Designation: F 1252 – 89 (Reapproved 1996)

Standard Test Method for Measuring Optical Reflectivity of Transparent Materials[1]

This standard is issued under the fixed designation F 1252; 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 a procedure for measuring the reflectivity of transparent materials, hereafter known as specimens. The results are repeatable without specifying a particular brand name of instrumentation.

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.*

1.3 The preferred units are acceptable metric units.

2. Terminology

2.1 *Definitions:*

2.1.1 *angle of incidence* (Θ_i)—in the plane of the light source, specimen, and photometer, the angle of incidence is the angle between the incident light ray and the normal light ray to the surface (see Fig. 1).

2.1.2 *angle of reflection* (Θ_r)—in the plane of the light source, specimen, and photometer, the angle of reflection is the angle between the reflected light ray and the normal light ray to the surface (see Fig. 1).

2.1.3 *field of view* (FOV)—the solid angle (degrees) that can be viewed through the photometer (see Fig. 2).

2.1.4 *light source*—unless otherwise specified, the National Institute of Standards and Technology (NIST) diffused nonpolarized Standard Illuminance C light source shall be used. The light source size will be such that there will be sufficient overlap of the front and rear images on the specimen to overfill the 1° field of view of the photometer. This overlap is illustrated in Fig. 3. (As angle of incidence and specimen thickness increase, the two images will diverge.) If a light source other than the NIST Illuminant C is used, it should be specified and reported as part of the test results.

2.1.5 *photometer*—any commercial photometer or photopic filtered radiometer with a field of view of 1°. A model with a viewfinder is recommended.

2.1.6 *pivot point*—the point in space at which the incident light ray and reflected light ray are to intersect (see Fig. 1).

2.1.7 *reflectivity*—the reflectivity of a transparent specimen is defined as the ratio of the luminance of the reflected image of a light source to the luminance of the light source. The reflectivity will depend upon several factors: the angle at which the reflected light is measured, the thickness, surface quality, and type of material of the specimen, whether the specimen is coated, the spectral distribution of the light source, and the spectral sensitivity of the measurement device. The reflectivity, as defined here, includes the small amount of scattered light that contributes to the luminance of the reflected image.

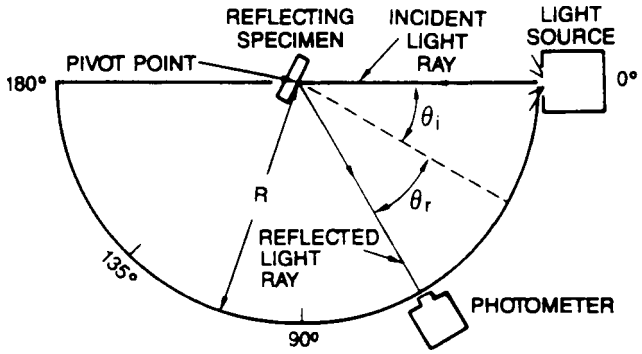

FIG. 1 Apparatus Set-Up

3. Summary of Test Method

3.1 The luminance of the standard source is determined by

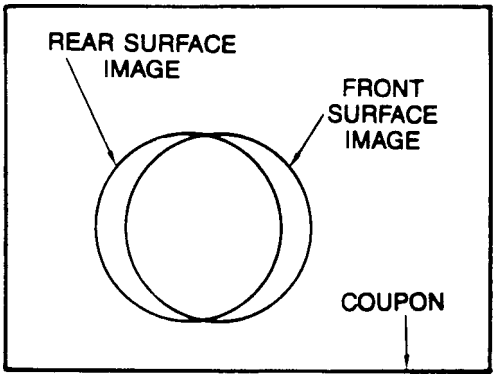

FIG. 2 Image Overlap

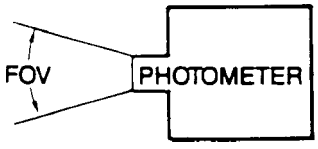

FIG. 3 Photometer Field of View

[1] This test method is under the jurisdiction of ASTM Committee F-7 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.08 on Transparent Enclosures and Materials.

