Designation: F 649 – 01

Standard Practice for Secondary Calibration of Airborne Particle Counter Using Comparison Procedures[1]

This standard is issued under the fixed designation F 649; 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 practice covers procedures for adjusting the size ranges of an airborne discrete particle counter (DPC) to match size/concentration data from a reference DPC that has been calibrated for counting and sizing accuracy in accordance with Practice F 328 and is kept in good working order. The practice is applied in situations where time, capabilities, or both, required for carrying out procedures in Practice F 328 are not available. It is particularly useful where more than one DPC may be required to observe an environment where the particulate material being counted and sized is different in composition from the precision spherical particulate materials used for calibration in Practice F 328 and/or all of the DPCs in use are not similar in optical or electronic design.

1.2 Procedures covered here include those to measure sampled and observed air volume or flow rate, zero count level, particle sizing and counting accuracy, particle sizing resolution, particle counting efficiency, and particle concentration limit.

2. Referenced Documents

2.1 *ASTM Standards:*

F 328 Practice for Calibration of an Airborne Particle Counter Using Monodisperse Spherical Particles[2]

E 20 Practice for Particle Size Analysis of Particulate Substances in the Range of 0.2μm to 75 μm by Optical Microscopy[3]

2.2 *IEST Standard:*

IEST RP-CC001.3 HEPA and ULPA Filters[4]

3. Summary of Practice

3.1 The DPC under test is used to sample from an environment containing polydisperse aerosol whose nature is that anticipated where the DPC will be used. At the same time, the reference DPC that has been calibrated in accordance with Practice F 328, and maintained in good working order, is used to sample from the same environment. The size range settings of the DPC(s) under test are adjusted so that the reported concentration data are in good agreement with the data produced by the reference DPC.

4. Significance

4.1 In some measurements, two or more DPCs must be used. Operators have noted that differing results may be obtained by two DPCs sampling the same air parcel, even when the DPCs have been recently been placed in good operating order and are operating within their design specifications.

4.2 Identical or closely similar data are not developed by the DPCs as a result of several possible causes. The most important is the difference between the ambient aerosol and the calibration aerosol in terms of both composition and particle size distribution. Another cause is variation in design and performance between the two DPCs. Still another cause is normal sample variance and the effects of possible difference in sample size. Thus, even with good sample handling procedure, these causes may result in differences of up to an order of magnitude in concentrations reported by two or more DPCs.

NOTE 1—A more detailed discussion of these factors is given in Appendix X1.

5. Interferences

5.1 Since the DPC is typically a high-sensitivity device, radio frequency or electromagnetic interference may affect it. Precautions should be taken to ensure that the test area environment does not exceed the RFE-EMI capabilities of the DPC. Electronic or operational verification can be made, such as indication of acceptable background level data reported.

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[1] This practice is under the jurisdiction of ASTM Committee E29 on Particle and Spray Characterizationand is the direct responsibility of Subcommittee E29.02on Non-Sieving Methods.

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[2] *Annual Book of ASTM Standards*, Vol 14.02.

[3] Discontinued; see *1993 Annual Book of ASTM Standards*, Vol 14.02.

[4] Available from Institute of Environmental Sciences and Technology, 940 E. Northwest Hwy., Mt. Prospect, IL 60056–3444.

6. Apparatus

6.1 *Reference DPC*—This DPC should have been calibrated within the last 6-month period in accordance with Practice F 328 and maintained in good operating order. It is recommended that the reference DPC be retained in a standardization or calibration laboratory and used only as a standard reference instrument.

6.2 *Gas Flowmeter*—A flow meter with low pressure drop characteristics is required to measure sample flow into the DPC. Use a variable area flowmeter with DPC rated flow near the top of the flowmeter scale. The flowmeter should be calibrated and operated for low pressure drop across the flowmeter.

6.3 *Tubing*—Smooth-walled tubing with inside diameter sized in accordance with the DPC(s) inlet section should be used. The tubing should be no longer than 1 m and should be of plastic material that will not release plasticizer or build up electrostatic charge.

