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

TECHNICAL REPORT

Guide to Protocols for Describing Lighting

CIE 213:2014

UDC: 28.97.972 Descriptor: Interior lighting

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 on by seven Divisions each with about 20 Technical Committees. 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 sept 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.

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 in sieben 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 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 3-34 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 3-34 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 3-34 der Division 3 "Innenraum und Lichtdesign" ausgearbeitet und vom Vorstand sowie Division 3 der Commission Internationale de l'Eclairage gebilligt worden. Das Dokument berichtet über den derzeitigen Stand des Wissens 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 3-34 “Protocols for Describing Lighting” took part in the preparation of this Technical Report. The committee comes under Division 3 “Interior Environment and Lighting Design”.

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GUIDE TO PROTOCOLS FOR DESCRIBING LIGHTING

Summary

Lighting quality encompasses human needs, architectural integration and economic constraints (including energy). To develop information about the luminous conditions that will fulfil lighting quality goals in various settings one needs to know how people respond, in the broadest sense, to electromagnetic radiation detected by the eye and processed by various physiological systems. Common definitions and measurement protocols for lighting installations are needed to support this work and to support communication with designers. This guide, the work of CIE Technical Committee 3-34, establishes a catalogue of application-independent descriptors of lighting and protocols associated with each descriptor. The committee developed a system of two categories of descriptors: basic descriptors, which ought to be reported in any project and which can generally be measured with relatively simple equipment, and specialized descriptors, which will not always be required and the measurement of which is more complex. This document is intended to aid the development of lighting quality concepts by providing a common basis for communication about the luminous conditions, existing or planned, in a space. By using the definitions provided here, and by following the protocols and the overall procedure, writers and readers alike can come to a deeper understanding of the physical conditions that stimulate human responses to light in the built environment.

GUIDE DES PROTOCOLES DE DESCRIPTION D'ÉCLAIRAGE

Résumé

La qualité de l'éclairage englobe les besoins de l'être humain, l'intégration architecturale et les contraintes économiques (y compris les contraintes énergétiques). Pour fournir de l'information sur les conditions lumineuses qui répondront aux objectifs de qualité en matière d'éclairage sous diverses conditions, on a besoin de connaître, au sens large, la réaction des gens aux radiations électromagnétiques détectées par l'œil et traitées par divers systèmes physiologiques. Des définitions et protocoles de mesure communs pour les installations d'éclairage sont nécessaires pour soutenir ce travail et communiquer avec les concepteurs. Ce guide, travail du comité technique 3-34 de la CIE, élabore un catalogue de descripteurs d'éclairage indépendants des applications et des protocoles associés à chaque descripteur. Le comité a mis en relief deux catégories de descripteurs : les descripteurs basiques, qui doivent figurer dans chaque projet et qui peuvent être généralement mesurés avec un équipement relativement simple, et les descripteurs spécialisés, qui ne sont pas toujours requis et dont la mesure est plus complexe. Ce document a pour but d'aider à l'élaboration de concepts en matière de qualité d'éclairage en offrant une base commune de communication sur les conditions lumineuses dans un espace, existantes ou planifiées. En utilisant les définitions fournies ici, et en suivant les protocoles et la procédure générale, les rédacteurs comme les lecteurs comprendront mieux les conditions physiques qui stimulent les réponses humaines à la lumière dans l'environnement bâti.

LEITFADEN FÜR PROTOKOLLE ZUR BESCHREIBUNG DER BELEUCHTUNG

Zusammenfassung

Lichtqualität ist verknüpft mit menschlichen Bedürfnissen, architektonischer Einbindung und ökonomischen Randbedingungen (inklusive Energie). Um die zur Erzielung von Beleuchtungsqualität in verschiedenen Szenarien erforderlichen Daten über die Beleuchtungsbedingungen zu erstellen, muss man wissen, wie Menschen, im weitesten Sinne, auf elektromagnetische Strahlung, welche vom Auge erfasst und durch verschiedene physiologische Systeme verarbeitet wird, reagieren. Allgemeingültige Definitionen und Messprotokolle für Beleuchtungsinstallationen werden benötigt, um diese Arbeit und die Kommunikation mit Planern zu unterstützen. Dieser Leitfaden, ausgearbeitet vom Technischen Komitee 3-34 der

CIE, führt einen Katalog von anwendungsunabhängigen Beleuchtungs-Deskriptoren und Protokollen, die jedem einzelnen Deskriptor zugeordnet sind, ein. Das Komitee entwickelte ein aus zwei Deskriptor-Kategorien bestehendes System: grundlegende Deskriptoren, die in jedem Projekt beschrieben werden sollten und welche im Allgemeinen mit relativ einfacher Gerätschaft gemessen werden können, und spezielle Deskriptoren, die nicht immer erforderlich sein werden und deren Messung komplexer ist. Dieses Dokument soll die Entwicklung von Lichtqualitäts-Konzepten durch Bereitstellung einer allgemeingültigen Basis für die Kommunikation der Beleuchtungsbedingungen, bestehenden oder geplanten, in einem Raum unterstützen. Durch Gebrauch der hier bereitgestellten Definitionen und durch Befolgung der Protokolle und des gesamten Vorgehens können Schreiber wie auch Leser zu einem tieferen Verständnis der physikalischen Bedingungen kommen, die zur Stimulierung menschlicher Reaktionen auf Licht in der gebauten Umwelt führen.

