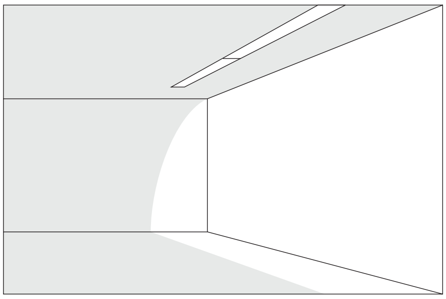

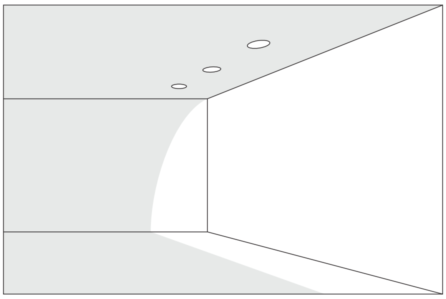

Wallwashers for fluorescent lamps (above) and halogen lamps (below). Uniform wall-washing can be achieved with the diffuse light produced by the fluorescent lamps or with the directed light from the halogen lamps.

3.3.1.1. Modelling and brilliance

Modelling and brilliance are effects that can be most easily achieved using directed light. Compact light sources are the most suitable, as their light intensity can be increased significantly by using reflectors.

The *modelling* of three-dimensional objects and surfaces is emphasized by the shadows and luminance patterns produced by directed light. Modelling is required when the material qualities emphasized (spatial form and surface structure) have an informative value - be it to check the quality of the material itself, for the lighting of a sculpture, the presentation of goods or the illumination of interestingly structured room surfaces.

Modelling can only be effected by directed light coming predominantly from one direction. To produce modelling effects it is therefore only possible using effectively point light sources, where the intensity of light is frequently increased using reflectors or other control systems. For this reason the first choice is compact lamps with rotationally symmetrical reflector systems. Linear light sources are not suitable for producing modelling, the longer the lamp, the less suitable it is, since the significant diffuse component lightens shadows.

If extremely dramatic modelling is required in confined areas low-voltage halogen lamps, which are very compact in form, are usually the most appropriate or, if increased luminous power is required, then metal halide lamps. To produce modelling effects there are a variety of compact lamp types which can be used: from general service lamps, reflector lamps and halogen lamps for mains voltage to high-pressure discharge lamps, whereby the modelling effect will inevitably be reduced as the size of the light source increases. Compact fluorescent lamps can produce a reasonable degree of modelling, e.g. when they are used in downlights. Conversely, linear fluorescent lamps produce predominantly diffuse light.

Brilliance is produced by points of light of extremely high luminance. These may be the light sources themselves, but brilliance is also produced when the light sources are reflected on glossy surfaces or when the light is refracted in transparent materials. Specular effects are frequently applied in display lighting or in prestigious environments to emphasize the transparency or sparkling quality of the illuminated materials to enhance their value or to create a festive atmosphere. Producing brilliance and specular effects demands more from the light source than producing modelling effects: it requires concentrated, practically point light sources. The sparkling effect depends predominantly on the lamp luminance. It is relatively independent of the luminous flux emitted by the lamp.
In contrast to lighting that produces modelling effects, brilliance does not require the light to be directed from one particular direction. It only requires the lamps to be point light sources. It is therefore not necessary to control the light using reflectors - exposed light sources can be used to create brilliance, in which case the light source itself and its effect on the illuminated material is perceived as being brilliant.

Low-voltage halogen lamps are primarily used for the creation of brilliance, as they are extremely compact light sources with high luminance. Metal halide lamps can also be used to produce brilliance, although their high luminous power may undermine the creation of specular effects because the overall environment is generally brighter.

Brilliance can also be produced by clear versions of halogen lamps for mains voltage. Larger light sources with light-diffusing surfaces, such as frosted incandescent lamps are less suitable, fluorescent lamps and compact fluorescent lamps not suitable at all.

3.3.1.2. Colour rendering

A light source can be said to have good colour rendering properties when there are only slight deviations in colour between a comprehensive range of colours illuminated by the lamp in comparison to a standardised reference light source of a corresponding colour temperature. Any statement made or data given on colour rendering therefore refers to a specific colour temperature. A colour rendering value that is valid for all luminous colours does not exist. Colour rendering is an important factor in lighting projects where it is important to be able to judge the quality and effect of colours, e.g. for matching colours, for the lighting of works of art or for the presentation of textiles. There are standards that stipulate the minimum colour rendering requirements for the lighting of workplaces.
The colour rendering quality of a light source depends on the composition of the specific lamp spectrum. A continuous spectrum provides optimum colour rendering, whereas line or band spectrums mean poorer colour rendering. The spectral distribution of the light is also of significance for colour rendering. Spectral distribution that differs from that of the reference light source will also have a deteriorating effect on colour rendering values due to the fact that only specific colour effects are emphasized.
The highest colour rendering index (Ra 100), i.e. colour rendering category 1A, is obtained from all forms of incandescent lamps, including halogen lamps, since they represent the reference light source

