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International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

TECHNICAL REPORT

CIE Standard General Sky Guide

CIE 215:2014

UDC: 628.921/.928
628.9.02

Descriptor: Daylighting of interiors
Light from celestial bodies and the sky

THE INTERNATIONAL COMMISSION ON ILLUMINATION

The International Commission on Illumination (CIE) is an organization 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 about 40 countries.

The objectives of the CIE are:

1. To provide an international forum for the discussion of all matters relating to the science, technology and art in the fields of light and lighting and for the interchange of information in these fields between countries.
2. To develop basic standards and procedures of metrology in the fields of light and lighting.
3. To provide guidance in the application of principles and procedures in the development of international and national standards in the fields of light and lighting.
4. To prepare and publish standards, reports and other publications concerned with all matters relating to the science, technology and art in the fields of light and lighting.
5. To maintain liaison and technical interaction with other international organizations concerned with matters related to the science, technology, standardization and art in the fields of light and lighting.

The work of the CIE is carried out by Technical Committees, organized in seven Divisions. This work covers subjects ranging from fundamental matters to all types of lighting applications. The standards and technical reports developed by these international Divisions of the CIE are accepted throughout the world.
A plenary session is held every four years at which the work of the Divisions and Technical Committees is reported and reviewed, and plans are made for the future. The CIE is recognized as the authority on all aspects of light and lighting. As such it occupies an important position among international organizations.

LA COMMISSION INTERNATIONALE DE L'ECLAIRAGE

La Commission Internationale de l'Eclairage (CIE) est une organisation qui se donne pour but la coopération internationale et l'échange d'informations entre les Pays membres sur toutes les questions relatives à l'art et à la science de l'éclairage. Elle est composée de Comités Nationaux représentant environ 40 pays.

Les objectifs de la CIE sont :

1. De constituer un centre d'étude international pour toute matière relevant de la science de la technologie et de l'art de la lumière et de l'éclairage et pour l'échange entre pays d'informations dans ces domaines.
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 les 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 Comités Techniques, organisés en sept Divisions. 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.

DIE INTERNATIONALE BELEUCHTUNGSKOMMISSION

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 rund 40 Ländern.

Die Ziele der CIE sind:

1. Ein internationales Forum 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 durch Technische Komitees geleistet, die in sieben Divisionen organisiert sind. 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 auf der ganzen Welt anerkannt.
Alle vier Jahre findet eine Session statt, in der die Arbeiten der Divisionen berichtet und überprüft werden, sowie 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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This Technical Report has been prepared by CIE Technical Committee 3-51 of Division 3 “Interior Environment and Lighting Design" and has been approved by the Board of Administration as well as by Division 3 of the Commission Internationale de l'Eclairage. 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.

Ce rapport technique a été élaboré par le Comité Technique CIE 3-51 de la Division 3 "Environnement intérieur et étude de l'éclairage" et a été approuvé par le Bureau et Division 3 de la Commission Internationale de l'Eclairage. Le document expose les connaissances et l'expérience actuelles dans le domaine particulier de la lumière et de l'éclairage décrit ici. Il est destiné à être utilisé par les membres de la CIE et par tous les intéressés. Il faut cependant noter que ce document est indicatif et non obligatoire.

Dieser Technische Bericht ist vom Technischen Komitee CIE 3-51 der Division 3 "Innenraum und Lichdesign" ausgearbeitet und vom Vorstand sowie Division 3 der Commission Internationale de l'Eclairage gebilligt worden. Das Dokument berichtet über den derzeitigen Stand von Wissen und Erfahrung in dem behandelten Gebiet von Licht und Beleuchtung; es ist zur Verwendung durch CIE-Mitglieder und durch andere Interessierte bestimmt. Es sollte jedoch beachtet werden, dass das Dokument eine Empfehlung und keine Vorschrift ist.

Any mention of organizations or products does not imply endorsement by the CIE. Whilst every care has been taken in the compilation of any lists, up to the time of going to press, these may not be comprehensive.

