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SECTION 01 45 23.13

CLEANROOM TESTING AND CERTIFICATION

PART 1 GENERAL

1.1 SUMMARY

a. Section Includes:

1. This Section specifies the requirements of the Cleanroom Certification Contractor (CCC), to measure and record the cleanroom conditions at the completion of construction in the as-built phase.

2. Retest as required after repairs, replacements, and adjustments are made to meet the cleanroom acceptance criteria.

3. Advise the Director and the Testing, Adjusting, and Balancing Contractor (TABC) on the adjustment and setting of dampers in access floor panels and cleanroom ceiling filters to achieve a final cleanroom certification.

b. Related Sections:

1. Section 01 35 13.46 - Clean Zone General Requirements.

2. Section 01 35 13.49 - Clean Zone Construction Management.

3. Section 01 45 23.16 - Cleanroom Certification Test Matrix, Table.

4. Section 01 71 03 - As-Built Vibration and Noise Survey.

1.2 SCOPE OF CERTIFICATION TESTS

The paragraph subsection identification letters in Section 01 45 23.16 - Cleanroom Certification Test Matrix, Table, Table 1, correspond to those for the test instruments specified under paragraph 2.3 and their respective test procedures specified under paragraph 3.3.

Perform specific acceptance and benchmark tests in the rated cleanrooms described in Section 01 45 23.16 - Cleanroom Certification Test Matrix, Table, Table 1. Meet the acceptance criteria listed in Section 01 45 23.16 - Cleanroom Certification Test Matrix, Table, Table 2 in the tested areas.

At completion of this as-built certification work, the customer may engage the services of a testing and certifying contractor, hereinafter referenced as the Hookup Cleanroom Certification Contractor (HCCC), to measure and record the cleanroom conditions affected by ongoing process tool move-in, installation, and hookup, continuing through the at-rest and operating cleanroom occupancy phases as required.

1.3 DESIGN CRITERIA

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The following criteria have been extracted from Airborne Particulate Cleanliness Classes: Class limits are given for each class name. The limits designate specific concentrations (particles per meter) of airborne particles with sizes equal to and larger than the particle sizes shown. Particle sizes are given in micrometers.

ISO Class	Class Limits					
	0.1	0.2	0.3	0.5	1	5
1	10	2				
2	100	24	10	4		
3	1000	237	102	35	8	
4	10000	2370	1020	352	83	
5	100000	23700	10200	3520	832	29
6	1000000	237000	102000	35200	8320	293
7				352000	83200	2930
8				3520000	832000	29300
9				35200000	8320000	293000

1.4 REGULATORY AND STANDARD PRACTICES REQUIREMENTS

a. International Organization for Standardization:

1. ISO Standard 14644-1 - Cleanrooms and Associated Controlled Environments, Part 1: Classification of Air Cleanliness.

b. Institute of Environmental Sciences and Technology:

1. IEST-RP-CC-006: Testing Cleanrooms.

2. IEST-RP-CC-007: Testing ULPA Filters.

3. IEST-RP-CC-024: Measuring and Reporting Vibration in Microelectronics Facilities.

c. Federal Standards - MIL-STD-1916: DOD Preferred Methods for Acceptance of Product.

d. Current edition of practices, methods, or standards as prepared by the following technical societies and associations. When conflicts exist between standards, notify Owner's Agent in writing.

1. AABC: National Standard for Total System Balance.

2. AMCA Publication 203: Field Performance Measurements of Fan Systems.

3. ANSI S1.13: Measurement of Sound Pressure Levels in Air.

4. ANSI S12.2: Criteria for Evaluating Room Noise.

5. ASHRAE: Systems Handbook.

6. ASHRAE 41.1: Standard Method for Temperature Measurement.

7. ASHRAE 41.3: Standard Method for Pressure Measurement.

8. ASHRAE 111: Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning, and Refrigeration Systems.

9. ASTM F50: Standard Practice for Continuous Sizing and Counting of Airborne Particles in Dust-Controlled Areas and Cleanrooms Using Instruments Capable of Detecting Single Sub-Micrometer and Larger Particles.

10. NEBB: Procedural Standards for Certified Testing of Cleanrooms.

e. Definitions:

1. Refer to Section 01 35 13.46 - Clean Zone General Requirements, for definitions applicable to this project.

2. Director: Clean Zone Director as defined in Section 01 35 13.49 - Clean Zone Construction Management.

1.5 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM F50	Ref Title
ASTM D2240	(2015; E 2017) Standard Test Method for Rubber Property - Durometer Hardness

1.6 SUBMITTALS

a. Architect approval is required for submittals with an "A" designation; submittals not having an "A" designation are for information only. When used, a designation following the "A" designation identifies the office that will review the submittal for the Architect. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29, SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00, SUBMITTAL PROCEDURES.

SD-01 Preconstruction Submittals

Qualifications; A, AE

Experience and References; A, AE

Testing and Certification Procedures; A, AE

Testing Schedule; A, AE

Sample Test Report; A, AE

Test Equipment and Instruments; A, AE

Samples; A, AE

Software and Analysis Approach; A, AE

SD-06 Test Reports

Field Reports; A, AE

Field Logs; A, AE

Identification of Problems; A, AE

SD-11 Closeout Submittals

Final Certification Report; A, AE

Refer to the Submittal Schedule at the end of Part 3 for more detail on the submittal requirements for this Section.

1.7 QUALITY ASSURANCE

a. Measurement: Sampling based upon accepted industry sampling and statistical procedures.

b. Equipment Calibration:

1. Traceable by serial number to the National Institute for Standards and Technology (NIST) within the previous 6 months.

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

c. The reference standards for field tests and project record documents to be the IEST RP CC 006, Testing Cleanrooms, and NEBB Procedural Standards for Certified Testing of Cleanrooms.

d. In event of conflict between the referenced standards or practices and this Section, this Section to prevail. Report conflicting requirements to the Owner's Agent and Director. Once the Owner's Agent and Director resolves the conflict, proceed with work.

1.8 QUALITY CONTROL

a. Proposing Firms:

1. Current and active status and in good standing with the Institute of Environmental Sciences and Testing (IEST).

2. National Environmental Balancing Bureau (NEBB) certified.

3. Been in business a minimum of 5 years, specializing in cleanroom testing and certification work.

4. Successfully completed a minimum of 5 similar project during the time specializing in cleanroom testing and certification work.

b. Project Manager:

1. Management position within the firm and a minimum of 5 years of combined engineering education and experience testing and certifying cleanrooms as a field engineer.

2. Recent experience over 2 consecutive years and at least two previous projects acting as the project manager.

3. Thorough knowledge of theoretical and practical aspects of cleanroom design and operation.

4. Have demonstrated procedures to correct cleanroom performance deficiencies.

5. Available upon request, a list of projects similar to this project that the project manager has managed or certified.

c. Field Engineer:

1. Minimum of 2 years of experience testing and certifying cleanrooms as a field engineer or field technician.

2. Have supervised field technicians assigned to complete the testing and certifying of the work.

3. Demonstrate basic knowledge of cleanroom systems and adjustments.

4. Responsible for witnessing onsite testing and data acquisition.

d. Field Technician:

1. Completed previous training in cleanroom operations and certifying procedures.

2. Thorough, demonstrable knowledge of test procedures and equipment.

3. Have worked in this capacity on at least one similar projects.

4. Performed field work under direct supervision of the field engineer.

1.9 COORDINATION

a. Jobsite Visits: At least four jobsite visits by the field engineer during strategic construction phases for the period that the finished cleanroom envelope is being constructed.

b. Field Correlation of Instruments:

1. The CCC is responsible for field correlation of instruments to be used by the Owner's Agent, the control contractor, the ceiling and filter vendors, the TABC, and other organizations thatmight perform subsequent validation or performance tests using itsown instruments after completion of the certification service.

