

SEMI F111-0413

TEST METHOD FOR EQUIPMENT FAN FILTER UNIT (EFFU) PARTICLE REMOVAL

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1 Purpose

1.1 This Test Method covers a procedure for measuring particle removal characteristic of equipment fan filter unit (EFFU) installed inside equipment.

1.2 Since EFFU is an assembly of particle filter, fan, and motor, the integrity of these parts is very important for the performance of EFFU. So a conventional particle removal test method for particle filters is not suitable to evaluate EFFU particle removal performance.

2 Scope

2.1 This Test Method defines an evaluation method for EFFU which is installed inside an enclosed space to remove particles that are generated inside process equipment. The particle removal performance of EFFUs is usually depending on the performance of filter media and air flow rate. To understand a performance of an EFFU, the filter media characteristic, air flow rate and the integrity of EFFU parts should be considered simultaneously. This Test Method is intended to demonstrate the system performance of EFFU.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 If the particle size distribution of interest is far different from that of test particles, the EFFU particle removal characteristic will be different.

3.2 Particles in the range of around 0.1 to 0.3 μm in diameter are relatively hard to remove by particle filters compare to other size particles.

3.3 This Test Method does not apply to fan filter unit (FFU).

3.4 The particle concentration inside the test chamber should not exceed the upper concentration limit of the particle counters as specified by the manufacturer.

3.5 The test result of EFFU may not be suitable for applying it in open environment.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI F38-0699 — Test method for efficiency qualification of point-of-use gas filters

4.2 ISO Standards¹

ISO 554 — Standard Atmospheres for Conditioning and/or Testing – Specifications

ISO14644-3 — Clean Rooms and Associated Controlled Environments – Part 3: Metrology and Test Methods

ISO14644-4 — Clean Rooms and Associated Controlled Environments – Part 4: Design, Construction and Start-up

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

¹ International Organization for Standardization, ISO Central Secretariat, 1 rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland; Telephone: 41.22.749.01.11, Fax: 41.22.733.34.30, <http://www.iso.ch>

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *CPC* — condensation particle counter

5.1.2 *EFFU* — equipment fan filter unit

5.1.3 *FPD* — flat panel display

5.1.4 *OPC* — optical particle counter

5.1.5 *FFU* — fan filter unit

5.2 Definitions

5.2.1 *equipment fan filter unit* — an active particle removal device with an assembly of filter, fan, motor and exterior case that is installed inside an equipment.

6 Test Set-up

6.1 Test Equipment

6.1.1 *Test Chamber* — The inside of test chamber must be fabricated with clean stainless steel. The make-up air must be filtered by ULPA filter. The chamber volume should be large enough to continue the test for more than 100 seconds until to reach the particle concentration of 0.1% of the initial particle concentration.

6.1.2 *Operating Temperature and Relative Humidity (RH)* — Tests shall be executed at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ RH according to ISO 554.

6.1.3 *Particle Counter* — A condensation particle counter (CPC) is recommended for particle monitoring equipment. Refer to SEMI F38-0699 (Reapproved 1104) § 6.2.

6.1.4 *Test Specimen* — The test EFFU must be placed in the center of the test chamber.

6.1.5 *Particle Sampling Probe* — an electrically conductive stainless steel sampling tube is recommended to minimize a charged particle sampling loss in the sampling tube.

6.1.6 *Test Particle* — Solid nonvolatile particle with the number mean diameter in the range of 0.1 to 0.3 μm .

7 Test Procedure

7.1 Fill the test chamber with test aerosol.

7.2 The particle monitoring instrument (CPC or OPC) should start monitoring particle concentration in the chamber. The particle sampling probe inlet must be located 10 cm upstream side away from of the center of EFFU inlet face.

7.2.1 It is recommended that the sampling probe inlet should face the incoming air direction.

7.3 Start the EFFU and continuously monitor the particle concentration.

7.4 If the particle concentration inside the test chamber decreases down to less than 0.1% of the initial particle concentration, then stop the test.

8 Calculation of Particle Removal Rate Constant (γ)

8.1 *Theoretical Background* — Figure 1 shows a particle concentration change in a test chamber. From this figure the particle concentration change governing equation is as follows;

$$\begin{aligned} V \frac{dC_i}{dt} &= S - R - Q_e \cdot C_i - \eta \cdot Q_r \cdot C_i \\ &= (S - R + Q_i \cdot C_0) - (Q_e + \eta \cdot Q_r) \cdot C_i \\ &= \beta - \alpha \cdot C_i \end{aligned} \quad (1)$$

where:

V = test chamber volume,

C_i = particle concentration inside the test chamber

C_0 = particle concentration in the make-up air,

Q_e = sampling air flow rate,

Q_i = make-up air flow rate,

Q_r = flow rate of EFFU,

S = particle generation inside the test chamber,

R = particle removal by diffusion and by sedimentation to the inside surface of the chamber,

η = particle removal efficiency of EFFU.

$$\beta = S - R + Q_i \cdot C_0$$

$$\alpha = Q_e + \eta \cdot Q_r$$

8.1.1 Integration of Equation 1 becomes:

$$\int \frac{dC_i}{\beta - \alpha \cdot C_i} = \int \frac{dt}{V} \quad (2)$$

8.1.1.1 With boundary condition; $C_i = C_{i,0}$ at $t = 0$.

$$C_i = \frac{\beta}{\alpha} - \left(\frac{\beta - C_{i,0} \cdot \alpha}{\alpha} \right) \cdot \exp\left(-\frac{\alpha \cdot t}{V}\right) \quad (3)$$

8.1.2 If $C_0 = 0$, $S = 0$, $R = 0$ then $\beta = 0$.

8.1.2.1 Equation 3 becomes:

$$\begin{aligned} C_i &= C_{i,0} \cdot \exp\left(-\frac{\alpha \cdot t}{V}\right) \\ &= C_{i,0} \cdot \exp(-\gamma \cdot t) \end{aligned} \quad (4)$$

where $\gamma = \frac{\alpha}{V}$ and $C_{i,0}$ is the initial particle concentration in the test chamber at time t . γ represent the particle removal characteristic of EFFU.

9 Test Result and Reporting

9.1 Figure 2 shows a typical particle removal test set-up for EFFU.

9.2 The particle concentration decay results are shown in Figure 3.

9.3 From the test data the slopes of the regression lines are the particle removal characteristics of the tested EFFUs. Report the average value of γ after 3 measurements. The regression region must start from at least 10 seconds after the EFFU operation and the regression interval must satisfy § 7.4.

9.4 A sample report format is provided in Related Information 1.