11. Drawing M-102B.1 - LEVEL 02 - MECHANICAL - AHU11 - PHASE 1
    a. REVISE routing and roof penetrations for AHU 11 temporary unit ductwork.
    b. ADD notes clarifying ductwork routing.
    c. ADD existing ductwork.

12. Drawing M-102B.3 - LEVEL 02 - MECHANICAL - AHU11 - PHASE 3
    a. REVISE routing of supply air duct work.
    b. REVISE routing of return air duct work.
    c. ADD notes clarifying ductwork routing.
13. Drawing M-103B.1 - ROOF - MECHANICAL - AHU11 - PHASE 1
   a. REVISE temporary ductwork routing.
   b. ADD note clarifying temporary ductwork construction.

14. Drawing M-600 - MECHANICAL SECTION DIAGRAMS
   a. REVISE AHU-4 sections.
   b. REVISE AHU-11 duct and piping section diagram.

15. Drawing M-601 - MECHANICAL SCHEDULE
   a. REVISE split system unit schedule.
   b. REVISE AHU 4 pump voltage.
   c. REVISE louver schedule.
   d. REVISE AHU Schedule
   e. ADD motor operated damper schedule

16. Drawing MP-103B.1 - ROOF - MECHANICAL PIPING - AHU11 - PHASE 1: REVISE routing of hydronic piping


18. Drawing E-101A.1 - LEVEL 01 - ELECTRICAL - AHU4
   a. ADD electrical receptacle for spot cooler and keynote #8.
   b. ADD keynote #7.
   c. ADD label for existing 208/120V kitchen panel.
   d. ADD label for plate warmer receptacle.


20. Drawing E-101.1 - LEVEL 01 - ELECTRICAL - AHU11 - PHASE 1
   a. DELETE existing Panel ‘KP’ and keynote #4.
   b. REVISE keynote #1.

E. REQUEST FOR INFORMATION
1. What is the scope of the duct cleaning for this project?
   Response: There will be no duct cleaning for existing ductwork. All new ductwork to follow duct handling requirements.

2. Will there be an exploratory demolition above the kitchen ceiling to determine the ceiling to roof assembly to included paint product, insulation type, and structural assembly, or are there As-built drawings that would provide this information?
   Response: Please refer to Appendix A for pictures regarding a previous project that installed an air handling unit.

3. Was environmental testing performed on the areas of disturbance for this project?
   Response: No testing was performed. Report any suspect materials to Owners Rep for testing.

4. The specifications do not appear to require a job trailer on this project, is that correct? Is there an area onsite that could be utilized for a construction office?
   Response: Owners representative will supply construction office location.
5. Will a dumpster location be provided in the loading dock area, or will the dumpsters be required to be located at the Contractor Staging and Parking Lot?
   Response: Owners representative will coordinate location for dumpster.

6. Would it be acceptable to wrap the hood with a flexible barrier rather than constructing a rigid barrier around the hood? This would allow for ceiling drywall work to take place against the hood, which will be required whether or not the alternates are accepted.
   Response: A flexible barrier will be acceptable as long as it is sealed effectively.

7. What type of Isolator will be used on the relief fan for AHU 11?
   Response: Refer to the revised Section 23 05 48 HVAC vibration Isolation specification.

END OF ADDENDUM #001

REE: ELP/sdb

Enclosures
PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bases.
B. Vibration Isolation.
C. Flexible Connectors.

1.2 SUBMITTALS

A. Submit shop drawings per Division 1 and the Vibration Isolation Submittal Form at the end of this section.
B. Vibration isolation submittals may be included with equipment being isolated, but must comply with this section.
C. Base submittals shall include equipment served, construction, coatings, weights, and dimensions.
D. Isolator submittals shall include:
   1. Equipment served
   2. Type of Isolator
   3. Load in Pounds per Isolator
   4. Recommended Maximum Load for Isolator
   5. Spring Constants of Isolators (for Spring Isolators)
   6. Load vs. Deflection Curves (for Neoprene Isolators)
   7. Specified Deflection
   8. Deflection to Solid (at least 150% of calculated deflection)
   9. Loaded (Operating) Deflection
  10. Free Height
  11. Loaded Height
  12. Kx/Ky (horizontal to vertical stiffness ratio – for spring isolators)
  13. Materials and Coatings
  14. Spring Diameters
E. Make separate calculations for each isolator on equipment where the load is not equally distributed.
F. Flexible connector shop drawings shall include overall face-to-face length and all specified properties.
G. Submit certification that equipment, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

   1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 BASIC CONSTRUCTION AND REQUIREMENT

A. Vibration isolation for this project is subject to seismic restraint requirements of Section 23 05 50.

B. Vibration isolators shall have either known undeflected heights or other markings so deflection under load can be verified.

C. All isolators shall operate in the linear portion of their load versus deflection curve. The linear portion of the deflection curve of all spring isolators shall extend 50% beyond the calculated operating deflection [e.g., 3" for 2" calculated deflection]. The point of 50% additional deflection shall not exceed the recommended load rating of the isolator.

D. The lateral to vertical stiffness ratio (Kx/Ky) of spring isolators shall be between 0.8 and 2.0.

E. All neoprene shall have UV resistance sufficient for 20 years of outdoor service.

F. All isolators shall be designed or treated for corrosion resistance. Steel bases shall be cleaned of welding slag and primed for interior use, and hot dip galvanized after fabrication for exterior use. All bolts and washers over 3/8" diameter located outdoors shall be hot dip galvanized per ASTM A153. All other bolts, nuts and washers shall be zinc electroplated. All ferrous portions of isolators, other than springs, for exterior use shall be hot dip galvanized after fabrication. Outdoor springs shall be neoprene dipped or hot dip galvanized. All damage to coatings shall be field repaired with two coats of zinc rich coating.

G. Equip all mountings used with structural steel bases with height-saving brackets. Bottoms of the brackets shall be 1-1/2" to 2-1/2" above the floor or housekeeping pad, unless shown otherwise on the drawings. Steel bases shall have at least four points of support.

H. Provide motor slide rails for belt-driven equipment per Section 23 05 13.

I. All isolators, except M1, shall have provision for leveling.

2.2 MOUNTINGS

A. Type M2:

1. Double deflection neoprene with minimum static deflection of 0.15" at calculated load and 0.35" at maximum rated load.

2. All metal shall be neoprene covered. Mounting shall have friction pads both top and bottom.

3. All units shall have bolt holes and be bolted down.
4. Use steel rails above the mountings to compensate for the overhang of equipment such as small vent sets and close coupled pumps.


