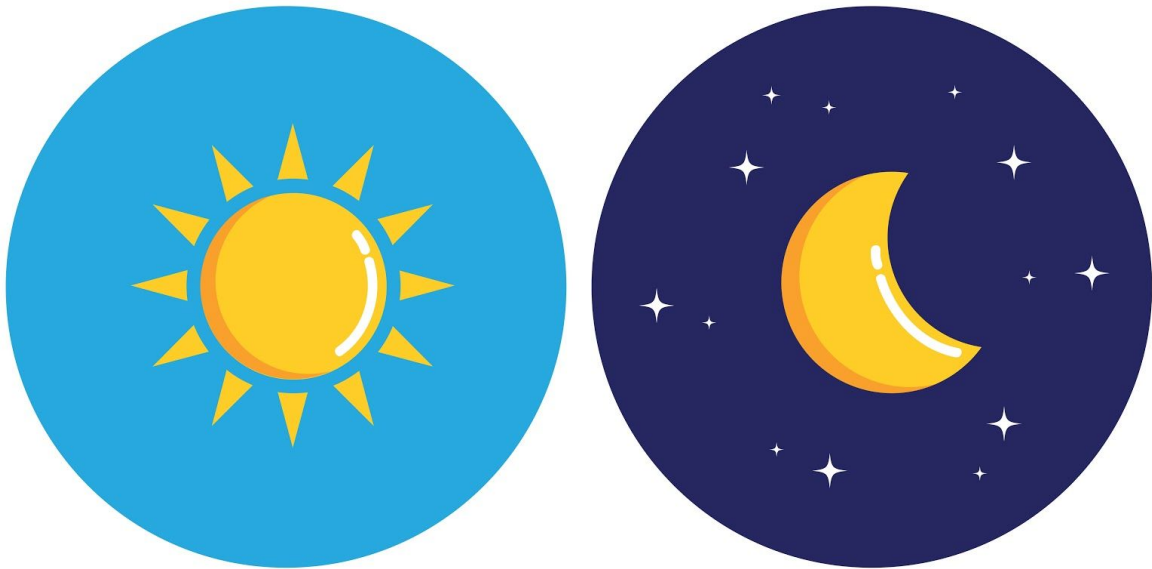


# Evaluation of Dalen Daylight Lamp



**AAU Lighting Design Research Group**

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## 1. Introduction

The goal of this report is to briefly evaluate the Dalen Daylight Lamp, aiming to efficient circadian lighting.

More specifically, this project:

- Describes metrics in terms with circadian lighting
- Evaluates Dalen Daylight Lamp in regards to a list of parameters and validates its actual quality (visual and non-visual) using relevant metrics and measurements with specialized equipment.

## 2. Standards and metrics in circadian lighting

With the discovery of the intrinsically photosensitive retinal ganglion cells (ipRGC) in 2002, a biochemical link was made between the circadian rhythm and circadian light (light that acts as a stimulus for the human circadian rhythm). This has enabled a shift in focus from lighting as a purely visual and functional aid (**visual impact**), to one that can equally enhance and help regulate aspects of the diurnal rhythm, and as such our health and well-being (**non-visual impact**). This has made lighting a recent addition to welfare technology, which relies to a great extent on solid state lighting technologies, in particular LED lighting.

In this context, the lighting research community is currently considering the development and use of metrics that characterize circadian light to establish a design-performance standard. This is the goal of the standard DIN SPEC 5031-100:2015-08 "Optical radiation physics and illuminating engineering – Part 100: Melanopic effects of ocular light on human beings - Quantities, symbols and action spectra" as well as DIN SPEC 67600:2013-04 [21] "Biologically effective illumination – Design guidelines".

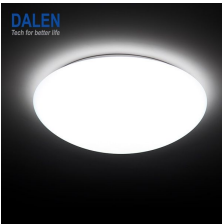
The most recent research suggests circadian light and circadian stimulus which are two metrics that characterize the spectral and absolute sensitivities of the human circadian system. These metrics have been developed by the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute and are based on fundamental knowledge of retinal physiology as well as the measured operating characteristics of circadian phototransduction—the process by which the retina converts light into neural signals for the circadian system—from response threshold to saturation.

Circadian stimulus is a transformation of circadian light into relative units, from zero (the threshold for circadian system activation) to 0.7 (response saturation), and is directly proportional to nocturnal melatonin suppression after one hour of light exposure (zero to 70 percent). In terms of applications, six field studies showed that daytime light exposures of **circadian stimulus greater than or equal to 0.3** are associated with better sleep, better mood, and lower depression. Perhaps of most interest, in three of those field studies, Alzheimer's patients who received light exposures of circadian stimulus **greater than or equal to 0.3 during daytime hours and less than 0.1 during the evening hours** consistently and significantly increased their sleep duration, improved their sleep quality, and reduced their symptoms of depression and agitation.

In this project the web-based version of the circadian stimulus calculator is used (available on <https://www.lrc.rpi.edu/cscalculator/>), in order to evaluate the potential for circadian-effective light exposure.

