Design Guidelines for Glare-free Daylit Work Environments

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Abstract
A strong focus on lighting quality and productivity as well as a renewed interest in energy efficiency in recent years has highlighted the lack of appropriate design guidance for architects, interior and lighting designers for creating glare-free daylit work environments, especially for offices. Well-developed design guidelines based on visual experience and careful monitoring of the design process from the start would likely go a long way in ensuring that daylit work environments are essentially glare-free. Extensive research on human vision and perception and innovation in architectural lighting design practice and technology have produced considerable opportunities for compiling a document aimed at providing useful design assistance for creating healthy and enjoyable work spaces. Work on a design guide is currently under way as part of the activities of the CIE Division 3 Technical Committee 3-39: Discomfort Glare from Daylight. It begins with the human visual senses and key parameters for describing and assessing visual environments. This paper outlines the approach taken and highlights the essential aspects considered.

Keywords: Office lighting, Daylighting, Lighting quality, Glare, Luminance-based lighting design

1. Office environments and daylight

Although wireless networks and similar technologies have partially eliminated the need to work in close physical proximity, office-based tasks remain important for a large sector of our workforce. All indications suggest that more new office buildings will be constructed. Others will be refurbished or refitted to upgrade existing environments. The majority will hopefully have windows as building occupants clearly prefer daylight as their source of illumination (1). The working population in most countries spends more and more time indoors. Most workers have little choice about selecting where they work. It is therefore important for designers to create high-quality working environments in which people like to work and can do so productively. Research clearly suggests that daylight provides added value with respect to amenity and satisfaction, productivity, well-being, comfort and health, desirability and marketability, as well as the potential for being more sustainable (2, 3, 4, 5 and 6). According to Fontoynont (7), standard daylighting techniques can provide light 3 to 20 times cheaper than electric lighting with best performances reached by daylight through roof apertures. His study so far has not addressed environmental impact and life-cycle analysis of lighting systems, but those factors could make daylighting even more attractive.

Current recommended practices clearly stress the impact of glare on occupant health, well-being and productivity. Most suggest assessment methods in the form of glare prediction formulae. Experts seem to agree that current prediction methods are far from reliable and suffer from significant flaws (7, 1, 8, and 9). Members of the CIE Technical Committee 3-39 and other researchers have in recent years attempted to provide new directions for establishing more suitable discomfort glare assessment methods for daylighting applications. While several new research approaches have produced promising results (e.g. 10, 11, 12, 13, 14, 15 and 16), validation studies are still needed to ensure these approaches are applicable to other settings than those under which they have been tested while conducting the research. Many currently available research publications and books provide lists of factors designers should consider when planning for glare-free daylit work environments. However, most designers struggle with finding relevant guidance for effectively addressing their concerns early in the design process and following up on assessing them again later in the design process. By the time sufficiently knowledgeable lighting experts get involved, the most influential design decisions have usually been made. For this reason, the Technical Committee 3-39 of the International Commission on Illumination (CIE) has proposed developing such design guidance and this work is currently under way.

2. High-quality, inspiring and sustainable architecture: Think qualitatively, act quantitatively

Whether it is a new construction or retrofit, any work environments should be of high quality and inspiring architectural design, support good occupant comfort and productivity, and use resources efficiently and sustainably. This cannot be achieved in isolation but requires effective coordination and communication between clients, design professionals, builders, regulatory bodies and other

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participants in the design process. Designers as well as clients today typically express strong commitment to daylighting design and to sustainability. Yet they might struggle with translating this desire into effective design criteria and decisions which achieve those goals.

Boyce suggests that high quality lighting allows you to see what you need to see quickly and easily in comfortable conditions while at the same time raising the human spirit (17). This highlights the realisation that visual comfort is more than just the absence of discomfort – much like good health is more than just the absence of illness. It needs to include a sense of well-being. A balanced diet and physical activity schedule are to health what a balanced lighting design scheme and visual aesthetics are to visual comfort and high quality lighting.