6.4 *Filtered Air Supply*—Compressed air that has been passed through a high efficiency filter (see IEST-RP-CC001.3) should be available. The filtered air must be available in quantity equal to or greater than the combined flow rate of both the DPC under test and the reference DPC if the ambient air concentration exceeds the limits indicated in 7.2.

6.5 *Blower*,[5] with free air capacity of approximately $2 m^3$/min and cut off static pressure of at least 50 Pa is recommended.

6.6 *Aerosol Mixing and Sample Supply Chamber*—A chamber with volume 1 to 2 times the volume handled by the DPC(s) in 1 min is recommended. The volume is not critical and any convenient container could be used. As an example, for a 28.3 L/min DPC, a commercial cylindrical fiberboard powder shipping container of 380 mm inside diameter and 460 mm long will provide a 50-L cylindrical chamber. Once the interior has been cleaned, the fiberboard walls can be easily drilled for aerosol sample inlets and outlets.

7. Preparation

7.1 *Preparation of Aerosol Chamber*—Attach the blower to one end of the chamber. For example, if a 50-L cylinder is used, attach the blower to one end of the chamber so that ambient air will be blown into the chamber. Next, place the filtered air supply line so that it exhausts at the center of the chamber and mixes with the air from the blower. Next, at the other end of the chamber insert the inlet lines to the DPC(s) under test and to the reference DPC, as shown in Fig. 1. The inlet section of the lines to the DPC(s) should be close to the central portion of the chamber and the configuration of the lines to the DPC(s) should be nearly identical with the line inlets as close together as possible.

NOTE 2—Any system that meets the requirements of 8.2, 9.5, and 9.10 can be used.

[5] Dayton, Stock No. 4C012, shaded pole blower, has been found suitable for this purpose.

8. Calibration and Standardization

8.1 The DPC under test should be in good operating order. Reference to the manufacturer's primary calibration data and standardize the operating levels of the instrument in accordance with the manufacturer's field standardization procedure. The reference DPC should be in good operating order and have undergone primary calibration within a period of no more than 12 months previous to its use in this practice.

8.2 The concentration of particles within the chamber must be below the level where particle coincidence errors are significant with both the reference DPC and DPC(s) under test withdrawing samples from the chamber. Control the flow of filtered air and the air stream from the blower supplying room air to the chamber so that the particle concentration indicated by the reference DPC is never more than 50 % of the manufacturer's recommended maximum concentration.

9. Procedure

9.1 Remove the sample lines from the chamber and connect these lines to the DPC(s) under test and to the reference DPC. Determine the air flow into each of the DPCs sampling from the chamber with a flow meter and with the sample inlet lines in the configuration that will take within the test chamber. Record this datum.

9.2 Connect the DPC(s) under test and the reference DPC to the test chamber as shown in Fig. 1.

9.3 Perform the manufacturer's recommended initial warmup and field standardization procedures on the DPC(s) under test.

9.4 Verify that the DPC under test operates at a satisfactory background level. For example, actuate the DPC(s) that are connected to the test chamber and start filtered air supply into the test chamber. Do not operate the blower at this time. Establish that an excess of filtered air over and above the DPC(s) withdrawal rate is flowing into the test chamber by noting that positive gas flow is present out of the blower, vents or both.

9.5 Verify that all DPC(s) record zero count after the filtered air supply has been operating for a sufficient period of time to clean out the interior of the air chamber interior. In most cases, a time period sufficient to flush the chamber four times will be adequate.

9.6 Start the blower and reduce the filtered air supply rate until the reference DPC shows a particle concentration of approximately 20 % of the DPC manufacturer's recommended maximum concentration for the DPC(s) under test.

9.7 Adjust the reference DPC gain, size ranges, or channel threshold settings to the desired levels and repeat these settings for the DPC(s) under test, in accordance with the manufacturer's recommended settings.

9.8 Determine the reported concentration of particles in each of the reference DPC size range(s) for the ambient aerosol-filtered air mixture presented to the test chamber and the several DPCs. Determine concentration from the particle count and sample flow rate (see 9.1) for each DPC.

