SECTION 1.A

BID FOR LUMP SUM CONTRACT

Date:____________________________

BID OF
(hereinafter called “Bidder”) a corporation* organized and existing under laws of the State of __________
a partnership* consisting of ____________________________,
an individual* trading as ____________________________,
a joint venture* consisting of ____________________________.

*Insert Corporation(s), partnership or individual, as applicable.

TO: Curators of the University of Missouri
   c/o Director, Campus Facilities- Planning Design and Construction
   Room L100 General Services Building
   Columbia, Missouri 65211

1. Bidder, in compliance with invitation for bids for construction work in accordance with
   Drawings and Specifications prepared by TreanorHL and their sub-consultants, entitled "LAFFERRE
   HALL – 3RD FLOOR – LAB & CLEANROOM SHELL SPACE FITOUT", project number CP181761,
   dated July 22, 2019 having examined Contract Documents and site of proposed work, and being
   familiar with all conditions pertaining to construction of proposed project, including availability of
   materials and labor, hereby proposes to furnish all labor, materials and supplies to construct project
   in accordance with Contract Documents, within time set forth herein at prices stated below. Prices
   shall cover all expenses, including taxes not covered by the University of Missouri’s tax exemption
   status, incurred in performing work required under Contract documents, of which this Bid is a part.

Bidder acknowledges receipt of following addenda:

Addendum No. ___________________________ Dated ________________
Addendum No. ___________________________ Dated ________________
Addendum No. ___________________________ Dated ________________
Addendum No. ___________________________ Dated ________________

2. In following Bid(s), amount(s) shall be written in both words and figures. In case of
   discrepancy between words and figures, words shall govern.

3. BID PRICING

   a. Base Bid:

      The Bidder agrees to furnish all labor, materials, tools, and equipment required to fit out
      Lafferre Hall – 3rd Floor lab and cleanroom shell space; all as indicated on the Drawings and
      described in these Specifications for sum of:

      ___________________________ DOLLARS ($ ___________________________).

   b. Additive Alternate Bids:

      Above Base Bid may be changed in accordance with following Alternate Bids as Owner may
      elect. Alternates are as described in Section 1.H of Project Manual. Alternates are written in
      a priority order, but Owner is not required to accept or reject in order listed. This is a one (1)
contract project, therefore, Alternates shall be studied by each Bidder to determine effect on Bids of Contractor and each Subcontractor and/or Material supplier.

(1) **Additive Alternate No. 1:** Provide stair access and openings C3201B and C3201C-W3039 between Computational Lab C3201 and Stair W3039 as well as **STORAGE** and door W3039A. Provide HVAC system to serve Equipment Room C3201A. All for sum of:

DOLLARS ($ ).

(2) **Additive Alternate No. 2:** Provide FM-200 fire suppression system to serve Equipment Room C3201A. All for sum of:

DOLLARS ($ ).

4. **PROJECT COMPLETION**

a. **Contract Period** - Contract period begins on the day the Contractor receives unsigned Contract, Performance Bond, Payment Bond, and "Instructions for Execution of Contract, Bonds, and Insurance Certificates." Bidder agrees to complete project within Two Hundred Forty (240) calendar days from receipt of aforementioned documents. Fifteen (15) calendar days have been allocated in construction schedule for receiving aforementioned documents from Bidder.

b. **Commencement** - Contractor agrees to commence work on this project after the "Notice to Proceed" is issued by the Owner. "Notice to Proceed" will be issued within seven (7) calendar days after Owner receives properly prepared and executed Contract documents listed in paragraph 4.a. above.

c. **Special scheduling requirements:**

(1) Outages requiring in excess of 48-hours shall be scheduled to occur during one of the following timeframes when scheduled classes are in recess:

- **Thanksgiving Recess:** November 25th, 2019 through November 29th, 2019
- **Winter Recess:** December 16th, 2019 through January 17th, 2020
- **Spring Break:** March 23rd, 2020 through March 27th, 2020
- **Summer Recess:** May 18th, 2020 through June 5th, 2020

(2) **On-Site Work Hours:** Contractor shall have access to project area 24 hours a day, 7 days a week.

a. The project may be completed during normal working hours, with the exception of Disruptive Activities. Contractor shall perform all disruptive activities Before 7:00am and after 5:00pm. The Contractor shall plan for the labor rates needed to complete Disruptive Activities before 7:00am and after 5:00pm.

b. Coordinate large deliveries with Owner to limit interruption to daily activities.

(3) **Existing Utility Interruptions:** Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions, and then only after providing temporary utility services according to requirements indicated:

a. Submit plan to Owner not less than fourteen (14) days in advance of proposed utility interruptions.

b. Contractor shall not shut down utilities without Owner present.
c. HVAC start-up will require shutdown of these services. Coordinate with Owner as indicated above.

d. Addition of new electrical panels will require shutdown of power to distribution panel. Coordinate with Owner as indicated above.

(5)(4) If Alternate No. 1 is accepted, access to adjacent CGI Suite shall be maintained in a secure manner, acceptable to Owner, once the opening between spaces is made.

(6)(5) If Alternate No. 1 is accepted, the Owner requires a 60-day advance notice and agreed scheduling for any outages related to electrical conduit rerouting in the CGI Suite necessary to accommodate new opening connection.

5. SUBCONTRACTOR LIST:

Bidder hereby certifies that the following subcontractors will be used in performance of Work:

NOTE: Failure to list subcontractors for each category of work identified on this form or listing more than one subcontractor for any category of work without designating the portion of work performed by each shall be grounds for rejection of bid. List name, city, and state of designated subcontractor, for each category of work listed in Bid For Lump Sum Contract. If work within a category will be performed by more than one subcontractor, Bidder shall provide name, city, and state of each subcontractor and specify exact portion of work to be performed by each. If acceptance/non-acceptance of Alternates will affect designation of a subcontractor, Bidder shall provide information, for each affected category, with this bid form. If Bidder intends to perform any designated subcontract work by using Bidder's own employees, then Bidder shall list their own name, city, and state. The bidder may petition the Owner to change a listed subcontractor only within 48 hours of the bid opening. See Information For Bidders Section 16 List of Subcontractors for requirements.

<table>
<thead>
<tr>
<th>Work to be performed</th>
<th>Subcontractor Name, City, State</th>
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<tbody>
<tr>
<td>Mechanical</td>
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<tr>
<td>Plumbing</td>
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<tr>
<td>Electrical</td>
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<tr>
<td>Laboratory Casework</td>
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6. SUPPLIER DIVERSITY PARTICIPATION GOALS

a. 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. Requests for waiver of this goal shall be submitted on the attached Application For Waiver form. A determination by the Director of Facilities Planning & Development, UM, that a good faith effort has not been made by Contractor to achieve above stated goal may result in rejection of bid.

c. The Undersigned proposes to perform work with following Supplier Diversity participation level:

MBE PERCENTAGE PARTICIPATION: _____________________ percent (_____ %)

SDVE PERCENTAGE PARTICIPATION: _______________ percent (____ %)
WBE, DBE, and/or VETERAN PERCENTAGE PARTICIPATION: __________ percent (___ %)

d. A Supplier Diversity Compliance Evaluation form shall be submitted with this bid for each diverse subcontractor to be used on this project.

7. BIDDER'S ACKNOWLEDGMENTS

a. Bidder declares that he has had an opportunity to examine the site of the work and he has examined Contract Documents therefore; that he has carefully prepared his bid upon the basis thereof; that he has carefully examined and checked bid, materials, equipment and labor required thereunder, cost thereof, and his figures therefore. Bidder hereby states that amount, or amounts, set forth in bid is, or are, correct and that no mistake or error has occurred in bid or in Bidder's computations upon which this bid is based. Bidder agrees that he will make no claim for reformation, modifications, revisions or correction of bid after scheduled closing time for receipt of bids.

b. Bidder agrees that bid shall not be withdrawn for a period of Sixty (60) days after scheduled closing time for receipt of bids.

c. Bidder understands that Owner reserves right to reject any or all bids and to waive any informalities in bidding.

d. Accompanying the bid is a bid bond, or a certified check, or an irrevocable letter of credit, or a cashier's check payable without condition to "The Curators of the University of Missouri" which is an amount at least equal to five percent (5%) of amount of largest possible total bid herein submitted, including consideration of Alternates.

e. Accompanying the bid is a Bidder's Statement of Qualifications. Failure of Bidder to submit the Bidder's Statement of Qualifications with the bid may cause the bid to be rejected. Owner does not maintain Bidder's Statements of Qualifications on file.

f. It is understood and agreed that bid security of two (2) lowest and responsive Bidders will be retained until Contract has been executed and an acceptable Performance Bond and Payment Bond has been furnished. It is understood and agreed that if the bid is accepted and the undersigned fails to execute the Contract and furnish acceptable Performance/Payment Bond as required by Contract Documents, accompanying bid security will be realized upon or retained by Owner. Otherwise, the bid security will be returned to the undersigned.

8. BIDDER'S CERTIFICATE

Bidder hereby certifies:

a. His bid is genuine and is not made in interest of or on behalf of any undisclosed person, firm or corporation, and is not submitted in conformity with any agreement or rules of any group, association or corporation.

b. He has not directly or indirectly induced or solicited any other bidder to put in a false or sham bid.

c. He has not solicited or induced any person, firm or corporation to refrain from bidding.

d. He has not sought by collusion or otherwise to obtain for himself any advantage over any other Bidder or over Owner.
e. He will not discriminate against any employee or applicant for employment because of race, color, religion, sex or national origin in connection with performance of work.

f. By virtue of policy of the Board of Curators, and by virtue of statutory authority, a preference will be given to materials, products, supplies, provisions and all other articles produced, manufactured, mined or grown within the State of Missouri. By virtue of policy of the Board of Curators, preference will also be given to all Missouri firms, corporations, or individuals, all as more fully set forth in “Information For Bidders.”

9. BIDDER’S SIGNATURE

Note: All signatures shall be original; not copies, photocopies, stamped, etc.

