

DIVISION 13

SPECIAL CONSTRUCTION

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SECTION 13 21 00 – CLEANROOM CONSTRUCTION

PART 1 - GENERAL

1.1 SUMMARY

- A. Drawings and general provisions of the Contract, and Division 1 Sections apply to work of this Section.
- B. This specification details construction features, components, installation, performance capabilities and design requirements for a complete engineered field-fabricated environmental cleanroom.
- C. The cleanroom shall be the product of a manufacturer/installation contractor regularly engaged in the business of designing, manufacturing, installing, and certifying cleanrooms.
- D. The manufacturer/installation contractor shall guarantee that the performance of the complete cleanroom will meet all the performance criteria established by this specification.
- E. The cleanroom manufacturer/installation contractor shall provide certification from a third party source.

1.2 REFERENCES

- A. International Standards Organization (ISO): Air cleanliness classification for cleanrooms and definition of terms for cleanroom work shall be in accordance with ISO 14644 Class 4, 5 and 6 (Formerly Class 10, 100 and 1,000).
- B. All cleanroom construction shall be in accordance with International and Local building codes.

1.3 RELATED DOCUMENTS

- A. General and Supplementary Conditions and Division 1
- B. Other Division 9 sections for floor finishes related to this section but not the work of this section.
- C. Division 6 Wood and Plastics; not the work of this section.
- D. Section 13 21 01 – Cleanroom Performance Testing
- E. Section 13 21 05 – Cleanroom Construction Protocol
- F. Section 13 21 40 – Cleanroom Fume Hoods and Other Air Containment Units
- G. Division 21: Fire Suppression

H. Division 22: Plumbing

I. Division 23: HVAC

J. Division 26: Electrical

1.4 DEFINITIONS

A. Clean Zone: A defined area, including the cleanroom and adjacent spaces that are exposed to the cleanroom supply and return airstreams.

B. HEPA Filter: High efficiency particulate air filter.

C. Protocol Level: The phase or degree of construction completion that mandates specified activities, training, security clearance, dress, work means and methods, cleaning procedures, and system performance to maintain the cleanliness of the clean zone.

D. Protocol Manager: The person vested with authority by the Cleanroom Protocol Contractor to supervise all construction personnel working within the Clean Zone and ensure requirements of the contract documents are met in completion of the Clean Zone construction.

E. ULPA Filter: Ultra-High efficiency particulate air filter.

1.5 PERFORMANCE REQUIREMENTS

A. Clean spaces are classified according to ISO 14644. Verification of room and air cleanliness shall be by measurement of the concentration of airborne particles at or above the size limits given below.

B. Classified spaces shall be as follows:

1. Refer to project drawings.

C. Airborne particulate cleanliness classification:

1. ISO Class 4 (formally Fed Std 209E Class 10); as-built; 0.1 μm (10,000 particles/ m^3), 0.2 μm (2,370 particles/ m^3), 0.3 μm (1,020 particles/ m^3), 0.5 μm (352 particles/ m^3), 1.0 μm (83 particles/ m^3).

2. ISO Class 5 (formally Fed Std 209E Class 100); as-built; 0.1 μm (100,000 particles/ m^3), 0.2 μm (23,700 particles/ m^3), 0.3 μm (10,000 particles/ m^3), 0.5 μm (3,520 particles/ m^3), 1.0 μm (832 particles/ m^3), 5.0 μm (29 particles/ m^3).

3. ISO Class 6 (formally Fed Std 209E Class 1,000); as-built; 0.1 μm (1,000,000 particles/ m^3), 0.2 μm (237,000 particles/ m^3), 0.3 μm (102,000 particles/ m^3), 0.5 μm (35,200 particles/ m^3), 1.0 μm (8,320 particles/ m^3), 5.0 μm (293 particles/ m^3).

D. Particle count within room space shall not exceed limits for above mentioned classifications as defined by ISO Class 4 – 6 throughout room at an elevation of 760 mm (30 inches) above floor level.

E. Levels of cleanliness apply while Cleanroom is at an "At Rest" condition.

1.6 DESIGN REQUIREMENTS

A. Environmental:

1. Refer to project drawings.

B. Room Pressure and Leakage:

1. Overall leakage rate of entire room and air handling system should not exceed 3 percent of total air supply with all doors closed and room in occupied condition. Positive pressure shall be sustained in operational Cleanroom spaces in accordance with the Drawings and with all equipment operating at design capacity.

<u>Cleanliness Class</u>	<u>Positive Pressure (leakage)</u>
ISO 4 (FS Class 10)	0.5 percent to 1 percent
ISO 5 (FS Class 100)	0.5 percent to 1 percent
ISO 6 (FS Class 1,000)	1 percent to 2 percent

2. When an entry door is opened, outward airflow shall be maintained. Special attention shall be directed to ensure an airtight enclosure by caulking, including penetrations for ductwork, piping, conduits, etc., to minimize air leakage.

1.7 SUBMITTALS **DRAFT (NOT FOR CONSTRUCTION)**

- A. Provide samples of each type of product materials, support components, finishes, and accessories illustrating installed products, finishes, and color.
- B. Detailed manufacturer product data sheets, for each proposed product type, which provides the necessary information to describe and evaluate the product and its performance. Provide MSDS product data for all materials and finishes used in the cleanroom (sealants, paints, powder coating, etc.).
- C. Shop Drawings: Submit complete shop fabrication and installation drawings, including plans, elevations, sections, details, schedules, and 3-dimensional layouts (as necessary). Minimum scale shall be $\frac{1}{4}'' = 1'$. Show relationship to adjoining materials and construction. Shop drawings shall depict final product design and installation. Shop drawings shall be prepared electronically and submitted in the form of reproducible or photocopies, prepared in standard Architectural drawing formats and scaled to defined dimensions.
- D. Upon completion of installation, operation and maintenance instructions will be furnished. Operation instructions shall include manufacturer's name, size, model, type, and serial numbers for the various elements of system; detailed drawings, wiring diagram, repair parts lists, lubrication manuals, and general maintenance instructions. Provide services necessary to properly instruct University personnel on operation and maintenance of all systems.
- E. Provide the following certified items:

1. Operating and maintenance procedures.
2. List of recommended spare parts.
3. Approved shop drawings.
4. Certified performance curves for equipment.
5. Warranty certificates.
6. As-built drawings.
7. Test reports.
8. Procedural instructions for future wall penetrations and proper sealant to be used.

- F. Upon completion of work, tests shall be completed, systems balanced and tested, and a qualified representative provided to instruct a representative of the Owner's maintenance department in proper operation and maintenance of all installed systems.

1.8 CLEANROOM CONTRACTOR QUALIFICATIONS

- A. In addition to the General Standards and as a condition of award, special standards must be met by the Cleanroom Manufacturer/Installation Contractor to demonstrate that the bidder possesses certain expertise that has been determined essential for adequate contract performance.
- B. The following will be required of the bidding contractors prior to award: A list of at least five (5) projects, completed within the last five (5) years, which included construction of ISO Class 5 (FS Class 1,000) or better certified Cleanroom spaces. These projects should be equal to or greater than this project's Cleanroom scope of work and include materials and systems of similar design and installation. Include documented experience for monitoring a cleanroom protocol program for all subcontractors working within the clean zone, including subcontractors not working directly for the cleanroom subcontractor. Include documented experience for academic and research University Cleanroom projects of equal or greater scope.
- C. Include a list of all ISO Class 6 (FS Class 1,000) or better certified Cleanroom spaces constructed within the last five (5) years or currently under construction. List should include size of filtered clean area, ISO classification, General Contractor, and Owner contact information. List should include the job title, place of performance, and the General Contractor's project manager's name, address and phone number; Owner's company name, address, name of person to be contacted and phone number.

1.9 WARRANTY

- A. Provide warranties in accordance with Division 1 requirements.
- B. Unless otherwise noted, provide one (1) year limited standard warranty against defects.

1.10 QUALITY ASSURANCE

- A. Deliver materials in good condition to the jobsite in the manufacturer's original unopened containers that bear the name and brand of the manufacturer, project identification, and shipping and handling instructions.

- B. Provide temporary protection of flooring, wall, and ceiling surfaces following installation as required during subsequent construction work and activities. Materials used for protection shall be suitable for Cleanroom spaces and shall not generate particulates.