2. Recommend to the Owner's Agent and Director the instrumentsto correlate, reconcile, or calibrate.

3. Schedule through the Owner's Agent and Director, time andplace to correlate instruments.

4. Correlate readings as recommended by the CCC and approved by the majority of the firms participating.

5. Provide Owner's Agent and the Director list of instruments reconciled and approved by contractors involved.

c. Confirm site visits, instrument field correlation, and certification activities in writing to the Owner's Agent and Director.

d. Schedule work activities with the Owner's Agent and the Director. Schedule may require that crucial tests get completed in asequence to permit selective partial occupancy.

e. Consult with the Owner's Agent and Director, on technical issues.

1.10 PROJECT RECORD DOCUMENTS

a. Furnish the final completed as-built certification report within 4 weeks after completion of field activities. Include the following at a minimum:

1. Typed or computerized field reports, charts, and forms complete with measured data referenced to sample location.

2. Written description of operating condition of each clean area.

3. Reduced set of architectural floor plan drawings, maximum size 11 by 17 inches, made from the project AutoCAD Contract Documents, obtained from the Owner's Agent, showing test and sample locations referred to on other field data sheets, as well as test results of final field conditions.

4. Separate section outlining any operating or contamination problems remaining at the end of the testing and certifying procedures. Describe the condition and its effect on cleanroom performance.

5. A list of instrumentation and test equipment used in the certifying process, including manufacturer, model and serial numbers, and last calibration date.

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 data and reports that were stored electronically, including charts, drawings, tables, and graphs, assembled and stored on electronic media using a software product approved by the Owner's Agent.

8. An analysis with recommendations relating to test results and operating conditions of each area tested.

9. A statement that certification work was performed in accordance with the Contract Documents.

b. Provide one hard-bound copy and one loose, unbound reproducible copy of the completed certification report for the Owner's Agent's review and acceptance.

c. Keep a copy of the report for a minimum of 7 years, making it available for examination, reproduction, discussion, or clarification during that time.

PART 2 PRODUCTS

2.1 CLEANROOM CERTIFICATION CONTRACTORS

a. CCCs need to have documented experience in certifying cleanrooms for a period of 10 years or more. Examples of Approved CCCs include the

following:

1. Cleanroom Sciences.

2. Pentagon Technologies.

3. AM Technical Solutions (AMTS)

2.2 MATERIALS

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

Cleanroom garments and accessories will be furnished and laundered by the Contractor.

Do not use DOP aerosol for challenge of the cleanroom filters. Provide filter challenge with atmospheric air or polystyrene latex (PSL) spheres only.

The Contractor will provide suitable office space with telephone and reproducing machines and also a secure locked storage area for test equipment.

INSTRUMENTATION

a. Bench Scan Filter Leakage Test:

1. Description:

(a) Flow test bench complete with filter face edge seals, frame clamps, PSL generator, nozzle distribution manifold, and discharge encapsulation shroud.

(b) Optical laser particle counter rated on 0.1 to 5 micrometer particle size sensitivity with equal to or greater than 90 percent counting efficiency and 5 percent maximum sizing error on a 0.1 micrometer range at sample flow rate of 28 liters per minute.

(c) Counter complete with front panel control with readout, remote data transmission, thermal tape printer with cleanroom paper, stainless steel stand, room and isokinetic sample probes, and storage/carrying case.

(d) Generator capable of producing a monodispersed challenge of 0.2 , 0.25 , or 0.3 micrometer-diameter PSL spheres with 90 percent of the material to be the size designated 0.25 micrometer. Develop average upstream concentration of 1,000,000 particles per cubic foot with a minimum challenge of 900,000 particles per cubic foot injected at all times.

b. Ceiling Scan Filter Leakage Test:

1. Description:

(a) Optical laser particle counter rated on 0.1 to 5 micrometer particle size sensitivity with equal to or greater than 90 percent counting efficiency and 5 percent maximum sizing error on a 0.1 micrometer range at sample flow rate of 28 liters per minute.

(b) Counter complete with front panel control with readout, remote data transmission, thermal tape printer with cleanroom paper, stainless steel stand, room and isokinetic sample probes, and storage/carrying case.

c. Airborne Particle Count Test:

1. Description:

(a) Optical laser particle counter rated on 0.1 to 5 micrometer particle size sensitivity with equal to or greater than 90 percent counting efficiency and 5 percent maximum sizing error on a 0.1 micrometer range at sample flow rate of 28 liters per minute.

(b) Counter complete with front panel control with readout, remote data transmission, thermal tape printer with cleanroom paper, stainless steel stand, room and isokinetic sample probes, and storage/carrying case.

d. Baseline Airborne Particle Count Test:

1. Description:

(a) Ultrafine Condensation Nucleus Counter: Rated at 0.003 to 1.0 micrometer particle size sensitivity on a sample flow rate of 1.5 liters per minute and 90 percent counting efficiency for 0.005 micrometer range sample.

(b) Counter complete with integral data processor and software, front panel control and readout, interconnect hardware, internal filtered vacuum pump, stand, room sample probe, and storage/carrying case.

e. Airflow Volume and Velocity Test:

1. Description:

(a) Electronic microanemometer rated at plus or minus 3 percent of airflow and velocity readings at plus or minus 2 percent of pressure readings with sea level air density correction.

(b) Package complete with microprocessor with memory and back-pressure compensation functions, 24 by 24 inch, 24 by 36 inch, and 24 by 48 inch flow hoods, Velgrid, AirFoil probe, and Temprobe sample nozzle, grid, test stand, battery pack with charger, and storage/carrying case.

f. Airflow Parallelism Test:

1. Description:

(a) Per ISO 14655-3, Annex B.

(b) Ribbon test stand including 8 by 8 foot portable stand with slim-profile or aerodynamic top frame set at a distance 12 inches below the filter face grid, fitted with strips of ribbon streamers suspended 24 inches on center along the top frame and reaching to within 24 inches of the floor. Provide dark-colored nonshed monofilament polyester ribbon as streamers, similar to Flo-Viz.

(b) Frame to be mobile or dismantled for access between rooms.

g. Pressurization Test:

1. Description:

(a) Electronic microanemometer rated at plus or minus 3 percent of airflow and velocity readings at plus or minus 2 percent of pressure readings with sea level air density correction.

(b) Package complete with microprocessor with memory and back-pressure compensation functions, 24 by 24 inch, 24 by 36 inch, and 24 by 48 inch flow hoods, velgrid, airfoil probe, and Temprobe sample nozzle, grid, test stand, battery pack with charger, and storage/carrying case.

h. Enclosure Induction Leak Test:

1. Description:

(a) Optical laser particle counter rated on 0.1 to 5 micrometer particle size sensitivity with equal to or greater than 90 percent counting efficiency and 5 percent maximum sizing error on a 0.1micrometer range at sample flow rate of 28 liters per minute.

(b) Counter complete with front panel control with readout, remote data transmission, thermal tape printer with cleanroom paper, stainless steel stand, room and isokinetic sample probes, and storage/carrying case.

i. Room Recovery Rate Test:

1. Acceptable Manufacturer: MSP Corporation or Equal.

2. Description: Ultrapure deionized fogger including wheeled cart, distribution hose and nozzles, stainless steel holding tank for deionized water.

j. Makeup Air Handler Final Filter Leakage Test:

1. Description:

(a) Optical laser particle counter rated on 0.1 to 5 micrometer

particle size sensitivity with equal to or greater than 90 percent counting efficiency and 5 percent maximum sizing error on a 0.1 micrometer range at sample flow rate of 28 liters per minute.