<table>
<thead>
<tr>
<th>Authorized Signature</th>
<th>Date</th>
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<tbody>
<tr>
<td>Printed Name</td>
<td>Title</td>
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<tr>
<td>Company Name</td>
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<td>Mailing Address</td>
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<td>Phone No.</td>
<td>Federal Employer ID No.</td>
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<tr>
<td>Fax No.</td>
<td>E-Mail Address</td>
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<tr>
<td>Circle one:</td>
<td>Individual Partnership Corporation Joint Venture</td>
</tr>
</tbody>
</table>

If a corporation, incorporated under the laws of the State of ____________

Licensed to do business in the State of Missouri? _____yes _____no

(Each Bidder shall complete bid form by manually signing on the proper signature line above and supplying required information called for in connection with the signature. Information is necessary for proper preparation of the Contract, Performance Bond and Payment Bond. Each Bidder shall supply information called for in accompanying "Bidder’s Statement of Qualifications.")

END OF SECTION
SECTION 1.H

ALTERNATES

Base Bid may be increased in accordance with following Additive Alternate proposal(s) as Owner may elect:

1. Additive Alternate No. 1: Provide stair access and openings C3201B and C3201C between Computational Lab C3201 and Stair W3039 as well as STORAGE and door W3039A. Remove, replace, and provide new finishes, services, ductwork, and other components as indicated on Drawings. Provide HVAC system to serve Equipment Room C3201A. Refer to Drawings for additional information.

2. Additive Alternate No. 2: Provide FM-200 fire suppression system to serve Equipment Room C3201A. Refer to Drawings for additional information.

END OF SECTION
SECTION 08 4113 - ALUMINUM-FRAMED STOREFRONTS

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. Section Includes:
   1. Interior storefront framing.

1.03 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components
      and profiles, and finishes.

B. Shop Drawings: For aluminum-framed storefronts. Include plans, elevations, sections, full-size
   details, and attachments to other work.

C. Samples for Initial Selection: For units with factory-applied color finishes.

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

1.04 CLOSEOUT SUBMITTALS
A. Maintenance Data: For aluminum-framed storefronts to include in maintenance manuals.

1.05 QUALITY ASSURANCE
A. Installer Qualifications: An entity that employs installers and supervisors who are trained and
   approved by manufacturer.

B. Product Options: Information on Drawings and in Specifications establishes requirements for
   aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated
   by dimensions, arrangements, alignment, and profiles of components and assemblies as they
   relate to sightlines, to one another, and to adjoining construction.
   1. Do not change intended aesthetic effects, as judged solely by Architect, except with
      Architect's approval. If changes are proposed, submit comprehensive explanatory data to
      Architect for review.

1.06 WARRANTY
A. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or
   replace aluminum that shows evidence of deterioration of factory-applied finishes within
   specified warranty period.
   1. Deterioration includes, but is not limited to, the following:
      a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
      b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
      c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS
A. General Performance: Comply with performance requirements specified, as determined by
   testing of aluminum-framed storefronts representing those indicated for this Project without
   failure due to defective manufacture, fabrication, installation, or other defects in construction.
   1. Aluminum-framed storefronts shall withstand movements of supporting structure
      including, but not limited to, story drift, twist, column shortening, long-term creep, and
      deflection from uniformly distributed and concentrated live loads.
   2. Failure also includes the following:
      a. Thermal stresses transferring to building structure.
b. Glass breakage.
c. Noise or vibration created by wind and thermal and structural movements.
d. Loosening or weakening of fasteners, attachments, and other components.

2.02 MANUFACTURERS
A. Basis-of-Design Product: Subject to compliance with requirements, provide Kawneer Trifab 400 Framing System or comparable product by one of the following:
   1. Efco
   2. Manko
   3. Oldcastle
   3.4. YKK AP America, Inc.
B. Source Limitations: Obtain all components of aluminum-framed entrance and storefront system, including framing

2.03 FRAMING
A. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.
   2. Glazing System: Retained mechanically with gaskets on four sides.
   3. Glazing Plane: Middle
B. Backer Plates: Manufacturer's standard, continuous backer plates for framing members, if not integral, where framing abuts adjacent construction.
C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.
D. Materials:
   1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
      a. Sheet and Plate: ASTM B 209.
      b. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221.
      c. Extruded Structural Pipe and Tubes: ASTM B 429/B 429M.
      d. Structural Profiles: ASTM B 308/B 308M.

2.04 GLAZING
A. Glazing: Comply with Section 08 8000 "Glazing."
B. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.
C. Glazing Sealants: As recommended by manufacturer.

2.05 ACCESSORIES
A. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.
   1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
   2. Reinforce members as required to receive fastener threads.
B. Anchors: Three-way adjustable anchors with minimum adjustment of 1 inch that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.

2.06 FABRICATION
A. Form or extrude aluminum shapes before finishing.
B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

C. Fabricate components that, when assembled, have the following characteristics:
   1. Profiles that are sharp, straight, and free of defects or deformations.
   2. Accurately fitted joints with ends coped or mitered.
   3. Physical and thermal isolation of glazing from framing members.
   4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
   5. Provisions for field replacement of glazing from interior.
   6. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.

D. Mechanically Glazed Framing Members: Fabricate for flush glazing without projecting stops.

E. Storefront Framing: Fabricate components for assembly using shear-block system.

2.07 ALUMINUM FINISHES

A. High-Performance Organic Finish: Two-coat fluoropolymer finish complying with AAMA 2604 and containing not less than 70 percent PVDF or FEVE resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers’ written instructions.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Prepare surfaces that are in contact with structural sealant according to sealant manufacturer's written instructions to ensure compatibility and adhesion. Preparation includes, but is not limited to, cleaning and priming surfaces.

3.03 INSTALLATION

A. General:
   1. Comply with manufacturer’s written instructions.
   2. Do not install damaged components.
   3. Fit joints to produce hairline joints free of burrs and distortion.
   4. Rigidly secure nonmovement joints.
   5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
   6. Seal perimeter and other joints watertight unless otherwise indicated.
B. Metal Protection:
   1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with materials recommended by manufacturer for this purpose or by installing nonconductive spacers.
   2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.
C. Install components plumb and true in alignment with established lines and grades.

3.04 ERECTION TOLERANCES

A. Erection Tolerances: Install aluminum-framed storefronts to comply with the following maximum tolerances:
1. Plumb: 1/8 inch in 10 feet; 1/4 inch in 40 feet.
2. Level: 1/8 inch in 20 feet; 1/4 inch in 40 feet.
3. Alignment:
   a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch wide, limit offset from true alignment to 1/16 inch.
   b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch wide, limit offset from true alignment to 1/8 inch.
   c. Where surfaces are separated by reveal or protruding element of 1 inch wide or more, limit offset from true alignment to 1/4 inch.
4. Location: Limit variation from plane to 1/8 inch in 12 feet; 1/2 inch over total length.

END OF SECTION 08 4113
SECTION 12 3553.13
METAL LABORATORY CASEWORK

PART 1 - GENERAL

1.01 SUMMARY
A. Section Includes:
1. Metal laboratory casework.
2. Utility-space framing at backs of base cabinets.
3. Filler and closure panels.
4. Laboratory countertops.
5. Tables.
7. Laboratory sinks.
8. Gas Cylinder Storage Cabinets
9. Acid and Corrosive Storage Cabinets
10. Flammable Storage Cabinets
11. Laboratory accessories.
B. Related Requirements:
1. Section 06 10 00 "Rough Carpentry" for wood blocking for anchoring laboratory casework.
2. Section 09 22 16 "Non-Structural Metal Framing" for reinforcements in metal-framed partitions for anchoring laboratory casework.
3. Section 09 65 13 "Resilient Base and Accessories" for resilient base applied to metal laboratory casework.

1.02 PREINSTALLATION MEETINGS
A. Preinstallation Conference: Conduct conference at Project site.

1.03 COORDINATION
A. Coordinate layout and installation of framing and reinforcements for support of laboratory casework.
B. Coordinate installation of laboratory casework with installation of fume hoods and other laboratory equipment.

1.04 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. Shop Drawings: For laboratory casework. Include plans, elevations, sections, and attachment details.
1. Indicate types and sizes of cabinets.
2. Indicate locations of hardware and keying of locks.
3. Indicate locations and types of service fittings.
4. Indicate locations of blocking and reinforcements required for installing laboratory casework.
5. Include details of utility spaces showing supports for conduits and piping.
6. Include details of support framing system.
7. Include details of exposed conduits, if required, for service fittings.
8. Indicate locations of and clearances from adjacent walls, doors, windows, other building components, and other laboratory equipment.
9. Include coordinated dimensions for laboratory equipment specified in other Sections.
C. Samples for Verification: For each type of cabinet finish and each type of countertop material, in manufacturer's standard sizes.

1.05 INFORMATIONAL SUBMITTALS
A. Qualification Data: For manufacturer.
B. Product Test Reports for Casework: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating compliance of laboratory casework with requirements of specified product standard and system structural performance specified in "Performance Requirements," Article.
C. Product Test Reports for Countertop Surface Material: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating compliance of laboratory countertop surface materials with requirements specified for chemical and physical resistance.

1.06 MAINTENANCE MATERIAL SUBMITTALS
A. Furnish complete touchup kit for each type and color of metal laboratory casework provided. Include fillers, primers, paints, and other materials necessary to perform permanent repairs to damaged laboratory casework finish.

1.07 QUALITY ASSURANCE
A. Manufacturer Qualifications: A qualified manufacturer that produces casework of types indicated for this Project that has been tested for compliance with SEFA 8 M.

1.08 DELIVERY, STORAGE, AND HANDLING
A. Protect finished surfaces during handling and installation with protective covering of polyethylene film or other suitable material.