But defining good lighting quality is not without significant challenges. Boyce (17) states that any debate on lighting quality will invariably have to involve some agreement on underlying assumptions. One such assumption would have to be that there is significant similarity between individuals and between groups in their reaction to the same lighting conditions. If there is no such agreement, there would be little chance of ever being able to clearly describe the characteristics necessary for good quality lighting. For visual performance concerns, individuals generally respond to the same change in lighting stimuli in the same way, even if there are some differences between individuals. Results of visual comfort studies unfortunately show large differences between individual responses to the same changes in lighting conditions. As visual comfort is at least in parts influenced by aesthetics, and our sense of aesthetics varies over time and with our experiences, good lighting quality will remain difficult to define. In the absence of such clear definition, it is easier to concentrate on avoiding those situations known to cause bad lighting quality. Glare, a result of excessive luminance contrasts in the visual field, is one of these conditions, which needs to be avoided.

Most designers tend to think qualitatively and often provide vivid descriptions of their intentions. This is indeed especially desirable in lighting design as it is the visual environment which is at stake. Qualitative descriptions lend themselves to being “visualised”, i.e. being explored with a mental image of what the eye and brain might eventually see once the design is completed.

Initially, a designer might describe the purpose of a building or space, as well as the desired qualitative experience which a particular type of occupant who performs specific tasks in the space might have. The occupant and the tasks to be done in the space are important vehicles or parameters.

The more specific the description is about what the space might look and feel like to the occupant in relation to those tasks, the better. What are the spatial and material qualities of its architecture? What does the occupant see in his/her field of view? What is its visual impact and aesthetic? What are desirable distributions of light and shadow to support such impact and aesthetic? How do daylight and sunlight contribute to the experience? How likely will it be that shading is needed to prevent high luminance contrasts or thermal discomfort? Does the view include the outdoors? What can be seen? As part of the process, the designer agrees with the client and other involved parties on which qualitative ideas should be realised. Qualitative concepts and descriptors are necessary, but usually need to be translated into quantitative, i.e. measurable values, at some point. A design guide could suggest what to consider at the different stages of the design process and how to test whether the agreed upon qualitative descriptors will create the desired effects once converted into quantitative entities.

An effective design guide could start with presenting different lighting concepts based on visual images and perception, with linking qualitatively expressed architectural design ideas with the appropriate quantitative concepts and lighting design terminology, and with providing a compendium of simple and complex design tools aimed at assessing various design decisions. It would need to stress clear definitions for and consistent use of lighting terminology to ensure effective communication between the different professionals involved in the process. The design guide would aid them in defining a suitable approach and will provide criteria and observations for continuous assessment of design decisions against agreed aims (general qualitative statements of what is desirable) and objectives (specific quantifiable outcomes) by providing questions and potential avenues for addressing them throughout the design process from conceptual design to design development and into commissioning or even post-occupancy evaluation.

Design thinking is likely to be qualitative, design action quantitative.

Extensive explorations of the desired building attributes and human experiences as well as quantifiable measures of whether they have been achieved should be debated and agreed upon in as much detail as possible early on. The planning process for daylighting design should go hand-in-hand with this process. This requires providing sufficient and appropriate levels of daylight to allow the building to be resource-efficient and the occupants to be productive while at the same time permitting them to experience personal comfort in their surroundings. This includes the absence of glare.

The design guide would stress the need for setting daylighting design goals as part of the overall architectural concept at the very beginning of the project. Spelling out the benefits and opportunities of carefully weighing alternative architectural and daylighting solutions early in the design process will give designers and clients a clearer sense of direction. While it appears to be common knowledge that building orientation, layout, floor-to-ceiling-heights, and the placement of daylight openings in the building envelope, as well as the choice of daylighting and lighting technology, have the most profound effect on the daylighting performance of the interiors, other factors such as maximising the available floor area and reducing exterior surfaces for energy reasons at times override the daylighting considerations. Architectural trends – such as floor-to-ceiling glazing surfaces – often have significant impact on the success of a building's daylighting performance; unfortunately mostly in the negative direction as they frequently permit too much sunlight to enter the work spaces. That can lead to overheating and glare discomfort. Designers, owners and building users need to be aware of such impacts prior to making essential design decisions.

