Designation: F25/F25M – 09 (Reapproved 2015)

Standard Test Method for Sizing and Counting Airborne Particulate Contamination in Cleanrooms and Other Dust-Controlled Areas[1]

This standard is issued under the fixed designation F25/F25M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers counting and sizing airborne particulate matter 5 µm and larger (macroparticles). The sampling areas are specifically those with contamination levels typical of cleanrooms and dust-controlled areas.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F50 Practice for Continuous Sizing and Counting of Airborne Particles in Dust-Controlled Areas and Clean Rooms Using Instruments Capable of Detecting Single Sub-Micrometre and Larger Particles

2.2 *ISO Standard:*

ISO 14644-1 Cleanrooms and Associated Controlled Environments—Part 1: Classification of Air Cleanliness[3]

2.3 *IEST Document:*

IEST-G-CC1003 Measurement of Airborne Macroparticles (1999)[4]

2.4 *SAE Document:*

SAE Abstract ARP-743, Procedure for the Determination of Particulate Contamination of Air in Dust-Controlled Spaces by Particle Count Method, August 1962[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *airflow:*

3.1.1.1 *unidirectional airflow*—air flow which has a singular direction of flow and may or may not contain uniform velocities of air flow along parallel lines.

NOTE 1—Formerly known as laminar airflow.

3.1.1.2 *non-unidirectional airflow*—air distribution where the supply air entering the room mixes with the internal air by means of induction.

3.1.2 *critical pressure*—for an orifice, with a constant upstream pressure, the downstream pressure at which the flow will not increase when the downstream pressure decreases.

3.1.3 *critical pressure ratio*—the ratio of the critical pressure of an orifice to the entrance pressure.

3.1.4 *customer*—organization, or the agent thereof, responsible for specifying the requirements of a cleanroom or clean zone.

3.1.5 *fiber*—particle having an aspect (length-to-width) ratio of 10 or more.

3.1.6 *macroparticle*—particle with an equivalent diameter greater than 5 µm.

[1] This test method is under the jurisdiction of ASTM Committee E21 on Space Simulation and Applications of Space Technology and is the direct responsibility of Subcommittee E21.05 on Contamination.

Current edition approved Oct. 1, 2015. Published November 2015. Originally approved in 1963. Last previous edition approved in 2009 as F25 – 09. DOI: 10.1520/F0025_F0025M-09R15.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from Institute of Environmental Sciences and Technology (IEST), Arlington Place One, 2340 S. Arlington Heights Rd., Suite 100, Arlington Heights, IL 60005-4516, http://www.iest.org.

[5] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

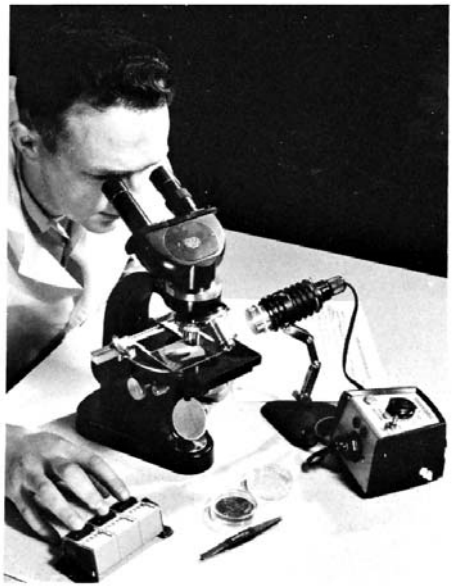


FIG. 1 Suitable Microscope: Inclined Binocular Body; Mechanical Stage; Triple Nosepiece; Ocular-Objective Combination to Obtain 40 to 45× and 90 to 150× Magnification

3.1.7 *M descriptor*—measured or specified concentration of macroparticles per cubic metre of air, expressed in terms of the equivalent diameter that is characteristic of the measurement method used.

3.1.7.1 *Discussion*—The M descriptor may be regarded as an upper limit for the averages at sampling locations (or as an upper confidence limit, depending upon the number of sampling locations used to characterize the cleanroom or clean zone). M descriptors cannot be used to define airborne particulate cleanliness classes, but they may be quoted independently or in conjunction with airborne particulate cleanliness classes.

