APPENDIX A-1 SAMPLE CLEANROOM SPECIFICATIONS

MICROELECTRONICS & SEMICONDUCTORS

SECTION xxxxx – CLEANROOM PERFORMANCE TESTING

PART 1 -- GENERAL

1.1 WORK INCLUDED

A. This Section specifies the requirements of the NEBB Certified Cleanroom Performance Testing (CPT) Firm to measure and record the cleanroom conditions during a _____ occupancy mode.

B. Advise the Owner and the NEBB Certified Testing, Adjusting, and Balancing (TAB) Firm providing the TAB work on the adjustment and setting of dampers in access floor panels and cleanroom ceiling filters to achieve a final cleanroom certification.

1.2 RELATED WORK

A. Use this section in conjunction with the following related Contract Documents to establish the total requirements for the testing of the cleanrooms:

1. Specifications: (List
2. Drawings: (List)
3. Standards: (List)
4. Other: (List)

1.3 SCOPE OF CLEANROOM PERFORMANCE TESTS

A. Perform specific primary and secondary tests described in the Contract Documents. Report the test results in accordance with the acceptance criteria as stated in the Contract Documents.

1.4 REGULATORY AND STANDARD PRACTICES REQUIREMENTS

A. Current edition of the NEBB *Procedural Standards for Certified Testing of Cleanrooms (NEBB-PSCTC).* This specification section contains multiple references to this acronym. When used or referenced in this specification, NEBB-PSCTC, is meant to identify the current publication and / or various sections, tables, equations, charts etc from the current publication.

B. Other: (List)

1.5 QUALITY ASSURANCE

A. Firm shall be a NEBB Certified CPT Firm.

B. Measurement: sampling based upon accepted NEBB sampling and statistical procedures.

C. 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 *Procedural Standards for Certified Testing of Cleanrooms*.

2. Calibrate test equipment that requires calibration within the project work schedule, prior to any testing with the instrument.

D. 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*.

1.6 QUALIFICATIONS

A . Firm Qualification:
The Certified CPT Firm shall be current, certified, and in good standing with the National Environmental Balancing Bureau (NEBB).

B. CPT Certified Professional:
The Certified CPT Professional shall be current, certified and in good standing with the National Environmental Balancing Bureau (NEBB) and employed by the NEBB Certified CPT Firm.

C. CPT Qualified Technician:
The Qualified Technician shall be current, qualified and in good standing with the National Environmental Balancing Bureau (NEBB) and employed by the NEBB Certified CPT Firm and shall have completed previous training in cleanroom operations and certifying procedures thorough, demonstrable knowledge of test procedures and equipment.

1.7 COORDINATION

A. Jobsite visits: Provide at least _____ jobsite visits by the CPT Certified Professional 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.

1.8 SUBMITTALS

A. Submit the following:
1. Qualifications of the NEBB Certified CPT Firm project specific staff.
2. Outline of the testing and certification procedures.
3. Schedule for the performance tests on this project.
4. List of instrumentation and test equipment and specimen certificates of calibration.
5. Samples of field reports, charts, and forms proposed to document measurements.

B. Submit the following to the Owner within 10 working days after completion of work:
1. Preliminary field reports compiled from each of the certification steps.
2. One copy of the working field logs for review and evaluation.
3. Evaluation of any problems which may affect final certification results.

1.9 PROJECT RECORD DOCUMENTS

A. Submit the final NEBB Certified CPT Report within 30 working days after completion.
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 280 mm x 432 mm (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*.

B. Provide one hard-bound copy and one unbound reproducible copy of the Final NEBB Certified CPT Report for the Owner's use.

PART 2 -- PRODUCTS

2.1 CLEANROOM PERFORMANCE TEST FIRM

A. The Certified CPT Firm shall be certified by the National Environmental Balance Bureau to provide cleanroom performance testing.

2.2 MATERIALS

A. Supply necessary personnel, materials, tools, test equipment, aerosol generators, instrumentation, and computers required to perform and analyze the cleanroom testing procedures described in this Section.

B. Cleanroom garments and accessories will be furnished and laundered by the Owner.

2.3 INSTRUMENTATION

A. All instrumentation requirements are based on standard temperature and pressure conditions (STP).

Test	Equipment / Instrumentation	Description	Calibration Interval
Airflow Velocity and Uniformity Test (Direct Air Velocity Measurement)	Anemometer	A digital anemometer capable of meeting the following requirements: Range: 0.25 – 12.5 m/s (50 - 2500 fpm) Accuracy: ± 5% of reading 0.50 m/s (100 fpm) or greater Accuracy: ± 10% of reading 0.50 m/s (99 fpm) or less Resolution: 0.005 m/s (1.0 fpm)	12 Months
Airflow Velocity and Uniformity Test (Indirect Air Velocity Measurement)	Manometer	A digital manometer capable of meeting the following requirements: Range: 0.25 – 12.5 m/s (50 - 2500 fpm) (Based on conversion of velocity pressure to velocity) Accuracy: ± 5% of reading Resolution: 0.1 m/s (20 fpm)	12 Months
	Tube Array	Multi-point velocity pressure measurement sensing device to be used with a digital manometer as specified above. Range: Not Applicable Accuracy: Not Applicable Resolution: Not Applicable	Not Required
	Pitot Tube or Single-Point Probe	Single point velocity pressure measurement sensing device to be used with a digital manometer as specified above. Range: Not Applicable Accuracy: Not Applicable Resolution: Not Applicable	Not Required
Airflow Volume and Uniformity Test	Direct Reading Hood	A flow capture hood with an integral analog or digital manometer capable of meeting the following requirements: Range: 50 - 1000 L/s (100 - 2000 cfm) Accuracy: ± 5% of reading, ± 2.5 L/s (± 5% of reading, ± 5 cfm) Resolution (Digital): 0.5 L/s (1.0 cfm) Resolution (Analog): 2.5 L/s (5.0 cfm)	12 Months

