

VDT WORKSTATION EVALUATION

by

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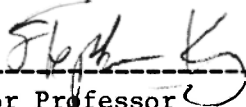
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INTRODUCTION

Electronic equipment is fast replacing traditional office equipment. Video display terminals (VDTs) are becoming more and more common. They have found a large field of application in commercial enterprises, banks, industry, etc. According to the Wall Street Journal an estimated 10 million VDTs will be in use by 1985 and by 1990, 40 to 50 percent of all American workers will be using electronic office equipment (Pulgram and Stonis, 1984). This change in the nature of the equipment and the work methods have necessitated an analysis of the ergonomic and medical aspects of the workstation in the light of new electronic equipment such as the VDT systems.

According to Armbruster (1983), during the 1960s and early 70s ergonomists established a considerable amount of evidence concerning the physical aspects of office equipment and the environment. But for some reason very little of this knowledge was applied to real world situations. However, in the mid-1970s ergonomics in computing systems began getting more attention mainly due to the efforts made in Europe, particularly in Scandinavia and the Federal Republic of Germany, to introduce national standards along with the technological change.

In recent years with the VDT systems becoming more and more affordable to a vast number of people, ergonomic design of the systems has now become necessary, more than ever, to

ensure that the systems can be used quickly and effectively by people with little or no prior training. One of the chief obstacles for the development and implementation of the ergonomic design in the VDT systems according to Armbruster (1983) has been the need to cater to the ergonomic criteria sometimes adds to the investment in new technology. In some cases changes to office environment are known to have cost as much as the hardware and software itself. However, experts in this area feel that if human factors criteria are built into the equipment from its inception, there should not be much of a cost increment. Also, it is suggested that when considering the apparent ergonomic costs one should also evaluate the costs of such things as staff unhappiness, poor operating efficiency, increased absenteeism due to physical and psychological stress and strains, etc.

After research on the ergonomic aspects of VDTs some countries have developed ergonomic standards relating to VDT workstations. These standards tend to be either general and qualitative or very detailed and quantitative. For example, a Norwegian regulation specifies that "Screens should be adjustable for luminance (brightness) and contrast". On the other hand, the regulation in the Federal Republic of Germany specifies that "In a negative presentation (light symbols on dark background) the contrast should lie between 3:1 and 15:1, better between 6:1 and 10:1" (cited in Armbruster, 1983). Therefore, instead of having all the standards in either of these extremes, i.e. totally qualita-

tive or totally quantitative, a more practical approach would be to have qualitative standards where precise measurements are difficult to make and have quantitative standards where measurements can be easily made. This also enables an ordinary office worker to evaluate the ergonomic aspects of the VDT workstation without requiring him/her to use any sophisticated gadgets or require the services of a professional.

This report focuses on the ergonomic aspects of the VDT workstations located in the various buildings at Kansas State University. After considering the various design criteria in order to have an ergonomically adequate VDT workstation, a set of criteria was developed along with the recommended standards. These criteria were mainly based on the recommendations of Ambruster (1983) and Olsen (1981) and were developed to carry out the ergonomic evaluation of an already existing VDT workstation. After the criteria were developed, 35 VDT workstations located on the Kansas State University campus were evaluated and how well the existing standards at these workstations relate to the recommended standards are reported and discussed.

PROBLEM

Based on the various ergonomic design considerations, develop a set of criteria to evaluate an existing VDT workstation. Using these criteria evaluate a number of workstations located on the Kansas State University campus and relate the standards to the conditions at these workstations.

DESIGN CONSIDERATIONS

As a matter of convenience the ergonomic aspects of a VDT workstation are divided into the following three categories.

Posture: This section concerns the postural aspects of the operator.

Workstation: This section concerns the ergonomic aspects of the work station equipment such as the work table, CRT, chair etc.

Illumination: This section concerns the lighting aspects of the workstation.

Posture

Posture is the arrangement of body segments in space. Postures at VDT workstations are very much constrained. This is due to the fact that operators are forced to keep the head as well as the hands more or less permanently in a fixed position. The head position is determined by the appropriate visual distance to the screen or to the source documents and also, sometimes, by the glare on the screen or on the source

documents. The position of the hands is determined by the location of the keyboard and/or sometimes by the location of the source documents. These restrictions can result in the operator adopting an unfavorable position often characterized by elements such as the operator's feet not resting comfortably on the floor, forearms and hands often held high at a level between shoulders and elbows, etc. These unfavorable positions produce fatigue and, if maintained for long periods, can produce more permanent aches.

