INTERNATIONAL STANDARD

ISO 3538

Second edition
1997-06-01

Road vehicles — Safety glazing materials — Test methods for optical properties

Véhicules routiers — Vitrages de sécurité — Méthodes d'essai des propriétés optiques

Reference number
ISO 3538:1997(E)

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 3538 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 11, *Safety glazing materials*.

This second edition cancels and replaces the first edition (ISO 3538:1978), which has been technically revised.

Annexes A to D of this International Standard are for information only.

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X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

Road vehicles — Safety glazing materials — Test methods for optical properties

1 Scope

This International Standard specifies optical test methods relating to the safety requirements for all safety glazing materials in a road vehicle, whatever the type of glass or other material of which they are composed.

2 Definitions

For the purposes of this International Standard, the following definitions apply.

2.1 optical angular deviation: Angle between the directions of the incident ray and the emergent ray refracted by the safety glazing material.

2.2 optical distortion (in a given direction): Algebraic difference $\Delta\alpha$ in angular deviations α_1 and α_2 measured between two points M and M′ on the surface of the safety glazing material, the distance between them being such that their projections on a plane at right angles to the direction of vision are separated by a given distance Δx (see figure 1). [ISO 3536:1992, 2.9]

NOTES

1 In figure 1, $\Delta\alpha = \alpha_1 - \alpha_2$ is the optical distortion in the direction MM′ considering the sign of the angles;

Δx = MC is the distance between two straight lines parallel to the direction of vision, and passing through the points M and M′.

2 Anti-clockwise deviation should be regarded as positive, and clockwise deviation as negative.

2.3 optical distortion (at a point M): Maximum optical distortion for all directions MM′ from the point M (see figure 1).

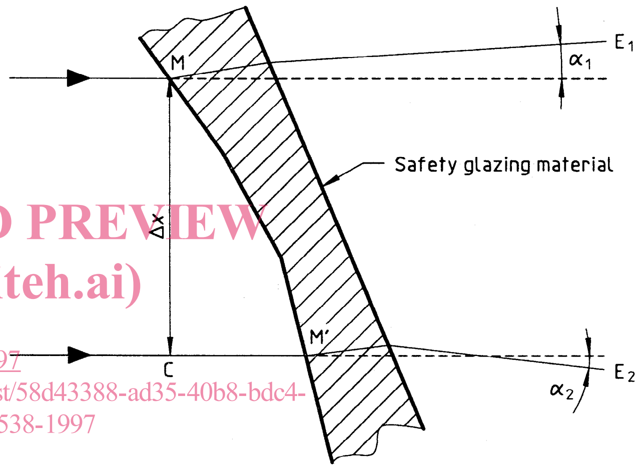


Figure 1 — Diagrammatic representation of optical distortion

2.4 CIE[1] standard illuminant A: Radiant source whose relative spectral radiant power distribution $S_A(\lambda)$ in the visible spectrum (wavelength range from 380 nm to 780 nm) corresponds to a black body radiator at 2 856 K.

2.5 CIE 1931 standard observer: Ideal observer with colour matching function $V(\lambda)$ corresponding to a field of view subtending a 2° angle on the retina.

NOTE 3 This is commonly called the "2° standard observer".

2.6 Luminous reflectance: Ratio of the reflected luminous flux to the incident luminous flux.

NOTE 4 Luminous reflectance depends on relative spectral power distribution of the light source.

[ISO 3536:1992, 2.10]

1) International Commission on Illumination.

3 Tests conditions

Unless otherwise specified, the tests shall be carried out under the following conditions:

a) temperature: 20 °C ± 5 °C;

b) pressure: 96 kPa ± 10 kPa [2];

c) relative humidity: (60 ± 20) %.

4 Application of tests

For certain types of safety glazing materials, it is not necessary to carry out all the tests specified in this International Standard, when the results, according to the purpose of testing, can be predicted with certainty from a knowledge of the properties of the safety glazing material concerned.

5 Requirements

5.1 Regular luminous transmission test

5.1.1 Purpose of test

The purpose of this test is to determine whether the safety glazing material has a certain regular luminous transmittance.

5.1.2 Apparatus

5.1.2.1 Light source realizing CIE standard illuminant A, consisting of an incandescent lamp, the filament of which is contained within a parallelepiped 1,5 mm × 1,5 mm × 3 mm. The voltage at the lamp terminals shall be such that the colour temperature is 2 856 K ± 50 K. This voltage shall be stabilized within ± 0,1 %. The instrument used to check the voltage shall be of appropriate accuracy.