1.11 ENVIRONMENTAL CONDITIONS

- A. Store materials in a clean, dry, enclosed space off the ground, and protected from the weather and from extremes of heat and cold. Protect adhesives and gels from freezing. Store flooring, adhesives and accessories in the spaces where they will be installed for at least 48 hours before beginning installation.
- B. Maintain a minimum temperature in the spaces to receive the flooring and accessories of 65°F (18°C) and a maximum temperature of 100°F (38°C) for at least 48 hours before, during, and for not less than 48 hours after installation or as otherwise specified by the flooring manufacturer. Thereafter, maintain a minimum temperature of 55°F (13°C) or as otherwise specified by the flooring manufacturer in areas where work is completed. Protect all materials from the direct flow of heat from hot-air registers, radiators, or other heating fixtures and appliances.
- C. Install flooring and accessories after the other finishing operations, including painting, have been completed. Close spaces to traffic during the installation of the flooring. Do not install flooring over concrete slabs until they are sufficiently dry to achieve a bond with the adhesive, in accordance with the manufacturer's recommended bond and moisture tests.

PART 2 - PRODUCTS (NOT FOR CONSTRUCTION)

2.1 CLEANROOM INSTALLATION CONTRACTORS

- A. Contractors: Subject to compliance with requirements, provide products and services by one of the following:
 1. AdvanceTEC, Inc.
 2. Cleanrooms West
 3. Daw Technologies
 4. FH Chase, Inc.
 5. Hodess Construction Corp.
 6. Performance Contracting, Inc.
 7. Approved equal – Subject to approval by Owner's representative obtained during bidding submittal process and prior to project award.

2.2 MATERIALS AND STANDARDS

- A. Quality of materials and standards of installation not specifically called out in this section of the Specifications shall be as specified for similar items in the following Divisions of the Specifications:
 1. Fire Protection Division 21
 2. Plumbing Division 22
 3. HVAC Division 23
 4. Electrical Division 26

2.3 CLEANROOM CONSTRUCTION SEALANT

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.

1. Sikaflex.
2. General Electric.
3. Approved equal.

B. Basis of Design: Sikaflex-1a Polyurethane sealant.

C. Materials:

1. Polyurethane Sealant: One-component, gun grade, polyurethane-base material. It shall be applicable in the horizontal, vertical, and overhead joints. The sealant shall cure under the influence of atmospheric moisture to form an elastomeric substance.
2. Any primers as required and recommended by the manufacturer.
3. Backer rod or bond breaker tape as required and recommended by the manufacturer.

D. Performance:

1. Properties of the uncured polyurethane sealant:

- a. Initial Cure (Tack-Free Time): TT-S-00230C - 4 hours.
- b. Final Cure 4 – 7 days
- c. Consistency: non-sag.
- d. Color: Architectural standard colors.

2. Properties of the cured polyurethane sealant:

- a. Tensile Stress: 175-psi min.(1.37 MPa).
- b. Elongation at Break: 550%.
- c. Modulus of Elasticity:
 - 1). 25%: 35 psi (0.24 MPa).
 - 2). 50%: 60 psi (0.41 MPa)
 - 3). 100%: 85 psi (0.59 MPa)
- d. Shore A Hardness (ASTM D-2240) at 21 days: 40+/- 5.
- e. Tear Strength (ASTM D-624) at 21 days: 55 lb./in.
- f. Adhesion in Peel (TT-S-00230C, ASTM C 794):
 - 1). Concrete: 20-lb. min. - 0% Adhesion Loss.
 - 2). Aluminum: 20-lb. min. – 0% Adhesion Loss.
 - 3). Glass: 20-lb. min. – 0% Adhesion Loss.
- g. Service Range: -40°F to 170°F (-40°C to 77°C).

- h. The sealant shall conform to Federal Specification TT-S-00230C, Type II, Class A.
- i. The sealant shall conform to ASTM C-920, Type S, Grade NS, Class 35.
- j. The sealant must comply with ANSI Standard 61 (NSF Approval) for use in contact with potable water.
- k. The sealant shall be non-staining.

E. Installation:

- 1. Surface Preparation: The joint and adjacent substrate must be clean, dry, sound and free of surface contaminants. Remove all traces of the old sealant, dust, laitance, grease, oils, curing compounds, form release agents and foreign particles by mechanical means. Blow joint free of dust using compressed air line equipped with an oil trap.
- 2. Mixing and Application: Per manufacturer's procedures.

PART 3 - EXECUTION

3.1 JOB CONDITIONS

- A. The General Contractor shall provide the shell space and an adjacent staging area in vacuum clean and wiped down condition and shall assist in maintaining the conditions necessary for the performance of the work in this area.
- B. Check project for conditions that affect work. Do not begin installation until unsatisfactory conditions are corrected. Defects caused by unsatisfactory conditions or untimely installation shall be corrected at no cost to University's Representative.
- C. The Cleanroom Contractor shall coordinate with sprinkler systems work for pipe penetrations and sprinkler head locations.
- D. The Cleanroom Contractor shall coordinate with fire alarm communications, telephone, and data systems, and other work for ceiling, wall, or floor penetrations.
- E. The Cleanroom Contractor shall coordinate other work performed within the cleanroom area as required to safeguard the cleanliness of the cleanroom area.

3.2 INSTALLATION OF UTILITIES

- A. The Cleanroom Contractor shall supervise protocol compliance during the installation of all mechanical, electrical, furnishings, and equipment in space above floor in all rooms designated as clean spaces.
- B. The Cleanroom Contractor shall be responsible for making and sealing all penetrations to Cleanroom walls, ceilings, and floors. All electrical and utility wall or ceiling boxes at clean room boundaries shall be sealed back type.
- C. Division 11, 13, 22, 23 and 26 and the Cleanroom Contractor shall coordinate location of furnishings, equipment, mechanical, electrical, and cleanroom equipment prior to construction to eliminate any interferences.

END OF SECTION 13 21 00

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SECTION 13 21 01 - CLEANROOM PERFORMANCE TESTING

PART 1 - GENERAL

1.1 SUMMARY

- A. This specification details the requirements for Cleanroom Performance Testing (CPT) by an NEBB certified Cleanroom certification agency to measure and record Cleanroom environmental conditions and document Testing, Adjusting, and Balancing (TAB) condition of primary and secondary HVAC air systems serving the Cleanroom facility.
- B. Drawings and general provisions of the Contract, and Division 1 Sections apply to work of this Section.

1.2 REFERENCES

- A. International Standards Organization (ISO): Air cleanliness classification for cleanrooms and definition of terms for cleanroom work shall be in accordance with ISO 14644 Class 4, 5 and 6 (Formerly Class 10, 100 and 1,000).
- B. National Environmental Balancing Bureau (NEBB): Current edition of the NEBB *Procedural Standards for Certified Testing of Cleanrooms (NEBB-PSCPT)*. This specification section contains multiple references to this acronym. When used or referenced in this specification, NEBB-PSCPT, is meant to identify the current publication and for various sections, tables, equations, charts from the current publication.

1.3 RELATED DOCUMENTS

- A. General and Supplementary Conditions and Division 1
- B. Section 13 21 40 – Cleanroom Fume Hoods and Other air Containment Units

1.4 DEFINITIONS

- A. Clean Zone: A defined area, including the cleanroom and adjacent spaces that are exposed to the cleanroom supply and return airstreams.
- B. CPT: Cleanroom Performance Testing.
- C. HEPA Filter: High efficiency particulate air filter.
- D. NEBB: National Environmental Balancing Bureau.
- E. CPT Technician: The person(s) vested with authority by the CPT agency to perform all CPT testing and documentation within the Clean Zone.

- F. CPT Supervisor: The person vested with authority by the CPT agency to supervise all CPT testing and documentation within the Clean Zone and ensure requirements of the contract documents are met in completion of the CPT activities.
- G. ULPA Filter: Ultra-High efficiency particulate air filter.

1.5 PERFORMANCE REQUIREMENTS

- A. Clean spaces are classified according to ISO 14644. Verification of room and air cleanliness shall be by measurement of the concentration of airborne particles at or above the size limits given below.
- B. Classified spaces shall be as follows:
 - 1. Refer to project drawings.
- C. Airborne particulate cleanliness classification:
 - 1. ISO Class 4 (formally Fed Std 209E Class 10); as-built; 0.1 μm (10,000 particles/ m^3), 0.2 μm (2,370 particles/ m^3), 0.3 μm (1,020 particles/ m^3), 0.5 μm (352 particles/ m^3), 1.0 μm (83 particles/ m^3).
 - 2. ISO Class 5 (formally Fed Std 209E Class 100); as-built; 0.1 μm (100,000 particles/ m^3), 0.2 μm (23,700 particles/ m^3), 0.3 μm (10,000 particles/ m^3), 0.5 μm (3,520 particles/ m^3), 1.0 μm (832 particles/ m^3), 5.0 μm (29 particles/ m^3).
 - 3. ISO Class 6 (formally Fed Std 209E Class 1,000); as-built; 0.1 μm (1,000,000 particles/ m^3), 0.2 μm (237,000 particles/ m^3), 0.3 μm (102,000 particles/ m^3), 0.5 μm (35,200 particles/ m^3), 1.0 μm (8,320 particles/ m^3), 5.0 μm (293 particles/ m^3).
- D. Particle count within room space shall not exceed limits for above mentioned classifications as defined by ISO Class 4 – 6 throughout room at an elevation of 760 mm (30 inches) above floor level.
- E. Levels of cleanliness apply while Cleanroom is at an “At Rest” condition.
- F. Cleanroom spaces shall be tested and certified to one ISO Class lower than intended design classification for as-built conditions with all furnishings installed and equipment operational (i.e. hoods, etc...).