(b) Counter complete with front panel control with readout, remote data transmission, thermal tape printer with cleanroom paper, stainless steel stand, room and isokinetic sample probes, and storage/carrying case.

k. Environmental Uniformity/Stability/Recovery Test:

1. Description:

(a) Multipoint electronic temperature and humidity sensor, recorder, and data logging instrument. Electronic temperature sensor accurate to 0.36-degree F dry bulb and to 1.0 percent relative humidity. Complete with data logger sensitive to plus or minus 0.1 percent resolution.

(b) Sensor complete with remote data transmission cabling, front panel control and readout, and storage/carrying case.

l. Noise Level Test:

1. Testing conducted by the Noise and Vibration Consultant per requirements of Section 01 71 03 - As-Built Vibration and Noise Survey.

m. Floor Vibration Test:

1. Testing conducted by the Noise and Vibration Consultant per requirements of Section 01 71 03 - As-Built Vibration and Noise Survey.

n. Lighting Level Test:

1. Description: Illumination level meter rated between zero and 500 foot-candles with storage/carrying case.

o. Light Wave Spectrum Test:

1. Description:

(a) Light wave meter with digital plotter, test probes, and storage/carrying case.

(b) Silicon-substrate witness test wafers furnished, placed, and analyzed by the Owner's Agent.

p. Floor Conductivity Test:

1. Description: Conductance meter including floor test kit rated at open-circuit voltage of 500 volts dc and scale range of 10K ohms to 50 megohms with storage/carrying case.

q. Electric Space Charge Test:

1. Description: Digital handheld electrostatic field meter, complete with chargeplate, rechargeable battery, charger, and storage/carrying case.

r. Electromagnetic Interference Test:

1. Description: Magnetic field search coil including data physics line Fourier analyzer, signal conditioner, digital plotter, meter, and storage/carrying case.

s. Total Particle Fallout Test:

1. Description: Witness test plate including 4 inch-diameter glass petri dish or silicon wafer prepared with gel coating consisting of one part Vaseline per nine parts solvent, then baked in 85 degree C oven for 10 minutes. Samples will be analyzed by the Owner.

t. Particle Identification Test:

1. Description: Air analyzer including vacuum pump, four-stage particle separator, SEM mounting plates, and cart. Samples will be analyzed by the Owner.

u. Hydrocarbon Outgas Elemental Test:

1. Acceptable Manufacturers: Hewlett Packard 9000 Series 300 computer, Hewlett Packard Model 5890 gas chromatograph, and Model 5971A autosampler.

2. Description: Air analyzer including charcoal sample tubes, DuPont Alpha
1 calibrated air sampler pump, flame ionization detector, and carbon disulfide desorber chemicals.

v. Nomura Elemental Mass Spectrometry Test:

1. Description: Collection container including a 4 inch-diameter jar filled with ultrapure 18 megohm deionized water. Samples will be analyzed by the Owner.

w. Viable Particle Fallout Test:

1. Description: Witness test plate including a 4 inch-diameter glass petri dish prepared with protein-based agar gel. Use an Anderson or DuPont air sample collector or slit selector cover to provide selective sample rates. Samples will be analyzed by the Owner.

x. Three-Dimensional Airflow Turbulence Test:

1. Description: Ultrasonic three-dimensional anemometer with microprocessor, three-directional flow sample nozzle head, software, test stand, and storage/carrying case.

y. Sodium Test:

1. Description: Air analyzer including DuPont Alpha 1 calibrated air sampler pump, 100 ml Nalgene polypropylene or quartz impinger with cap and sample tubes, DI water and 0.5 micrometer dry Teflon filter strainers. Samples will be analyzed by the Owner.

PART 3 EXECUTION

3.1 INSPECTION

a. Facility Completion at Construction Stage 5, as defined in Section 01 35 13.46, Clean Zone General Requirements:

1. Building perimeter walls, roof, and accessories installed to create a pressurized envelope around the clean zone.

2. Clean zone perimeter walls, ceiling, raised floor panels, doors, and necessary interior partitions installed that are essential to successful system performance. If approved by the Owner's Agent and Director, use temporary barriers for area isolation.

3. Cleanroom ceiling scan filter leakage tests completed, and repairs finished.

4. Permanent personnel gowning area in operation.

5. 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.

6. Tool hookup or miscellaneous construction activities curtailed in the test area.

b. Facility Utility Support Systems:

1. Air-handling systems serving the clean zone installed and operating under automatic controls.

2. Initial testing and balancing complete on the air and water systems serving the clean zone air-handling systems.

3. Process exhaust systems and pressurization control fans installed and operating to simulate clean zone pressurization.

4. Fan vibration and noise tests complete.

5. Cleanroom lights, sprinklers, and safety devices installed and operational.

6. Housekeeping vacuum system operational and used by janitorial crews.

7. Support systems required to perform certification tests operating normally for a minimum stable period of 5 days.

3.2 PREPARATION

Confirm that activities within the facility comply with the requirements of Section 01 35 13.46 - Clean Zone General Requirements.

Inspect the entire clean zone, accompanied by the Owner's Agent and Director, and note existing conditions that could jeopardize the certification results. Obtain the Owner's Agent and Director's written release before proceeding with certification steps.

Coordinate field certification activities with the Director and the Owner's Agent to permit observation of any test procedure.

Perform certification activities in increments of one cleanroom element, one clean aisle with adjacent cores, or building structural module, unless scheduled otherwise by the Director.

Pack and store any removed damaged filters.
Allow for retest as stated within each test procedure.

3.3 PROCEDURES AND FIELD TESTS

a. 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 module.

(b) Provide flow test bench, optical laser particle counter, and PSL generator.

(c) Introduce PSL challenge spheres from the generator into the inlet of the air blower. A challenge of at least 20,000,000 particles per cubic foot sized 0.2 to 0.26 micrometer is requiredat the filter.

(d) Test the upstream challenge when each filter module is placed in the bench.

(e) Scan the entire downstream filter face area in overlapping strokes, moving the probe at 2 inches per second, spaced a distance of 1 inch from the filter face.

(f) Visually inspect the urethane media potting sealant on both the upstream and downstream sides at the media perimeter for cracks or gaps in the sealant.

3. Documentation:

(a) List the model and serial number of rejected filters.

(b) Identify the nature/location of the leak, the test challenge size/concentration, and the measured penetration/particle count.

(c) Create statistical data showing filters tested with acceptance and rejection rate.

b. Ceiling Scan Filter Leakage Test:

1. Purpose of Test:

(a) Determine integrity of ceiling cleanroom filter modules after installation in the ceiling grid.

(b) Determine leakage through any component in the ceiling assembly.

(c) Locate leaks created by ceiling defects.

2. Test Procedure:

(a) Test the entire ceiling assembly.

(b) Provide optical laser particle counters, PSL aerosol generator, and accessories. Automatic filter scanning equipment will not be acceptable.

(c) Introduce PSL spheres from the generator into the inlet of the recirculation air blower or into the test port of each individual ducted filter. An average challenge of 1,000,000 particles per cubic foot sized 0.2 to 0.3 micrometer is required at the filter, although a challenge of 20,000,000 particles per cubic foot is desired.

(d) Measure and record the upstream challenge at the filter at least once every hour. Measure upstream filter challenge at two test ports in each packaged ceiling plenum module.

(e) Scan the entire downstream filter face area isokinetically in overlapping strokes, moving the probe at 2 inches per second or 1 square foot per minute, at a distance 1 inch below the filter face. Scan the entire perimeter, center support mullions, and

corners at a traverse rate of 10 fpm maximum. Provide side shields for filter modules located in partial-coverage ceilings to block induced air influx from adjacent blank panels. Allow 10 minutes scan time per filter module, including all joints.

