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CIE

COMMISSION INTERNATIONALE DE L'ECLAIRAGE
INTERNATIONAL COMMISSION ON ILLUMINATION
INTERNATIONALE BELEUCHTUNGSKOMMISSION

TECHNICAL REPORT

PRACTICAL METHODS FOR THE MEASUREMENT OF REFLECTANCE AND TRANSMITTANCE

CIE 130-1998

UDC:	535.345.1	Descriptor:	Regular transmittance
	535.312		Regular reflectance
	535.361.1		Diffuse transmittance
	535.361.2		Diffuse reflectance

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The International Commission on Illumination (CIE) is an organisation devoted to international co-operation and exchange of information among its member countries on all matters relating to the art and science of lighting. Its membership consists of the National Committees in 39 countries and one geographical area and of 11 individual members.

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2. D'élaborer des normes et des méthodes de base pour la métrologie dans les domaines de la lumière et de l'éclairage.
3. De donner des directives pour l'application des principes et des méthodes d'élaboration de normes internationales et nationales dans les domaines de la lumière et de l'éclairage.
4. De préparer et publier des normes, rapports et autres textes, concernant toutes matières relatives à la science, la technologie et l'art dans les domaines de la lumière et de l'éclairage.
5. De maintenir une liaison et une collaboration technique avec les autres organisations internationales concernées par des sujets relatifs à la science, la technologie, la normalisation et l'art dans les domaines de la lumière et de l'éclairage.

Les travaux de la CIE sont effectués par 8 Divisions, ayant chacune environ 20 Comités Techniques. Les sujets d'études s'étendent des questions fondamentales, à tous les types d'applications de l'éclairage. Les normes et les rapports techniques élaborés par ces Divisions Internationales de la CIE sont reconnus dans le monde entier.

Tous les quatre ans, une Session plénière passe en revue le travail des Divisions et des Comités Techniques, en fait rapport et établit les projets de travaux pour l'avenir. La CIE est reconnue comme la plus haute autorité en ce qui concerne tous les aspects de la lumière et de l'éclairage. Elle occupe comme telle une position importante parmi les organisations internationales.

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Die Internationale Beleuchtungskommission (CIE) ist eine Organisation, die sich der internationalen Zusammenarbeit und dem Austausch von Informationen zwischen ihren Mitgliedsländern bezüglich der Kunst und Wissenschaft der Lichttechnik widmet. Die Mitgliedschaft besteht aus den Nationalen Komitees in 39 Ländern und einem geographischen Gebiet und aus 11 persönlichen Mitgliedern.

Die Ziele der CIE sind :

1. Ein internationaler Mittelpunkt für Diskussionen aller Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik und für den Informationsaustausch auf diesen Gebieten zwischen den einzelnen Ländern zu sein.
2. Grundnormen und Verfahren der Meßtechnik auf dem Gebiet der Lichttechnik zu entwickeln.
3. Richtlinien für die Anwendung von Prinzipien und Vorgängen in der Entwicklung internationaler und nationaler Normen auf dem Gebiet der Lichttechnik zu erstellen.
4. Normen, Berichte und andere Publikationen zu erstellen und zu veröffentlichen, die alle Fragen auf dem Gebiet der Wissenschaft, Technik und Kunst der Lichttechnik betreffen.
5. Liaison und technische Zusammenarbeit mit anderen internationalen Organisationen zu unterhalten, die mit Fragen der Wissenschaft, Technik, Normung und Kunst auf dem Gebiet der Lichttechnik zu tun haben.

Die Arbeit der CIE wird in 8 Divisionen, jede mit etwa 20 Technischen Komitees, geleistet. Diese Arbeit betrifft Gebiete mit grundlegendem Inhalt bis zu allen Arten der Lichtanwendung. Die Normen und Technischen Berichte, die von diesen international zusammengesetzten Divisionen ausgearbeitet werden, sind von der ganzen Welt anerkannt.

Tagungen werden alle vier Jahre abgehalten, in der die Arbeiten der Divisionen überprüft und berichtet und neue Pläne für die Zukunft ausgearbeitet werden. Die CIE wird als höchste Autorität für alle Aspekte des Lichtes und der Beleuchtung angesehen. Auf diese Weise unterhält sie eine bedeutende Stellung unter den internationalen Organisationen.