Test	Equipment / Instrumentation	Description	Calibration Interval
Airflow Volume and Uniformity Test	Manometer	A digital manometer capable of meeting the following requirements: Range: 0.25 - 12.5 m/s (50 - 2500 fpm) Accuracy: ± 5% of reading Resolution: 0.1 m/s (20 fpm)	12 Months
	Pitot Tube or Single-Point Probe	Single point velocity pressure measurement sensing device to be used with a digital manometer as specified above. Range: Not Applicable Accuracy: Not Applicable Resolution: Not Applicable	Not Required
Leak Testing (w/Photometer)	Aerosol photometer	The instrument shall have a threshold sensitivity of 10^{-4} micrograms per liter of challenge aerosol particles and be capable of measuring concentrations over a range of 10^5 times the threshold sensitivity. *Sample flow rate* shall be 28.3 L/min (1.0 cfm) with a probe inlet sized to provide isokinetic sampling. Readout shall be either linear or logarithmic with an accuracy of 1% of full scale of the selected range.	12 Months
	Aerosol Generator	A device that can aerosolize either a polydispersed or a monodispersed artificial particle medium for filter integrity testing, including Laskin nozzle type, thermal generator, atomizer, etc.	Not Required
	Scanning Probes	Isokinetic (square or rectangular) scanning probe fitted with a sampling tube no longer than a length recommended by the aerosol photometer manufacturer or 8.0 mm (25 feet).	Not Required
Leak Testing (w/Particle Counter)	Particle Counter (Scanning)	A light scattering instrument with display or recording means to count and size discrete particles in air, as defined by ASTM F50-69. Instruments of this type shall provide for a sampling flow rate of 28.3 L/min (1.0 cfm) and a threshold size discrimination of a minimum of 0.2 micrometer in size. The unit shall be provided with an isokinetic sampling probe to maintain the probe inlet velocity at the test airflow rate.	12 Months
	Particle Counter (Upstream Verification)	A light scattering instrument with display or recording means to count and size discrete particles in air, as defined by ASTM F50-69. Instruments of this type shall provide for a sampling flow rate of 0.283 L/min (0.01 cfm) and a threshold size discrimination of a minimum of 0.2 micrometer in size.	12 Months
	Scanning Probes	Isokinetic (square or rectangular) scanning probe fitted with a sampling tube no longer than a length recommended by the particle counter manufacturer.	Not Required

Test	Equipment / Instrumentation	Description	Calibration Interval
	Diluter	A device that allows a ratio sample of 10:1, 100:1, or as required to achieve a minimum of 80% counting efficiency with the scanning particle counter 10% of upstream challenge.	12 Months
Airborne Particle Count Cleanliness Classification Test	Particle Counter	A light scattering instrument with display or recording means to count and size discrete particles in air, as defined by ASTM F50-69. Instruments of this type shall provide for a sampling flow rate of 28.3 L/min (1 cfm) and a threshold size discrimination of a minimum of 0.2 micrometer in size. The unit shall be provided with an isokinetic sampling probe to maintain the probe inlet velocity at the test airflow rate.	12 Months
	Sampling Probes	Isokinetic (square or rectangular) scanning probe fitted with a sampling tube no longer than a length recommended by the particle counter manufacturer or 8.0 m (25 ft).	Not Required
Room Pressurization Test	Manometer Change Resolution to equal 10 Pa (0.25 in.w.g.) for magnehelic	An analog or digital manometer capable of meeting the following requirements: Range: 0 - 125 Pa (0 – 0.50 in.w.g.) Accuracy: ± 2% of reading Resolution: 2.5 Pa ≤ 250 Pa (0.01 in.w.g. ≤1 in.w.g.) 25 Pa > 250 Pa (0.1 in.w.g. >1 in.w.g.)	12 Months
Airflow Parallelism Test	Test Medium	A non-contaminating smoke vapor source, streamers, thread or string	Not Required
	Support Stand & Support Stand with Pointer	A device for positioning the test medium at the specified location and height that is aerodynamically designed to yield the least impact to room airflow.	Not Required
	Plumb Bob or Spirit Level	A small mass of heavy material suspended by a line and used to ascertain a vertical line.	Not Required
	Tape Measure	Linear measurement device with a minimum resolution of 1.0 mm (1/16 inch)	Not Required
Enclosure Integrity Test	Aerosol Generator	A device that can aerosolize either a polydispersed or a monodispersed artificial particle medium for filter integrity testing, including Laskin nozzle type, thermal generator, ultrasonic humidifier, atomizer, etc.	12 Months
	Particle Counter	A light scattering instrument with display or recording means to count and size discrete particles in air, as defined by ASTM F50-69. Instruments of this type shall provide for a sampling flow rate of 28.3 L/min (1 cfm) and a threshold size discrimination of a minimum of 0.2 micrometer in size. The unit shall be provided with an isokinetic sampling probe to maintain the probe inlet velocity at the test airflow rate.	12 Months