(f) Scan joints in the ceiling assembly, including the gap between the ceiling grid and filter module, wall-to-ceiling joint, sprinkler pipe and electrical conduit penetrations, and blank panel edge seals. Blank panels do not require scan tests where the cleanroom filters are the ducted style.

(g) Extend test time under any portion of the filter showing a single leak by sampling directly under the leak. A reading of 150 counts in a 10 second time span constitutes a significant leak requiring repair.

h) Scan each joint and the entire area encompassed by the side shrouds under the ceiling automated wafer transporter.

i) Document in the logbook the filter serial number and failure criteria for rejected filter modules. Repairs and leaks will be corrected by others.

j) Retest those repaired filter modules judged acceptable by the Owner's Agent and Director. Assume retest of 5 percent of the total filters in the ceiling assembly measured during initial tests.

k) Repeat the filter scan test for 10 percent of installed ceiling filters without any upstream PSL test challenge to determine particles shed by the media itself. Perform scan under media face only as described in paragraph B.2.e above.

3. Acceptance Criteria:

(a) Reject filter modules with direct leaks detected at the perimeter frame, center divider, center test ports, or within the media pack.

(b) Reject any filter module when aerosol penetration exceeds 0.1 percent of the upstream challenge concentration.

(c) Locate and tag leaks through the ceiling assembly that require sealing.

(d) Reject any filter module with more than ten individual repairs or with a single repaired area of 1 square inch or 1 linear inch or with an accumulative total repair area of 1 percent of media pleated face area.

4. Documentation:

(a) List the model and serial number and installed location of rejected filters, including failure criteria.

(b) Identify the nature/location of the leak, the test challenge size/concentration, and the measured penetration/particle count. Record particle sizes in increments of 0.1, 0.2, 0.3, 0.5, 1, and 5 micrometers.

(c) Identify repaired leaks that were accepted by the Owner's Agent and Director.

(d) Create and maintain a logbook showing test procedures and results.

(e) Record location of filter modules or components that failed, mapped on a cleanroom reflected ceiling layout.

c. Airborne Particle Count Test:

1. Purpose of Test: Determine particle count levels at reference particle size to ensure systems operate within design criteria.

2. Test Procedure:

a) Measure and record the airborne particle counts.

b) 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.

c) Measure and record the particle count at a distance 42 inches above the floor in the center of each test sector or 12 inches above process equipment obstructing the standard test station. Sample volume and locations are established in ISO Standard 14644-1.

(d) Perform at least one measurement in every rated cleanroom smaller than the sector test area.

(e) Sequential sample counting procedures described in ISO Standard 14644-1 may be used. If used, describe the procedure.

(f) Measure and record particle concentration three feet outside each cleanroom door opening into an area less clean (higher contamination class) for a period of 2 minutes each, with the door in the closed position.

(g) Measure and record particle concentration inside each cleanroom chemical/parts pass-through cabinet for a period of 2 minutes each. For purposes of the proposal, perform tests in 5 pass-through cabinets.

(h) Measure and record particle concentration at two fixed stations under the ceiling automated wafer transporter as the transport carriage moves over the sample probe a total of ten times.

(i) Identify, tag, and record any test stations or sectors that do not meet design criteria and require corrective action.

(j) Retest those test stations or sectors that require corrective modifications in order to achieve design criteria. Assume retest of 5 percent of the total test stations measured during initial tests.

3. Acceptance Criteria:

(a) Obtain airborne particle counts necessary to determine the room cleanliness classification. Use only the 0.1 micrometer reference size to establish room acceptance.

(b) Compute the following data to establish compliance with these acceptance criteria for each room classification:

1) The particle concentration measured at each station falls at or below the values listed in the table.

2) Particle concentrations measured underneath the automated wafer transporter does not exceed a value of 100 times the average room background of adjacent measurements.

3) If sample size is less than ten readings per clean area, calculate 95 percent upper confidence limit, and this value to fall below the specified area class limits.

4) If sequential sampling is used, follow ISO Standard 16441-1 criteria.

4. Documentation:

(a) Create bar chart showing particle counts versus frequency/repeatability count, as well as minimum, mean, and maximum values.

(b) Copy one representative strip chart from each clean aisle/test station printed during the test procedures.

(c) Record particle counts for sizes 0.1, 0.2, 0.3, 0.5, and 1 micrometer for each test station mapped on a cleanroom layout.

d. Baseline Airborne Particle Count Test (Alternative A1):

1. Purpose of Test: Create baseline particle count levels on reference size 0.02 micrometer at strategic locations within the cleanroom.

2. Test Procedure:

(a) Measure and record particle counts for 10 minutes each at 30 test stations selected by the Owner's Agent.

(b) Complete the airborne particle count test and prerequisite tests before starting benchmark particle count sampling.

(c) Obtain the particle counts at a distance 42 inches above the floor using the CNC particle counter.

(d) Sample for particle count at each test station for the sample volume in accordance with ISO Standard 14644-1.

3. Acceptance Criteria:

(a) Obtain airborne particle counts necessary to determine the room class identified in Section 01 45 23.16 - CleanroomCertification Test Matrix, Table, Table 2.

(b) Compute the following data for each area: the average of particle counts measured at each test station to determine correlation with Table 2; the mean of these averages.

4. Documentation:

(a) Create bar chart showing particle counts versus frequency/repeatability count.

(b) Create graphs showing particle counts versus time for the 10 minute test interval for each test station.

(c) Copy strip charts printed during the test procedures.

(d) Record particle counts for sizes 0.01, 0.02, 0.05, 0.1, 0.2, 0.3, and 0.5 micrometer for each test station mapped on a cleanroom layout.

e. Airflow Volume and Velocity Test:

1. Purpose of Test:

(a) Determine supply airflow volume delivered through each ceiling filter.

(b) Determine volume uniformity throughout the clean aisle/cleanroom.

(c) Determine air velocity profile 12 inches below the face screen of each ceiling filter.

2. Test Procedure:

(a) Measure and record the supply airflow volume delivered through the filter module using the totalizing flow hood. Specific hood sizes are required for each filter size. Check supply airflow volume on only a 10 percent sample of the total quantity of filters installed in each cleanroom.

(b) Measure and record the velocity profiles.

(c) Document the supply airflow volume for any filter module that falls outside the tolerance required for acceptance. Air adjustments will be performed by the TABC.

(d) Measure and record the air velocity profile for 10 seconds each filter. Two Velgrid readings are required below all size 2 by 4 foot filter modules. Select the average of the two values for the recorded reading.

(e) Retest any noncompliant filter module, as well as the adjacent eight filter modules, filter modules in the same air distribution duct or plenum module whenever any filter module requires corrective repair or system air balancing in order to achieve design criteria. Assume retest of 10 percent of the totaltest stations measured during initial tests. Retest is only required on filter modules fitted with an airflow adjustmentdamper.

3. Acceptance Criteria:

(a) Obtain supply airflow volume for every ceiling filter module to fall within plus or minus ten percent of the design air supply volume.

(b) Obtain air velocity readings at a distance 12 inches below the plane of the ceiling to create initial baseline reference velocity profile at certification that falls within plus or minus 20 percent of the mean of velocity values from that respective filter module only if the filter module has been fitted with airflow adjustment damper.

(c) Obtain average velocity readings throughout each clean aisle or test sector that demonstrate the room velocity requirements shown in Section 01 45 23.16 - Cleanroom Certification Test Matrix, Table, Table 2.

(d) Achieve velocity uniformity throughout each clean aisle/cleanroom such that 90 percent of all readings fall within plus or minus 20 percent, and 100 percent of all readings fall within plus or minus 30 percent of the average velocity described in paragraph 3.3.e.3.c above.

4. Documentation:

(a) Compute and document cleanroom average airflow volume from data collected for each filter module.

(b) Record air supply volume for each filter module mapped on a cleanroom layout.

