Designation: F 25 – 68 (Reapproved 1999)

Standard Test Method for Sizing and Counting Airborne Particulate Contamination in Clean Rooms and Other Dust-Controlled Areas Designed for Electronic and Similar Applications[1]

This standard is issued under the fixed designation F 25; 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. The sampling areas are specifically those with contamination levels typical of clean rooms (white and gray rooms) and dust-controlled areas designed for electronic work. It is not a test method for dust counting in which isokinetic sampling is a factor (Appendix X1).

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

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 limitations prior to use.*

NOTE 1—Information is included relative to modifications to the referee techniques which will make the test method more suitable for specific routine monitoring, such as described in Appendix X4.

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *Major Projected Dimension* of a particle is designated as the particle size.

2.1.2 *Standard Unit of Length* for sizing purposes is the micrometer, µm, which is 0.001 mm or 0.000 04 in. Only particles with a measurable length greater than 5 µm are to be counted.

2.1.3 *Fiber* is considered a particle, no distinction being made with respect to length to width ratios.

3. Summary of Test Method

3.1 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 microparticle contamination. The operator must have adequate basic training in microscopy and the techniques of particle sizing and counting.

4. Apparatus

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

4.2 *Vacuum Pump*, capable of producing a vacuum of 500 torr (500 mm Hg) while pumping at a rate of 10 L/min.

4.3 *Flowmeter*, calibrated and having a capacity in excess of 10 L/min, or a limiting orifice,[2] calibrated with the pump, filter holder, and filter used for this method at a flow rate of 10 ± 0.5 L/min. Ensure visually that the orifice is free of restricting matter before each test.

4.4 *Membrane Filters*,[2] 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.

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

4.6 *Forceps*,[2] with unserrated tips.

4.7 *Binocular Microscope*,[3] (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.

[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.

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[2] The following apparatus, or equivalent, is satisfactory for this test method; except where mentioned otherwise, the part numbers refer to equipment available from Millipore Filter Corporation, Bedford, MA.

(*1*) Filter holder, Millipore XX50 047 10; or Gelman 1200 A with 1207 Adapter available from Gelman Instrument Co., Chelsea, MI.

(*2*) Limiting Orifice, XX50 000 00.

(*3*) Filter, AA Black Grid, 0.80 µm.

(*4*) Forceps, XX62 000 06,

(*5*) Check Slide Photographic, XX50 000 50 or equivalent,

(*6*) Aerosol Monitors, Type MABG037A0, and

(*7*) Adapter, XX62 000 04.

[3] Microscopes such as Bausch & Lomb No. TBV-5, Series C; American Optical Co. X2BUHBW, Leitz SM 0.4.4S 25/81; and Zeiss: Model KF 124–212 (with accessories): or equivalent, have been found satisfactory for this purpose.

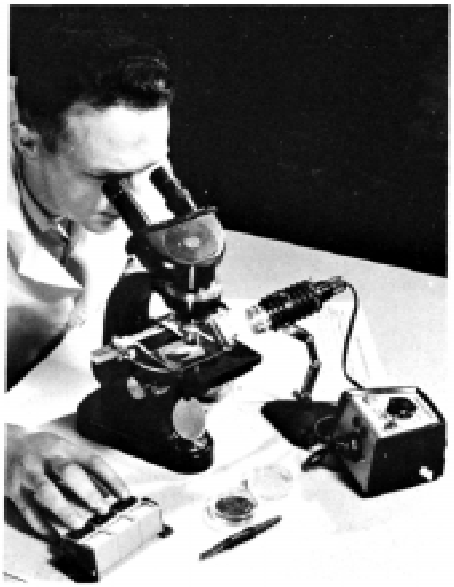


FIG. 1 Suitable Microscope: Inclined Binocular Body; Mechanical Stage; Triple Nosepiece; Ocular-Objective Combination to Obtain 40 to 45× and 90 to 150× Magnification

4.8 *Normal Counter,*[4] (2 gang) or equivalent.

4.9 *Microscope Lamp,*[5] 6 V, 5 A, high-intensity.

4.10 *Ocular Micrometer Scale,*[6] 5-mm linear scale with 100 divisions.

4.11 *Stage Micrometer,*[7] standard 0.01- to 0.1-mm scale.

