www.osram.com/fci

Light is energy

Outstanding quality of light and color contrasts through optimized FCI

Shop lighting with LED systems

Light is OSRAM

OSRAM

LED lighting
Efficient systems for shop lighting

The correct lighting of shop windows and sales rooms puts customers in a buying mood. Light takes on several roles: it gives orientation, accents products and stages the entire indoor area.
The right light is active sales promotion and considerably supports purchasing decisions. Lighting creates atmosphere and puts products in the right light – assuming the shop lighting satisfies the high attractive color rendering requirements.

LED instead of HID

White tones and colors in shops should be attractive and natural just like daylight.

The lighting market is going through a period of technological change, with semiconductor-based technologies such as LEDs presenting customers with new possibilities in terms of efficiency and flexible lighting systems.

High intensity discharge lamps have normally been used in sales room up to now. LED lighting systems meanwhile achieve a consistently higher quality of light and efficiency and additionally provide an economic alternative to HID lamps.

The benefits of LED systems are clear:
- a lifetime up to three times longer than traditional solutions
- lower power consumption
- simple dimmability
- extremely low light modulation
- no IR or UV radiation

One of the main benefits of HID lamps is their good color rendering. A requirement that also LED systems must fulfil in the sales area so that they can be a real alternative.

LED systems conserve resources and are durable

LED modules do not contain any lead or mercury. Their low energy consumptions considerably reduces the climatic impact of CO_2.

Clear savings potentials by efficient light

In retail, lighting represents a considerable cost factor: In the non-food trade, lighting represents more than 60 % of the energy costs and is the highest cost factor! This is often combined with high maintenance costs. With modern LED lighting solutions, individually adapted to the individual shop scenario, significant potential savings can be realised.

Sales room illuminated with LEDs

Attractive color rendering
Requirements on shop lighting

Despite all the quantitative benefits of LED solutions, the focus in the sales area is on the quality of the color rendering and is a decisive criterion in the choice of a lighting system. Existing systems can be replaced or new lighting systems based on LED can be realised only with LED systems that achieve natural color rendering. White should illuminate without color or grey tones appearing, and colors should be reproduced vividly and attractively just like daylight.

Objective quality assessment – but how?

Different methods and indexes were developed to measure the color rendering quality of lamps as objectively as possible. They are normally based on spectral measurements that compares reference measurements with a standardised light source. One or more values are then calculated mathematically from the measured data. This allows the qualitative comparison of values from different light sources that were determined in the same way.

Though there are numerous methods and indexes that are determined differently and have different emphases. These values can not be directly compared with each other. For the relatively new LED technology no index has yet become established that satisfactorily allows assessment of the quality of light from LED modules and simultaneously incorporates the subjective human color perception.

Subjective perception of color

When indexes such as the Color Rendering Index (CRI) can be used as the basis for the quality of light, good comparability and assessment of the quality of light can definitely be achieved with, for example, HID lamps. For LED modules though, this index by itself has not proved to be sufficient.

Significant difference in color quality are sometimes perceived in a direct comparison of different LED modules with the same CRI. Objective assessment and classification of LED modules is therefore not possible. This means that existing systems can not simply be expanded by LED modules with an identical CRI value without risking differences in the color appearance.

Attractive color rendering is an important criterion for shop lighting

Can the quality of light be objectively assessed?

Quantifiable values are needed for assessment of the quality of light in the planning for shop lighting. In addition to illuminance, the color temperature and color rendering index are usually specified.

Color temperature

The color temperature is a measure for characterising the color of the radiated light in more detail. The color temperature (CCT=Correlated Color Temperature) is given in Kelvin (K) and corresponds to the color of the radiation of a black body that would have been heated to the appropriate temperature (Planckian radiator or black body radiator). The spectrum largely follows Planck's radiation law. Light can have a continuous spectrum when it, like sunlight or the light from an incandescent bulb, is emitted from a glowing body. The color impression ranges from red (low temperature) over warm and cold white up to blue (high temperature).

