Advances in Industrial Ergonomics and Safety I
Edited by Anil Mital
Taylor & Francis 1989

THE DESIGN OF REST BREAKS FOR VIDEO DISPLAY TERMINAL WORK: A REVIEW OF THE RELEVANT LITERATURE

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Recent studies have demonstrated a daily accumulation of eye and musculoskeletal strain in video display terminal (VDT) workers which is not eliminated by the use of high quality workstations or conventional rest break schedules (e.g., Zwahlen et al., 1984; Schleifer and Amick, 1988). These types of observations have prompted calls for limitations on the period of continuous VDT work. For example, the Swedish National Board of Occupational Safety and Health has suggested an upper limit of 1-2 hours of continuous VDT work. While the logic for such recommendations is substantial, there has been little empirical study of the effects of increased rest breaks, or shortened work periods, in VDT work. There is, however, an extensive literature on the design of rest break schedules in light, repetitive (industrial) work. This literature has been largely ignored in discussions regarding rest break design in VDT work, but is highly relevant since the tasks studied share common stress factors with VDT work (e.g., constrained static postures and the need for continuous attention).

Presented below is a synopsis of the literature on rest breaks in light, repetitive work and of the less developed literature specifically examining rest break effects in VDT/office work. This synopsis is organized in relation to the two main considerations in the design of rest breaks in VDT/office work: i.e., break frequency/duration and content.

BREAK FREQUENCY AND DURATION

Research by the (British) Industrial Fatigue Research Board (IFRB) was the first to demonstrate the benefits of increased rest breaks. Studies conducted by this group showed that productivity increased in assembly tasks when mid-morning and mid-afternoon rest breaks were introduced into the workday (Vernon and Bedford, 1924; Wyatt, 1927; Wyatt and Fraser, 1925). More recently, a study of clerical workers by Bhatia and Murrell (1969) found that 10-minute hourly breaks were favored by the workers, and produced greater productivity gains in comparison to more infrequent 15-minute breaks. Similar effects were shown in a VDT task by Horie et al. (1987). These findings are consistent with conventional wisdom that short, frequent breaks are preferable to longer, more infrequent breaks (Rohmert, 1973).

Additional support for hourly breaks is provided by studies of VDT work which indicate that single, mid-morning and mid-afternoon breaks may have negligible effects (Delvolve and Quennec, 1983; Schleifer and Amick, 1988; Zwahlen et al., 1984). Furthermore, a study by Floru et al. (1986) points to the efficacy of short, hourly breaks in routine VDT work. In this study, 5-minute breaks inserted after a 40-minute period of work were effective in eliminating performance decrements which normally occurred after that period.

Muscle fatigue studies suggest the need for even more frequent breaks in VDT work. VDT work is often characterized by constrained postures and static loads. Two studies (Waersted et al., 1986; Kogi, 1982) reported, respectively, sustained forces reaching 6 and 20 percent of maximum voluntary contraction (MVC) in keyboard tasks. However, data suggest that forces greater than 10 percent MVC cannot be sustained for more than 10-15 minutes without perceptions of fatigue (Bjorksten and Jonsson, 1977).

The need for short, frequent breaks in repetitive VDT work is also suggested by extrapolation from trends in VDT users' discomfort ratings over the workday. An algorithm (yet to be empirically tested) developed by Zwahlen and Adams (1987) predicts that six, 12-minute breaks will prevent musculoskeletal discomfort from exceeding the "quite-a-bit" threshold for 99 percent of the VDT population (for the repetitive task upon which the model was developed). Regarding the frequency of breaks, however, a cautionary note is in order. Too frequent breaks can interfere with work rhythms (Rohmert, 1973), and may increase costs due to disruptions in production.

It is sometimes advocated that workers be given self-discretion in the control of both break duration and frequency. However, the limited number of empirical studies in this area argue against this proposition. When breaks are self-regulated, there is a tendency to work beyond the appearance of performance decrements, or to terminate breaks before recovery is complete (Murrell, 1971; Henning, 1987).