B. Type M3: (2020.02.15 ADD_001)

1. Free standing, laterally stable spring isolators without housings and complete with 1/4" neoprene friction pads.

2. Units shall have bolt holes but need not be bolted down unless called for or needed to prevent movement. If bolted down, prevent short circuiting with neoprene bushings and washers between bolts and isolators. Bolt holes shall not be within the springs.

3. All mountings shall have leveling bolts.


2.3 THRUST RESTRAINTS

A. Type TR1:

1. Horizontal thrust restraints shall consist of spring elements in neoprene cups with grommets to prevent short circuiting hanger rods and nuts and washers for pre-compression.

2. Select springs for deflection of 0.75" to 1.50" at maximum calculated thrust. Springs shall be field adjusted for 1/2" movement. Spring constant may not exceed 50% of the vertical stiffness of the mounts (M3, etc.).

3. Centrifugal fans shall incline slightly forward when off and discharge directly in line with the ductwork at maximum static pressure.

4. Fabricate structural supports as needed to attach thrust restraints.

5. If connected to a housing, check maximum thrust the housing can restrain and connections required.


2.4 HANGERS

A. Type H1:

1. Vibration hangers shall consist of a double-deflection neoprene element with a projecting bushing or oversized opening to prevent steel-to-steel contact.

2. Static deflection shall be at least 0.15" at calculated load and 0.35" at maximum rated load.

3. Provide hangers with end connections as required for hanging ductwork or piping.

B. Type H2:

1. Vibration hangers shall contain a steel spring in a neoprene cup with a grommet to prevent short circuiting the hanger rod.

2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.

3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30º arc before contacting the grommet and short circuiting the spring.

4. Provide end connections for hanging ductwork or piping.


2.5 BASES

A. Type B1:

1. Rectangular structural steel bases.

2. All perimeter members shall be beams or channels with minimum depth of 10% of the longest base dimension or 14" maximum if rigidity is acceptable to the equipment manufacturer.

3. Use height saving brackets, unless noted otherwise.


2.6 FLEXIBLE CONNECTORS (NOISE AND VIBRATION ELIMINATORS)

A. Type FC1:

1. Spherical flexible connectors with multiple plies of nylon tire cord fabric and either EPDM or molded and cured neoprene. Outdoor units shall be EPDM.

2. Steel aircraft cables or threaded steel rods shall be used to prevent excess elongation.

3. All straight through connections shall be made with twin-spheres properly pre-extended as recommended by the manufacturer.

4. Connectors up to 2" size may have threaded ends.

5. Connectors 2-1/2" and over shall have floating steel flanges recessed to lock raised face neoprene flanges.

6. All connectors shall be rated for a minimum working pressure of 150 psi at 200°F.
7. Acceptable Manufacturer: Metraflex "Double Cable-Sphere", Minnesota Flex Corp., Mercer "200 Series", Twin City Hose "MS2".

B. Type FC2:

1. Stainless steel flexible connectors with corrugated stainless steel hose body and stainless steel braided casing.
2. Rated for minimum working pressures of 150 psi at 70°F and 100 psi at 800°F.
3. Sizes 2” and under shall have steel threaded connections.
4. Sizes 2-1/2” and over shall have 150 lb. steel flanges.
5. Suitable for 1/2” permanent misalignment.

2.7 VIBRATION ISOLATION CURBS

A. Spring Isolated Curbs:

1. Provide factory fabricated vibration isolated curb consisting of an upper floating section resting on a rigid rectangular steel tube structure containing adjustable steel vibration isolation springs.
2. The top of the curb shall be a minimum of 20” above the roof surface.
3. Vibration Isolation:
   a. Isolators shall consist of free standing, unhoused laterally stable steel springs.
   b. Springs shall be zinc electroplated.
   c. Springs shall rest on a minimum of 1/4” neoprene pad.
   d. Springs shall provide a minimum of 1-1/2” deflection calculated based on final assembled loads.
4. Provide continuous wood nailing strip and counter flashing along entire perimeter of the curb.
5. Provide continuous air and water seal, such as an EPDM bellows, around the entire curb.
6. Curb assembly shall withstand 125#/sf lateral wind loading against the supported equipment.
7. The curb shall be designed with lateral restraint to meet seismic requirements specified in Section 23 05 50.
8. Coordinate internal structural cross framing with ductwork and piping routed in the curb.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install all products per manufacturer’s recommendations.

B. Provide vibration isolation as indicated on the drawings and as described herein.

C. Clean the surface below all mountings that are not bolted down and apply adhesive cement equal to Mason Type WG between mounting and floor. If movement occurs, bolt mountings down. Isolate bolts from baseplates with neoprene washers and bushings.

D. All static deflections listed in the drawings and specifications are the minimum acceptable actual deflection of the isolator under the weight of the installed equipment - not the maximum rated deflection of the isolator.

E. Support equipment to be mounted on structural steel frames with isolators under the frames or under brackets welded to the frames. Where frames are not needed, fasten isolators directly to the equipment.

F. Where a specific quantity of hangers is noted in these specifications, it shall mean hanger pairs for support points that require multiple hangers, such as rectangular ducts or pipes supported on a strut rack.

3.2 PIPE ISOLATION

A. The first three hangers from vibration-isolated equipment shall be type H1.

B. For base mounted pumps without resilient mountings, the first five hangers shall be Type H1.

C. Where piping is floor-supported, use M2 instead of H1 and M3 instead of H2.

D. Install flexible connectors in all piping connected to vibration producing equipment. This includes all fans, base-mounted pumps, compressors, etc. Absence of flexible connectors on piping diagrams does not imply that they are not required.

E. Use Type FC1 where pressures are lower than 150 psi, temperatures are below 220°F, and the fluid handled is compatible with neoprene and EPDM.

F. Use Type FC2 for all other services. FC2 shall be installed parallel with equipment shafts.

G. Provide sufficient piping flexibility for vibrating refrigerant equipment or furnish flexible connectors with appropriate temperature and pressure ratings.

H. Vibration isolators shall not cause any change in position of piping that will result in stresses in connections or misalignment of shafts or bearings. Equipment and piping shall be maintained in a rigid position during installation. Do not transfer load to the isolators until the installation is complete and under full operational load. Hanger H3 and Mounting M4 may be used instead of other products for this purpose.