(c) Record the low, average, and high air velocity readings for each filter module mapped on a cleanroom layout.

f. Airflow Parallelism Test:

1. Purpose of Test:

(a) Verify parallel vertical flow paths of supply airflow.

(b) Detect and eliminate horizontal and vertical upflow air patterns.

2. Test Procedure:

(a) Measure and record the parallel vertical flow path.

(b) Make provisions in the clean aisle/cleanroom to set the test stand in 8 feet by 8-foot test sectors. Where clean aisle is 10 feet wide or narrower, take two rows of readings.

(c) Observe and photograph vertical air path at 30 critical test stations selected by the AE with input from MIT LL.

(d) Document changes in vertical air paths near each door as it opens and closes.

(e) Document areas where air deflection exceeds acceptance criteria.

(f) Retest those test sectors that require corrective modifications or system air balancing in order to achieve design criteria. Assume retest of 5 percent of the total test stations measured during initial tests.

3. Acceptance Criteria:

(a) Parallel vertical flow paths whereby 100 percent of test stations fall within 20 degrees of vertical, and 90 percent of test stations fall within 14 degrees of vertical in any two perpendicular room axes for areas fitted with full ceiling filter coverage and airflow adjustment dampers in every floor panel.

(b) Parallel vertical flow paths whereby 100 percent of test stations fall within 30 degrees of vertical, and 80 percent of test stations fall within 20 degrees of vertical in any two perpendicular room axes for areas with standard undampered floor panels, solid floor panels, or low-wall return grilles.

(c) Confirm absence of vertical upflow air patterns anywhere in the cleanroom.

(d) Obtain parallel flow readings throughout each clean aisle or test sector that demonstrate the requirements shown in Section 01 45 23.16 - Cleanroom Certification Test Matrix, Table, Table 2.

4. Documentation:

(a) Provide photographs of air path at selected test stations equally distributed between different areas.

(b) Identify probable cause of any test sectors where vertical path cannot be maintained and recommend corrective action.

(c) Record nonconforming air patterns in any test sector as a velocity vector mapped on a cleanroom layout.

(d) Record, calculate, and document the deflection of air patterns mapped on a cleanroom layout.

g. Pressurization Test:

1. Purpose of Test:

(a) Confirm capability of cleanroom air-handling systems to maintain cascaded air pressure regime within the clean zone.

(b) Verify performance of pressure controls as doors are activated.

(c) Confirm pressure differential across return air components.

2. Test Procedure:

(a) Measure and record the relative positive pressure between each clean aisle/cleanroom and the adjacent area of any cleanliness class physically separated by a wall and the absolute reference point identified on the Drawings.

(b) Measure and record the relative positive pressure between each clean aisle/cleanroom and adjacent areas of lesser class when just one of the interconnecting doors is open and the absolute reference point identified on the Drawings.

(c) Measure and record the relative positive pressure sequentially from the area with the highest cleanliness requirement outward through contiguous spaces to the outdoors. Verify the pressurization cascade identified under cleanroom criteria in Section 01 45 23.16 - Cleanroom Certification Test Matrix, Table, Table 2.

(d) Measure and record the relative positive pressure across pass-throughs, vestibules, and air locks.

(e) Measure and record the differential pressure across return air registers, perforated and grated floor tiles, and relief air dampers at 30 test stations selected by the Owner's Agent.

(f) Retest those zones that require system air balancing in order to achieve design criteria. Assume retest of 5 percent of the total test stations measured during initial tests.

3. Acceptance Criteria:

(a) Achieve continuous positive pressure gradient from the clean aisle/cleanroom to adjacent areas in compliance with design criteria when all doors are in the normally closed position.

(b) Maintain positive pressure from the clean aisle/cleanroom to adjacent areas of higher contamination with one interconnecting door open.

4. Documentation:

(a) Identify probable cause of any area where pressurization cannot be maintained.

(b) Record absolute pressures, relative room pressure differentials and overall pressurization gradients mapped on a building layout.

h. Enclosure Induction Leak Test (Alternative A2):

1. Purpose of Test:

(a) Determine source of unfiltered air infiltrating through cleanroom construction joints.

(b) Confirm airtight construction at perimeter construction joints, doors, and windows between the clean aisle/cleanroom and adjacent areas of higher contamination.

2. Test Procedure:

(a) Measure and record enclosure leakage for clean aisles and cleanroom.

(b) Scan wall joints, wall-to-ceiling grid joints, and door frame/cracks at a distance 2 inches in front of the crack at a probe speed of approximately 10 feet per minute. Introduce supplemental PSL challenge where sufficient ambient particle density does not occur outside cleanroom.

(c) Scan around opening of all utility penetrations through the clean zone perimeter envelope.

(d) Scan an additional 30 test stations inside the cleanroom at suspected leakage locations as selected by the Owner's Agent.

(e) Retest leakage locations after repair. Assume retest of 5 percent of the total test stations measured during initial tests.

3. Acceptance Criteria: Achieve continuous readings with no particle counts in excess of 0.001 times the particle concentration in the adjacent reference area.

4. Documentation: Record infiltration leaks for each test station mapped on a cleanroom layout.

i. Room Recovery Rate Test (Alternative A3):

1. Purpose of Test:

(a) Determine ability of cleanroom air-handling system to recover cleanliness levels after an internal particle upset.

(b) Test ability of airflow pattern to reestablish laminar flow after personnel movement through area.

(c) Determine reference recovery rates at strategic locations within the cleanroom.

2. Test Procedure:

(a) Measure and record the recovery rate at 30 test stations used in pressurization test.

(b) Measure and record recovery rate for clean aisles and cleanroom.

(c) Make provisions in the cleanroom to set the generator test stand in 8 foot by 8 foot test sectors.

(d) Introduce test challenge for 10 seconds and record dispersal time.

(e) Locate particle counter sampling probe directly below the generator nozzle or in front of the nearest return air inlet.

(f) Take particle counts in 10 second intervals until the background count returns to normal.

(g) Document the dispersal time in the product zone.

(h) Assume that no retests will be required at any test station.

3. Acceptance Criteria:

(a) Accept ISO Class 3+ through 5 areas where total particle dispersal has been achieved within 120 seconds.

4. Documentation:

(a) Identify probable cause of any test station where dispersal exceeded acceptance time.

(b) Record dispersal time for each test station mapped on a cleanroom layout.

j. Makeup Air Handler Final Filter Leakage Test:

1. Purpose of Test:

(a) Determine integrity of filter modules after installation in the makeup air handler final filter frame.

(b) Determine particle contribution from the duct distribution system to the makeup airstream.

2. Test Procedure:

(a) Test the entire final filter assembly in every makeup air handler after completion of the installation when the units are operating.

(b) Provide optical laser particle counter, PSL generator, isokinetic sample probes, and accessories.

(c) Introduce PSL spheres from the generator into the upstream plenum of the final filter assembly. A challenge of greater than 1,000,000 particles per cubic foot sized 0.2 to 0.26 micrometer is required at the generator outlet.

(d) Measure and record the upstream challenge at the final filter.

(e) Measure particle counts in the airstream downstream of the final filter.

(f) Scan joints, perimeter edge seals, and corners in the final filter frame assembly.

(g) Extend test time for any portion of the filter showing high particle counts of at least 150 particles in a 10 second time span.

(h) Identify rejected filter modules requiring repair. Document the serial number and failure criteria in the logbook.

(i) Retest those repaired filter modules judged acceptable by the Director. Assume retest of one air handler measured during initial tests.

(j) Measure particle counts in the makeup supply airstream immediately upstream of two recirculation air handlers served by each of the makeup air handlers.

3. Acceptance Criteria:

(a) Reject any filter module with direct leaks detected at the perimeter frame, center divider, center test ports, or within the media pack.