BREAK CONTENT

Productivity gains have been shown when activity or task changes are substituted for rest breaks (Bennett et al., 1974; Miles and Skilbeck, 1944). More recently, attention has turned to the potential benefits of exercise during VDT work. While research in this area is limited, a number of studies suggest that exercises are valuable in reducing acute discomforts (Laporte, 1966; Lee and Humphreys, 1985; Winkel and Jorgensen, 1986) and possibly even chronic disorders (Ferguson and Duncan, 1976) associated with VDT work, or other keyboard work.

CONCLUSIONS

Although more research specific to VDT work and associated health outcomes is needed, the existing literature strongly suggests that frequent rest breaks would benefit both productivity and comfort in VDT work.

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Controlling Glare Problems in the VDT Work Environment

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The introduction of video display terminals may exacerbate lighting problems already present in the workplace. The sources and characteristics of glare are described. Glare control measures, including the location and design of lighting systems, managing outdoor light and using screen filters and hoods, are reviewed.

Many office workers enjoy using a video display terminal (VDT). This new office technology enables them to accomplish in a matter of seconds or minutes what may have formerly required several hours using a conventional typewriter or business machine. In addition to the promise of reduced effort and increased productivity, the use of a powerful computerized device such as a VDT can give office workers a renewed sense of importance and job satisfaction.

Along with the apparent advantages of using a VDT in office tasks, however, there are some difficulties. Particularly troublesome are lighting problems in the VDT workplace. For example, a bright overhead light fixture or sunlight streaming through an office window are potential sources of visual discomfort for the VDT user. Annoying reflections from the screen of the VDT are another common problem.

While lighting problems are often present even in traditional office environments, the introduction of the VDT has increased the potential for such problems. The purposes of this paper are to help the office worker understand the causes of glare and other lighting-related problems that may occur when VDTs are used, to explain the adverse effects of glare on vision and eye comfort, and to offer practical suggestions for preventing such problems.

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A Review of Related Research

A number of field investigations indicate that glare is a rather common problem in offices where VDTs are used on a regular basis. One of the first investigations indicating this problem was a 1974 Swedish study by Hultgren and Knave[1] showing that most of the operators surveyed complained of glare from windows and ceiling lights, and also reported eyestrain symptoms such as stinging and sore eyes.

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In a San Francisco study of VDTs undertaken by the National Institute for Occupational Safety and Health (NIOSH),[2,3] windows and light fixtures were found to be potential sources of glare at 46 of 53 workstations surveyed. Additionally, screen reflections from windows and overhead light sources were present at most of the workstations. A questionnaire survey of VDT users in these offices found that glare was one of the most common complaints, with 80 percent of the individuals reporting being bothered by glare at least occasionally.

Results from a NIOSH-funded study[4] by the University of Wisconsin of several hundred state government VDT users revealed that 67 percent were found to be bothered by screen glare at least occasionally. Screen glare was also found to be a significant predictor of visual discomfort.

In a study of 905 VDT users at New York State office facilities,[5] NIOSH investigators found that 31 percent of the survey participants rated lighting conditions as producing "much glare" and 42 percent were bothered by screen glare.

Overall, these studies suggest a recurring pattern of discomfort from lighting problems in VDT workplaces.

SOURCES OF GLARE PROBLEMS

Light Measurement

Lighting terms can be technical and confusing. It may therefore be helpful at the outset to provide a brief explanation of lighting concepts and terms. ***Illumination*** refers to the amount of light that falls on any surface, such as a desk, table, or document holder. It is usually illumination that is measured when the sufficiency of light in a room or office is assessed. Illumination is measured in units called footcandles (ft.c, English system) or Lux (Lx) in the metric system. One footcandle is approximately ten Lux.

Luminance refers to the amount of light emitted or reflected from any surface—for example, a light fixture, lampshade, or sheet of paper. It is the luminance of an object to which we are referring when we speak of the brightness of an object. Luminance is measured in foot-Lamberts (ft.L, English system) or candles per square meter (cd/m^2) in the metric system. One foot-Lambert equals approximately 3.5 cd/m^2. Note that simply increasing or decreasing the illumination in a room by adjusting the power of a light fixture will not necessarily affect the brightness of all objects in the room in the same way. If objects do not reflect much light (for example, a dark carpet) they will not appear very bright regardless of how much light falls upon them. The luminance of an object is determined by both the amount of light falling upon it and its reflectance (ability to reflect light).