I. Support piping to prevent extension of flexible connectors.
3.3 VIBRATION ISOLATION OF DUCTWORK

A. The first three hangers on all fan systems shall be Type H1 with at least 0.20" minimum static deflection.

B. Provide flexible duct connections as described in Section 23 33 00 at all fan inlets and outlets and on the mechanical room side of all locations where ducts penetrate mechanical room walls.

3.4 VIBRATION ISOLATION SCHEDULE

<table>
<thead>
<tr>
<th>EQUIPMENT DESIGNATION</th>
<th>BASE TYPE</th>
<th>ISOLATOR TYPE</th>
<th>STATIC DEFLECTION</th>
<th>FLEXIBLE CONNECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief Fan</td>
<td>NA</td>
<td>M3 or H2 or H3</td>
<td>0.75&quot; 4.5&quot;</td>
<td>NA</td>
</tr>
<tr>
<td>(2020.02.15 ADD_001)</td>
<td>B1</td>
<td>H3</td>
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</tbody>
</table>

Note 1: AHU internal fan isolation shall be determined by AHU manufacturer. Isolation selected shall be a minimum of 98% efficient at scheduled CFM and static pressure.

END OF SECTION
<table>
<thead>
<tr>
<th>COLUMN 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<th>10</th>
<th>11</th>
<th>12</th>
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<tbody>
<tr>
<td>ITEM SERVED</td>
<td>MIN DEFL (&quot;)</td>
<td>TAG</td>
<td>MODEL</td>
<td>MAX LOAD (#)</td>
<td>DEFL @ MAX LOAD (&quot;)</td>
<td>DEFL TO SOLID (&quot;)</td>
<td>FREE HT (&quot;)</td>
<td>Kx/Ky</td>
<td>LOAD (#)</td>
<td>DEFL (&quot;)</td>
<td>DEFL RATIO</td>
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<td>COLUMN NOTES: Note numbers correspond to the column numbers above.</td>
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<tr>
<td>1. Item served should match designation on the design drawings.</td>
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<td>2. List the deflection scheduled or specified in the design documents.</td>
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<td>3. List the designation for this isolator. This is most useful when one item has multiple different isolators to support its weight.</td>
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<td>4. List the manufacturer's complete model designation for the isolator.</td>
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<td>5. List the manufacturer's maximum rated load for the isolator.</td>
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<td>6. List the isolator deflection at the maximum rated load in column 5.</td>
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<td>7. For spring isolators list the deflection when the springs are solid. This is not normally the same entry as in column 6.</td>
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<td>8. List the height of the isolator when unloaded. Shop drawings must show where this is measured.</td>
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<td>9. List the rated horizontal to vertical stiffness ratio. This must be between 0.8 and 2.0.</td>
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<tr>
<td>10. List the calculated equipment load on each isolator. For items with unequal weight distribution, calculate each isolator separately.</td>
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<tr>
<td>11. List the calculated deflection under the calculated load. For springs this will be column 10*(column 6 / column 5).</td>
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<td>12. List the answer from dividing column 7 by column 11. This must be at least 1.5. If not, select an isolator with more nominal deflection.</td>
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<tr>
<td>GENERAL NOTES:</td>
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<tr>
<td>1. When submitting hangers or supports for a weight range, fill in two rows - one for the maximum and one for the minimum weight.</td>
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</tbody>
</table>
PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ductwork Reinforcement
B. Ductwork Sealants
C. Rectangular Ductwork
D. Round and Flat Oval Ductwork
E. Exposed Ductwork (Rectangular, Round, or Oval)
F. Flexible Duct
G. Acoustical Lagging
H. Leakage Testing
I. Ductwork Penetrations
J. Duct Cleaning

1.2 DEFINITIONS

A. Duct Sizes shown on drawings are inside clear dimensions. Maintain clear dimensions inside any lining.

B. Transitions are generally not shown in single-line ductwork. Where sizes change at a divided flow fitting, the larger size shall continue through the fitting.

1.3 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required duct systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

B. Duct drawings shall be at 1/4” minimum scale complete with the following information:

1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.

2. Differentiate ducts that are lined or wrapped. Include insulation thickness, type of insulation, and acoustical lagging.

3. Location and size of all duct access doors.

4. Room names and numbers, ceiling types, and ceiling heights.

5. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.

C. IMEG will provide electronic file copies of ventilation drawings for contractor’s use if the contractor signs and returns an “Electronic File Transfer” waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings. Architectural plans will need to be obtained from the Architect.
PART 2 - PRODUCTS

2.1 GALVANIZED DUCTWORK

A. General Requirements:

1. Duct and reinforcement materials shall conform to ASTM A653 and A924.

2. Interior Ductwork and reinforcements: G60 galvanized (0.60 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise.

3. Exterior Ductwork: G90 galvanized (0.90 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise. G60 is not acceptable for exterior use.

4. Ductwork reinforcement shall be of galvanized steel.

5. Ductwork supports shall be of galvanized or painted steel.

6. Strap hanger shall be a minimum of 1 inch, 18 gauge galvanized steel attached to the bottom of ducts with spacing as required by SMACNA.

7. Aircraft cable and slip cable hangers are acceptable for ducts up to 18”ø. Protective sleeve tubing shall be used on the cable when supporting duct with exterior insulation. Corner saddles are required when supporting rectangular ductwork. Acceptable manufacturers are Gripple, Ductmate, Duro Dyne, or Architect/Engineer approved.

8. All fasteners shall be galvanized or cadmium plated.

2.2 DUCTWORK REINFORCEMENT

A. General Requirements:

1. All reinforcement shall be external to the duct except that tie rods may be used with the following limitations.

   a. Ducts must be over 18" wide.

   b. Duct dimensions must be increased 2” in one dimension (h or w) for each row of tie rods installed.

   c. Tie rods must not exceed 1/2” diameter.

   d. Manufacturer of tie rod system must certify pressure classifications of various arrangements, and this must be in the shop drawings.

2.3 DUCTWORK SEALANTS

A. One-part joint sealers shall be water-based mastic systems that meet the following requirements: maximum 48-hour cure time, service temperature of -20°F to +175°F, resistant to mold, mildew and water, flame spread rating below 25 and smoke-developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes. Mastic used to seal flexible ductwork shall be marked UL 181B-M. Joint sealers for use on exterior weather exposed ductwork shall be rated for -30°F to +175°F and 2000-hour minimum UV resistance per ASTM G-53.
B. Pressure sensitive tape used for sealing ductwork shall be minimum 2.5-inch wide, listed and marked UL 181A-P, having minimum 60 oz/inch peel adhesion to steel, and service temperature range from -20°F to +250°F.