1.6 DESIGN REQUIREMENTS

- A. Refer to requirements indicated on drawings.

1.7 SUBMITTALS

- A. Submit the following prior to start of work:
 - 1. Qualification of the NEBB certified Cleanroom Performance Testing firm.
 - 2. Qualification of the CPT agency project specific staff members.
 - 3. Testing procedures for certification of each performance parameters.
 - 4. Testing apparatus instrumentation and equipment including certificates of current calibration during the testing process.

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5. Samples of each test report.
- B. Submit the following certified items within ten (10) working days following completion of work:
1. Provide a single collated test report with all items.
 2. Preliminary test reports for each CPT parameter.
 3. Copy of working field notes or logs to document project specific tasks.
 4. Procedural instructions which may affect operational certification results.
- C. Submit the final NEBB Certified CTP Report within thirty (30) working days after completion of all field activities. Include the following (minimum requirements):
1. Typed, hand-written or computerized field reports, charts, and forms complete with measured data referenced to sample location.
 2. Written description of operating condition of each cleanroom.
 3. Reduced set of architectural floor plan drawings, maximum size 11-by-17 inches, made from the project CADD Contract Documents, obtained from the Owner, showing test and sample locations referred to on other field data sheets.
 4. Separate narrative section outlining any operating or anomalies at the end of the testing procedures.
 5. A list of instrumentation and test equipment used in the certifying process, including manufacturer, model and serial numbers, and NIST-traceable calibration certificate.
 6. Written description of tests performed, including the purpose, instrumentation, procedure, results, date tests were taken, names of field technicians performing the tests, and analysis of the data. Present data in tabular form and display graphically to permit full understanding of the tests.
 7. Electronic copies of the Final NEBB Certified CPT Report shall be submitted in PDF format.
 8. A narrative outline with recommendations relating to test results and operating conditions of each area tested.
 9. A statement that cleanroom testing was performed in accordance with the NEBB Procedural Standards for Certified Testing of Cleanrooms.
 10. Provide one hard-bound copy and one unbound reproducible copy of the Final NEBB Certified CPT Report for the Owner's use.

1.8 QUALITY ASSURANCE

- A. Cleanroom Performance Testing (CTP) Agency Qualifications:
1. In addition to the General Standards and as a condition of award, special standards must be met by the Cleanroom CPT agency to demonstrate that the bidder possesses certain expertise that has been determined essential for adequate contract performance.
 2. The following will be required of the bidding contractors prior to award: A list of at least five (5) projects, completed within the last five (5) years, which included construction, testing, and certification of ISO Class 5 (FS Class 1,000) or better certified Cleanroom spaces. These projects should be equal to or greater than this project's Cleanroom scope of work. Include documented experience for academic and research University Cleanroom projects of equal or greater scope.

3. Include a list of all ISO Class 6 (FS Class 1,000) or better certified Cleanroom spaces tested and certified within the last five (5) years or currently under construction. List should include size of filtered clean area, ISO classification, General Contractor, and Owner contact information. List should include the job title, place of performance, and the General Contractor's project manager's name, address and phone number; Owner's company name, address, name of person to be contacted and phone number.

B. CPT Supervisor Qualifications:

1. The supervisor shall be current, qualified and in good standing with the National Environmental Balancing Bureau (NEBB) and employed by the NEBB Certified CPT Firm.

C. CPT Technician Qualifications:

1. Completed previous training in cleanroom operations and certifying procedures.
2. Thorough, demonstrable knowledge of test procedures and equipment.

D. Equipment Calibration:

1. Traceable by serial number to the National Institute for Standards and Technology (NIST) in accordance with the current edition of the NEBB CPT Procedural Standard.
2. Calibrate test equipment that requires calibration within the project work schedule, prior to any testing with the instrument.

E. Testing Procedures:

1. The reference standards for field tests and project record documents shall be in accordance with the current edition of the NEBB *Procedural Standards for Certified Testing of Cleanrooms*.
2. Measurement sampling based upon accepted NEBB sampling and statistical procedures.

1.9 WARRANTY

- A. Provide warranties in accordance with Division 1 requirements.

1.10 COORDINATION

- A. Jobsite visits: Provide at least two (2) jobsite visits by the CPT Supervisor during strategic construction phases for the period that the finished cleanroom envelope is being constructed.
- B. Schedule work activities with the Owner and the General Contractor/Construction Manager. Schedule may require that crucial tests be completed in an alternate sequence to allow selective partial occupancy.

PART 2 - PRODUCTS

2.1 CLEANROOM PERFORMANCE TESTING (CPT) AGENCY CONTRACTORS

- A. Contractors: Subject to compliance with requirements, provide products and services by one of the following:
1. Air Filtration Management, Inc.; Tel:(610) 867-3869; www.airfiltrationmgmt.com
 2. BTC Services; Tel: (801) 974-5911.
 3. CCS Inc.; Tel: (401) 765-5743; www.cleanroomcerts.com
 4. ENV Services; Tel: (800) 345-6094; www.envservices.com
 5. Pentagon Technologies; Tel: (480) 497-6880; www.pen-tec.com
 6. Approved equal – Subject to approval by Owner’s representative obtained during bidding submittal process and prior to project award.

PART 3 - EXECUTION

3.1 INSPECTION

- A. NEBB CPT Firm and the NEBB CPT Supervisor shall be responsible to inspect the facility to verify that the construction of the cleanroom spaces shall be in a condition ready for the specified test occupancy state. Inspection should include, but not limited to, the following items:
1. Building perimeter walls, roof, and accessories installed to create a pressurized envelope around the cleanroom.
 2. Cleanroom perimeter walls, ceiling, raised floor panels, doors, and necessary interior partitions installed that are essential to successful system performance. If approved by the Construction Manager or Owner, use temporary barriers for area isolation.
 3. Permanent personnel gowning area in operation.
 4. Final wipe down cleaning procedures complete on:
 - a. Cleanroom finished surfaces.
 - b. HVAC system ducts, plenums, and air handler surfaces exposed to airflow.
 - c. Wall and floor cavities used as part of the cleanroom air handling strategy.
 - d. Building structural elements and utility systems in contact with the cleanroom airstream.
 5. Tool hookup or miscellaneous construction activities curtailed in the test area.
- B. NEBB CPT Firm and the NEBB CPT Supervisor shall be responsible to inspect the facility to verify that the building environmental systems shall fully operational, under control and commissioned and shall be in a condition ready for the specified test occupancy state. Inspection should include, but not limited to, the following items:
1. Air-handling systems serving the cleanroom installed and operating under automatic controls and fully commissioned.
 2. Testing, adjusting and balancing complete for both the air and the hydronic systems serving the cleanroom air-handling systems.

3. Process exhaust systems and pressurization control fans installed and operating to simulate cleanroom pressurization.
4. Cleanroom lights, sprinklers, and safety devices installed and operational.
5. Housekeeping vacuum system operational.
6. Support systems required to perform certification tests operating normally for a minimum stable period of 5 days.

3.2 PREPARATIONS

- A. Confirm that activities within the facility comply with the requirements of the specified cleanroom occupancy test state.
- B. Inspect the entire cleanroom, accompanied by the Construction Manager or Owner, and note existing conditions that could jeopardize the certification results. Obtain the Construction Manager or Owner's written release before proceeding with certification steps.
- C. Coordinate field certification activities with the Construction Manager or Owner to permit observation of any test procedure.

3.3 TESTING GENERAL REQUIREMENTS

- A. The testing, balancing, adjusting and performance verification of the air distribution in the Cleanrooms shall include, but is not limited to:

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1. As-Built Facility Test and Balance.
2. At-Rest Facility Performance Acceptance tests.