Table 1 shows the incidence of some of the physical troubles reported from five different groups of office operators during a study conducted by Hunting, et al. (1980). The results of this study reveal that serious impairments were observed in each group and also soreness in muscles and other medical symptoms were observed in many of these operators.

Criteria for posture (See Figure 1). Experts in ergonomics , after a number of studies, have recommended the correct positions for the operator's hands, neck, shoulders, etc. But it is very rare that an operator's posture corresponds to these recommendations. Sometimes, the reasons for the bad posture can not be easily seen. Sometimes, however, it is possible to identify these reasons and take corrective action. However, the author feels that, to have a reasonably good posture , the following are some of the important criteria which have to be satisfied.

TABLE 1

Incidence of almost "daily pains" in five office jobs

| Groups | Incidence of "almost daily" pains | | | | |
|--------------------------|-----------------------------------|------|----------|---------------|----------------|
| | n | Neck | Shoulder | Right arm (%) | Right hand (%) |
| Data-entry terminals | 53 | 11 | 15 | 15 | 6 |
| Accounting m/c operators | 119 | 3 | 4 | 8 | 8 |
| Conversational terminals | 109 | 4 | 5 | 7 | 11 |
| Typists | 78 | 5 | 5 | 4 | 5 |
| Traditional office work | 55 | 1 | 1 | 1 | 0 |

Source: Hunting, W. et al. Constrained postures of VDU operators. In Grandjean, E. and Vigliani, E. (Eds.) Ergonomic aspects of visual display terminals. London: Taylor and Francis, 1980.