5.1.2.2 Optical system (see figure 2), consisting of two colourless lenses, L1 and L2, each with a focal length, *f*, of at least 500 mm and corrected for chromatic aberrations. The clear aperture of the lenses shall not exceed *f*/20. The distance between the lens L1 and the light source shall be adjusted in order to obtain a light beam which is substantially parallel. A diaphragm, A1, shall be inserted to limit the diameter of the light beam to 7 mm ± 1 mm. This diaphragm shall be situated at a distance of 100 mm ± 50 mm from the lens L1 on the side remote from the light source. A second diaphragm, A2, shall be placed in front of lens L2 which shall have the same characteristics as L1. The detector of the measuring equipment (5.1.2.3) shall be placed in the focal plane of lens L2. The image of the light source shall be centered on the detector. A diaphragm, A3, with a diameter slightly larger than the cross-section of the largest dimension of the image of the light source is placed in front of the detector in order to prevent scattered light created by the sample from reaching the detector. The point of measurement shall be taken at the centre of the light beam.

5.1.2.3 Measuring equipment, of which the detector shall have a relative spectral responsivity in substantial agreement with the CIE spectral luminous efficiency function for photopic vision (see annex A). The sensitive surface of the detector shall be covered with a diffusing medium and shall have at least twice the cross-section of the largest dimension of the image of the light source. If an integrating sphere is used as the detector, the image of the light source shall be in the entrance port of the integrating sphere and the aperture of the sphere shall be at least twice the cross-section of the measuring beam at that aperture.

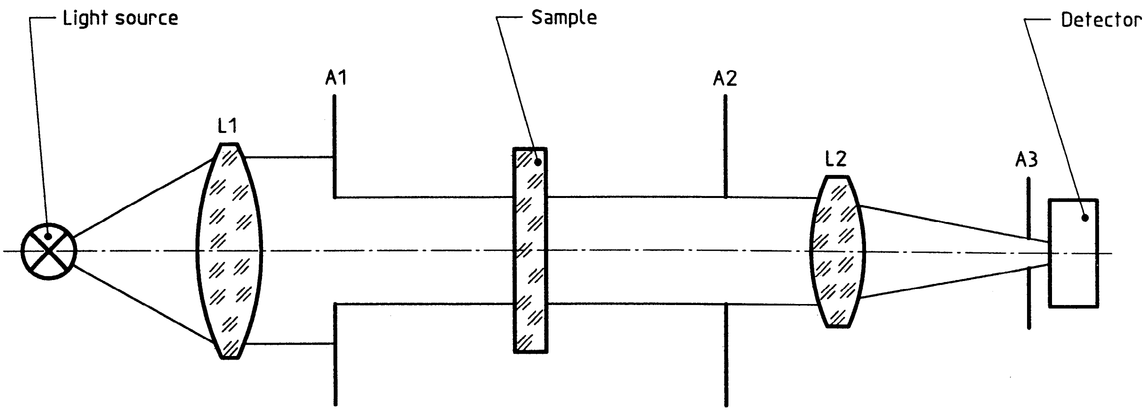


Figure 2 — Measurement of regular transmittance

2) 1 kPa = 1 000 N/m^2 = 10 mbar

The linearity of the detector and the associated indicating instrument shall be less than or equal to ± 2 % of full scale, or ± 10 % of the magnitude of the reading, whichever is the smaller.

5.1.3 Procedure

Adjust the instrument indicating the response of the detector to indicate 100 divisions when the safety glazing material is not inserted in the light path. When no light is falling on the detector, the instrument shall read zero.

Place the safety glazing material between the diaphragms A1 and A2 and adjust its orientation in such a way that the angle of incidence of the light beam is equal to 0° ± 5°. Measure the regular transmittance of the safety glazing material: for every point measured, read the number of divisions, n, shown on the indicating instrument.

The regular transmittance τ_r is equal to $n/100$ and is determined for any point on the safety glazing material.

5.1.4 Expression of results

Record the regular transmittance determined for any point on the safety glazing material in accordance with 5.1.3.

5.1.5 Alternative methods

Other methods giving equivalent luminous transmittance results are acceptable provided the accuracy specified in 5.1.2.3 is achieved.

5.2 Secondary image separation test

5.2.1 Purpose of test

The purpose of this test is to determine the angular separation between the primary and secondary images.

5.2.2 Types of test

Two types of test are recognized:

a) target test;

b) collimation telescope test.

These tests may be used for approval purposes, quality control or product evaluation as appropriate.

5.2.3 Target test

5.2.3.1 Principle

This method involves viewing an illuminated target through the safety glazing material.