- B. All tests shall be conducted by a NEBB certified and competent technician.
 1. The technician shall have a minimum of two (2) years of service devoted to the test, balance and performance verification of Cleanroom facilities.
 2. Provide all instruments, lubricants, test equipment, material and labor required for the tests.
 3. The tests shall be started only after the Cleanroom Contractor has completed the initial operating and balancing adjustments. The General Contractor shall review the pretest check list.
 4. The As-Built Facility testing shall be conducted under the direct supervision of the Cleanroom Contractor.
 5. The At-Rest Facility Performance Acceptance Test shall be conducted by the Cleanroom Contractor. Tests shall be performed and the results witnessed and confirmed by the Owner's representative prior to final acceptance of the Cleanroom systems.
- C. Instrumentation shall be in accordance with the description given in each test procedure, and shall have a demonstrated accuracy and sensitivity suitable for the test procedure. All instruments shall be calibrated according to the manufacturer's recommendation and/or accepted industry practice. Owner's representative may require the calibration of any instrument prior to test and balance.

- D. Instrumentation shall include, but is not limited to:

1. Particle Counter (ASTM F50-68).
2. Inclined manometer.
3. Electronic direct reading anemometer.
4. Direct reading flowhood.
5. Anor velometer.
6. Direct readout tachometer.
7. Clip-on ampmeter/voltmeter.
8. Thermometers (dry bulb and wet bulb).
9. Pressure gauges.
10. Pitot tubes.

E. The following tests shall be performed:

CLEANROOM TEST & CERTIFICATION								
Room	Design Class	Test/Cert Class (As-Built)	Airflow Velocity, Volume (Filter Face & Room)	Filter Leak Test	Airborne Particle Counts / Class (0.1 & 0.5 um Particles)	Pressure	Temperature	Humidity
Gowning/Airlock	ISO 6	ISO 6	X	X	X	X	X	
Clean Prep	ISO 6	ISO 6	X	X	X	X	X	
Balance Room	ISO 6	ISO 6	X	X	X	X	X	X
Clean Lab 1	ISO 5	ISO 5	X	X	X	X	X	
Clean Lab 2	ISO 5	ISO 5	X	X	X	X	X	
Clean Lab 3	ISO 5	ISO 5	X	X	X	X	X	
TIMS Prep	ISO 6	ISO 6	X	X	X	X	X	
TIMS Machinery	ISO 6	ISO 6	X	X	X	X	X	
Laminar Hoods	ISO 4	ISO 4			X			

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3.4 BALANCING PRIMARY AIR SYSTEMS (BY DIVISION 23)

- A. Adjust and balance air handling systems for design quantities. Conduct balancing with filters in place and all automatic control devices and dampers operative and adjusted.
- B. Adjust fan speed within the limits of the adjustable sheaves and motor horsepower to the required output.
- C. Balance main and branch air quantities using a velocity traverse with pitot tube. Following balancing of duct system, take readings at each outlet and record.

- D. All required exhaust fans operational.
- E. Balance all systems to design values plus or minus 5 percent.

3.5 PRIMARY AIR SYSTEMS TEST DATA (BY DIVISION 23)

A. Fan Data:

1. Manufacturer name and model number.
2. Design airflow rate.
3. Actual airflow rate.
4. Design speed.
5. Actual speed.
6. Motor name, rated amps, kW, RPM, voltage.
7. Inlet and discharge static pressure.
8. Motor amps.
9. Motor starter heater size.

B. Air Outlet Data:

1. Outlet size.
2. Actual free area.
3. Manufacturer's test factor.
4. Measured average velocity.
5. Design airflow rate.
6. Measured airflow rate.
7. Airflow rate percentage above or below design.

C. Makeup Air Intake Data:

1. Size of inlet.
2. Actual free area.
3. Measured average velocity.
4. Makeup air temperature.

3.6 TEMPERATURE AND HUMIDITY STABILITY (BY DIVISION 23)

A. Apparatus:

1. Installed sensor instrumentation for BMS/DDC controls.
2. BMS/DDC control workstation with trend data collection.

B. Procedure:

1. Perform this test after completion of the initial test and balance and the system has been in full stable operation for at least 24 hours.
2. Temperature and Humidity stability test duration shall be minimum 48-hours.
3. Collect trend data for temperature and humidity for installed sensors at a minimum interval of every 5 minutes during test period.
4. Provide trend analysis of raw data collection to determine temperature and humidity stability (controlling band) and maximum rate of change of each 1 hour

period of test duration. Provide report to present trend analysis results along with raw data collection tables.

C. Acceptance: Temperature and humidity stability readings shall satisfy the operating conditions throughout the room as required by the design criteria.

1. Temperature:

a. Controlling Band:

- 1). TIMS Machinery Room: setpoint $\pm 0.4F$.
- 2). All other areas: criteria not defined.

b. Maximum Rate of Change:

- 1). TIMS Machinery Room: $< 3.6F/hour$.
- 2). All other areas: criteria not defined.

2. Humidity:

a. Controlling Band:

- 1). Balance Room: 45% - 60% RH; setpoint 50%, +10% RH, - 5% RH
- 2). All other areas: criteria not defined.

b. Maximum Rate of Change: criteria not defined.

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3.7 AIR VELOCITY AND AIRFLOW UNIFORMITY (BY CPT AGENCY)

A. Apparatus

1. Electronic direct-reading anemometer or direct-reading airflow rate flowhood.

B. Procedure:

1. Airflow volume through each individual air supply distribution device shall be determined by either average velocity/area calculation or direct airflow rate measurement. Each device measurement shall be recorded.
2. Velocity measurements will be an average of several readings taken 100 mm to 150 mm (4 inches to 6 inches) from air supply device face.
3. Device dampers and return air registers shall be adjusted to provide proper airflow and room pressure.
4. The individual air supply airflows shall be totalized for the room to provide the average room laminar airflow velocity based on the room square footage area.

C. Acceptance:

1. The average room laminar airflow velocity shall be within 5% of the following:
 - a. ISO 6: 25 fpm average room air velocity.
 - b. ISO 5: 50 fpm average room air velocity.

2. Individual measurements shall be within 20 percent of the average measurement for a room.

3.8 AIR CLEANLINESS LEVEL (BY CPT AGENCY)

A. Apparatus: Particle counter.

B. Procedure:

1. Air cleanliness will be tested according to the procedures established by ISO Class 4, 5 and 6.
2. A monitoring plan, described in ISO 14644-1 will be submitted for approval by Owner representative before air cleanliness testing is performed.

C. Acceptance: The air cleanliness level must meet the acceptance criteria established by ISO Class 4, 5 and 6.

3.9 ROOM PRESSURE (BY CPT AGENCY)

A. Apparatus: Inclined Manometer and Smoke Sticks.

B. Procedure:

1. With all Cleanroom doors closed, measure and record the pressure differential between the designated areas and the adjoining spaces or exterior ambient.

C. Acceptance:

1. Pressure differentials with all doors closed shall be maintained to the design conditions schedules.
2. With the doors open, an inward airflow is unacceptable as evidenced by the airflow direction.

3.10 TEMPERATURE AND HUMIDITY (BY CPT AGENCY)

A. Apparatus:

1. Dry-bulb thermometers.
2. Either relative humidity indicator or wet-bulb thermometer, or electronic digital relative humidity meter.

B. Procedure:

1. Perform this test after completion of the initial test and balance and the system has been in full operation for at least 4 hours.
2. Temperature and Humidity stability test duration shall be minimum 48-hours.
3. Divide the work area into 3 m by 3 m (10 foot by 10 foot) grids and record each measurement.
4. Each measurement shall utilize a 60 – 120 second sample rate.
5. Electronic meter sensors to be calibrated with standard saturated salt solutions prior to testing, to ensure accuracy.

- C. Acceptance: Average temperature and humidity readings shall satisfy the operating conditions throughout the room as required by the design criteria.

3.11 FINAL FILTER LEAK TEST (BY CPT AGENCY)

- A. Apparatus: Particle counter.
- B. Procedure: ISO 14644-3 Annex B6.
- C. Acceptance:
 - 1. Any detectable leak greater than one scale division on the logarithmic scale shall be either repaired or the filter replaced.
 - 2. The extent to which repairs may be made is limited to the area of patching material required. The maximum area of patch allowable shall not exceed 1 percent of filter face area. Any patch area in excess of 1 percent of filter face area shall be rejected and the filter shall be replaced.