Colour rendering cat. Quality	Applications
1A Optimum	Textile, paint and printing industry Prestigious spaces Museums
1B Very good	Meeting rooms Hotels Restaurants Shop windows
2A Good	Administration buildings Schools Sales spaces
2B Acceptable	Industrial manufacturing plants Circulation zones
3 Adequate	Exterior lighting Warehouses
4 Low	Industrial halls Exterior lighting Floodlighting

Allocation of colour rendering categories in accordance with the CIE and the colour rendering qualities of lamps and their typical lighting tasks.

for the warm white range. De-Luxe versions of fluorescent lamps, plus some metal halide lamps have a colour rendering index above 90 and are classified as colour rendering category 1A. The remaining fluorescent lamps and metal halide lamps are classified as colour rendering category 1B or, as the luminous efficacy increases at the expense of colour rendition, fall into colour rendering categories 2A or 2B. High-pressure mercury and sodium lamps with enhanced colour rendering are classified at category 2B, with standard versions classified as category 3. Category 4 only contains low-pressure sodium lamps.

3.3.1.3 Luminous colour and colour temperature

Similar to colour rendering, the luminous colour of a light source is dependent on the spectral distribution of the light emitted by the lamp. In the case of incandescent lamps this distribution is a result of the temperature of the filament, hence the reference to colour temperature. In the case of discharge lamps, however, a comparative value must be used as a guideline - the most similar colour temperature.
In practice it is not customary to provide exact colour temperature data. Luminous colour is roughly categorized into warm white, neutral white and daylight white. Through the specific combination of luminous substances it is possible, in the case of discharge lamps, to create a further range of special luminous colours, which cannot be adequately described using colour temperature classification.

The luminous colour of a lamp affects the colour spectrum of illuminated objects. Warm white lamps emphasize the red and yellow ranges of the spectrum, daylight white the blue and green, i.e. cold colours. Luminous colour can be applied as a design factor for the presentation of objects which have defined colour ranges, for example. Some luminous colours are expressly blended for the presentation of specific types of articles. Luminous colour also affects our subjective appreciation of a lighting situation; colder luminous colours at high illuminances and from diffuse lighting are comparable to the light of the sky, warm colour appearances at lower illuminances in the form of directed light are comparable to candlelight and considered to be pleasant. Recommended luminous colours are included in the published standards for the lighting of workplaces.

Light sources with exclusively warm white luminous colour comprise all forms of incandescent lamps plus high-pressure sodium lamps. There are also fluorescent lamps, metal halide lamps and high-pressure mercury lamps available that are classified as being warm white. Light sources with neutral white luminous colour include fluorescent lamps, metal halide lamps and high-pressure mercury lamps. Daylight white light sources include fluorescent lamps and metal halide lamps. Fluorescent lamps are the only light sources available in special luminous colours. The luminous colour of a lamp can, in fact, be manipulated, either by providing the outer envelope with a special coating, as is the case for daylight quality incandescent lamps, or by applying a conversion filter.

3.3.1.4 Luminous flux

The luminous flux of a lamp is especially important if the number of lamps with which the lighting is to be created has been predetermined. It may be that the lighting is being designed using only a few high output lamps, or that a large number of low light output lamps are to be used. The objective is not to select a few lamps of average luminous intensity, but to vary between large and small "lumen packages". Low-voltage halogen lamps, conventional incandescent lamps and compact fluorecent lamps are examples of small lumen packages. Halogen lamps for mains voltage, fluorescent lamps and high-pressure discharge lamps have higher luminous power. Metal halide lamps have the highest values.

3.3.1.5 Efficiency

The efficiency of a lighting installation depends largely on the choice of lamps. The influence of other aspects, e.g. the choice of control gear and control equipment is of less importance. When selecting lamps on the basis of their efficiency there are a number of criteria that may be of primary importance, irrespective of the basic conditions inherent in the lighting task.

The *luminous efficacy* of a lamp is important when maximum luminous power, and illuminance, is to be achieved using a minimum of electric power. Incandescent lamps and halogen lamps have the lowest luminous efficacy at around 10-20 lm/w. The luminous efficacy of fluorescent lamps, high-pressure mercury lamps and metal halide lamps is higher at 40-100 lm/w. The exceptionally high luminous efficacy of sodium lamps (up to 130 lm/w in the case of high-pressure lamps) is achieved at the expense of colour rendering.

The *rated life of a lamp* is always important when maintenance of the lighting installation results in considerable expense or if conditions make maintenance difficult, e.g. in the case of particularly high ceilings or in rooms that are in continual use. The rated life of incandescent