Concept of Glare

Glare is produced by light sources within the field of vision that are of a higher luminance than other objects to which the eyes are adapted. Glare is experienced as a feeling of discomfort or annoyance, or as a reduced ability to discern objects in the visual environment. The latter effect is usually referred to as "disability glare," the former as "discomfort glare." The blinding effect of headlights from an oncoming automobile is a good example of disability glare. The annoying effect of headlight reflections in the rear view mirror is a good example of discomfort glare. Discomfort glare is the most common glare problem in the office environment. A light source cannot cause disability glare unless it is almost directly in a person's line of sight.

A distinction is usually made between "direct glare" from sunlight or a lighting fixture, and "indirect glare" due to reflections from a video screen or glossy surfaces such as a desk, floor, or keyboard. The extent to which direct or indirect glare is a problem depends primarily on the brightness of the light source and how close it is to the line of sight. The closer it is to the line of sight, the less bright it has to be to cause a problem.

Direct Glare

While sources of direct glare are present in any office environment, the presence and use of a video display terminal increase the likelihood of problems caused by direct glare. Instead of looking down at work materials on a desk, the VDT user gazes horizontally at the video screen. Thus direct glare sources such as overhead lights and windows are closer to the line of sight. (That is, they are more likely to be visible to the VDT user as he or she looks at the screen.) In addition, the amount of light required in a VDT work environment is generally somewhat less than that needed in a conventional office. VDTs do not require light from a direct source as does paper. On the contrary, the objective is to prevent light that can cause screen reflections or obscure the text that is displayed. With the eyes adjusted to a somewhat darkened workstation, extra caution is needed to ensure that other objects in the field of view (including the document from which the person is working) are no brighter than need be for adequate visibility, so that they do not glare.

As indicated, one potential source of direct glare in the VDT workplace is unshielded windows. In many cases the windows are left bare in order to supplement ambient lighting or to afford the worker a pleasant view. Unfortunately, the relatively high luminance of sunshine can produce considerable glare for the VDT user.

Another common source of direct glare is the overhead lighting fixtures (called luminaires). The type, location, and luminance of overhead fixtures are important factors to consider. Bright fixtures that are unshielded and located close to the line of sight of the VDT user are very likely to produce visual discomfort.

There are a number of mathematical formulas for quantifying glare levels. A detailed discussion of these formulas is beyond the scope of this article. It should be noted, however, that a purely physical approach to assessing glare or glare potential may not be adequate. Factors such as individual motivation and interest in the task seem to play an important role in whether or not glare is reported.

Indirect or Reflected Glare

Indirect glare (reflection) is probably the most common lighting-related problem for VDT users. Indirect glare occurs when light from bright objects such as light fixtures is reflected from smooth or glossy surfaces, such as highly polished floors, table tops, or VDT screens, into the eyes of the VDT user.

Reflected glare from the VDT screen can be in the form of either a "specular" or a "diffuse" reflection. A specular reflection is a mirror-like reflection in which a sharp image such as the keyboard is reflected from the screen back to the operator. Specular reflections are caused by light from an object reflecting off the smooth glass surface of a VDT screen.

The fact that the VDT screen is slightly convex means that troublesome reflections can result from objects at wide angles to the screen. The common practice of tilting the VDT slightly backwards increases the opportunity for bright reflections from ceiling fixtures.

Diffuse screen reflections do not result from light reflected from the front glass surface of the VDT, but rather from light that penetrates the glass and is reflected off the phosphor layer behind the glass. (It is the phosphor that glows to produce the VDT image.) Because the phosphor layer is rather rough, light is scattered as it reflects back to the operator. No clear reflected image can be seen. Rather, when light is reflected off the VDT, the background of the VDT image simply appears brighter. Diffuse reflections are sometimes called "veiling" reflections because when they occur it appears that a veil of light is cast over the image.

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Screen reflections can be disturbing to the VDT user for two reasons. First, a specular reflection can be simply annoying. More commonly, both specular and diffuse screen reflections reduce the contrast in brightness between the characters appearing on the screen and the screen background. That is, light reflected from the screen washes out the characters and makes them difficult to see.