3.12 AT-REST FACILITY PERFORMANCE ACCEPTANCE TEST (BY CPT AGENCY)

- A. Upon completion of initial testing, balancing and adjusting, and with the Cleanroom complete with all environmental equipment in operation but empty of any production equipment, and with all operating personnel absent, the following tests shall be performed:

- 1. Temperature
- 2. Humidity
- 3. Room Pressure
- 4. Airflow Uniformity
- 5. Air Cleanliness Level
- 6. Final Filter Leak Test

END OF SECTION 13 21 01

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SECTION 13 21 05 – CLEANROOM CONSTRUCTION PROTOCOL

PART 1 - GENERAL

1.1 SUMMARY

- A. Drawings and general provisions of the Contract, and Division 1 Sections apply to work of this Section.
- B. This section specifies the general requirements for all personnel, components, materials, equipment, tools, and protocol requirements to be utilized in the construction, start-up, commissioning, and certification of the Cleanroom spaces.
- C. The Cleanroom Protocol procedures shall be developed and implemented by a contractor regularly engaged in the business of cleanroom construction, installation protocols for cleanliness, and certifying cleanrooms.
- D. The cleanroom manufacturer/installation contractor shall provide certification listed herein from a third party source.

1.2 REFERENCES

- A. Air cleanliness classification for cleanrooms and definition of terms for cleanroom work shall be in accordance with ISO Class 4, 5 and 6 (Formerly Class 10, 100 and 1,000). All cleanroom construction shall be in accordance with International and Local building codes.

1.3 RELATED DOCUMENTS

- A. Section 11 53 43 – Laboratory Service Fittings and Fixtures
- B. Section 13 21 00 – Cleanroom Construction
- C. Section 13 21 40 – Cleanroom Fume Hoods and Other Air Containment Units
- D. Division 21: Fire Suppression
- E. Division 22: Plumbing
- F. Division 23: HVAC
- G. Division 26: Electrical

1.4 DEFINITIONS

- A. Clean Zone: A defined area, including the cleanroom and adjacent spaces, that is exposed to the cleanroom supply and return airstreams.
- B. HEPA Filter: High efficiency particulate air filter, including ULPA (Ultra-High efficiency particulate air) filters.

- C. Protocol Level: The phase or degree of construction completion that mandates specified activities, training, security clearance, dress, work means and methods, cleaning procedures, and system performance to maintain the cleanliness of the clean zone.
- D. Protocol Manager: The person vested with authority by the cleanroom protocol contractor to supervise all construction personnel working within the clean zone and ensure requirements of the contract documents are met in completion of the clean zone construction.

1.5 SUBMITTALS

A. Cleanroom Protocol:

- 1. Written performance and method protocol procedures shall be prepared and submitted by contractor performing tasks and services specified herein. Cleanroom protocol procedures shall include the following items used in the performance of services:
 - a. Manpower, organization, and responsibilities of all members performing work.
 - b. Procedures to be utilized.
 - c. Sequence of construction events and protocol levels.
 - d. Products to be utilized.
 - e. Equipment to be utilized.

2. Written protocol procedures shall be developed for each of the construction protocol levels for the following activities and services:

- a. Instruction and training material and procedures for clean construction workers.
- b. Monitoring and enforcement of clean construction protocol.
- c. Design and use of temporary construction and equipment to maintain clean construction boundary and entry/exit of personnel and equipment to the clean construction boundary.
- d. Procedures and equipment for continuous and special cleaning.
- e. Testing procedures and equipment including for air, water, and other cleanroom related activities.

- B. Submit manufacturer's product data for all supplies and equipment used in cleanroom protocol procedures.
- C. Submit MSDS information for all products used inside the cleanroom for cleaning supplies, sealants, and other applicable products.

1.6 CLEANROOM PROTOCOL CONTRACTOR QUALIFICATIONS

- A. In addition to the general standards and as a condition of award, special standards must be met by the cleanroom protocol contractor to demonstrate that the bidder possesses certain expertise that has been determined essential for adequate contract performance.

- B. The following will be required of the bidding contractors prior to award: A list of at least five (5) projects, completed within the last five (5) years, which included construction of ISO Class 6 (Class 1,000) or better clean spaces. These projects should be equal to this project's cleanroom scope of work. Include documented experience for monitoring a cleanroom protocol program for all subcontractors working within the clean zone, including subcontractors not working directly for the cleanroom subcontractor.

PART 2 - PRODUCTS

2.1 INSTALLATION PROTOCOL MANAGEMENT CONTRACTORS

- A. Contractors: Subject to compliance with requirements, provide products and services by one of the following:
1. AM Cleanroom Build & Performance Division (AM Technical Solutions)
 2. Cleanrooms West
 3. Protocol Management Services, Inc.
 4. Performance Contracting, Inc.
 5. Approved equal – Subject to approval by Owner's representative obtained during bidding submittal process and prior to project award.

2.2 INSTALLATION PROTOCOL

- A. The Following guidelines shall be followed in order to establish procedures for dress, conduct, and activities inside the Clean Zone as necessary to maintain safety and contamination requirements:

1. The protocol manager shall have full authority over all operations inside the clean zone.
2. All persons entering the clean zone shall complete training respective of the protocol level incorporated.
3. Construction personnel shall receive training on clean build protocol, at regularly scheduled training sessions from the protocol management contractor. Manufacturer's representatives, service personnel, Owner representatives and end users to receive special training on clean protocol prior to entering the clean zone.
4. There shall be one training session for protocol levels 2 and 3, and another for protocol level 4.
5. Personnel access to the clean zone shall be through the designated personnel construction gowning entrance. Material and tool entry shall be through a material entry pass-through, and pre-clean area only.
6. Any approved sub-contractor shall use dedicated, clean construction tools in the clean zone inspected for each level of protocol. Tools which are used on a daily or regular basis are to remain in the clean zone until they are no longer needed.
7. Any approved sub-contractor shall clean as they work, always leaving the construction zone in at least the same or better condition than when the work began.

- B. The following activities are banned anywhere inside the clean zone and adjacent spaces during all construction protocol levels:

1. Eating or drinking foodstuffs.
2. Chewing gum.
3. Smoking or chewing tobacco.
4. Spitting.
5. Standing, walking or sitting on electrical conduits, and bus duct, HVAC ductwork, fire sprinkler piping, or other building utility piping, process high purity piping, specialty gas piping, HEPA filter modules, cleanroom light fixtures or any other cleanroom component.
6. Breaking open any clean products specially sealed and wrapped for protection prior to the material entry airlock.
7. Cutting, threading, grinding, or welding pipe, conduit, bus duct, or fittings.
8. Operating any propane, acetylene, diesel, gas, air, or oil fueled tools, high-lift or other construction equipment.
9. Installing or spilling oil, stain, paint, sealant, cleaning agent, caulking, or other diffusing product onto the structural floor before application of specified sealers and paints.
10. Using chemicals and cleaners not previously approved by the cleanroom protocol management contractor and site environmental health and safety representative.
11. Entering or working inside the clean zone in garments and footwear that are not in compliance with the posted construction protocol level.
12. Entering or working inside the clean zone without clearance from the cleanroom protocol management contractor and Protocol Manager.

C. The following procedures and criteria shall be followed by all persons entering and working in the clean zone during all construction protocol levels:

1. Walk on sections of tacky walk-off mat provided at entry to the clean zone.
2. Unpack, wipe down, and vacuum clean all construction material, tools, and accessories to remove grease and contamination in the material entry pass-through.
3. Wipe up spills of caulking, sealant, paint and the like immediately.
4. Dispose of all outer packaging materials including tie-straps, plastic seal wraps, product protecting devices and other debris in trash receptacles. Do not let debris accumulate on floor.
5. Provide continuous HEPA filtered vacuum pick-up during drilling, coring, cutting, or similar particle generating work activities after beginning cleanroom protocol level.
6. Provide all necessary construction tools that are cleaned, stored, and used only within the designated clean zone after beginning of protocol level.
7. No wood, paper, foam, or cardboard containers or packing allowed in the clean zone after beginning of protocol level 2.
8. Limit quantity of material inventory stored in the clean zone to a quantity that can be used during the current shift.

2.3 CLEAN / BUILD PROTOCOL TRAINING PROGRAM

A. Prior to construction start, the cleanroom protocol management contractor will provide a cleanroom protocol-training program. A draft protocol and training program shall be submitted during the proposal stage to confirm the requirements of the specifications. Its intent will be to expose each individual trade to the intricacies of a cleanroom and the

“clean build” process. Attendance is mandatory for all workers involved with the cleanroom project. The primary goal of the protocol training is to:

1. Help contractors understand the reasons for various restrictions on activities within the cleanroom.
2. Provide overall exposure to the sub-micron level of cleanliness required in the different cleanroom classifications.
3. Inform them on specific cleanroom components such as the use of air locks, air showers, and gowning procedures.
4. Emphasize the necessity for continuous daily clean-up programs.
5. In conjunction with the pre-construction training activity the process will be monitored and adjusted at the weekly contractor coordination meeting. These meetings will further:
 - a. Gauge the level of compliance to these restrictions and allow the cleanroom contractor to adjust enforcement of same if necessary.
 - b. Ensure tradesman participation and involvement in an overall commitment to maintain the integrity of this facility.
 - c. Serve as a venue to present and post any and all weekly “restricted access” area(s) and help schedule clearance of the areas.