1.09 FIELD CONDITIONS
A. Locate concealed framing, blocking, and reinforcements that support casework by field measurements before being enclosed, and indicate measurements on Shop Drawings.
B. Environmental Limitations: Do not deliver or install laboratory casework until building is enclosed, utility roughing-in and wet work are complete and dry, and temporary HVAC system is operating and maintaining temperature and relative humidity at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
B. Basis-of-Design Product: Subject to compliance with requirements, provide Kewaunee Scientific Corporation Alpha System or comparable product by one of the following:
   1. Kewaunee Scientific Corporation (Basis-of-Design)
   2. Mott
   3. ICI Scientific
C. Source Limitations: Obtain laboratory casework from single source from single manufacturer unless otherwise indicated.
D. Product Designations: Drawings indicate sizes and configurations of laboratory casework by referencing designated manufacturer’s catalog numbers. Other manufacturers’ laboratory casework of similar sizes and similar door and drawer configurations and complying with Specifications may be considered. See Section 01 60 00 “Product Requirements.”

2.02 PERFORMANCE REQUIREMENTS
A. System Structural Performance: Laboratory casework and support framing system shall withstand the effects of the following gravity loads and stresses without permanent deformation, excessive deflection, or binding of drawers and doors:
   4. Shelves: 40 lb/sq. ft.

2.03 CASEWORK, GENERAL
A. Casework Product Standard: Comply with SEFA 8 M, “Laboratory Grade Metal Casework.”
B. Flammable Liquid Storage: Where cabinets are indicated for solvent or flammable liquid storage, provide units that are listed and labeled as complying with requirements in NFPA 30 by FM Approvals.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.04 METAL CABINET AND TABLE MATERIALS
A. Metal: Cold-rolled, commercial steel (CS) sheet, complying with ASTM A 1008/A 1008M; matte finish; suitable for exposed applications.
B. Nominal Metal Thickness:
1. Sides, Ends, Fixed Backs, Bottoms, Tops, Soffits, and Items Not Otherwise Indicated: 0.048 inch. Except for flammable liquid storage cabinets, bottoms may be 0.036 inch reinforced.
2. Back Panels, Doors, Drawer Fronts and Bodies, and Shelves: 0.036 inch except 0.048 inch for back panels and doors of flammable liquid storage cabinets and for unreinforced shelves more than 36 inches long.
3. Intermediate Horizontal Rails, Table Aprons and Cross Rails, Center Posts, and Top Gussets: 0.060 inch.
4. Drawer Runners, Sink Supports, and Hinge Reinforcements: 0.075 inch.
5. Leveling and Corner Gussets: 0.105 inch.
2.05 AUXILIARY CABINET MATERIALS
A. Acid Storage-Cabinet Lining: 1/4-inch-thick, polyethylene or polypropylene.
B. Glass for Glazed Doors: Clear tempered glass complying with ASTM C 1048, Kind FT, Condition A, Type I, Class 1, Quality-Q3; not less than 5.0 mm thick.
2.06 COUNTERTOP TABLETOP, SHELF, and SINK MATERIALS
A. Chemical-Resistant Plastic Laminate:
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
2. High-pressure decorative laminate, complying with NEMA LD 3, that has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:
   a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), amyl acetate, benzene, butyl alcohol, carbon tetrachloride, chloroform, dimethyl formamide, dioxane, ethyl acetate, ethyl alcohol, ethyl ether, formaldehyde (37 percent), gasoline, gentian violet, hydrogen peroxide (3 percent), methyl alcohol, methyl ethyl ketone, methylene chloride, mono chlorobenzene, naphthalene, toluene, trichloroethylene, xylene, and zinc chloride (saturated).
   b. Slight Effect: Cresol, tincture of iodine, sodium sulfide (15 percent).
3. Color: As selected by Architect from chemical-resistant, plastic-laminate manufacturer's full range.
4. Core Materials for Plastic Laminate:
   a. Certified Wood: Core materials shall be produced from wood and wood products certified as "FSC Pure" according to FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship," and to FSC STD-40-004, "FSC Standard for Chain of Custody Certification."
   b. Particleboard: ANSI A208.1, Grade M-2; made with binder containing no urea formaldehyde.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Durcon Incorporated
2. Physical Properties:
   a. Flexural Strength: Not less than 10,000 psi.
   b. Modulus of Elasticity: Not less than 2,000,000 psi.
   c. Hardness (Rockwell M): Not less than 100.
   d. Water Absorption (24 Hours): Not more than 0.02 percent.
   e. Heat Distortion Point: Not less than 260 deg F.
3. Chemical Resistance: Epoxy-resin material has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:
   a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), benzene, carbon tetrachloride, dimethyl formamide, ethyl acetate, ethyl alcohol, ethyl ether, methyl alcohol, nitric acid (70 percent), phenol, sulfuric acid (60 percent), and toluene.
   b. Slight Effect: Chromic acid (60 percent) and sodium hydroxide (50 percent).
4. Color: Match Durcon "Graphite".

2.07 METAL CABINETS AND TABLES

A. Fabrication: Assemble and finish units at point of manufacture. Use precision dies for interchangeability of like-size drawers, doors, and similar parts. Perform assembly on precision jigs to provide units that are square. Reinforce units with angles, gussets, and channels. Except where otherwise specified, integrally frame and weld cabinet bodies to form dirt- and vermin-resistant enclosures. Where applicable, reinforce base cabinets for sink support. Maintain uniform clearance around door and drawer fronts of 1/16 to 3/32 inch.

B. Cabinet Style: Flush Overlay

C. Flush Doors: Outer and inner pans that nest into box formation, with full-height channel reinforcements at center of door. Fill doors with noncombustible, sound-deadening material.

D. Glazed Doors: Hollow-metal stiles and rails of similar construction as flush doors, with glass held in resilient channels or gasket material.

E. Hinged Doors: Mortise for hinges and reinforce with angles welded inside inner pans at hinge edge.

F. Drawers: Fronts made from outer and inner pans that nest into box formation, with no raw metal edges at top. Sides, back, and bottom fabricated in one piece with rolled or formed top of sides for stiffening and comfortable grasp for drawer removal. Provide drawers with rubber bumpers, polymer roller slides, and positive stops to prevent metal-to-metal contact or accidental removal.

G. Adjustable Shelves: Front, back, and ends formed down, with edges returned horizontally at front and back to form reinforcing channels.

H. Toe Space: Fully enclosed, 4 inches high by 3 inches deep, with no open gaps or pockets.

I. Tables: Welded tubing legs, not less than 2 inches square with channel stretchers as needed to comply with product standard. Weld or bolt stretchers to legs and cross-stretchers, and bolt legs to table aprons. Provide leveling device welded to bottom of each leg.

1. Leg Shoes: Satin-finished, stainless-steel, open-bottom, slip-on type.

J. Utility-Space Framing: Steel framing units consisting of two steel slotted channels complying with MFMA-4, not less than 1-5/8 inches square by 0.105-inchnominal thickness, that are connected at top and bottom by U-shaped brackets made from 1-1/4-by-1/4-inchsteel flat bars. Framing units may be made by welding specified channel material into rectangular frames instead of using U-shaped brackets.

K. Filler and Closure Panels: Provide where indicated and as needed to close spaces between cabinets and walls, ceilings, and indicated equipment. Fabricate from same material and with same finish as cabinets and with hemmed or flanged edges unless otherwise indicated.

1. Provide knee-space panels (modesty panels) at spaces between base cabinets, where cabinets are not installed against a wall or where space is not otherwise closed. Fabricate from back-to-back panels or of hollow construction to eliminate exposed hemmed or flanged edges.

2. Provide utility-space closure panels at spaces between base cabinets where utility space would otherwise be exposed, including spaces below countertops.

3. Provide closure panels at ends of utility spaces where utility space would otherwise be exposed.

2.08 METAL CABINET FINISH

A. General: Prepare, treat, and finish welded assemblies after assembling. Prepare, treat, and finish components that are to be assembled with mechanical fasteners before assembling. Prepare, treat, and finish concealed surfaces same as exposed surfaces.

B. Preparation: After assembly, clean surfaces of mill scale, rust, oil, and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it.

C. Chemical-Resistant Finish: Immediately after cleaning and pretreating, apply laboratory casework manufacturer's standard two-coat, chemical-resistant, baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils.

1. Chemical and Physical Resistance of Finish System: Finish complies with acceptance levels of cabinet surface finish tests in SEFA 8 M. Acceptance level for chemical spot test shall be no more than four Level 3 conditions.
2. Colors for Metal Laboratory Casework Finish: As selected by Architect from manufacturer's full range.

2.09 HARDWARE
A. General: Provide laboratory casework manufacturer's standard, commercial-quality, heavy-duty hardware complying with requirements indicated for each type.
B. Hinges: Stainless-steel, five-knuckle hinges complying with BHMA A156.9, Grade 1, with antifriction bearings and rounded tips. Provide two for doors 48 inches high or less and three for doors more than 48 inches high.
C. Hinged Door and Drawer Pulls: Solid-aluminum, stainless-steel, or chrome-plated-brass, back-mounted pulls. Provide two pulls for drawers more than 24 inches wide.
   1. Design: As selected from manufacturer's full range.
   2. Overall Size: As selected from manufacturer's full range.
D. Door Catches: Nylon-roller spring catches. Provide two catches on doors more than 48 inches high.
E. Drawer Slides: Side mounted full extension, epoxy-coated steel, self-closing; designed to prevent rebound when drawers are closed; complying with BHMA A156.9, Type B05091.
   1. Provide Grade 1HD-100; for drawers not more than 6 inches high and 24 inches wide.
   2. Provide Grade 1HD-200; for drawers more than 6 inches high or 24 inches wide.
   3. Heavy Duty (Grade 1HD-100 and Grade 1HD-200): Full-overtravel-extension, ball-bearing type.
F. Locks: Cam or half-mortise type, brass with chrome-plated finish; complying with BHMA A156.11, Type E07281, Type E07261, Type E07111, or Type E07021.
   1. Provide a minimum of two keys per lock and two master keys.
   2. Provide at all doors, pairs of doors, and drawers.
   3. Keying: Key locks alike within each room; key each room separately.
   4. Master Key System: Key all locks to be operable by master key.

