



LED LIGHT

WHITE PAPER FROM
LOEVSCHALL A/S

BEFORE YOU GO ANY FURTHER

Loevschall A/S is a Danish B2B company with more than 30 years experience with the development of integrated LED lighting solutions. We are the market's leading supplier of light and we have regular customers in more than 7 countries.

On the following pages we are sharing some of our knowledge about light. It is our hope to enhance the general knowledge about the technical aspects of light and by doing so making *good light* an integrated and natural part of people's everyday life and awareness.

Find more information on our website or LinkedIn

www.loevschall.dk

<https://www.linkedin.com/company/18241865/>

LOEVSCHALL
THE GOOD LIGHT

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LUMEN, LUX, KELVIN, CRI

WHAT IS LIGHT?

No matter if you are a reading this paper as a professional buyer, an educator or a private person, we are glad that you have found this rapport and we hope that the next couple of pages will provide the information you need in order to make the right decision about which light that suits your need.

Light is becoming increasingly important – and when something becomes important, it has a tendency to become complicated.

Light is no exception and on the next pages we will be presenting our knowledge about the technical specs in light.

These technicalities are necessary to take into consideration if you want to make sure that your final lighting solution suits your surroundings, the surrounding's function, the surrounding's inventory and to you.

Light influences our daily rhythm, our well-being and the way we get to perceive the things surrounding us. The ideal light is the light from the sun. Below the sunlight everything looks its best. Due to this, artificial light must be as close to sunlight as possible.

But, there are a number of technicalities that we can change in order to not only make our light as good as sunlight, but also make it fit the exact function we have developed it to perform.

It is our hope that the next pages will provide you with the information you need, and we wish you good luck with your next lighting purchase.

LED

THE TIME OF THE DIOD

Before we begin to investigate light and the many technical aspects of light, we will provide you with a basic understanding of LED. We are often using it and we mention it in several contexts when we talk about light, but what is LED actually?

LED stands for Light Emitting Diode. LED bulbs consist of multiple lighting diodes. Diodes are small, electrical components which allow electricity to flow through in one direction. When electricity runs through a diode it exceeds light. Lighting diodes are extremely small and take up very little space which have made it possible to integrate them into places where it has not previously been possible to integrate light.

An example is our drawer light which can be placed in the tiniest of drawers, since the drawer light is just 5 mm high. This would not have been possible without the development of the diode.



In comparison to the old incandescent light bulbs, diodes neither contain mercury, glass or gasses. Due to this, they are a more durable and resilient solution. Previously, problems with overheating of the incandescent bulbs were big and energy consuming problems in stores which often had to turn the lights off for longer periods of time in order to make them cool of. This is not a problem for the LEDs and combined with the small, compact size, LEDs have become an attractive solution to lamps and light.

LEDs often have integrated lenses which breaks the light in order to concentrate the lighting beam in one direction. If you put together 10-20 LEDs, you will get a bright beam which is why most LEDs have fixtures integrated. These often consist of frosted plastic which helps spreading the beam from the LEDs in order to make the lighting angel even in all directions.

LUMEN

THE LIGHT'S STRENGTH

Before, we were using a lighting source's power consumption as an indicator for how much light was issued. Today we are more correctly using the term "Lumen". The reason why Lumen was introduced is because power consumption does not tell anything about how the light looks, instead it tells something about the light's power consumption. Therefore, in order to get a better idea about how the light actually looks, Lumen was implemented.

But, what is lumen?

The light's brightness is called lumen. This means that when you are measuring lumen you are measuring how much light a bulb emits. The higher the lumen, the more light.

WATT

ENERGY CONSUMPTION

Today, watt is exclusively an indicator for how high the light source's energy consumption is. It is a measure of the effect and it measures how much energy the light source uses per second.

When a light source has been used a while, it has had a total amount of energy. This amount is measured in kiloWatt hours (kWh).