9.9 Adjust the sensitivity for each of the individual channels or size settings for the DPC(s) under test until the number concentration is equivalent to that recorded by the reference

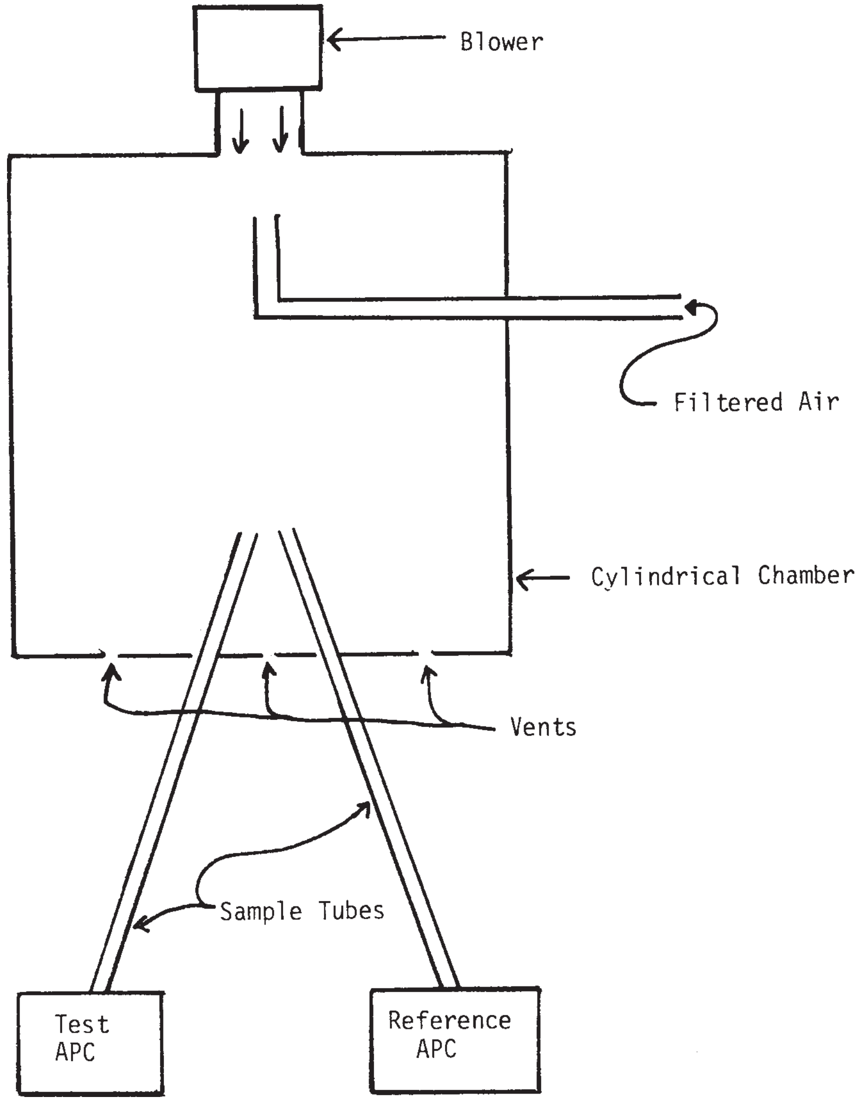

FIG. 1 Test Procedure Arrangement

DPC within ± 20 %. During this procedure, it may be necessary to vary the filtered air supply inlet rate to keep the aerosol concentration in the test chamber at a level that does not vary by more than ± 15 % in the smallest size range when averaging data from a series of measurements.

9.10 After the individual channel sensitivities have been adjusted for the DPC under test, repeat the measurement at least five times (replicate measurement can be halted when the moving average is within tolerance) to obtain replicate data comparing the concentrations in each of the size ranges for the reference DPC and for the DPC(s) under test. Alternate the tubing to the DPC under test and to the reference DPC to ensure that inlet tube bias does not affect the data. Make sure that the maximum variance to be allowed between the mean of the data obtained from the reference DPC and the data obtained from the DPC(s) under test is no more than twice the variance anticipated on the basis of available data (see Appendix X1).