3. Critical issues for glare-free daylit environments

3.1 Balanced luminous surroundings

Appropriately balanced lighting is the most essential factor in designing for glare-free environments. What this means will depend on the situation. While existing lighting design codes and standards rely predominantly on illuminance-based recommendations and typically specify horizontal illumination levels, current qualitative thinking moves towards luminance-based lighting design as the eye responds to luminance differences, i.e. differences in brightness found in the visual field and in the space overall. In theory, the analysis of luminance ratios and distributions in different lighting scenarios allows the designer to carefully assess visual comfort conditions. The earlier such assessments occur, the better. Lighting scenarios can be virtual or "real". For the latter, both scale models and full-size mock-ups could be considered, depending on the complexity of the possible lighting solutions. Finding the right luminance balance for the different parts of the visual field observed when performing specific tasks is not a trivial undertaking. The designer needs to be aware of all the potential tasks to be performed in the space, where they are likely to be performed and who is performing them.

Daylighting conditions in a room and the associated view connections are key factors influencing an occupant's choice of workspace layout. Sharing a workspace with others will result in different layouts than having an individual space due to privacy needs and relationships with co-workers. This will likely result in very different luminance distributions in the visual field. For daylighting design, the most critical luminance relationships are those between the daylight opening, its immediately adjacent surfaces and the surfaces surrounding the work tasks. Understanding the geometry between sun, sky, daylight opening and interior space at different times of the day and throughout the seasons is the key to setting the stage for visual comfort. But placing the opening just right to achieve a good balance between views of the outdoors, visual comfort, thermal control and architectural integrity can be tricky. For visual and thermal comfort there might be some overlap, but this depends on the location and season. In winter, direct sunlight might contribute to warmth, but might at the same time create visual discomfort in the form of distracting patterns on the work plane or even glare. Where does the daylighting designer start? If visual comfort is the priority, then the next paragraph might come as a little bit of a surprise, as it is not the usual starting point. But it is certainly worth considering.

3.2 Adaptation luminance

An observer's adaptation luminance is probably the most important variable in any assessment of visual comfort. Cuttle (18, pp. 34-39) gives an excellent appraisal of the importance of adaptation luminance. It is essentially the average luminance across the whole visual field which an observer views and to which he/she is adapted. Without adaptation luminance there is no reference for the observer's response to a specific lighting condition and the comfort or discomfort he/she experiences.

Adaptation luminance (L_{adapt}) cannot usually be measured directly with simple and inexpensive instrumentation, but measuring the illuminance at the plane of the eye of an observer (E_{eye}) will lead to a very good approximation ($L_{adapt} = E_{eye} / \pi$). One should know that any given average luminance across the whole visual field might be created by many and very different luminance distributions. A reasonably uniform luminance distribution (e.g. as experienced when only viewing a completely overcast sky through a daylight opening) could result in the same average luminance across the visual field as a non-uniform distribution with some dark and some very bright patches of luminance (e.g. as experienced when viewing buildings and their differently reflecting surfaces as well as bright sky patches through a window). The associated visual comfort, however, will likely be very different, depending on size, luminance and location of individual surfaces or light sources in the visual field.

During daylight hours the adaptation luminance can vary substantially depending on the sky conditions and sun position as well as the resulting luminances on surfaces in the field of view. It can equally vary solely with movement of the eyes or the whole body from one viewpoint or space to another depending on the luminance levels experienced when viewing different surfaces. Adaptation is thus almost always somewhat transient. Adaptation to new lighting conditions also takes a little time, from a few seconds to several minutes, depending on the magnitude of the luminance shift. A fast shift from low to high luminance levels or vice versa, results in significant difficulty. This is well illustrated by glare perceived from bright headlights of an oncoming car at night. Our eyes, when adapted to the low luminance levels of the night-time road, are unable to handle the sudden appearance of the very high luminance levels presented by the headlights. The design of work environments can become very complex when the range of adaptation luminance levels varies substantially from one viewpoint to another, especially if view shifts occur frequently. Spatial luminance shifts should therefore occur gradually, allowing the eye to sufficiently adapt to the new visual conditions. For visual comfort to be achieved luminance ratios should also not exceed certain values. Typical recommendations assume a 1:3 ratio between the visual task and its immediate surroundings, a 1:10 ratio between the visual task and other more near surfaces in the visual field, and a ratio of 1:20 for the more distant surfaces in the visual field. A 1:40 ratio between the task and any surface in the field of view is generally seen as the maximum permissible. Studies of preferred luminance conditions in offices (e.g. 19), however, found that most workers actually preferred lower ratios. But an eye which views a bright sun patch while adapted to the luminance of a computer screen will experience ratios many times greater than the recommended ones. A luminance ratio of 1:3 is also perceived as a clear difference in brightness levels and helps in adding interest to a visual scene.

