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Optics and optical instruments — Test methods for telescopic systems —

Part 5:
Test methods for transmittance

Optique et instruments d'optique — Méthodes d'essai pour systèmes télescopiques —

Partie 5: Méthodes d'essai du facteur de transmission

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. 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.

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ISO 14490-5 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 4, *Telescopic systems*.

ISO 14490 consists of the following parts, under the general title *Optics and optical instruments — Test methods for telescopic systems*:

— *Part 1: Test methods for basic characteristics*

— *Part 2: Test methods for binocular systems*

— *Part 3: Test methods for telescopic sights*

— *Part 4: Test methods for astronomical telescopes*

— *Part 5: Test methods for transmittance*

— *Part 6: Test methods for veiling glare index*

— *Part 7: Test methods for limit of resolution*

Annexes A and B of this part of ISO 14490 are for information only.

Optics and optical instruments — Test methods for telescopic systems —

Part 5:
Test methods for transmittance

1 Scope

This part of ISO 14490 specifies the test methods for the determination of the transmittance of telescopic systems and observational telescopic instruments.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 14490. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 14490 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6728:1983, *Photography — Camera lenses — Determination of ISO colour contribution index (ISO/CCI)*

ISO 10526, *CIE standard illuminants for colorimetry*

ISO/CIE 10527:1991, *CIE standard colorimetric observers*

ISO 14132-1:[1)], *Optics and optical instruments — Vocabulary for telescopic systems — Part 1: General terms and alphabetical indexes of terms in ISO 14132*

ISO 14490-1:[1)], *Optics and optical instruments — Test methods for telescopic systems — Part 1: Test methods for basic characteristics*

CIE Publ. 18.2:1983, *The basis of physical photometry*

3 Terms and definitions

For the purposes of this part of ISO 14490 the terms and definitions given in ISO 14132-1 apply.

4 Principle

To determine the spectral transmittance $t(l)$ the flux of radiation in a limited bundle of rays will be measured before entering $\Phi_o(l)$ and after passing $\Phi_p(l)$ through the optical system. The transmittance results from the equation (1):

$$t(l) = \frac{\Phi_p(l)}{\Phi_o(l)} \tag{1}$$

1) To be published.

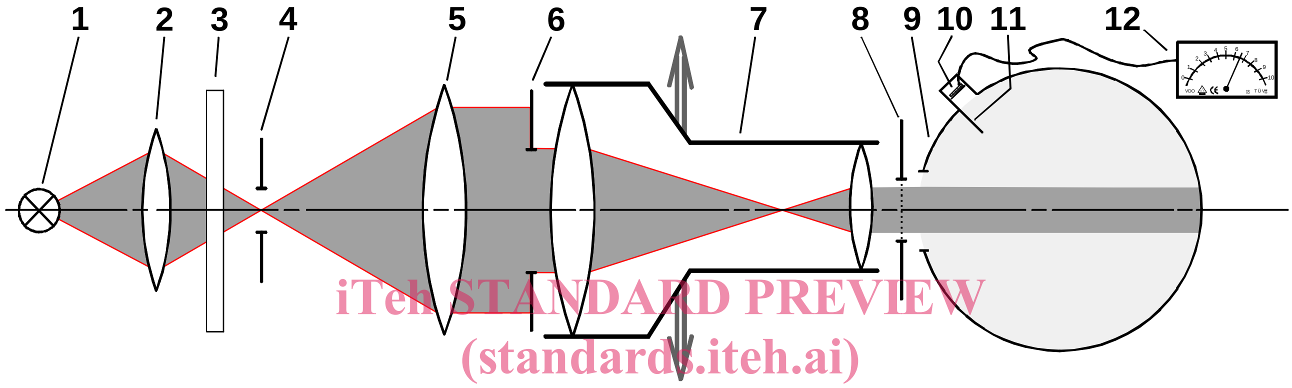
During the spectral measurement the emergent light of the radiation source will be limited to a small wavelength band by means of a monochromator or a set of filters.

5 Test arrangement

5.1 General

The measuring device consists of a radiation source (optionally with condenser), the monochromator or a set of filters, a collimator lens, the aperture stop, the specimen mounting, a veiling glare stop, the integrating sphere, the radiation detector and the measuring and evaluation unit (signal processing).