1 Introduction

1.1 Terms of Reference

Most lighting design is for spaces occupied by people, with installations intended to support their activities and needs. Although historically the emphasis was on designing primarily to make tasks and objects visible, there has been a shift of late to a more inclusive consideration of the needs of people in spaces. CIE has been part of this shift in emphasis, convening the First CIE Symposium on Lighting Quality in 1998. One outcome of this event was a more broad definition of *lighting quality*, encompassing human needs, architectural integration and economic constraints (including energy) (Veitch 1998; Veitch et al. 1998) (Figure 1).

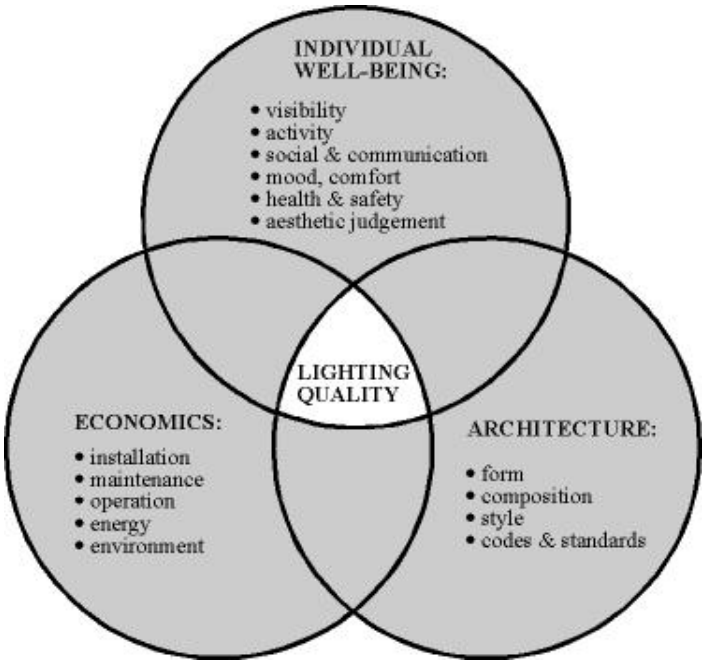

Figure 1 — Lighting quality definition developed at the First CIE Symposium on Lighting Quality (Veitch 1998)

There has been a persistent desire to develop information about the luminous conditions that will fulfil lighting quality goals in various settings. However, to generate this information one needs to know how people respond, in the broadest sense, to electromagnetic radiation detected by the eye and processed by various physiological systems. Researchers who wish to improve our understanding in this area require common definitions and measurement protocols to achieve the goals of replication that are necessary for scientific advances. These definitions and protocols will be most useful to designers if they are in common with the information available during the design process, and if they take into consideration the other factors that designers must incorporate in their work. The absence of such agreement was clear at a workshop at the 1999 Warsaw session of the CIE (Veitch et al. 1999), following which TC 3-34 was created.

The Terms of Reference of TC 3-34 were:

1) To establish a catalogue of application-independent descriptors of lighting.
2) To provide relevant, specific, objective definitions of supporting concepts (e.g. 'field of view').
3) To develop a measurement protocol for each of the descriptors, with the goal of achieving protocols for use equally by researchers, in recommendations and in design.

4) To prepare a strategy and action plan for widespread promulgation and application of these protocols and definitions by researchers, journal editorial boards, lighting educators, CIE Technical Committees and Standards, and in other lighting organizations.

Our founding principle is the recognition that research and design have a common need for clarity, both in the language used to describe the physical stimulus, whether it be from the sky or from electric or combustion sources, and in the elements that one uses to describe that physical stimulus in a space. This need for commonality includes both the qualitative words we use and the measurement protocols for those elements that have quantitative measurements. This report is an attempt at establishing these definitions in a practical way that both researchers and designers can use.

As part of CIE Division 3 (Interior Environment and Lighting Design), the focus of this committee is lighting for interiors. The reader may judge the extent to which the contents may also apply to exterior or other lighting applications.

