When appearances are deceptive – hazards associated with light flickering

Subcommittee "Lighting" of the "Administration" Expert Committee, position: 20 October 2025

When lighting flickers, this can lead to a stroboscopic effect and thus to a risk of accidents and health problems. Entrepreneurs should already be paying attention to suitability when purchasing lighting devices, including modern LED lighting devices.

Table of contents

1 Light flickering: an often unrecognised accident and health risk

Light-emitting diodes, better known as LEDs, are now used for lighting in many workplaces. However, lighting systems with LEDs can also pose an underestimated accident risk, especially when working with unprotected moving machine parts. If LED lighting is operated with unsuitable ballasts, a stroboscopic effect can occur, a kind of optical illusion: for example, the rotating blade of a circular saw appears to stand still. Consequently, the risk of accidents increases. In this case, work must be temporarily stopped and the light replaced as soon as possible.

The stroboscopic effect is a consequence of what is known as light flicker. This occurs when light is not emitted evenly, but the brightness (illuminance) changes rapidly. If the frequency of the change is too slow, flicker can be perceived. If the light source is located about 30 degrees to the side of a person, the flicker is more easily visible. This is because the human eye is more sensitive to flicker at the sides. It can resolve the consequences of individual light pulses up to a repetition rate of 90 Hz, the flicker fusion threshold. Since LEDs are operated at a minimum of 100 Hz, light flicker is rarely seen on the luminaires themselves. When light flicker is visible, it is usually in connection with movement, such as the stroboscopic effect. This can

cause the perception of movement to not correspond to the actual speed because the clock rate of the light pulse is identical to or a multiple of that of the moving object.

Figure 1 – Rotating saw blade on a circular saw

Dangerous optical illusion

In good lighting conditions, you can clearly see that the saw blade is rotating. If the LED lighting is operated with unsuitable ballasts, a stroboscopic effect can occur, for example when working with a circular saw: it appears as if the rotating saw blade is standing still or moving only slowly – a dangerous optical illusion.

2 How flickering occurs

Light flickering often occurs in connection with the dimming of LEDs and also occurs when users cannot dim the lighting themselves. The reason: the ballasts used there are already controlled by the manufacturer and thus unnoticed by the user by means of pulse width modulation (PWM). To do this, the light source is switched on and off at short intervals. The more the light is dimmed, the shorter the light pulses become. With constant current reduction (CCR; sometimes also referred to as amplitude dimming or analogue dimming), on the other hand, there is no light flicker.

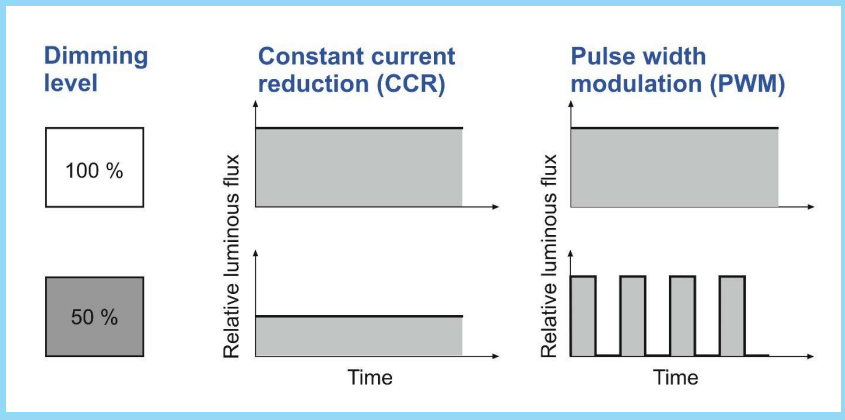

Figure 2 – Two different dimming modes

How dimming works

using uniform constant current reduction (middle) or

using the on/off function (bright/dark) of pulse width modulation (right)

3 The problem with light flickering

LEDs can also cause problems when the flicker is not even perceptible to the human eye. In addition to the

stroboscopic effect, light flicker can also affect the health and well-being of employees in other ways. For example, it can cause the following problems:

- Vision problems, in particular blurred vision when reading
- Red eyes, burning eyes, increased tearing, foreign body sensation in the eye, eyelid twitching
- Increased sensitivity to glare
- Headaches, discomfort, increased incidence of migraines
- Irritation when detecting moving objects

If these symptoms only occur under artificial lighting and not in daylight, this is an indication that they are triggered by the way the artificial lighting is operated.

For entrepreneurs, this means: they must ensure good lighting that is flicker-free.

3.1 Quick check to assess visual conditions

In principle, all workplaces should be flicker-free. This is particularly important for the following demanding visual tasks and for specific employees:

Table 1 - Checklist – when is an inspection necessary?

No.		Yes	No
1	Are there moving or rotating tools, machine parts or other fast-moving work equipment at the workplace?		
2	There are many or exclusively very small, relevant visual details.		
3	Employees must be able to recognise moving visual objects quickly and reliably.		
4	Rapid changes of perspective are necessary.		
5	Some employees are sensitive to flickering.		
6	There have already been complaints from employees about the lighting.		
7	There is a risk of epileptic seizures among employees.		

3.2 Quick check of the lighting system

Figure 2 – Left: Motionless hand. Middle: The moving hand continues to appear as a single object. Right: The fingers of the hand are visible multiple times due to the stroboscopic effect – light flickering is present here.