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measuring it directly with the photometer. The luminance of the reflection of the source is then measured off the specimen at a specified geometry. The luminance of the reflection is divided by the luminance of the source to obtain the reflectivity of the specimen.

4. Significance and Use

4.1 Reflections from aircraft transparencies of instrument lights and other cockpit objects have been a concern to many pilots. Attempts to reduce these reflections have been hampered by the lack of a repeatable measurement method and variances in reflection measuring instrumentation. The problem with measuring instrumentation is that different brands will often give significant value differences using the same specimen surface.

4.2 This test method reduces the instrument variations by standardizing the light source, calculation method, and area of specimen surface being measured; a brand of instrumentation is not specified. Since the reflectivity is defined as the ratio of two luminance measurements and does not depend on an absolute measurement, dependence upon the accuracy of the measuring instrument is reduced.

4.3 The test method may be used to objectively compare the reflection characteristics of various transparent materials. Furthermore, the test method may be used to evaluate reflections of a specified spectral source by using that source in place of the standard light source.

4.4 Provisions are made to check for polarization effects of the sample and to record the reflectivity of a standard specimen. These provisions are offered as an option to the tester; it is up to the user or the requiring agency to determine the significance and use of these data.

4.5 Since the reflections are measured photopically, the results are representative of what the pilot would visually perceive.

5. Apparatus and Setup

5.1 The apparatus shall be set up as shown in Fig. 1.

5.2 The angle of incidence Θ_i shall be determined by the user or requiring agency. Since $\Theta_i = \Theta_r$, the total angle of reflection $\Theta = 2\Theta_i = 2\Theta_r$. $\Theta_i$and Θ_r shall be accurate to within $\pm 0.5°$, hence Θ shall be accurate to within $\pm$ 1°.

5.3 The distance from the source to the specimen shall equal the distance from the photometer to the specimen (R). To ensure that the reflection measurement is made over an area of at least 1.58 cm^2 (0.25 $in.^2$) on the specimen, the distance R shall meet the condition:

$$R = 81.3 \pm 2.54 \text{ cm} = 32 \pm 1 \text{ in.} \quad (1)$$

5.4 The minimum surface length across the specimen surface shall be 10.2 cm (4.0 in.).

5.5 The testing will be done in a room with no other light source besides the specified light source.

5.6 A flat black surface (such as black velvet) shall be behind the specimen during measurement to prevent second source reflection.

6. Procedure

6.1 Allow the light source and photometer to warm up per manufacturer's specification.

6.2 The pivot point is the point in space at which the surface of the specimen will be placed (6.5) such that the reflection occurs at the desired geometry. Establish the pivot point by marking the point with a small object, such as a piece of cardboard. Position the light source at a proper distance from the pivot point (5.3).

6.3 Locate the photometer at a position equidistant from the pivot point such that the source, pivot point, and photometer are in line (see Fig. 4). Direct the photometer such that its FOV

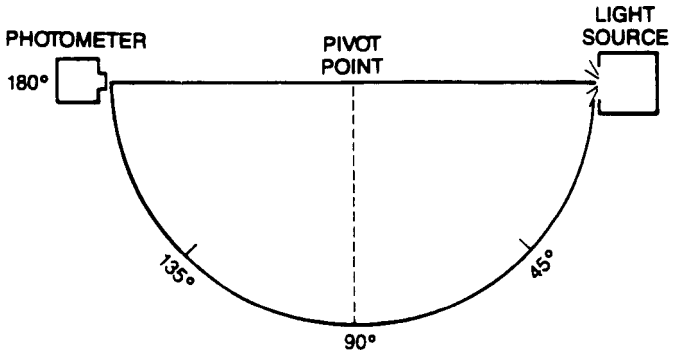

FIG. 4 Apparatus Set-Up for Source Measurement

is centered on the luminance source. Focus the photometer on the source and record the luminance L.