One design approach for visually comfortable spaces is to determine suitable adaptation luminance levels which in turn inform the range of suitable surface luminances in the field of view. Desirable adaptation luminance levels with reference to the tasks to be performed might thus become the base luminance levels for the space. For older building occupants, adaptation luminances should vary less as the eyes will be less able to adapt as quickly to new conditions. On the other hand, studies to date found no significant impact of age on preferred luminance conditions in office environments (19).

To consider appropriate adaptation levels in order to create comfortable visual conditions from the outset of a lighting design project, one might start with the horizontal illuminance levels created by a window at the location of the visual task at hand. Based on the reflectance values of the surfaces at or near the visual task and the illuminance levels, approximate surface luminance levels can be determined. These surface luminance levels could form the base levels for the expected range of adaptation luminance. The cubic illuminance measurements proposed by Cuttle (20) could perhaps be useful in this context, but they have not yet been applied to the assessment of discomfort glare.

Let us assume that a white sheet of paper (approximate reflectance of 75%) with 10 point text read under a diffuse horizontal illuminance of 500 lux on a dark blue table (approximate reflectance of 20%) from a reading distance of 40 cm (average surface reflectance in the visual field across paper and table top of approximately 60%) would result in an illuminance at the eye of 315 lux. Then the resulting adaptation luminance would be 100 cd/m^2. The luminance of the adjacent window surface (approximately 1 meter away and along the left side of the workstation) was measured at 2,475 cd/m^2. A common LCD screen for a laptop computer, for example, might have a maximum luminance of about 350 cd/m^2 when a white screen is displayed, and around 100 cd/m^2 when the standard MS

Windows XP-blue background is displayed. The luminance of the usually dark keyboard might only be 5 to 10 cd/m^2. Under very low illuminance levels, the luminance ratio between keyboard and screen would most certainly lead to visual discomfort as the LCD screen would become a glare source if the user tried to adapt to the keyboard luminance. For normal office task illuminance levels (300 to 500 lux) it would very likely be acceptable. Under such conditions it would likely also be comfortable to shift the view between a horizontal reading task on paper and an almost vertical reading task on the laptop computer's LCD screen. The view of a daylight aperture surface with a luminance of more than 2500 cd/m^2 would, however, most likely result in glare discomfort.

3.3 Surfaces, their size, location and luminance

As already alluded to, surfaces which might be in an occupant's field of view at any time during the performance of a (critical) visual task could affect visual comfort. The magnitude of this effect depends on their size, location and luminance. Bright surfaces attract attention and observers tend to be drawn to look at them even if there is no important visual information provided by such surface. It is therefore important to understand the possible ranges of luminance which particularly critical surfaces might exhibit. If recommended luminance ratios between the task and surrounding surfaces are exceeded, discomfort or even disability glare might result. Controlling such offending luminance ratios through effective daylighting design becomes essential, for example by altering surface reflectance values. In some cases electric lighting might be used to counterbalance excessive daylight in one area by increasing the illumination from electric light sources elsewhere, but the effect on energy use should be considered before taking this latter step. For glare control it is also advisable to keep luminances of vertical surfaces in the field of view near the window reasonably high as this lowers the potential for discomfort glare and in increases user acceptance of a space through creating a cheerful ambience. Harsh or striated patterns on walls and ceilings should be avoided. Luminance patterns should make sense in relation to the architectural, interior and lighting design of a space, i.e. they should reinforce the visual information in a scene. Confusing light patterns can result in loss of visual and mental harmony and lead to problems with spatial orientation.

