



Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics¹

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This test method has been approved for use by agencies of the Department of Defense to replace Method 3022 of Federal Test Method Standard 406. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method covers the evaluation of specific light-transmitting and wide-angle-light-scattering properties of planar sections of materials such as essentially transparent plastic. A procedure is provided for the measurement of luminous transmittance and haze. Material having a haze value greater than 30 % is considered diffusing and should be tested in accordance with Practice E 167.

1.2 The values stated in SI units are to be regarded as the standard.

NOTE 1—For greater discrimination among materials that scatter a high percent of light within a narrow forward angle, such as is the case with abraded transparent plastics, adjust the hazemeter and perform measurements in accordance with Test Method D 1044.

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.*

NOTE 2—There is no similar or equivalent ISO standard.

2. Referenced Documents

2.1 ASTM Standards:

- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing²
- D 883 Terminology Relating to Plastics³
- D 1044 Test Method for Resistance of Transparent Plastics to Surface Abrasion⁴
- D 1898 Practice for Sampling of Plastics⁴
- E 167 Practice for Goniophotometry of Objects and Materials⁵
- E 259 Practice for Preparation of Reference White Reflectance Standards⁶
- E 284 Terminology of Appearance⁵
- E 691 Practice for Conducting an Interlaboratory Test Program to Determine the Precision of a Test Method⁷

¹ This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.40 on Optical Properties.

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² Annual Book of ASTM Standards, Vols 08.01, 10.01, and 10.02.

³ Annual Book of ASTM Standards, Vols 08.01 and 08.04.

⁴ Annual Book of ASTM Standards, Vol 08.01.

⁵ Annual Book of ASTM Standards, Vol 14.02.

⁶ Annual Book of ASTM Standards, Vols 06.01 and 15.09.

⁷ Annual Book of ASTM Standards, Vols 06.03, 08.03, and 14.02.

3. Terminology

3.1 *Definitions*—Terms applicable to this test method other than those given below are defined in Terminology D 883 and Terminology E 284.

3.1.1 *haze*—the cloudy or turbid aspect or appearance of an otherwise transparent specimen caused by light scattered from within the specimen or from its surfaces.

3.1.2 *luminous transmittance, n*—the ratio of the luminous flux transmitted by a body to the flux incident upon it.

3.2 *Description of Term Specific to This Standard:*

3.2.1 *haze, n*—in this test method, the percent of total transmitted light which, in passing through the specimen, deviates from the incident beam through forward scatter by more than 0.044 rad (2.5°) on the average.

4. Significance and Use

4.1 Light that is scattered upon passing through a film or sheet of a material can produce a hazy or smoky field when objects are viewed through the material. Another effect can be veiling glare, as occurs in an automobile windshield when driving into the sun.

4.2 Although haze measurements are made most commonly by the use of a hazemeter, a spectrophotometer may be used, provided that it meets the geometric and spectral requirements of Section 5. The use of a spectrophotometer for haze measurement of plastics can provide valuable diagnostic data on the origin of the haze.⁸

4.3 Regular luminous transmittance is obtained by placing a clear specimen at some distance from the entrance port of the integrating sphere. However, when the specimen is hazy, the total hemispherical luminous transmittance must be measured by placing the specimen at the entrance port of the sphere. The measured total hemispherical luminous transmittance will be greater than the regular luminous transmittance, depending on the optical properties of the sample. With this test method, the specimen is necessarily placed at the entrance port of the sphere in order to measure haze and total hemispherical luminous transmittance.

4.4 Haze data representative of the material may be obtained by avoiding heterogeneous surface or internal defects not characteristic of the material.

4.5 Haze and luminous-transmittance data are especially useful for quality control and specification purposes.

⁸ Billmeyer, F. W., Jr., and Chen, Y., "On the Measurement of Haze," *Color Research and Application*, Vol 10, 1985, pp. 219–224.

5. Apparatus

5.1 The instrument used for measurement shall meet the geometric and spectral requirements of this section.⁹

5.2 A light source and a photodetector shall be supplied, and the combination shall be filtered to provide an output corresponding to the luminosity response of the 1931 CIE Standard Colorimetric Observer with CIE Standard Illuminant C or, alternatively, Illuminant A. The output shall be proportional to within 1 % to the incident flux over the range of flux used. Spectral conditions for source and detector must be constant throughout the test of each specimen.

5.3 Use an integrating sphere to collect transmitted flux; the sphere may be of any diameter as long as the total port areas do not exceed 4.0 % of the internal reflecting area of the sphere. The entrance and exit ports shall be centered on the same great circle of the sphere, and there shall be at least 2.97 rad (170°) of arc between centers. The exit port shall subtend an angle of 0.14 rad (8°) at the center of the entrance port. With the light trap in position, without the specimen, the axis of the irradiating beam shall pass through the centers of the entrance and exit ports. For a hazemeter, position the photocell or photocells on the sphere 1.57 ± 0.17 rad ($90 \pm 10^\circ$) from the entrance port and baffle it from direct exposure to the entrance port. In the pivotable modification where the interior wall adjacent to the exit port is used as the reflectance reference, the angle of rotation of the sphere shall be 0.140 ± 0.008 rad ($8.0 \pm 0.5^\circ$).