5.2.3.2 Apparatus

5.2.3.2.1 Light box, approximately 300 mm × 300 mm × 150 mm, the front of which supports the target (5.2.3.2.2) and is most conveniently constructed from glass masked with opaque black paper or coated with matt black paint. The box shall be illuminated by a suitable light source. The inside of the box shall be coated with matt white paint.

5.2.3.2.2 Target, conforming to figure 3, and preferably in the form of either

a) an illuminated "ring" target, the outer diameter, D, of which subtends an angle of η at a distance x [see figure 3 a)], or

b) an illuminated "ring and spot" target, the dimensions of which are such that the distance, D, from a point on the edge of the spot to the nearest point on the inside diameter of the ring, subtends an angle of η at a distance x [see figure 3 b)].

NOTE 5

η is the angular limit value, in minutes of arc, of secondary image separation;

x is the distance, greater than or equal to 7 m, from the safety glazing material to the target, as shown in figure 4;

$D = x \tan \eta$

The target may be designed in such a way that the test can be carried out on a simple "Go—No Go" basis.

It may be convenient to use other forms of target, such as shown in figure 6. It is also acceptable to replace the target system with a projection system and to view the resulting images on a screen.

5.2.3.3 Procedure

Mount the safety glazing material at the designed rake angle on a suitable stand in such a way that the observation is carried out in the horizontal plane passing through the centre of the target.

The light box shall be viewed in a dark or semi-dark room, through each part of the area being examined, in order to detect the presence of any secondary image associated with the illuminated target. Rotate the safety glazing material as necessary to ensure that the correct direction of view is maintained. A monocular may be used for viewing.