(b) Reject any filter bank when aerosol penetration exceeds 0.01 percent of the upstream challenge concentration.

(c) Reject any filter with more than two repairs or repairs larger than 1 square inch each.

4. Documentation:

(a) List the model and serial number of rejected filters.

(b) Identify the nature/location of the leak, the test challenge size/concentration, and the measured penetration/particle count.

(c) Create statistical data showing filters tested with acceptance and rejection rate.

k. Environmental Uniformity/Stability/Recovery 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 clean zone.

(c) Confirm stability of environmental conditions at control sensing points.

(d) Determine ability of facility support systems to recover to design environmental conditions after an internal thermal upset.

(e) Demonstrate ability of the cleanroom air-handling and control systems to achieve a continuous 7 day environmental profile in conformance with project design criteria.

(f) Correlate test instrumentation with built-in facility monitoring system equipment.

2. Test Procedure:

(a) Measure and record the dry bulb and dew point temperature and relative humidity uniformity/stability. Environmental tests can be set up and run concurrently with other tests where results are not jeopardized. Support systems to have been in normal automatic operation under control of calibrated permanent controllers for at least 7 days.

(b) Place test probes uniformly within the space with at least one-fourth of the probe sites adjacent to sample points of the facility monitoring system.

(c) Position quantity of test probes within one clean aisle at a distance 24 inches below the face of the ceiling grid with probe area not to exceed 120 square feet each (or more frequent if recommended by CCC). For large or open cleanrooms, divide the area into test sectors corresponding to the temperature control and recirculation air handler distribution zones with test sectors not to exceed 200 square feet each.

(d) Measure and record dry bulb and dew point temperature and relative humidity readings in the first clean aisle/test sector. Simultaneously record the samples from the probe sites to verify uniformity. Time span for test intervals and overall duration of documentation to be:

Cleanliness ISO Class	Recording Interval	Recording Duration
3 and less	6 minutes	12 hours
3+ through 7	6 minutes	6 hours

(e) Relocate test probes to each of the remaining clean aisle/test sectors and repeat the 12 point data recording.

(f) Relocate the test probes to one critical clean aisle/test sector selected by the Owner. Repeat the point data recording on 10 second intervals for 2 hour duration.

(g) Adjust temperature and humidity control set points in the same critical clean aisle/test sector to place the space environmental conditions beyond required criteria. From the operating set point, the temperature to be adjusted upward by 2 degrees F and the dew point temperature upward by 2 degrees F and relative humidity upward by 5 percent. A portable heater and humidifier may be used, which can be energized to create internal upset conditions in lieu of adjusting control settings. Repeat the data recording on a continuous basis for 2 hour duration during adjustment period.

(h) Readjust temperature control set point only back to desired operating condition. Repeat the data recording on 10 second intervals for 2 hour duration or until the original set point temperature has been achieved for a 10 minute interval.

(i) Readjust humidity control set point only back to desired operating condition. Repeat the data recording on 10 second intervals for 2 hour duration or until the original set point dew point temperature has been achieved for a 10 minute interval.

(j) Redistribute the test probes so one probe site is located in each of the critical test sectors selected by the Owner's Agent from previous clean aisle/test sectors. Place the probe adjacent to the facility monitoring control sample points where possible. Repeat the data recording on 6 minute recording intervals for a 7 day continuous time span.

(k) Retest those clean aisles/test sectors that require corrective modifications or adjustments in order to achieve design criteria. Assume retest of two test station setups measured during initial tests.

3. Acceptance Criteria:

(a) Achieve temperature uniformity throughout contiguous areas of the cleanroom from test station readings within plus or minus 1.0 degree F of the mean temperature value from the readings.

(b) Achieve relative humidity uniformity throughout contiguous areas of the cleanroom from all test station readings within plus or minus 5 percent of the mean humidity value from the readings.

(c) Demonstrate stability of both temperature and absolute humidity in the critical test sectors to be within the range of uniformity values over a continuous time span of 7 days. Calculate and plot corresponding relative humidity profiles.

(d) Verify recovery time is less than 5 minutes for both dry bulb and dew point temperatures and relative humidity to return to normal control set points after an internal upset of both conditions.

4. Documentation:

(a) Plot temperature versus time by test station.

(b) Create charts showing temperature versus frequency/repeatability count by test sector.

(c) Create charts showing dew point temperature and relative humidity versus frequency/repeatability count by test sector.

(d) Provide data logs and charts for the one critical area selected by the Owner.

(e) Provide data logs and charts for the 7 day performance demonstration.

(f) Plot both dry bulb and dew point temperature and relative humidity versus time for each test station mapped on a cleanroom layout.

(g) Record the average dry bulb temperature and relative humidity calculated from the 2 hour interval for each test station mapped on a building layout.

l. Noise Level Test:

1. Testing conducted by the Noise and Vibration Consultant per requirements of Section 01 71 03 - As-Built Vibration and Noise Survey.

m. Floor Vibration Test (Alternative A4):

1. Testing conducted by the Noise and Vibration Consultant per requirements of Section 01 71 03 - As-Built Vibration and Noise Survey.

n. Lighting Level Test:

1. Purpose of Test:

(a) Determine the lighting intensity levels and uniformity provided by the normal lighting system in the white-light areas and yellow-light areas identified.

(b) Determine the lighting intensity levels provided by the emergency lighting system in the white-light areas and yellow-light areas identified.

2. Test Procedure:

(a) Measure and record the lighting levels. Operate lighting continuously for at least 300 hours prior to testing.

(b) Measure lighting intensity at 42 inches above the finish floor on a nominal 10 foot by 20 foot test sector.

(c) Measure areas having aisles greater than 20 feet in width:

1) At approximately the center of the area, take measurements within an area of 10 feet by 20 feet.

2) At wall parallel to light fixtures, take readings over an area of 10 feet by 20 feet (long dimension parallel to the wall with the first row taken at the wall plane).

3) At wall perpendicular to light fixtures, take readings over an area of 10 feet by 20 feet (long dimension parallel to the wall with the first row taken at the wall plane).

(d) Measure areas having aisles less than 20 feet in width. Take readings over a 20 foot length of cleanroom aisle.

(e) Measure and record the emergency lighting levels at the same test stations described for normal lighting levels tests.

3. Acceptance Criteria:

(a) Achieve foot-candle values within plus or minus 20 percent of those indicated in design criteria.

(b) Verify Uniformity of Illumination:

1) Large Open Areas: 2:1 (average: minimum).

2) Other Areas: 4:1 (average: minimum).

4. Documentation:

(a) Record data using a Cartesian coordinate system (X Y Z) with the origin (X = 0 and Y = 0) at the southwest corner of the area to be tested.

(b) Express area results in average maintained foot-candles with average minimum ratios and standard deviation from design criteria.

(c) Plot foot-candle values for each test station mapped on a cleanroom layout. Indicate test stations that had yellow light.

o. Light Wave Spectrum Test (Deleted)

p. Floor Conductivity Test (Alternative A5):

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) Perform conductivity tests at 10 test stations selected by the Owner's Agent between points on the floor covering in accordance with NFPA 99, except as modified herein and between the floor tile frame and the pedestal bases.

1) Test floor with temperature and relative humidity maintained within the specified limits and with floor panels placed/secured normally to the support pedestals.

2) Each electrode (two required) to weigh 5 pounds and have a flat, circular contact area 2 1/2 inches in diameter, which to comprise a surface of aluminum or tinfoil 0.0005 inch to 0.001 inch thick, backed by a layer of rubber 1/4 inch thick, and measuring between 40 and 60 durometer hardness as determined with a Shore Type A durometer (ASTM D2240).