Test	Equipment / Instrumentation	Description	Calibration Interval
Recovery Test	Aerosol Generator	A device that can aerosolize either a polydispersed or a monodispersed artificial particle medium for filter integrity testing, including Laskin nozzle type, thermal generator, ultrasonic humidifier, atomizer, etc.	12 Months
	Particle Counter	A light scattering instrument with display or recording means to count and size discrete particles in air, as defined by ASTM F50-69. Instruments of this type shall provide for a sampling flow rate of 28.3 L/min (1 cfm) and a threshold size discrimination of a minimum of 0.2 micrometer in size. The unit shall be provided with an isokinetic sampling probe to maintain the probe inlet velocity at the test airflow rate.	12 Months
Lighting Level and Uniformity Test	Light Meter	A portable photo-electric illumination meter approved for field measurement in accordance with the Illumination Engineering Society Lighting Handbook (IES).	12 Months
Sound Level Test (performed w/SLM)	Sound level meter (SLM)	Sound level meter (SLM) for sound pressure measurements shall meet the Type 1 or Type 2 requirements specified in the most current version of *ANSI S1.4 American National Standard Specification for Sound Level Meters.*	12 Months
	Full and Third Octave Filters	Filters for sound pressure measurements shall meet the requirements specified in the most current version of *ANSI S1.11 American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters.*	12 Months
	Acoustic Calibrators	Calibrators for sound pressure calibration shall meet the requirements specified in the most current version of *ANSI S1.40-1984 (R2001) American National Standard Specification for Acoustical Calibrators.*	12 Months
Sound Level Test (performed w/Real Time Analyzers)	Real Time Analyzer	Real Time Analyzer for sound pressure measurements shall meet the minimum requirements as specified in ANSI S1.4 and S1.11 and, Lines of resolution: ≥ 400 Frequency range capability: 0 – 20.0 kHz True dynamic range: ≥ 70 dB Sum and exponential averaging Peak hold function Memory for storage of measurements	12 Months
	Full and Third Octave Filters	Full and Third Octave Filters for sound pressure measurements shall meet the requirements specified in the most current version of *ANSI S1.11 American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters.*	12 Months

Test	Equipment / Instrumentation	Description	Calibration Interval
	Acoustic Calibrators	Acoustic Calibrators for sound pressure calibration shall meet the requirements specified in the most current version of *ANSI S1.40-1984 (R2001) American National Standard Specification for Acoustical Calibrators.*	12 Months
Vibration Level Tests (performed w/SLM)	Sound level meter (SLM)	Sound level meter (SLM) for sound pressure measurements shall meet the Type 1 or Type 2 requirements specified in the most current version of *ANSI S1.4 American National Standard Specification for Sound Level Meters.*	12 Months
	Accelerometers / Transducers	Accelerometers / Transducers for vibration measurements shall have the following minimum specifications: Sensitivity: (± 10%) ≥ 100 mV/G Measurement Range: ± 490 m/s² (50 G) peak Frequency Range: 1 to 1000 Hz at ± 5 % Mounted Natural Frequency: ≥ 30,000 Hz	12 Months
	Vibration Integrators	Vibration Integrators for SLM for vibration measurements shall meet the minimum requirements as specified below: Displacement: 0.003 - 2.5 mm (0.1 to 100mils) Velocity: 0.13 – 2500 mm/s (0.005 to 100 in/sec) Acceleration: 0.098 – 980 m/s² (0.01 to 100 G's) Frequency Range: 1 to 10,000 Hz Frequency Resolution: 1/3-Octave – 12.5 to 20,000 Hz	12 Months
	Vibration Calibrators	Vibration Calibrators for vibration calibration of SLM shall have the following minimum specifications: Operating Frequency: 159.2 Hz Acceleration Output: 9.82 m/s² (1 G rms) ± 3% Distortion (with 0 to 100 gram load) ≤ 3%	12 Months
Vibration Level Tests (performed w/ Vibration Meter)	Vibration Meter	Vibration Meter for vibration measurements shall meet the minimum requirements as specified below: Displacement: 0.00254 mm to 2.54 mm (0.1 to 100 mils), Velocity: 0.13 - 2500 mm/s (0.005 to 100 in/sec) Acceleration: 0.098 – 980 m/s² (0.01 to 100 G's) Frequency Range – 1 to 200 Hz (0 to 12,000 CPM) Frequency Resolution Narrowband – 1 Hz	12 Months
	Accelerometers / Transducers	Accelerometers / Transducers for vibration measurements shall have the following minimum specifications: Sensitivity: (± 10%) ≥ 100 mV/G Measurement Range: ± 490 m/s² (50 G) peak Frequency Range: (1 to 1000 Hz) at ±5% Mounted Natural Frequency: ≥ 30,000 Hz	12 Months