See figure 1.



1 — radiation source; 2 — condenser; 3 — monochromator; 4 — selectable diaphragm as field stop; 5 — collimator lens; 6 — aperture stop; 7 — test specimen; 8 — veiling glare stop; 9 — integrating sphere; 10 — detector; 11 — baffle; 12 — measuring and evaluation unit

Figure 1 — Test arrangement (schematic)

5.2 Source of radiation and condenser

The radiation source shall emit a continuous flux of radiation in the specified wavelength range. The variation of flux during the measurement of a pair of values shall be less than 1 %. The condenser adapts the radiation source to the optical measurement path.

5.3 Monochromator or set of filters

Grating or prism monochromators can be used to select the wavelength. The smallest adjustable wavelength distance shall be less than 2 % of the dominant wavelength of the respective measurement.

The necessary spectral bandwidth depends on the sample. It shall be ensured that a steep alteration of the transmission curve is detected correctly. Thus the bandwidth shall be smaller than the distance in the wavelength, at which the transmittance is changed by 4 %. This condition cannot always be satisfied because of measuring and energy reasons or because the time/cost effort is not adequate. In these cases a maximum bandwidth of 4 % of the wavelength is allowable. A bandwidth of less than 2 % of the wavelength is necessary if the colour rendition indices are to be calculated.

Instead of a monochromator a set of filters can be used. They are especially useful with flat shaped transmittance curves. The number of measuring points shall allow for a definite curve fitting. Measurement with spectral filters can be applied as well if only single measuring points are required.

5.4 Collimator

The collimator may contain a refracting lens or mirror. The collimator has to be adjusted to the aligned components in such a way that full and uniform illumination of the following aperture stop is assured. The axial chromatic aberration of a refracting lens should be less than or equal to 1% of its focal length in the spectral range used. An off-axis parabolic mirror or an equivalent system is also suitable as a collimator.

5.5 Aperture stop

The aperture stop should be circular and located close to objective lens of the test specimen if possible. The diameter should be ≤ 80 % (50 % recommended) of the maximum available aperture of the test specimen. Auxiliary systems can be used for beam forming to realize these requirements. These systems shall stay in the ray path during measuring with and without test specimen.

5.6 Specimen mounting

The mounting of the test specimen shall be designed in a way that the test specimen can be adjusted and held stable.

5.7 Veiling glare stop

A veiling glare stop with a diameter 1,1 times the diameter of the image of the aperture stop is located in the image plane of the aperture stop, consequently in the exit pupil of the telescope. The veiling glare stop shall be dull black on both sites. It shall be designed in a way that the veiling glare resulting from the test specimen and upsetting the measurement result is reduced as far as possible; it shall further be designed in a way that the necessary radiation for the measurement passes through unobstructed.

5.8 Integrating sphere

The integrating sphere shall be located near the veiling glare stop to ensure that the light passing through the veiling glare stop will be completely collected by the integrating sphere. The integrating sphere has two openings, one for the input of the bundle of rays to be measured and one for the detector. Both openings shall not be located opposite each other. The direct radiation incident on the detector is prevented by baffles. The surfaces of the two openings together shall not occupy more than 5 % of the internal surface of the sphere. The diameter of the integrating sphere opening shall exceed the maximum diameter of the image of the aperture stop (item 6 in figure 1) by 5 % to 7 %.

The reflectivity of the internal coating of the integrating sphere should be as high as possible and diffuse across the whole spectral range. The reflectivity across the whole spectral range from 380 nm to 780 nm should be at least 85 %.

5.9 Radiation detector

The linearity of the radiation detector shall be better than 0,5 % including the accompanying signal processing.

6 Procedure

6.1 Preparation of the test assembly

Insert the test specimen in its mounting with the objective lens facing the radiation source (see figure 1). Locate the veiling glare stop, as required.

Take care to avoid multiple reflections between aperture stop, test specimen, or other parts, which may upset the measurement result, by the use of additional protective screens.

For systems with a reticle at an intermediate image plane, take care that parts of the test specimen's reticle do not obscure any of the light passing through it. Ensure that the ambient light does not influence the measurement result.

6.2 Determination of the measuring values

Carry out the measurements in the spectral range from 370 nm to 780 nm.