The human eye has particular difficulty in dealing with high levels of luminance directly in the view region of the fovea. As a potential glare source moves towards the peripheral regions, the permissible luminance limit increases. Since most visual tasks require the worker to look straight ahead or slightly downwards, the high luminance of a vertical surface in or near the centre of the visual field is likely to be more uncomfortable than the luminance of the same magnitude from a horizontal surface at the same location due to the resulting apparent area. For daylit indoor spaces, Robbins (21, p. 236) suggests luminance limits for various angles of vertical displacement from a horizontal line of sight.

Table 1. Suggested luminance limits for glare sources at various angles of vertical displacement from a horizontal line of sight (according to Robbins, Ref. 21, converted from foot-Lamberts).

Angle of Vertical Displacement from Horizontal Line of Sight	Suggested Luminance Limit
45°	2570 cd/m^2
35°	1833 cd/m^2
25°	1284 cd/m^2
15°	856 cd/m^2
5°	582 cd/m^2

As a view of the sky or a bright ground plane (e.g. one covered in snow) through a window might give rise to luminance values in the field of view exceeding 10,000 cd/m^2, it is advisable to carefully consider how such a window might be shaded when discomfort glare occurs. Indoor room surfaces, partitions, furniture, luminaires and other equipment also impact on the overall visual experience of a building occupant and can alter the appearance of a space considerably from the originally planned design scheme. Their surface reflectance should be high, but not glossy, to keep contrast ratios between task and surroundings low. Occasional checks might be performed by knowledgeable lighting designers to provide information to workers when changes appear to have impacted negatively on the visual environment.

Research initiated by Schiler (22) and further developed by Osterhaus (14) suggests a simple method to assess the impact of potential glare sources based on luminance histograms of high dynamic range (HDR) images from digital cameras or computer simulations. Additional validations studies are planned, particularly in light of the work of Wienold and Christoffersen (13) which presents an opportunity to test the discomfort glare assessment technique via luminance histograms from a very large database of HDR-images, associated lighting measurements and corresponding subjective evaluations of daylit work environments. The analysis of these data might reveal further insight into appropriate luminance relationships.

3.4 View of outdoor environments

Providing an interesting and preferably multi-layered view of outdoor environments – including the sky – from a workplace is another factor designers should take to heart. Research clearly shows the benefits of interesting and informative views for worker health, well-being and productivity (4). Building occupants are also willing to commit additional financial resources to the provision of interesting views out and are willing to forgo some of their visual comfort in exchange for a view (1). Inappropriate initial design decisions might make it impossible to provide those views. When designing daylighting systems, it is important to recognise the impact of selected daylighting and solar shading devices on views under different operating conditions. On the other hand, a building occupant's desire to experience an interesting view might lead to the experience of discomfort glare. It is therefore advisable to separate the experience of this special view from the experience of the normal view of the visual task to be performed. Where possible, workstations should be placed in a way which directs the view of normal tasks at approximately right angles to the view out the window. Placing the daylight aperture so that the immediately adjacent surfaces have high luminance, e.g. by placing a window next to a wall perpendicular to the wall containing the window, helps in reducing glare problems. Some daylighting design guides recommend to avoid the direct view of the sky through a window as the sky typically exhibits the highest luminance values. Based on occupants' desire to receive information about the weather and to see the sky change throughout the day or season, this seems to be inappropriate. To reduce the impact of discomfort glare from the sky, a splayed reveal around the daylight aperture can be used. At the head of a vertical aperture, such reveal can also be illuminated by electric lighting or reflected daylight to reduce contrast effects between sky and wall surfaces (see also 21, pp. 244-245).