Test	Equipment / Instrumentation	Description	Calibration Interval
	Vibration Integrators	Vibration Integrators for SLM for vibration measurements shall meet the minimum requirements as specified below: Displacement: 0.003 - 2.5 mm (0.1 to 100 mils) Velocity: 0.13 – 2500 mm/s (0.005 to 100 in/sec) Acceleration: 0.098 – 980 m/s² (0.01 to 100 G's) Frequency Range: 1 to 10,000 Hz Frequency Resolution: 1/3 Octave Band: 12.5 to 20,000 Hz	12 Months
	Vibration Calibrators	Vibration Calibrators for vibration calibration of SLM shall have the following minimum specifications Operating Frequency: 159.2 Hz Acceleration Output: 9.82 m/s² (1 G rms) ± 3% Distortion (with 0 to 100 gram load) ≤ 3%	12 Months
General Temperature and Moisture Uniformity Test	Air Temperature Measurement Instrument	An analog or digital thermometer capable of meeting the following requirements: Range: 4.5°C - 38°C (40°F to 100°F), Accuracy: ± 1% of reading, Resolution: 0.1°C (0.2°F)	12 Months
	Humidity Measurement Instrument	An analog or digital hygrometer capable of meeting the following requirements: Range: 10% - 90% RH, Accuracy: ± 2% RH, Resolution: 1% RH	12 Months
Comprehensive Temperature and Moisture Uniformity Test	Data Recorder - Temperature	Electronic thermometers and temperature sensors with readout devices capable of meeting the following requirements: Range: 4.5°C - 38°C, (40°F - 100°F) Accuracy: ± 0.05°C, (±0.1°F) Resolution: ± 0.05°C. (±0.1°F) Instruments shall be capable of recording temperature and humidity or dew point at specified time intervals and time periods.	12 Months
	Data Recorder - Humidity	Humidity measuring instruments and sensors used with readout devices capable meeting the following requirements: Range: 10% - 90%, Accuracy: ±0.1%, Resolution: ±0.1% Instruments shall be capable of recording temperature and humidity or dew point at specified time intervals and time periods.	12 Months
Electrostatic Tests	Electrostatic Voltmeter Electrostatic Field meter	Voltmeter or field meter shall have a range of ± 8.163 kv/cm (±19.99 kv/inch) with an accuracy of ± 5% and a response time of less than 2 seconds for 0 kv to ± 5 kv	12 months
	Ohmmeter	Ohmmeter shall have an open circuit voltage of 500 volts (DC) and a nominal internal resistance of not less than 100,000 ohms	12 months

Test	Equipment / Instrumentation	Description	Calibration Interval
	Electrodes	Electrodes shall weigh 2.27 kg (5 pounds) and have a flat, circular contact area 64 mm (2.5 inches) in diameter, which shall comprise of a surface of aluminum or tin foil 0.0127 to 0.0254 mm (0.005 inch to 0.001 inches) thick, backed by a layer of rubber 6.4 mm (1/4 inch) thick and measuring 40 and 60 durometer hardness as determined with a Shore Type A durometer (ASTM D2240-68).	12 months
	Charged Plate Monitor	Device shall have a measuring range of -5 kv to + 5 kv with an error of ± 5% of full scale and a response time of 0.1 seconds short circuit current shall be between 2.5 mA and 5 mA. At any value of connected resistance, R_x, the terminal voltage (V) shall be: $V = \frac{R_x}{R_x + \text{internal resistance}} \text{ x } 500 \text{ V } (\pm 15\%)$	12 months
Conductivity Tests	Ohmmeter	Ohmmeter shall have an open circuit voltage of 500 volts (DC) and a nominal internal resistance of not less than 100,000 ohms.	12 months
	Electrodes	Electrodes shall weigh 2.27 kg (5 pounds) and have a flat, circular contact area 64 mm (2.5 inches) in diameter, which shall be comprised of a surface of aluminum or tin foil 0.0127 to 0.0254 mm (0.005 inch to 0.001 inch) thick, backed by a layer of rubber 6.4 mm (1/4 inch) thick and measuring 40 and 60 durometer hardness as determined with a Shore Type A durometer (ASTM D2240-68).	12 months
Electromagnetic Interference (EMI) Test	Magnetic Field Meter	A magnetic field meter with a dynamic range of 0.1 to 4000 milligauss	12 months
	Magnetic Field Sensor	A magnetic field sensor with an external, multi-turn loop.	12 months

PART 3 – EXECUTION

3.1 INSPECTION

A. The NEBB Certified CPT Firm and the NEBB Certified CPT Professional 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. The NEBB Certified CPT Firm and the NEBB Certified CPT Professional 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 work 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 PREPARATION

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 CLEANROOM PRIMARY AND SECONDARY TEST PROCEDURES

A. Airflow Velocity Test:

1. Purpose of Test:
   a. Determine the average supply airflow velocity delivered through each ceiling filter.
   b. Determine the airflow velocity uniformity throughout the cleanroom.
   c. Determine air velocity profile 50 mm,150 mm or 300 mm (2 in, 6in. or 12 in.) below the face screen of each ceiling filter.

2. Test Procedure:
   a. Measure and record the supply airflow velocity delivered through the filter using thermal anemometer or a tube array with a digital manometer.
   b. Measure and record the airflow velocity profiles.
   c. Measure and record the air velocity profile for 5 seconds. Select the average of the two values for the recorded reading.