4.12 *Standard Counting Specimens.* [2]

5. Sampling (Fig. 2)

5.1 The airborne particles shall be collected with the aid of a vacuum source on a membrane filter of 960-mm^2 effective filtering area. The filter surface must be vertical with respect to the floor. For an inplant method of sampling using aerosol monitors, see Appendix X4.

5.2 The standard sample for this test method shall be 10 ft^3 (283 L). For inplant procedure, the sample size may be adjusted for specific conditions.

5.3 The sample shall be taken at waist level (36 to 40 in. (0.9 to 1.0 m)) from the floor) or at bench level unless the area is limited. Sampling points shall be as designated on the sampling plan in Appendix X2. The number of samples for averaging is a function of the floor area of the space being sampled (see 5.4). These sampling locations give a statistical average for the entire room. It is recommended that areas of critical operations also be monitored for closer control of these specific areas.

5.4 The sample shall be taken at the respective locations illustrated on the sampling plan in Appendix X2. Sample at 1 for areas of cabinet size. Sample at 1′ and 2′ for areas less than 150 ft^2 (13.9 m^2). Sample at 1, 2, 3, 4, and 5 for areas up to 1000 ft^2 (92.9 m^2). For areas larger than 1000 ft^2, increase sampling by four locations per 1000 ft^2. If desired, for an average room dust count, a single sample may be taken for 5½ min at each of the five designated sampling points.

5.5 Locations are approximate. Location 1 is the area center, 1′ and 2′ are centers of triangles on respective bases. Locations 2, 3, 4, and 5 are half distances from center to respective corners on area diagonals, as shown in the sampling plan.

6. Preparation of Apparatus

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

6.2 Maintain the laboratory equipment and area used for counting and sizing the airborne particulate in a condition of cleanliness paralleling or superior to the area sampled. Plastic microscope hoods have proven satisfactory as covering in the absence of a laboratory.

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

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

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

6.6 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.

6.7 Make a background count (Note 2), following microscopical methods outlined in this method, upon any filter with a contamination level approximating 10% or greater of the estimated test sample (Note 3). This count will be subtracted from the total count (P_t) obtained in 8.1 for each size range.

6.8 Place acceptable filters in clean petri dishes and cover. Identify dishes for test use.

NOTE 2—For routine work a background count on two filters per box of 100 is adequate under present rigid production methods.

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

7. Procedure

7.1 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. 3) 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) (Fig. 2).

7.2 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. 4). Twist the locking ring in place to secure the filter.

7.3 When in the sampling area, place the filter holder in a horizontal position (filter surface vertical) 36 to 40 in. (91 to

[4] The Veeder Root counter has been found satisfactory for this purpose.

[5] The AO Spencer Universal, or equivalent, lamp has been found satisfactory for this purpose.

[6] Bausch & Lomb No. 31-16-01, or equivalent, scale has been found satisfactory of this purpose.

[7] Bausch & Lomb No. 31-16-99, or equivalent, micrometer has been found satisfactory for this purpose.

FIG. 3 Inserting a Typical Orifice

FIG. 4 Placing the Filter on a Typical Screen Support

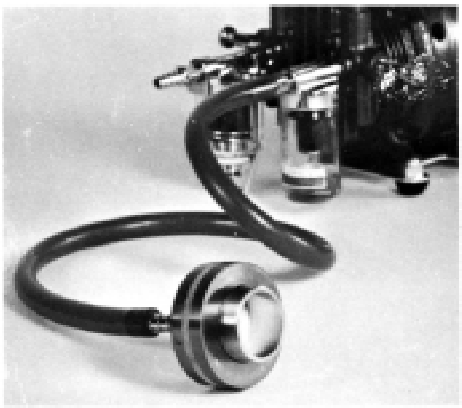


FIG. 2 Typical Air Sampling-Filtration Apparatus

102 mm) from the floor level for purposes of sampling. Apply the vacuum and adjust to a flow of 10 L/min. When using the orifice, no adjustment is necessary. However, the pump should be checked with the manometer to ensure its ability to maintain a vacuum of 500 torr (500 mm Hg) or better while sampling.

7.4 The filter should 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.

7.5 *Microscopical Analysis*:

7.5.1 Place the ocular micrometer in one eyepiece. Using a stage micrometer, calibrate the measuring eyepiece (ocular micrometer) for each magnification (Fig. 5). (A whipple disk similarly calibrated is satisfactory for many inplant investigations.)