- Warm white: less than 3000 K
- Neutral white: 3000 to 5000 K
- Cold white (daylight): greater than 5000 K

The color rendering index (CRI)

The color rendering index was developed in the 1960s to assess the color rendering of the emerging fluorescent tubes. As opposed to incandescent bulbs, the spectrum of fluorescent tubes is not continuous, rather it is discrete. This narrow band spectrum therefore differs very markedly to the light from incandescent bulbs.

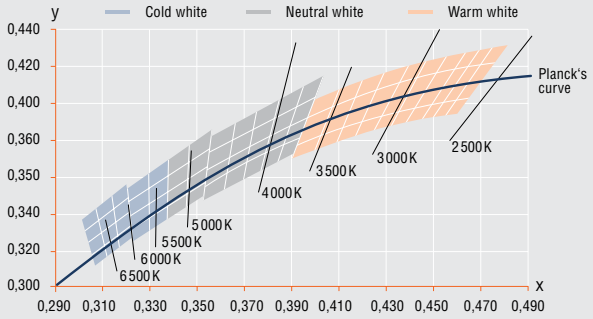
The goal with the color rendering index was to provide a reproducible value that defines the extent to which the color rendering of a lamp differs from daylight or an incandescent bulb, and therefore to enable comparability of lamps.

How is the value determined?

The basis for determination of the value is the spectral measurement (secondary spectrum) of 14 standardised test colors (DIN 6169) illuminated by the test light source. For color temperatures up to 5000 K a black body radiator is used as the reference light source, a standard daylight spectrum for color temperatures above 5000 K.

14 color rendering indexes (R1, R2, ..., R14) are derived mathematically from the comparison of the spectra reproduced from each of the 14 test colors (1, 2, ..., 14) illuminated with the test light source versus illuminated with the reference light source.

$$R_a = \frac{R_1 + R_2 + ... + R_7 + R_8}{8}$$



Color temperature along Planck's curve

The test colors are to a large part based on pastel colors. The arithmetic mean of the first eight color rendering indexes is obtained to calculate the frequently used general color rendering index (R_a).

The same color rendering index does not mean the same color rendering

An ideal black body radiator or daylight achieve a color rendering index of 100. The scale ranges from 0 (unsatisfactory) to 100 (excellent). A light source can achieve a high general color rendering index (R_a) and nevertheless have a spectral characteristics curve that differs considerably from a black body radiator. This can be explained, for example, by a restricted color set (8 colors) and calculation of an arithmetic mean from a few measured values. For instance, the high and low values in the different color ranges can therefore cancel each other out. This means in practice that the color temperature and color rendering index by themselves are inadequate for making the quality of light comparable for LED modules.

European ecological design legislation

European Ecological Design Directive (EU) No. 1194/2012 specifies at least R_a = 80 for LED modules. All OSRAM LED modules comply with this specification. The R_a value can be found on the product data sheets of our e-catalogue and on all packaging.

An old method rediscovered
Feeling of Contrast Index: FCI

With the goal of enabling even better comparability in general, Kenjiro Hashimoto, Tadashi Yano, Masanori Shimizu and Yoshinobu Nayatani developed a method for assessment of the color rendering quality (2007). This method has the goal of incorporating subjective color perception and calculating a measurable comparison value.

Content of the study

The basis for the FCI is the CIELAB color space that defines colors as they are perceived by a standard observer in D65 standard light. In their study[1)] the scientists also presented and compared FCI values and R_a values (CRI) from the same light sources.

The most important results of the study are:

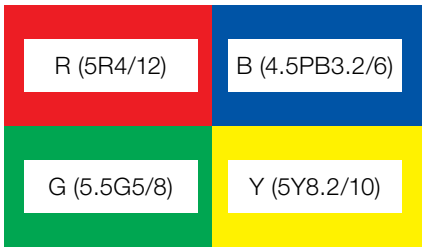
- The FCI is suitable for assessment of the color quality for all types of light source
- The FCI and R_a are fully different, but the combination of both indexes is ideal for quantitative assessment of the color rendering quality
- This FCI as an index is particularly suitable with products are to be attractively illuminated and presented

How is the new index value determined?