2.10 COUNTERTOPS, SHELVES AND SINKS
A. Countertops, General: Provide units with smooth surfaces in uniform plane, free of defects. Make exposed edges and corners straight and uniformly beveled. Provide front and end overhang of 1 inch, with continuous drip groove on underside 1/2 inch from edge.
B. Sinks, General: Provide sizes indicated or laboratory casework manufacturer's closest standard size of equal or greater volume, as approved by Architect.
   1. Outlets: Provide with strainers and tailpieces, NPS 1-1/2, unless otherwise indicated.
   2. Overflows: Where indicated, provide overflow of standard beehive or open-top design with separate strainer. Height 2 inches less than sink depth. Provide in same material as strainer.
C. Epoxy Countertops, Tabletops, and Sinks:
   1. Countertop Fabrication: Fabricate with factory cutouts for sinks, holes for service fittings and accessories, and butt joints assembled with epoxy adhesive and concealed metal splines.
      a. Countertop Configuration: Flat, 1 inch thick, with beveled edge and corners, and with drip groove and applied backsplash.
      b. Countertop Construction: Uniform throughout full thickness.
   2. Tabletop Fabrication:
      a. Tabletop Configuration: Flat, 1 inch thick, with beveled edge and corners, and with drip groove at perimeter.
      b. Tabletop Construction: Uniform throughout full thickness.
   3. Sink Fabrication: Molded in one piece with smooth surfaces, coved corners, and bottom sloped to outlet; 1/2-inchminimum thickness.
      a. Provide with polypropylene strainers and tailpieces.
      b. Provide sinks for drop-in installation with 1/4-inch-thick lip around perimeter of sink.
      c. Provide manufacturer's recommended adjustable support system for table- and cabinet-type installations.

2.11 OVERHEAD SERVICE CARRIERS
A. Unistrut channels supported from structure above equally spaced at 48" on center maximum
1. Where width of ducts and other construction produces hanger spacings that interfere with locations of hangers required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.

2. Do not connect or suspend from ducts, pipes, or conduit.

3. Assembly shall be provided with powder coat finish selected from standard colors.

4. Services Supported:
   a. Compressed Air
   b. Vacuum
   c. Electrical and Data services as indicated on drawings

B. Cable tray system as manufactured by P/W Industries, Cope Cable Tray or equal, to be suspended from Overhead Service Carrier.

2.12 CEILING SERVICE LINEAR (CSL)
   A. 8-inch wide ceiling service linear panel
   B. Provide Alpha System Ceiling Service Panel as manufactured by Kewaunee Scientific Corporation. Provide linear panel pre-plumbed and pre-wired for utilities indicted. Coordinate with Mechanical and Electrical Documents

2.13 GAS CYLINDER CABINETS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   B. Basis-of-Design Product: Matheson Model 1170 gas cylinder cabinet.
   C. Product Requirements:
      1. Meets or exceeds Article 80 UFC requirements)
      2. Cabinet: 12 gauge cold rolled steel
      3. Gaskets: Neoprene with oil resistant adhesive
      4. Window: 1/4" wire reinforced safety glass
      5. Paint: 2-part polyurethane; interior and exterior –light gray
      6. Cabinet Floor: Zinc-plated steel
      7. Doors: 1 and 2 cylinder cabinets – one door with left hand hinge
      8. Doors: 3 cylinder cabinet – double door with off-center post
      9. Integral Sprinkler: Fuse rating of 155°F and flow capacity of 35 GPM @ 40 psi
      10. Water Pipe Connection: 1/2” NPT Female

2.14 ACID AND CORROSIVE STORAGE CABINETS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   C. Product Requirements:
      1. Doors: Self-close and self latching
      2. Shelves: 1
      3. Capacity: 30 gallon
      4. Dimensions: 46” high x 43” wide x 18” deep

2.15 FLAMMABLE STORAGE CABINETS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
   C. Product Requirements:
      1. Doors: Self-close and self latching
      2. Shelves: 1
      3. Capacity: 30 gallon
      4. Dimensions: 46” high x 43” wide x 18” deep

2.16 LABORATORY ACCESSORIES
   A. Reagent Shelves: Provide as indicated, fabricated from same material as adjacent countertop unless otherwise indicated.
B. Drying Rack: Polypropylene, epoxy, or phenolic-composite pegboards with removable polypropylene pegs and stainless-steel drip troughs with drain outlet.
   1. Provide tubing from drain outlet to sink
C. Cylinder Restraints:
   1. USA Safety Cylinder Restraint Bracket; Model GB200FS, or equal.
D. Retaining Lip
   1. Wall mounted opening adjustable shelving units.
      a. 3/4" retaining lip at lower shelf only.
E. Three Joint Snorkel Exhaust
   1. Provide Movex model Terfu MT-1500-75 snorkel, Nederman Inc., or equal.
   2. Ceiling mounted Terfu ceiling bracket MTI or equal; coordinate with exhaust duct size and requirements.
   3. Hood type: As selected by owner from manufacturer's full range.

**PART 3 - EXECUTION**

**3.01 EXAMINATION**

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances, location of reinforcements, and other conditions affecting performance of the Work.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

**3.02 INSTALLATION OF CABINETS**

A. Comply with installation requirements in SEFA 2.3. Install level, plumb, and true; shim as required, using concealed shims. Where laboratory casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical. Do not exceed the following tolerances:
   1. Variation of Tops of Base Cabinets from Level: 1/16 inch in 10 feet.
   2. Variation of Bottoms of Upper Cabinets from Level: 1/8 inch in 10 feet.
   3. Variation of Faces of Cabinets from a True Plane: 1/8 inch in 10 feet.
   5. Variation in Alignment of Adjacent Door and Drawer Edges: 1/16 inch.
B. Base Cabinets: Fasten cabinets to utility-space framing, partition framing, wood blocking, or reinforcements in partitions, with fasteners spaced not more than 16 inches o.c. Bolt adjacent cabinets together with joints flush, tight, and uniform.
   1. Where base cabinets are installed away from walls, fasten to floor at toe space at not more than 24 inches o.c. and at sides of cabinets with not less than two fasteners per side.
C. Wall Cabinets: Fasten to hanging strips, masonry, partition framing, blocking, or reinforcements in partitions. Fasten each cabinet through back, near top, at not less than 16 inches o.c.
D. Install hardware uniformly and precisely. Set hinges snug and flat in mortises.
E. Adjust laboratory casework and hardware so doors and drawers align and operate smoothly without warp or bind and contact points meet accurately. Lubricate operating hardware as recommended by manufacturer.

**3.03 INSTALLATION OF COUNTERTOPS**

A. Comply with installation requirements in SEFA 2.3. Abut top and edge surfaces in one true plane with flush hairline joints and with internal supports placed to prevent deflection. Locate joints only where indicated on Shop Drawings.
B. Field Jointing: Where possible, make in same manner as shop-made joints, using dowels, splines, fasteners, adhesives, and sealants recommended by manufacturer. Shop prepare edges for field-made joints.
   1. Use concealed clamping devices for field-made joints in plastic-laminate countertops. Locate clamping devices within 6 inches of front and back edges and at intervals not exceeding 24 inches. Tighten according to manufacturer's written instructions to exert a uniform heavy pressure at joints.
C. Fastening:
   1. Secure epoxy countertops to cabinets with epoxy cement, applied at each corner and along perimeter edges at not more than 48 inches o.c.
   2. Where necessary to penetrate countertops with fasteners, countersink heads approximately 1/8 inch, and plug hole flush with material equal to countertop in chemical resistance, hardness, and appearance.
D. Provide required holes and cutouts for service fittings.
E. Seal unfinished edges and cutouts in plastic-laminate countertops with heavy coat of polyurethane varnish.
F. Provide scribe moldings for closures at junctures of countertop, curb, and splash with walls as recommended by manufacturer for materials involved. Match materials and finish to adjacent laboratory casework. Use chemical-resistant, permanently elastic sealing compound where recommended by manufacturer.
G. Carefully dress joints smooth, remove surface scratches, and clean entire surface.

3.04 INSTALLATION OF SINKS
A. Comply with installation requirements in SEFA 2.3.
B. Underside Installation of Epoxy Sinks: Use laboratory casework manufacturer’s recommended adjustable support system for table- and cabinet-type installations. Set top edge of sink unit in sink and countertop manufacturers’ recommended chemical-resistant sealing compound or adhesive, and firmly secure to produce a tight and fully leakproof joint. Adjust sink and securely support to prevent movement. Remove excess sealant or adhesive while still wet and finish joint for neat appearance.
C. Drop-in Installation of Epoxy Sinks: Rout groove in countertop to receive sink rim if not shop prepared. Set sink in adhesive and fill remainder of groove with sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess adhesive and sealant while still wet and finish joint for neat appearance.

3.05 INSTALLATION OF LABORATORY ACCESSORIES
A. Install accessories according to Shop Drawings, installation requirements in SEFA 2.3, and manufacturer’s written instructions.
B. Securely fasten adjustable shelving supports, stainless-steel shelves, and pegboards to partition framing, wood blocking, or reinforcements in partitions.
C. Install shelf standards plumb and at heights to align shelf brackets for level shelves. Install shelving level and straight, closely fitted to other work where indicated.
D. Securely fasten pegboards to partition framing, wood blocking, or reinforcements in partitions.

3.06 CLEANING AND PROTECTING
A. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.
B. Protect countertop surfaces during construction with 6-mil plastic or other suitable water-resistant covering. Tape to underside of countertop at a minimum of 48 inches o.c.

END OF SECTION 12 3553.13
SECTION 23 34 19
LABORATORY MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
B. Section 23 0100 “Basic Mechanical Requirements” and Section 23 0500 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

1.2 SUMMARY
A. This Section includes the following:
   1. Air volume control products associated with laboratory fume hoods and rooms.
   2. Fan Filter Units (FFU)
B. Related Sections: The following Sections contain requirements that relate to this Section.
   1. Division 23 Section “Metal Ductwork” contains requirements that relate to this Section.
   2. Division 23 Section “Duct Accessories” for duct flexible connectors.
   3. Division 23 Section “Control Systems” for control devices.