Dimensions in millimetres

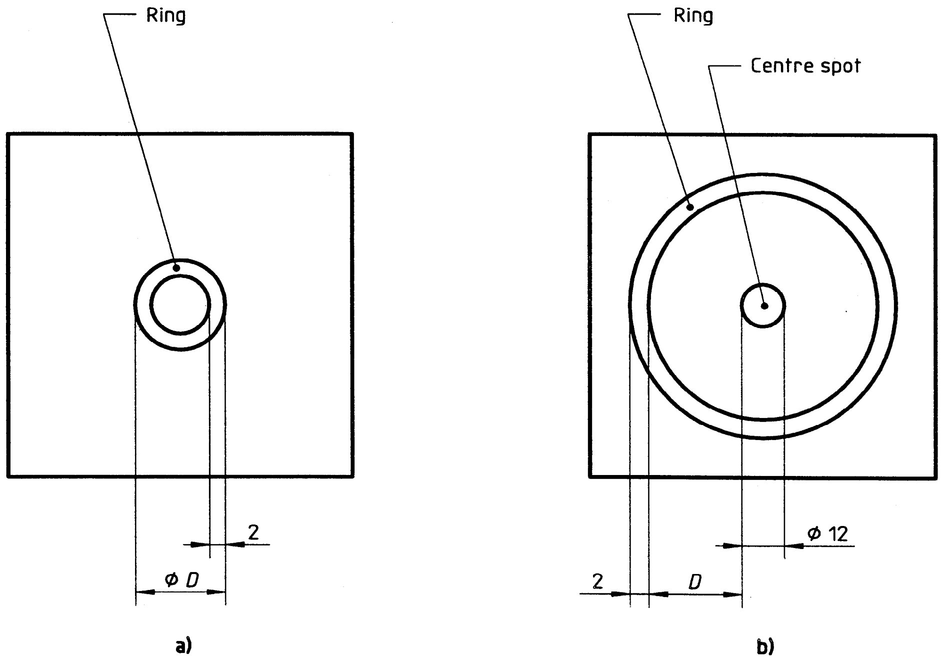


Figure 3 — Dimensions of targets

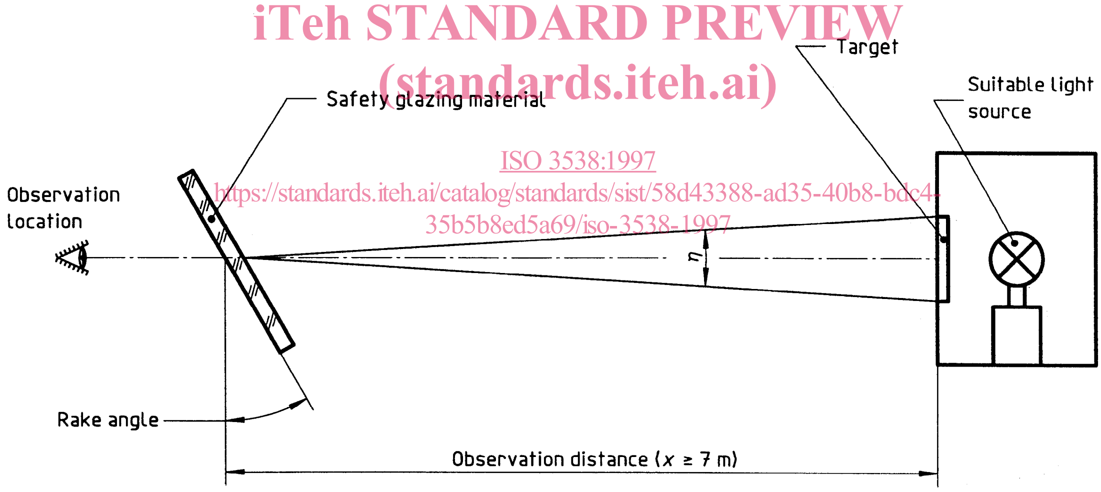


Figure 4 — Arrangement of apparatus for target test

5.2.3.4 Expression of results

Record whether

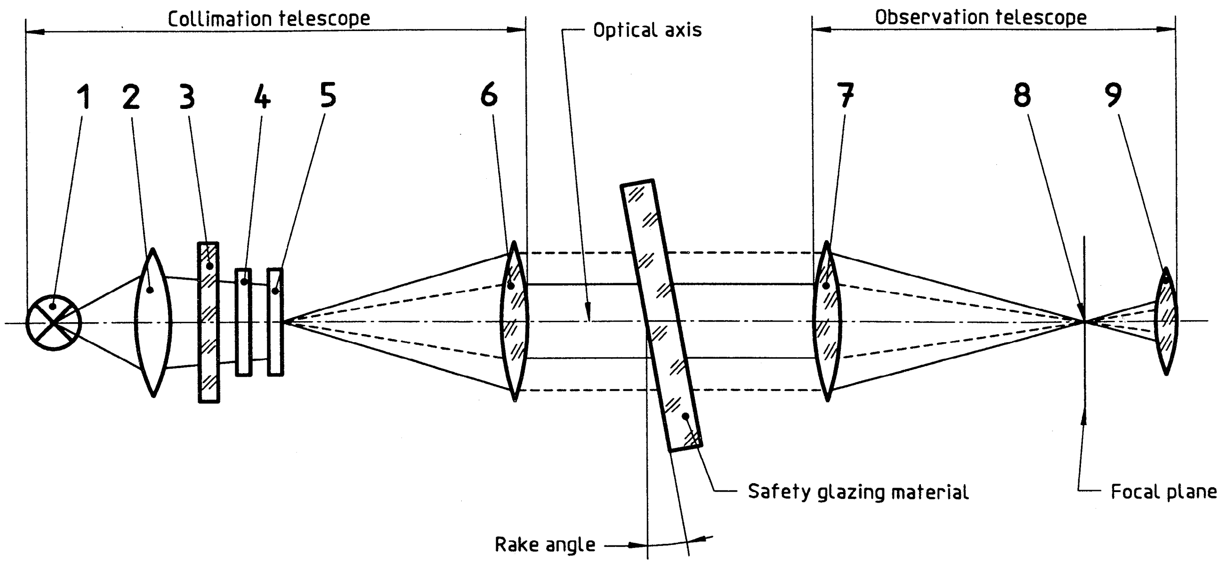
— using the "ring" target [5.2.3.2.2 a)], the primary and secondary images of the circle separate, i.e. whether the limit value of η is exceeded, or,

— using the "ring and spot" target [5.2.3.2.2 b)], the secondary image of the spot shifts beyond the point of tangency with the inside edge of the ring, i.e. whether the limit value of η is exceeded.

5.2.4 Collimation telescope test

5.2.4.1 Apparatus

The apparatus consists of a collimator and telescope conforming to figure 5. Any equivalent optical system may, however, be used.



1) Bulb
2) Condenser, aperture > 8,6 mm
3) Ground-glass screen, aperture greater than condenser aperture
4) Colour filter, diameter > 8,6 mm, with central hole ≈ 0,3 mm diameter
5) Polar co-ordinate plate, diameter > 8,6 mm
6) Achromatic lens, $f \geqslant 86$ mm, aperture of 10 mm
7) Achromatic lens, $f \geqslant 86$ mm, aperture of 10 mm
8) Dark spot, diameter ≈ 0,3 mm
9) Achromatic lens, $f = 20$ mm, aperture $\leqslant$ 10 mm

Figure 5 — Apparatus for collimation telescope test

5.2.4.2 Principle

The collimation telescope forms, at infinity, the image of a polar co-ordinate system with a bright point at its centre (see figure 6).

