

**SECTION 01112**  
**CLEANROOM TESTING AND ACCEPTANCE**

**PART 1 - GENERAL**

**1.1 SECTION INCLUDES**

- A. Contractor shall employ the services of a "Testing Agency" to measure and record the cleanroom conditions and resolve all nonconforming areas prior to attesting that the cleanroom is complete and ready for CNMS's occupancy. Refer to Section 1.05 Performance Requirements for a list of tests to be conducted.
- B. The Testing Agency shall be an independent company and shall not be employed as a subcontractor for other cleanroom related construction works on the CNMS project.
- C. The field Engineer for the Testing Agency shall visit the job site a minimum of once every two weeks for one day's duration each during the period that construction work is being performed on the finished cleanroom for knowledge of the installation, inspections, and completion of construction. The cost of the time and associated expense for these visits shall be included in the bid.
- D. HEPA Filter Repair and Replacement: If defective HEPA filters are identified during the course of work, the Testing Agency shall immediately notify the Contractor and CNMS's Representative, and repair or replacement shall be performed under the direction of the Contractor with approval from the CNMS's Representative.

**1.2 RELATED WORK**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Project Specification Sections apply to this section:
  - 1. Section 01110 – Cleanroom Construction Protocol
  - 2. Section 01111 – Cleanroom Construction and Cleaning Procedures
  - 3. Section 08311 – Manual Cleanroom Doors
  - 4. Section 08300 – Automatic Cleanroom Doors
  - 5. Section 09650 – Resilient Flooring
  - 6. Section 13019 – Ceiling Grid Support
  - 7. Section 13020 – Gasketed Cleanroom Ceiling System
  - 8. Section 13036 – Cleanroom Wall System
  - 9. Section 15503 – Recirculation Air Handling Units - Cleanroom
  - 10. Section 15885 – High Efficiency Particulate Air (HEPA) Filters
  - 11. Section 15990 – Testing, Adjusting and Balancing
  - 12. Section 15766 – Fan Filter Units (FFU)
- C. In the event of conflict regarding requirements for the referenced cleanroom testing between this section and any other section, the provisions of this section shall govern.

**1.3 REFERENCES**

- A. ISO Standards: Institute of Environmental Sciences and Technology (IEST), 940 East Northwest Highway, Mount Prospect, IL 60056
  - 1. 14644-1: Cleanrooms and Associated Controlled Environments

2. (Including Part 1: Classification of Air Cleanliness).
  3. 14644-3: Metrology and Test Methods (including Annex A, B, and C)
  4. 14644-4: Design, Construction and Start-Up
  5. 14644-6: Terms and Definitions
- B. IES-RP-CC006.2 – Testing Cleanrooms
- C. IES-RP-CC-002.1 – Laminar Flow Clean Air Device
- D. IES-RP-CC-013-86T – Equipment Calibration or Validation Procedures
- E. IES-RP-CC-001-86 – HEPA Filters
- F. “Procedural Standards for Certified Testing of Cleanrooms”:
1. National Environmental Balancing Bureau (NEBB)  
8224 Old Courthouse Road  
Vienna, VA 22180
- G. ESD Association Standard ESD-S-7,1-1994
1. Electrostatic Discharge Association  
200 Liberty Plaza  
Rome, NY 13440
- H. SEMI S2 Safety Guidelines for Semiconductor Manufacturing Equipment. Semi I78 0998 Electrostatic compatibility guide to assessment and control of ESD and Electrostatic attraction for equipment.
1. SEMI  
805 East Middlefield Rd.  
Mountainview, CA 94043-4080
- I. NEBB, Procedural Standards for Measuring Sound and Vibration
1. National Environmental Balancing Bureau (NEBB)  
8224 Old Courthouse Rd  
Vienna, VA 22180

#### 1.4 DEFINITIONS

- A. Cleanroom Types:
1. UNIDIRECTIONAL AIRFLOW (laminar): Controlled airflow through the entire cross-section of a clean zone with a steady velocity and approximately parallel streamlines.
  2. NON-UNIDIRECTIONAL AIRFLOW (turbulent): Air distribution where the supply air entering the clean zone mixes with the internal air by means of induction.
- B. Occupancy States:
1. As-Built: Condition where the installation is complete with all services connected and functioning but with no production equipment, materials, or personnel present.
  2. At-Rest: Condition where the installation is complete with equipment installed and operating in a manner agreed upon by the customer and supplier, but no personnel present.
  3. Operational: Condition where the installation is functioning in the specified manner, with the specified number of personnel present and working in the manner agreed upon.
- C. Testing Agency: The Cleanroom testing company or agency.

