



Designation: D 2986 – 95a (Reapproved 1999)

Standard Practice for Evaluation of Air Assay Media by the Monodisperse DOP (Diethyl Phthalate) Smoke Test¹

This standard is issued under the fixed designation D 2986; 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 The dioctyl phthalate (DOP) smoke test is a highly sensitive and reliable technique for measuring the fine particle arresting efficiency of an air or gas cleaning system or device. It is especially useful for evaluating the efficiency of depth filters, membrane filters, and other particle-collecting devices used in air assay work.

1.2 The technique was developed by the U.S. Government during World War II.² Its validity for use in evaluation of air sampling media has been well demonstrated.³

1.3 Although a little latitude is permissible in the associated equipment and in the operation method, experience has shown the desirability of operating within established design parameters and recognized test procedures.⁴

1.4 This practice describes the present DOP test method, typical equipment, calibration procedures, and test particles. It is applicable for use with commercially available equipment.

1.5 *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.* For specific safety precaution, see 6.1.

2. Referenced Documents

2.1 ASTM Standards:

D 1356 Terminology Relating to Sampling and Analysis of Atmospheres⁵

¹ This practice is under the jurisdiction of ASTM Committee D-22 on Sampling and Analysis of Atmospheres and is the direct responsibility of Subcommittee D22.01 on Quality Control.

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² Knudson, H. W., and White, Locke, Ens. USNR, "Development of Smoke Penetration Meters," *Naval Research Laboratory Report No. P-2642*, P.B. No. 119781, September 1945.

³ Smith, Walter, J., and Surprenant, N. F., "Properties of Various Filtering Media for Atmospheric Dust Sampling," *Proceedings, ASTM*, Vol 53, 1953, pp. 1122–1135.

⁴ *Instruction Manual—Penetrometer, Filter Testing*, DOP, Q127 136-300-138B, Edgewood Arsenal, MD, July 1963.

⁵ *Annual Book of ASTM Standards*, Vol 11.03.

3. Terminology

3.1 *Definitions*—For other definitions of terms used in this practice, refer to Terminology D 1356.

3.2 Other terms are defined as follows:

3.3 *optical owl, n*—an optical instrument for visual estimation of the particle diameter of the monodisperse aerosol by the angular dependence of light scattering, in accordance with the Mie theory.

4. Summary of Practice

4.1 A monodispersed aerosol of 0.3- μm diameter is continuously generated by condensation of DOP vapor under controlled conditions. By selective valve arrangement, a metered portion of this aerosol is drawn through a specimen mount containing the item under test. Flow rate through the specimen is adjustable and the corresponding flow resistance is noted as part of the test.

4.2 With aerosol generation stabilized (constant particle size and concentration), aerosol concentration is measured upstream and downstream of the specimen under test by use of a linear forward light-scattering photometer.

4.3 Results are expressed as percent of DOP penetration at the flow rate used.

5. Apparatus

5.1 Equipment for use with this technique consists of several interoperational parts. These are indicated in proper relative arrangement by the diagrammatic sketch, Fig. 1. In Fig. 1, the letter designations refer to the same parts as described in the immediately following subsections:

5.2 *Air Supply Source (a)*—This can be a blower as shown diagrammatically or a compressed air source with stepdown regulator. In any case, the air supply source must be clean, free of entrainment, and sufficient to provide full flow against the total resistance of aerosol generator and aerosol conductor lines to the excess aerosol exhaust point.

5.3 *DOP Aerosol Generator (b)*—The generator is designed to produce uniform size liquid droplet particles of 0.3- μm diameter at a concentration of about $100 \pm 20 \mu\text{g/L}$ of air. Further description of the generator is given in 8.3.