3. Acceptance Criteria:
   a. The average supply airflow velocity for each filter should be within ±10% of the design airflow supply velocity.
   b. The average or total airflow velocity for the cleanroom shall be within ±10% of the design.
   c. The relative standard deviation shall not exceed 15%.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Sample Location Documentation
   e. As Left Data: Minimum airflow velocity, Maximum airflow velocity, Average airflow velocity
   f. Test Results Data
   g. Report all airflow measurements with corresponding grid locations.
   h. Relative Standard Deviation
   i. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

B. Airflow Volume Test:

1. Purpose of Test:
   a. Determine the supply airflow volume delivered through each ceiling filter.
   b. Determine the airflow volume uniformity throughout the cleanroom.

2. Test Procedure:
   a. Measure and record the supply airflow volume delivered through the filter using a flow hood. Use appropriate size capture enclosure for each filter application.
   b. Measure and record the airflow volumes.

3. Acceptance Criteria:
   a. The average supply airflow volume for every ceiling filter should be within ±10 % of the design airflow supply volume.
   b. The average or total airflow volume for the cleanroom shall be within ±10% of the design.
   c. The relative standard deviation shall not exceed 15%.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Sample Location Documentation
   e. Duct Size and Individual Velocities
   f. As Left Data: Total Airflow Volume
   g. Test Results Data
   h. Report all airflow measurements with corresponding grid locations.
   i. Relative Standard Deviation (If multiple airflow volume measurements are made on multiple devices).
   j. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

C. Cleanroom Ceiling System / Filter Leakage Test:

1. Purpose of Test:
   a. Determine integrity of cleanroom ceiling system / filters after installation.
   b. Determine leakage through any component in the ceiling system assembly.

2. Test Procedure:
   a. Verify that the design airflow velocity has been balanced by the NEBB Certified TAB Firm prior to performing the filter installation leak test.
   b. Test the entire ceiling system assembly.
   c. Provide optical laser particle counters, PSL aerosol generator, and accessories.
   d. Introduce microspheres from the generator into the recirculation air system. A minimum challenge of 35,300,000 particles per cubic meter 1,000,000 particles per cubic foot) is required at each filter.
   e. Measure and record the upstream challenge within the localized ceiling system at least once every 4 hours.

f. Calculate the scan rate per Equation 10-2 in the NEBB *Procedural Standards for Certified Testing of Cleanrooms*. Prior to calculating the scan rate, obtain the Construction Manager's or Owner's written approval to the Np value that will be used in the calculation.

g. Scan the entire downstream filter face area isokinetically in overlapping strokes, moving the probe at the calculated scan rate, the scan rate is to be no more than 0.05 m/s (10 fpm), at a distance 25 mm (1 inch) below the filter face. Scan the entire perimeter, center support mullions, and corners. Provide filter shrouds in partial filter coverage ceilings to block air entrained from adjacent non-airflow components.

h. Scan joints in the ceiling system assembly, including the gap between the ceiling grid and filter, wall-to-ceiling joint, sprinkler pipe and electrical conduit penetrations, and blank panel edge seals.

i. A particle count detection exceeding Np will indicate a significant leak. Extend test duration under any portion of the ceiling system where Np is exceeded to a minimum sample volume of 14.2 L (0.5 ft^3).

j. Repairs, leaks and retesting of cleanroom ceiling systems shall be performed in accordance with the requirements as stated in the contract documents or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

3. Acceptance Criteria:
   a. Reject any component of the cleanroom ceiling system where the leak exceeds 0.01% percent of the measured upstream challenge concentration.
   b. Reject any filter where one dimension exceeds 38 mm (1.5 inch) in length or with an accumulative total repair area of 3 percent of media pleated face area.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Challenge Medium
   e. Upstream Challenge Concentration / Particle Size
   f. Leak:
      1. Location
      2. Percent of Penetration
      3. Type (Media, Grid, Gel, Etc.)
   g. Test Results Data
   h. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
   i. Scan Rate

j. Repairs (Individual):
   1. Number
   2. Size
   3. Location
   4. Area
   5. Repairs: Total percentage of repair area

D. Airborne Particle Count Cleanliness Classification Test:

1. Purpose of Test: The airborne particle count cleanliness classification test is performed to determine the actual particle count level within the facility at the specified occupancy state.

2. Test Procedure:
   a. Complete the installed ceiling cleanroom filter leakage scan test, makeup air handler cleanroom final filter media test, parallelism test, pressurization test, air velocity uniformity test, and the enclosure induction leak test before starting airborne particle count sampling.
   b. Measure and record the particle count at a distance 1066 mm (42 inches) above the floor on a sample location grid and sample volume basis as defined in ISO Standard 14644-1.
   c. Retesting of failed particle count sample locations shall be performed in accordance with the requirements as stated in the contract documents or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

3. Acceptance Criteria:
   a. The air in a cleanroom or controlled environment shall have met the acceptance criteria for an airborne particulate cleanliness class (see Table 10-1 of the NEBB *Procedural Standards for Certified Testing of Cleanrooms* (PSCTC). The cleanroom cleanliness classification is acceptable when the averages of the particle concentrations measured at each of the locations fall at or below the class limit. Additionally, if the total number of locations sampled is greater than one and less than ten, the mean of these averages must fall at or below the class limit with a 95% UCL.
   b. If the results are non-compliant based on the 95% UCL calculation due to a single “outlier” value, it does not need to be included in a recalculation of the 95% UCL analysis provided that the outlier is due to procedural error or equipment malfunction. Additionally, the calculation is repeated with all remaining sample locations and at least three samples remain in the calculation. Additionally the cause of the outlier is documented. Deletion of the outlier in the 95% UCL calculation shall be as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
   c. Clean work zones within the cleanroom may also be allowed. These clean work zones shall be classified based on the maximum allowable particle count within that clean work zone.