Toute mention d'organisme ou de produit n'implique pas une préférence de la CIE. Malgré le soin apporté à la compilation de tous les documents jusqu'à la mise sous presse, ce travail ne saurait être exhaustif.

Die Erwähnung von Organisationen oder Erzeugnissen bedeutet keine Billigung durch die CIE. Obgleich große Sorgfalt bei der Erstellung von Verzeichnissen bis zum Zeitpunkt der Drucklegung angewendet wurde, besteht die Möglichkeit, dass diese nicht vollständig sind.

The following members of TC 3-51 "CIE Standard General Sky Guide" took part in the final preparation of this guide by using previously unpublished material of CIE. The committee comes under Division 3 "Interior Environment and Lighting Design". TC 3-51 finalized the guide following activities of the previous TC 3-37 "A Guide for the Application of the CIE Standard General Sky" chaired by Y. Uetani, D. Kendrick and D. Dumortier and with main contributions by I. Ashdown, S. Darula, P. Greenup, R. Kittler, J. Mardaljevic and G. Roy during 2002 - 2010.

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CONTENTS

CIE STANDARD GENERAL SKY GUIDE

Summary

This report collects information for the application of the CIE Standard General Sky for general users and designers. The guide provides an explanation of the CIE Standard General Sky concept, which is described in ISO 15469:2004/CIE S 011:2003, and of its simplified use by practitioners. The document includes an extensive list of references on the subject and gives recommendations for prediction methods, tools and computer programs.

GUIDE DU CIEL GÉNÉRAL NORMALISÉ CIE

Résumé

Ce rapport résume les informations sur l'utilisation du ciel général normalisé CIE pour les utilisateurs en général et les concepteurs. Le guide fournit une explication du concept du ciel général normalisé CIE, défini dans ISO 15469:2004/CIE S 011:2003, et de son utilisation simplifiée par les professionnels. Le document contient une liste détaillée de références sur le sujet et donne des recommandations sur les méthodes de prédiction, les outils et les programmes informatiques.

LEITFADEN FÜR DEN “CIE STANDARD GENERAL SKY”

Zusammenfassung

Dieser Bericht fasst Informationen zur Anwendung des "CIE Standard General Sky" für gewöhnliche Nutzer und Planer zusammen. Der Leitfaden stellt eine Erläuterung des Konzepts des "CIE Standard General Sky", welches in ISO 15469:2004/CIE S 011:2003 beschrieben wird, und dessen vereinfachte Anwendung durch Fachleute bereit. Das Dokument beinhaltet eine ausführliche Liste von Referenzen zum Thema und gibt Empfehlungen für Vorhersagemethoden, Hilfsmittel und Computerprogramme.

1 Introduction

The Joint ISO/CIE Standard ISO 15469:2004/CIE S 011/E:2003 “Spatial Distribution of Daylight – CIE Standard General Sky” (subsequently referred to as the “ISO/CIE Standard”) lists a set of sky luminance distributions for a wide range of atmospheric conditions. It provides a universal basis for the classification of measured sky luminance distributions and a method of calculating sky luminance distributions for daylight prediction and daylighting design procedures.

The purpose of this guide is to assist the user in the application of the ISO/CIE Standard in accordance with CIE recommendations for the application of Standard Sky Luminance Distributions (SSLD). It should be read as an adjunct to the ISO/CIE Standard because reference is made from time to time to formulae and diagrams to be found in that document.

Daylight design predictions and window system evaluations have traditionally been based on the worst-case winter weather conditions in Europe, namely the standard overcast sky, with relative values expressed as daylight factors on an interior working plane. However, this assumption ignores variable daylight conditions, especially in clear sky climates. It also fails to account for modern daylighting design approaches that seek to minimize glare and balance interior light distributions with electrical illumination.