In the focal plane of the observation telescope, a small dark spot with a diameter slightly larger than that of the projected bright point is placed on the optical axis, thus obscuring the bright point.

When a sample which exhibits a secondary image is placed between the telescope and the collimator, a second, less bright point appears at a certain distance from the centre of the polar co-ordinate system. The secondary image separation can be read out as the distance between the points seen through the observation telescope (see figure 6), i.e. the distance between the dark spot and the bright point at the centre of the polar co-ordinate system represents the deviation of the optical axis.

5.2.4.3 Procedure

Firstly, examine using a simple scanning technique the area of the safety glazing material giving the most severe secondary image. Then examine the worst area using the optical system prescribed in 5.2.4.1 and measure the maximum secondary image separation at the appropriate angle of incidence.

5.2.4.4 Expression of results

Record the maximum secondary image separation.

5.3 Optical distortion test

5.3.1 Purpose of test

The purpose of this test is to determine the optical distortion of the safety glazing material.

5.3.2 Principle

The optical distortion of the safety glazing material is evaluated by projecting an appropriate slide (raster) through the safety glazing material being tested onto a display screen. The change in shape of the projected image caused by the glazing material provides a measure of the distortion.

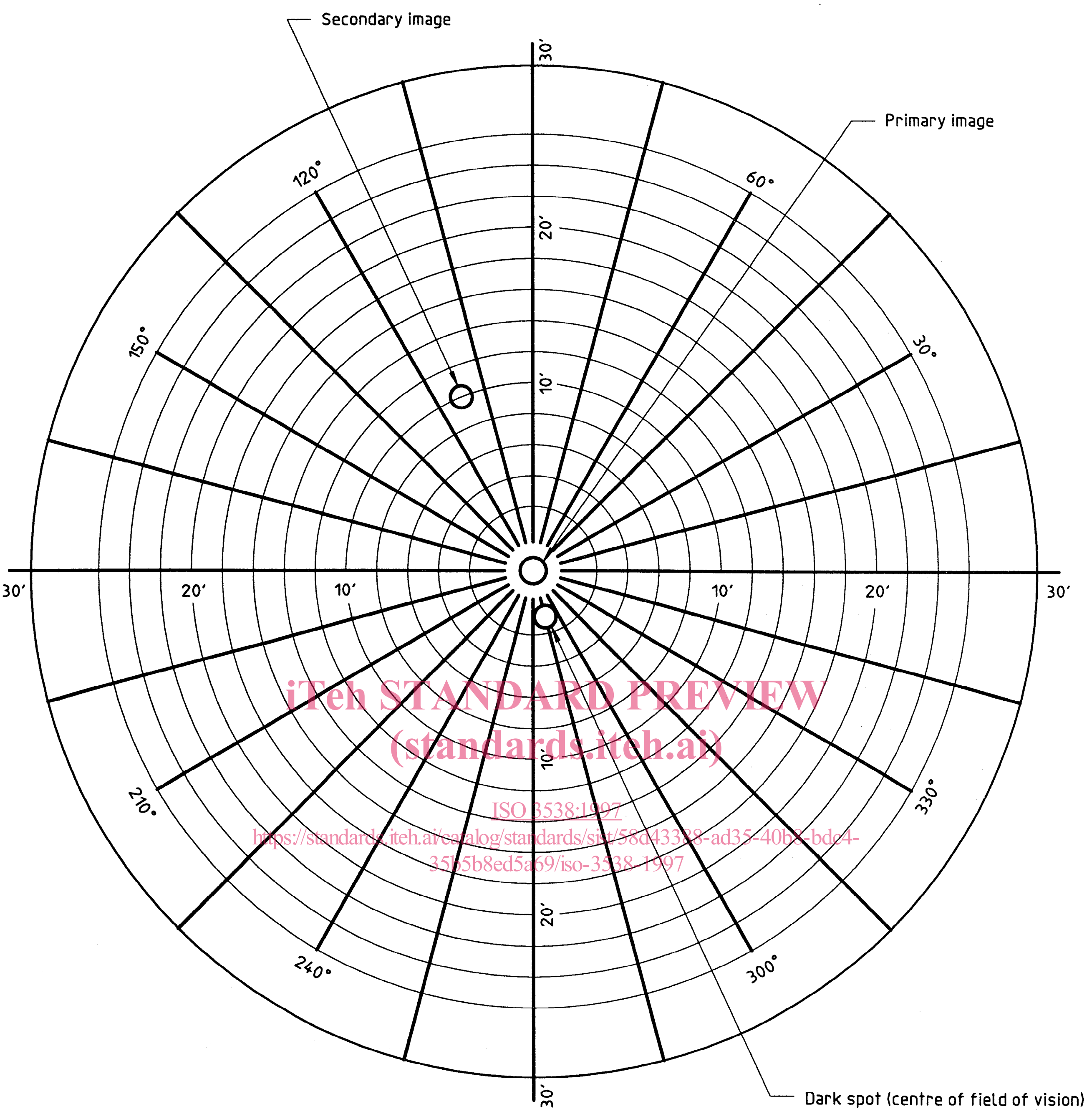


Figure 6 — Example of observation by the collimation telescope test

5.3.3 Apparatus

The apparatus shall consist of the following items, arranged as shown in figure 7.

5.3.3.1 Projector, of good quality, with a high-intensity, point light source, having for example, the following characteristics:

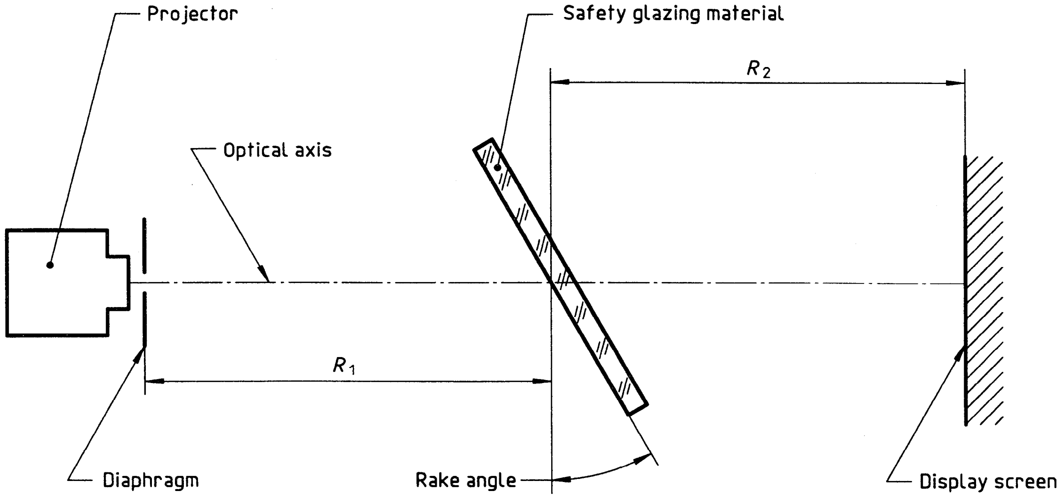
— focal length, at least 90 mm;

— aperture, approximately 1/2,5;

— 150 W quartz halogen lamp (if used without a filter);

— 250 W quartz halogen lamp (if a green filter is used).

The projector is shown schematically in figure 8. An 8 mm diameter diaphragm is positioned approximately 10 mm from the front lens of the projector.



R_1 = 4 m
R_2 = 2 m to 4 m (4 m preferred)