1.3 PERFORMANCE REQUIREMENTS
A. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS
A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections.
B. Product Data including rated capacities of each unit, weights (shipping, installed, and operating), furnished specialties, accessories, and the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound power ratings.
   3. Material gages and finishes, including color charts.
   4. Dampers, including housings, linkages, and operators.
   5. Manufacturer’s standard color chart.
C. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
D. Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that include air flow, static pressure, and sound power levels for each of the second through sixth octave bands in dBA.
E. Certifications: Certify that air capacities, pressure drops, and selection procedures meet or exceed specified requirements.
F. Manufacturer’s Installation Instructions: Indicate support and hanging details, installation instructions, recommendations, and service clearance requirements.
G. Wiring diagrams detailing wiring for power and control systems and differentiating clearly between manufacturer-installed and field-installed wiring.
H. Maintenance data for air-handling units to include in the operation and maintenance manual specified in Division 01 and in Division 23 Section “Basic Mechanical Requirements.”
I. Operation and Maintenance Data: For fan filter units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE
A. Documented aspiration tests shall have been performed in conjunction with the fan performance test.
B. Sound testing shall be in accordance with AMCA 300.
C. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL where available.
D. Listing and Labeling: Provide electrically operated fixtures specified in this Section that are listed and labeled by a Nationally Recognized Testing Laboratory (NRTL) as defined in OSHA Regulation 1910.7.
E. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Lift and support units with the manufacturer’s designated lifting or supporting points.

1.7 PROJECT CONDITIONS
A. Field Measurements: Verify dimensions by field measurements. Verify clearances.

1.8 COORDINATION AND SCHEDULING
A. Coordinate the installation of equipment supports.

1.9 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 for each modular air-handling unit.
   1. Filters: Furnish one (1) additional set for each fan filter unit.
   2. Gaskets: Furnish one (1) additional complete set for each fan filter unit.

1.10 DEFINITIONS
A. ADR refers to the Aircuity Air Data Router
B. AWP refers to Aircuity’s Architectural Wall probe
C. BAS refers to the Building Automation System. (Similar terms are: EMS, Energy Management System; BMS, Building Management System; FMS, Facility Management System; or ATC, Automatic Temperature Control.)
D. DPB refers to Aircuity’s Duct Probe
E. FMC refers to the Facility Monitoring System Contractor. The FMC is the Contractor responsible for the implementation of this Section of the Specifications
F. FMS refers to the hardware, software and other components comprising the Facility Monitoring System as herein described
G. I/O refers to Input/Output. Thus, "I/O device" means "Input/Output device"
H. IMS refers to the Aircuity Information Management System
I. LACS refers to the Laboratory Airflow Control System
J. MD refers to the MD MicroDuct Tubing
K. OT refers to the OT Tubing
L. OSC refers to the OSC Structured Cable
M. PCM refers to a pump control module
N. RS refers to Aircuity’s Room Probe
O. SST refers to the Aircuity Sensor Suite

1.11 WARRANTY
A. Provide 18-month manufacturer warranty from the date of shipment for all fan filter units.

PART 2 - PRODUCTS
2.1 MANUFACTURERS
A. Volume Boxes: Subject to compliance with requirements, provide laboratory air volume control products by one of the following:
1. Phoenix Controls Corporation.
2. Accutrol, LLC.

B. Fan Filter Units: Subject to compliance with requirements, provide fan filter unit products by one of the following:
2. Terra Universal Incorporated

2-C. Facility Monitoring System (FMS): Subject to compliance with requirements, provide laboratory monitoring by Aircuity, Inc. Newton Massachusetts. No other manufacturers are allowed. Note, Lafferre Hall currently has Aircuity products on other floors within the building. This project shall fit out the 3rd Floor with sensors and accessories to tie into the existing systems currently installed.

2.2 LABORATORY AIRFLOW CONTROL SYSTEM
A. All laboratory airflow controls shall be provided to allow all supply air, general exhaust and fume hood exhaust to operate in a variable flow configuration. All electric actuators shall only be high speed on all control valves.
B. A laboratory airflow control system shall be furnished and installed to control the airflow into and out of laboratory rooms and reheat coils within those rooms. The exhaust flow rate of a laboratory fume hood shall be precisely controlled to maintain the indicated minimum and maximum airflows into the fume hood. The fume hood control shall be of variable air volume type. The laboratory control system shall vary the amount of makeup/supply air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain laboratory pressurization in relation to adjacent spaces (positive or negative) as indicated on the Drawings. The plans and specifications for the laboratory airflow control system are based on systems and equipment manufactured by Phoenix Controls Corporation.
C. Laboratory Airflow Control System Warranty: Warranty shall commence upon the date of shipment and extend for a period of thirty-six (36) months, whereupon any defects in materials or laboratory airflow control system performance shall be repaired by the supplier at no cost to the Owner.
D. Each laboratory space shall have a dedicated laboratory airflow control system.
E. The laboratory airflow control system shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood’s exhaust airflow to maintain a constant face velocity.
F. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position (with no more than 5% overshoot/undershoot) of required airflow. Rate of sash movement shall be between 1.0 to 1.5 feet per second.
G. The hood exhaust airflow control device shall be automatically switched between in-use and standby levels based on operator presence immediately in front of the hood. A presence and motion sensor shall activate the switching. The airflow control device shall achieve the required in-use command value in less than one second from moment of detection with no more than a 5% overshoot or undershoot.
H. The laboratory airflow control system shall maintain specific airflow (+/- 5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change (within 0.3-inch to 3.0-inch w.c., for low pressure valves, and 0.6-inch to 3.0-inch w.c. for medium pressure valves), airflow change, or quantity of airflow control devices on the manifold.
I. The laboratory airflow control system shall maintain a specific airflow (+/- 5% of signal) with a minimum 16 to 1 turndown to ensure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.
J. Airflow Control Valves (ACV):
1. The airflow control valve shall be a venturi air valve.
2. All valve controllers shall be shut-off type and high-speed electric actuators only. Coordinate location of each airflow control valve controller installation location individually with floor plans and all Contractor trades. Controllers must be installed in an accessible
3. The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure, irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system.

4. The airflow control device shall maintain accuracy within ±5% of signal over an airflow turndown range of no less than 16 to 1. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

5. The airflow control device shall be constructed of one of the following two types, Class A or Class B as described below.

6. Class A – The airflow control device for non-corrosive airstreams such as supply and general exhaust shall be constructed of 16 gauge aluminum. The device’s shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be spring grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, or polyester, or PPS (polyphenylene sulfide) composite.

7. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.

8. Class B – The airflow control device for corrosive airstreams such as fume hoods shall have a baked-on corrosion resistant phenolic coating. The device’s shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of Teflon or PPS (polyphenylene sulfide) composite.

9. An electric actuator shall be factory mounted to the valve. Loss of control power shall cause normally open valves to fail to maximum position, and normally closed valves to fail to minimum position.

10. Certification: Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of at least ±1% of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to ±5% of signal at a minimum of eight different airflows across the full operating range of the device.

11. All airflow control devices shall be individually marked with device specific, factory calibration data. As a minimum, it should include: tag number, serial number, model number, eight point characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.

12. The airflow control device shall use closed loop control to linearly regulate airflow based on a 0 to 10 volt control signal. The device shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow.

K. Neutralizer: Provide a neutralizer to be used in conjunction with general exhaust and supply air valves. See plans for locations.

1. The attenuator shall consist of resonator chambers that are tuned to the output frequencies of the air valve, providing a reduction in sound power levels over the entire sound spectrum.

2. Construction: 24 gauge galvanized steel.

3. Field provided square to round transition is required for single valve units.

4. The pressure drop across the device shall be less than 0.1-inch w.c.
2.3 FAN FILTER UNITS

A. General:
1. The fan filter unit shall be supplied to provide unidirectional supply air at controlled discharge velocities. The units shall include a High Efficiency Particulate Air (HEPA).
2. Modules sizes, electrical characteristics, efficiencies, capacities, and options shall be as scheduled on drawings.

B. Performance:
1. The unit shall provide filtered air tested at an average velocity of 90 fpm (+/- 15 fpm) measured 12 inches from the face of the unit in accordance with IEST-RP-CC0022.2.
2. The room sound level shall be less than 55 dBA when measured at 30 inches from the filter face at 90 fpm average face velocity in accordance with IEST-RP-CC0022.2.
3. The unit is to be factory sealed and tested to assure leakage is consistent with the filter.

C. Construction:
1. Plenum material shall be:
   a. Aluminum.
2. Face material shall be:
   a. Expanded metal grille with powder-coat paint finish
3. Plenum shall be walkable up to 250 lbs.
4. The diffuser plenum shall feature four (4) eyebolts at each plenum corner for securing the unit to structural supports above the ceiling.
5. The 51% free-area perforated distribution plate shall be secured to the face using quarter-turn fasteners with anti-slip, snap-in retainers and stainless steel retainer cables for ease of installation and removal.
6. Inlet: standard round or optional rectangular collar for non-ducted applications.
7. Eye bolts for hanging shall be mounted on the top four (4) corners of the plenum and capable of each supporting 75 lbs.

D. Filters:
1. The filter shall be framed in extruded aluminum with an integral cavity filled with a urethane gel to provide a leak-tight seal between the filter frame and the border.
2. Filter type shall be:
3. High Efficiency Particulate Air (HEPA) filter shall provide 99.997% efficiency on .30 μm particulate, with an initial pressure drop of 0.45” wg at 100 fpm.
4. Filter shall be UL 900 classified.
5. Filter pack depth shall be 2.5”.
6. Filter media shall be borosilicate micro-fiberglass.
7. Filter shall be:
   a. Bench top removable and replaceable, mounted in an extruded aluminum frame with an upstream gasket. Bench top replaceable filters shall be supplied with a room-side accessible static pressure port in an extruded aluminum center divider.

E. Plenum Finish shall be:
1. All aluminum components shall have B12 White baked-on powder coat finish.
   a. The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.
   b. The paint film thickness shall be a minimum of 2.0 mils.
   c. The finish shall have a hardness of 2H.
   d. The finish shall withstand a minimum salt spray exposure of 1000 hours.
   e. The finish shall have an impact resistance of 80 in-lb.