4. Documentation:
   a. Technician’s Name

b. Test Date(s)
c. Instrument Identification
d. Standard Operating Procedure
e. Test Occupancy State
f. Test Results Data
g. Particle Size(s) of Interest
h. Actual Room Classification
i. UCL 95 calculation of preformed
j. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

E. Pressurization Test:

1. Purpose of Test:
   a. Confirm capability of cleanroom air-handling systems to maintain cascaded air pressure differentials between the cleanroom and the adjacent support areas per the design requirements.

2. Test Procedure:
   a. Measure and record the relative pressure differentials between each cleanroom and the adjacent area.
   b. Measure and record the relative pressure differentials sequentially from the area with the highest cleanliness requirement outward through contiguous spaces to the outdoors.

3. Acceptance Criteria:
   a. Compare actual pressure differential to design requirements.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Test Results Data
   e. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

F. Airflow Parallelism Test:

1. Purpose of Test:
   a. Verify parallel vertical flow paths of supply airflow.

2. Test Procedure:
   a. Measure and record the parallel vertical flow path.
   b. Divide the cleanroom into equal area grids. The maximum grid spacing shall be 3m x 3m (10 ft x 10 ft). Perform the test in the middle of each grid.

c. Secure the plumb line, spirit level or straight edge as required, mark the plumb line at 305 mm (12 inch) intervals, the distance from the plumb line to the streamer or vapor is determined at a distance of 915 mm and 1525 mm (36 inches and 60 inches) above the floor, introduce the test medium using a support stand at the specified height. Calculate the angle of deflection.

3. Acceptance Criteria:
   a. The angle of deflection should not be greater than 14° from center when measured higher than 915 mm (36 inches) above the floor.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Test Results Data
   e. Test Location Diagram
   f. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

G. Recovery Test:

1. Purpose of Test:
   a. Determine ability of cleanroom air-handling system to recover cleanliness levels after an internal particle upset.

2. Test Procedure:
   a. Measure the particle counts at an initial condition in the cleanroom
   b. Generate the particulate challenge at the supply air inlet to the cleanroom to raise the particle count to following levels:

      ISO Class 5 and Cleaner: 100 times the established target cleanliness level.

      ISO Class 6 and Above: 10 times the established target cleanliness level.
   c. Shutoff the aerosol challenge
   d. Take particle counts for 6 second sample periods for each minute until the particle count is returned to the target cleanliness level measured prior to the introduction of the challenge particles.
   g. Document the recovery time.

3. Acceptance Criteria:
   a. Acceptance of the facility is subject to approval of satisfactory recovery rate as agreed to by the Owner.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Initial Particle Counts at Particle Size(s) of Interest
   e. Challenge Medium
   f. Challenge Concentration
   g. Test Results Data: Recovery Time
   h. Ending Particle Count at Particle Size(s) of Interest
   i. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

H. Lighting Level Test:

1. Purpose of Test:
   a. Determine that the installed lighting levels and lighting uniformity meet the specified requirements.

2. Test Procedure:
   a. For high intensity, or fluorescent systems, in relatively new lamp installations, verify that lamps have been in operation for a minimum of 100 hours before measurements are taken.
   b. Verify that high intensity discharge or fluorescent systems have been illuminated for at least two hours before measurements are taken.
   c. Luminance measurements should be made under actual working conditions. All lighting in the area including general lighting, task lighting and supplementary lighting should be in normal use.
   d. Measurements shall be made at work surface elevation and from a specified work point location with the combinations of daylight and electric lighting facilities available.
   e. Prepare a measurement grid based on room size and luminaries type, spacing and location.
   f. Measure lighting intensity at 915 mm (36 inches) above the finish floor using Equations 11-1, 11-2, 11-3, 11-4, or 11-5 of the NEBB *Procedural Standards for Certified Testing of Cleanrooms*. Use the appropriate equation for the cleanroom lighting layout.

3. Acceptance Criteria:
   a. Compare actual lighting levels to design criteria requirements.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Test Location Diagram
   e. Test Results Data

f. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

I. Sound Level Test:

1. Purpose of Test:
   a. Determine the operating sound level in the cleanroom produced by the facility support systems based on the specified occupancy state during the test.

2. Test Procedure:
   a. Measure and record the operating noise in the cleanroom when the cleanroom is at the specified occupancy test state.
   b. Place pickup sensors to achieve a direct line of sight between the sound source and the sound meter at 1220 mm (48 inches) above the floor and at least 915 mm (36 inches) from a wall, column, or any other large surface capable of altering the sound measurements.
   c. Record sound pressure data in all eight-octave bands.