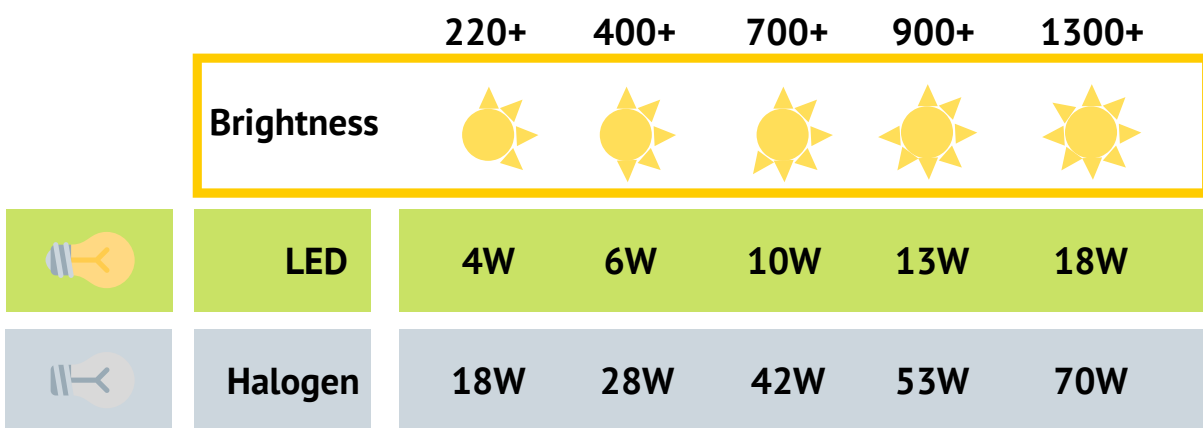


Figure 1: From watt to lumen.

KELVIN

COLOUR TEMPERATURE

Kelvin is an indicator for the colour temperature in your light source. Kelvin should not be confused with CRI-value which is about light's ability to replicate and render colour.

As a rule of thumb, you can assume that the higher the kelvin number, the whiter and thus colder the light.

On the contrary, a low kelvin number emits a warmer light. A light source with a kelvin number on 1500 emits a light which resembles the light you get from a candle, while a source with 3500 kelvin is reminiscent of the light on a sunny day around noon. In Scandinavia we like the "warm light" which is created below 3000 K, while Southern Europe prefers a colder light – 4000-5000 K.

MULTIWHITE®

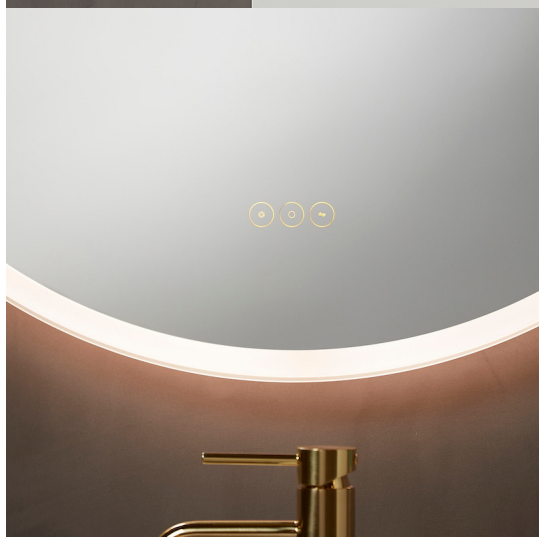
There is a huge variety in the amount of kelvin people want in their rooms. In the bathroom in the morning it can be an advantage to have your light set to a whiter tone with around 4000-6000 kelvin.

A white light with a high kelvin number prevents your brain in producing melatonin which is a natural hormone that makes you sleepy. A lower kelvin number would on the contrary be suitable in the evening in order to encourage the brain to develop melatonin. Research shows that the body reacts naturally on the warm colour tone by relaxing and preparing for the night because the warm light reminds our inherited biology about sunset.

At Loevschall A/S we have developed a technology which makes the change in kelvin possible. *MultiWhite®*.

With the MultiWhite® technology you have the possibility to decide on your lighting source's colour temperature in order to adjust it to your body's needs and natural rhythm. By doing so, you also get to control which mood there should be in your home.

Atmosphere	Candle light	Incandescent bulb	Midday sun	Overcast sky	Blue sky
Kelvin	1.500 K	2.700 K	3.500 K	7.000 K	10.000 K



MULTIWHITE®

BY LOEVSCHALL A/S

Light is about more than just what we can see. Light has a huge effect on the human body, how we function and how we feel.