3) Measure resistance by a suitably calibrated ohmmeter with a tolerance defined as follows:

a) Short-circuit current to be between 2.5 mA and 5 mA.

b) At any value of connected resistance, Rx, the terminal voltage, V, to be: Rx 500V ±15 percent Rx + internal resistance

c) Internal resistance to be greater than 100,000 ohms.

b. Measure and record conductivity between points on the floor covering at 10 test stations selected by Owner's Agent.

1) Take measurements on continuous flooring between pairs of points with the electrodes 3 feet apart.

2) Take measurements on raised floor tiles between pairs of points:

a) Center of test tile to center of any 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.

c. Measure and record conductivity from floor covering to building ground (raised floors only) at 10 test stations selected by the Owner's Agent. Make measurements between five pairs of points in each room with one electrode on the floor connected tothe ohmmeter. The other terminal of the ohmmeter to be connectedto the nearest building column or exposed grounded conductor.

d. Retest those test sectors that require corrective modifications or adjustments in order to achieve design criteria. Assume retest of 5 percent of the total test stations measured during initial tests.

3. Acceptance Criteria:

(a) Verify floor panel-to-panel test achieves average values less than 1 megohms.

(b) Verify floor-to-building ground test achieves average values less than 1 megohms.

4. Documentation: Provide tabularized data with individual data and averaged values and record for each test station mapped on a building layout.

Q. Electric Space Charge Test (Alternative B1):

1. Purpose of Test:

(a) Benchmark the airborne positive and negative ion densities at strategic locations within the clean zone.

(b) Simulate the residual surface voltage expected on a test wafer in free air.

2. Test Procedure:

(a) Measure ion density at a height of 42 inches above the finished floor at 10 test stations selected by the Owner's Agent. Test to indicate the density of positive and negative ions, respectively, in ions per cubic centimeter.

(b) Perform residual voltage test:

1) Charge the plate monitor having a capacitance to ground of 20 pf to 5,000V and measure the time required for the plate's voltage to decay to less than 10 percent of the original voltage

(500V).

2) Perform tests at the same stations as the ion density test. Locate charge plate meter 42 inches above the finish floor. Test to occur within 15 minutes of execution of ion density test at each location.

3) Repeat test starting with 1,000V.

3. Acceptance Criteria - Residual Voltage Test: Obtain ion densities and residual voltage values to create initial benchmark at certification.

(a) 1,000V Test: Plate voltage to decay from 5,000V to 100V in less than 60 seconds.

4. Documentation:

(a) Collect data from ion density test with tabular record of positive and negative ion densities for each test station.

(b) Collect data from residual voltage test with tabular data for each test and voltage level indicating decay time and steady-state residual voltage.

(c) Record the test stations mapped on a cleanroom layout.

r. Electromagnetic Interference Test (Alternative B2):

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 8 critical test stations selected by the Owner's Agent.

(b) Take measurements 42 inches above the finished floor on a 4 foot by 4 foot test sector over entire 100 square-foot test area, except at specific SEM locations where measurements will be taken on a 2 foot by 2 foot grid over an 8 foot by 8 foot area.

(c) Measure magnetic field intensity level without any process equipment located in the fab but with the lights and fans operating.

(d) Secure magnetic field intensity (flux density) in milligauss.

3. Acceptance Criteria: Obtain magnetic field intensity values to create initial benchmark at certification.

4. Documentation:

(a) Record data using a Cartesian coordinate system with the

origin (X = 0 and Y = 0) at the southwest corner of the area to be tested. Each reading to be the maximum of three mutually perpendicular directions.

(b) Plot magnetic field intensity levels for each test station mapped on a facility layout.

s. Total Particle Fallout Test (Alternative B3):

1. Purpose of Test: create benchmark particle accumulation on a witness plate at strategic locations within the cleanroom.

2. Test Procedure:

(a) Collect total particle fallout samples at 5 critical test stations selected by the Owner's Agent.

(b) Place exposed witness test plates at a distance 42 inches above the finished floor.

(c) After 1 hour sample period, place plates in clean wafer boat and deliver to the quality assurance staff via the Owner's Agent for microscopic analysis.

3. Acceptance Criteria: Obtain total particle fallout values to create initial benchmark at certification.

4. Documentation: Duplicate the MIT IL's particle fallout reports and record for each test station mapped on a cleanroom layout.

t. Particle Identification Test (Alternative B4) (Deleted)

u. Hydrocarbon/Outgas Elemental Test (Alternative B5):

1. Purpose of Test:

(a) Measure effectiveness of makeup air handler filter assemblies for extraction of hydrocarbon elements.

(b) Create benchmark hydrocarbon concentration in selected air samples at strategic locations around the facility.

2. Test Procedure:

(a) Measure and record hydrocarbon concentrations at the outside air intake, make-up air supply to recirculation unit and at the final supply air discharge of 3 recirculation air handlers serving the clean zone selected by the Owner's Agent.

(b) Measure and record hydrocarbon air samples in the building at 10 critical test stations selected by the Owner's Agent.

(c) Calibrate analyzer using zero standard and known upscale span gases.

(d) Test for the three specific compounds of Freon, isopropyl alcohol, and triethylphosphorous.

3. Acceptance Criteria: Obtain concentration values to create initial benchmark at certification.

4. Documentation: Record hydrocarbon concentrations for each test station mapped on a building layout.

v. Nomura Elemental Mass Spectrometry Test (Alternative B6):

1. Purpose of Test: Create benchmark airborne contaminants and chemical constituents in selected air samples at strategiclocations within the cleanroom.

2. Test Procedure:

(a) Collect elemental air samples at 5 critical test stations selected by the Owner's Agent.

(b) Acquire 500 ml samples of high-purity, 18 megohm deionized water in ultraclean glass belljars.

(c) Place open collection containers at a distance 42 inches above the finished floor.

(d) After 24 hour sample period, place jars in clean container and deliver to the quality assurance staff via the Owner's Agent for mass spectroscopy analysis.

3. Acceptance Criteria: Obtain composition values to create initial benchmark at certification.

4. Documentation: Duplicate the Owner's Agent 's mass spectrometry reports and record the contaminant constituents foreach test station mapped on a cleanroom layout.

w. Viable Particle Fallout Test (Alternative B7) (Deleted):

x. Three-Dimensional Airflow Turbulence Test (Alternative B8):

1. Purpose of Test: Determine turbulent air intensity and velocity of supply air path at strategic locations within the cleanroom.

2. Test Procedure:

(a) Measure and record the airflow path through the cleanroom at 5 critical test stations selected by the Owner's Agent.

(b) Place ultrasonic directional sensor at the first test station. Develop a main 4 foot by 4 foot sample sector with 1 foot by 1 foot subsectors.

(c) Measure and record velocity samples at distances of 10 feet,

8 feet, 6 feet, 4 feet, and 2 feet above the finished floor.

(d) Relocate test equipment to each of the remaining test stations and repeat the data recording.

3. Acceptance Criteria: Obtain turbulence intensity values to create initial benchmark at certification.

4. Documentation:

(a) Prepare sketches of the turbulence test setup.

(b) Record flow readings of average velocity, maximum and minimum velocities, and turbulence intensity.

(c) Prepare three-dimensional chart and contour plots showing turbulence intensity as a function of distance and position.

(d) Prepare three-dimensional chart and contour plots showing velocity profiles as a function of distance and position.

(e) Record the test stations mapped on a cleanroom layout.

y. Sodium Test (Alternative B9):

1. Purpose of Test:

(a) Measure effectiveness of makeup air handler filter assemblies for extraction of sodium elements.

(b) Determine residual sodium concentrations at strategic locations within the cleanroom.

2. Test Procedure:

(a) Collect sodium chloride samples at the outside air intake and at the final supply air discharge of 3 makeup air handlers serving the cleanroom selected by the Owner's Agent.