7.5.2 Knowing the subdivisions of the stage micrometer (top), the divisions of the measuring eyepiece (bottom) may be sized from it (Fig. 5).

NOTE 4—*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.

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

7.5.4 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.

7.5.5 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 5—Analysis for particles in the 0.5- 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.

7.5.6 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. Fibers are counted as particles.

7.6 *Method of Counting Particles*:

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

7.6.2 With the lower magnification (approximately 45×) count the entire effective filter area for particles larger than 50 µm. Use a manual counter[4] for this purpose.

7.6.3 At the higher magnification, estimate the number of particles in the 5- to 50-µm range over the effective filtering area by scanning one unit area. If the total number of particles in this range is estimated to be less than 500, count the number of particles in this range also over the entire effective filtering area. If the number is greater, the counting procedure in 7.7 applies.

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

7.7 *Statistical Particle Counting*:

7.7.1 When the estimated number of particles over the effective filtering area in the 5- to 50-µm range exceeds 500, the method entails the selection of a unit area for statistical counting, counting all particles in the unit area which are in the 5- to 50-µm range, and then similarly counting additional unit areas in accordance with the counting plan of Fig. 6 until the following statistical requirement is met:

$$F_n \times N_t = >500 \quad (1)$$

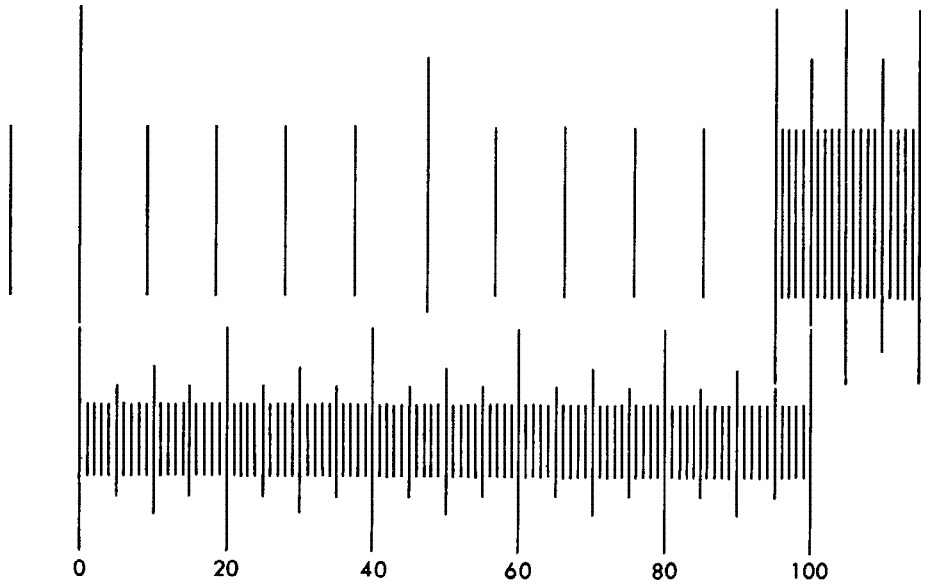


FIG. 5 Calibrating the Measuring Eyepiece

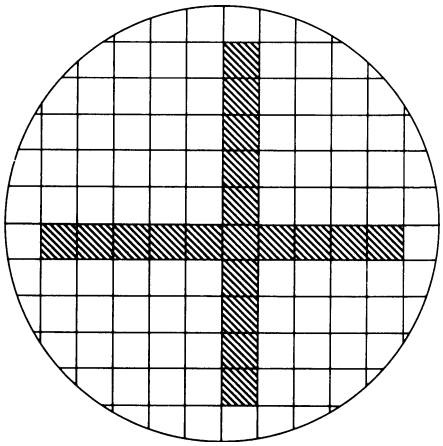


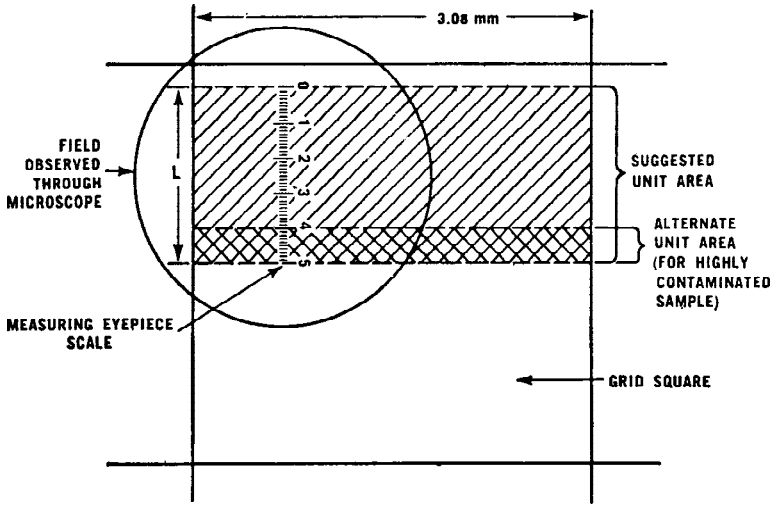
FIG. 6 Double-Diameter Counting Plan (Shaded Area Used)

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

7.7.2 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. 6. Count a number of grid squares or unit areas within different grid squares as indicated in the counting plan of Fig. 7 until the statistical requirements of 7.7.1 are met.

NOTE 6—An alternative test method for statistical particle counting is presented as Appendix X3.

7.7.3 Select unit areas for counting so that the average total number of particles in a unit area does not exceed 50 particles. (See Fig. 7 for alternative unit areas.)



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

FIG. 7 Alternative Unit Areas

7.7.4 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.

7.7.5 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.