MultiWhite® is Loevschall's answer on how to maximize the light's influence on your day, because MultiWhite® makes you in control of adjusting the light's temperature exactly how you want it.

LUX

ILLUMINATION

When a surface is hit by a light beam, it lights up. The incoming light per square meters is called the illuminance and it is measured in lux.

Thus, lux is a measurement on how much light hits a surface. Here, we are measuring the total “amount” of visible light on the surface and by doing so we get an indication about how much visible light is present and what the light intensity is on the surface that is being illuminated.

Lux is an effective measure to clarify how we perceive the light intensity from a light beam on a surface. When we focus the light output on a smaller area, we get a very clear light which lights up the surface.

On the contrary, if we are spreading out the light output into a wide beam over a bigger area, we will experience a weaker, less concentrated light.

With lux we are therefore measuring the light intensity in a given area.



A LARGE SURFACE, LESS LIGHT INTENSITY

Our Noir-lamps have a large, luminous surface. Therefore, the light from the lamp is shared across a large area and the measure of lux on the surface is less than for example with a spot light. This creates a comfortable, soft and non-directional light which among other things provides a really good light above the dining table, in the living room or by the bed.

SMALL LENSES, CONCENTRATED LIGHT INTENSITY

Spots as our ID-LED spots consist of several, small diodes with specially designed lenses, that directs the light beam at a smaller area. In this area we are measuring a high amount of lux.

DIRECTIONAL LIGHT

SPOT-LIGHT

When creating directional light, we are normally using spots. The opposite from spots and directional light, is non-directional light used in lamps and light sources which have a higher lighting angle.

The normal pear-shaped bulb sends the light out in all directions in order to light up a bigger area as for an example an entire room. Spots are doing the opposite since they only light up a smaller area.

Due to this, we call spots for directional light and we are using the measuring unit Candela instead of Lumen when we measure how much light a spot sends out to the area it shines upon.

One of our specialties in Loevschall A/S is to direct the light to the right place.

We do this by designing special lenses to our spots and thus you get a good light which shines exactly where you want it.

CANDELA

Candela is primarily a measuring unit which we are using when talking about spots. Candela specifies how much light a spot is sending in one direction or in a certain angle. This angle is measured in degrees and indicates how large an area the spot covers.

THE SIZE OF THE LIGHT SOURCE

SHARP OR DIFFUSED LIGHT

The size of the light source is especially important for the light's creation of shadows. The smaller the light source is and the distance the light is from the object it shines upon, the more precise and sharp are the shadows. In this light you get a sense of "sharp" light which you can get with a spot.

In opposition, a big source of light with a grander surface will make the light seems soft and diffuse and the shadows will become softer and less precise. Our Noir pendant has a large surface which makes sure that the light shines soft and comfortable in the entire room.



CRI VALUE

COLOUR RENDERING

The CRI measures have been used for around 40-50 years. Despite this, it is only recently that knowledge about CRI value has been present in people's minds when choosing light and light sources. One of the explanations could be that the CRI value is difficult to see when looking at a light source. However, it has an enormous importance when you need to know how good your light source is to replicate the right colours.

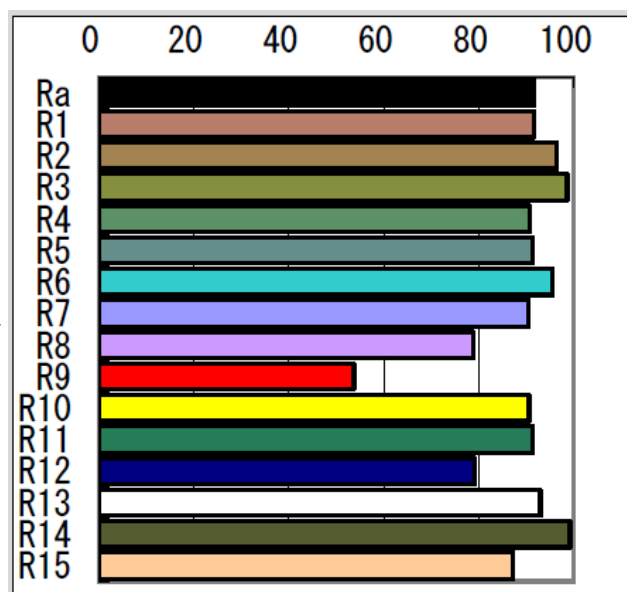
CRI tells how good the colour rendering is or put in another way: How natural the colours look below your light source.

