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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Luminous Reflectance Factor of Acoustical Materials by Use of Integrating-Sphere Reflectometers[1]

This standard is issued under the fixed designation E 1477; 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 measurement of the luminous reflectance factor of acoustical materials for use in predicting the levels of room illumination.

1.2 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 284 Terminology of Appearance[2]

E 308 Practice for Computing the Colors of Objects by Using the CIE System[2]

E 1164 Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation[2]

E 1264 Classification for Acoustical Ceiling Products[3]

E 1331 Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry[2]

E 1345 Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements[2]

E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry[2]

3. Terminology

3.1 *Definitions*—Definitions of appearance terms in Terminology E 284 are applicable to this test method.

3.1.1 *integrating sphere, n*—an optical device used either to collect flux reflected or transmitted from a specimen into a hemisphere or to provide isotropic irradiation of a specimen from a complete hemisphere, consisting of an approximately spherical cavity with apertures (ports) for admitting and detecting flux, and usually having additional apertures over which sample and reference specimens are placed and for including or excluding the specularly reflected components. **(E 284)**

3.1.2 *luminous, adj*—weighted according to the spectral luminous efficiency function $V(\lambda)$ of the CIE. **(E 284)**

3.1.3 *reflectance factor, R, n*—ratio of the flux reflected from the specimen to the flux reflected from the perfect reflecting diffuser under the same geometric and spectral conditions of measurement. **(E 284)**

3.1.4 *perfect reflecting diffuser*—ideal reflecting surface that neither absorbs nor transmits light, but reflects light in a diffused manner with the radiance of the reflecting surface being the same for all reflecting angles, regardless of the angular distribution of the incident light. **(E 284)**

4. Summary of Test Method

4.1 Test specimens are measured for (total) luminous reflectance factor by standard color-measurement techniques using a spectrophotometer, tristimulus (filter) colorimeter, or other reflectometer having a hemispherical optical measuring system, such as an integrating sphere. The specular component is included to provide the total reflectance factor condition. The instrument standard is referenced to the perfect reflecting diffuser. Luminous reflectance factor is calculated as CIE tristimulus value Y for the CIE 1964 (10°) standard observer and CIE standard illuminant D 65 (daylight) or F 2 (cool white fluorescent).

5. Significance and Use

5.1 Acoustical materials are often used as the entire ceiling of rooms and are therefore an important component of the lighting system. The luminous reflectance of all important components must be known in order to predict the level of illumination that will be obtained.

5.2 The reflecting properties of a surface are measured relative to those of a standard reflector, the perfect reflecting diffuser, to provide a reflectance factor. The luminous reflectance factor is calculated for a standard illuminant, and a standard observer, for the standard hemispherical (integrating-sphere) geometry of illumination and viewing, in which all reflected radiation from an area of the surface is collected. In this way the reflecting properties of an acoustical material can be represented by a single number measured and calculated under standard conditions.

5.3 Acoustical materials generally have a non-glossy white

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[1] This test method is under the jurisdiction of ASTM Committee E-12 on Color and Appearance and is the direct responsibility of Subcommittee E12.02 on Spectrophotometry and Colorimetry.

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[2] *Annual Book of ASTM Standards*, Vol 06.01.

[3] *Annual Book of ASTM Standards*, Vol 04.06.

or near-white finish. The types of surface cover a wide range from smooth to deeply fissured. Measurement with integrating-sphere reflectometers has been satisfactory although multiple measurements may be required to sample the surface adequately. Instruments with other types of optical measuring systems may be used if it can be demonstrated that they provide equivalent results.

5.4 The use of this test method for determining the luminous reflectance factor is required by Classification E 1264.

6. Apparatus

6.1 *Reflectometer*—Any spectrophotometer, tristimulus (filter) colorimeter, or other reflectometer having a hemispherical optical measuring system and allowing the measurement or calculation of CIE 1964 (10°) tristimulus value *Y* for standard illuminant D 65 or F 2 may be used. The instrument standard shall be calibrated to provide absolute reflectance factors relative to the perfect reflecting diffuser. For this test method, the perfect reflecting diffuser shall be assigned a reflectance factor of 100.00.

7. Procedure

7.1 Standardize and operate the instrument in accordance with Practice E 1164 and either Test Method E 1331 or Test Method E 1347, whichever is applicable. Make the measurements with the specular component included.

7.2 Most reflectometers compute the luminous reflectance factor automatically; select parameters to obtain CIE *Y* for the 1964 (10°) standard observer and standard illuminant D 65 or F 2. If the computation is not automatic, calculate *Y* in accordance with Test Method E 308.

7.3 Operate the reflectometer with the largest available area of illumination or view. Measure at least three test specimens randomly selected from the tiles or panels constituting each sample.

7.4 Additional test specimens or multiple measurements of each test specimen may be required to meet the tentative tolerance of ±0.1 unit of *Y*. Compute the number of test specimens or of multiple measurements in accordance with Practice E 1345.

NOTE 1—Drilled acoustical materials, which have large diameter holes of appreciable depth, have a high reflectance from the tile surface and a low reflectance from the hole location. Fissured tiles provide a similar but less exaggerated condition. In addition, fissured tiles and striated tiles have reflectances that depend on the angle of incidence of the light relative to the general direction of the surface features. This test method provides a suitable average over these surface features.

8. Report

8.1 Report the following information:

8.1.1 The material or sample identification,

8.1.2 The instrument used, and any pertinent information concerning its standardization and operation,

8.1.3 The number of test specimens measured and the number of multiple measurements of each test specimen, and

8.1.4 The average luminous reflectance factor for the material tested and the CIE illuminant used.

9. Precision and Bias

9.1 *Repeatability*—Measurement data obtained show that repeatability of test equipment is on the order of 0.2 unit for the *Y* CIE function of the CIE 10° Observer and Illuminat D65.

9.2 *Reproducibility*—The reproducibility within a laboratory is on the order of 0.4 unit for the *Y* CIE function of the CIE 10° Observer and Illuminat D65. This value includes operator reproducibility, test equipment repeatability, and nominal sample variation.

9.3 Each user should evaluate the precision and bias of his instrument by routinely measuring typical specimens, and then deciding whether the resulting uncertainties are sufficiently small for the purpose for which the data are being obtained.

10. Keywords

10.1 acoustical materials; integrating sphere; luminous reflectance factor; reflectometer