C. Where pressure sensitive tape is called for on drawings and specifications for sealing flexible ductwork, tape shall be minimum 2.5-inch wide, UL 181 B-FX listed, and marked tape having minimum 60 oz/inch peel adhesion to steel and service temperature range from -20°F to +250°F. Acceptable manufacturers include: Venture Tape 1581A, Compac #340, Scotch Foil Tape 3326, Polyken 339.

2.4 RECTANGULAR DUCT - SINGLE WALL

A. General Requirements:

1. All ductwork gauges and reinforcements shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space consuming reinforcement.

2. Transitions shall not exceed the angles in Figure 4-7.

B. Exceptions and modifications to the 2005 HVAC Duct Construction Standards are:

1. All ducts shall be cross-broken or beaded.

2. Snap lock seams are not permitted.

3. Turning vanes shall be used in all 90° mitered elbows, unless clearly noted otherwise on the drawings. Vanes shall be as follows:

a. Type 1:

1) **Description:** Single wall type with 22-gauge (0.029”) or heavier vanes, 3-1/4” blade spacing, and 4” to 4-1/2” radius. Vanes hemmed if recommended by runner manufacturer. Runners shall have extra-long locking tabs. C-value independently tested at below 0.26. EZ Rail II by Sheet Metal Connectors or equal.

2) **Usage:** Limited to 3,000 fpm and vane lengths 36” and under.

b. Type 2:

1) **Description:** Double wall type with 3-1/4” blade spacing, 4-1/2” radius, 24-gauge minimum, and SMACNA Type 1 runners. C-value below 0.27.

2) **Usage:** No limits other than imposed by the manufacturer. Provide intermediate support for vanes over 48” long.

c. Type 3 (acoustical - where acoustical lagging is located or as noted on drawings):

1) **Description:** Same as Type 2, except filled with fiberglass and with slotted or perforated inner curve. Minimum insertion loss of 9 dB at 250 Hz and 6 dB at 1 KHz.
2) **Usage:** No limits other than imposed by the manufacturer. Provide intermediate support for vanes over 48” long.

d. Turning vanes shall operate quietly. Repair or replace vanes that rattle or flutter.

e. Runners must be installed at a 45° angle. Elbows with different size inlet and outlet must be radius type.

f. Omitting every other vane is prohibited.

4. Where smooth radius rectangular elbows are shown, they shall be constructed per SMACNA Figure 4-2. Type RE1 shall be constructed with a centerline duct radius R/W of 1.0. Where shown on drawings, Type RE3 elbows with 3 vanes shall be used with centerline duct radius R/W of 0.6 (SMACNA r/W=0.1). RE1 or RE3 elbows may be used where mitered elbows are shown if space permits. **Mitered elbows (with or without turning vanes) may not be substituted for radius elbows.** Do not make branch takeoffs within 4 duct diameters on the side of the duct downstream from the inside radius of radius elbows.

5. Rectangular branch and tee connections in ducts over 1” pressure class shall be 45° entry type per Figs. 4-5 and 4-6. Rectangular straight taps are not acceptable above 1” pressure class.

6. Bellmouth fittings shown on return duct inlets shall expand at a 60-degree total angle horizontally and vertically (space permitting) and have length of at least 25% of the smallest duct dimension.

7. Round taps off rectangular unlined ducts shall be flanged conical or bellmouth type (equal to Buckley Bellmouth or Sheet Metal Connectors E-Z Tap), or 45° rectangular with transition to round (equal to Sheet Metal Connectors Inc. High Efficiency Takeoff). Straight taps are acceptable if pressure class is 1” or less, round duct is 12” diameter or less, and the tap is not located between fans and TAB devices.

8. Duct offsets shall be constructed as shown on drawings. Additional offsets required in the field shall be formed of mitered elbows without turning vanes for offsets up to 30° maximum angle in accordance with SMACNA offset Type 2. Offsets of greater than 30° angle shall be formed of radius elbows with centerline radius R/W=1.0 or greater. SMACNA Type 1 offsets are not permitted.

9. Cushion heads are acceptable only downstream of TAB devices in ducts up to ± 2” pressure class and must be less than 6” in length.

10. Slide-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

a. Apply sealant to all inside corners. Holes at corners are not acceptable.

b. **Acceptable Manufacturers:** Ductmate Industries - 25/35/45, Nexus, Mez, or WDCI. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer’s approval before any fabrication begins.
11. Formed-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.
   a. Apply sealant to all inside corners. Holes at corners are not acceptable.
   b. Flanges shall be 24-gauge minimum (not 26 gauge).
   c. Acceptable Manufacturers: Lockformer TDC, TDF, United McGill, or Sheet Metal Connectors. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer’s approval before any fabrication begins.

2.5 RECTANGULAR DUCT – DOUBLE WALL (FOR ALL EXTERIOR DUCTWORK) (2020.01.15 ADD_001)

A. All applicable portions of Rectangular Duct – Single Wall shall apply.

B. Furnish and install double-wall insulated airtight duct as shown on the drawings.

C. Duct Construction:
   1. Galvanized steel exterior wall with solid galvanized steel interior wall.
   2. Rectangular double wall duct shall be suitable for pressures listed in the ductwork application schedule.
   3. All ductwork gauges and reinforcement shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space-consuming reinforcement.
   4. Ducts shall 2" thick and completely metal enclosed with annular space completely filled with 1-1/2# density glass fiber insulation. Insulation shall have flame spread/smoke developed ratings of less than 25/50 per ASTM E84, NFPA 255, or UL 723.
   5. Divided flow fittings may be separate fittings or factory installed taps with the following construction requirements:
      a. Airtight, continuous welds at intersection of fitting body and tap.
      b. Tap liner spot welded to inner liner with weld spacing not over 3".
      c. Insulation packed around the tap area for complete cavity filling.
      d. Carefully fit branch connections to cut-out openings in inner liner without spaces for air erosion of insulation or sharp projections for noise and airflow disturbance.
   6. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.
7. Support inner liner of ducts and fittings with metal spacers welded to maintain spacing and concentricity.