When a light source is turned on, it lights up its surroundings and reflects the colours that the surroundings cannot absorb and thus these colours will get back into your eyes.

The CRI value is measurements from 8 colours and it measures how good the light source is to render the colours correctly.

The reason why you are able to see your red shirt as red, is because your red shirt absorbs the primary colours green and blue but the red colour is not absorbed and is therefore reflected back to you. This is why your eye pays special attention to the red colour and show you the shirt as red. In this situation the light's CRI value plays an important role. The worse your light source's CRI value is, the more boring are the colours which are reflected back to you. If you look at your red shirt below a poor light (light with a low CRI value) you will experience that the shirt looks less red than it is.

But, what exactly has light to do with this?



CRI VALUE

WHAT IS THE CONNECTION BETWEEN CRI AND LIGHT?

In order to answer this question, we have to move a step back – all the way back to understanding what light is made of. Light, white light, is a mixture of all colours of light. If you mix all the colours together, you will get a white light as you will recognize from most light sources. If you were to bend the rainbow you would also get a white light.

But, you can make white light even though you do not have all the colours in the colour spectrum. Combine a few colours when making light, and you can successfully create light, which will be perceived as white light. However, it is white light, but it *does not* contain all colours. Thus, it is not always the case that your white light contains a whole rainbow.

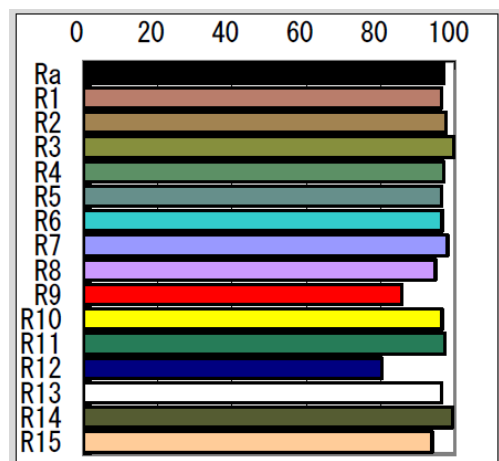
It is here, that your red shirt and our CRI measurements begin to matter.

When you create LED light, the blue colour is the foundation when making white LED light.

This means, that most LEDs are emitting a lot of blue light. However, the light still seems white until we look at the things that the light is shining upon.

If a standard, cheap LED bulb shines upon your red shirt, the amount of red light in the bulb is limited and the red colour will not be reflected back to your eyes. Due to this, when you are looking at your shirt below a cheap, bad light, your shirt will look boring and it will seem like the colour has abandoned it. This is because the light does not contain the right amount or variation of colour. Blue light also has the disadvantage that it makes us awake and “fresh” and this can influence your health and well-being when you are exposed to too much white light with a lot of blue colour. Being exposed to this light will also influence your sleep and your ability to relax.

CRI measure from our ID-LED spot. This spot gets a value around 95.



CRI VALUE

ARTIFICIAL LIGHT

Our eyes and brain are actually really good at intercepting which kind of colour temperature a light source has and thus we are really good at compensating for it. This means, that when we look at an apple in a blue-ish light and then in a red-ish light, it will roughly look the same even though the light and colours reflecting from the apple are not the same. Different colour temperatures are natural and our sense of sight is biologically developed from when we as animals had to find food in a light with shifting colour temperatures. The natural light in the morning are a bit redder than it is at the middle of the day but the apple is ripe all day. It was pretty clever that our ancestors knew this when they were gathering food.

The problem arises when we are exposed to artificial light sources as the LED. The colour pallet in artificial light is created with the mean to get a white light and consequently our brain and eyes can not compensate for this, as they could in natural light. You will often be able to sense that the light looks wrong, but you will not be able to explain *why*.