3. Acceptance Criteria:
   a. Compare actual sound pressure levels to design noise criteria requirements.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Test Location Diagram
   e. Test Results Data: Operating Sound Pressure Levels: NC Curve, RC Curve or A-Weighted Value
   f. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

J. Vibration Level Test

1. Purpose of Test:
   a. Determine vibration impact of normal activities, functions and operations in the cleanroom.
2. Test Procedure:
   a. Measure and record vibration displacement, velocity, and acceleration at test stations selected by the Owner in the specified occupancy state.
   b. Place accelerometers on top of structural and building support members, equipment bases, and raised floor tiles as directed by the owner.
   c. Measure and record the vibration levels in rms for peak-to-peak displacement, zero-to-peak velocity, and zero-to-peak acceleration.

3. Acceptance Criteria:
   a. Acceptance of the facility is subject to approval of satisfactory vibration levels as agreed to by the Owner.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Test Location Diagram
   e. Test Results Data: (data stated in appropriate units (SI or IP) and reported in terms of displacement, velocity, acceleration and / or frequency based on scope requirements)
   f. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

K. Comprehensive Temperature and Humidity Uniformity Test:

1. Purpose of Test:
   a. Confirm the capability of the facility support systems to control temperature and relative humidity to meet the project criteria.
   b. Verify uniformity of environmental conditions throughout contiguous areas of the cleanroom.
   c. Confirm stability of environmental conditions at control sensing points.

2. Test Procedure:
   a. Designate a minimum of one temperature and relative humidity measurement location in each temperature control zone.
   b. Verify that the HVAC system(s) TAB work has been completed prior to performing this test.
   c. Verify that the airflow uniformity test have been competed and accepted.
   d. Allow the HVAC system to operate under automatic control for a minimum of 24 hours prior to beginning this test. Support systems shall have been in normal automatic operation under control of calibrated permanent controllers for at least 7 days.
   e. Uniformly place each temperature and humidity sensor at each designated work level sampling location, allow the sensor to stabilize.
   f. Measure and record the temperature and humidity measurement simultaneously at each location every 6 minutes for a minimum period of 2 hours.

3. Acceptance Criteria:
   a. Acceptance of the facility is subject to approval of satisfactory temperature and humidity uniformity as agreed to by the Owner.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Test Location Diagram
   e. Work Height Level
   f. Test Results Data
   g. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

L. Electrostatic Test:

1. Purpose of Test:
   a. Benchmark the airborne positive and negative ion densities at strategic locations within the cleanroom.

2. Test Procedure:
   a. Surface Voltage Level: The measuring point(s) or the object to be measured shall be as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
      1. Hold the probe to a grounded metal plate and adjust the output of the electrostatic voltmeter to zero.
      2. Hold the probe parallel to the plate and at a distance that is in accordance with the manufacturer's recommendations.
      3. The metal plate should have a surface area large enough for the required probe aperture and be large enough for the probe to surface spacing ratio.
      4. Hold the probe in the same position as for zero adjustment. Then place the probe near the object surface which has the charge and measure the surface voltage.
   b. Static Dissipative Test: The electrodes should be set at the correct distance from the surface in accordance with the manufacturer's recommendations.
      1. Hold the probe to a grounded metal plate and adjust the output of the electrostatic voltmeter to zero.
      2. Specific test conditions should be as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
   c. Ion Generator Test: An Ion generator performance is evaluated by taking the discharge time and measurements of the offset voltages. The imbalance of positive and negative ions that are in the ionized airflow can result are determined by the offset voltage measurements. The efficiency of eliminating static charges that are caused by using ion generators is determined by measuring the discharge time. The measuring point(s) or the object to be measured should be as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

1. Using isolated conductive plates of a known capacitance.
2. From a power source, the isolated conductive plates are charged to a known positive voltage.
3. Expose the isolated conductive plates to the airflow that is being ionized by the bipolar ion generator.
4. Measure the change in static charge of the plates.
5. Measure the time in which it takes the static voltage on the plate to be reduced to 10% of the initial voltage condition which is the discharge time.
6. Repeat this procedure with the plates charged to a known negative voltage.

d. Offset Voltage Tests: The measuring point(s) or the object to be measured should be as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
   1. Using isolated conductive plates of a known capacitance.
   2. Ground the isolated conductive plates.
   3. Confirm that the voltage is zero.
   4. Connect an electrostatic voltmeter to the plate.
   5. Expose the isolated conductive plates to the airflow that is being ionized by the bipolar ion generator until the voltage becomes stable.

3. Acceptance Criteria - Acceptance of the facility is subject to approval of satisfactory electrostatic tests as agreed to by the Owner. Note: The owner's criteria will depend on the electrostatic sensitivity of devices that are located in the work area.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Test Location Diagram
   e. Test Parameters
   f. Test Results Data
   g. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

M. Conductivity Test:

1. Purpose of Test:
   a. Determine resistance between specified points on the floor.
   b. Determine resistance from the floor covering to building ground at strategic locations within the building.