An initial check to see whether the LED lighting flickers can be carried out quickly. Here's how: simply use your own hand with spread fingers, a pen or a springy folding rule. The effect, as shown in Figure 4, becomes visible during rapid movement when the light shines directly on the object or hand. This simple assessment is sufficient for office areas, for example.

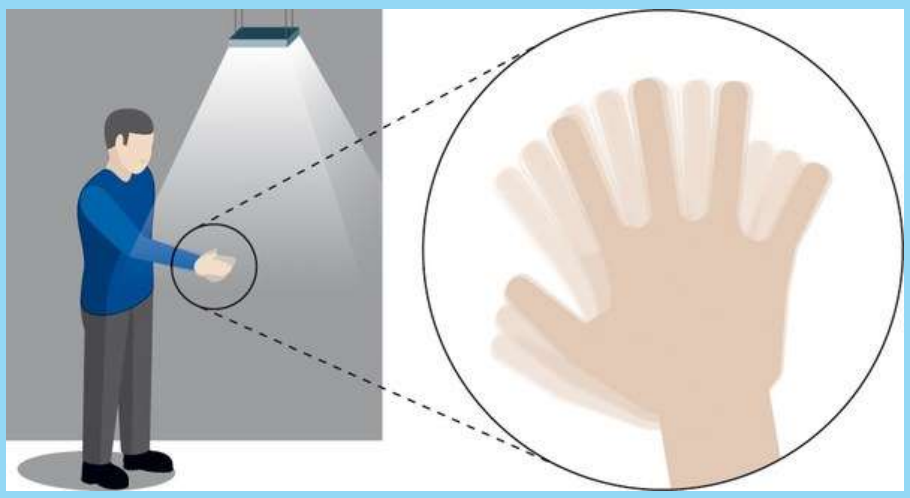

Figure 4 – Check with a fast-moving object

Initial flicker check

The light must shine on the fast-moving object, in this case the hand. It is important that the person does not look into the light or be dazzled by it.

In the case of moving parts such as circular saw blades and milling tools, light flicker can be detected by directly observing the moving parts in certain frequency ranges. If stroboscopic effects occur, quick action is necessary, for example if a rotating saw blade appears to be standing still. In Germany, according to the Technical Rules for Workplaces (Technische Regeln für Arbeitsstätten/ASR) A3.4, the machine must not continue to be operated together with the lighting system if unprotected moving parts are accessible.

To check whether all frequency ranges are flicker-free, the speed of the parts must be changed. This happens, for example, when the machine is switched on and the speed increases during start-up.

4 Procurement and use of LED lights: What to consider

Two values are currently used to assess light flicker:

- P_{st}^{LM} stands for Short-Term Light Modulation and describes the inherent flicker under static conditions, i.e. without movement of the observer or object. This value must be less than 1.
- The Stroboscopic Visibility Measure (SVM) applies between 80 and 2,000 Hz and characterises the stroboscopic effect when the object being viewed moves. Since 1 September 2024, the SVM value for undimmed LED light sources operated directly from mains voltage must be below 0.4 in the European Union.

Both values are either specified in the luminaire data sheets or can be requested from the manufacturer by users. They apply to full-load operation, i.e. non-dimmable operation. In addition, it can be assumed that some employees will still perceive flickering or the stroboscopic effect at these values.

In practice, it makes sense to ensure that lighting systems are operated with a constant current or with a pulse rate above 1,000 Hz (pulses per second). This also applies to LED luminaires if they are dimmable or if intelligent building technology can provide dimming.

The highest demands on flicker-free lighting are when the work involves dynamic visual tasks or when employees are impaired by flickering lights (see checklist). In this case, it is best to avoid PWM completely.

Requirements for all lights

Minimum:
- $P_{st}^{LM} \leq 1$
- SVM ≤ 0.4

Recommended for luminaires with permanently installed PWM:
- f (pulses per second) > 1,000 Hz

Requirements if luminaires are to be dimmed (if none of the conditions from the quick check under 3.1 apply)

- Dimming via constant current dimming if possible
- For PWM dimming: f (pulses per second) > 1,000 Hz

Requirements for more demanding conditions (see quick check under 3.1)

- Operation of the luminaire with constant current
- Dimming using CCR
- No dimming via PWM
- No use of control gear that operates the LEDs with rectified sinusoidal mains voltage or otherwise pulsed

5 Analysis provides clarity

If light flicker is suspected, the persons in charge should request the relevant data from the manufacturer. If this data is not available, a luminaire can be removed and sent to a specialised measurement laboratory. Such laboratories can be found in the register of experts published by the German Society for Lighting Technology and Lighting Design (LiTG).

It is often difficult to measure directly at the workplace, as external influences cannot usually be avoided there. However, it is worth ruling out interference in the building's power supply, as this can cause even faultless light sources to flicker.

6 Possible measures

In the case of fluorescent lamps, a three-phase circuit and electronic control gear can provide a remedy. In the case of LEDs, the remedy is not so simple. At critical workplaces (see quick check under 3.1), only constant current dimming may be used. In case of doubt, the persons in charge must replace the luminaires or have them replaced.

Literature

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List of figures

- Figure 1 – stevecoleimages-iStock
- Figure 2 – Cornelia Vandahl, TU Ilmenau
- Figure 3 – Cornelia Vandahl, TU Ilmenau
- Figure 4 – Jörg Block, illustrator

Imprint

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