- D. Balancing Agency: The air testing a balancing company or agency.
- E. HEPA Filter: Generic term that covers types of HEPA, i.e. ULPA, Ultra, 14EPA, etc.
- F. Protocol Manager: The person vested with authority to enforce compliance to clean build protocols

## 1.5 PERFORMANCE REQUIREMENTS

- A. The testing agency shall perform all tests listed below. These tests shall be conducted for a Non-unidirectional airflow (turbulent) and As-built cleanroom occupancy state.
  - 1. Cleanroom Classification Test
  - 2. Installed Filter Leakage Test
  - 3. Air Flow Test
  - 4. Temperature and Humidity Test
  - 5. Electrostatic Discharge Test
  - 6. Floor Conductivity Test
  - 7. Lighting Level Test
  - 8. Electromagnetic Interference Test
  - 9. Vibration Test
  - 10. Sound Pressure Level Test

## 1.6 SUBMITTALS

- A. Submittals shall be provided in accordance with Division 1, and the requirements of this section. The following are required prior to start of construction work inside the cleanroom:
  - 1. Qualifications of all Field Technicians, the Field Engineer, the Project Director, and the Testing Agency.
  - 2. Documentation that the Testing Agency, the Field Engineer, and the Project Director have met all qualification requirements of the NEBB.
  - 3. Written presentation outlining the testing procedures and sequence to be performed.
  - 4. Description of all instrumentation and test equipment to be used, as well as calibration documentation.
  - 5. Sample of all field reports, charts, and forms proposed to document the field-measured conditions.
  - 6. Sequence of test procedures to be used.
- B. After completion and acceptance of all required tests, the Testing Agency shall compile the test data and shall submit copies of the complete report to the CNMS's Representative for review and approval. The report submitted shall be signed and dated by the Testing Agency's Project Director.
- C. Contents of the completed report shall be in accordance with IES-RP-CC-006-84-T. The completed report shall include, but is not limited to, the following items:
  - 1. Report: Tabulate all test data on 8-1/2 x 11-inch sheets bound in a report. Identify all test data by grid location. Grids shall be reviewed with the CNMS's Representative.
  - 2. Drawings: Print of the 1/8-inch scale Cleanroom Floor Plans and Reflected Ceiling Plans made from the contract drawings with testing locations shown on the drawings. Drawings shall be titled, "Cleanroom As-built Testing Drawings."
  - 3. Test Equipment: Complete list of all test equipment used in performing the work with serial numbers and verification of the latest calibration date. All equipment will be reviewed with the CNMS's Representative prior to commencement of work.
  - 4. Guarantee: Written statement signed by the Project Director and the person in charge of on-site work of the Testing Firm stating that all work has been performed in

accordance with these specifications unless approved by the CNMS's Representative and specifically noted otherwise in report.

5. Description of all tests performed, including the purpose, instrumentation, procedure, results, and analysis of the data. Data shall be presented and graphically displayed in an approved form by the CNMS's Representative to permit full understanding of all tests. Include the date tests were taken and the names of field technicians performing the tests.
6. Five copies of the completed Testing Report, submitted for review and acceptance by the CNMS's Representative.
7. Description of the operating condition of all clean areas during the tests.

## 1.7 QUALITY ASSURANCE

- A. All cleanroom air systems shall be tested by a qualified firm specializing in cleanroom certification. The Testing Agency shall work closely with all construction trades as required to complete construction of the cleanroom in accordance with the Construction Documents.
- B. Firms or agencies proposing on this service shall have been in business a minimum of four (4) years specializing in cleanroom testing and certifying work. A list shall be available upon request of projects similar in size, complexity, and cleanliness classification to this project that the firm has completed. Include the project name, description of mechanical system, range of services provided, and the name and phone number of the design consultant who were responsible for final acceptance of the service.
- C. The Testing Agency's Project Director shall have a minimum of two years of experience testing and certifying cleanrooms as a field engineer or field technician. He shall supervise all field engineers and field technicians assigned to complete the testing of the work, and shall be responsible for all on-site testing and data acquisition. No field tests shall be taken without the Field Engineer's presence.
- D. All Testing Agency Field Technicians shall have completed previous training in cleanroom operations and certifying procedures, shall have worked in this capacity on at least one other similar project, and shall only perform fieldwork under direct supervision of the Field Engineer.
- E. A sample of all field data reports, charts, and forms used by the Testing Agency shall be submitted with the proposal. In addition, a sample test report of a similar project shall be available for inspection by the CNMS's Representative to verify the Testing Agency's expertise in data collection, interpretation, and documentation.
- F. Reference standards for all field tests shall be the Institute of Environmental Sciences (IES) IES-RP-CC-006-84T, Recommended Practice for Testing Cleanrooms and the Procedural Standards for Certified Testing of Cleanrooms, National Environmental Balancing Bureau.