F. Face and frame finish shall be:
1. All aluminum components shall have White B12 Standard baked-on powder coat finish.
a. The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.

b. The paint film thickness shall be a minimum of 2.0 mils.

c. The finish shall have a hardness of 2H.

d. The finish shall withstand a minimum salt spray exposure of 1000 hours.

e. The finish shall have an impact resistance of 80 in-lb.

G. Fan:
1. The centrifugal type fan shall be supplied with rubber mounts to isolate the motor/blower assembly from the diffuser plenum. Fans are to be of metal construction with a direct drive:
   a. Forward curved impeller
   b. Backward curved impeller

2. Plastic construction shall not be acceptable.

H. Electrical Systems:
1. Single point power connection.

I. Fan Motor:
1. The fan motor shall be:
   a. Electrically Commutated Motor (ECM):
      1) Constant Torque Program
         a) A constant torque program shall be provided to allow the ECM to vary the airflow with fluctuations in both upstream static pressure and filter pressure drop.
         b) The constant torque program shall prevent unexpected motor operation or motor shutdown due to upstream static pressure fluctuations.
         c) The constant torque program shall be used for ducted applications where fluctuations in upstream pressure may occur.
      2) Constant Flow Program
         a) A constant flow program shall be provided to allow the ECM to compensate for fluctuations in both upstream static pressure and filter pressure drop, providing constant airflow.
         b) The constant flow program shall be used for non-ducted applications where the inlet static pressure is zero or slightly negative.
         c) Fan motor shaft directly connected to fan and isolated from casing to prevent transmission of vibration.

2. Fan motor shall have internal thermal and overload protection.
3. Fan motor shaft shall be directly connected to the fan impeller, and isolated from casing to prevent transmission of vibration.
4. Fan motor shall be supplied with a motor speed controller (select one):
   a. ECM standard speed controller
      1) The ECM speed controller shall operate on 24 VAC supply voltage.
      2) The ECM speed controller shall have dual outputs to control up to two motors simultaneously.
      3) The ECM speed controller shall be supplied with a BAS interface to accept 2-10 VDC signal for variable speed remote control, as well as be able to remotely shut off via BAS signal.
      4) The ECM speed controller shall be supplied as a wall mounted kit, shipped loose for field installation.

J. Options:
1. Filter replacement style:
   a. Bank Top replaceable filter
K. Pre-filter:
   1. Non-ducted units:
      a. Unit shall be provided with 25-30% MERV 4 washable pre-filter.
   2. Ducted units:
      a. Unit shall be provided with 25-30% MERV 4 washable pre-filter with side access filter housing.

L. Disconnect Switch: A factory supplied disconnect switch shall be provided for disconnection of power to the terminal block.

M. Power cord:
   1. An eight foot (2.4 m) power cord shall be supplied for use with a 115 V power supply.

N. Motor/blower access:
   1. Room side access

O. Filter status indicator shall be communicated by:
   1. LED Indicator light:
      a. The LED indicator light shall be visible from the occupied area to determine the filter loading status without opening the diffuser.
      b. The LED light shall turn from green to yellow when the pressure drop across the filter exceeds the specified limit.
      c. The LED kit shall be provided with a switch, factory pre-calibrated for 150% of initial clean filter pressure drop.
      d. The LED kit shall operate on a 24 VAC power supply, provided by others.

P. Motor status shall be communicated by:
   1. Motor status LED:
      a. The LED indicator light shall be visible from the occupied area to determine the motor operating status without opening the diffuser.
      b. The motor LED shall be green to indicate normal motor operation, and that the unit static pressure is above 0.2” wg.
      c. The motor LED shall turn from green to red when the motor is not in operation, and when the unit static pressure is below 0.2” wg.
   2. Motor status BAS signal:
      a. The factory-calibrated motor BAS signal shall close a dry contact to generate a BAS signal when the motor is not operating.
      b. Unit shall be field wired to the terminal block according to manufacturer’s instructions.

2.4 FACILITY MONITORING SYSTEM (FMS)

A. General:
   1. The purpose of the FMS is to establish with extreme precision the proper amount of ventilation needed based on analysis of the air within the facility for airborne contaminants. This analysis will involve precise comparison between air within any space being ventilated and the air being supplied to it, the air outside the building, or both as indicated in specific applications.
   2. Data captured during the analysis and through the ventilation management process will be analyzed and formatted into a host of on screen displays, analytical reports, and analysis based notification of operational deficiencies. These analyses will encompass data sets gathered over time, and should not be confused with simple alarm notifications.
   3. The system architecture shall utilize local room, duct and outside air probes networked to distributed Air Data Routers and Sensors Suites communicating over a data and air sampling network. The air sampling network shall consist of an air packet transportation network that shall transport air samples from the environment being monitored to distributed Sensor Suites located throughout the facility. The air sampling network shall
consist of intelligent air packet routers, an electrically conductive MicroDuct® network, Structured Cable and where applicable MD or OT Tubing. Gathering of air samples shall occur via room, wall, duct mounted, and outside air sampling probes located as indicated in the documents.

4. The FMS shall provide continuous monitoring of environmental conditions and ventilation performance as prescribed in the Sensor Suite section. With an active Aircuity Services Commitment the FMS shall provide protected information access via a web based user interface to analytical summaries, and in onscreen graphical form, system reports and analysis based notifications. Web-based utilities are to be included to export FMS data as a comma separated values (.csv) file format. The FMS shall interface with other analog and microprocessor based building subsystems as shown on the drawings, specified herein and in other sections.

B. Acceptable Facility Monitoring System Contractor (FMC)

1. The FMC shall have support services within a 200-mile radius of Project Site and comply with the service requirements of a three (3) hour response time. Any technicians working on the FMS will be certified by the FMS manufacturer for such work. Support services is defined as having access to complete parts inventory, having all required test and diagnostic equipment, and having factory certified technicians on the systems specified herein.

C. Contractor Responsibilities

1. The FMC shall furnish all necessary hardware, wiring, Structured Cable, Tubing, computing equipment and software required to provide a complete and functional system necessary to perform the design intent and as defined in this specification.

2. Installation of all FMS components; and all electrical work required as an integral part of this section as noted in Part 3 Execution including but not limited to Sensor Suites, Air Data Routers, Room, Wall, Duct, and Outside Air Probes, Transformers, Vacuum Pumps, Information Management Systems, Structured Cable, MD Tubing, and where applicable OT Tubing, etc.,

D. Contractor (FMC) Experience and Performance

1. The FMC shall have a local office or representative, staffed with factory certified technicians, fully capable of providing instruction, routine maintenance, and emergency maintenance service on all system components. The FMC shall be responsible for replacement of all products supplied at all times for a period of not less than 1 year following project completion and shall provide a three hour response to a service/warranty call from the owner.

E. The FMC shall provide all zone attribute data and programming and shall coordinate object naming conventions and network map requirements with the Owner’s internal BAS department. The naming convention shall be submitted with the FMC Shop Drawings for review and approval by Owner’s BAS department.

F. Products:

1. Air Data Routers

   a. The Air Data Router shall be furnished as a complete, self-contained, unit housing all electronics, air solenoid valves, sampling manifolds, firmware, and software. Unit shall be furnished with all internal devices and wiring assembled and tested at the factory.

   b. The Air Data Router shall feature backbone connections capable of accepting OSC Structured Cable for the purpose of daisy chaining all ADRs. MD Tubing and OT Tubing shall not be used to daisy chain ADRs.

   c. Air Data Routers shall receive commands from the Sensor Suite to open the solenoid valve of each test area to be monitored while simultaneously closing all other solenoid valves in the system. A direct path between the test area being sampled and the virtual sensors located with the Sensor Suite shall be established to draw
a continuous stream of air through the OSC backbone and OSC/MD/OT test area connection.

d. Air Data Routers shall consist of an enclosure; terminations areas for both field wiring and Structured Cable and MicroDuct or, with the provision of enlarger fittings (catalog number OT-E11), OT Tubing connections; a communications/processor board; high capacity solenoid valves; and sampling manifold.

e. Air Data Router shall have the ability to interface with the OSC Structured Cable, MD Tubing, or OT Tubing. Air Data Router shall utilize an internal, factory pre-assembled air sampling manifold to interface to the on-board solenoid valves, and push to connect speed fittings for ease of interface to the Structured Cable and MD Tubing or, with the provision of enlarger fittings (catalog number OT-E11), OT Tubing. Romex connectors and knockouts shall be factory furnished and installed on the Router.

f. Air Data Routers shall be capable of sampling of up to four locations.

g. Air Data router shall be capable of accepting universal 0−10Vdc or 4−20mA inputs and outputs through expansion boards for interfacing to other third party devices and controllers.

h. Up to 30 Air Data Routers shall communicate on an isolated RS-485 network with the Sensor Suite.

i. All point data, algorithms and application software within the Air Data Routers shall be programmable from the Information Management System. Each Air Data Router shall contain both software and firmware to receive and perform full test sequencing schemes downloaded from the System.

j. Each Air Data Router shall contain a serial port for the interface with a portable computer. Air Data Router and network integration shall be possible through this port.

k. Air Data Routers shall be capable of proper operation in an ambient temperature environment of 40 degrees F to 120 degrees F (4.4°–49°C), 0–90% RH (non-condensing).

l. Air Data Routers shall have LED indication for visual status of communication and power.

m. Air Data Routers shall operate on 24Vac power fed from a common 120/24Vac transformer. Low voltage power shall be distributed to the Air Data Routers through the associated Structured Cable.