2.4 PRE-CLEANROOM CONSTRUCTION ACTIVITIES

- A. The following describes construction activities to be complete prior to the cleanroom construction

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1. The building superstructure must be complete including slab floors, exterior walls, roof, exterior windows and doors, structural steel and welding.
 2. Fire protection mains, plumbing drains, and cleanroom perimeter walls shall all be in place at this time.
 3. All interior surfaces (i.e., columns, joists, walls, etc.) shall be painted or coated to prevent future shedding of particulate into the cleanroom.
 4. Temporary gowning room and a material entry pass-through shall be constructed at the cleanroom entrances.
 - a. The temporary gowning room and material entry pass-through may be constructed of corrugated plastic sheets (coroplast), heavy-duty sheet plastic, and a structural support system as necessary.
 5. All utilities required for the clean zone are brought through the perimeter clean zone boundary wall and capped for final distribution in clean zone. All penetrations through the clean zone boundary wall to be sealed airtight.

2.5 CLEAN ZONE CONSTRUCTION PROTOCOL LEVELS

- A. General milestones for clean construction protocol levels include (Note: levels may overlap):
1. Level 1: Rough Construction Phase
 2. Level 2: Cleanroom Floor/Ceiling/Wall Finish Installation
 3. Level 3: Cleanroom Furnishings and Equipment Installation

4. Level 4: Start-up test and Certification

2.6 PROTOCOL LEVEL 1 (ROUGH CONSTRUCTION PHASE)

A. Level 1 Activities:

1. The building superstructure must be complete including slab floors, exterior walls, roof, exterior windows and doors, structural steel and welding.
2. Interior partitions walls must be complete.
3. Fire protection mains, plumbing drains, and cleanroom perimeter walls shall all be in place at this time.
4. All interior surfaces (i.e., columns, joists, walls, etc.) shall be painted or coated to prevent future shedding of particulate into the cleanroom.
5. Temporary gowning/material staging areas shall be constructed at the cleanroom entrance(s).
6. Install air handling units and associated ductwork, including ductwork required for outdoor make-up air.
7. Hang cleanroom ceiling support system.
8. Install MEP overhead rough in.
9. Seal air tight all duct openings.
10. Initial gross cleanup of the clean construction zone including overhead mechanical systems prior to entering Level 2 protocol.
11. Provide startup of make-up air systems for room pressurization prior to moving to Level 2 protocol.

B. Cleanliness Level (Level 1)

1. No smoking or chewing tobacco is allowed.
2. No eating or drinking within the clean zone.
3. No gasoline or diesel powered equipment allowed. All lifting equipment/power tools shall be electric powered.
4. Grinding, cutting, drilling, or other operations (i.e. cutting drywall) which generate dust contamination must be controlled by means of daily vacuuming or cleanup.
5. Substrates, over which succeeding work is to be installed, shall be carefully inspected and wiped clean to eliminate entrapment of any contamination in the finished work.
6. Surfaces of material and equipment being installed shall be wiped clean using clean water and lint-free wipes. Oil and grease must be cleaned with a solution approved by the Protocol Manager. Dirty wipes must be replaced and disposed of.
7. Floors must be vacuumed or wet mopped weekly.
8. All trash and debris must be removed from building daily.
9. Thorough cleaning with HEPA vacuuming and dry/wet wipe down to remove all loose dirt, dust, debris from all exposed surfaces prior to moving to protocol level 2.

2.7 PROTOCOL LEVEL 2 (FLOOR / CEILING / WALL FINISH INSTALLATION)

A. Level 2 Activities:

1. This establishes the time at which major building construction activities within the clean zone should be completed and access limited.

2. Cleanroom space shall be subject to daily cleaning.
3. All material entering clean zone must be wiped down at established temporary material entry pass-through.
4. Installation of secondary overhead suspension (turnbuckle & threaded rod).
5. All tools entering the clean zone shall be thoroughly cleaned with solution approved by the protocol manager.
6. Contractors working within the cleanroom envelope shall wear booties and hairnets.
7. Install cleanroom piping systems.
8. Install flooring and protective covering.
9. Install ceiling and finishes.
10. Install wall finishes.

B. Cleanliness Level (Level 2):

1. No smoking or chewing tobacco is allowed in clean zone or its perimeter.
2. No eating or drinking at the clean zone levels.
3. Immediate clean-up of debris created by construction activities.
4. No grinding, cutting, welding or drilling is allowed within clean zone.
5. No powder or air actuated tools allowed.
6. No gasoline or diesel powered equipment allowed.
7. Ladder, scaffold and/or gang box feet/wheels must have protective covers.
8. All tools (including ladders, scaffolding, and gang boxes) entering the clean zone must be thoroughly cleaned of all dirt, grease and oil. If this is not possible then new tools must be utilized.
9. All materials entering the clean zone shall be unwrapped/uncrated in an established material entry pass-through, and all surfaces thoroughly cleaned of all dirt, grease, oil, lint or other contaminants by means of non-shedding, lint-free wipes and approved cleaning solution. If vacuuming is required, vacuum must be HEPA filtered.
10. Work shoes must be cleaned before entering clean zone (and donning of shoe covers) by use of shoe cleaners and/or tacky mats.
11. All personnel entering the clean zone must wear clean work boots, clean work clothes, shoe covers/booties, latex gloves, and hairnets. Shoe covers that are torn or soiled must be replaced immediately.
12. Intermediate cleaning with HEPA vacuuming brush/bristle agitation of surfaces and wet IPA wipe down of surfaces and components to remove all dirt, dust, debris from all areas. Perform cleaning immediately prior to moving to Level 3 Protocol.

2.8 PROTOCOL LEVEL 3 (CLEANROOM FURNISHINGS INSTALLATION)

A. Level 3 Activities:

1. Continuous daily clean-up procedures are accelerated.
2. Cleanroom furnishing systems are installed and sealed to floor, walls, and ceiling.
3. Cleanroom ceiling and wall systems and all overhead work complete.
4. Install all wall-mounted devices i.e. control sensors, fire alarm sensors, strobes, horns, pull stations, exit and emergency lighting.
5. Install all wall-mounted cleanroom furnishings and equipment.
6. Remove airtight seal from all air handling units & blowers and perform final blow down.

7. Seal fire sprinkler system in the ceiling system.
8. Final installation and hook-up of light fixtures in ceiling system.
9. All overhead electrical, fire alarm, telecommunications, and controls work shall be completed.

B. Cleanliness Level (Level 3):

1. No tobacco use allowed.
2. No food of any kind is allowed.
3. No powder or air actuated tools are allowed.
4. No gasoline or diesel powered equipment allowed.
5. No grinding, cutting, drilling or dust generating activities allowed in the clean zone.
6. When it becomes necessary to change any work already installed by cutting or drilling, the material must be removed to the staging area. If this is not possible or timely, then temporary barriers must be installed to isolate the work from surrounding cleanroom materials and continuous vacuum removal must be incorporated.
7. All personnel entering the clean zone must wear clean work boots, clean work clothes, shoe covers/booties, latex gloves, smock lab coats, beard covers, and hairnets. Any torn or soiled cleanroom garments must be replaced.
8. Continuous cleaning, vacuuming and trash removal is required as generated.
9. All materials entering the clean zone shall be unwrapped/uncrated in a designated material entry pass-through and all surfaces thoroughly cleaned of all dirt, grease, oil, lint or other contaminants by means of non-shedding, lint-free wipes and approved cleaning solution. If vacuuming is required, vacuum must be HEPA filtered.
10. Superclean complete cleaning with HEPA vacuuming brush/bristle agitation of surfaces and wet IPA wipe down of all surfaces and components to remove residual dirt, dust, debris from all areas. Perform cleaning immediately prior to moving to Level 4 Protocol.

2.9 PROTOCOL LEVEL 4 (START UP TEST)

A. Level 4 Activities:

1. Install HEPA filters in air-handling systems.
2. Install cleanroom ceiling air screens.
3. Cleanroom certification and testing.
4. Perform final wipedown of cleanroom walls, ceiling, and furnishing surfaces.