When we measure the CRI value we measure 8 different colours and you get a precise indication on how much of the 8 colours the light contains. Natural light contains 100% of all the colours and when we develop light, our goal is therefore to get as close to natural light as possible in order to secure that all the colours are rendered correctly.

The CRI value scale:

CRI 100: Perfect colour rendering. Natural sunlight.

CRI 90-99: Extremely good colour rendering. You find this in most of Loevschall's products.

CRI 80-89: Good colour rendering.

CRI below 80: Less good colour rendering.

If you have a light source below CRI 40, several people report discomfort and in this light, people would look like corpses and food will look rotten.

CRI VALUE

WHY IT MATTERS FOR YOU AND YOUR PRODUCT

Stores and product-displays experience what the CRI value means when they want their products to look as good as possible below the light. Therefore, they need a lamp or a light source with a high CRI value in order to show all the correct colours in the products, making it way more appealing to the buyer. The architect and the designer are using many resources on designing their products and choosing the exact right colours. However, if their final products are displayed below a bad light, their work has been in vain, the colours will seem vague and the nuances will be lost.

The CRI value also influences your home, office and workplace. When the CRI value in your light sources are high the details and the shadows will appear more pleasing to the eyes. Your steak at the kitchen counter will look grey and unappetizing below a light with a poor CRI value while it on the contrary will look red and appetizing below a good light.



Our Emerald spot has a high CRI-value and thus it is designed to give you the best light.

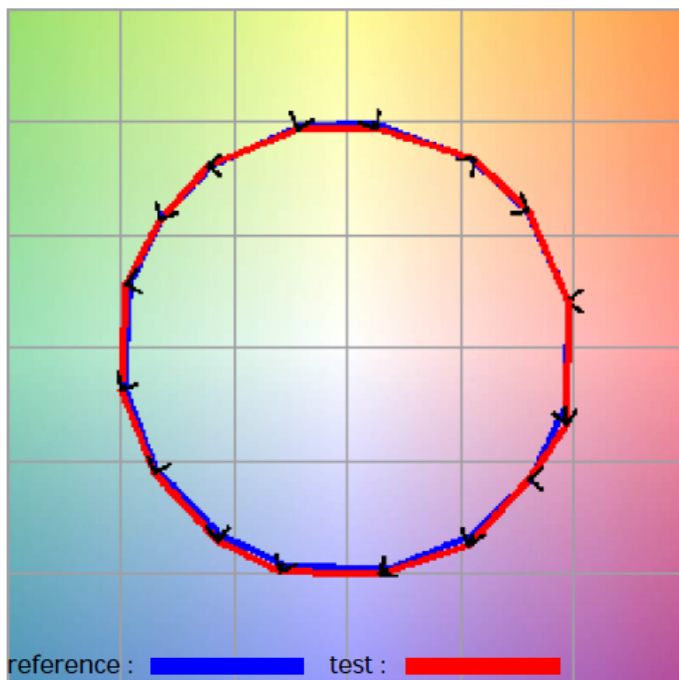
TM30

AN ALTERNATIVE TO THE CRI.

Since the colour rendering in light is important for our health and our perception of the surroundings, the CRI measures have been critiqued for being insufficient. Among other things, the CRI measurements are only measuring 9 colours in which none are skin colours (which are very important to replicate right if you are standing in front of a mirror) and no strong colours such as red. Besides, the CRI value is the average of all the colours which means that the light source can be good at reproducing the measured colours R1-R8 but not the R9-R15 colours, but you will still get a high CRI value even though the light source is not good.

This critique led to the development of TM30 measurements which eventually will replace the CRI value.

TM30 consists of 99 different colours which all are taken from real objects as paint, textiles, ink, skin colour, food, flower and fauna.



A TM30 measurement of our ID-LED 12 V. spot. We are measuring from a reference (blue) which represents the optimal measurement and thus it becomes possible to compare it to our own measurement (red). In this case our LED spot have an extremely good TM30 value (96, 102).