5.4 Illuminate the specimen by a substantially unidirectional beam; the maximum angle that any ray of this beam may make with the beam axis shall not exceed 0.05 rad (3°). This beam shall not be vignetted at either port of the sphere.

5.5 When the specimen is placed against the entrance port of the integrating sphere, the angle between the perpendicular to the specimen and a line connecting the centers of entrance and exit ports shall not exceed 0.14 rad (8°).

5.6 When the beam is unobstructed by a specimen, its cross-section at the exit port shall be approximately circular, sharply defined, and concentric within the exit port, leaving an annulus of 0.023 ± 0.002 rad ($1.3 \pm 0.1^\circ$) subtended at the entrance port.

NOTE 3—It is important to verify whether the unobstructed-beam diameter and centering at the exit port are maintained, especially if the source aperture and focus are changed.

NOTE 4—The tolerance stated on the annulus of 0.002 rad (0.1°) corresponds to an uncertainty of ± 0.6 % in a haze reading.¹⁰ This is relevant for assessing the precision and bias of this test method.

5.7 The surfaces of the interior of the integrating sphere, baffles, and reflectance standard, if used, shall be of substantially equal reflectance, matte, and highly reflecting throughout the visible spectrum.¹¹

5.8 A light trap shall be provided that will absorb the beam completely when no specimen is present, or the

instrument design shall obviate the need for a light trap.

5.9 A schematic drawing of the optics of a hazemeter is shown in Fig. 1.

5.10 A series of calibrated haze standards is required for periodic verification of the accuracy of instrumental response. Ideally, if the haze of narrow-angle-scattering specimens (such as plastic films) is to be measured, narrow-angle-scattering glass haze standards should be used;^{8,10} however, these are not known to be commercially available. In their absence, wide-angle-plastic standards¹² may be used, but these are less sensitive to the size and centering of the annulus described by Billmeyer and Chen⁸ and Weidner and Hsia,¹⁰ and particular attention should be paid to Note 1 when only plastic haze standards are used.

6. Test Specimens

6.1 Sample the material in accordance with Practice D 1898. Obtain specimens that are free of defects not characteristic of the material unless such defects constitute variables under study.

6.2 Cut each test specimen to a size large enough to cover the entrance port of the sphere. A disk 50 mm (2 in.) in diameter, or a square with sides of the same dimensions, is suggested. The specimen shall have substantially plane-parallel surfaces free of dust, grease, scratches, and blemishes, and it shall be free of visibly distinct internal voids and particles, unless it is specifically desired to measure the contribution to haze due to these imperfections.

6.3 Prepare three specimens to test each sample of a given material unless specified otherwise in the applicable material specification.

7. Conditioning

7.1 *Conditioning*—Condition the test specimens at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) and 50 ± 5 % relative humidity for not less than 40 h prior to test, in accordance with Procedure A of Practice D 618, for those tests in which conditioning is required. In cases of disagreement, the tolerances shall be $\pm 1^\circ\text{C}$ (1.8°F) and ± 2 % relative humidity.

7.2 *Test Conditions*—Set up the test apparatus in an atmosphere maintained at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) and 50 ± 5 % relative humidity.

8. Procedure

8.1 Determine the following four readings:

Reading Designation	Specimen in Position	Light Trap in Position	Reflectance Standard in Position	Quantity Represented
T_1	no	no	yes	incident light
T_2	yes	no	yes	total light transmitted by specimen
T_3	no	yes	no	light scattered by instrument
T_4	yes	yes	no	light scattered by instrument and specimen

8.2 Repeat readings for T_1 , T_2 , T_3 , and T_4 with additional specified positions of the specimen to determine uniformity.

⁹ Hazemeters made by BYK-Gardner, Inc., 2435 Linden Lane, Silver Spring, MD 20910, meet these requirements. Other manufacturers of this equipment, which meet the requirements, may exist but have not been identified.

¹⁰ Weidner, V. R., and Hsia, J. J., "NBS Reference Hazemeter: Its Development and Testing," *Applied Optics*, Vol 18, 1979, pp. 1619-1626.

¹¹ Highly reflective matte barium sulfate paint or pressed polytetrafluoroethylene powder are excellent for this purpose. See Practice E 259.

¹² Calibrated plastic haze standards are available from BYK-Gardner, Inc., 2435 Linden Lane, Silver Spring, MD 20910.