7.7.6 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 7.7.1. This same procedure applies to those special requirements for counting and sizing in closer size ranges between 5 and 50 µm.

7.7.7 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.

8. Calculation

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

$$P_t = N_t \times [960/(n \times A_t)] \quad (2)$$

where:

P_t = total number of particles of a size range on the filter (should a background count be obtained, subtract this 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 foot of sample by dividing the number of particles, P_t, by the sample size (10 ft^3(0.3 m^3) standard):

$$\text{Particles/ft}^3 = P_t/10 \quad (3)$$

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

8.2 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 as shown in Appendix X2 (Fig. X2.2). Plotted data make for easy comparisons over extended operating periods.

9. Precision and Bias

9.1 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.

9.2 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.

9.3 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.[2]

9.4 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.

10. Keywords

10.1 contamination; particulate

APPENDIXES

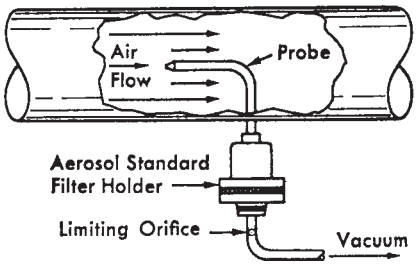
(Nonmandatory Information)

X1. ISOKINETIC SAMPLING OF A MOVING GAS STREAM IN A DUCT OR PIPELINE

X1.1 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. Because of the low viscosity of gas, moving gas streams present several special sampling problems, which may disturb the results unless care is taken.

X1.2 To collect a representative sample of particulate contamination from a ducted air stream, insert a probe (as shown in Fig. X1.1) coupled to an aerosol standard filter holder under vacuum and equipped with a limiting orifice.

X1.3 Achievement of accurate isokinetic sampling demands 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



NOTE 1—Sampling rate and probe dimensions must be carefully adjusted.

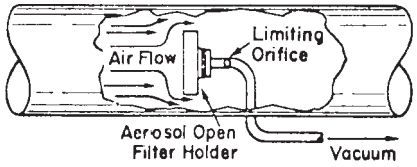
FIG. X1.1 Isokinetic Sampling from a Duct

dimensions, for example,

$$\frac{\text{flow in duct (L/min)}}{\text{deduct cross}-\text{sectional area}} = \frac{\text{sampling rate (L/min)}}{\text{probe}-\text{opening area}} \quad \text{(X1.1)}$$

X1.4 Failure to match the probe and duct velocities will cause a distortion of results favoring either large particles (probe velocity lower than duct velocity) or small particles (prove velocity higher than duct) (Fig. X1.2).

X1.5 Probes should have thin walls, sharp edges, as large an inside diameter as practicable, but with a minimum inside diameter of 0.25 in. (6.4 mm); they should head directly up stream and be bent at a 1-in. (25.4-mm) minimum radius.