6.4 Locate the photometer at a position equidistant from the pivot point such that the angle between the source, pivot point, and photometer is twice the desired angle of incidence[2] (see Fig. 1). Direct the photometer such that the pivot point is centered in the FOV.

6.5 Position the desired specimen such that the center of front surface is at the pivot point. Remove any object that may have been used to mark the pivot point. Keeping the photometer and source fixed, adjust the attitude of the specimen until the image of the source completely covers the photometer's FOV. Depending on the specimen, the image of the source may be separated into two images due to reflections from the front and back surfaces of the specimen. In this case, position the source such that the overlapping region of the images is centered over the FOV. Focus the photometer on the image of the source and measure the luminance of the source reflection using the desired transparent specimen. Record this value as L_s.

6.6 (Optional) Repeat the measurement as in 6.5 and with the transparent specimen rotated 90° around an axis normal to the surface. Record this reading as L_p (see Fig. 5).

6.7 Steps 6.3-6.6 should be repeated a minimum of three times for each specimen (varying the location of the reflection upon the surface of the specimen each time) to account for localized variances in reflectivity and to establish repeatability.

6.8 As an option to the user or requiring agency, a standard specimen may wish to be identified. If so, perform steps 6.3-6.6

[2] There exists a maximum angle of incidence for which measurements can be made. For the apparatus specified, this angle, Θ_{max}, depends only upon the size, thickness, and index of refraction of the specimen. A thin specimen four inches wide will permit measurements for Θ up to 132°. Θ_{max} will decrease as the specimen thickness increases. For most measurements a four inch wide specimen will be adequate; a larger width may be required for very thick specimens and/or large values of Θ.

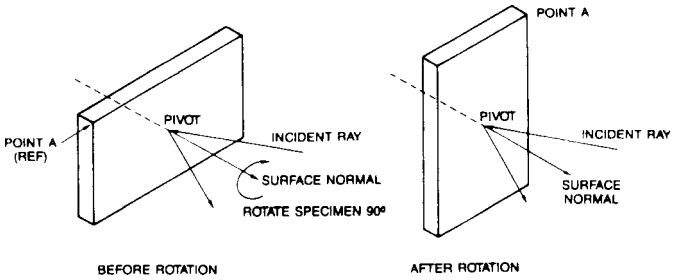

FIG. 5 Rotation of Sample for Polarization Check

using the standard specimen. Record the luminance value as L_{st}.

6.9 Fill out Fig. 6 to calculate the reflection.

7. Precision and Bias

7.1 *Precision*—The precision of this test method as determined by the statistical examination of the interlaboratory test results is as follows:

7.1.1 *Repeatability*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions would, in the long run, in the normal and correct operation of the test method exceed the following values only in one case in twenty:

$$\text{Repeatability} = 0.0095$$

7.1.2 *Reproducibility*—The difference between two single and independent results obtained by different operators working in different laboratories on identical material would in the long run, exceed the following values only in one case in twenty:

$$\text{Reproducibility} = 0.026$$

7.2 *Bias*—Bias depends upon conformance to the conditions of the test method. Care should be taken to ensure that the specimens are clean, the ambient lighting is controlled, and the apparatus is positioned correctly. Scratches on the surface of the specimens may affect the accuracy of results.

	Reflection data				Reflection Calculations		
	Reflection of Source (L)	Reflection of Specimen (L_s)	Reflection of Rotated Specimen (L_p) (Optional)	Reflection of Standard (Optional)	Specimen Reflection (L_s/L)	Polarization Check (L_p/K) (Optional)	Glass Standard (L_{st}/L) (Optional)
Run 1							
Run 2							
Run 3							

Sample Identification _____ Date _____
Source Identification _____ User _____
Standard Identification _____

FIG. 6 Calculation of Reflection