Headaches. Eye strain. Near blurred vision. Blurred distance vision after performing near work. Light sensitivity. Eye irritation. Many of these vision-related symptoms are associated with demanding visual work—especially near-visual work (Sheedy, 1995). Within the last decade, the proliferation of computer use has increased the incidence of these symptoms among office workers, and research has focused on the relationship between modern office lighting and the visual health, satisfaction, and productivity of office workers. The American Society of Interior Designers reported that 68 percent of employees complain about office lighting conditions; a Silicon Valley study determined that 79 percent of visual display terminal (VDT) users requested improved lighting; and a Louis Harris survey, the Steelcase Office Environment Index, concluded that workers regard eyestrain as the primary office health hazard (Hedge et al., 1990).

Lighting for paper-based work vs. VDT work

Although VDTs for computers have been used in offices for several years, many questions still exist concerning the relationship among the machines, their environment, and their users. Historically, office lighting systems were designed for paper-based work. Such tasks as reading paper documents and writing by hand are accomplished on horizontal work surfaces, under and parallel to the plane of office lighting. Legibility for paper-based work relies on the relative luminance of characters against the paper. Reports of reflected glare problems for paper-based tasks are infrequent, unless a glossy paper is used. Repositioning the document solves that problem.

The geometry for VDT work, however, includes several variables that differ markedly from those for paper-based work. Consider the common desktop configuration for a computer workstation. Typically, computer screens are viewed in a plane more or less orthogonal (at right angles) to the plane of lighting. Additionally, the range of adjustment for screen position is much less than the almost limitless range for paper documents. Moreover, computer screens, unlike paper, generate luminous characters and/or backgrounds, so character visibility usually does not depend on adequate ambient illumination. In fact, high illumination levels as well as poor screen position relative to lighting position can create reflected glare problems (Hedge et al., 1995). The disparity between lighting requirements for paper-based work and those necessary for computer-based work creates a dilemma in offices where these working conditions must coexist. How can this problem be resolved and how can employees be provided with stimulating, attractive work environments that contribute to their health and safety?

Factors for office lighting

Before renovating an old lighting system, it should be assessed carefully. Workers’ complaints are often the impetus to renovate a lighting system. The following are some guidelines for assessing lighting complaints in the workplace:

- Are the complaints about specific features or the lighting system in general?
- Are complaints related to specific locations or tasks?
- How many people complain?

In general, the lighting system is likely to be at fault if
- complaints are from several people doing different tasks in different locations;
- complaints are from only one location but are made by people doing different tasks; or
- complaints are made by several people all doing the same task but in different locations (HS(C), 1987).

Whether renovating an existing system or choosing a design for a new one, several conditions contributing to proper office lighting should be considered:

**Visual impact.** The visual impact of an office space, which affects feelings of well-being, interest, and enthusiasm, greatly depends on the composition of light within it in terms of perceived luminance and color variations. One example of luminance variation used frequently is wall washing, a wall is subtly lighted at a greater luminance than ceiling or floor, generating a boundary in a large, open space. Local task lighting is another design technique offering dynamic visual impact and fulfilling functional requirements.

**Contrast.** Aside from creating a stimulating environment, some luminance variation or contrast is necessary for vision. Lack of luminance differences hinders a person's ability to interpret space configuration. Conversely, high contrast in luminance differences can be distracting and cause glare. Office interiors must strike a balance between these extremes.

**Luminance ratios and visual effects.** Luminance differences may be expressed by the ratio between one luminance and another. Luminance ratio influences three separate factors: transient adaptation, disability glare, and discomfort glare.

**Transient adaptation** refers to the photochemical reaction within the eye and pupil dimension adjustments to optimize the visual process. Transient adaptation occurs over a finite period which depends on luminance differences within the particular environment. For example, if luminance ratios vary radically within the visual scene, transient adaptation is slower. The eye's ability to respond in this manner deteriorates with age.

**Disability glare** can be caused when windows or luminaries within the visual field interfere with normal viewing processes, reducing visibility. This effect becomes more pronounced with age.