TM30

FROM 8 TILL 99 COLOURS

Some of the challenges when having to measure TM30 colours are the focus on skin colours which are extremely difficult to replicate correctly. At Loevschall this focus is very important for us since we are developing mirrors with integrated light. Therefore, we can not be satisfied with a good CRI-value, and we have to strive for a good TM30 measurement as well in order to make sure that the skin colours on the person standing in front of the mirror are rendered correctly. It would be a shame to stand in front of your mirror and look like a grey corpse or seem paler or redder than you actually are.

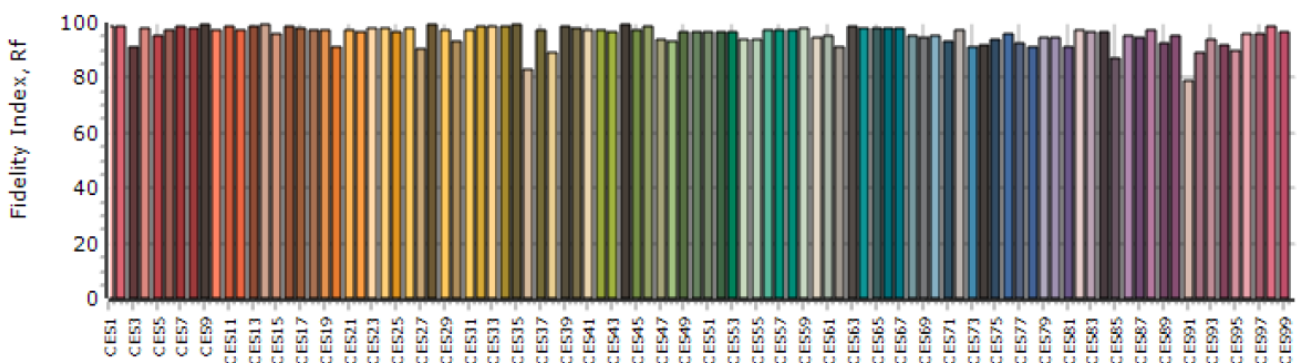
TM30 is measured with the help of two units: Rf (fidelity) and Rg (gamut).

Rf is known from the CRI value and it measures how good the light source is at rendering the colours.

The big difference from the CRI to the TM30 is that the TM30 measures 99 colours instead of only 8.

With a Rf measure you measure the colours from a scale on 0 to 100, and the 100 represents a precise reproduction of the original colours.

Rg adds a new element to the measurements since this unit takes colour saturation into consideration. An Rg measure can not stand alone but when we compare it with another source with the same values, it becomes easy to see the difference in the correlating colour renders. Due to this, the TM30 measure are way more precise in comparison to the CRI-value.



The CRI measures 99 colours.

OUR RECOMMENDATIONS

Recommendations for light can be difficult and there is no “one solution fits all” guide since it depends on the amount of natural light, your personal preferences and the number of light sources in your room. However, we have tried to gather our knowledge and below we present some of our preferences when choosing lights and lamps.

LIGHT IN THE LIVING ROOM

Our general preference for the living room is good and comfortable light. A dimmable pendant with a large surface and integrated LED light creates an even and calm light in this room. A light with a high CRI-value is also preferred as it renders the colours in your interior to perfection and displays the natural colours.

Lumen: 600 - 900 lumen

Kelvin: 3.000 kelvin

Angle: 80 - 99°

CRI-value: >95

LIGHT IN THE KITCHEN

Light in the kitchen can vary depending on where you want your light. In general, the kitchen is one of the rooms where we spend a lot of time and it has gradually become multi-purposed. Due to this, it is a good place to integrate various light sources. A good spot could have these values:

Lumen: 90 - 200 lumen

Kelvin: 2.800 - 3.500 kelvin

CRI-value: >95

LIGHT IN THE BATHROOM

Light in the bathroom can vary from spots to pendants to mirrors with integrated light and in this room the kelvin is especially important. For example, you should choose a light source with kelvins that does not stress your brain with too much cold light. We recommend having a light source with MultiWhite® in order for you to control the colour temperature.

LIGHT IN THE OFFICE

You can easily find specific publications about light at the office, since this has a huge influence on the employee's productivity and well-being. We recommend light sources with a high CRI-value and around 3.000 kelvin.