2.6

Controlling light

Luminaires have a number of functions. The first is to accommodate one or more lamps plus any necessary control gear. Mounting, electrical connection and servicing must be as easy and safe as possible.

The construction of the luminaires guarantees that the user is protected from contact with live components (electric shock) and that there is no danger of surrounding surfaces and objects overheating (fire prevention). Luminaires that are to be applied under specific operating conditions – e.g. rooms where there is a danger of an explosion, or damp or humid spaces – must be designed to meet the more stringent requirements. Besides these electrical and safety aspects luminaires also have an aesthetic function as an integral part of the architectural design of a building. It is equally important that the form and arrangement of the luminaires and the lighting effects are appropriate.

The third and perhaps most essential task the luminaire has to fulfil is to control the luminous flux. The aim is to produce a light distribution in accordance with the specific functions the luminaire is required to fulfil, utilizing energy as effectively as possible.

Even in the days of the first artificial light source, the flame, luminaires were developed to ensure that the light source could be mounted and transported safely. With the advent of considerably stronger light sources – first gas lighting and later electric lamps – it became more important to construct luminaires that could control luminance and ensure that the light was distributed as required.

Luminaire technology was first confined to providing a shielding element for the lamp and reducing the luminous intensity of the lamp by means of diffusing lampshades or canopies. This was one way of limiting glare, but did not control the distribution of the light, which was absorbed or able to scatter in undefined directions. You will still find this combination of lamp and lampshade today – especially in the decorative market – in spite of their being relatively inefficient.

The introduction of reflector and PAR lamps, which were used widely in the USA, marked the first step towards controlling light purposefully and efficiently. In these light sources the light is concentrated by the reflectors that form an integral part of the lamp and efficiently directed as required in defined beam angles. In contrast to luminaires with exposed lamps, the lighting effect was therefore no longer confined to the vicinity of the luminaire. It became possible to accentuate specific areas from almost any point within the space. The reflector lamp took on the task of controlling the light; the luminaire only served as a device to hold the lamp and as a means for limiting glare.

One disadvantage of reflector lamps was the fact that every time you replaced the lamp you also replaced the reflector, which meant high operating costs. Apart from that, there were only a few standardised reflector types available, each with different beam angles, so for special tasks – e.g. asymmetrical light distribution in the case of a washlight – there was frequently no suitable reflector lamp available. The demand for more differentiated lighting control, for enhanced luminaire efficiency and improved glare limitation led to the reflector being taken from the lamp and integrated into the luminaire. This means that it is possible to construct luminaires that are designed to meet the specific requirements of the light source and the task which can now be applied as instruments for differentiated lighting effects.

2.6.1 Principles of controlling light

Various optical phenomena can be used in the construction of luminaires as a means for controlling light:

2.6.1.1 Reflection

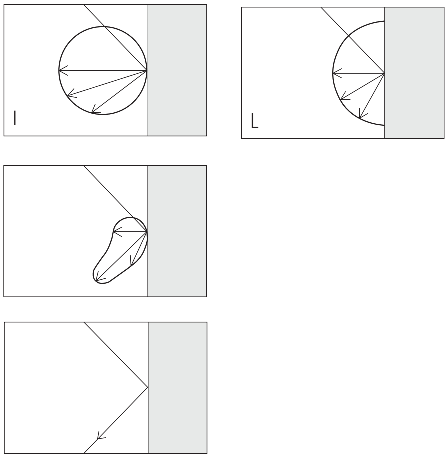
In the case of reflection, the light falling onto a surface is fully or partially reflected, depending on the reflecting coefficient of this surface. Besides reflectance the degree of diffusion of the reflected light is also significant. In the case of specular surfaces there is no diffusion. The greater the diffusing power of the reflecting surface, the smaller the specular component of the reflected light, up to the point where only diffuse light is produced.

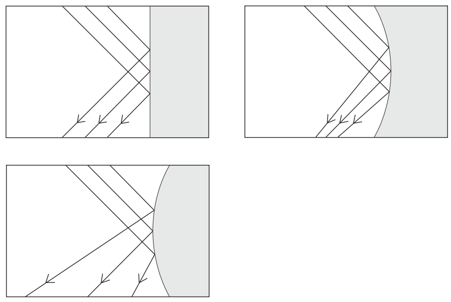
Specular reflection is a key factor in the construction of luminaires; the purposeful control of light can be achieved through specially designed reflectors and surfaces, which also define the light output ratio.

2.6.1.2 Transmission

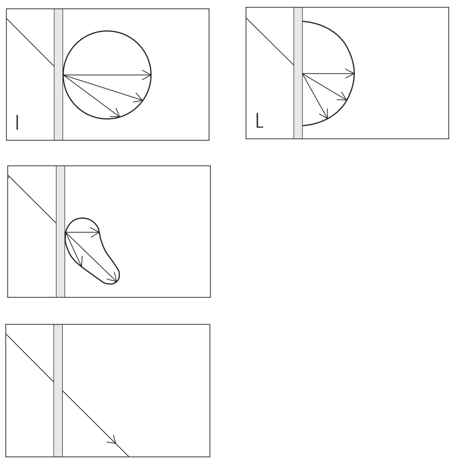
Transmission describes how the light falling on a body is totally or partially transmitted depending on the transmission factor of the given body. The degree of diffusion of the transmitted light must also be taken into account. In the case of completely transparent materials there is no diffusion. The greater the diffusing power, the smaller the direct component of the transmitted light, up to the point where only diffuse light is produced.

Transmitting materials in luminaires can be transparent. This applies to simple front glass panels, or filters that absorb certain spectral regions but transmit others, Luminous intensity distribution I (top left) and luminance distribution L (top right) in the case of diffuse reflection. The luminance distribution is the same from all angles of view. Luminous intensity distribution in the case of mixed reflection (centre) and specular reflection (below).





Specular reflection of parallel beams of light falling onto a flat surface (parallel path of rays), concave surface (converging rays) and convex surface (diverging rays).



Luminous intensity distribution I (top left) and luminance distribution L (top right) in the case of diffuse transmission. The luminance distribution is the same from all angles of view. Luminous intensity distribution in the case of mixed transmittance (centre) and direct transmittance through transparent material (below).

Reflection factor of common metals, paint colours and building materials.

Metals	
Aluminium, highly specular	0.80–0.85
Aluminium, anodised, matt finish	0.75–0.85
Aluminium, matt finish	0.50–0.75
Silver, polished	0.90
Copper, polished	0.60–0.70
Chrome, polished	0.60–0.70
Steel, polished	0.50–0.60

Paint finish	
White	0.70–0.80
Pale yellow	0.60–0.70
Pale green, light red, pale blue, light grey	0.40–0.50
Beige, ochre, orange, mid-grey,	0.25–0.35
dark grey, dark red, dark blue, dark green	0.10–0.20

Building materials	
Plaster, white	0.70–0.85
Gypsum	0.70–0.80
Enamel, white	0.60–0.70
Mortar, light	0.40–0.50
Concrete	0.30–0.50
Granite	0.10–0.30
Brick, red	0.10–0.20
Glass, clear	0.05–0.10