First, determine a measuring value $S_o(l)$ which is proportional to the flux of radiation $F_o(l)$ through the aperture stop using the measuring instrument without the test specimen and without the veiling glare stop. Then insert the test specimen into the ray path and determine the measuring value $S_p(l)$ which is proportional to the flux of radiation $F_p(l)$. The ratio of both values with and without the test specimen gives the spectral transmittance:

$$t(l) = \frac{\Phi_p(l)}{\Phi_o(l)} = \frac{S_p(l)}{S_o(l)} \qquad (2)$$

Carry out the procedure at the required wavelengths to determine the spectral slope. The wavelengths shall be chosen in a way that the shape of the transmittance curve can be surely recognized.

6.3 Further test methods

Integral and thus much less expensive testing methods are sufficient for many purposes such as comparison measuring or verification of required transmission values for a standard illuminant. The transmittance can be measured directly by integral testing methods utilizing the test assembly (see Figure 1) and additional suitable compensating filters, e. g. a conversion filter that reduces the sensitivity of the integrating sphere and the detector to the sensitivity of the eye. A calibrated specimen should be used to verify the accuracy of this simplified test method. If necessary the measured values of an integral measurement are to be confirmed by a spectral measurement and calculation according to this part of ISO 14490. If a measurement set-up without an integrating sphere is used, the photodetector shall to be checked to ensure that readout does not depend of the illuminated area of the photodetector using the procedure laid down in Annex A.

7 Accuracy of the measurement

The repeatability of the respective transmittance value shall not exceed 0,02. The test assembly shall be designed and the parts chosen such that this requirement is fulfilled.

8 Presentation of the results

The measuring results shall be presented in tabular and graphical form, as follows:

a) for presentation in tabular form the results shall be indicated in a table with three decimal digits;

b) for graphical presentation the values shall be plotted linearly over the wavelength.

9 Analysis

9.1 Effective transmittance for photopic vision

The effective transmittance for photopic vision t_D valid for the total visible wavelength range is determined by the radiation function, the spectral transmittance of the telescope and the spectral slope of the relative luminosity curve for photopic vision. As a radiation function the standard illuminant D65 according to ISO 10526 is used. Thus the following equation is valid for the effective transmittance for photopic vision:

$$t_{\mathrm{D}}(l) = \frac{\int_{380\,nm}^{780\,nm} S^{\mathrm{D65}}(l) \cdot t(l) \cdot V(l) \cdot dl}{\int_{380\,nm}^{780\,nm} S^{\mathrm{D65}}(l) \cdot V(l) \cdot dl} \qquad (3)$$

where

$t(l)$ is the spectral transmittance of the telescope;

$S^{\mathrm{D65}}(l)$ is the radiation function (relative spectral power distribution) of the standard illuminant D65 according to ISO 10526;

$V(l)$ is the relative spectral luminosity factor for photopic vision according to Table 2 of CIE Publ. 18.2:1983.

Wavelength intervals of 5 nm will be adequate for most measurement purposes.

9.2 Effective transmittance for scotopic vision

The following equation for calculation of the effective transmittance for scotopic vision t_{N} results if the relative luminosity curve for scotopic vision is inserted:

$$t_{\mathrm{N}}(l) = \frac{\int_{380\,nm}^{780\,nm} S^{\mathrm{D65}}(l) \cdot t(l) \cdot V'(l) \cdot dl}{\int_{380\,nm}^{780\,nm} S^{\mathrm{D65}}(l) \cdot V'(l) \cdot dl} \qquad (4)$$

where

$t(l)$ is the spectral transmittance of the telescope;

$S^{\mathrm{D65}}(l)$ is the radiation function (relative spectral power distribution) of the standard illuminant D65 according to ISO 10526;

$V'(l)$ is the relative spectral luminosity factor of scotopic vision according to Table 3 of CIE Publ. 18.2:1983.

Wavelength intervals of 5 nm will be adequate for most measurement purposes.

10 Test report

A test report shall be presented and shall include the general information specified in clause 13 of ISO 14490-1 and the result of the test as specified in clause 8 (items a) and b)) and in 9.1 and 9.2 above.

In addition details of the aperture stop shall be given.

The presentation of the result as specified in B.1 and B.2 is optional.