Figure 7 — Arrangement of the apparatus for the optical distortion test

Dimensions in millimetres

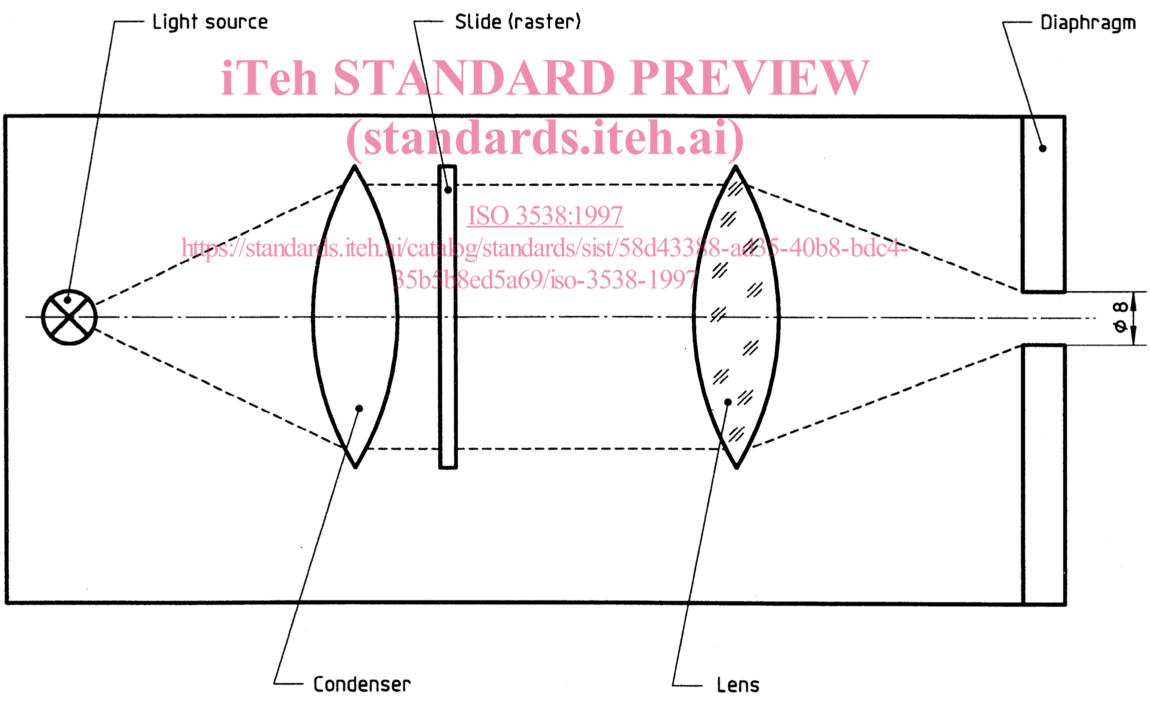


Figure 8 — Optical arrangement of the projector

5.3.3.2 Slides (rasters), consisting for example, of an array of bright circular shapes on a dark background as shown in figure 9. The slide shall be of sufficiently high quality and contrast to enable measurement to be carried out with an error of less than 5 %.

In the absence of the safety glazing material to be examined, the diameter of the circular shapes shall be such that when projected on the screen these form an array of circles of diameter, *d*, equal to

$$\frac{R_1 + R_2}{R_1} \times \Delta x$$

where

R_1 is the distance between the diaphragm of the projector and the safety glazing material (see figure 7);

R_2 is the distance between the safety glazing material and the display screen (see figure 7);

Δx is the distance between two points of measurement (see note 1 in 2.2 and figure 1).

NOTES

6 Because of the possibility of distortion in the optical distortion system, it is recommended that only the centre zone of the projected image be used for measurement purposes.

7 The arrangement of the apparatus should be such that the ratio R_1/R_2 is equal to one, in order to preserve the accuracy of measurement.

Other arrangements which enable equivalent accuracies may be used.

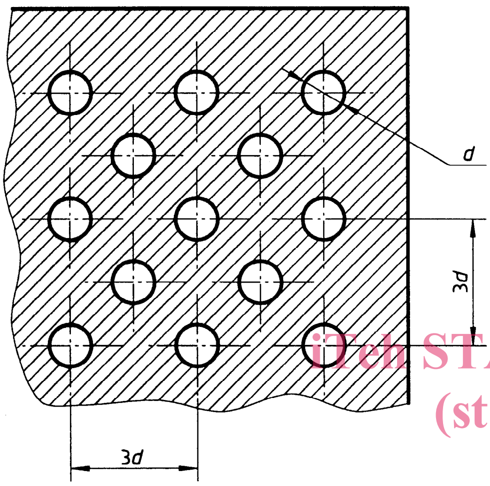


Figure 9 — Enlarged section of an example slide

5.3.3.3 Support stand, preferably of a type which permits vertical and horizontal scanning, as well as rotation of the safety glazing material.

5.3.3.4 Checking template, for measuring the change in dimensions, where a rapid assessment is required. A suitable design is shown in figure 10.

5.3.4 Procedure

5.3.4.1 General procedure

Mount the safety glazing material on the support stand (5.3.3.3) at the designed rake angle. Project the test image through the area being examined. Rotate the safety glazing material or move it either horizontally or vertically in order to examine the whole of the specified area.

Evaluate the optical distortion of the safety glazing material by measuring the maximum diameter of the projected image (Δd) in all directions at any point of the surface to be examined, in order to find the maximum value.

5.3.4.2 Assessment using checking template

Where a rapid assessment is sufficient, to a precision of not better than 20 %, calculate the value of A (see figure 10), in millimetres, from:

$$A = 0{,}145 \Delta\alpha_L R_2$$

where

$\Delta\alpha_L$ is the limit value for the change deviation;

R_2 is the distance, in metres, from the safety glazing material to the display screen.

