Lighting

Ina Luckute Jessica Kodra

a) Basic Requirements for Light Sources (Lamps)

Before buying or designing a lamp, one should consider the following important factors:

What is the Energy Efficiency? The efficiency indicates how much light is produced per unit of energy; therefore, a lamp with a high efficiency reduces energy costs and environmental impact.

What is the Luminous Flux? It is the total light output measured in lumens. This should match the needs of the environment it is being placed in, e.g., a home or an industrial place

What is the Colour-Rendering Index? This measures how accurately a light source displays colours in comparison to natural light, measured on a scale from 0 to 100. For general use, a CRI of greater than 80 is recommended, but for critical tasks, a CRI of greater than 90 is preferable.

What is its Lifetime/Durability? For light sources, this is typically measured in hours (e.g., 15,000 to 50,000 hours for LEDs). A longer lifespan reduces waste and maintenance costs.

What is the Flicker and Glare Control? There should be minimal flickering in a good lamp, and the glare is what protects human health, especially in workplaces/offices.

What is its Environmental Impact? Is it made from non-toxic materials, such as mercury-free? Is it recyclable, and what was the resource consumption during production?

What is the Cost and Availability? Initial purchase cost vs. lifetime cost. This includes energy consumption and replacement frequency.

b) How to Estimate Important Parameters of Light Sources in a Laboratory

Whether a lamp is ‘good’ or not, the following tests can be performed:

- Photometric Testing:

Photometric tests help determine how much light a lamp produces and how it is distributed. The way it works is that an integrating sphere measures the total luminous flux which is the brightness of the lamp. At the same time, a goniophotometer is used to measure the angular distribution of the light. Evaluating how the light spreads in a space is important when considering the location of the light like in an office or street lighting

- Spectroradiometry:

This measures the spectral power distribution of a light source. From this, information such as the Colour Rendering Index and colour temperature can be calculated. They evaluate how well the lamp renders colour and if it gives a cool or warm tone.

- Lifetime Testing:

Lamps are operated continuously in controlled conditions to simulate long-term use to test how they will age. Its lifespan is determined when the output drops below 70%.

- Thermal Testing:

How hot a lamp can become in use is important as it can shorten its lifespan and damage components. This test assesses its thermal capabilities.

- Power Consumption Tests:

A test to measure the actual energy consumed is useful to determine how energy efficient the lamp truly is, whether it converts electricity to light effectively.

- Flicker Measurement:

Flicker meters or high-speed cameras tracks flickering. Even if not visible to the human eye, flickering can cause headaches, eye strain, and other health issues

- Environmental Tests:

Tests are made for high humidity, a range of temperatures, and mechanical vibrations. They show if a light source can perform reliably in real-world environments without failure.

Researchers and manufacturers determine the quality of a lamp by combining these tests.

c) Is There Still Room for Improvement? Future Research Directions

There is much research to improve lighting technology in the future, with a focus on enhancing efficiency without compromising the quality. Smart and adaptive lighting systems are being developed. These will work to automatically adjust the colour and temperature of the light based on its environmental conditions. There is also research being done on human-centric designs that support people's health by aligning with circadian rhythms and reducing eye strain. Sustainability is also a key focus, with research being done to create recyclable sources and using materials that are non-toxic. Advances in manufacturing, including the use of nanotechnology and new materials like quantum dots, aim to reduce costs and boost performance.

Conclusion

A lamp that is considered good is able to balance having a great efficiency with great light quality, takes into consideration the environmental impact, and user comfort. Laboratory testing ensures that lamps are meeting performance standards and are currently working to align lighting technology with sustainability, health, and innovation goals.