2. Test Procedure:
   a. Tile-to-Tile: Perform conductivity tests at the specified number of tile pairs.

1. Floor shall be tested with temperature and relative humidity maintained as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
2. Measure five (5) pair of test stations as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
3. Measure resistance with a suitably calibrated ohmmeter.
4. Measurements on raised floor tiles shall be made between pairs of points and may include some, or all, of the following:
    a. Center of test tile to center of adjacent tile.
    b. Corner of test tile to corner of any tile two positions away.
    c. Center of test tile to any supporting pedestal.
    d. Center of test tile to conductive paint finish covering main structural concrete floor.

b. Floor-to-Building Ground: Perform conductivity tests from the floor covering to the building ground (raised floors only).
1. Floor shall be tested with temperature and relative humidity maintained as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
2. Measurements shall be made at twenty (20) tests locations as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
3. Measurements shall be made at each of the 20 test locations in each room and the results averaged.
4. Measure resistance with a suitably calibrated ohmmeter.
5. Measurements shall be made with the one electrode on the floor connected to the ohmmeter. The other terminal of the ohmmeter shall be connected to the nearest building column or exposed grounding conductor.

3. Acceptance Criteria:
    a. The floor tile-to-tile test shall achieve an average value of less than 1 megaohm.
    b. The floor-to-building ground test shall achieve an average value of less than 1 megaohm.

4. Documentation: Provide tabularized data with individual data and averaged values and record for each test station mapped on a building layout.
    a. Technician's Name
    b. Test Date(s)
    c. Instrument Identification
    d. Test Location Diagram
    e. Test Parameters
    f. Test Results Data

g. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

N. Electromagnetic Interference Test:

1. Purpose of Test: determine electromagnetic interference caused by the 60-hertz magnetic field levels at strategic locations within the facility.

2. Test Procedure:
   a. Measure and record magnetic field intensity at 5 critical test stations selected by the Owner.
   b. Take measurements 1067 mm (42 inches) above the finished floor.
   c. Measure magnetic field intensity level without any process equipment located in the cleanroom but with the lights and fans operating.
   d. Measure and record magnetic field intensity (flux density) in milligauss.

3. Acceptance Criteria:
   a. Acceptance of the facility is subject to approval of satisfactory EMI Tests as agreed to by the Owner. Normal acceptance values are less than 1 milligauss.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Test Location Diagram
   e. Test Parameters
   f. Test Results Data
   g. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

O. Room Air Change Rate Test:

1. Purpose of Test:
   a. Determine the number of times the air is being exchanged within the cleanroom on an hourly basis. The room air change rate per hour (ACH) is determined by measuring the total airflow volume being supplied or returned from the cleanroom (whichever is greater) and by calculating the overall volume of the cleanroom.

2. Test Procedure:
   a. Determine if the cleanroom is under a positive or negative pressure.
   b. If the pressure is positive, measure and record the supply airflow volume delivered through the filter using a flow hood. Use appropriate size capture enclosure for each filter or supply diffuser application.

c. If the pressure is negative, measure and record the return / exhaust airflow volume being captured by all return openings and process exhaust devices using a flow hood for return openings and appropriate traverse points on all process exhaust devices. Use appropriate size capture enclosure for each return opening application. Use appropriate traverse locations and traverse grid spacing for each process exhaust device.
d. Measure the volume of the cleanroom space.
e. Calculate the ACH by dividing the airflow volume by the cleanroom volume.

3. Acceptance Criteria:
   a. Acceptance of the facility is subject to approval of satisfactory ACH rate as agreed to by the Owner.

4. Documentation:
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Room Identification
   e. As Left Data: Total Airflow Volume per Hour, ACH
   f. Test Results Data
   g. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

P. Bench-Scan Filter Leakage Test:

1. Purpose of Test:
   a. Determine integrity of each filter shipment by spot testing random statistical samples.

2. Test Procedure:
   a. Test every filter, or if owner approved, develop a statistical sample based on the following:
      1. Test all filters which show signs of damage.
      2. Test every fifth filter and upon failure, test additional untested filters as agreed to between the NEBB Certified CPT Firm and the Owner.
   b. Provide flow test bench, optical laser particle counter, microsphere generator and a particle controlled environment.
   c. Introduce microsphere challenge upstream of the filter. A minimum challenge shall be at least 211,800,000 particles per cubic meter (6,000,000 particles per cubic foot).
   d. Measure the upstream challenge of each filter.
   e. Scan the entire downstream filter face area in overlapping strokes, moving at

the calculated scan rate (See NEBB-PSCTC) spaced a distance of 25.4 mm (1 inch) from the filter face.

f. Repairs, leaks and retesting of filters shall be performed in accordance with the requirements as stated in the contract documents or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.

3. Acceptance Criteria:
   a. Reject any component of the cleanroom ceiling system where the leak exceeds 0.01% percent of the measured upstream challenge concentration.
   b. Reject any filter where one dimension exceeds 38 mm (1.5 inch) in length or with an accumulative total repair area of 3 percent of media pleated face area.

4. Documentation (Failed Filters only):
   a. Technician's Name
   b. Test Date(s)
   c. Instrument Identification
   d. Challenge Medium
   e. Upstream Challenge Concentration / Particle Size
   f. Leak:
      1. Location
      2. Percent of Penetration
      3. Type (Media, Frame, Etc.)
   g. Test Results Data
   h. Identify all performance data that exceeds the acceptance criteria as specified herein or as agreed to between the Owner / Buyer and the NEBB Certified CPT Firm.
   i. Scan Rate
   j. Repairs (Individual):
      1. Number
      2. Size
      3. Location
      4. Area
   k. Repairs (Total):
      1. Total percentage of repair area