**Discomfort glare** is a sensation of annoyance or pain produced by high or inconsistent distribution of brightness in the field of vision.

Table 1 and the luminance illustration provide luminance ratio recommendations for limiting the effects of the previously described conditions (Illuminating Engineering Society of North America [IES] report, 1990).

**Reflectance.** Reflectance may be expressed as that proportion of the light falling on a surface that is reflected from the surface. If half the light is reflected, the reflectance would be 0.50 or 50 percent. Perception of luminance depends as much on surface reflectance as it does on luminance.

**Ceiling luminance limits.** VDT visual tasks often require an almost horizontal line of sight when viewing the screen. In large, open offices, considerable ceiling surface area may be in the field of view, therefore, limited luminance of the ceiling plane is necessary to preclude discomfort glare.

**Illuminance.** Illuminance selection depends on the visual task, room size, number of occupants, room surface reflectances, and workers' ages. The IES Illuminance selection procedure guidelines incorporate this range of values and prescribe luminance accordingly.

**Visual task.** When visual tasks are evaluated, luminance differences are measured and specified by contrast. The visibility of the details of a task is determined by its contrast with the background, its size, and the duration for viewing.

**Office lighting systems—what's available?**

Three major office lighting systems are in use in American offices today.

**Plastic lensed downlighting** was the standard office light system during the 1960s and 1970s. It may be found in new construction also. In the 1980s, **parabolic downlighting**—for ex-

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<table>
<thead>
<tr>
<th>Table 1. Maximum Luminance Ratios for Offices Containing VDTs*</th>
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<tr>
<td><strong>Ratios</strong></td>
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<tr>
<td>Between paper-based visual tasks and an adjacent VDT screen</td>
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<tr>
<td>Between a visual task (paper or VDT) and adjacent dark surroundings</td>
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<td>Between a visual task (paper or VDT) and adjacent light surroundings</td>
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<tr>
<td>Between a visual task (paper or VDT) and more remote dark surfaces</td>
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<tr>
<td>Between a visual task (paper or VDT) and more remote lighter surfaces</td>
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</table>

*The luminance of the VDT is taken as the average luminance of a character-filled screen.
optical system to distribute light over a greater area of the ceiling above the luminaria, producing a more even ceiling illumination and fewer screen glare problems.

**Results**

A pre- and post-renovation survey evaluated the reactions of office workers to two office lighting systems: a parabolic downlighting system and a ceiling-suspended, lensed-indirect uplighting system. Questionnaire data were collected on work content, perception of ambient environmental conditions (including office lighting), work-related health symptoms, job stress, job satisfaction, and self-reported productivity, and environmental data on illumination, air temperature, and relative humidity. The lensed-indirect lighting system was more favorably rated on several subjective lighting impressions scales, and for computer work, workers reported fewer screen glare problems and fewer and less frequent problems with tired eyes and eye focusing. Productivity was less hindered by the lensed-indirect lighting, and satisfaction with office lighting and rating of lighting quality were significantly higher for this system. These reactions were not associated with any differences in levels of illumination between the lighting systems. Ratings of lighting satisfaction and lighting importance were inversely related. Overall, some two-thirds of workers indicated a preference for working under the lensed-indirect lighting system.

**Conclusion**

Lighting appropriate for all tasks in the office workplace is essential to worker health, satisfaction, and productivity. This can be accomplished by paying careful attention to the office lighting system. In this way, employers can greatly reduce lighting-related complaints and increase the efficiency of their workers.
Additional questions?

For answers to specific questions on this topic, call Alan Hedge, Cornell University, 607-255-1957. For general information, call Lorraine Maxwell, Cornell University, 607-255-1966.

Christine Siney is gratefully acknowledged for her work on drafts of this factsheet.

References

Hedge, A., Sims, W. R., and Becker, F. D. Lighting the Computerized Office: a summary of the two-part study conducted by Cornell University, Department of Design and Environmental Analysis, Cornell University, Ithaca, N.Y. 1990.


Future topics

In Facilities Planning and Management Notes, we would like to address concerns of readers involved in the planning, design, and maintenance of facilities. Let us know what topics you'd like to see in future issues.

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