3.1.8 *occupancy states:*

3.1.8.1 *as-built*—condition where the installation is complete with all services connected and functioning but with no additional equipment, materials, or personnel present.

3.1.8.2 *at-rest*—condition where the installation is complete with equipment installed and operating in a manner agreed upon by the customer and supplier, but with no personnel present.

3.1.8.3 *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.

3.1.9 *particle size*—major projected dimension of the particle.

4. Summary of Test Method

4.1 The test method is based on the microscopical examination of particles impinged upon a membrane filter with the aid of a vacuum. The number of sampling points is proportional to the floor area of the enclosure to be checked. The apparatus and facilities required are typical of a laboratory for the study of macroparticle contamination. The operator must have adequate basic training in microscopy and the techniques of particle sizing and counting.

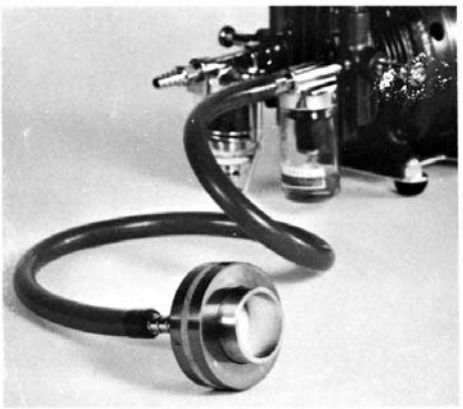


FIG. 2 Typical Air Sampling-Filtration Apparatus

5. Apparatus

5.1 *Filter Holder,*[6]aerosol open type having an effective filtering area of 960 ± 25 mm^2.

5.2 *Adapter.*[7]

5.3 *Flow-Limiting Orifice,*[8]10 L/min.

5.4 *Membrane Filters,*[9]black, 0.80-µm mean pore size, 47-mm diameter, with imprinted grid squares having sides 3.10 ± 0.08 mm. Pressure drop across the filter used shall be no greater than 50 torr for an air flow rate of 1 L/min·cm^2.

5.5 *Forceps,* with unserrated tips.

5.6 *Vacuum Pump,* capable of producing a pressure of 34 kPa (260 torr) (vacuum of 500 torr) downstream of the orifice at a flow rate of 10 L/min through the orifice.

5.7 *Flowmeter,* calibrated and having a capacity in excess of 10 L/min.

5.8 *Glass Microscope Slides,* 50 mm by 75 mm, or 47-mm plastic disposable petri dishes.

[6] The sole source of supply of the apparatus known to the committee at this time is 47 mm Stainless Steel, Millipore XX5004710, available from Millipore Corporation, 290 Concord Rd., Billerica, MA 01821. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[7] The sole source of supply of the apparatus known to the committee at this time is Luer slip to ¼ in. -⅜ in. ID hose Stainless Steel, XX6200004, available from Millipore Corporation, 290 Concord Rd., Billerica, MA 01821. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[8] The sole source of supply of the apparatus known to the committee at this time is Limiting Orifice Set (5 orifices including 10 L/min), XX5000000, available from Millipore Corporation, 290 Concord Rd., Billerica, MA 01821. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[9] The sole source of supply of the apparatus known to the committee at this time is AABG04700, Black Grid, 0.80 µm, available from Millipore Corporation, 290 Concord Rd., Billerica, MA 01821. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

5.9 *Binocular Microscope,* (Fig. 1) with ocular-objective combinations to obtain 40 to 45× and 90 to 150× magnifications. Latter objective shall have numerical aperture of 0.15 min.

5.10 *Normal Counter,*[10](2 gang) or equivalent.

5.11 *Microscope Lamp,* 6 V, 5 A, high-intensity.

5.12 *Ocular Micrometer Scale,* 5-mm linear scale with 100 divisions.

5.13 *Stage Micrometer,* standard 0.01-mm to 0.1-mm scale.

6. Sampling Apparatus

6.1 The airborne particles shall be collected, with the aid of a vacuum source, on a membrane filter of 960-mm^2 effective filtering area.

6.2 The apparatus specified in 5.1, 5.2, and 5.3 or equivalent shall be used.

6.3 Fig. 2 is picture of a typical sampler.

6.4 Fig. 3 is a drawing of a typical sampler assembly.

6.5 Sampler airflow is maintained using the vacuum pump, specified in 5.6, connected to the sampler and either a flowmeter to measure flow or a calibrated orifice to control flow.

