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

# TECHNICAL REPORT

## CIE 2017 Colour Fidelity Index for accurate scientific use

### CIE 224:2017

UDC: 159.937.51  
535.67  
612.843.31  
535.66

Descriptor: Perception of colour  
Colour of objects  
Colour vision  
Colorimetry

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## 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 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 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 Lichtenwendung. 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 1-90 of Division 1 "Vision and Colour" and has been approved by the Board of Administration as well as by Division 1 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 1-90 de la Division 1 "Vision et Couleur" et a été approuvé par le Bureau et Division 1 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 1-90 der Division 1 "Sehen und Farbe" ausgearbeitet und vom Vorstand sowie Division 1 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.

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## CIE 2017 COLOUR FIDELITY INDEX FOR ACCURATE SCIENTIFIC USE

### Summary

The CIE Colour Rendering Index (CRI), defined in CIE 13.3-1995, in particular the general colour rendering index,  $R_a$ , is widely adopted and used by the lighting industry, in regulatory documents and in international and regional standards and specifications. However, limitations of the CRI have been recently addressed, especially for solid-state light sources, whereby the  $R_a$  values do not always correlate well with visual evaluation by general users. This mismatch arises, first, from inaccuracies of the CRI in its intended role as a colour fidelity index; and second, from perception-related colour quality effects beyond colour fidelity. It was determined by the CIE that, for both aspects, better colour quality characterization methods are needed to measure and specify white-light sources, and the work was divided into two corresponding tasks: (1) to develop a scientifically accurate colour fidelity index, assigned to TC 1-90, and (2) to develop one or more perception-related colour quality measures beyond fidelity, assigned to TC 1-91 for initial work.

This Technical Report, developed by TC 1-90, is a research report describing a general colour fidelity index,  $R_f$ , as a scientifically accurate measure of colour fidelity with respect to a reference illuminant, although there still remain some technical issues for further research. This colour fidelity index, based on the fidelity index of the Illuminating Engineering Society of North America, defined in TM-30-15, addresses aspects for only the first part of the limitations of the CRI – it does not address the need for perception-related colour quality measure(s) beyond fidelity. However, it does correct several previously reported inaccuracies of the CRI as a colour fidelity measure. The important improvements of this measure, relative to the CRI, are the update of the colour difference calculation, in particular the object colour space, and the incorporation of 99 test-colour samples which provide a more uniform distribution of slope and curvature values as a function of wavelength and which have colour appearance values that are more widely and uniformly distributed in the three dimensions of a uniform colour space.

The general colour fidelity index,  $R_f$ , represents how closely the colour appearances of the entire sample set are reproduced (rendered) on average by a test light as compared to those under a reference illuminant. Thus, similar to the general colour rendering index,  $R_a$ , the general colour fidelity index,  $R_f$ , combines the computed colour differences for all test-colour samples in one single average index value, and is only one aspect of colour quality not considering perception/preference effects. Therefore, it is considered that such unintended uses of CRI as an overall colour quality measure for end users is not better fulfilled by the more scientifically accurate general colour fidelity index,  $R_f$ . This is because the users' evaluation is influenced by factors beyond colour fidelity such as chroma effects, and the detailed nature of specific illumination tasks. The general colour fidelity index,  $R_f$ , is therefore not a replacement of the general colour rendering index,  $R_a$ , neither for the purpose of rating and specification of products nor for regulatory or other minimum performance requirements. Replacement of the CRI will be a matter of future study and discussion that will include the evaluation of the general colour fidelity index,  $R_f$ , along with development of a harmonized set of new colour quality measures for assessing perception-related effects beyond colour fidelity and practical aspects for manufacturers and end-users.

## INDICE DE FIDELITE DES COULEURS CIE 2017 POUR UN USAGE SCIENTIFIQUE PRECIS

### Résumé

L'indice de rendu des couleurs de la CIE (IRC), défini dans la publication CIE 13.3-1995, et en particulier l'indice général de rendu des couleurs ( $R_a$ ), est largement adopté et utilisé par l'industrie de l'éclairage, dans les réglementations et dans les normes nationales et internationales. Cependant, certaines limites de l'IRC ont été récemment soulignées. En particulier, les valeurs de  $R_a$  ne correspondent pas toujours à l'évaluation visuelle des observateurs pour les sources à base de semi-conducteurs. Ce décalage provient,