## 3. Evaluation

### 3.1 Luminaire

Company	Product	Image
Dalen Daylight Lamp	Dalen	

### 3.2 Description of experiment

#### 3.2.1 Measurements

##### Metrics on Visual impact

- Vertical Illuminance levels (lux)
- Color temperature (Kelvin)
- Spectral power distribution curve (SPD)
- Flicker

##### Metric on non-visual impact

- Circadian stimulus metric

##### Others:

- CE-Mark / Medical product
- Glare
- Intended use and setup needs

### 3.2.2 Set-up

The following measurements took place in the Light lab (Lighting Design lab) at Aalborg University Copenhagen during the period of weeks 24 and 25.

The luminaire was measured, dependant on its function and its future usage. Considering the above, the aim was to generate **measurements at eye level** in order to generate information for their optimal usage.

Glare is caused by a significant ratio of luminance between the task (that which is being looked at) and the glare source. Numerous methods for measuring direct discomfort glare have been proposed over the years. Until recently the most widely used was the Unified Glare Rating (UGR), proposed by Sorensen in 1987 and adopted by the International Commission on Illumination (CIE) in 1995 before being recommended for international application. The UGR adds up the contributions of all glare sources in the visual field, taking into account source luminance, source size, source position and background luminance. UGR value may also vary depending on the size of the room, the reflection factors of the ceiling, walls, and floor, and the position and viewing direction of the observer in the room. Given this, it has been decided not to report specific numbers, but only subjective evaluations, since as discussed before, glare is highly subjective and dependent on usage and environment. Therefore, each luminaire will be characterized as low, medium or high risk of glare but as mentioned above those can vary according to placement.

Ultraviolet (UV) designates a band of the electromagnetic spectrum with wavelength from 10 nm to 400 nm, shorter than that of visible light but longer than X-rays. UV radiation is present in sunlight constituting about 10% of the total light output of the Sun. It is not visible to human eyes, but can affect human health, most notably by causing skin cancer. UV light can be useful to humans, as well (production of vitamin D). However, the considered LED luminaries do not produce UV radiation (since LED lights do not produce any UV light due to the phosphors within an LED lamp that convert the Ultraviolet light to white light. Incandescent and fluorescent bulbs can emit UV radiation, but the levels are extremely low, especially when compared to reptile basking bulbs or tanning bulbs. In this context, UV light for the tested luminaries was not measured.

For the luminaire, the following information is provided:

- Category
- Specifications
- Measurements (on visual and non-visual impact)
- Description on indented use and setup needs

### 3.3 Luminaire data

**LUX** is the measurement of intensity of incident light on a surface. For all measurements taken, LUX values were taken vertically at eye level in order to calculate the various CS.

**Flicker** measurements included three metrics: percentage, index and frequency. Flicker frequency of a luminaire should be at its lowest of around 50-60Hz. Measurements of flicker frequency of around these values could be causing headaches and migraines.

**CRI (Color rendering index)** should be over 80 and it is indicating color appearance of objects under the light effect of the luminaire. CRI is actually a quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source. The closer to 100 the index value gets, the better. CRI values don't appear on monochromatic luminaire presets (e.g. blue or red light)

**TM30 -15 RF** and **TM30-15 RG** define the color fidelity and gamut index accordingly. RF takes values from 0-100 while RG values over 100 translate to average increase in color saturation while below that an average decrease. TM30 - 15 values don't appear on monochromatic luminaire presets (e.g. blue or red light)

**GAI** is another representation of color saturation and is advised for good indication to expect from 80-100 while below or above that, would indicate over or undersaturated color appearances. GAI values don't appear on monochromatic luminaire presets (e.g. blue or red light)

### 3.4 Dalen Daylightlamp

Category: Ceiling luminaire

Specifications:

CCT : 2.800 Kelvin - 6.000 Kelvin. Can be adjusted in 10 steps. Stepless with the app.

- Diameter: 60 cm x 13 cm
- Weight: 2.8 kg
- Material: Plastic
- Color: White
- LED

Measurements(1st round):

(W:warm, 4K: 4000Kelvin, C:cold)

Distance(cm)	0				50			
	W	4K	Whole	C	W	4K	Whole	C
4 CCT								
Vertical Illuminance from distance(Lux)	77	83	105	81	263	320	353	277
Color Temperature Avg(Kelvin)	3065	4038	4786	6144				
Circadian stimulus value(CS)	0.12	0.09	0.15	0.15	0.31	0.29	0.36	0.37
Flicker percentage(%)	0.2							
Flicker index(0-1)	0.00							
Flicker frequency(Hz)	150							
CRI(Ra)	97							
TM30 Rf	93							
TM30 Rg	102							
GAI	96.7							

Table 1: 1st round of measurements

Measurements( CS 2nd round. Minimum dimming + night mode):

(W:warm, 4K: 4000Kelvin, C:cold, N:night)

Distance(cm)	0					50				
	W	4K	Whole	C	N	W	4K	Whole	C	N
4 CCT										
Vertical Illuminance from distance(Lux)	32	30	31	33	1	145	138	140	150	3
Circadian stimulus value(CS)	0.05	0.03	0.05	0.06	0.001	0.2	0.15	0.19	0.25	0.003

Table 2: 2nd round of CS measurements

Dalen measurements description:

The dalen lamp measurements were taken with the aim of assessing its capability of providing CS on eye level and by assuming placement in ceiling height of 2.7m.