6.5.1 The flow rate may be adjusted using a flowmeter and valve downstream of the sampler with filter and other elements installed.

6.5.2 A calibrated orifice, 5.3, may be used to control the airflow rate. The specified flow rate for the orifice depends on critical pressure ratio of less than 0.53 for air at room temperature and pressure. The limiting orifice shall be calibrated with the pump, filter holder, and filter used for this test method. The required flow rate is 10 ± 0.5 L/min.

6.6 Inspect the sampler, including the orifice, to ensure that it is free of restricting matter before each test. Clean if required.

7. Sampling in a Cleanroom, Clean Zone, or other Controlled Areas

7.1 *Sampling Plan:*

7.1.1 A sampling plan shall be provided.

7.1.2 ISO 14644-1 and IEST-G-CC1003 may be used as guides for the plan.

7.2 The filter surface may be vertical or horizontal with respect to the floor.

7.2.1 The orientation of the filter depends on airflow direction for unidirectional airflow areas.

7.2.1.1 Sampling in a unidirectional airflow shall be as close to isokinetic as is possible.

7.2.1.2 IEST-G-CC1003 provides additional information on isokinetic sampling.

7.2.2 For nonunidirectional airflow areas, the customer may specify an orientation or the process being monitored in the cleanroom may indicate which orientation would be preferred.

7.2.2.1 In nonunidirectional airflow, airflow directions and velocities vary with location and time.

7.2.2.2 IEST G-CC1003 recommends a sample inlet probe, with an inlet diameter of at least 20 mm, facing upward. This will collect larger particles that tend to settle out of the air.

7.3 The standard sample for this test method shall be 300 L (10 ft^3).

7.3.1 The sample size may be adjusted for specific conditions.

7.3.2 The number of particles sampled shall meet statistical criteria of ISO 14644-1 or other accepted statistical sampling criteria.

7.4 The sample shall be taken at waist level [0.9 to 1.0 m (36 to 40 in.)] from the floor), at bench level, or at other points as specified by the customer. The sample points may be selected for relevance to and sensitivity of the operations being performed in the cleanroom.

7.5 The number and location of sampling points shall be as designated in the sampling plan.

7.5.1 The minimum number of sample locations as specified in ISO 14644-1, Annex B may be used:

$$N_L = \sqrt{A} \quad (1)$$

where:

N_L = minimum number of sampling locations (rounded up to a whole number), and

A = area of the cleanroom or clean zone in square metres.

In the case of unidirectional horizontal airflow, the area A may be considered as the cross section of the moving air perpendicular to the direction of the airflow.

7.5.2 The nature of the operations or the customer may select the number of sampling points.

8. Sampling in a Duct or Pipe

8.1 The sampling of a moving gas stream in a duct or pipeline requires isokinetic sampling.

[10] The sole source of supply of the apparatus known to the committee at this time is the Veeder-Root counter, available from Veeder-Root, 6th Ave. & Burns Xing, Altoona, PA 16602. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

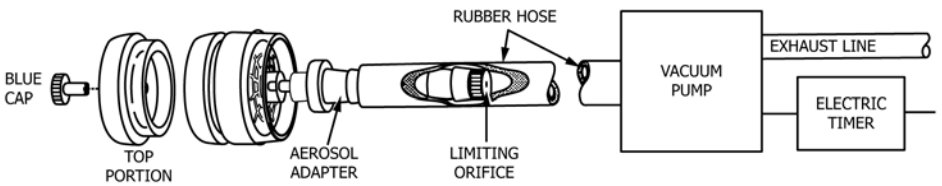


FIG. 3 Typical Aerosol Monitor Sampling System

8.2 Often by reason of the total flow, the allowable pressure drop, or the physical dimensions of the system (as for example an air conditioning air duct), it is impracticable to sample the entire flow.

8.3 Because of the low viscosity of gas, moving gas streams present several special sampling problems, which may disturb the results unless care is taken.

8.4 To collect a representative sample of particulate contamination from a ducted air stream, insert a probe (as shown in Fig. 4) coupled to the sampling apparatus described in 5.1, 5.2, and 5.3.

