Designation: E128 – 99 (Reapproved 2011)

Standard Test Method for Maximum Pore Diameter and Permeability of Rigid Porous Filters for Laboratory Use[1]

This standard is issued under the fixed designation E128; 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 the determination of maximum pore diameter and permeability of rigid porous filters used in the laboratory for filtration or diffusion. They are applicable to filters made of sintered glass, ceramic, metal, or plastic. This test method establishes a uniform designation for maximum pore diameter and also provides a means of detecting and measuring changes which occur through continued use.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard does not purport to address all of the safety problems, 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D845 Specification for Five-Degree Xylene (Withdrawn 1980)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *maximum pore diameter*—the diameter in micrometres of a capillary of circular cross section that is equivalent (with respect to characteristics related to surface-tension effects) to the largest pore in the filter under consideration.

NOTE 1—It is recognized that the maximum pore diameter as defined herein does not necessarily indicate the physical dimensions of the largest pore in the filter, and furthermore, that the pores are highly irregular in shape. Because of this irregularity in shape and other phenomena characteristic of filtration, a filter may be expected to retain all particles larger than the maximum pore diameter as defined and determined by this test method, and will generally retain particles which are much smaller than the determined diameter.

3.1.2 *permeability*—the flow of air, in millimetres per minute per square centimetre of filter area per 1 cm of water pressure differential.

4. Summary of Test Method

4.1 *Maximum Pore Diameter,* is determined by immersing the filter in a suitable test liquid and applying air pressure until the first bubble of air passes through the filter. The maximum pore diameter is calculated from the surface tension of the test liquid and the applied pressure.

4.2 *Permeability* is determined by measuring the flow of air through the filter when subjected to a pressure differential.

5. Apparatus

5.1 Because of the variety of shapes of apparatus in which porous filters are incorporated, the apparatus for this test method is not specified in detail. Apparatus that has been found satisfactory is illustrated in Fig. 1 and Fig. 2.

6. Procedure

6.1 *Maximum Pore Diameter*—Thoroughly wet the clean filter to be tested by soaking it in the prescribed test liquid (see Table 1). Connect the filter to a controllable source of clean, dry compressed air, and a manometer (Fig. 1). Immerse the filter just below the surface of the test liquid (Note 2) and gradually increase the air pressure at a rate of about 5 mm/min in the area of the test until the first dynamic bubble passes through the filter and rises through the liquid. The appearance of the first true dynamic bubble is readily recognized since it is followed by a succession of additional bubbles. Read the pressure from the manometer. If the test is to be repeated, thoroughly re-wet the filter by soaking it in the test liquid, before proceeding with the retest. Calculate the maximum pore diameter from the following equation (see Appendix X1 for derivation):

$$D = 30\gamma/p \quad (1)$$

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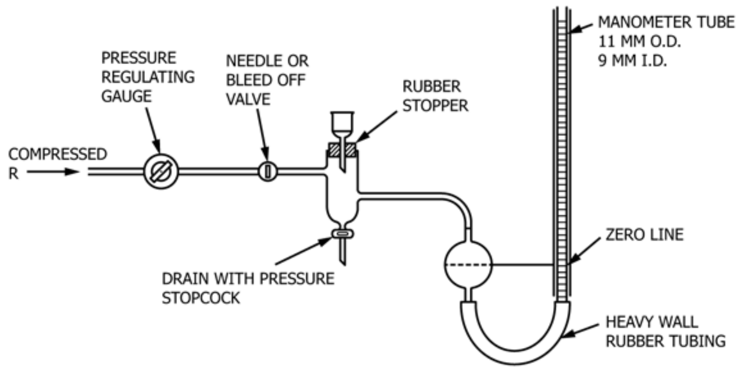
[1] This test method is under the jurisdiction of ASTM Committee E41 on Laboratory Apparatus and is the direct responsibility of Subcommittee E41.01Apparatus Materials.

Current edition approved Oct. 1, 2011. Published November 2011. Originally approved in 1957. Last previous edition approved in 2005 as E128 – 99(2005). DOI: 10.1520/E0128-99R11.

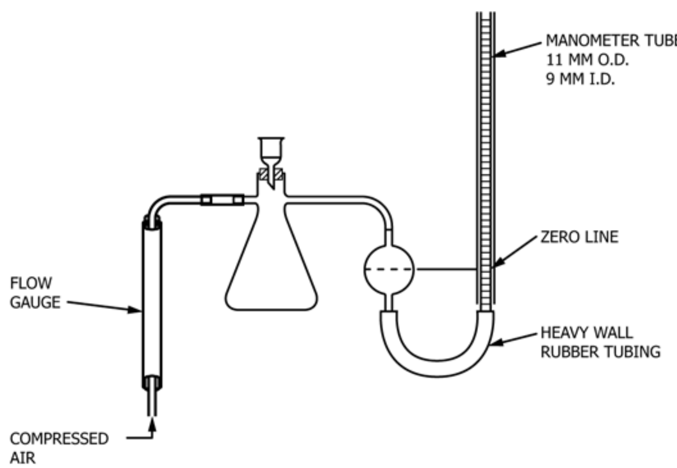
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.