2. Sensor Suites

a. The Sensor Suite shall be a distributed, network based, multipoint sensing device. The Sensor Suite shall be furnished as a complete, self-contained unit housing all electronics, sensing card cage, sampling manifolds, flow regulators, pressure regulators, firmware, and software.

b. The Sensor Suite shall provide communications between the Air Data Router sub network and the Information Management System over an isolated RS-485 network. The Sensor Suite shall support communications with a sub network of 30 Air Data Routers; 30 other Sensor Suites, and an Information Management System.

c. The Sensor Suite base unit shall consist of an enclosure; hinged door with keyed lock; terminations area for both field wiring and Structured Cable subnet connections for limb A and B; a communications/processor board; electronic flow measurement and controller assembly; and sensor bay.

d. The Sensor Suite shall utilize a card cage to allow for the ease of selection and installation of a diverse array of environmental and specialty sensors. At a minimum, the Sensor Suite shall incorporate the following sensors to meet the required applications:
Overview

1) The Laboratory Airflow Control System (LACS) will control the airflow control valves in response to the greatest of three demands:

2) Temperature control
3) Fume hood demand
4) Multi-Parameter DCV (MpDCV) command from the FMS
5) The temperature controls and fume hood controls will operate independent of the FMS and shall override the MpDCV command when required to maintain comfort, space pressurization, and well-being.
6) The FMS will provide analog proportional MpDCV signals that correspond to the contaminant levels (TVOC, particles, CO2, etc.) sensed within the General Exhaust (GEX) duct probe(s) for each lab as indicated in Table 1 below.
7) The Aircuity system shall provide an MpDCV signal that corresponds to an Air Change per Hour (ACH) ventilation rate that is defined by the contaminant levels (TVOC, Particles, CO2, etc.) sensed within the Laboratory. These sensed parameters shall be measured against a supply air reference point that shares the same sensor set and is representative of the air being supplied to the space, typically at the Air Handling Unit, to provide a space-specific differential measurement. This differential measurement shall be converted to an MpDCV signal in ACH based on a prescribed control range for each contaminant type and sent to the LACS.

Reduction in Minimum Ventilation Setpoint, Air Changes per Hour (ACH)

8) When the GEX air contains a contaminant (e.g. TVOC, particles, CO2, etc.) concentration, as sensed by the FMS, that is below minimum setpoint (configured within the LACS) the minimum airflow setpoint within the LACS shall be reset to [4] ACH during occupied hours and [2] ACH during unoccupied hours. The actual lab ACH shall be dynamic and equal to the higher of the temperature control demand, the fume hood exhaust demand, and the MpDCV command from the FMS.

Increase in Air Changes per Hour (ACH)

9) When the GEX air contains a contaminant concentration, as sensed by the FMS that is above high setpoint (configured within the LACS) the minimum airflow setpoint within the LACS shall be reset to a maximum ACH of 18 during both occupied and unoccupied hours.

10) For GEX contaminant concentration levels that are between the low and high setpoints, the LACS shall correspondingly and proportionally increase the minimum airflow during both occupied and unoccupied hours.

11) Once the GEX air contains a contaminant concentration, as sensed by the FMS that is below setpoint (configured within the LACS) the minimum airflow setpoint within the LACS shall be reset as described above.

12) Table 1 – DCV Signal and Differential Contaminant Ranges:

<table>
<thead>
<tr>
<th>Signal</th>
<th>DCV Signal (ACH)</th>
<th>TVOCs – PID</th>
<th>TVOCs-MOS</th>
<th>CO2</th>
<th>Particles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0.1</td>
<td>0.3</td>
<td>300</td>
<td>500,000</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>1</td>
<td>3</td>
<td>3,000</td>
<td>5,000,000</td>
</tr>
</tbody>
</table>

13) The above sequence of operations assumes the pneumatic and electrical integrity of the FMS system is in good working order and is functioning as designed. However, there are instances where the FMS may produce invalid or no data (i.e., during a scheduled sensor swap, when the systems are shut down, or upon a catastrophic system failure). To safely
To accommodate these scenarios, the following failsafe logic should be programmed into the BAS/LACS:

15) For installations where the FMS is integrated with the BAS/LACS via BACnet, the BAS/LACS shall not only read the present values of each BACnet point, but also the reliability property of each BACnet point.

16) While operating in any mode, in the event that the reliability property of a BACnet point generated by the FMS in any particular room(s) switches from a “Reliable” state to an “Unreliable” state, the BAS/LACS shall:
   a) Issue an alarm for those affected rooms, and
   b) Ignore any MpDCV value produced by the FMS for those affected room(s), and command the minimum air change rate in each affected room back to their code-prescribed minimum air change rate values.

17) The LACS shall be allowed to resume normal operational control sequence only after the reliability properties of all associated BACnet point have switched back to a ‘reliable’ state.

18) For installations where the FMS is integrated with the BAS/LACS via hardwired analog control wiring, the specified control ranges shall be either 4-20mA, 1-5V, or 1-10V (forward or reverse acting).

19) With this approach, during any mode of operation, any analog signal read by the BAS/LACS of 0mA or 0V shall be interpreted as a system failure or a loss of communication with the FMS.

20) When this occurs, the BAS/LACS shall issue an alarm for those affected rooms and drive those same rooms to their code-prescribed minimum air change rate values until the associated analog signals return to their normal signal ranges.

21) For installations which utilized BOTH integration methods described above, both approaches for configuring failsafe values shall be utilized to ensure the safest possible sequence of operation and integration methods for all occupants of the rooms.

- The Sensor Suite shall have the ability to “multitask” by concurrently drawing an air sample from one limb while sensing the parameters of the air sample in the other limb.
- The Sensor Suite shall be modular in nature and allow for the addition and removal of the sensors for application specific sensing requirements, and ease of calibration and service.
- The Sensor Suite shall house an on-board flow regulator, orifice plate, and differential pressure sensor to maintain a continuous, regulated flow rate through the Structured Cable.
- On-board diagnostics shall continuously perform system checks.
- The Sensor Suite will continuously monitor atmospheric pressure and compensate sensor outputs accordingly as the atmospheric pressure changes.
- Each Sensor Suite shall contain a serial port for the interface with a portable computer. Sensor Suite and network integration shall be possible through this port.
- Sensor Suites shall be capable of proper operation in an ambient temperature environment of 40 degrees F to 120 degrees F (4.4°–49°C), 0–90% RH (non-condensing).
- Sensor Suites shall have LED indication for visual status of communication and power.
- Sensor Suites shall operate on 24Vac power fed from a common 120/24Vac transformer connected to the Sensor Suite provided by the FMC.
- To mitigate the potential for Sensor Suite failure, the Sensor Suite shall not be mounted to the same support structure as the vacuum pumps.
3. **High Flow Vacuum Pump**
   
   a. EACH Sensor Suite will be equipped with a High Flow Vacuum Pump (HFP) that will draw samples from the sampling ports in the system, through the Sensor Suite, and then discharge them. Samples will be discharged into the nearest exhaust duct so the samples may be discharged directly from the building.
   
   b. EACH Sensor Suite will be provided with a Pump Control Module (PCM) card for monitoring system vacuum pressure and, for systems featuring dual pump systems, controlling automatic pump switchover upon primary pump failure.
   
   c. The HFP105/106/205/206 will meet the following specifications:
      
      d. Minimum Vacuum Pressure: -8.5 PSig
      e. Minimum Flow Rate: 29 LPM (1.02 SCFM)
      f. Pump mounting: Pump shall be mounted securely using the factory supplied mounting assembly to prevent it from moving due to vibration, and in a location where the sound of the pump will not be heard outside the immediate area. The pump mounting assembly shall not be secured to the same structure as the IMS or Sensor Suite.
      
      g. Standby pump with automatic switchover: Provides a second pump, identical to the first, with an automatic switchover controller that will automatically take over should the on-line pump stop for any reason other than a complete failure of all local AC power. In the event this occurs, or if some other event occurs resulting in a loss of vacuum at the SST, the standby pump will be placed in operation and a notification will be sent to the Aircuity remote monitoring team, notifying customer support that the backup pump is in operation, prompting a field visit. At any point, if there is a sustained loss of vacuum at the SST, a notification will be sent to the Aircuity remote monitoring team, and all BACnet points whose integrity is affected by the loss of vacuum condition will be marked as “unreliable”, which can be observed by the BMS, so that they can respond accordingly. The notification will be reset once the loss of vacuum condition is remedied.

4. **OSC Structured Cable**
   
   a. The FMS shall utilize a pre-engineered system of Structured Cable to facilitate network wide communications, distribution of low voltage power to Air Data Routers and Sensor Suites, and provide a sampling conduit for air samples all within a single cable.
   
   b. The cable shall contain the necessary wires to distribute communications, data and low voltage power throughout the FMS. As a minimum, Structured cable shall consist of:
      
      c. Communications – 22 AWG twisted shield pair with drain wire
      d. Low Voltage Power – 18 AWG, 3 wire
      e. An inner pathway, MicroDuct, shall be furnished as an integral part of the OSC Structured Cable to facilitate collection of zone air samples. MicroDuct shall be lined with a smooth, electrically conductive, chemically inert surface to ensure air samples remain pure and uncorrupted and do not adhere to the wall lining during transport.
      
      f. Structured Cable shall not require any specialized tools for installation. Installation of the cable shall follow traditional local area network practices.
      
      g. Structured Cable shall carry incremental length markings (in feet) throughout the cable length.
      
      h. The minimum length of Structured Cable run between an ADR test area connection and an end device shall be no shorter than 20’ (6.1 m).

5. **Vacuum Pump System Tubing**
a. Vacuum Tubing shall be 0.5” OD x 0.375” ID (1.27 OD x 0.95 ID cm), dimensionally stable and shall conform to NFPA 90A flame and smoke spread indices for return air plenum installations.

b. Vacuum Tubing shall not require any specialized tools for installation. Installation of the Tubing should follow the customer’s building standards.

6. Sensors

a. Sensors are the property of Aircuity whose warranty is covered under the Aircuity Services Commitment agreement.

b. Sensors shall be installed in a listed enclosure (the Sensor Suite) in a climate-controlled environment which is maintained between 40°F–120°F (4.4°C–49°C) and 0–90% RH (non-condensing).

c. Quality of sensors: All sensors shall possess the properties published in section 2.5-B.4 of this specification. For each set of installed sensors a certificate of calibration shall be made available for viewing on MyAircuity.com.

d. Sensors shall be physically removed from the sensor suite, and replaced with freshly calibrated sensors a minimum of every 6 months after the initial sensor installation.

e. Immediately after replacement, sensors are to be shipped back to Aircuity in the postage paid return box provided by Aircuity.