3.5 Solar shading and control

There is a large selection of solar shading and control devices available. It ranges from fixed to moveable, from exterior to interior, from manually to automatically controlled, and from tinted or coated glazing and simple roller blinds to laser-cut panels and anidolic (non-imaging) light-redirecting systems. Careful consideration needs to be given to the selection of shading devices to achieve the desired outcomes. Some shading devices might be useful in reducing direct sunlight on a desk and the glare which might arise from this, but might also create significant view obstructions. Anidolic systems require a separate view aperture and attention to the luminance levels at the indoor light exit point of the systems which typically are fairly high (23). Blinds, louvers and fins can be mounted internally or externally to reduce glare. If they are not adjustable or removable they will, however, reduce daylight penetration into the space even when discomfort glare is not a noticeable concern. Reducing the visible transmittance of glazing in conjunction with solar radiation control is typically not advisable as it also reduces daylight penetration and might lead to a gloomy space appearance. Control strategies for shading and glare avoidance need to be carefully considered. Automated control might annoy occupants when the system takes actions the occupants do not want. A good understanding of solar geometry, climate data and available solar control options is essential for the designer, especially when a view occurs in the direction of incoming direct solar beam radiation.

4. Proposed organisation of the design guide

Daylighting design has two main focal points: providing a high quality lighting environment which supports our visual performance, comfort, health and well-being but which also provides sustainable energy use through the reduction of electric lighting and heating or cooling loads. Daylight is the preferred choice of illumination, supplemented by electric lighting only when or where needed. The user of the glare-free daylighting design guide is urged to keep these goals in mind when deciding on suitable solutions for avoiding glare and increasing visual comfort. The proposed guide is based on a daylighting design approach which stresses the human visual senses and experience, and highlights the interrelationships between physical representation through quantifiable outcomes and the likely qualitative occupant experience. As such it supports luminance-based, rather than illuminance-based, design and assessment methods. Within that context, the design guide suggests which factors might be important and appropriate for a specific daylighting design problem. To help address the identified design problem, it provides a compendium of simple and complex design tools aimed at assessing various design decisions. The guide assumes that discomfort glare from daylight and from electric lighting will be assessed separately. If discomfort glare from both individual lighting systems is within allowable boundaries, it is also likely that the combined effect will be acceptable. It also makes reference to relevant publications to allow designers to delve deeper into the subject if they so desire. Designers will hopefully become better informed and able to respond to the needs of their clients.

4.1 Proposed design guide content outline

- Daylighting terminology, measurement metrics, instruments and how to use them to make meaningful measurements

  Research reports repeatedly describe difficulties in comparing research results from different studies and results from building performance evaluations due to a lack of common research or assessment methodologies and actual measurement protocols (19). It appears thus advisable to provide easy to use guidance on the appropriate terminology for daylighting design, on methodologies, and on which measurements to make for assessing visual comfort, as well as where and how in order to keep measurement errors as small as possible.
- Initial design considerations

  Along the lines of the topics discussed in this paper and in reference to relevant research findings, the design guide will provide useful starting points and suggest possible avenues to arrive at suitable qualitative and quantitative criteria for establishing initial design concepts for glare-free daylighting.
- Design development and appropriate assessment strategies

  It is highly advisable to begin making assessments of design choices as early as possible to avoid costly design revisions later on. Assessment strategies and tools will vary according to the level of detail provided and the complexity of the design parameters involved at a given stage of the design development.
- Interpreting design assessment results for refining the design scheme

  Discussions with design professionals reveal difficulties in interpreting results from the application of assessment tools, especially computer simulations. This is due in parts to a lack of having comparable data from other like projects and not being able to put the results from the simulation in question into perspective. The design guide attempts to provide useful ranges of suitable qualitative descriptions and appropriate quantitative values for these descriptions on the basis of built examples and research projects.
- Examples

  Designers typically engage in a pre-design precedent search providing inspiration and visual imagery, but also possible facts about the likely performance of such design precedents for the design task at hand. It seems therefore desirable to provide references to daylighting design projects for work environments which are known to function well with respect to visual comfort and some which exhibit serious impediments for comfort.
- Design tools and how to use them

  A section on advice for the application of the different tools available for assessing various design scenarios would assist designers selecting tools appropriate at a given design stage and what to keep in mind when using them.
- References and further reading

  Throughout the design guide, references will be provided to relevant research findings and literature which might allow the designer to enter deeper into the topics discussed. A listing of all of the literature cited in the design guide will be provided, preferably grouped according to key concepts as well as according to key words from the title or content of the referenced work.