Beyond the VDT screen, there are numerous other surfaces in any office that can reflect glare, including walls, floors, worktables, the document from which one is working, and the stand on which the document is placed. However, the major source of reflected glare in the VDT workplace is the VDT screen.

Glare Sensitivity and VDT User Characteristics

In general, older individuals require more light to see clearly. But increasing the amount of light in the environment increases the opportunity for glare or reflections. Compounding the problem is the increased scattering of light that occurs in the eye of older persons, making glare sources more intolerable. Hence, extra care must be taken in the design of lighting systems in VDT workplaces for older VDT users to provide sufficient light yet prevent glare.

GLARE CONTROL MEASURES

Lighting System Design

There are a number of concrete actions that can be taken to prevent or alleviate problems with glare or reflection. The most desirable means of controlling glare is through proper design of ambient lighting systems. In this regard, the design, location, and amount of light produced by overhead fixtures are critical. In general, the potential for glare and reflection problems is minimized by reducing the level of ambient illumination. While there are no hard and fast rules for specific lighting levels, maintaining the level of light within a range of 200 to 500 Lux should help control reflection and still ensure sufficient light to perform most office tasks. However, as the level of light falls below 500 Lux, supplemental lighting of documents at the VDT workstation may be necessary.

It is helpful to cover the bulbs of overhead fixtures with diffusing lenses, thereby scattering the light and preventing sharp glare sources. However, the lenses most commonly used for this purpose do little to prevent light from reaching the eye or VDT screen. To the extent possible, the fixture should be designed so that it does not project light horizontally into the VDT screen or eye of the operator. Therefore it is preferable to use "baffles" or "parabolic louvers" (which are fitted below fluorescent fixtures) rather than diffusing lenses since the former direct most of the light downward.

The use of indirect lighting systems eliminates the sources of concentrated glare, but the wide reflections off the walls and ceilings can result in stray light reaching the VDT and causing diffuse reflections from the screen. Therefore, it is also important that highly reflective (that is, bright, glossy) surfaces be minimized in the VDT workplace.

Overhead lights should always be positioned so that they are not in the user's field of vision as he or she gazes at the screen. In addition, placement of a lighting fixture directly behind or above the workstation also should be avoided since light may then reflect off the screen or desk top into the VDT user's eyes. A better placement is off to one side of the workstation and as high as possible.

Windows

While many people prefer natural light over artificial light, excessive reliance on windows for office lighting can create problems. If the intensity and angle of sunlight coming through an unguarded office window is not controlled, it is likely that troublesome glare and reflection will result. There are a number of steps, short of removing the windows, that can help minimize these problems. Office windows can be equipped with blinds, drapes, or other shielding devices that control the flow of sunlight. The blinds or drapes should be easy to operate. Several small sections of drapes or blinds are preferable to fewer larger units because the former can more readily accommodate the varying lighting needs and preferences of all the people in the room. Vertical blinds are especially useful since they can be adjusted to prevent light from reaching one workstation while allowing someone else to see out.

VDT Workstation Placement

Proper placement and orientation of the video display unit is one of the simplest ways to reduce glare and reflection. As mentioned, the display unit should be positioned so that no source of bright light will enter directly into a VDT user's line of vision as he gazes at the screen. For example, where windows are present the video display unit should be placed so that the user's line of sight is parallel to the window pane (in other words, the VDT screen is perpendicular to the window). Also, a VDT should be placed so that the path of the user's gaze is parallel to and between rows of overhead fixtures. Screen reflections from any light fixtures directly behind the workstation can be minimized by tilting the display unit downward (or slightly toward) the operator. Finally, the use of office dividers or other types of barriers placed around the VDT workstation can help reduce direct and indirect glare.

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Screen Filters

Filters placed in front of the VDT screen can be very effective in controlling reflections from the screen. One very common type of filter is the "neutral density filter." This filter reduces reflections from the screen phosphor (which are diffuse reflections) by filtering the light as it passes through the filter on the way to screen, and again as the reflected light passes back through the filter toward the operator. Though light from the glowing phosphor also passes through the filter, the image should be easier to see than the reflected light, since the reflected light is filtered twice and the light from the text on the screen is filtered only once. Hence, use of this filter should actually make the text look brighter against the screen background.