8. Formed-on flanged transverse joint systems are acceptable if they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.
   
   a. Apply sealant to all inside corners. Holes at corners are not acceptable.
   
   b. Flanges shall be 24-gauge minimum (not 26 gauge).
   
   c. Acceptable Manufacturers: Lockformer TDC, TDF, United McGill, or Sheet Metal Connectors. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

2.6 RECTANGULAR DUCT – CLOSED CELL RIGID PANEL (FOR EXPOSED DUCT ON ROOF ONLY) (2020.01.15 ADD_001)

A. Furnish and install ductwork as shown on the drawings.

B. Duct Construction:

   1. Panel shall be manufactured of CFC free closed cell rigid thermoset resin thermally bonded on both sides to a factory applied 0.001” aluminum foil reinforced with fiberglass scrim. Zero permeability water tight barrier. Thermal conductivity shall be no greater than 0.13 BTU.in/Hr.ft°F. Standard panel is 30 mm thickness panel with R-8.1 Continuous rating of 185 degree F inside ducts or ambient temperature surrounding ducts.

   2. All duct liner shall be UL listed. Silicone adhesive (Interior only). UV stable 1000 micron high impact resistant titanium infused vinyl (exterior). Factory manufactured cohesive bonded strips duct connectors. Factory manufactured all aluminum grip flange.

   3. Ducts shall be fully factory manufactured. 90 degree mitered elbows shall have turning vanes. Fabricated duct segments in accordance with manufacturer’s written details. Designed and fabricated duct segments and fittings will be in accordance with SMACNA Duct Construction Standards latest edition. Duct shall be constructed to exceed requirements for snow and wing loads. Supports on straight runs of ductwork shall be positioned at centers not exceeding 13 feet for duct sections when fabricated in 13 foot length with duct girth less than 84”. Larger duct sizes and short segments with duct girth greater than 84” are to be supported at 8 foot centers or less.

   4. Acceptable Manufacturer: Thermaduct or approved equal.

2.7 ROUND AND FLAT OVAL SPIRAL SEAM DUCTWORK - SINGLE WALL

A. Conform to applicable portions of Rectangular Duct Section. Round or flat oval ductwork may be substituted for rectangular ductwork where approved by the Architect/Engineer. The spiral seam ductwork shall meet the standards set forth in this specification. The
ductwork shall meet or exceed the specified cross-sectional area and insulation requirements. The substitution shall be coordinated with all other trades prior to installation.

B. Flat oval duct in negative pressure applications shall have flat sides reinforced as required for rectangular ducts of the same gauge with dimensions equal to the flat span of the oval duct.

C. 90° elbows shall be smooth radius or have a minimum of five sections with mitered joints and R/D of at least 1.5.

D. Duct and fittings shall meet the required minimum gauges listed in chapter 3 of the SMACNA requirements for the specified pressure class. Ribbed and lightweight duct are not permitted.

E. Ductwork shall be suitable for velocities up to 5,000 fpm.

F. Divided flow fittings may be made as separate fittings or factory installed taps with sound, airtight, continuous welds at intersection of fitting body and tap.

G. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.

H. Ducts with minor axis less than 22” shall be spiral seam type. Larger ducts may be rolled, longitudinal welded seam type. SMACNA seams RL-2 and RL-3 are not permitted.

I. Reinforce flat oval ducts with external angles. Internal tie rods are permitted only as indicated for rectangular ductwork.

J. Transverse Joint Connections:
   1. Crimped joints are not permitted.
   2. Ducts and fittings 36” in diameter and smaller shall have slip joint connections. Size fitting ends to slip inside mating duct sections with minimum 2-inch insertion length and a stop bead. Use inside slip couplings for duct-to-duct joints, and outside slip couplings for fitting-to-fitting joints.
   3. Ducts and fittings larger than 36” shall have flanged connections.
   4. Secure all joints with at least 3 sheet metal screws before sealing.
   5. Slide-on flanges as manufactured by Ductmate Industries - SpiralMate, Accuflange, or Sheet Metal Connectors are acceptable. Self-sealing duct systems are also acceptable (Lindab, Ward “Keating Coupling”).

2.8 FLEXIBLE DUCT

A. Flexible duct shall be listed and labeled as UL 181 Class 1 Air Duct Material, and shall comply with NFPA 90A and 90B, and meet GSA, FHA and other U.S. Government agency standards. Flexible duct shall bear the ADC Seal of Certification.

B. Flame Spread/Smoke Developed: Not over 25/50.

C. Flexible duct shall have corrosion-resistant wire helix, bonded to an inner liner that prevents air from contacting the insulation, covered with minimum 1-1/2", 3/4 lb/cf density fiberglass
insulation blanket, sheathed in a vapor barrier of metalized polyester film laminated to glass mesh.

D. Inner liner shall be airtight and suitable for 6" WC static pressure through 10" diameter and shall be airtight and suitable for 4" WC static pressure 12" through 16" diameter. Outer jacket shall act as a vapor barrier only with permeance not over 0.1 perm per ASTM E96, Procedure A. "R" value shall not be less than 4.0 ft²°F/hr/Btu. Temperature range of at least 0-180°F. Maximum velocity of 4,000 fpm.

E. Usage:
   1. Take-offs from supply ducts to inlets of terminal air boxes. Do not exceed 36" in length.
   2. Connections to air inlets and outlets. Do not exceed 6'-0" in length.

F. Stretch all flexible duct to prevent sags and reduce air friction. Shorten and reinstall all sagging or loose flexible duct. Avoid sharp elbows. Elbows shall maintain 1.5 diameter centerline turning radius.

G. Install per the SMACNA Flexible Duct Manual. Secure inner layer with draw band. Wrap with pressure sensitive tape for protection prior to installing draw band. Pressure sensitive tape alone is not acceptable.

2.9 ACOUSTICAL LAGGING

A. Type A: Lagging shall be a loaded vinyl noise barrier, fiberglass scrim facing, and 1" thick quilted fiberglass decoupling layer. Lagging shall have a minimum STC of 28, and Class A flammability (maximum 25/50) rating per ASTM E-84. Install lagging per manufacturer’s recommendations.

B. Type B: Lagging shall be a loaded vinyl noise barrier, fiberglass scrim facing, and 2" thick quilted fiberglass decoupling layer. Lagging shall have a minimum STC of 30, and Class A flammability (maximum 25/50) rating per ASTM E-84. Install lagging per manufacturer’s recommendations.

C. Refer to drawings for acoustical lagging locations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide openings in ducts for thermometers and controllers.

B. Locate ducts with space around equipment for normal operation and maintenance.

C. Do not install ducts or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the electrical equipment. Unless intended to serve these rooms,
do not install any ductwork or equipment in electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms.