1.2 Scope of the Report

The challenge of precise terminology is large and begins with the use of the word “light”. The 1978 CIE document “Light as a true visual quantity” defined light as “…radiant power weighted according to the spectral sensitivity of the human eye” (CIE 1978). The CIE presently offers two international standard definitions (CIE 2011):

> 1: characteristic of all sensations and perceptions that is specific to vision
>
> 2: radiation that is considered from the point of view of its ability to excite the human visual system

The International Lighting Vocabulary goes on to specify that if there is a possibility of confusion between these meanings, the term “perceived light” is to be used in place of the first meaning.

This second meaning is the sense in which the word “light” is used in this report. Light is the medium that carries information to the visual system (in the form of variations in radiant energy over time, wavelength and intensity). This electromagnetic radiation, both direct and reflected from objects in space, stimulates chemical reactions in the eye that, interpreted, lead to perception, emotion and action (Figure 2). The scale of information conveyed visually extends from the largest expanse of the surroundings through the smallest details.

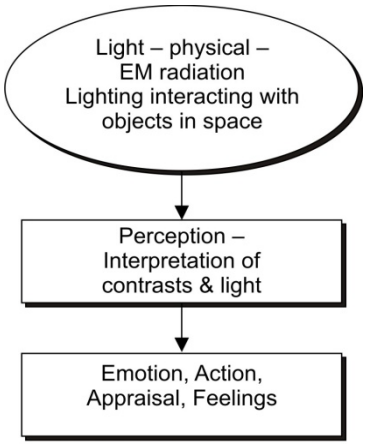

Figure 2 — Schematic representation from the physical manifestation to the viewer's responses

Light is the stimulus, the physical quantity that initiates sensory, perceptual, cognitive and behavioural processes that researchers study and that are the outcomes that lighting designers seek to animate in the people who experience their creations. The aim of most behavioural or human factors research in lighting is to understand the specifics of this

sequence. For example: What room surface luminance makes a room appear pleasantly bright? How does a dark ceiling make a space appear cave-like; or when might it appear intimate? It may be said that lighting designers use this sequence in reverse: they begin from understanding the desired end-point; knowing the viewer, understanding the emotions or actions that are wanted in response to the lighting installation. The job of the lighting designer is to work backwards, to develop a lighting scheme that will elicit the desired response.

There are three senses in which one might use the phrase “to describe lighting”:

1) to specify the lighting equipment, controls and layout for the purposes of design and installation;
2) to report the physical parameters that produce the visual sensation in the person in the space; and
3) to describe the distribution of light as it affects the appearance of the space and the objects in it under a given set of physical parameters.

The focus of this committee report is on the specification of the physical quantities encompassed by items 1 and 2 above. This report draws a clear distinction between the physical and the experiential. We are concerned here with describing the stimulus, not the response; we find that in some respects the lighting literature confuses the two.

Consider, for example, complex mathematical formulae for combining physical quantities into indices, such as the Unified Glare Rating (UGR) or the Daylight Glare Index. The values in the index are not the same as the experience. If one has calculated UGR, one has applied a particular model about the inter-relation of adaptation luminance, source luminance, size and position, and has made a prediction concerning the likely degree of discomfort that occupants might experience. We tend to overlook or to forget that this is a prediction, not a measurement of discomfort, and that the prediction of a psychological phenomenon has random error. Although few people may believe that UGR or other glare prediction models fully account for the experience, we rarely discuss other variables that could influence whether or not that set of physical conditions will or will not lead to discomfort – for in some contexts, areas of high relative luminance that mathematical formulae would predict to be uncomfortable are perceived as interesting points of sparkle. Our imprecision leads us to think we fully understand the phenomenon.

1.3 Report Content and Structure

The purpose of the rest of this report is to provide a means to avoid perpetuating imprecision by providing a common set of procedures and protocols for specifying the physical quantities to which the viewer responds. The committee has developed a common set of protocols for measuring and reporting the physical stimulus, to permit replication of the scientific work and to form a consistent, common practice for designers in talking about and describing lit spaces. This report comes as we shift to a broad approach to lighting research and design, related to the visual experience as a whole, considering peripheral as well as central, foveal vision, and considering the broad range of human behaviours and responses. This wider approach also incorporates non-visual biological processes, such as those discussed in CIE Publication 158 *Ocular lighting effects on human physiology and behaviour* (CIE 2004/2009).

Clause 2 of the report provides a brief overview of the sensory, perceptual, appraisal and non-visual processes triggered by the receipt of ocular light. Its purpose is to lay the foundation for the body of the report. Clause 3 lays out a procedure for describing lighting. Clause 4, the body of the report, consists of a catalogue of lighting descriptors, organized into broad categories. We provide a definition for each category, then a list of descriptors. For complete characterization, one would need to specify all the descriptors provided for all the categories. However, this level of detail is more than most researchers or designers will need; therefore we have provided a set of Basic Descriptors and one of Specialized Descriptors. All of the Basic Descriptors are necessary to form a minimally complete specification of a lighting environment. Where possible, the specialized descriptors should be included as well for a thorough specification.