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COMMISSION INTERNATIONALE DE L'ECLAIRAGE
CIE Central Bureau
Kegelgasse 27, A-1030 Vienna, AUSTRIA
Tel: +43(01)714 31 87 0, Fax: +43(01)714 31 87 18
e-mail: ciecb@cie.co.at
WWW: http://www.cie.co.at/

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This Technical Report has been prepared by CIE Technical Committee 2-14 of Division 2 “Physical measurement of light and radiation” and has been approved by the Board of Administration of the Commission Internationale de l'Eclairage for study and application. The document reports on current knowledge and experience within the specific field of light and lighting described, and is intended to be used by the CIE membership and other interested parties. It should be noted, however, that the status of this document is advisory and not mandatory. The latest CIE proceedings or CIE NEWS should be consulted regarding possible subsequent amendments.

Ce rapport technique a été préparé par le Comité Technique CIE 2-14 de la Division 2 “Mesures physiques de la lumière et des radiations” et a été approuvé par le Bureau d'Administration de la Commission Internationale de l'Eclairage, pour étude et application. Le document traite des connaissances courantes et de l'expérience dans le domaine spécifique indiqué de la lumière et de l'éclairage, et il est établi pour l'usage des membres de la CIE et autres groupements intéressés. Il faut cependant noter que ce document est indicatif et non obligatoire. Pour connaître d'éventuels amendements, consulter les plus récents comptes rendus de la CIE ou le CIE NEWS.

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This guide is dedicated to the memory of the late Professor Jürgen Krochmann.

The following members of TC 2-14 "Measurement of Reflectance and Transmittance, including Turbid Media" took part in the preparation of this Technical Report. The TC comes under CIE Division 2 "Physical Measurement of Light and Radiation".

J. Krochmann* (Chairman)	Germany
P. Polato (Chairman)	Italy
F. Geotti-Bianchini	Italy
D. Gundlach	Germany
J.J. Hsia	U.S.A.
L. Morren	Belgium
H. Terstiege	Germany
J. Verrill	Great Britain

* Professor J. Krochmann passed away on 27 January 1991.

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PRACTICAL METHODS FOR THE MEASUREMENT OF REFLECTANCE AND TRANSMITTANCE

SUMMARY

The characteristics of materials related to their reflection and transmission properties are defined in accordance with the International Lighting Vocabulary and other relevant CIE publications.

The parameters affecting these characteristics and the principles of measurement involved, which are the same whether the measurement is made in terms of spectral or weighted (e.g. luminous) characteristics, are specified.

Methods, using an integrating sphere, are recommended for the measurement of

- reflectance for directional ρ, $\rho(\varepsilon)$ and hemispherical ρ_{dif} incidence of radiation,
- diffuse reflectance ρ_d,
- transmittance for directional τ, $\tau(\varepsilon)$ and hemispherical τ_{dif} incidence of radiation,
- diffuse transmittance τ_d.

Specific methods are also recommended for the measurement of

- regular reflectance ρ_r,
- regular transmittance τ_r,
- radiance/luminance factor β (radiance/luminance coefficient q).

The absorptance α can either be measured directly or calculated from the measured values of reflectance and transmittance. Both procedures are described.

The principal measurement errors are examined and, where possible, methods for their elimination indicated.

METHODES PRATIQUES DE MESURE DES FACTEURS DE REFLEXION ET DE TRANSMISSION

RESUME

Les caractéristiques des matériaux qui se réfèrent à leurs propriétés de réflexion et de transmission des rayonnements optiques sont définies en conformité avec le Vocabulaire International de l'Eclairage et autres publications de la CIE sur le même sujet.

Les paramètres pouvant affecter les caractéristiques susdites et les principes de mesure sont spécifiés, ces principes étant les mêmes qu'il s'agisse de mesures de caractéristiques spectrales ou intégrales (lumineuses par exemple).

Des méthodes de mesure faisant usage d'une sphère intégratrice sont recommandées pour les déterminations

- du facteur de réflexion sous incidence directionnelle ρ, $\rho(\varepsilon)$ et hémisphériques ρ_{dif},
- du facteur de réflexion diffuse ρ_d,
- du facteur de transmission sous incidence directionnelle τ, $\tau(\varepsilon)$ et hémisphériques τ_{dif},
- du facteur de transmission diffuse τ_d.

Des méthodes de mesure particulières sont recommandées pour les déterminations

- du facteur de réflexion régulière ρ_r,
- du facteur de transmission régulière τ_r,
- du facteur de luminance β (ou du coefficient de luminance q), ces grandeurs pouvant être énergétiques ou lumineuses.