D. Provide temporary closures of metal or taped polyethylene on open ducts to prevent dust from entering ductwork. Supply ductwork shall be free of construction debris, and shall comply with Level “C” of the SMACNA Duct Cleanliness for New Construction Guidelines.

E. Repair all duct insulation and liner tears.

F. Install manual volume dampers in branch supply ducts so all outlets can be adjusted. Do not install dampers at air terminal device or in outlets, unless specifically shown.

G. Insulate terminal air box reheat coils. Seal insulation tight to form a tight vapor barrier.

H. Install flexible duct in accordance with the ADC Flexible Duct Performance and Installation Standards.

I. Flexible duct shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required, to include, but not limited to, all connections to air inlets, air outlets, and terminal air boxes.

J. Install all exterior ductwork per SMACNA Fig. 6-3. Where drawings do not indicate otherwise, ductwork seams and joints shall be sealed watertight and pitched to shed water.

K. Support all duct systems in accordance with the SMACNA HVAC Duct Construction Standards: Metal and Flexible and the SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems, where applicable. Refer to Section 23 05 50 for seismic requirements.

L. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by California Building Codes.

M. Adhesives, sealants, tapes, vapor retarders, films, and other supplementary materials added to ducts, plenums, housing panels, silencers, etc. shall have flame spread/smoke developed ratings of under 25/50 per ASTM E84, NFPA 255, or UL 723.

N. All duct support shall extend directly to building structure. Do not support ductwork from pipe hangers unless coordinated with piping contractor prior to installation. Do not allow lighting or ceiling supports to be hung from ductwork or ductwork supports.

O. Kitchen Grease and Dishwasher Ductwork:

1. All kitchen grease and dishwasher ductwork shall be installed with a continuous slope and grease tight welds on all seams and joints.

3.2 DUCTWORK APPLICATION SCHEDULE

<table>
<thead>
<tr>
<th>USAGE</th>
<th>MATERIAL</th>
<th>PRESSURE CLASS</th>
<th>SEAL CLASS</th>
<th>INSULATION</th>
</tr>
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<tbody>
<tr>
<td>Supply Duct from Fan to Terminal Air Boxes — Single Wall</td>
<td>Galvanized Sheet Metal - Rectangular</td>
<td>+3&quot;</td>
<td>A</td>
<td>2&quot; thick Type A (R=6.0) or 2&quot; thick Type C (R=7.1)</td>
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IMEG #18004255.00
UM Women’s and Children’s Hospital
Air Handling Unit Replacement
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<th>USAGE</th>
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<th>PRESSURE CLASS</th>
<th>SEAL CLASS</th>
<th>INSULATION</th>
</tr>
</thead>
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<td>Supply Duct from Fan to Terminal Air Boxes – Single Wall</td>
<td>Galvanized Sheet Metal - Spiral Seam Round</td>
<td>+3&quot;</td>
<td>A</td>
<td>2&quot; thick Type A (R=6.0) or 2&quot; thick Type G (R=7.1)</td>
</tr>
<tr>
<td>Supply Duct from Fan to Terminal Air Boxes</td>
<td>Galvanized Sheet Metal w/Slide-On Flange System or Formed-on Flanges</td>
<td>+3&quot; (+6&quot;)</td>
<td>A</td>
<td>2&quot; thick Type A (R=6.0) or 2&quot; thick Type C (R=7.1)</td>
</tr>
<tr>
<td>Supply Duct from Fan to Terminal Air Boxes – Double Wall</td>
<td>Galvanized Sheet Metal (spiral seam round or rectangular)</td>
<td>+3&quot;</td>
<td>A</td>
<td>1&quot; thick Type E (R=3.7) or 2&quot; thick Type E (R=7.4)</td>
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<tr>
<td>Exterior Supply Duct from Fan to Terminal Air Boxes – Double Wall</td>
<td>Closed Cell Ductwork Galvanized Sheet Metal Rectangular</td>
<td>+3&quot;</td>
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<td>(2020.01.15 ADD_001)</td>
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<td>Exterior Supply Duct from Fan to Terminal Air Boxes – Single Wall with Aluminum Jacket</td>
<td>Closed Cell Ductwork Galvanized Sheet Metal Rectangular</td>
<td>+3&quot;</td>
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<td>(2020.01.15 ADD_001)</td>
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<tr>
<td>Supply Duct from Terminal Air Boxes to Outlets</td>
<td>Galvanized Sheet Metal - Rectangular</td>
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<td>1-1/2&quot; thick Type A (R=4.5)</td>
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<tr>
<td>Supply Duct from Terminal Air Boxes to Outlets</td>
<td>Galvanized Sheet Metal – Spiral Seam Round</td>
<td>+2&quot;</td>
<td>A</td>
<td>1-1/2&quot; thick Type A (R=4.5)</td>
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<td>Constant Volume from Fan to Outlet</td>
<td>Galvanized Sheet Metal - Rectangular</td>
<td>+2&quot;</td>
<td>A</td>
<td>1-1/2&quot; thick Type A (R=4.5)</td>
</tr>
<tr>
<td>Constant Volume from Fan to Outlet</td>
<td>Galvanized Sheet Metal – Spiral Seam Round</td>
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<td>A</td>
<td>1-1/2&quot; thick Type A (R=4.5)</td>
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<tr>
<td>Return Duct</td>
<td>Galvanized Sheet Metal</td>
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<td>1&quot; thick Type C</td>
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<td>Exterior Return Duct - Double Wall</td>
<td>Closed Cell Ductwork Galvanized Sheet Metal Rectangular</td>
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<td>A</td>
<td>(2020.01.15 ADD_001)</td>
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<td>AHU Exhaust Air Duct</td>
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<td>1-1/2&quot; thick Type A (R=4.5)</td>
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<td>USAGE</td>
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<td>PRESSURE CLASS</td>
<td>SEAL CLASS †</td>
<td>INSULATION (Refer to Section 23 07 13 for insulation types) ³</td>
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<tr>
<td>Outside Air Intake from Louver to Heating Coil</td>
<td>Galvanized Sheet Metal</td>
<td>-2&quot;</td>
<td>A</td>
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<tr>
<td>Mixed/Make-up Air Duct</td>
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<td>A</td>
<td>1-1/2&quot; thick Type A (R=4.5)</td>
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<td></td>
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<td>2&quot; thick Type A (R=6.0)</td>
</tr>
<tr>
<td>Relief Air Louver to Backdraft Damper</td>
<td>Galvanized Sheet Metal</td>
<td>+2&quot;</td>
<td>A</td>
<td>1 1/2&quot; thick Type B (R=6.0)</td>
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<td>1 1/2&quot; thick Type B (R=6.0)</td>
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<tr>
<td>Ductwork Accessories (Fabric Flex Connectors, Equipment Flanges, etc.)</td>
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<tr>
<td>All Terminal Air Box/Reheat Coil Headers and Duct Mounted Coil Headers</td>
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<td>--</td>
<td>(Note 2)</td>
<td>1-1/2&quot; thick Type A (R=4.5)</td>
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</tbody>
</table>

† Seal Class is per SMACNA HVAC Air Duct Leakage Test Manual
³ Type A insulation (Flexible Fiberglass Wrap) R-values noted are based on installed values (25% compression).