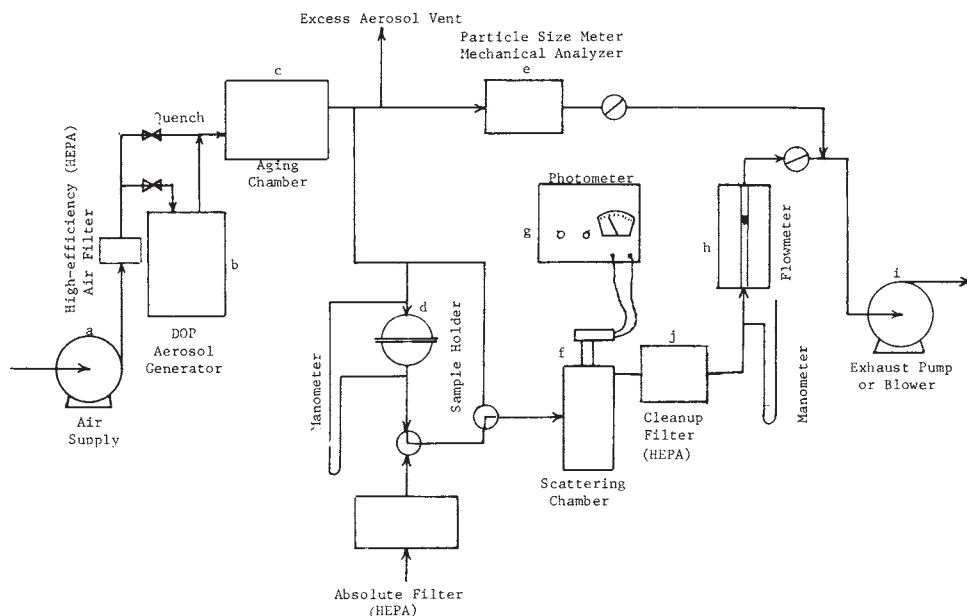


FIG. 1 Simplified Diagram Showing Relation of Principal Parts of DOP Aerosol Test Apparatus

5.4 *Aging Chamber (c)*—This is simply a large vessel (usually about 20 L in volume) wherein some dwell time is provided to permit stabilization of the aerosol.

5.5 *Sample Holder (d)*—Size and design of the sample holder can be accommodated to the item under test. However, for evaluation of filter media, a circular test area of $100 \text{ cm}^2 \pm 2\%$ is specified. Provision is made to measure flow resistance across the test piece. A wire screen may be used to support the sample.

5.6 *Particle Size Analyzer (e)*—Particle size in the aerosol is indicated by the particle size analyzer. The visual owl may be used to verify the aerosol particle size. The electronic owl is an adaption designed to remove the human factor; it has proven to be highly successful. Both instruments operate by optical rotation of light scattered at a 90° angle. Paragraph 8.4 gives further detail for the optical owl.

5.7 *Scattering Chamber (f)*—The scattering chamber is used to determine concentration of aerosol either upstream or downstream of the item under test. Further detail for a typical chamber is given in 8.5.

5.8 *Photometer (g)*—This is a combination of sensitive multiplier phototube and meter. The multiplier phototube mounts on the scattering chamber and detects light forward scattered by any particles in the chamber. Further description of the photometer is given in 8.6.

5.9 *Flowmeter (h)*—A float-type flowmeter (rotameter) is used, capable of reading a flow rate well in excess of the maximum test rate to be used. A meter reading somewhat above 100 L/min is the common size. It must be protected against fouling by any DOP accumulation.

5.10 *Exhaust Pump or Blower (i)*—This can be either a positive displacement pump or blower or a multistage turbine-type blower. In any case, there must be more than sufficient capacity to draw air through the total resistance of test specimen, scattering chamber, flowmeter, and all of the related lines, valves, filters, etc., at the maximum test rate (usually 85 L/min).

5.11 *Cleanup Filter (j)*—This should be a filter of sufficiently high capacity and efficiency to remove smoke from the airstream before it passes through the flowmeter. Aerosol particles would ultimately affect the accuracy of the meter.

6. Reagents and Materials

6.1 *dioctyl phthalate, (DOP)*—Technical grade.

NOTE 1—DOP is under investigation as a possible carcinogen. Use only by trained personnel wearing appropriate safety equipment to avoid skin contact and inhalation.

7. Procedure

7.1 It is necessary to have the equipment prepared and calibrated in advance of any test work. Once prepared and in adjustment, the equipment can be turned on at any time and operated as long as desired with only occasional minor readjustment. Instruction for preparation and operation of each item of equipment is given below.

7.2 *Aerosol Generator*—Turn on the air supply and heating units of the DOP aerosol generator. Wait until the aerosol output has been stabilized; usually this will require $\frac{1}{2}$ h or more from a cold start. Draw a portion of the aerosol through the particle size analyzer, verify the aerosol particle size, and adjust generator conditions until particle diameter is $0.30 \mu\text{m}$ (by adjustment of quench air temperature).

7.3 *Adjustment of Photometer*—Using the same flow rate that will be used for the test specimen (usually $32 \text{ L/min} \pm 2\%$ through 100 cm^2 of area $\pm 2\%$ when testing filter media), aerosol from the generator is passed directly through the scattering chamber. Adjust the *Gain* potentiometer of the galvanometer circuit in the photometer until the meter reads 100.0.

7.3.1 Draw clean filtered air through the scattering chamber. Adjust for stray light so that the photometer meter reads zero on the most sensitive scale.

7.4 *Penetration Measurement*—Mount the sample to be tested in the sample holder, making certain that all seals are