The need and ability to predict and simulate skylight in different daylight climates, connected with energy conservation, solar energy use and air-conditioning of interiors, initiated regular one-minute measurements at the International Daylight Measurement Programme (IDMP) stations and introduced new criteria respecting the classification of sky luminance patterns (CIE, 1994). These activities in turn fostered the development of methods for expressing sun and sky luminance distributions in absolute units, a requirement for interior lighting design that integrates daylight with electric lighting design and lighting controls.

In the last decade, several advances and improvements have been achieved in:

1) the definition of luminance and illuminance characteristics of the sun and sky as primary radiation and light sources, with their standardization for world-wide application (e.g. definition of the standard solar constant and luminous solar constant, the CIE Standard General Sky, ratio parameterization etc.);
2) the regular recording of sun and skylight variations in daylight annual profiles in one-minute steps at many stations of the IDMP network, enabling the study and expression of long-term interrelations and the parameterization of their effects (e.g. in standard Daylight Reference Years);
3) the development of computer programs as professional tools for the simulation of building performance, including daylighting design, with simulations based on the CIE Standard General Sky and physically realistic radiative flux transfer algorithms.

These challenges continue to stimulate lighting research, and are forming an innovative chapter in daylight theory by introducing progressive methods, models, criteria, and simulation systems. To be useful to lighting designers and researchers alike, they need to be based on a common internationally-agreed and applicable system of daylight measurement and simulation respecting the ISO and CIE standards.

2 Scope

This Guide provides the following:

1) An explanation of the CIE Standard General Sky concept and its simplified use by general practitioners, together with an appropriate list of generally available references.
2) A recommended procedure for the classification and frequency analysis of skies usable for various design or energy use purposes, with a recommended procedure to derive absolute values from the values expressed in relative units of the ISO/CIE Standard, i.e. luminance in $cd \cdot m^{-2}$ and illuminance in lx, when necessary for supplementary electric lighting or any control purposes.

3) Examples of production of CIE sky type frequencies around the world as annual daylight profiles (Daylight Reference Years) using the application of all or several standard skies.

4) The possibilities to simulate sky luminance distributions in artificial sky facilities.

This Guide is intended to be used by both, users of sky models (for daylight estimation and lighting simulation purposes) as well as the developers of computer software that use the models to estimate the availability of daylight in their simulation models.

Users are those who

1) are interested in the range of sky luminance patterns that can be modelled by the SSLD models presented in the ISO/CIE Standard, and

2) must choose a particular model or series of models, for use in a computation of daylight availability or a lighting simulation to match their locale.

Developers are those who

1) are developing building simulation software systems that implement the SSLD model equations, and

2) must ensure that their implementations are correct.

For practical use additional computations are required, for example:

1) The sun position must be determined from the local latitude, longitude, date and time, using a suitable Equation of Time, and

2) the zenith luminance can be determined by local measurements or estimated in relation to known local diffuse horizontal illuminance.

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in CIE S 017/E:2011, partly reproduced here, and the following apply.

3.1
CIE standard clear sky
cloudless sky for which the relative luminance distribution is as described in ISO 15469:2004/CIE S 011:2003 Spatial distribution of daylight – CIE standard general sky

[SOURCE: CIE S 017/E:2011 ILV, term 17-164]

3.2
CIE standard overcast sky
completely overcast sky for which the ratio of its luminance, L_γ, in the direction at an angle, γ, above the horizon to its luminance, L_z, at the zenith is given by the relation:

$$L_\gamma = \frac{L_Z(1+2\sin\gamma)}{3}$$

[SOURCE: CIE S 017/E:2011 ILV, term 17-169]

Note 1 to entry: This formula is used in ISO 15469:2004/CIE S 011:2003 for definition of the traditional CIE standard overcast sky, which is referred to as 'Sky Type 16',

Note 2 to entry: This is equivalent to the overcast Sky Type 1 in ISO 15469:2004/CIE S 011:2003, which is defined by an exponential function.

3.3
clear sky
cloudless sky

3.4
daylight
part of global solar radiation capable of causing a visual sensation

[SOURCE: CIE S 017/E:2011 ILV, term 17-278]