Note 1: Apply aluminum based adhesive sealant tape at non-flanged joints on ducts serving dedicated outside air supply (DOAS) and exhaust system in addition to Class A sealant.
Note 2: Apply aluminum based adhesive sealant tape on TAB boxes (all seams and joints of the box and duct connections) serving dedicated outside air supply (DOAS) system.

3.3 DUCTWORK SEALING

A. General Requirements:

1. Openings, such as rotating shafts, shall be sealed with bushings or similar.

2. Pressure sensitive tape shall not be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification.

3. All connections shall be sealed including, but not limited to, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seams need not be sealed.

4. Mastic-based duct sealants shall be applied to joints and seams in minimum 3 inch wide by 20 mil thick bands using brush, putty knife, trowel, or spray, unless manufacturer’s data sheet specifies other application methods or requirements.

B. For Seal Class A ducts, all transverse joints, longitudinal seams, and duct wall penetrations shall be sealed. Joints are inclusive of, but not limited to, girth joints, branch and sub-branch intersections, duct collar tap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, duct, plenum, and casing abutments to building structures.
3.4 TESTING

A. Duct - 2" WG or Less (positive or negative):

1. Systems shall not leak more than shown in Table 4-1 of SMACNA HVAC Air Duct Leakage Test Manual for Seal Class A.

2. Leak testing of these systems is not normally required for interior ductwork. However, leak tests will be required if, in the opinion of the Architect/Engineer, the leakage appears excessive. All exterior ductwork shall be tested. If duct has outside wrap, testing shall be done before it is applied.

3. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.

4. Seal ducts to bring the air leakage into compliance.

5. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

B. Duct - 3" WG and Above (positive or negative):

1. All new ductwork shall be completely pressure tested. If duct has outside wrap, testing shall be done before it is applied.

2. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.

3. Seal ducts to bring the air leakage into compliance.

4. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

C. Test procedure shall be as listed in the latest edition of the SMACNA HVAC Duct Leakage Manual, with the following additional requirements:

1. Test pressure shall be the specified duct pressure class. Testing at reduced pressures and converting the results mathematically is not acceptable. This is required to test the structural integrity of the duct system.

2. If any leak causes discernible noise at a distance of 3 feet, that leak shall be eliminated, regardless of whether that section of duct passed the leakage test.

3. All joints shall be felt by hand, and all discernible leaks shall be sealed.

4. Totaling leakage from several tested sections and comparing them to the allowable leakage for the entire system is not acceptable. Each section must pass the test individually.

5. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing. Failure to notify the Architect/Engineer of pressure testing may require the contractor to repeat the duct pressure test after proper notification.
6. Upon completion of the pressure test, the contractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.

7. All access doors, taps to terminal air boxes, and other accessories and penetrations must be installed prior to testing. Including terminal air boxes in the test is not required.

8. The required leakage class for Seal Class A, both round and rectangular ducts, shall be 4.

9. Positive pressure leakage testing is acceptable for negative pressure ductwork.

3.5 DUCTWORK PENETRATIONS

A. All duct penetrations of firewalls shall have fire or fire/smoke dampers where required by code.

B. Dampers shall be compatible with fire rating of wall assembly. Verify actual rating of any wall being penetrated with Architect/Engineer.

C. Seal all duct penetrations of walls that are not fire rated by caulking or packing with fiberglass. Install trim strip to cover vacant space and raw construction edges of all openings in finished rooms. Install escutcheon ring at all round duct openings in finished rooms. Trim strips and rings shall be same material and finish as exposed duct.

3.6 DUCTWORK CLEANING

A. General:

1. This section applies to the cleaning of ductwork and HVAC system components.

2. The HVAC system cleaning contractor shall be a certified member of the National Air Duct Cleaners Association (NADCA) or shall maintain membership in a nationally recognized non-profit industry organization dedicated to the cleaning of HVAC systems.

3. The HVAC system cleaning contractor shall furnish all necessary equipment, materials, and labor to adequately perform the specified services.

4. The HVAC system cleaning contractor shall be capable of remediation of exposed damaged insulation in air handlers and/or ductwork requiring replacement.

5. Regulatory Requirements:

a. Contractor shall submit to the Owner SDS for all chemical products proposed to be used in the cleaning process.

B. Perform the services specified here in accordance with current NADCA standards.

C. System Component Inspections and Site Preparations:

1. Prior to beginning any cleaning work, perform a visual inspection of the HVAC system to determine appropriate methods, tools, and equipment needed. The cleanliness inspection should include air handling units, other air moving
equipment, and ductwork. In systems with multiple air handling units, a representative sample of the units should be inspected.

2. Coordinate any system shutdowns with the Owner a minimum of 24 hours in advance of any needed shutdowns.

3. The cleanliness inspection shall be conducted without negatively impacting the indoor environment through excessive disruption of settled dust, microbial amplification, or other debris. Follow the Owner’s infection control policy where contamination is suspected and/or where even small amounts of contaminant may be of concern.

4. Damaged system components found during the inspection shall be documented and brought to the attention of the Owner and Architect/Engineer.

5. Conduct a site evaluation, and establish a specific, coordinated plan detailing how each area of the building will be protected during each phase of the project.

D. HVAC System Cleaning Requirements:

1. Collect debris removed during cleaning and take precautions to avoid dispersing debris from cleaning operations outside the HVAC system.

2. Use HEPA filters if particulate collection equipment exhausts inside the building.

3. When particulate collection equipment exhausts outside the building, precautions shall be taken to locate the equipment downwind and away from all air intakes and other points of entry into the building.

4. Cleaning operations shall be undertaken only with particulate collection equipment in place, including adequate filtration to contain debris removed from the HVAC system.