On the other hand, the neutral density filter is not effective in controlling specular reflections from the glass surface of the screen faceplate. Such reflections can be reduced by etching the surface of the faceplate or by coating it with a substance that absorbs the light causing the reflection. Neutral density filters are commonly etched or treated in this way, and thus can be highly effective against both specular and diffuse reflections.

One common filter, called a "micro-mesh" filter, helps control both specular and diffuse reflections. This type of filter is comprised of a mesh or honeycomb of nylon fibers that prevent ambient light coming toward the display at a wide angle from passing through to the VDT screen, and thereby reduce bothersome reflections. However, by the same principle, the mesh gridwork can also diminish the legibility of characters on the screen when it is viewed at an angle.

Another type of filter that is highly effective in reducing specular and diffuse reflections is the

"Another simple way to reduce reflection is to place a hood around the screen."

"circular polarizing" filter. The function of this type of filter is difficult to explain in a few words. Suffice it to say that it blocks light in a fashion somewhat similar to the way in which polaroid sunglasses work.

Unfortunately, all filters and screen treatments have drawbacks. Screen or filter coatings can be scratched and produce reflections from finger smudges. Etched surfaces can make characters a bit blurry. Filters that block reflections from the screen also dim the characters a bit. Careful trial and error is a good means of selecting a filter. Many variations of these types of filter are available. The best solution will depend a great deal upon the particular glare problems in a specific workplace.

Hoods

Another simple way to reduce reflection is to place a hood around the screen. Hoods can range from makeshift cardboard flaps to commercially-available devices that attach to the top and sides of the screen. One problem in using a hood is that it may cast shadows on the screen. Also, the hood must be installed in such a way that it does not require the VDT user to adopt an awkward posture when sitting at the terminal.

CONCLUSION

In most places where VDTs are in use, steps will need to be taken to bring glare and reflection problems under control. Many of the control measures described here may be necessary; the most appropriate steps will vary from situation to situation. Do not rely upon any solution or complement of solutions until it is tested in a specific workplace and found effective.

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Part II

NIOSH Bibliography on Video Display Terminals

A. NIOSH-AUTHORED DOCUMENTS

1. NUMBERED PUBLICATIONS

NIOSH numbered publications document the results of NIOSH research. Included in this category are Criteria Documents, Current Intelligence Bulletins, Alerts, Health and Safety Guides, technical reports of scientific investigations, compilations of data, work-related booklets, symposium and conference proceedings, and NIOSH administrative and management reports. The following numbered publications on video display terminals (VDTs) are listed alphabetically by title.

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NIOSH PUB NO: 97-148. 14 pp.
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(Full text included in Part I.)

Potential Health Hazards of Video Display Terminals, *1981*.
NIOSH PUB NO: 81-129. 75 pp.
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A Report on Electromagnetic Radiation Surveys of Video Display Terminals, *1977*.
NIOSH PUB NO: 78-129. 27 pp.
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2. TESTIMONY

NIOSH testimony consists of both written comments and oral testimony presented before Congressional committees and at hearings convened by regulatory agencies. The following list of NIOSH testimony on VDTs is arranged in reverse chronological order.

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Millar JD [1984]. Congressional testimony, Subcommittee on Health and Safety, Committee on Education and Labor, U.S. House of Representatives, May 15. 11 pp.
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3. JOURNAL ARTICLES, BOOK CHAPTERS, and PROCEEDINGS

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4. HEALTH HAZARD EVALUATIONS (HHE)

HHE reports are the results of requests from employees, employee representatives, or employers to NIOSH to determine if a hazard exists in the workplace. Each report examines conditions at a specific worksite(s). HHE reports can also be designated as hazard evaluation and technical assistance (HETA) reports, government hazard evaluations (GHE), mining hazard evaluations (MHE), or technical assistance (TA) reports. The following HHE reports on VDTs are list alphabetically by company or agency name.

