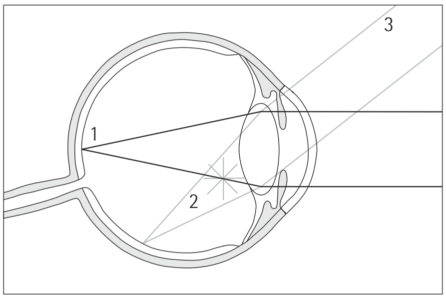
In the case of physiological glare the retinal image of the object being viewed (1) is superimposed by luminances that occur in the eye from the dispersion (2) of the light produced by a glare source (3).



2.5.3 Glare

An essential feature of good lighting is the extent to which glare is limited. There are two aspects to glare: the objective depreciation of visual performance, and the subjective disturbance felt by individuals through excessive luminance levels or stark contrasts in luminance levels within the field of vision.

In the case of objective depreciation in visual performance the term *physiological glare* is applied. In this case the light from a glare source superposes the luminance pattern of the visual task, thereby reducing visibility. The reason for this superimposition of the luminous intensities of visual task and glare source may be the direct overlay of the images on the retina. Superimposition of scattered or disturbing light, which arises through the dispersion of the light from the glare source within the eye, is often enough to reduce visual performance. The degree of light scattering depends primarily on the opacity of the inner eye. The latter increases with age and is the reason why older people are considerably more sensitive to glare.

The most extreme case of physiological glare is disability glare. This arises when luminance levels of more than 10^4 cd/m^2 are evident in the field of vision, e.g. when we look directly at artificial light sources or at the sun. Disability glare does not depend upon the luminance contrast in the environment. It cannot be eliminated by increasing the luminance level. Disability glare seldom presents a problem in architectural lighting. Here it is more a question of relative glare, whereby the reduction of visual performance is not caused by extreme luminances, but by high luminance contrasts within the field of vision.

If the glare source is not the cause of a reduction in visual performance, but merely a subjective interference factor the term *discomfort glare* is used. Discomfort glare occurs when an individual is involuntarily or unconsciously distracted by high luminance levels within the field of vision. The person's gaze is constantly being drawn away from the visual task to the glare source, although this area of increased brightness fails to provide the expected information. A glare source is also frequently referred to as visual noise, and as such can be compared with a disturbing sound that continually attracts our attention and undermines our perception.

Repeatedly having to adjust to various brightness levels and the distance between the visual task and the glare source eventually leads to eye strain, which is considered to be unpleasant or even painful. Although visual performance may objectively remain unchanged, discomfort glare can lead to a high degree of unease, which in turn will have an effect on the person's overall performance at his/her workplace.

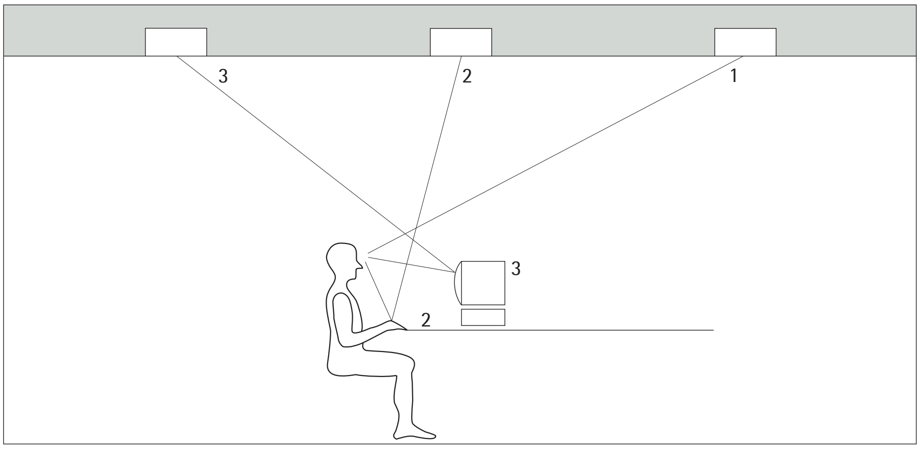
In contrast to disability glare, which can be explained irrespective of the specific situation as the exceeding of given luminance or luminance contrast values, discomfort glare is a problem that concerns the processing of information, which cannot be described out of context – the information content of the visual environment and the perceptual information we require in a given situation. Although there may be considerable luminance contrasts occurring within the field of vision, discomfort glare does not become a problem, if these contrasts are expected and provide valuable information, e.g. the sparkling light of a crystal chandelier or an appealing view out of a window. On the other hand, even slight differences in luminance levels can give rise to discomfort glare, if these contrasts overlay more important information and themselves provide no information; e.g. in the case of reflections on glossy paper, when we look at a uniformly overcast sky or at a luminous ceiling. Disability and discomfort glare both take two forms. The first is *direct glare*, where the glare source itself is visible in the field of vision of the visual task. In this case the degree of glare depends mainly on the luminous intensity of the glare source, its luminance contrast to the visual task, its size and proximity to the visual task.