## 1.8 PROJECT CONDITIONS

- A. With the exception of vibration testing, testing shall not proceed until all other work on the cleanroom has been completed and the commencement of testing work has been approved.
- B. Vibration testing shall occur at the end of the Normal Clean Stage of construction as defined in Section 01110 as well as at the completion of cleanroom construction as described in Part 1.8C below.
- C. Condition of Cleanrooms Prior to Testing:

1. The HVAC system installation for the cleanroom, including all of the exhaust systems and makeup air system associated with the cleanroom operation, shall have been completed, including all air and water side testing, adjusting, and balancing.
2. All fans shall have been balanced in-place and an acceptance report submitted.

## 1.9 WARRANTY

- A. The service to be furnished by the Testing Agency shall be considered complete and accepted when the Testing Report has been approved by the CNMS's Representative.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. Testing Agencies:
  1. Air Filtration Management, Inc. (AFM)  
P.O. Box 26  
Bethlehem, PA 18016-0269
  2. Protocol Inc.  
6650 SW Redwood Lane, Suite 160  
Portland, OR 97224
  3. Certification and Calibration Services, Inc. (CCS)  
3201 Fair Oak Dr.  
Rowlett, TX 75089
  4. Pentagon Technologies  
3274-B Medlock Bridge Road  
Norcross, GA 30092  
[www.pentagon-technologies.com](http://www.pentagon-technologies.com)
  5. Approved Equal
- B. The Testing Agency shall supply materials, tools, equipment, cleanroom garments, and instrumentation required to perform the cleanroom system testing as described in this section.
- C. Once the cleanroom has been installed, only a polystyrene latex (PSL) aerosol of 0.26 micron shall be used.

### 2.2 EQUIPMENT

- A. All test equipment used in the testing procedures shall be state-of-the-art. Calibration of equipment shall be traceable to NBS Standards within the previous nine months.
- B. The equipment for the following tests shall comply, at a minimum, with the standards set forth in ISO 14644-3, Annex C – Test Instrumentation:
  1. Cleanroom Classification Test
  2. Installed Filter Leakage Test
  3. Air Flow Test
  4. Temperature and Humidity Test
  5. Electrostatic Discharge Test
- C. Vibration measurements shall be taken to characterize the process floor vibration levels. Vibration test equipment shall be accurate to within 1 dB. Test equipment calibration records shall be made with accelerometers with a minimum sensitivity of 01 volt/g. Vibration data shall be analyzed with an adjustable resolution Fourier Transform analyzer.

- D. Airborne noise measurements shall be made in the cleanroom areas. Measurement equipment shall conform to ANSI S14, "Specifications for Type 1 Sound Level Meters" and to ANSI S1.11, "Specifications for Octave, Half-Octave, and Third-Octave Band Filter Sets." Measurement equipment shall be calibrated with an acoustical calibrator conforming to ANSI 1.40, "Specifications for Acoustical Calibrators."
- E. Lighting tests for foot-candle levels and uniformity measurements shall be taken with a Simpson Illumination Level Meter.
- F. Floor conductivity tests shall measure and record resistance through portions of the conductive floor system. Tests shall be taken with a Biddle Mark IV test kit.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. The Testing Agency shall supervise and conduct all tests in the presence of the Contractor's Field Superintendent or his assigned cleanroom Quality Assurance Representative.
- B. The as-built facility tests shall be performed after the air systems balancing agency and piping systems balancing agency have made their initial operating and balancing adjustments and are satisfied that the installation is ready for acceptance testing. Final clean down and commissioning procedures shall also be completed.
- C. All cleanroom re-circulation fans, makeup fans, process fume exhaust systems, and automatic control loops shall be in operation during tests. All mechanical systems and all fans related to the cleanroom system shall be certified to be operating normally and delivering design airflow.
- D. Testing reports shall be reviewed and approved by the CNMS's Representative before the cleanroom is complete.
- E. Tests described below are not identified necessarily in their sequence. The sequence of test procedures shall be as stated in the submittals.

