This document is not an ASTM standard and is intended only to provide the user of an ASTM standard an indication of what changes have been made to the previous version. Because it may not be technically possible to adequately depict all changes accurately, ASTM recommends that users consult prior editions as appropriate. In all cases only the current version of the standard as published by ASTM is to be considered the official document.

Designation: D 1746 – ~~97~~03

Standard Test Method for Transparency of Plastic Sheeting[1]

This standard is issued under the fixed designation D 1746; 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.

This test method has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method covers the measurement of the transparency of plastic sheeting in terms of regular transmittance (T_r). Although generally applicable to any translucent or transparent material, it is principally intended for use with nominally clear and colorless thin sheeting.

1.2 The values stated in SI units are to be regarded as the standard. The values given in ~~parentheses~~ brackets 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—There is no similar or equivalent ISO standard.

NOTE 2—For additional information, see Terminology E 284 and Practice E 1164.

2. Referenced Documents

2.1 *ASTM Standards:*

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[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 .

Current edition approved July 10, ~~1997.~~ 2003. Published ~~April 1998.~~ September 2003. Originally ~~published as D 1746 – 60 T.~~ approved in 1960. Last previous edition approved in 1997 as D 1746 – 9~~6~~7.

***A Summary of Changes section appears at the end of this standard.**

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D 618 Practice for Conditioning Plastics for Testing[2]
D 883 Terminology Relating to Plastics[2]
D 1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics[2]
E 284 Terminology of Appearance[3]
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]
E 1164 Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation[3]
E 1316 Terminology for Nondestructive Examinations[5]
E 1345 Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements[3]
E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry[3]
E 1348 Test Method for Transmittance and Color by Spectrophotometry Using Hemispherical Geometry[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *regular transmittance*—the ratio

3.1.1 For definitions of undiffused transmitted flux to incident flux. The regular transmittance may equal the total transmittance but cannot exceed it. (For terms used in this test method, limitations on the geometry of the optical system are specified in Section 5.)

3.1.2 *transmittance*—the ratio of the flux transmitted by a specimen refer to the radiant flux incident on the specimen. Terminologies D 883, E 284, and E 1316.

4. Significance and Use

4.1 The attribute of clarity of a sheet, measured by its ability to transmit image-forming light, correlates with its regular transmittance. Sensitivity to differences improves with decreasing incident beam- and receptor-angle. If the angular width of the incident beam and of the receptor aperture (as seen from the specimen position) are of the order of 0.1° or less, sheeting of commercial interest have a range of transparency of about 10 to 90 % as measured by this test. Results obtained by the use of this test method are greatly influenced by the design parameters of the instruments; for example, the resolution is largely determined by the angular width of the receptor aperture. Caution should therefore be exercised in comparing results obtained from different instruments, especially for samples with low regular transmittance.

4.2 Regular transmittance data according to in accordance with this test method correlate with the property commonly known as "see-through," which is rated subjectively by the effect of a hand-held specimen on an observer's ability to distinguish clearly a relatively distant target. This correlation is poor for highly diffusing materials because of interference of scattered light in the visual test.

5. Apparatus

5.1 The apparatus shall consist of a light source, source aperture, lens system, specimen holder, receptor aperture, photoelectric detector, and an indicating or recording system, arranged to measure regular transmittance. The system shall meet the following requirements:

5.1.1 An incandescent or vapor-arc lamp, with a regulated power supply such that fluctuations in light intensity shall be less than ±1 %. If an arc lamp is used, an appropriate filter shall be used to limit light only to the spectral range from 540 to 560 nm.

5.1.2 A system of apertures and lenses shall be used that will provide a symmetrical incident beam. When measured with the indicating or recording system of the apparatus, using a receptor aperture having a width or diameter subtending an angle of 0.025 ± 0.005° at the plane of the specimen, the incident beam shall meet the following requirements:

Angle, °	Maximum Relative Intensity
0	100
0.05	10
0.1	1
0.3	0.1

The source aperture may be circular or a rectangular slit having a length-to-width ratio of at least 10.

5.1.3 A holder shall be provided that will secure the specimen so that its plane is normal to the axis of the incident beam at a fixed distance from the receptor aperture. Provision must be made for rotating the specimen if slit optics are used. Provision for transverse motion may be provided to facilitate replication of measurements.

5.1.4 An aperture shall be provided over the receptor so that its diameter or width subtends an angle, at the plane of the

[2] *Annual Book of ASTM Standards*, Vol 08.01.
[3] *Annual Book of ASTM Standards*, Vol 06.01.
[4] *Annual Book of ASTM Standards*, Vol 14.02.
[5] Webber, Alfred C., "Method for the Measurement
[5] *Annual Book of Transparency of Sheet Materials," Journal of the Optical Society of America ASTM Standards, JOSAA, Vol 47, No. 9, September 1957, pp. 785–789. 03.03.*

specimen, of 0.1 ± 0.025°. The image of the source aperture with no specimen in place shall be the same shape as the receptor aperture centered on and entirely within it.