5. Take measures to control odors, mist, and vapors during the cleaning process.

6. All HVAC system components must be visibly clean as defined in the NADCA Standards.

7. Volume dampers, control dampers, and other mechanical devices inside the HVAC system must have their positions marked prior to cleaning and, upon completion, must be restored to their marked positions.

8. Service Openings:

   a. Use existing service openings where possible.

   b. Create openings where needed. Seal openings per the original duct pressure and leakage classification after use.

   c. Closures must not significantly restrict or alter the system airflow.

   d. Closures must be insulated to prevent heat transfer and condensation.

   e. Openings must not compromise the structural integrity of the system.
f. Openings shall conform to applicable NFPA and SMACNA standards, and NADCA Standard 05.

g. Do not cut openings in flexible duct. Disconnect flexible duct at the ends as needed for proper cleaning and inspection.

h. Clearly mark all service openings that can be reopened and mark their locations in the final report.

9. The Contractor may remove and reinstall ceiling sections for cleaning access. Conform to the Owner's infection control policy for ceiling removal and dust control.

10. Clean all connected inlets and outlets.

11. Air Handling Unit Cleaning (Unit Identification):

   a. Thoroughly clean supply, return, and exhaust fans. Clean fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies. Remove all visible surface deposits in accordance with NADCA Standards. Contractor shall:

      1) Clean all internal surfaces, components, coils (including fins), condensate pans, and drains.

      2) Assure that a suitable operative drainage system is in place prior to beginning washdown procedures. Take care not to wet any insulation during washdown.

12. Duct System Cleaning:

   a. Create service openings as needed for cleaning inaccessible areas.

   b. Mechanically clean all duct systems such that the systems are capable of passing NADCA cleaning verification tests.

   c. Seal all openings, grilles, diffusers, etc. in the system to be cleaned.

   d. Attach high-pressure vacuum unit to ductwork near fan. Do not exceed the negative pressure rating of ductwork.

   e. From farthest opening, work dirt from duct back to extraction point using compressed air, brushes, and scrapers.

   f. Do not damage lining or devices during cleaning. Replace any damaged material.

E. Cleaning Methods

1. Source Removal Cleaning Method:

   a. Clean the HVAC system using source removal mechanical cleaning methods designed to extract contaminants from the HVAC system and safely remove contaminants from the facility. Select source removal methods that will render the HVAC system visibly clean and capable of passing cleaning verification and other specified tests included in this section. No cleaning method or combination of methods shall be used that
could potentially damage the HVAC system or negatively alter the system integrity.

b. Operate vacuum collection devices continuously during cleaning. A vacuum device shall be connected to the downstream end of the section being cleaned. The vacuum collection device must maintain sufficient negative pressure in all areas being cleaned to contain debris and protect the indoor environment.

c. All vacuum devices exhausting air inside the building shall be equipped with HEPA filters, including hand-held vacuums and wet vacuums.

d. All vacuum devices exhausting outside the facility shall be equipped with particulate collection devices including a washable cloth filter bag to contain debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Release of debris outdoors must not violate any codes or regulations.

e. All methods require mechanical agitation devices to dislodge debris adhered to interior HVAC system surfaces such that debris may be safely conveyed to vacuum collection devices. Acceptable methods include those that will not potentially damage the integrity of the ductwork nor damage porous surface materials, such as liners inside the ductwork, or system components.

f. Exterior gas-fired vacuum collection equipment shall be located at least 20 feet away from the building.

g. Where vacuum collection hoses run into the building, the Contractor shall seal the opening airtight so dust from the collection equipment cannot re-enter the building.

h. Hoses for mechanical agitation devices should not enter the building in the same location as the vacuum hoses. Utilize a remote building opening for the tool entry location.

2. Coil Cleaning:

a. Any cleaning method may be used that renders the coil visibly clean and capable of passing NADCA Coil Cleaning Verification tests. Coil drain pans shall be subject to Non-Porous Surfaces Cleaning Verification. The drain for the condensate drain pan shall be operational. Cleaning methods shall not cause any appreciable damage to, displacement or erosion of, or inhibit heat transfer of the coil surface and shall conform to coil manufacturer recommendations when available. Coils shall be thoroughly rinsed with clean water.

3. Biocide Agents and Coatings:

a. Biocide agents shall only be applied if active fungal growth is reasonably suspected or where unacceptable levels of fungal contamination have been verified through testing.

b. Biocide agents shall only be used where the Owner agrees in writing that he/she accepts coating the contaminated materials instead of replacement.
c. Application of any biocide shall be performed after removal of surface deposits and debris.

d. When used, apply biocides and coatings in strict accordance with manufacturer's recommendations, including minimum surface thickness for effectiveness and the EPA registration listing.

e. Coatings shall be sprayed directly onto interior ductwork surfaces rather than "fogged" downstream onto surfaces. A continuous film must be achieved on the surface to be treated by the coating application.

F. Verification of Cleanliness:

1. The HVAC system cleaning contractor shall verify the cleanliness of the system, with help from the Owner.

2. Cleanliness of HVAC systems shall be verified immediately after mechanical cleaning, before application of any treatment or introduction of any treatment-related substance to the HVAC system (including biocides and coatings), and before the HVAC system is restored to normal operation.

3. The HVAC system shall be inspected visually. If no contaminants are evident, the system shall be considered clean. However, the Architect/Engineer and Owner reserve the right to require further verification of system cleanliness through Surface Comparison Testing or the NADCA vacuum test.

4. NADCA vacuum test analysis shall be performed by a qualified third party experienced in testing of this nature.

5. If visible contaminants are evident, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection at the Contractor's expense.

6. Verification of Coil Cleanliness:
   a. Cleaning must restore the coil pressure drop to within 10 percent of the pressure drop measured or cataloged when the coil was first installed. If the original pressure drop is not known, the coil will be considered clean only if it is free of foreign matter or residue based on a thorough visual inspection.

G. Final Report:

1. At the conclusion of the project, the Contractor shall provide a report to the Owner and Architect/Engineer indicating the following:
   a. Success of the cleaning project as verified through visual inspection and/or gravimetric analysis.
   b. Areas of the system found to be damaged and/or in need of repair.
   c. Locations of service openings.

3.7 ACOUSTICAL LAGGING

A. Where indicated on drawings, completely wrap ductwork with lagging and seal all joints airtight with tape recommended by the lagging manufacturer to prevent acoustical leakage
at joints. Overlap lagging 2" at any wall, floor, or structural deck penetration to prevent acoustical leakage.

END OF SECTION
KITCHEN ROOF PHOTOS FROM PREVIOUS AHU INSTALLATION