Le facteur d'absorption α peut être mesuré directement ou calculé à partir des mesures des facteurs de réflexion et de transmission. Les deux procédures sont décrites.

Les erreurs de mesure les plus importantes et, dans la mesure du possible, des méthodes pour les éliminer, sont indiquées.

PRAKTISCHE METHODEN FÜR REFLEXIONS- UND TRANSMISSIONSMESSUNGEN

ZUSAMMENFASSUNG

Die Eigenschaften von Materialien in bezug auf ihre Reflexion und Transmission werden in Übereinstimmung mit dem Internationalen Wörterbuch der Lichttechnik und den entsprechenden CIE Publikationen definiert.

Es werden die Parameter, die diese Eigenschaften und Meßverfahren beeinflussen, angegeben, wobei die Verfahren zur Messung der spektralen und integralen (z.B. lichttechnischen) Eigenschaften gleich sind.

Meßmethoden, die eine Ulbricht-Kugel benutzen, werden empfohlen für

- Reflexionsgrad bei gerichtetem, ρ, $\rho(\varepsilon)$ und diffusem ρ_{dif} Strahlungseinfall,
- Grad der gestreuten Reflexion ρ_d,
- Transmissionsgrad bei gerichtetem τ, $\tau(\varepsilon)$ und diffusem τ_{dif} Strahlungseinfall,
- Grad der diffusen Transmission τ_d.

Spezielle Meßmethoden werden empfohlen für

- Grad der gerichteten Reflexion ρ_r,
- Grad der gerichteten Transmission τ_r,
- Strahldichte/Leuchtdichtefaktor β (Strahldichte/Leuchtdichtekoeffizient q).

Der Absorptionsgrad α kann entweder direkt gemessen werden oder aus den gemessenen Reflexions- und Transmissionsgraden errechnet werden. Beide Verfahren werden beschrieben.

Es werden auch die häufigsten Meßfehler und, so weit wie möglich, Methoden zu ihrer Beseitigung angeführt.

1. SCOPE

The CIE has published four Technical Reports which are basic documents for this Publication:

- International Lighting Vocabulary [1];
- Radiometric and Photometric Characteristics of Materials and their Measurement [2];
- Absolute Methods for Reflection Measurements [3];
- A Review of Publications on Properties and Reflection Values of Material Reflection Standards [4].

The reflection and transmission properties of materials in the wavelength range of optical radiation, particularly light, are important in many fields. This report deals mainly with the wavelength range 200 nm < λ < 3 000 nm. These properties are characterized by reflectance and transmittance with their regular and diffuse components, and radiance/luminance factor.

Different methods are described in the literature for the measurement of these characteristics and the results may differ according to the method used. It is, therefore, necessary to standardize one or more methods for the measurement of each defined quantity, designed to keep systematic errors as small as possible. This is the only way to ensure that the results of measurements, obtained with different instruments are comparable.

This CIE Technical Report sets out to define recommended methods for measuring the most important characteristics of reflection and transmission in industrial laboratories and to describe both the measurement geometry and the radiometric/photometric specification of the equipment used for irradiation and detection.

Absolute measurements of diffuse reflectance and measurements of the gonioradiometric/goniophotometric properties of materials are outside the scope of this publication. They are the subject of the work of other CIE Technical Committees.

Measurements on retroreflecting materials are also not treated here [5] and only a few brief notes, for guidance, are given on luminescent materials [2].

2. DEFINITIONS

The definitions relating to materials which are given in this Technical Report apply to optical radiation and particularly to visible radiation. The characteristics used for the description of these properties are generally expressed in terms of radiant, luminous or spectral quantities, but can also relate to other spectral weighting functions (see 3.1.2).

The definitions given here are taken from the International Lighting Vocabulary [1]. Where additional explanatory notes not in the ILV have been added, these are indicated by an asterisk *.

2.1 Processes

2.1.1 Reflection

Process by which radiation is returned by a surface or a medium, without change of frequency of its monochromatic components.

Note 1: Part of the radiation falling on a medium is reflected at the surface of the medium (surface reflection); another part may be scattered back from the interior of the medium (volume reflection).

Note 2: The frequency is unchanged only if there is no Doppler effect due to the motion of the materials from which the radiation is returned.

2.1.2 Transmission

Passage of radiation through a medium without change of frequency of its monochromatic components.