Considering all the above, measurements for estimating illumination levels on eye level of the lamp were taken from a vertical distance of 100cm and while lux sensor was facing horizontally. The two distances chosen to measure (0cm and 50cm) represent the distance of the sensor from the center of the lamp. See side Diagram 1 demonstrating the process of measuring LUX levels. The temperatures as seen above are the following: W:warm, 4K: 4000Kelvin, Whole light preset, C:cold and N: night light.

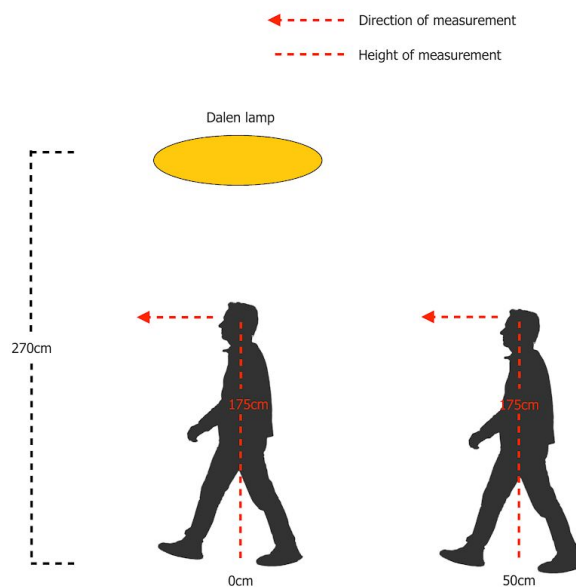


Diagram 1: Illuminance measurement



Dalen was able to provide CS of 0.3 in all of its settings but more importantly in its whole and coldest settings. The illuminance levels represent the values that were taken on its highest dimming setting. Reducing lamp intensity will be resulting in lower CS values.

Regarding the 2nd round of measurements, CS values were measured for the Dalen's minimum dimming levels and also in its night light mode. As this can also be observed on Table 2 , for a user distance of 50cm from the fixture, the CS values are around 0.2 other than the coldest temperature which is at 2.5 CS. For the measurements taken exactly below the fixture, CS values are restricted to minimum ranges which is also dependent, to a high degree, on the illuminance values measured. Lastly the night light mode, due to its reduced lumen output was able to deliver extremely low CS values in the range of: 0.001 to 0.003.

#### Glare Assessment:

Dalen daylight lamp was tried in various dimming levels and its controller provided presets but due to its LED sparse placement and its diffuser plate was determined as a low-risk glare fixture.

#### Description on intended use and setup needs:

- Ceiling placement for domestic usage
- Dynamic lighting aiming in following the circadian rhythm
- Controllable via WiFi, app or remote controller
- Remote controller provides dimming and CCT controlling options while it comes with 2 presets, one whole light that has an output of 4700K and intense illumination(10000Lux in distance c.a. 8cm)



Figure 1: Dalen Lamp

## 4. Conclusions

Dalen Daylight Lamp was tested in the Light lab (Lighting Design lab) at Aalborg University Copenhagen (<https://www.light.aau.dk/Lighting+Design+Research+Group/>) regarding the performance on metrics on visual and non-visual impact.

Dalen is a ceiling luminaire offering a wide range of CCT values (2800 - 6000 Kelvin). Our measurements show a range from 3065 to 6144 Kelvin (similar to the reported values).

The measured flicker percentage is only 0.2% which makes Dalen able to be used in environments sensitive to flickering (e.g. in healthcare).

CRI, TM30 and GAI measured values are also very good in providing great colour fidelity and colour saturation.

Dalen is offering a great variety of various CS values, so that, it can be used for different settings and purposes to support circadian rhythm, following the rule of CS greater than or equal to 0.3 during daytime hours and less than 0.1 during the evening hours.

In this context, the really low values of CS measured in the night mode (see Table 2), makes Dalen a very good choice to be used as a night light.

For the daytime, Dalen is showing very satisfactory CS values, especially considering that this is a ceiling lamp with no “direct” access to the eye level. As expected, the cold setting with the maximum intensity is offering the greatest CS value (CS value of 0.37 - see Table 1), which is considered very effective for circadian stimulation in morning/noon.

At that point, it should be also noted that Dalen is performing really well regarding the circadian stimulation also in the case of using warm CCT with the maximum intensity: CS value of 0.31 for the warm setting of 3065 Kelvin - see Table 1.

Other settings providing lower values of CS (e.g. when having minimum dim and warm CCT) can be used in the afternoon/evening hours.