8.5 Achieving accurate isokinetic sampling requires that the gas linear velocity at the probe opening match that in the duct. Equal velocities may be achieved by a proper ratio between the probe opening and the limiting orifice dimensions, for example:

$$\frac{\text{flow in duct (L/min)}}{\text{duct cross} - \text{sectional area}} = \frac{\text{sampling rate (L/min)}}{\text{probe opening area}} \quad (2)$$

8.6 Failure to match the probe and duct velocities will cause a distortion of results favoring either large particles if the probe velocity lower than duct velocity or small particles if the probe velocity higher than duct velocity.

8.7 Fig. 5 shows an open-type holder installed in a duct. Some large particles are diverted from the filter by airflow around the filter holder. Most small particles are diverted.

8.8 Probes shall have thin walls, sharp edges, as large an inside diameter as is practicable, but with a minimum inside diameter of 6.4 mm (0.25 in.).

8.8.1 Practice F50 provides some guidelines for sample probe tubing.

8.8.1.1 Sample transit tubes should be configured so that the flow Reynolds number is maintained in the range 5000 to 25 000.

8.8.1.2 For particles in the size range 0.1 µm to approximately 2 µm in diameter and a flow rate of 30 L/min (1 ft^3/min), a transit tube up to 30 m long can be used.

8.8.1.3 For particles in the size range approximately 2 to 10 µm, a maximum transit tube length of 3 m can be used.

8.8.1.4 If a flexible transit tube is to be used, then no radius of curvature below 150 mm shall be used.

8.8.2 Tubing diameter, length, and bend radius shall be selected to maximize the transport of particles of the maximum size to be measured.

8.9 Probes shall head directly up stream.

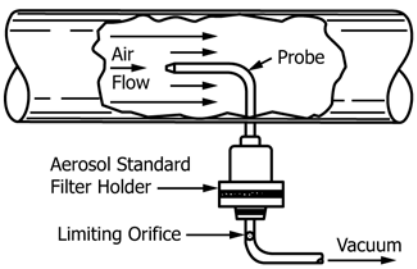


FIG. 4 Isokinetic Sampling from a Duct

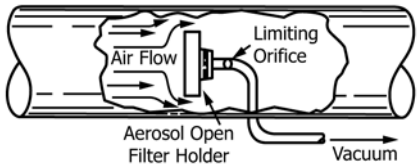


FIG. 5 Faulty Sample from a Rapid-Ducted Gas Stream

8.10 Sampling rate and probe dimensions shall be carefully adjusted to match duct and probe air velocities.

9. Preparation of Apparatus

9.1 Before sampling, remove dirt and dust from the filter holder by washing in a free-rinsing detergent, ketone-free isopropyl alcohol, submicron-filtered reagent grade petroleum ether (boiling range 30 to 60°C) or trichloromonofluoromethane or trichlorotrifluoroethane.

9.2 The clean laboratory equipment used for counting and sizing the collected particles shall be in a HEPA-filtered clean bench or equivalent clean area.

9.3 Plastic microscope hoods shall be installed on the microscope to minimize particle deposition on the filter being counted.

9.4 Personnel performing sizing and counting operations shall be equipped with cleanroom garments consistent with good practice.

9.5 Clean and prepare microscope slides and petri dishes for preserving the membrane filter and specimen. Lens tissue properly used is satisfactory for this operation.

9.6 Handle hazardous chemicals used in the method with recognized precautions.

9.7 Establish a background count on membrane filters by examining each filter used for referee purposes. Examination at 40 to 50× magnifications through the microscope will reveal low or high background count.

9.8 For routine work, a background count on two filters per box of 100 is adequate under present rigid production methods.

9.9 Make a background count, following the microscopical methods outlined in this method.

9.10 A background is required upon any filter with a contamination level approximating 10 % or greater of the estimated test sample. This count will be subtracted from the total count (*Pt*) obtained for each size range.

9.11 If the background count is estimated to be greater than 10% of the total count from a 0.3 m^3 (10-ft^3) specimen, a larger sample [0.4 or 0.6 m^3 (15 or 20-ft^3)] volume) may be used to eliminate the need for following the background count procedure.