G. System Software Overview

1. The FMC shall provide all software required for configuration, operation and commissioning of the FMS system specified herein. All functionality described herein shall be regarded as a minimum. The FMC shall provide the following as a minimum:

2. Completed database.

3. Configuration of all Air Data Router, Sensor Suite, System and user interface application programs.

4. All Configuration Tools, and all software licenses, required to configure and operate all products installed on this project.

5. The ability to override raw sensed data for the purposes of commissioning the system after integration with a BMS.

b.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the fans, laboratory air volume control products, and other system components. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Verify that conditions are suitable for installation.

C. Verify that field measurements are as shown on the drawings.

3.2 INSTALLATION

A. Install fans filter units according to manufacturer’s written instructions.

B. Install units with clearances for service and maintenance.

C. Install in accordance with manufacturer’s instructions.

D. See drawings for the size (s) and locations of fan filter unit inlets.

E. Support components individually from structure in accordance with SMACNA (SRM).

F. Do not support components from ductwork.

G. Laboratory Airflow Control System Installation:
1. Install the sash sensors, interface boxes, and fume hood monitor on the fume hood under initial supervision of the laboratory airflow control system supplier. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels. Sash interface boxes with interface cards shall be mounted in an accessible location.

2. Install the laboratory control unit (if panel-mounted) and wall-mounted power supply (as required) in an accessible location in the designated laboratory room.

3. Terminate and connect all cables as required. In addition, integrated laboratory control unit connectors shall be furnished by this contractor.

4. Install all airflow control devices in the ductwork and connect all airflow control valve linkages.

5. Connect Neutralizer with sheet metal screws. Seal any gaps with duct sealant. Assemble multiple units according manufacturer’s recommendation. Install attenuator with airflow direction arrow pointing in the direction of airflow. The attenuator shall be installed between the valve and the first air device (diffuser, grille, or register).

6. Perform all controls work in complete and strict accordance with Division 23 Section “Control Systems.”

H. Facility Monitoring System Installation:

1. General
   a. Install all equipment and systems specified herein in accordance with the manufacturer’s most current version of the installation guide. In the event of conflicting information between this document and the installation guide, the most stringent requirement shall apply.
   b. Verify that mechanical and control systems are complete and ensure that the systems are capable of being started and operated in a safe and normal condition before attempting to operate the FMS.
   c. Install software in the Management System. Implement all features of programs to specified requirements and as appropriate for sequence of operation.
   d. Connect and configure equipment and software to achieve sequence of operation specified.

2. Wiring Installation
   a. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division 26 sections of these specifications.
   b. All wiring shall be installed neatly and professionally, in accordance with requirements of applicable Specification Division 26 section and all national, state, and local electrical codes. All the wiring shall be installed in accordance with the current National Electrical Code (NEC).
   c. Provide wiring as required by functions as specified and as recommended by equipment manufacturer to serve specified control functions.
   d. Install wiring and cables according to Division 26 section and as follows:
   e. Bundle and harness multi-conductor cable in place of single cables where several cables follow a common path.
   f. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   g. All exposed control wiring and control wiring in the mechanical, electrical, telephone, and similar rooms shall be installed in raceways. All other wiring shall be installed neatly and inconspicuously.
   h. All control wiring shall be installed in a neat and workmanlike manner parallel to building lines with adequate support. Both conduit and plenum wiring shall be supported from or anchored to structural members. Conduit or plenum wiring supported from or anchored to piping, duct supports, the ceiling suspension system, is not acceptable. Wiring buried in slab-on-grade concrete or explosion-
proof areas shall be in rigid metal conduit. Provide adequate strain relief for all field terminations.

3. Field Device Installation
   a. All room and wall probes shall be mounted so as to be accessible in accordance with ADA Guidelines, unless otherwise noted on the drawings.
   b. Freestanding enclosures and panels shall be supported on steel unistrut frames, or approved equal, and be securely anchored to the floor and be well braced.
   c. Enclosures and panels mounted directly to the wall shall be provided with all clearances required by the manufacturer’s installation guide.
   d. A minimum of 3’ (1 m) working clearance shall be provided in front of all enclosures and panels; clearance shall be ensured to permit the enclosure door to open at least 90° from its closed position.
   e. Mounting height shall be a maximum 6’-6” (2 m) to the top of the Sensor Suite enclosure.
   f. All field devices shall be installed in a location which is easily accessible after installation for the purposes of troubleshooting & future modifications.
   g. IMSs and SSTs shall not be installed on the same support structure or wall as the vacuum pump bracket.

4. Control Power
   a. Class 2 step-down transformers shall provide 24VAC power for all Air Data Routers, Sensor Suites, and associated FMS components from nearest electrical power panel noted below or as indicated on the electrical drawings—coordinate the installation and location thereof with Electrical Contractor and all other trades.
      1) The primary side of all Class 2 step-down transformers shall be fed by dedicated branch circuits with grounding conductors from the nearest building electrical distribution power panel. Branch circuits shall be installed per local state and federal codes by a licensed electrician.
      2) The secondary side of all class 2 step-down transformers, used for the purposes of providing power to Air Data Routers, Sensor Suites and associated FMS components, shall not be grounded.
      3) It is highly recommended that the IMS and OSI (if applicable) be powered from a power source with power loss and surge protection. The IMS and OSI shall be powered from a 120VAC dedicated power receptacle installed per local state and federal codes by a licensed electrician.
      4) Where applicable, all FMS equipment shall be powered by the same source of emergency power as the air handling units and BAS themselves. For example, if the Air Handling units are served by the building’s generators, the FMS must also be served by the generators.

5. Final Installation of Critical Sensors
   a. Sensors will be held at the manufacturer’s location and not shipped to the site until checkout & startup of the all other portions of the FMS is complete, and mechanical systems are operational and ready to implement the sequences that will result in ventilation being performed on demand as indicated by the FMS.

6. Acceptance of Completed FMS Installation
   a. Upon completion of the installation, the FMC shall initiate the Optimization phase of the start-up process for the Aircuity system and perform all necessary calibration, testing, and debugging operations including, but not limited to, the vacuum decay test. An acceptance test shall be performed by the FMC in the presence of the design engineer, job site project manager, and owner’s representative. Acceptance test shall be scheduled with at least 10 working days advance notice. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections.
b. After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.

c. Demonstrate compliance with specifications, including calibration and testing, and air sampling test sequences. Adjust, calibrate, and fine tune equipment to achieve sequence of operation specified.

d. The acceptance test shall include, but not be limited to:
   1) The FMC shall verify the proper operation of all input/outputs.
   2) The FMC shall verify all inputs meet or exceed manufacturer’s stated tolerances for accuracy.
   3) The FMC shall verify that all on-line graphical displays of air sampling test data accurately represent the real time state of the field conditions.
   4) The FMC shall verify the reliability of all communications of all Air Data Routers and Sensor Suites.
   5) The test shall include functional verification of all interfaces and system integration required to meet the scope of this project.
   6) Participation in a joint session with the BAS contractor to demonstrate that the complete sequence of operation is being executed accordingly.

e. Acceptance: When the field test procedures have been successfully demonstrated to the design engineer, job site project manager, or owner’s representative and the system performance is deemed satisfactory, the system parts will be accepted for beneficial use and placed under warranty. At this time, a "notice of completion" shall be issued by the owner's representative and the warranty period shall start.

6. CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts and duct accessories.

B. Electrical: Conform to applicable requirements in Division 26 Sections. Connect wiring and ground equipment according to Division 26 Sections.

3.4 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of fans, including duct and electrical connections, and to report results in writing.

3.5 ADJUSTING & CLEANING

A. Adjust damper linkages for proper damper operation.

B. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

C. Clean fan interiors to remove foreign material and construction debris. Vacuum clean fan wheel and cabinet.

D. Lubricate all bearings.

E. Ensure supply air to the fan filter units by performing pitot traverse on the main supply duct.

F. Balance outlets according to manufacturer’s recommendations.

G. Verify that field measurements are as shown on the drawings.

3.6 COMMISSIONING

A. Perform the following operations and checks before startup of exhaust fans:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices, and that connections for ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnects.
   3. Perform cleaning and adjusting specified in this Section.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operation. Reconnect fan drive system.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in the fully open position.

B. Starting procedures for fans are as follows:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel.
2. Adjust fan to indicated RPM.
3. Measure and record motor voltage and amperage.
4. Replace fan and motor as required to achieve design conditions.

3.7 DEMONSTRATION

A. Train Owner’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
B. Review data in the operation and maintenance manuals. Refer to Division 01.
C. Schedule training with Owner, through Architect, with at least 7 days’ advance notice.
D. Demonstrate operation of products specified in this Section. Conduct walking tour of the Project. Briefly identify location and describe function, operation, and maintenance of each product.
E. Laboratory Airflow Control System Start-Up: System start-up shall be provided by a factory authorized representative of the laboratory airflow control system manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, and general exhaust) and system programming.

F. The laboratory airflow control system supplier shall furnish a minimum of four hours of owner training, by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves, and general troubleshooting procedures. Operation and Maintenance manuals, including as-built wiring diagrams and component lists shall be provided for each training attendee.

G. The FMC shall provide factory-trained instructor to give full instructions to designated personnel in the operation, maintenance, and programming of the system. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The training shall be specifically oriented to the system and interfacing equipment installed.
1. Instructions shall include 2 parts, the “New Equipment Orientation” and the “Product & Service Training”.
2. New Equipment Orientation: A “walk-through” session shall include showing where all field equipment is located throughout the area involved in the project.
3. Product & Service Training: Train on-site personnel on the navigation and interpretation of the data and information provided by the system.
   a. Train personnel on procedures and schedules for troubleshooting, servicing, and maintaining equipment.
   b. Train personnel on using the web based user interface and data management system.

END OF SECTION