5. Conclusions and further research opportunities

It still appears to be a significant challenge to provide a definite tool for the assessment of discomfort glare from daylight. What remains missing in the current understanding of discomfort glare, but also of other fields relevant to lighting quality, is a suitable set of dependent variables which can be used to measure and assess the desired outcomes of good (day)lighting design, the operation of the proposed underlying mechanisms, and peoples' perception of the lighting. Boyce (17, p. 79) has proposed that "by using multiple dependent variables, it should be possible to build up a consistent picture of the effects of lighting and the mechanisms through which they occur." Until then, it does indeed appear more useful to focus on avoiding glare, rather than attempting to define what good glare-free daylighting design should be. In 2005 the author of this paper and colleagues at UCL's Bartlett School of Graduate Studies have proposed to apply functional magnetic resonance imaging to advance the knowledge about the underlying principles in the perception and experience of discomfort glare (24). A project proposal by UCL along those lines has just received funding in the 2009 round. It is expected that results from this research will provide significant new knowledge for improving daylighting design decisions. Researchers at Lawrence Berkeley National Laboratory, in conjunction with experts on daylight glare from around the world, have applied for funding to develop a new test-bed facility to systematically study discomfort glare from large-area daylight apertures on the basis of samples of representative populations, internationally agreed methodologies and assessment/measurement protocols and attempt to provide useful links between old and new research projects and results. The discovery of a third photoreceptor in the ganglion-cell layer of the human retina and its link to the circadian system (5 and 25) is also expected to change some of the current paradigms surrounding daylighting design and in particular the specification of appropriate levels of illumination if they are to address additional aspects of health and well-being.

Acknowledgements

This work has been supported by the Aarhus School of Engineering (Denmark), the HafenCity University of Hamburg (Germany) and the Faculty of Science and School of Architecture at Victoria University of Wellington (New Zealand), as well as members of the CIE Technical Committee 3-39. Their assistance and feedback have been very valuable and are gratefully acknowledged.

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Design for Environment. Eco-efficiency and sustainability - G6 - issue 1. Design for Environment. Table of Contents.Â You can also find the ACADEMY Guidelines on www.airbus.com. I. What is Design for Environment? The design phase of most products is often determinant for their environmental performance throughout their life cycle, and the majority of a productâ€™s environmental impacts will be fixed during this phase A350. The environmental impact of products can be so significantly reduced through an optimised design. Design for Environment concept (DfE) is a way to systematically consider design performance with respect to environmental, health and safety objectives over the full product or process life cycle Design for the Environment (DfE) is a design approach to reduce the overall human health and environmental impact of a product, process or service, where impacts are considered across its life cycle. Different software tools have been developed to assist designers in finding optimized products or processes/services. DfE is also the original name of a United States Environmental Protection Agency (EPA) program, created in 1992, that works to prevent pollution, and the risk pollution presents to humans minimizing glare (with the obvious disadvantages of low daylight availability or view quality), this scheme provides an ideal baseline for comparisons, while it is also a realistic setting in cases of manual shading especially for instances of high direct transmitted illuminance. Â· Second, a typical shading control industry standard was utilized, aiming to maximize the use of daylight.Â An interesting opportunity for creating guidelines would be a correlation between a design value such as work plane illuminance (or a daylight metric, e.g., UDI, as suggested by Mardaljevic et al., 2012) and glare probability. Representative experimental results for March and April using the SB70XL glazing are shown in Fig.6a. 5. Conclusions and further research opportunities. Acknowledgements. Design Guidelines for Glare-free Daylit Work Environments. Werner Osterhaus.Â Well-developed design guidelines based on visual experience and careful monitoring of the design process from the start would likely go a long way in ensuring that daylit work environments are essentially glare-free. Extensive research on human vision and perception and innovation in architectural lighting design practice and technology have produced considerable opportunities for compiling a document aimed at providing useful design assistance for creating healthy and enjoyable work spaces.