9.12 Place acceptable filters in clean petri dishes and cover.

9.13 Identify dishes for test use.

10. Procedure

10.1 With the aid of laboratory pressure tubing of rubber or plastic, connect the filter holder to the vacuum train which

includes the filter holder, and either or both a limiting orifice of 10 L/min (Fig. 6) or a flowmeter having a capacity of 10 L/min, and a source of vacuum (vented outside sampling area or filtered to prevent contamination of the area samples).

10.2 The vacuum pump shall be vented outside the clean-room or sampling area or filtered to prevent contamination of the area samples.

10.3 With clean unserrated forceps, carefully remove the membrane filter from the petri dish and place, with grid side up, on the screen support of the filter holder (Fig. 7). Twist the locking ring in place to secure the filter.

10.4 When in the sampling area, place the filter holder in the desired location and orientation.

10.5 Apply the vacuum and adjust to a flow of 10 L/min. When using the orifice, no adjustment is necessary. However, the pump shall be checked with the manometer to ensure its ability to maintain a pressure of 34 kPa (260 torr) [vacuum of 500 torr] or better while sampling.

10.6 The filter shall be removed from the holder with forceps and placed between clean microscope slides or in a clean petri dish for transport to the microscope counting area.

10.7 *Microscopical Analysis:*

10.7.1 Place the ocular micrometer in one eyepiece. Using a stage micrometer, calibrate the measuring eyepiece (ocular micrometer) for each magnification (Fig. 8). (A whipple disk similarly calibrated is satisfactory for many investigations.)

10.7.2 Knowing the subdivisions of the stage micrometer (top), the divisions of the measuring eyepiece (bottom) may be sized from it (Fig. 8).

NOTE 2—*Example*—Stage micrometer 100 µm per major division, 10 µm per minor division; 100 divisions of the measuring eyepiece subtend 1050 µm, one division of the measuring eyepiece = 10.5 µm.

10.7.3 Place the microscope slide or petri dish containing the specimen under the microscope. The petri dish cover must be removed.

10.7.4 Adjust the microscope lamp intensity and direct it on the specimen from an oblique position to obtain the maximum definition for sizing and counting. High intensity illumination is a critical requirement.

FIG. 6 Inserting a Typical Orifice

FIG. 7 Placing the Filter on a Typical Screen Support

10.7.5 Use a magnification of approximately 45× for counting particles 50 µm or larger and approximately 100× for particles smaller than 50 µm. (Greater magnification may be advantageous for examination to identify particles.)

NOTE 3—Analysis for particles in the 0.5-µm to 5.0-µm size range may be achieved by using transmitted light techniques, after rendering the white filter transparent by placing the filter on immersion oil of refractive index 1.515. A magnification of at least 500× is required. For transmitted light microscopy, a white filter must be used (instead of black filter) since only the white filter can be rendered transparent with immersion oil. If a smaller pore size filter is used, the flowmeter and limiting orifice will require calibration with filter holder and filter in place.

10.7.6 Particles should be counted and tabulated in two size ranges: particles greater than 50 µm and particles 5 to 50 µm. Particles smaller than 5 µm are not to be counted by this method. The size of a particle is determined by its greatest projected dimension.

10.8 *Method of Counting Particles:*

10.8.1 Adjust the microscopic focus and lamp position so that maximum clarity of filter surface and particle definition is obtained.

10.8.2 With the lower magnification (approximately 45×), count the entire effective filter area for particles in the ranges larger than 50 µm.

10.8.3 Use a manual counter or equal for counting the particles.

10.8.4 At the higher magnification, estimate the number of particles in the 5-µm to 50-µm ranges over the effective filtering area by scanning one unit area.

10.8.5 If the total number of particles in this range is estimated to be less than 500, count the number of particles in each size range being measured over the entire effective filtering area.

10.8.6 A statistical analysis shall be performed on the particle counts in each size range to determine the uncertainties in the measurement.

10.8.7 If the total number of particles in the 5-µm to 50-µm ranges is estimated is greater than 500, the counting procedure in 10.9 applies.