B. Cleanliness level (Level 4):

1. All level 3 requirements in effect with the following additions:
 - a. Access to clean zones shall be limited only to personnel needing access to perform work and who have gone through a cleanroom construction indoctrination program (security badges issued).
 - b. Cleanroom badges are to be worn on the outside of the cleanroom gowns and be visible.
 - c. Signage installed at all clean zone access points which include a checklist for required cleaning to be performed prior to access.

- d. Gowning to include cleanroom coveralls with hood and face masks, boot covers, hairnet, beard covers and gloves.
- e. Material entry pass-through areas and gowning rooms to be strictly controlled by cleanroom monitor.

PART 3 - EXECUTION

3.1 JOB CONDITIONS

- A. The General Contractor shall provide the shell space and an adjacent staging area in vacuum clean and wiped down condition and shall assist in maintaining the conditions necessary for the performance of the work in this area.
- B. Check project for conditions that affect work. Do not begin activities and services until unsatisfactory conditions are corrected. Defects caused by unsatisfactory conditions or untimely installation shall be corrected at no cost to Owner.
- C. The Cleanroom Protocol Contractor shall monitor and coordinate all work performed within the cleanroom area as required to safeguard the cleanliness of the cleanroom area.

END OF SECTION 13 21 05

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SECTION 13 21 40 – CLEANROOM FUME HOODS AND OTHER AIR CONTAINMENT UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following equipment and related accessories for use in cleanroom environments.
 - 1. Non-metallic acid chemical fume hoods.
 - 2. Benchtop vertical laminar flow workstation.

1.2 RELATED DOCUMENTS

- A. General and Supplementary Conditions and Division 1
- B. Related Sections for cleanroom construction and construction protocol.
- C. Section 11 53 10: Laboratory Casework
- D. Division 21: Fire Suppression
- E. Division 22: Plumbing
- F. Division 23: HVAC
- G. Division 26: Electrical

1.3 REFERENCES (LATEST EDITION)

- A. NFPA 70 - National Electric Code
- B. NFPA 318 - Protection of Cleanrooms
- C. ANSI/FM Approvals 4910 – Cleanroom Materials Flammability Test Protocol
- D. ISO Standard 14644-1 - Classification of Cleanliness for Cleanrooms
- E. IES-RP-CC-002.2 - IES Standard for Unidirectional Flow Clean Air Devices
- F. American Council of Industrial Hygienist - Latest edition
- G. ASHRAE - 110 - Method of Laboratory Fume Hood Testing
- H. NSF 49 – Biosafety Cabinetry: Design, Construction, Performance, and Field Certification.
- I. ISO Standard 14644-2 Specification of Testing and Monitoring for Compliance w/ 14644-1
- J. IES-RP-CCO 34.1 HEPA and ULPA Filter Leak Testing

- K. NFPA 45 - Standard on Fire Protection for Laboratories Using Chemicals
- L. NFPA 496 – Standard for Purged and Pressurized Enclosures for Electrical Equipment
- M. Underwriters Laboratories 6-1010-1 International Standard for Laboratory Hoods and Cabinets

1.4 DEFINITIONS

- A. OEM: Original Equipment Manufacturer- A company who produces hardware to be marketed under another company's brand or be included as an integral part of another company's product.
- B. PAH: Perchloric Acid Hood
- C. VLFH: Vertical Laminar Flow Hood

1.5 EQUIPMENT DESCRIPTIONS

A. Design Requirements:

1. Fume hoods and other air containment units shall be purpose – designed specifically for ISO classified cleanroom use with trace metals analysis. Materials of construction and finishes that may shed particles or may off-gas shall not be used. All exposed materials and surfaces to room air and internal chamber airstream shall be non-metallic or purpose-coated materials to avoid any exposed metal surfaces. Construction materials for all work decks and containment plenums shall be matched specifically based on the end-user chemical review.
2. Electrical wiring shall comply with the National Electrical Code and compliant with UL approved methods.

B. Performance Requirements:

1. Fume hoods shall be manufactured for installation and use inside cleanroom facilities.
2. Fume hoods and other air containment units shall meet specified exhaust requirements and maintain design exhaust velocities across the front access opening with less than 125 Pa (0.50 inch wg) static air pressure drop developed across the unit from the room to the exhaust duct connection.
3. Units shall be tested and evaluated "AM" (As Manufactured) under a modified ANSI/AHRAE 110 testing procedures at design operating conditions and shall meet a minimum performance rating:
 - a. Static Tests: 4.0 AM 0.05 ppm
 - b. Walk-by: 4.0 AM 0.10 ppm maximum and must return to 0.05 ppm within 15 seconds.
4. Electrical wiring shall comply with the National Electrical Code and compliant with UL approved methods.

1.6 SUBMITTALS

A. Quality Assurance:

1. Manufacturer and installing contractor qualifications.

B. Product Data:

1. Provide manufacturers description, materials of construction, finish, itemized features, and operating characteristics for each hood and wet processing bench station. Include original equipment manufacturers' (OEM's) documentation for furnished specialties, equipment, and accessories.
2. Submit testing and quality assurance procedures.
3. Describe finishing and cleaning for materials to be used in the Cleanroom.
4. Describe packaging and shipping procedures.
5. Provide on-site product inspection procedures.

C. Shop Drawings: For each fume hood and wet processing bench station provide:

1. Fabrication drawings, including dimensions, weights, required clearances, method of field assembly, location and size of each field connection, and access features. At a minimum provide views for working deck plan, front and rear elevations, and side section(s).
2. OEM equipment installation details.
3. Airside Performance: Exhaust and laminar supply airflows and static pressure requirements.
4. Wiring Diagrams: Power, signal, and control wiring.
5. Plumbing Diagrams.

D. Performance/Certification Submittals:

1. Factory UL field inspection reports for each unit.
2. Factory As-Manufactured (AM) test results in accordance with modified ANSI/ASHRAE 110 performed on each hood size, style, and configuration.
3. Field As-Installed (AI) test results in accordance with modified ANSI/ASHRAE 110 for each installed hood.

1.7 WARRANTY

- A. Provide warranties in accordance with Division 1 requirements.

1.8 QUALITY ASSURANCE

- A. In addition to the General Standards and as a condition of award, special standards must be met by the cleanroom hood Manufacturer/Installation Contractor to demonstrate that the bidder possesses certain expertise that has been determined essential for adequate contract performance.

1. Manufacturer Qualifications: Provide a list of at least five (5) projects, completed within the last five (5) years, which included manufacturing of chemical fume hoods for use within ISO Class 5 or better certified cleanroom spaces. These projects

should be similar to this project's scope of work and include materials and systems of similar design and installation. Include documented experience for academic and research University cleanroom projects over the same period. List should include the project title, place of performance, General Contractor's project manager's contact information for reference, and Owner's representative and contact information for reference.

2. Installer Qualifications: A factory trained and authorized representative of the manufacturer shall install units and equipment required for this Project. Provide a list of at least three (3) projects, completed within the last five (5) years, which included installation of chemical fume hoods for use within ISO Class 6 or better certified cleanroom spaces. These projects should be similar to this project's scope of work and include materials and systems of similar design and installation. Include documented experience for academic and research University cleanroom projects over the same period. . List should include the project title, place of performance, General Contractor's project manager's contact information for reference, and Owner's representative and contact information for reference. Installing contractors complying with this specification may be provided by the following:

- a. Dow Diversified
- b. ISEC
- c. Approved Substitution.

- B. Product Options: As fabricated, drawings for each unit, which indicate size, profiles, and dimensional requirements of hoods, and processing stations, and show location and installation details of OEM equipment.

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use. Design and construction of the hoods shall comply with NFPA 70, "National Electrical Code."

- D. Installation: Installation shall be performed by an factory trained and authorized representative of the manufacturer and at a minimum shall include the following:

1. Equipment setting.
2. Coordination and verification of utility connections.
3. Start-up, Testing, and Commissioning.
4. Programming adjustments.
5. Owner Training.

1.9 DELIVERY, STORAGE AND HANDLING

- A. Delivery, storage and handling shall be in accordance with the submitted detail procedures as approved by manufacturer.
- B. High purity OEM components shall be shipped to site in OEM's original protective packaging and only opened for direct installation in the Cleanroom.
- C. Installed piping shall be protected with both end caps and bagged ends. Exposed ends or projections shall be encased and protected from shipping and handling damage.

- D. Manufactured units shall be completely cleaned, sealed, and packaged in an ISO Class 5 Cleanroom before shipping to maintain the highest level of factory cleanliness through the shipping and handling process.