NOTE 1—For tests on filter-type crucibles, use a standard rubber crucible adapter. For test sticks and candles a rubber stopper with a rubber tubing attached is suitable. Clean dry compressed air shall be used.

FIG. 1 Apparatus for Determining Maximum Pore Diameter of Rigid Porous Filters



NOTE 1—For tests on filter-type crucibles, use a standard rubber crucible adapter. For test sticks and candles a rubber stopper with a rubber tubing attached is suitable. Clean dry compressed air shall be used.

FIG. 2 Apparatus for Determination of Permeability

TABLE 1 Test Liquids Suitable for Use with Various Types of Filters

Filter		Suitable Test Liquids[A]	
Material of Construction	Max Pore Diameter, µm	Liquid	Approximate Surface Tension, dynes/cm at 20°C
Glass	>4	water	72
	<4	alcohol[B]	22
Porcelain	>3	water	72
	<3	alcohol	22
Stainless steel	all	alcohol	22
		xylene[C]	29
Tetrafluoro-polyethylene	all	alcohol	22
Trifluoromonochloropolyethylene	all	alcohol	22

[A] The specified liquids wet the respective filters completely. Other liquids which meet this criterion may be used. Values for surface tension in Table 1 are for general guidance only and are approximate; surface tension of the liquid used should be determined.
[B] Ethyl alcohol 95 %.
[C] Five-° xylene conforming to Specifications D845.

where:

D = maximum pore diameter as defined in 3.1.1,
γ = surface tension of test liquid in dynes/cm at the temperature of the test, and
p = pressure, mm Hg (Note 3).

The uniformity of distribution of pores approaching the maximum pore size may be observed by gradually increasing the air pressure and noting the uniformity with which streams of bubbles are distributed over the surface of the filter. Cracks, fissures, and clogged areas are easily discerned by this operation (Note 4).

NOTE 2—If there is significant head of liquid above the surface of the filter, the back pressure so produced shall be deducted from the observed pressure, as follows:

$$\text{Back pressure} = \frac{\text{head of test liquid} \times \text{density of test liquid}}{\text{density of mercury}} \quad (2)$$

Example—If the filter is immersed 3 cm below the surface of water as the test liquid, a correction of 2.2 mm must be subtracted from the pressure observed on a mercury manometer.

NOTE 3—With the coarser grades of filters it is more convenient to measure the pressure in millimetres of water, in which case the relationship becomes:

$$D = (30\gamma \times 13.53)/p \quad (3)$$

NOTE 4—It is recommended that porous filters, where practical, be permanently marked by the manufacturer with the letters ASTM, followed by a hyphenated number which is the range, in micrometres, within which the maximum pore diameter falls. When the maximum pore diameter of a new filter is tested by this test method, it may be expected to be within the marked range; greater deviation may be found after use.

6.2 *Permeability*—Connect the dry filter with the controllable source of clean, dry compressed air, and a suitable flowmeter and manometer (Fig. 2). Adjust the pressure differential to 10 cm water and observe the rate of flow of air through the filter in millilitres per minute. Calculate the permeability as follows:

$$\text{Permeability} = R/Ap \quad (4)$$

where:

R = rate of flow of air, mL/min,
A = effective area (Note 5) of the filter, and
p = observed pressure of water, cm water (Note 6).

NOTE 5—In determining the effective area of the filter, care should be taken to exclude that portion of the filter which was rendered ineffective by sealing the filter to the apparatus.

NOTE 6—The procedure for determination of permeability may be employed to provide an approximate indication of the filtering rate of individual filters. However, immediately after being put into use the permeability will change and may be expected to change further with repeated use. Consideration has been given to marking filters with a designation of permeability. However, the factors governing permeability in use make this undesirable at the present time.

7. Precision and Bias

7.1 The precision of this test method is being determined and will be published when the study has been completed.

8. Keywords

8.1 diameter; filters; permeability; porous

APPENDIX

(Nonmandatory Information)

X1. DERIVATION OF THE PORE DIAMETER EQUATION

X1.1 In the classical determination of surface tension by capillary rise, a capillary tube is immersed vertically in a liquid which wets the tube. The surface tension of the liquid creates a force which draws the liquid upward into the capillary until this force is in equilibrium with the downward force caused by the action of gravity on the column of liquid. This equilibrium condition is expressed by the equation.

$$2\pi r\gamma cos\theta = \pi r^2 hdg \quad (X1.1)$$

where:

r = radius of the capillary,
h = height of the column of liquid,
γ = surface tension of the liquid,
d = density,
θ = angle of contact between the surface of the liquid and the wall of the capillary, and
g = acceleration due to gravity.

When γ is in dynes per centimetre, h and r will be in centimetres. When the liquid wets the capillary with a zero contact angle as is specified by the method, $\theta = 0$ and $\cos\theta = 1$, so that Eq X1.1 may be restated as:

$$r = 2\gamma/hdg \quad (X1.2)$$

or

$$D = 4\gamma/hdg \quad (X1.3)$$

where D = diameter of the capillary in centimetres. But under the conditions of the method it is more convenient to measure the diameter in micrometres and the pressure, p, in millimetres of mercury. Making these substitutions, the expression becomes:

$$D = 30\gamma/p \quad (X1.4)$$