Appalachian Laboratory for Occupational Safety and Health, Morgantown, WV, April 1983.
GHE No. 81-429-1299. 29 pp.
NTIS NO: PB84-210822 A03

AT&T, Southern Bell and United Telephone, NC, May 1986.
HETA No. 85-452-1698. 17 pp.
NTIS NO: PB87-105458 A03

Baltimore Sun, Baltimore, MD, July 1983.
HETA No. 80-127-1337. 164 pp.
NTIS NO: PB94-207776 A08

Blue Cross of Northern California, Oakland, CA, March 1983.
HETA No. 82-247-1280. 12 pp.
NTIS NO: PB84-210400 A03

Blue Shield of California, San Francisco, CA, January 1980.
TA No. 79-060-843. 64 pp.
NTIS NO: PB84-242775 A04

British Airways, Kennedy Airport, Jamaica, NY, August 1983.
HETA No. 82-100-1349. 14 pp.
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General Telephone Company of Michigan, Alma, MI, July 1985.
HETA No. 84-297-1609. 19 pp.
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Library of Congress, Washington, DC, March 1992.
HETA: 91-070-2194. 25 pp.
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Los Angeles Times, Los Angeles, CA, January 1993.
HETA: 90-013-2277. 126 pp.
NTIS NO: PB93-188456 A07

Midwest Stock Exchange, Chicago, IL, February 1979.
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Narragansett Electric Company, Providence, RI, October 1981.
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NTIS NO: PB91-116251 A05

North Clackamas School, District No. 12, Milwaukie, OR, July 1983.
HETA No. 83-014-1343. 14 pp.
NTIS NO: PB85-102903 A03

Oakland Tribune, San Francisco, CA, 1980.
TA No. 79-061-844. 56 pp.
NTIS NO: PB84-241801 A04

Ruan Transport Corporation, Des Moines, IA, January 1986.
HETA No. 85-434-1655. 17 pp.
NTIS NO: PB86-221595 A03

San Francisco Newspaper Agency, Chronicle and Examiner, San Francisco, CA, January 1980.
TA No. 79-062-845. 68 pp.
NTIS NO: PB82-172164 A04

Social Security Administration, Baltimore, MD, January 1983.
HETA No. 82-329-1246. 26 pp.
NTIS NO: PB84-173822 A03

Social Security Administration, Teleservice Centers, Boston, MA and Fort Lauderdale, FL, September 1994.
HETA: 92-0382-2450. 25 pp.
NTIS NO: PB95-169868 A03

Southern Bell, Atlanta, GA, August 1984.
HETA No. 83-329-1498. 21 pp.
NTIS NO: PB85-208379 A03

St. Louis Post-Dispatch, St. Louis MO, February 1994.
HETA 93-0969-2389. 18 pp.
NTIS NO: PB94-171873 A03

U.S. West Communications, Phoenix, AZ; Minneapolis, MN; and Denver, CO; July 1992.
HETA 89-299-2230. 61 pp.
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United Airlines Corp., San Francisco, CA, June 1975.
HHE No. 74-116-202. 16 pp.
NTIS NO: PB-249382 A03

USA Today/Gannett Co., Inc., Rosslyn, VA, April 1990.
HETA No. 89-069-2036. 38 pp.
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5. MISCELLANEOUS REPORTS

Miscellaneous reports include all other NIOSH-authored documents not included in the previous four sections.

Arndt R, Sauter S, Dainoff M, Helander M, Kromer K, Snyder H, Schleifer L, Smith M [1984]. Health issues - video display terminals. 64 pp.
NTIS NO: PB88-126115 A04

Dainoff M [1979]. Occupational stress factors in secretarial/clerical workers, annotated research bibliography and analytic review. 117 pp.
NTIS NO: PB87-163416 A06

Hurrell Jr J, Smith M, Dainoff M, Schleifer L [1980]. Job stress and information processing: some research needs. 7 pp.
NTIS NO: PB85-219335 A02

Schleifer L, Burg J, Hicks K [1985]. Questionnaire survey of VDT operators at the New York State Departments of Motor Vehicle and Taxation and Finance. 28 pp.
NTIS NO: PB86-111242 A03
[For companion report, see citation in Contract reports.]