PART 2 - PRODUCTS

2.1 ACID CHEMICAL FUME HOODS

A. MANUFACTURERS

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Control, Inc. P.O. Box 1738, Henderson, North Carolina 27536, USA;
Phone: 252.492.2300
 - b. or approved equal.

B. MANUFACTURED UNITS

- 1. Fume hoods and wet processing bench stations as described in Part 1 of this Section shall be factory-assembled, pre-wired, pre-plumbed, and factory-tested.
- 2. Cleanliness critical fabrications and component installations shall be performed under clean conditions as submitted by the manufacturer and approved by Owner.
- 3. During the fabrication process and after testing is complete, the manufactured units shall be cleaned of all dust, dirt, grease, oils, stains and fabrication markings as a preparation for Cleanroom installation prior to sealing and packaging for shipment.

C. MATERIALS

- 1. Non-metallic fume hoods shall be fabricated from the following:
 - a. White stress-relieved PVC Type 1 sheet stock plastics meeting UL94V-O fire retardant plastics unless otherwise noted.
 - b. Raw sheet stock materials shall be inspected prior to fabrication and shall be certified to be free of any visual or structural defects.
 - c. All joints shall be thermally welded to make leak tight, structurally sound, flush joints.
 - d. Fasteners: Fasteners shall be non-metallic or have protective sealed plastic caps.

D. COMPONENTS

- 1. Acid fume hoods:
 - a. Units shall have an instrument compartment-mounted "Low Face Velocity Alarm" which provides audible and visual warnings when the exhaust volume drops below a safe level as detected by a face velocity airflow monitor. Alarm shall be housed in a negative pressure enclosure with swing open clear access door for operator interface to provide no exposed metal to the room.

- b. Exhaust louver above rear work surface shall be adjustable and set at the factory for design conditions. A permanent means of identifying the louver adjustment position(s) for certification shall be provided.
- c. Units identified for free-standing mounting against fixed walls shall be configured for top connection of air ducts and electrical services with service access from the top of the unit unless otherwise noted. Plumbing connection(s) shall be located as indicated in the drawings. Electrical connection shall be located at top right hand side of unit. The exhaust plenum, exhaust transition connection(s), and utility connections shall be configured to allow the rear of the unit to make contact with the fixed wall in final location.
- d. Where equipped, base cabinets shall be vented to accommodate chemical storage beneath the work surface or containment tub. Base cabinet storage areas shall have hinged access doors on the cleanroom side.
- e. Slide-out trays shall be installed in the base cabinet storage areas to provide "pull-out" access of stored contents. Trays shall be fully welded to provide leak tight containment.
- f. Refer to contract drawings for required external piping utility connections.
- g. Sink drains and tailpiece shall be polypropylene for non-metallic units with DWV pipe. The installer of the Cleanroom drain piping system shall install P-traps within the sink cabinet when connecting the unit directly to a laboratory wastewater drain system.
- h. All other internal utility piping shall be Teflon PFA tubing which terminates with a NPT, flare, or union fitting.
- i. General purpose sinks shall have a formed bottom sloping to a 25 mm (1 in.) center drain and shall be plumbed to drain.
- j. Non-recirculating PVDF gooseneck faucet for UHP-DI water shall be installed at the general-purpose sink and factory piped to the hood pure water equipment base cabinet for connection to pure water supply valve by Div 22.
- k. LED lighting shall provide 100 foot-candles minimum at the work surface for non-UV filtered lighting. Lighting shall utilized LED tube or strip lamps, 3500K color temperature. Lights shall be mounted above ceiling panel in a fume-tight, sealed compartment. Light switch shall be mounted on the instrument panel and include a sealed cover to provide metal-free exposure to the room.
- l. Duplex electrical GFCI-type receptacles shall be mounted at locations indicated in the drawings.
- m. Units shall have leveling feet with nominal 2" floor clearance for airflow and a minimum of 25 mm (1 in.) adjustment travel. A minimum of six leveling feet shall be used to support unit with one at each corner and 2 at the mid-span of the front and rear long-axis sides. The base cabinets shall be reinforced for leveling feet load attachment and to support upper loads without distortion or deflection.
- n. Exhaust and supply air plenums shall transition to a standard ANSI bolted pattern duct flange for connection to the duct systems by the Mechanical Contractor.
- o. Fabricate fume hoods with a front canted at 7 degrees away from operator for ergonomic comfort.
- p. Provide a full view, vertically rising safety sash with encapsulated counter weights for ease of operation. Sash shall close within one inch of the work

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surface or close completely with a bypass airfoil sill. Provide sash stop with manual override at normal operating height as indicated in the drawings. Provide side post labeling with arrow at specified normal sash operating height stating "MAXIMUM OPERATING SASH HEIGHT".

- q. For units operating with constant air volume (CAV) exhaust airflow controls, air by-pass louvers shall be located in the upper front of the hood to provide a near constant exhaust volume design without excessive face velocities at lower sash openings. For units operating with variable air volume (VAV) exhaust airflow controls, provide a restricted bypass closure to limit bypass air.
- r. Fume hoods shall have solid flat work decks.
- s. Perchloric Acid hood shall have a water collection trough at the rear of the work deck to collect duct and hood washdown water. The trough shall be double-sloped bottom to center drain outlet for positive collection and drainage of all washdown water. Trough shall stand "proud", with raised lip or fully welded leak-tight berm, from remaining work deck to prevent any chemical spills on the work deck from entering the drain trough.

2.2 BENCHTOP VERTICAL LAMINAR FLOW WORKSTATIONS

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

- 1. AirClean Systems
- 2. Air Control, Inc.
- 3. or approved equal

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- B. Description: Self-contained benchtop vertical laminar flow workstation to provide clean ISO 4 (Class 10) work zone for laminar air flow for process protection when supplied with ISO 4 (Class 10) supply air.

- C. Basis of Design: AirClean Systems model AC6624LF.

- D. Features:

- 1. Microprocessor controller.
- 2. ISO 4 vertical laminar flow air.
- 3. Clear polycarbonate shell for front/sides visibility.
- 4. Polypropylene construction for chemical resistance.
- 5. Integral lighting.
- 6. Ductless – no external duct connections.
- 7. Power cord with NEMA plug for standard 110vac receptacle.
- 8. Timer.

- E. Safety Features:

- 1. Real-time filter load monitoring.
- 2. Filter safety lockout to ensure correct filter replacements.
- 3. Filter and electronics located above the workspace.
- 4. Fully assembled and tested.
- 5. Certifications: UL, CSA, CE.

6. ISO 4 tested.

PART 3 - EXECUTION

3.1 SOURCE QUALITY CONTROL:

A. Testing:

1. General: One of each style and size of fume hood manufactured according to the approved shop drawing shall be factory tested in accordance with modified ASNI/ASHRAE 110 testing. Owner reserves the right to attend the hood testing. Hood Manufacturer shall provide all testing facility and all equipment necessary for the test. At least two week notice of proposed test date shall be provided to Owner.
2. Test Room: The hood to be tested shall be set up in a test room of sufficient size so that a minimum on 1500 mm (5 ft.) of clear space is available in front of and on both sides of the hood for viewing of performance tests.
3. Exhaust System: A hood exhaust system, properly calibrated so that known exhaust air volumes can be easily attained, shall be provided. The exhaust capacity shall be sufficient to exhaust the hood with the design face velocity.

3.2 INSTALLATION

- A. For the purposes of this specification installation is broken down into two (2) work events. The setting of the individual hoods and the facility connection hook-ups to each hood.

B. Equipment Setting:

1. Equipment supplier will set and level hoods and benches into location. Setting of equipment will not take place until cleanroom work is such that all hoods can be set in their entirety and equipment will not be subject to damage from other trades.
2. Facility Connections:
 - a. All facility connections to hoods to be performed by others. All connections shall be installed in accordance with manufacturer's documentation.

3.3 CONTAINMENT FIELD TESTING

A. Fume Hoods:

1. Balance, test and certify each exhausted fume hood in accordance with ASHRAE 110 As-Installed (AI) for Flow Visualization, Face Velocity, and Tracer Gas Containment Testing Requirements.
2. Field tests shall be performed by a qualified independent testing company on each unit to determine face velocity, air flow patterns, and containment.
3. Units shall achieve an As-Installed (AI) performance rating equal or better than 0.10 ppm with 4.0 Lpm tracer gas release rate when tested in accordance with ASHRAE 110 or modified ASHRAE 110 procedures.
4. Balancing and air terminal controls of the exhaust air system serving the units shall be by Division 23.

END OF SECTION 13 21 40

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