NOTE 1—By using an open-type holder, large particles are scrubbed from the filter by air passage; small particles are largely diverted.

FIG. X1.2 Faulty Sample from a Rapid-Ducted Gas Stream

X2. ROOM SAMPLING PLAN—DATA REPORTING—DATA PLOTTING

X2.1 Fig. X2.1 provides a room sampling plan and a form for reporting data. Fig. X2.2 illustrates the graph paper to be used for plotting data.

Sample: Model: Date:
Area Sampled: _____ Sample Volume: _____
Sample Factor = Total Filter Area/Area counted = 960 mm^2/A C

Range	Sample Location					Average Count	Sample Factor	Total Count	Particles per ft^3
	1	2	3	4	5				
5–15μm or 5–50 μm									
5–25 μm or >50 μm									
25–50 μm									
50–100 μm									
>100 μm									

Remarks:

Clean Room Sampling Plan:

Sample at 1 for cabinet size areas.
Sample at 1' and 2' for areas less than 150 ft^2.
Larger areas to 1000 ft^2, use 1, 2, 3, 4, and 5.
Average the readings.

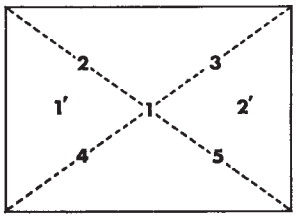


FIG. X2.1 Form for Data Reporting and Room Sampling Plan

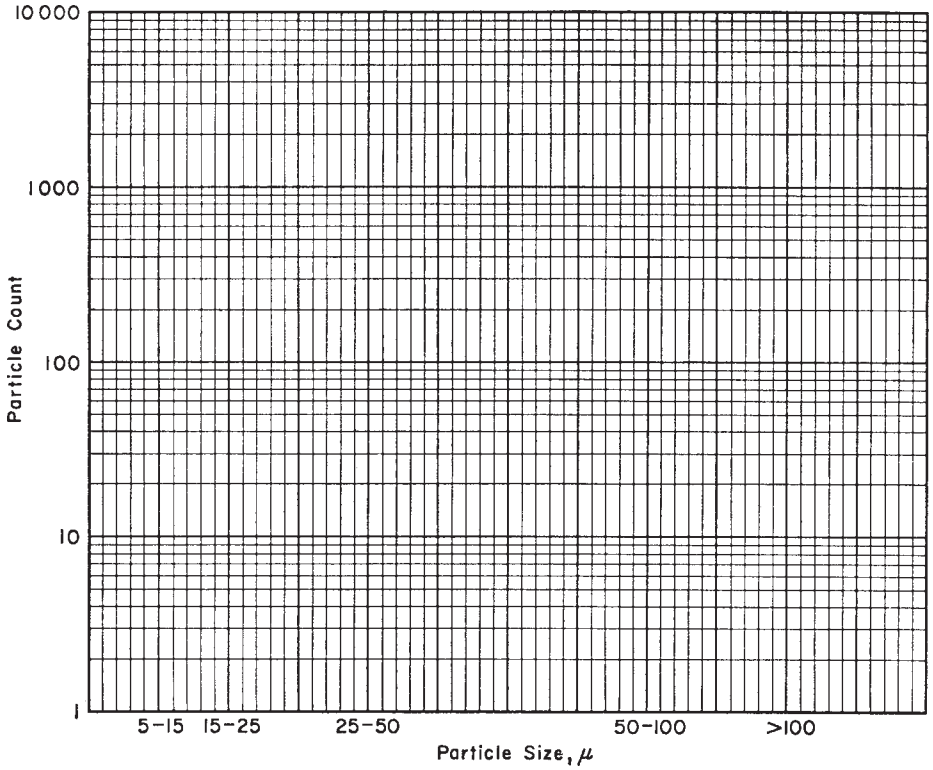


FIG. X2.2 Semilog Graph Paper for Plotting Size Counts

X3. TEST METHOD OF COUNTING PARTICLES

X3.1 Record data for all subsequent use. To ensure reproducible results, the operator should be checked periodically with a secondary standard.[8]

X3.2 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.

X3.3 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.

X3.4 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.

X3.5 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.

X3.6 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 (Note X3.1). To obtain the total statistical count, multiply the sum of the particles counted in the areas by the calibration factor as defined in X3.11.