10.8.8 The largest projected dimension of the particle determines the size category of the particle.

10.8.9 Fibers may be counted separately if so specified by the customer.

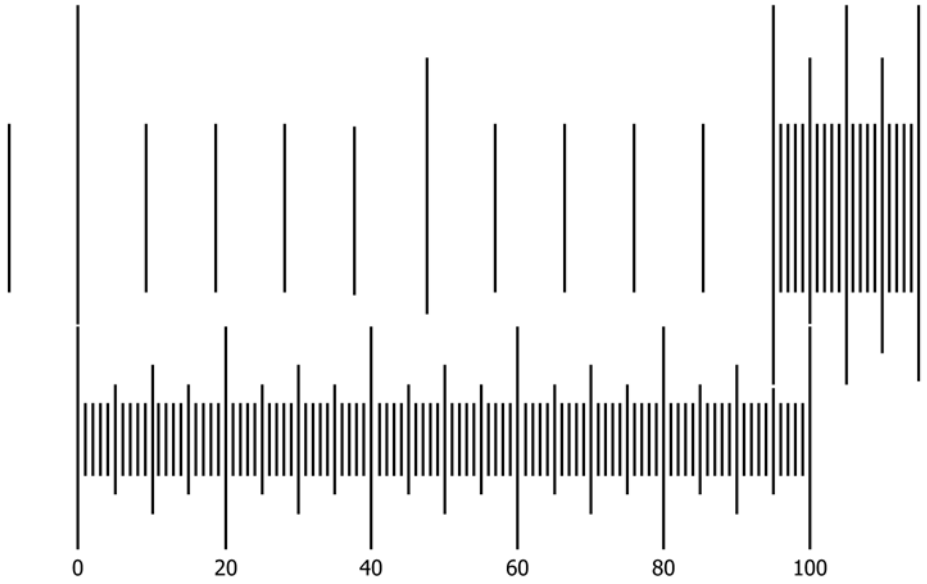


FIG. 8 Calibrating the Measuring Eyepiece

10.9 *Statistical Particle Counting:*

10.9.1 When the estimated number of particles over the effective filtering area in the 5-µm to 50-µm ranges exceeds 500, the method entails the selection of a unit area for statistical counting, counting all particles in the unit area which are in each range being measured, and then similarly counting additional unit areas in accordance with the counting plan of Fig. 9 until the following statistical requirement is met:

$$F_n \times N_t = > 500 \quad (3)$$

where:

F_n = number of grid squares or unit areas counted, and
N_t = total number of particles counted in F_n areas.

10.9.2 After establishing with low-magnification examination that particle distribution on the filter is uniform, for the referee method, use the counting plan as shown in Fig. 9. Count a number of grid squares or unit areas within different grid squares as indicated in the counting plan of Fig. 10 until the statistical requirements of 10.9.1 are met.

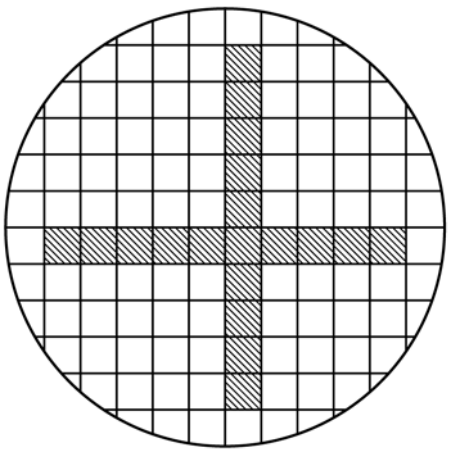


FIG. 9 Double-Diameter Counting Plan (Shaded Area Used)

10.9.3 Select unit areas for counting so that the average total number of particles in a unit area does not exceed 50 particles. (See Fig. 10 for alternative unit areas.)

10.9.4 If a particle lies on the upper or left boundary line of a counting area, count this particle as if it were within the boundaries of the counting area.