5.1.5 A photoelectric detector shall be provided such that the indicated or recorded response to incident light shall be substantially a linear function and uniform over the entire range from the unobstructed beam (I_o) to 0.01 I_o or less.

5.1.6 Means shall be provided for relatively displacing the receptor or the image of the source aperture (in the plane of the receptor aperture) by at least 1° from the optical axis of the undeviated incident beam; for circular apertures, in two directions at right angles to each other; for slit optics, in the direction of the short dimension of the slit.

NOTE 3—This provision is necessary for checking the geometry of the incident beam (5.1.2) and for readjusting for maximum light intensity in the event that the beam is deviated by a specimen with nonparallel surfaces.

NOTE 4—Apparatus meeting these requirements has been described in the literature, and commercial versions are available.[6] and commercial versions are available.[7]

6. Reference Materials

6.1 Since no regular transmittance standards are known to be available, it is recommended that specimens of glass or other material believed to maintain constant light transmission properties with time be selected that yield different regular transmittance values for use as reference materials.

6.2 Measure the regular transmittance value of each specimen, and label it with the value obtained.

6.3 Keep these reference materials for checking for changes in instrument performance in the future.

7. Test Specimens

7.1 All specimens should be nominally colorless (Note 5) and transparent to translucent, have essentially plane parallel surfaces, and be free of surface or internal contamination.

NOTE 5—Transparency of colored or highly reflective materials may be measured by the ratio of T_r / T_t, where T_t is the total luminous transmittance (see Test Method D 1003, E 1347, or E 1348).

7.2 Nonrigid specimens must be held in a suitable holder so that they are flat and free from wrinkles.

7.3 A minimum of three test specimens shall be prepared for each material unless otherwise specified in the applicable material specification. Practice E 1345 provides procedures for reducing variability in test results to meet stated tolerance limits by using measurements of multiple specimens (or multiple measurements on a single specimen).

8. Conditioning

8.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) [73.4 ± 3.6°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 where conditioning is required. In cases of disagreement, the tolerances shall be 1°C (1.8°F) [1.8°F] and ±2 % relative humidity.

8.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F) [73.4 ± 3.6°F] and 50 ± 5 % relative humidity, unless otherwise specified in the test methods. In cases of disagreement, the tolerances shall be 1°C (1.8°F) [1.8°F] and ±2 % relative humidity.

9. Instrument Adjustment

9.1 Turn the instrument on and allow it to come to a stable operating temperature.

9.2 With the light beam blocked at sample position, set the reading to zero.

9.3 With the light beam unblocked, adjust the reading to a maximum by moving the receptor aperture so that the receptor receives the maximum intensity from the light. Either set this value to 100 or record it as I_o.

9.4 Check for changes in instrument performance by reading the reference materials prepared in Section 6.

10. Procedure

10.1 Turn the instrument on and allow it to come to a stable operating temperature.

10.2 With the light beam blocked at sample position, set the reading to zero.

10.3 With the light beam unblocked, set the reading to 100 and record it as I_o.

10.4 Mount a test specimen in the instrument so that it is neither wrinkled nor stretched, but centered and normal to the light beam. Record the reading as I_r. Rotate the specimen 90° to measure the directionality of the specimen and record the reading as I_{90}. If no directionality is detected in the specimen, then the test may be performed without the 90° rotation.

10.5 Repeat 10.4 for the other two specimens (minimum).

[6] A Clarity Meter is available from Zebedee, P.O. Box 395, Landrum, SC 29356, (800)462-1804.

[6] Webber, Alfred C., "Method for the Measurement of Transparency of Sheet Materials," *Journal of the Optical Society of America*, JOSAA, Vol 47, No. 9, September 1957, pp. 785–789.

[7] A Clarity Meter is available from Zebedee, P.O. Box 395, Landrum, SC 29356, (800)462-1804.

10.6 A test result is the mean of these three readings (minimum) for each angle of rotation. Report the results in one of two ways: (*a*) per direction or (*b*) averaged. Individual results must also be reported.

11. Calculation

11.1 Calculate the percent regular transmittance, T_r, as follows:

$$T_r = 100 I_r / I_o \tag{1}$$

where:

I_r = light intensity with the specimen in the beam, and
I_o = light intensity with no specimen in the beam.

NOTE 6—No calculation is needed if I_o is set to 100 or a conversion chart or special scale is used to interpret the instrument reading.