NOTE X3.1—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. 7).

X3.7 Select unit areas so that there will be no more than about 50 particles of a size range in a unit area. (See Fig. 7 for the alternative unit areas.)

X3.8 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.

X3.9 The largest dimension of the particle determines the size category of the particle.

X3.10 Divide the results by ten and report them in each size range as particles per cubic foot.

X3.11 *Calculation of Calibration Factor:*

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

X3.11.1 The calibration factor is the ratio of the effective filtration area (100 grid squares or 9.6 cm^2 to the area counted).

X3.11.2 To arrive at a calibration factor, start with the microscope adjusted for the power under consideration.

X3.11.3 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.

X4. TEST METHOD FOR DETERMINING AIRBORNE PARTICULATE CONTAMINATION IN MANUFACTURING AREAS

X4.1 Scope

X4.1.1 This appendix describes a technique for determining airborne particulate contamination 5 µm or greater in size by a filtration and particle count method. A maximum variance of ±20 % in results should be expected for replicate samples. No attempt is made in this method to set forth acceptable contamination levels for the various classes of contamination-controlled environments.

X4.2 Summary of Test Method

X4.2.1 Air from the test area is passed through an aerosol monitor containing a Type AA 0.8-µm black membrane filter using a vacuum to conduct the filtration. The air flow rate is controlled by means of a limiting orifice or an air flowrator, and the total volume of air sampled is controlled by the sampling time. The filter disk is examined microscopically, using a high-intensity oblique incident light source to determine the number of particles 5 µm or larger collected from the air sample.

X4.3 Description of Terms Specific to This Standard

X4.3.1 *Particulate Size* is expressed as the maximum dimension or diameter of the particle.

X4.3.2 *A Micrometer, µm,* is 10^{-6} m or 1/25 of a mil (0.001 in.).

X4.4 Apparatus

X4.4.1 *Expendable Materials*:

X4.4.1.1 *Aerosol Monitors*.[2]

X4.4.1.2 *Microscope Slides*

Size 50 by 75 mm (optional).

X4.4.2 *Nonexpendable Equipment*:

X4.4.2.1 *Vacuum Pump*, capable of maintaining a vacuum of 500 torr while pumping at a rate of 10 L/min.

X4.4.2.2 *Aerosol Adapter*. [2]

X4.4.2.3 *Limiting Orifices*, [2] calibrated with the monitor and aerosol adapter used for this method at a flow rate of 10 ± 0.5 L/min.

X4.4.2.4 *Microscope*, with mechanical stage, with magnification of approximately 100×. Recommended is a binocular microscope with 10× eyepieces and a 10× objective lens.

X4.4.2.5 *Forceps*, flat, with unserrated tips.

X4.4.2.6 *Microscope Lamp*, high intensity (6 V, 5 A).

X4.4.2.7 *Ocular Micrometer Scale*, [6] 5-mm linear scale divisions with 100 divisions.

X4.4.2.8 *Stage Micrometer*, 0.1 to 0.01 calibration.

X4.4.2.9 *Manual Counter*. [4]

X4.4.2.10 *Electrical Timer*, 60-min range.

X4.5 Sampling

X4.5.1 A 10-ft^3 (0.3-m^3) sample of air shall be taken by sampling at a rate of 10 L/min for 28 min.

X4.5.2 Samples for this test method should be as representative as possible of the area being sampled. Procedures for procuring such samples should be checked at the outset for reproducibility by the testing of replicate samples from the sampling area.

X4.6 Procedure

X4.6.1 *Preparation of Equipment*:

X4.6.1.1 Use the aerosol monitors as received and open as specified only at the start of the sampling period.

X4.6.1.2 Maintain the microscope and accessories in a state of maximum cleanliness. Protect the microscope by a dust cover when not in use.

X4.6.1.3 Perform the microscopic counting analysis of samples in as clean an area as possible. A dust-controlled room or a hood pressured with filtered air is recommended for the microscope-counting portion of the procedure.

X4.6.2 *Sampling*:

X4.6.2.1 Attach the limiting orifice of 10 L per min to the threaded outlet end of the aerosol adapter and connect the assembled adapter-orifice to a vacuum source.

NOTE X4.1—The vacuum pump exhaust should be isolated from the area being sampled, as it may be a source of extraneous airborne contaminant.