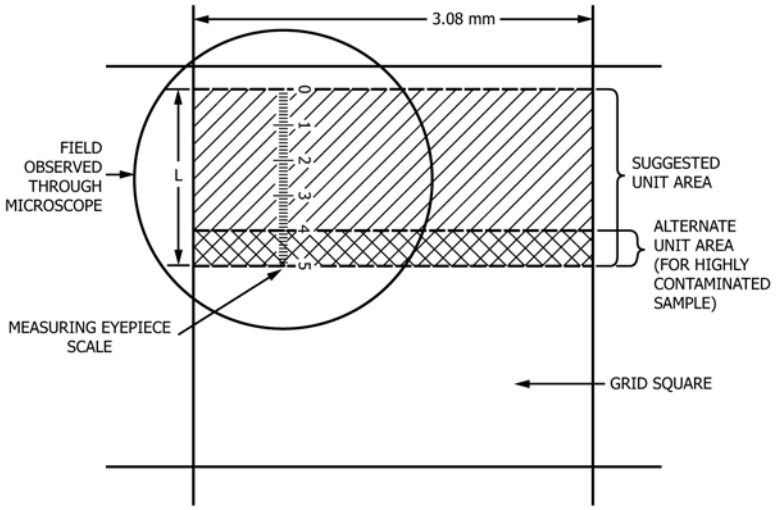
NOTE 4—With membrane filter on stage, movement of the stage makes particles appear to pass the divisions on the measuring eyepiece.

10.9.5 Start and finish a selected grid square or unit area by sizing and counting from the left edge of a grid line, scanning exactly one grid square width as the operation continues from left to right. Optional unit areas are: a grid square, a rectangle defined by the width of a grid square and the calibrated length of the ocular micrometer scale, and a rectangle defined by the width of a grid square and a portion of the length of the ocular micrometer scale.

10.9.6 Scan the unit area for particles by manipulating the stage so that particles to be counted pass under the ocular micrometer scale. Only the maximum dimension of the particle is regarded as significant, and for particles improperly oriented relative to the ocular micrometer scale, make an estimate of maximum dimension. The eyepiece containing the ocular micrometer should not be rotated to size specific particles. Using a manual counter, count all particles in the selected area which are in the 5 to 50 µm range as indicated by the ocular micrometer scale. Record the number of particles in each unit area counted to have a record of the number of unit areas and the particles counted to meet requirements of 10.9.1. This same procedure applies to those special requirements for counting and sizing in closer size ranges between 5 and 50 µm.

10.9.7 In obtaining the total number of particles, count 10 or more grid squares or unit areas on the filter disk. From this count, calculate the total number of particles, which would be present on the total effective filtration area of 100 imprinted grid squares.

10.10 *Alternate Counting Method:*



NOTE 1—With membrane filter on stage, movement of the stage makes particles appear to pass the divisions on the measuring eyepiece

FIG. 10 Alternative Unit Areas

10.10.1 Record data for all subsequent use. To ensure reproducible results, the operator should be checked periodically with a secondary standard (such as SAE ARP-743).

10.10.2 In obtaining the number of particles of a given particle size range, the number of particles on a representative number of grid squares of the filter disk are counted. From this count, the total number of particles, which would be present statistically on the total effective filtration area of 100 imprinted grid squares, is calculated.

10.10.3 If the total number of particles of a given particle size range is estimated to be between 1 and 50, count the number of particles over the entire effective filtering area.

10.10.4 If the total number of particles of a given particle size range is estimated to be between 50 and 1000, count the number of particles in 20 randomly chosen grid squares and multiply this number by 5 to obtain the total statistical particle count.

10.10.5 If the total number of particles of a given particle size range is estimated to be between 1000 and 5000, count the number of particles on 10 randomly chosen grid squares and multiply this number by 10 to obtain the total statistical particle count.

10.10.6 If the estimated total number of particles of a given size range exceeds 5000, count the particles within at least 10 randomly chosen unit areas. To obtain the total statistical count, multiply the sum of the particles counted in the areas by the calibration factor as defined in 10.10.11.

NOTE 5—The basic unit area for the statistical count (if it is not based on the grid markings on the filter) will be defined by using the ocular micrometer and will be the area swept by scanning the length of an individual grid square with the length of the ocular micrometer scale or any appropriate portion of the scale (Fig. 10).

10.10.7 Select unit areas so that there will be no more than about 50 particles of a size range in a unit area. (See Fig. 10 for the alternative unit areas.)

10.10.8 If a particle lies on the upper or left boundary line of a counting area, count this particle as if it were within the boundaries of the counting area.

10.10.9 The largest dimension of the particle determines the size category of the particle.

10.10.10 Divide the results by ten and report them in each size range as particles per cubic metre.

10.10.11 *Calculation of Calibration Factor:*

10.10.11.1 The calibration factor is the ratio of the effective filtration area (100 grid squares or 9.6 cm^2 to the area counted).