The second form of glare is *reflected glare*, in which the glare source is reflected by the visual task or its ambient field. This form of glare depends on the abovementioned factors and the specular quality and position of the reflecting surface.

Discomfort glare caused by reflected light creates considerable problems for persons reading texts printed on glossy paper or working at computer monitors, as the eye is continually straining to accommodate to the visual task, which is at close range, and the distraction of the reflected glare source, which is located at some distance away.

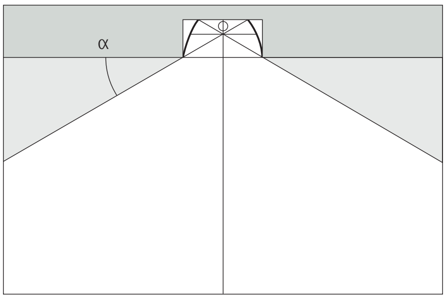
The evaluation of luminances and luminance contrasts that may lead to unwanted glare is predominantly dependent on the type of environment and the requirement that the lighting aims to fulfil. The rules that govern a festive or theatrical environment are entirely different from those for workplaces; what may be desired brilliance in one case may be considered to be unwanted glare in another. The predominant directions of view also play a significant role; lighting that may be glare-free for a person sitting upright in a chair may constitute glare if that same person leans back.

There is a set of formalised rules that apply to glare limitation in the field of lighting at workplaces; as a rule, they are

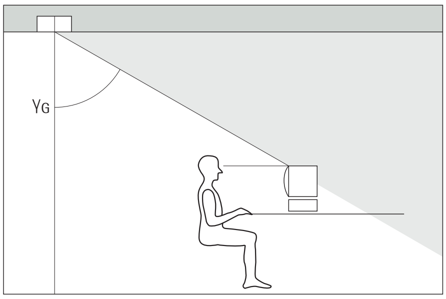


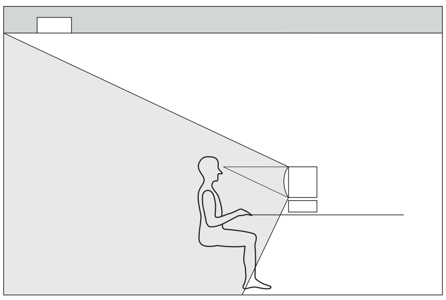
With regard to glare a distinction is made between direct glare, caused primarily by luminaires (1), reflected glare in the case of horizontal visual tasks (2) and reflected glare in the case of vertical visual tasks, e.g. at VDT workstations (3).

The luminance of luminaires that cause reflections on conventional computer monitors should not exceed 200 cd/m² above a critical angle γ_G. Normally γ_G values lie between 50° and 60°.



Glare limitation at VDT workstations: for areas with VDT workstations a cut-off angle α of at least 30° is recommended.





Luminance levels of walls that produce reflections on monitors should not exceed 200 cd/m² on average, or 400 cd/m² as a maximum. The reflection of windows on computer monitors should basically be avoided.

based on a person working seated at a desk with louvred luminaires providing the lighting. From the height of the sitting position and the preferred direction of view areas can be defined in which light sources will tend to produce the most glare. Apart from glare through windows glare is mainly produced by luminaires located in specific parts of the ceiling.

In the case of direct glare this is the area of ceiling in front of the seated person and perceived at angles lower than 45°. In the case of reflected glare, the glare is caused predominantly by luminaires located in the ceiling area directly in front of the person. Reflected glare on VDTs, that is to say on practically vertical surfaces, presents a special case. In this case glare is mainly caused by glare sources in the ceiling area behind the person. Glare can be minimised by reducing luminance contrasts – for example, by raising the ambient luminance or lowering the luminance of the glare source. Glare can also be avoided by suitably arranging the luminaire geometry. Continuous rows of louvred luminaires should not be installed cross-wise to the direction of view, for example, but parallel to the direction of view and between the workplaces.

Suitable glare limitation can be achieved by the correct choice of luminaires. Especially developed reflectors can guarantee that luminaires positioned above the critical angle do not produce any unacceptable luminances. By installing luminaires that emit only minimal direct light downwards can also make a substantial contribution towards limiting reflected glare.

In Germany DIN 5035 is used for the evaluation of glare limitation at the workplace. It describes a specific process for checking that limiting values between comfort and direct glare are not exceeded. The luminance of the installed luminaires is determined at angles of 45°–85° and entered in a diagram. Depending on the rated illuminance, the type of luminaires and the required visual compfort the lighting installation aims to meet, luminance limiting curves can be drawn on the diagram that are not to be exceeded by the luminance curve stipulated for the luminaire installed.

In the case of direct glare there is the quantitative method of evaluating luminance limiting curves. Reflected glare can only be evaluated according to qualitative criteria, however. For reflected glare in the case of horizontal reading, writing and drawing tasks there is a process that describes the degree of reflected glare in quantitative terms via the contrast rendition factor (CRF). The contrast rendition factor in this case is defined as the ratio of the luminance contrast inherent to a visual task under totally diffuse standard