11.2 Calculate the test result or average transmittance of the three, or more, readings.

11.3 Calculate the standard deviation of the average transmittance (standard deviation of n readings/$n^{1/2}$).

12. Report

12.1 Report the following information:

12.1.1 Sample designation,

12.1.2 Instrument used,

12.1.3 Average regular transmittance (see 11.2) in machine direction and 90° rotation or average of both directions,

12.1.4 Number of specimens tested and direction of testing,

12.1.5 Standard deviation (see 11.3), and

12.1.6 Any measured anisotropy.

13. Precision and Bias

13.1 *Precision*:

13.1.1 Table 1 is based on a round robin conducted in 1987, per Practice E 691, involving seven materials tested by seven laboratories. Each material tested was represented by four specimens run on separate days, and each specimen was evaluated in duplicate in one day. This procedure yielded eight test results for each material under evaluation, from each laboratory. The instruments used were Gardner clarity meters, which are no longer commercially available.

13.1.2 Table 2 is based on a round robin conducted in 1994, per Practice E 691, involving six materials tested by nine laboratories using Zebedee clarity meters. Four specimens of each material were measured in five places. The mean of the five measurements on each specimen was considered a test result. Measurements of these materials using three different old Gardner clarity meters yielded results consistent with those obtained with the Zebedee meters. ~~Note 7—**Caution:** The following explanations of r and R (13.1.3-13.1.6) are intended only to present a meaningful way of considering the approximate precision of this test method. The data in Table 1 and Table 2 should not be applied rigorously to acceptance or rejection of material, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 13.1.3-13.1.6 would then be valid for such data.~~

13.1.3 Summary statistics are given in Table 1 and Table 2. In the tables, for the material indicated, S_r is the pooled within-laboratory standard deviation of a test result, S_R is the between-laboratory reproducibility standard deviation of a test result, $r = 2.83 \times S_r$(see 13.1.4), and $R = 2.83 \times S_R$. **Warning—**The following explanations of r and R (13.1.3-13.1.6) are intended only to present a meaningful way of considering the approximate precision of this test method. The data in Table 1 and Table 2 should not be applied rigorously to acceptance or rejection of material, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 13.1.3-13.1.6 would then be valid for such data.

TABLE 1 Round Robin on Clarity or Transparency Using Old Gardner Clarity Meters, Summary

Material Designation	Average Transparency	S_r	S_R	r	R
1	10.6	0.66	1.27	1.86	2.33
2	12.7	0.48	1.60	1.36	4.54
3	46.4	2.10	2.81	5.92	7.76
4	73.2	1.79	2.45	5.05	6.94
5	84.8	1.01	1.41	2.86	4.00
6	89.1	0.36	0.49	1.03	1.40
7	90.8	2.00	2.60	5.67	7.35

TABLE 2 Round Robin on Clarity or Transparency Using Zebedee CL-100 Meter, Summary Expressed in Percent

Material[A]	Average	*S*	S_{R}	*r*	*R*
E	21.21	0.98	1.24	2.74	3.47
D	44.34	2.07	2.46	5.80	6.89
C	57.62	2.38	2.38	6.66	6.66
F	77.19	2.47	2.47	6.92	6.92
A	89.9	0.14	0.22	0.39	0.62
B	90.2	0.23	0.34	0.64	0.95

[A] A and B were photographic films, and C through F were packaging films.

13.1.4 *Repeatability*—In comparing two mean values for the same material, obtained by the same operator using the same equipment on the same day, the means should be judged not equivalent if they differ by more than the *r* value for that material.

13.1.5 *Reproducibility*—In comparing two mean values for the same material obtained by different operators using different equipment on different days, either in the same laboratory or in different laboratories, the means should be judged not equivalent if they differ by more than the *R* value for that material.

13.1.6 Judgments made as described in 13.1.4 and 13.1.5 will be correct in approximately 95 % of such comparisons.

13.1.7 For further information, see Practice E 691.

13.2 *Bias*—Bias cannot be determined since there is no accepted reference method for determining this property. There is no bias between the Zebedee and old Gardner clarity meters.

14. Keywords

14.1 clarity; plastic; regular transmittance; sheeting; transmittance; transparency

SUMMARY OF CHANGES

This section identifies the location of selected changes to this test method. For the convenience of the user, Committee D-20 has highlighted those changes that may impact the use of this test method. This section may also include descriptions of the changes, or revisions of the changes, or both.

D 1746 – 03:
(*1*) Deleted the terms regular transmittance and transmittance, and added references to terminology standards in Section 3.
(*2*) Added specimen directionality evaluation in 10.4 and 10.6.
D 1746 – 97:
(*1*) The minimum number of specimens required for the test was specified.
(*2*) Added a statement addressing the number of readings to constitute a test result.
(*3*) Added references to Guide E 1345 for reducing the variability of mean test results through the use of multiple measurements on test specimen(s).
(*4*) Added instructions for calculating an average transmittance and a standard deviation for a specific material.

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