10. Interpretation of Results

10.1 Following the adjustments carried out in Section 8, then the DPC(s) will have been adjusted to produce the same results with aerosol of the type that is being examined by the reference DPC. In most industrial laboratories in buildings, this ambient aerosol will remain fairly constant in nature. If the DPC is moved to a different geographical area and is to be used where different mixtures of components containing atypical materials are present, such as maritime and urban aerosols, then the procedure may have to be operated in the area where the DPC is to be used. The procedure is designed to modify the response calibration curve for the DPC under test to match the response of a reference instrument to an aerosol that is typical of the one to be encountered in routine usage.

10.2 In normal practice, data will be duplicated to ± 10 % between similar instruments that have been carefully adjusted in the same atmospheric aerosol. If instruments of different characteristics are used and the aerosol particle size distribution changes over the ranges normally expected in an industrial laboratory, then data from the two dissimilar instruments can vary within a range of ± 40 %.

APPENDIX

(Nonmandatory Information)

X1. BASIS FOR VARIATION BETWEEN TWO OR MORE DPCS

X1.1 Primary calibration is carried out with spherical latex particles of known size, monodisperse particles with standard deviation normally less than 1 % of the mean, with smooth surface and homogeneous in nature. When these particles pass through a DPC the reported size varies due to variations in the uniformity of illumination intensity (particularly at the edges of the sensing volume), particle velocity in accordance with the profile of a laminar flow stream, and in point-to-point sensitivity variations of the photodetector surface. In addition, manufactured instruments will be fabricated with some small tolerances in dimensions of mechanical components, and performance of optical and electronic components. These tolerance ranges may result in differences of several percent in response to the same particles from instrument to instrument. The result of these several factors is that the resolution or the breadth of the pulse height distribution produced from monodisperse particles may have a relative standard deviation as great as 20 % to 30 % of the mean. This value may vary from one DPC to another.

X1.2 When the DPC is calibrated and used only with monodisperse, smooth spherical particles, then the modal pulse height is used as a reference level for sizing and reasonable correlation in counting is obtained between different DPCs. However, ambient aerosol is composed of irregular particles with variations in optical properties and with particle size distribution where the number of particles is frequently an inverse third or fourth power function of the particle size. Then the resolution of the DPC plays an important part in the determination of the indicated number, particularly in the smallest size setting where background noise may also interfere. Thus, the combination of effects of particle composition, of particle size distribution, and of instrument resolution may result in appreciable differences in number reported by two DPCs that have been calibrated in terms of sizing to an accuracy of 5 % or better for calibration particles.

X1.3 If DPCs of different design are used, then the change in response as a function of particle optical properties will differ with different optical systems. That is: although two different DPCs may be calibrated to give the same results with a standard calibration aerosol, the ambient aerosol with its different refractive index and light absorption properties may produce varying responses with each optical system for separate particle sizes.

X1.4 If the sample ducts to each DPC are not configured fairly identical, then transport losses will occur differently in each duct. These losses are due to diffusion to the duct walls, to inertial impaction at turns in the duct, to gravitational settling in long horizontal duct runs, to electrostatic deposition at duct entries and along nonconducting ducts, and so forth.

X1.5 If the DPCs are used for small samples, either as a result of short sample times or of low flow rates, then the point-to-point variability even in a single air parcel will result in wide differences between measurements. The statistical probability of correct particle number determination is defined on the basis of a Poisson or spatial random distribution. An inherent property of this distribution is the equality between the variance and the mean. The standard deviation of a DPC is then equal to the square root of the mean; that is, a count of 100 particles has a relative standard deviation of 10 %; a count of 1000 particles has a relative standard deviation of 3 %; 10 000 particles must be counted for a relative standard deviation of 1 %. Data will fall within one standard deviation of the mean values about 69 % of the time. The remainder of the data will be outside of that limit. Data will fall within two standard deviations of the mean 95 % of the time.

X1.6 The concentration of the aerosol to be sampled must be limited below the point where optical coincidence will cause interference with correct counting and sizing. The DPC manufacturer will normally supply the concentration versus coincidence error information for any instrument.