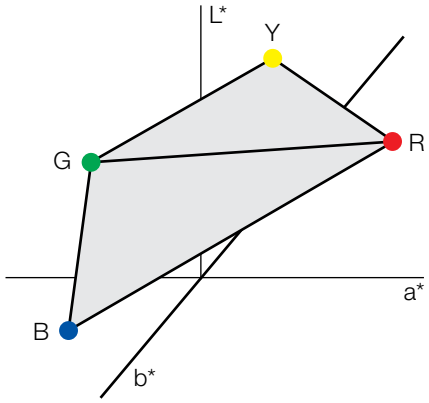
The FCI is based on the comparison of the color space (gamut, G) from a test lamp (T) with the color space from a standard light source (D65). The basis for the test measurements is a color pattern with four saturated color fields that is illuminated by the test lamp. The calculated color space is determined by the color coordinates of the CIELAB color space.

The feeling of contrast index (FCI) is calculated with the formula below:

$$FCI = \left(\frac{G(T)}{G(D65)} \right)^{1.5} \times 100$$



Pattern with four saturated color fields



Color space (gammut) with CIELAB coordinates

CIELAB color space

The color space defined by the CIE (Commission internationale de l'éclairage) describes all perceivable colors. The most important attributes of the L*a*b* color model are device independence and the relationship to color perception. This means: colors are defined independently of their type of generation or rendering technology in such a way as they are perceived by a standard observer in standard lighting conditions.

The D65 standard light...

... is a standard light source defined by the International Commission on Illumination (CIE) that equates to average daylight. The color temperature lies at 6504 K.

[1)] A New Method for Specifying Color Rendering Properties of Light Sources Based on Feeling of Contrast, 2007, Kenjiro Hashimoto, Tadashi Yano, Masanori Shimizu and Yoshinobu Nayatani

The SSL4EU project
The scientific basis

Project SSL4EU sponsored by the EU was established with the aim of determining the spectral distribution in various lighting situations that is preferred by people of all ages. The results serve as the basis for optimisation of the spectral distribution of lamps. The focus was on the perception by humans in different room situations. The studies and interviews were carried out at the "Aalto University, Finland" and "University of Pannonia, Hungary" universities as well as at OSRAM.

Interview and measurement

Different lighting situations were examined based on questionnaires (subjective perception) and measurements (quantitative assessment). LED modules with 20 independently controlled channels were used to enable simulation of the widest range of spectral distributions. One part of a study with 180 test persons was carried out in a laboratory with light boxes and the other part in real room situations (approximately 60 tests).

Result and statement regarding the study on FCI

In shop lighting a high correlation of the subjective assessment of the test persons with the determined FCI was established.
Shop lighting with FCI values in the range 130 to 150 were assessed as being the best. The test persons assessed the color rendering as being pleasant, intensive and vivid. Tests carried out internally by OSRAM have also shown that the FCI is very well suited for assessment of the color rendering quality of LED modules.

Test installations in shops

Examples of FCI values

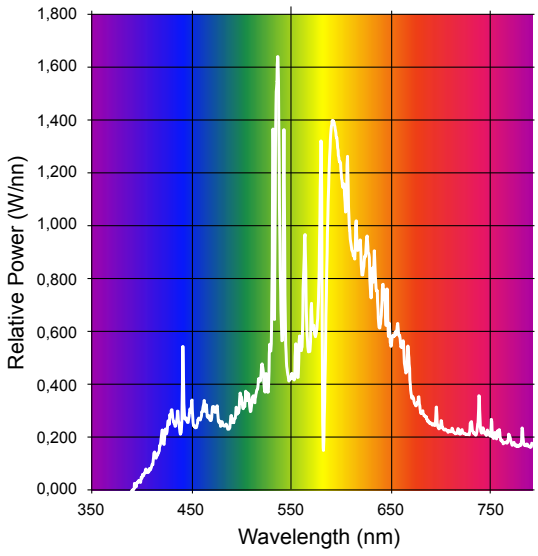
Halogen lamp:	110
Compact fluorescent lamp:	120
HID lamp:	125
OSRAM PrevaLED Core Style:	138