(b) Collect sodium chloride samples at 10 critical cleanroom test stations selected by the Owner's Agent at a distance 42 inches above the floor.

(c) Obtain wet samples by drawing air through 50 ml volume of DI water in the 100 ml impinger sample tube. Sample at a flow rate of 1 liter per minute for 30 minutes.

(d) Obtain dry samples by drawing air through the Teflon filter media. Sample at the same flow rate of 1 liter per minute for 30 minutes.

(e) Desorb the contaminants from the dry filters with 15 ml of DI water. Place in an ultrasonifier for 15 minutes.

(f) Store samples in Nalgene polypropylene bottles.

(g) Deliver samples to the quality assurance staff via the Owner's Agent for atomic absorption spectrometer analysis.

3. Acceptance Criteria: Obtain sodium values to create initial benchmark at certification.

4. Documentation: Duplicate the MIT LL's sodium report from sample analysis and record sodium concentrations for each test station mapped on a building layout.

3.4 SUBMITTAL SCHEDULE

ITEM NO.	SUBMITTAL REQUIREMENT	CLASSIFICATION	AS INDICATED
01 45 23.13 - 01	Qualifications: Qualifications of the CCC staff.	SD-01	
01 45 23.13 - 02	Experience and References: List showing projects similar in size, complexity, and cleanliness classification to this project that the firm has completed. Include for each project: 1. Project name. 2. Description of cleanroom HVAC system. 3. Services provided.	SD-01	
01 45 23.13 - 03	Testing and Certification Procedures Outline of the testing and certification procedures. Indicate test procedures planned for particle counting, whether statistical sample or sequential sample counting.	SD-01	
01 45 23.13 - 04	Testing Schedule: Schedule for the acceptance and benchmark performance tests on this project.	SD-01	
01 45 23.13 - 05	Sample Test Report: A sample test report of a similar project.	SD-01	

01 45 23.13 – 06	List of Test Equipment and instruments to be used, including: 1. Date of purchase. 2. Model and serial numbers. 3. Calibration records: 4. Procedure. 5. Source of the standard. 6. Last three calibration dates. 7. Calibration interval. 8. Curves. 9. Application restrictions.	SD-01	
01 45 23.13 – 07	Samples of field reports, charts, and forms proposed to document measurements.	SD-01	
01 45 23.13 – 09	Software and Analysis Approach: Recommended approach and software for computerized statistical analysis of the field tests. Include in the analysis: averages, standard deviation, ranges, and distribution curves that will permit database trend analysis.	SD-01	
01 45 23.13 – 11	Field Reports: Preliminary field reports compiled from each of the certification steps.	SD-06	Furnish to Owner's Agent and Director within 1week after completion of work in each area
01 45 23.13 – 12	Field Logs: Three assembled copies of the working field logs for review and evaluation, provided to Owner's Agent and Director.	SD-06	
01 45 23.13 – 13	Identification of Problems: Evaluation of any problems which jeopardize final certification results or schedule.	SD-06	Furnish to the Director within 1 week after completion of work in each area

01 45 23.13 - 14	Final Certification Report: Draft copy of the final assembled as-built certification report.	SD-06	Furnish to Owner's Agent and the Director within 2 weeks after completion of work

-- End of Section --

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SECTION 01 45 23.16

CLEANROOM CERTIFICATION TEST MATRIX, TABLE

Table 1

Acceptance Tests																	
Room Number or Space Criterion	Bench	Clg. Leak	Air Count	Base Count	Volume	Parallel	Pressure	Induction	Recovery	MAH Leak	Environ-ment	Noise	Vibration	Lt. Level	Lt. Spect.	Conduct.	Space Charge
	A(1)	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Recirculation Air Deck										X							
General Building Spaces							X										
Alternative Tests (2)				A1				A2	A3							A5	B1
ISO Class 4 Spaces	X	X	X	A1	X	X	X	A2	A3	X	X			X		A5	B1
ISO Class 5 Spaces	X	X	X							X	X			X		X	B1
ISO Class 6 Spaces			X								X			X			
ISO Class 7 Spaces			X								X			X			

Notes:

1. Filter manufacturer, prior to filter shipment provides filter bench test.
2. "Alternative Tests" included in Table 1 are part of the Contractor scope.

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Table 1 (Continued)

Room Number	Electromag	Tot. Part.	Part. I.D.	Hcarbon	Nomura	Viable	3D Turb.	Sodium	Keyed Remarks
	R	S	T	U	V	W	X	Y	
Recirculation Air Deck				B5				B9	
General Building									
Alternative Tests	B2	B3		B5	B6		B8	B9	
ISO Class 4 Spaces	B2	B3		B5	B6		B8	B9	
ISO Class 5 Spaces									
ISO Class 6 Spaces									
ISO Class 7 Spaces									

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Table 2

Legend:

ACH	Air changes per hour	Noise	NC criteria curve
Area	Square feet	Parallelism	Degrees off vertical
Humidity	Percent relative	Temperature	Degrees F DB
Lighting	Foot-candles/white/yellow	Velocity	Feet per minute

Room Number	Area (sf)	Class/Ref As-Built	Percent Filter Coverage	Filter Flow	Room Velocity	Parallelism	Noise Criteria	Temperature Set/Range	Humidity Set/Range	Lighting Level/Color	Pressure Note (Note 1)
ISO 4 Bay	Note 2	ISO 4	100	720	90	14	NC60	68 +/-2.0	40 +/-5	Note 5	Note 3
ISO 4 Litho Bay	Note 2	ISO 4	100	720	90	14	NC60	68 +/-2.0	40 +/-5	Note 5	Note 3
ISO 5 Bay	Note 2	ISO 5	100	720	90	N/A	NC60	68 +/-2.0	40 +/-5	Note 5	Note 3
ISO 6 Bay	Note 2	ISO 6	36	720	32 (160 ACH)	N/A	NC55	68 +/-2.0	40 +/-5	Note 5	Note 3
ISO 5 Airlock	Note 2	ISO 5	100	720	90	N/A	NC60	68 +/-2.0	40 +/-5	Note 5	Note 3
ISO 4 Airlock	Note 2	ISO 4	100	720	90	N/A	NC60	68 +/-2.0	40 +/-5	Note 5	Note 3
MIF Wipe Down	Note 2	ISO 6	20	720	18 (90 ACH)	N/A	NC55	68 +/-2.0	40 +/-5	Note 5	Note 3
Chemical Transfer	Note 2	ISO 6	50	720	45 (225 ACH)	N/A	NC60	68 +/-2.0	40 +/-5	Note 5	Note 3
Consumables Storage	Note 2	ISO 6	30	720	27 (135 ACH)	N/A	NC60	68 +/-2.0	40 +/-5	Note 5	Note 3
ISO 4 Airlock	Note 2	ISO 4	100	720	90	N/A	NC60	68 +/-2.0	40 +/-5	Note 5	Note 3
CSL Gowning/ CSL Pregown	Note 2	ISO 6	36	720	32 (160 ACH)	N/A	NC55	68 +/-2.0	40 +/-5	Note 5	Note 3
Chase	Note 2	Resultant	N/A	N/A	Resultant	N/A	NC60	68 +/-2.0	40 +/-5	Note 5	Note 3
Fan Deck	Note 2	N/A	N/A	N/A	N/A	N/A	NC80	68-78 +/-5	Range: 35-65	Note 5	Note 4

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Notes:

1. Pressure shown is relative to the reference point per mechanical airflow diagram drawings.
2. Refer to schedules on the drawings for filter sizes and quantities.
3. Reference MH002 for pressure gradient.
4. Balance to 0.05” WC positive to outside.
5. Refer to requirements of Cleanroom Ceiling Specification 13 06 10, paragraph 1.6 C.

END OF SECTION