The relationship between the change in diameter of the projected image, Δd, in millimetres, and the change in angular deviation, $\Delta\alpha$, in minutes of arc, is given by

$$\Delta d = 0{,}29 \Delta\alpha R_2$$

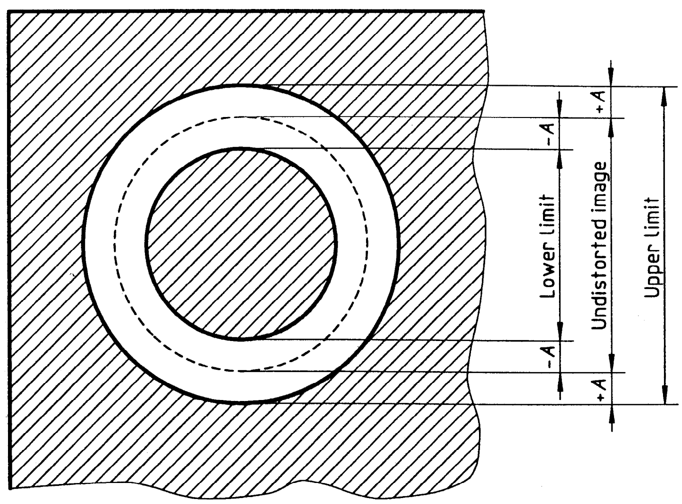


Figure 10 — Design for a suitable checking template

5.3.4.3 Measurement using photoelectric device

Where a precise measurement is required, i.e. a precision of better than 10 % of the limit value, measure Δd on the projection axis and the value of the spot width at the point where the luminance is equal to one-half of the maximum luminance value.

5.3.5 Expression of results

Record the change in the maximum diameter of the projected image (Δd).

5.3.6 Alternative method

In addition, a strioscopic technique is permitted as an alternative to the projection techniques, provided that the precision of the measurements given in 5.3.4.2 and 5.3.4.3 is maintained.

5.4 Visibility after fracture test

5.4.1 Purpose of test

The purpose of this test is to determine whether the safety glazing material allows a certain visibility after fracture on the outside face of the safety glazing material.

5.4.2 Apparatus

5.4.2.1 Instrument capable of causing the glazing material to break from the impacted surface; for example a hammer with a pointed head or an automatic punch.

5.4.3 Procedure

Fix the test piece tightly on a second test piece of the same shape and dimensions by means of transparent adhesive tape on the periphery, placing photographic paper between the test pieces. Start exposure of the photographic paper no later than 10 s after the impact and terminate exposure not more than 3 min after the impact. Only the deepest lines, representing the initial fracture, shall be taken into consideration.

The points of impact shall be situated as follows (see figure 11):

Point 1: 30 mm from the edge, in one corner, or in the part of the safety glazing material where the radius of curvature of the perimeter is of minimum value.

Point 2: 30 mm from the edge, on one of the medians.

Point 3: at the centre of the primary vision area.

Point 4: for curved glazing materials, on the longest median at the point of maximum curvature. For curved glazing materials, the impacts shall be made from the convex side, or, if necessary, from the concave side.

5.4.4 Expression of results

Evaluate the visibility after fracture by inspection of the photographic record in relation to the number of particles and their sizes within the primary vision area.

5.5 Luminous reflection test

5.5.1 Purpose of test

The purpose of this test is to provide a simple, practical and broadly applicable test method for appraising luminous (standard illuminant A) reflectance of enhanced reflecting safety glazing materials for road vehicles.

This test applies to conditions where feasibility, rather than accuracy of measurement, is of prime importance, for example where measurements are

Dimensions in millimetres

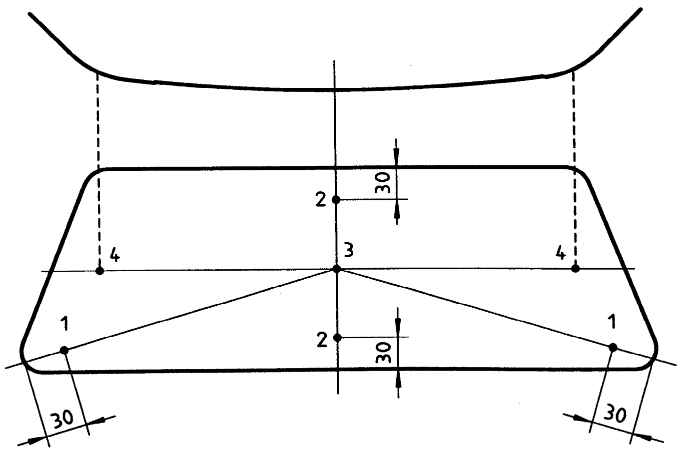


Figure 11 — Points of impact