Rooms with different illumination

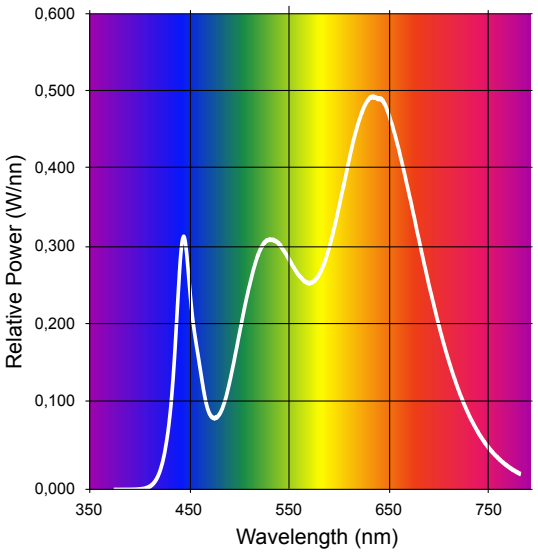
LED modules with optimal FCI
Excellent color rendering

LED modules such as the OSRAM PrevaLED Core provide an excellent quality of light for shop lighting. The Core Style achieves a FCI of 138, a nearly optimal value for balanced color rendering. Lower FCI values make colors appear rather pale. Higher values cause bright colors.

Spectrum comparison
HID/PrevaLED Core Style



Standard HID (high intensity discharge lamp)
CRI = 92 | FCI = 125



PrevaLED Core Style (LED module)
CRI = 85 | FCI = 138

PrevaLED Core Style

Shop solution with outstanding FCI

Product features

- Brilliant white and vivid colors due to optimized feeling of contrast index (FCI)
- Optimized OSRAM true color technology to achieve high FCI values
- Protection against overheating due to thermal shutdown
- High driver flexibility allows cost-effective and intelligent systems
- LEDset II reduces luminaire design effort when combined with OTi DALI drivers
- 5 year guarantee (see: www.osram.com/guarantee)

Areas of application

- Spotlighting in shops and retail
- Exhibition halls
- Museums, galleries

Product features

- Spot module with standardised interfaces
- Reversible shutdown on module or thermal derating with OTi DALI
- Connection via spring-type terminal with stranded and solid wires
- Chip technology from OSRAM Opto Semiconductors
- CE marked and UL listed, ENEC

Equipment / Accessories

- System matches to OPTOTRONIC OTi DALI, OT FIT and OTe LED drivers

Good binning

With the industrial production of LED chips, deviations in photometric properties occur within differing manufacturing batches. The binning process sorts the LEDs of a particular batch. LEDs are sorted in compliance with the ANSI standard (American National Standards Institute).

This standard is fulfilled by all OSRAM LED modules. The binning value for all OSRAM LED modules is specified in the e-catalogues on the specific product data sheet.

Competence for high quality of light
In further areas of application

Exhibition and museum lighting place high demands on the quality of light. Rooms that also get natural daylight through light openings should also be virtually identically illuminated by artificial light. Vice versa, rooms without windows should be illuminated with a quality corresponding to daylight.

Exhibition and museum lighting
The main requirements on modern museum lighting are:
- High color rendering quality
- Variable light colors
- Light color consistency
- Dimmable with constant light color and color rendering

Lighting for the Lenbachhaus
The new lighting system in the Lenbachhaus is based on LED technology and was realised by OSRAM. The primary aim was to achieve a light as natural as possible in which the works of art are displayed as best as possible. Visitors to the museum should not be aware of "light".
An extremely high quality of light and color accuracy was achieved over the entire possible color range from 3000 K to 6000 K in this installation.

Exhibition room in the Lenbachhaus

07/15 OSRAM LLS SMK OEM

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