10.10.11.2 To arrive at a calibration factor, start with the microscope adjusted for the power under consideration.

10.10.11.3 Using the stage micrometer, measure the length of the ocular micrometer scale that is used to define the width of the unit area. The length of the unit area is defined by the size of the grid square or 3.08 mm.

11. Calculation

11.1 Calculate the total number of particles in a given size range on the filter as follows:

$$P_t = N_t \times [960/(n \times A_t)] \quad (4)$$

where:

P_t = total number of particles of a size range on the filter; subtract the background count from the P_t value after calculation but before dividing by sample volume;
N_t = total number of particles counted in n unit areas;
n = number of unit areas counted;
A_f = unit area in, mm^2; and
960 = total effective filter area, mm^2.

Results should be expressed for each size range in particles per cubic metre of sample by dividing the number of particles, P_t, by the sample size (0.3 m^3 standard):

$$\text{Particles/m}^3 = P_t/0.3\ m^3 \quad (5)$$

Final results are expressed in particles per cubic foot of sampled atmosphere in size ranges determined.

11.2 Ready comparison of particle distribution is possible by increasing the number of size ranges counted and then by

plotting size counts on semilog or log-log graph paper. Plotted data make for easy comparisons over extended operating periods.

12. Test Report

12.1 The results from testing each cleanroom or clean zone shall be recorded and submitted as a comprehensive report, along with a statement of compliance or noncompliance with the specified requirements for airborne macroparticle concentrations.

12.2 The test report shall include the following:

12.2.1 The name and address of the testing organization, and the date on which the test was performed;

12.2.2 A clear identification of the physical location of the cleanroom or clean zone tested (including reference to adjacent areas if necessary), and specific designations for coordinates of all sampling locations;

12.2.3 The specified designation criteria for the cleanroom or clean zone, including the ISO classification, the relevant occupancy state(s), and the considered particle size(s);

12.2.4 The type of airflow in the cleanroom;

12.2.5 Details of the test method used, with any special conditions relating to the test or departures from the test method, and identification of the test instrument and its current calibration certificate;

12.2.6 The test results, including particle concentration data for all sampling location coordinates; and

12.2.7 The classification of the cleanroom or clean zone per ISO 14644-1;

12.3 If the report includes classification measurements, the report requirements of ISO 14644-1, Section 4.4 shall be followed.

13. Precision and Bias

13.1 The precision and bias of this test method can be no higher than the sum total of the variables. To minimize the variables attributable to an operator, a trained microscopist technician is required. Variables of equipment are recognized by the experienced operator, thus further reducing possible error.

13.2 The 500-count method has been determined to have merit. Considering the possibility of having from 2 to 5 specimens per referee investigation, the fatiguing factor is less than that for more time-consuming methods of counting.

13.3 For training personnel, low to medium concentration specimens may be prepared on a grid filter and preserved between microslides as standards for a given laboratory. Standard counting specimens are available for this purpose.

13.4 This test method can be adapted for projection microscopical analysis by the use of white filter, transmitted light, and a properly marked projection screen. The projection techniques should be checked against a direct microscope count, because the optics of projection equipment are sometimes inadequate for resolution of small particles.

14. Test Report

14.1 The results from testing each cleanroom or clean zone shall be recorded and submitted as a comprehensive report, along with a statement of compliance or noncompliance with the specified requirements for airborne macroparticle concentrations.

14.2 The test report shall include the following:

14.2.1 The name and address of the testing organization, and the date on which the test was performed;

14.2.2 A clear identification of the physical location of the cleanroom or clean zone tested (including reference to adjacent areas if necessary), and specific designations for coordinates of all sampling locations;

14.2.3 The specified designation criteria for the cleanroom or clean zone, including the ISO classification, the relevant occupancy state(s), and the considered particle size(s);

14.2.4 The type of airflow in the cleanroom;

14.2.5 Details of the test method used, with any special conditions relating to the test or departures from the test method, and identification of the test instrument and its current calibration certificate;

14.2.6 The test results, including particle concentration data for all sampling location coordinates; and

14.2.7 The classification of the cleanroom or clean zone per ISO 14644-1.

14.3 If the report includes classification measurements, the report requirements of ISO 14644-1, Section 4.4 shall be followed.

15. Keywords

15.1 airborne particle concentration; cleanroom; contamination; macroparticle