Schnorr T, Grajewski B, Hornung R, Thun M, Egeland G, Murray W, Conover D, Halperin W [1991]. Investigation of spontaneous abortion among video display terminal users, final report. 24 pp.
NTIS NO: PB91-189209 A03
[For published version of this report, see 1991 journal article by Schnorr et al.]

Smith M [1983]. Psychological stress due to computerized office technology. 18 pp.
NTIS NO: PB89-165062 A03

Smith M [1984]. A review of NIOSH ergonomics VDT research. 22 pp.
NTIS NO: PB89-165112 A03

B. NIOSH-FUNDED DOCUMENTS

1. GRANT and COOPERATIVE AGREEMENT REPORTS

Grant and cooperative agreement (CA) reports are generated primarily from an agreement between NIOSH and a non-governmental organization. They typically describe scientific research conducted by that organization and funded by NIOSH. Grant and CA reports, listed below in alphabetical order by author, may be published either as final reports available from NTIS or as journal articles. For the former, NTIS ordering information is shown; for the latter, bibliographic information is provided to permit retrieval from public or university libraries.

Barr AE [1997]. Effect of VDT mouse design on task and musculoskeletal performance.
Grant No. R03-OH-03260. 5 pp.
NTIS NO: PB97-206239 A01

Barr AE, Ozkaya N, Nordin M, Lee E [1996]. Effect of mouse design on CTD risk and user skill.
Grant No. R03-OH-03260. 4 pp.
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Emurian HH [1991]. Stress effects of human-computer interactions.
Grant No. R01-OH-02614. 58 pp.
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Gerr F, Marcus M, Ortiz D [1996]. Methodological limitations in the study of video display terminal use and upper extremity musculoskeletal disorders. American Journal of Industrial Medicine *29*(6):649-656.
Grant No. R01-OH-03160

Marklin RW, Simoneau GG, Monroe J [1997]. An ergonomics study of alternative keyboard designs.
Grant No. R03-OH-03184. 186 pp.
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McAbee RR, Gallucci BJ, Checkoway H [1993]. Adverse reproductive outcomes and occupational exposures among nurses. An investigation of multiple hazardous exposures. AAOHN Journal *41*(3):110-118.
Grant No. T15-OH-07087

Morgenstern H, Graves M, Kelsh MA [1994]. Occupational epidemiology of carpal tunnel syndrome.
Grant No. R03-OH-02765. 134 pp.
NTIS NO. PB95-269866 A08

Ortiz DJ, Marcus M, Gerr F, Jones W, Cohen S [1997]. Measurement variability in upper extremity posture among VDT users. Applied Ergonomics *28*(2):139-143.
Grant No. R01-OH-03160

Pastore LM, Hertz-Picciotto I, Beaumont JJ [1997]. Risk of stillbirth from occupational and residential exposures. Occupational and Environmental Medicine *54*(7):511-518.
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2. CONTRACT REPORTS

Contract reports are generated primarily from a contractual agreement between NIOSH and a non-governmental organization. They typically describe scientific research contracted and paid for by NIOSH and conducted by that organization.

Guy AW [1987]. Measurement and analysis of electromagnetic field emissions from 24 video display terminals in American Telephone and Telegraph office, Washington, D.C.
Purchase Order No. 85-35744. 40 pp.
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Hurlebaus A, Posner S, Johnson B [1985]. The occupational health implications of video display terminals: a bibliography, 1981-1985.
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NTIS NO: PB91-130500 A13
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Salvendy G [1981]. Proceedings of the international conference on machine-pacing and occupational stress.
Contract No. 210-80-0002. 480 pp.
NTIS NO: PB84-180785 A22

Sauter SI, Gottlieb MS, Jones KC, Dodson VN, Rohrer KM [1983]. Job and health implications of VDT use: initial results of the Wisconsin - NIOSH study. Communications of the Association for Computing Machinery *26*(4):284-294.
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Sauter S, Gottlieb, Rohrer K, Dodson V [1983]. The well-being of video display terminal users, exploratory study.
Contract No. 210-79-0034. 261 pp.
NTIS NO: PB84-240449 A12

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