### 3.2 FIELD TESTING PROCEDURES

- A. Measurement procedures will be performed in accordance with ISO 14644 and IEST RP-006.2 Testing Cleanrooms. All testing shall be conducted in the "as-built" occupancy state.
- B. Cleanroom Classification Test:  
Perform this test to verify that facility can achieve intended air cleanliness level.
  - 1. Scope of measurement: All cleanroom spaces (HEPA filter installed spaces).  
Number of points per ISO 14644-1 for each area classification.
  - 2. Measuring procedure: Per ISO 14644-3, Annex B1.
  - 3. Tolerance: Meets requirement of specification for each area.
- C. Installed Filter Leakage Test:
  - 1. Scope of measurements: All installed ULPA filters are leak-free.
  - 2. Measurement procedure: Per ISO 14644-3, Annex B6 using aerosol challenge method with PSL.
  - 3. Tolerance: No leaks as defined by a guaranteed efficiency of filters at 99.9995 percent for particles @ MPPS. Any leaks shall be recorded and re-tested after replacement or repair. Repairs shall be limited according to IES-RP-CC-006.2 to a total of 3% or less

of the filter face and patches shall be limited to 1.5 in one direction. The filter manufacturer or supplier shall correct deficiencies found as directed by the Testing Agency.

- D. Airflow Test:
1. Scope of measurements: All installed ULPA filters.
  2. Measurement procedure: Per ISO 14644-3, Annex B4
  3. Tolerance: Average velocity per specification standards. Deviation shall not to exceed 15%.
- E. Temperature and Humidity Test:
1. Scope of measurement: Take temperature and humidity reading in each cleanroom bay and in support labs (north support labs and slab on grade labs).
  2. Measuring procedure: Per ISO 14644-3, Annex B9 (Temperature) and B10 (Humidity).
  3. Tolerance: Meets requirement of specification.
- F. Electro-Static Discharge Test (in Cleanrooms):
1. Scope of measurement: Test 20% of wall panels and 20% of all ESD resilient flooring. Both electrostatic and Ion generator (ionizer) test shall be conducted for the items listed above.
  2. Measuring procedure: Per ISO 14644-3, Annex 11.
  3. Tolerance: Meets requirements of specifications.
- G. Floor Conductivity Test:
1. This test shall be carried out according to the procedure as outlined in NFPA 99 Chapter 3 at bay & chase cleanroom and support labs. Test points shall be as designated by CNMS's representative or Contractor.
- H. Vibration Test:
1. Tests will be performed at both the completion of the Normal Clean Stage of construction and in the as-built condition of the cleanroom.
  2. At both test times, the tests will be performed at two locations at points designated by CNMS's representative.
  3. Coordinate timing of vibration testing to prevent false readings from construction related activities.
- I. Sound Pressure Level Test:
1. Scope and procedure of measurement: Per IEST RP-006.2 Testing Cleanrooms Section 6.10 Noise Level Test.
- J. Lighting Level Test:
1. Scope of measurement: Number of points per IEST RP-006.2 Testing Cleanrooms Section 6.9 Lighting Level Test.
  2. Measuring procedure: Per IEST RP-006.2 Testing Cleanrooms Section 6.9 Lighting Level Test, measured at 30" above finished floor.
  3. Minimum light levels: Photolithography, E-Beam Resist, E-Beam Litho: 50 footcandles  
All other cleanroom areas: 70 footcandles
- K. Electromagnetic Interference (EMI) Test:
1. Electromagnetic field measurements shall be taken in areas required by CNMS and the Contractor. A search coil with a dynamic range of 0.1 to 4,000 milligauss and a bandwidth of 30 to 500 Hz shall be used. Readings shall be taken in 3 axes on a 4-

foot grid at an elevation of 60 inches above the floor. The source of readings exceeding 1.0 milligauss shall be determined.

### 3.3 ACCEPTANCE CRITERIA

#### A. Verification Procedures:

1. At the beginning of all field testing procedures, the Testing Agency shall demonstrate to the CNMS's Representative each of the tests performed in the course of field data collection, using instruments from the original readings.
2. The Project Director shall present and review all field data with the CNMS's Representative to ensure that a full understanding is transferred to the CNMS's staff of the base operating condition of the cleanroom at completion of construction.

#### B. Documentation:

1. The Project Director shall oversee any changes or corrections required of the final report, and then stamp the final sets signifying his approval of the final testing log.
2. The Testing Agency shall deliver five complete sets of all testing data and logs in bound form to the CNMS's Representative.

**END OF SECTION 01112**