X4.6.2.2 Connect an electric timer to the vacuum pump power source and set for 28 min. Alternatively, a mechanical timer may be used.

X4.6.2.3 Remove the bottom (red) plug from the aerosol monitor and attach it to the free end (Luer) of the aerosol adapter.

X4.6.2.4 Position the monitor in accordance with Fig. X4.1, pry off the top portion of the monitor, and store it in a clean container.

X4.6.2.5 Turn on the pump and sample for 28 min.

X4.6.2.6 When sampling time has elapsed, release the vacuum, replace the top portion of the monitor, and remove the monitor from the aerosol adapter. The bottom plug need not be replaced. Identify the monitor with a sample identification tag. (Counting may be postponed.)

X4.6.3 *Microscopical Analysis*:

X4.6.3.1 With the microscope set up including a 10× objective and 10× eyepieces, one of which contains the ocular micrometer, calibrate the latter in accordance with standard microscopy practice. At this magnification, one division of the referenced ocular micrometer will be approximately 5 µm, but this must be checked with the stage micrometer.

X4.6.3.2 Remove the filter from the monitor by first removing the monitor cover and retaining the ring and then inserting a suitable probe through the bottom outlet hole to raise the support pad and filter. With flat-bladed forceps, place the filter, grid side up, on a glass microscope slide with grid lines parallel to the edges of the slide.

NOTE X4.2—To keep the filter flat so that its surface will be in a single microscope plane, it is advisable either to grease the glass slide with stopcock grease before placing the filter thereon or to tape the edges of the filter to the glass slide carefully.

X4.6.3.3 Set the external microscope lamp at a low oblique angle and adjust to high intensity so as to obtain optimum particle definition.

X4.6.4 *Statistical Particle Counting*—The test method comprises the selection of a field size or unit area, counting all particles in the field that are larger than 5.0 µm (one ocular micrometer division), then similarly counting additional randomly selected fields until the following statistical requirement is met:

$$F_n = N_t = >500 \quad \text{(X4.1)}$$

where:
F_n = number of fields counted and
N_t = total number of particles in F_n fields.

X4.6.4.1 Adjust the microscope focus and lamp position so that a maximum clarity of filter surface and particle definition is obtained.

X4.6.4.2 Select a field size so that there are no more than about 50 particles larger than 5 µm in the field. Optional fields 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 the grid square and a portion of the length of the ocular micrometer scale (Fig. 7).

X4.6.4.3 Scan the unit area for particles 5 µm or larger 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 with four particles improperly oriented relative to the ocular microscope, an estimate shall be made. The eyepiece containing the ocular micrometer should not be rotated to size specific particles. Using a manual counter,[4] count all particles in the selected field that are equal to or exceed the 5-µm dimension as indicated by the ocular micrometer scale. Record the number of particles in each field counted to establish uniformity of distribution and have a record of the number of fields counted.

X4.7 Calculation

X4.7.1 Calculate the total number of particles 5 µm or larger on the filter as follows:

$$P_t = N_t \times 900/(N \times A_t) \quad \text{(X4.2)}$$

where:
P_t = total number of particles 5 µm or larger on the filter,
N_t = total number of particles counted in N fields,
N = number of fields counted,
A_t = area of one field, mm^2, and
900 = effective total filter area (for aerosol monitor filter), mm^2.

NOTE X4.3—1 mm = 1000 µm and 1 $mm^2 = 10^6$ μm^2.

X4.7.2 Results should be expressed in particles per cubic foot of sample by dividing the P_t calculated by the sample size (10 ft^3), or

$$\text{Particles/ft}^3 = P_t/100 \quad \text{(X4.3)}$$

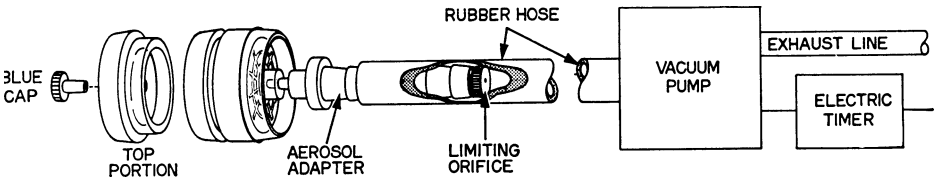


FIG. X4.1 Typical Aerosol Monitor Sampling System