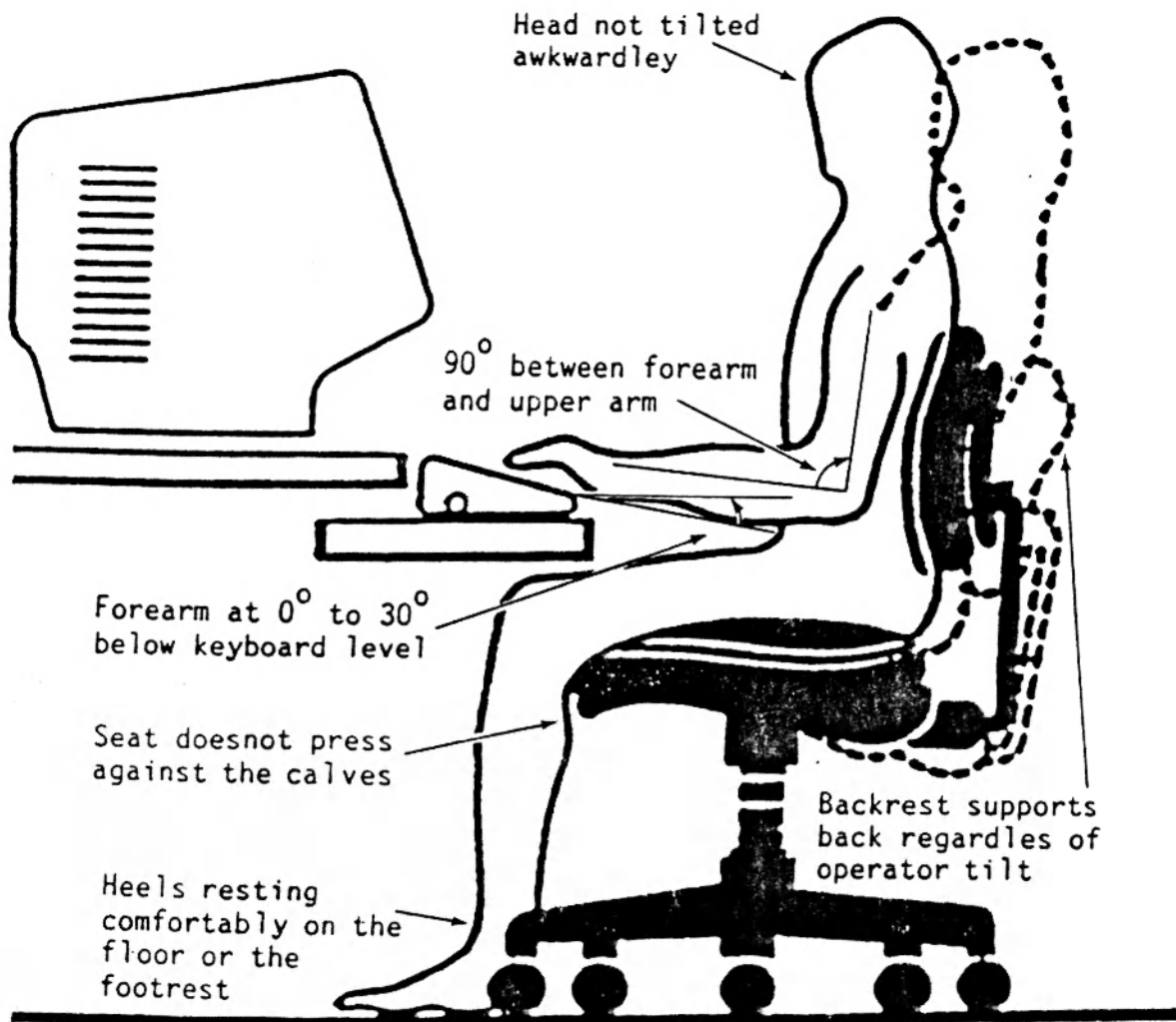


Figure 1. Postural aspects of VDT operator

Source: Modified from Pulgram, William and Stonis, Richard. Designing the automated office. New York: Whitney library of design, 1984.

- * The operator should have his/her heels touch the floor or the footrest.
- * It is necessary to make sure that the seat of the chair is not too deep and the front edge of the seat does not press against the calves of the operator when the operator is seated.
- * To support the lumbar region of the spine properly, the chair's backrest should be adjusted to fit snugly in to the small of the operator's back, and tilt backward and forward to accommodate seated movement.
- * Sometimes, to avoid glare on the CRT or on the document, the operator tends to keep his/her tilted awkwardly. Therefore it is necessary to make sure that the operator is able to operate with his/her head held in a comfortable position.
- * The recommended angle between forearm and upperarm is 90°.
- * The recommended angle of forearm to the keyboard is 0 to 30° below keyboard level.

Workstation

Many studies in the past have shown that there is a strong relationship between the design of workplace and certain incidence of physical impairments. For example, a recent study (Hunting, et al., 1980) has shown that the higher the keyboard levels the higher the incidence of physical impairments and the more the hands and arms are

rested the lesser the incidence of physical impairments. Inadequate design of the workplace causes the operator to adopt faulty postures which not only lead to discomfort, fatigue and poor work performance among workers but also to serious physical impairments.

According to Grandjean, Hunting, Maeda and Laubli (1983), postural efforts are static efforts and can cause acute localised fatigue in the statically loaded muscles. This is one of the predominant reasons for a VDT operator's poor work performance and physical impairments. This is due to the fact that the space of action of the operator is limited; the movements are limited and stereotyped for fingers, hands and arms; the position of the head is governed by the visual angle and visual distance; the position of the hands is governed by the location of keyboard and/or sometimes by the location of the source documents. These restrictions in movement requires the operator to experience long lasting static posture.

Therefore, the major objective in the design of a VDT workplace should be to minimize static efforts due to inadequate posture by having all the workplace dimensions suited to the body size of the operator as well as the operator's biomechanical requirements. Also, the work place should allow the operator to adopt postures which allow as many muscles as possible to contribute.

In order to meet the above requirements, ergonomists

have established the following broad guidelines.

- * All equipment and items which must be manipulated should be within the normal arm reach of the operator.
- * Work surface height, the seat height, and footrest height should be sufficiently adjustable to meet individual requirements.
- * The arrangement of the parts of the main working equipment i.e. the screen, keyboard and the document holder must be independent and must be adjustable in height and inclination.
- * All workplaces with keyboards should give an adequate possibility of resting hands or forearms. This is especially recommended for jobs on conversational terminals characterized by frequent waiting times.

Figure 2 shows the prototype of the workplace designed by Buti et al. (1980). When this design was tested over a number of operators who were allowed to adjust the angles A , B, C, and D and also the height H according to their needs, it was found that the range of variation in the angles A (0 to 15°), B (0 to 20°), and C (0 to 20°), was sufficient and the angle D and the height H could be fixed at 14° and 720 mm respectively. However, it should also be noted that an excess of adjustability can be confusing to the user. Adjusting workplace components is often employed in the first few weeks of use and then can be left in wrong positions which is, if not more, at least as harmful as an inadequately designed workplace.

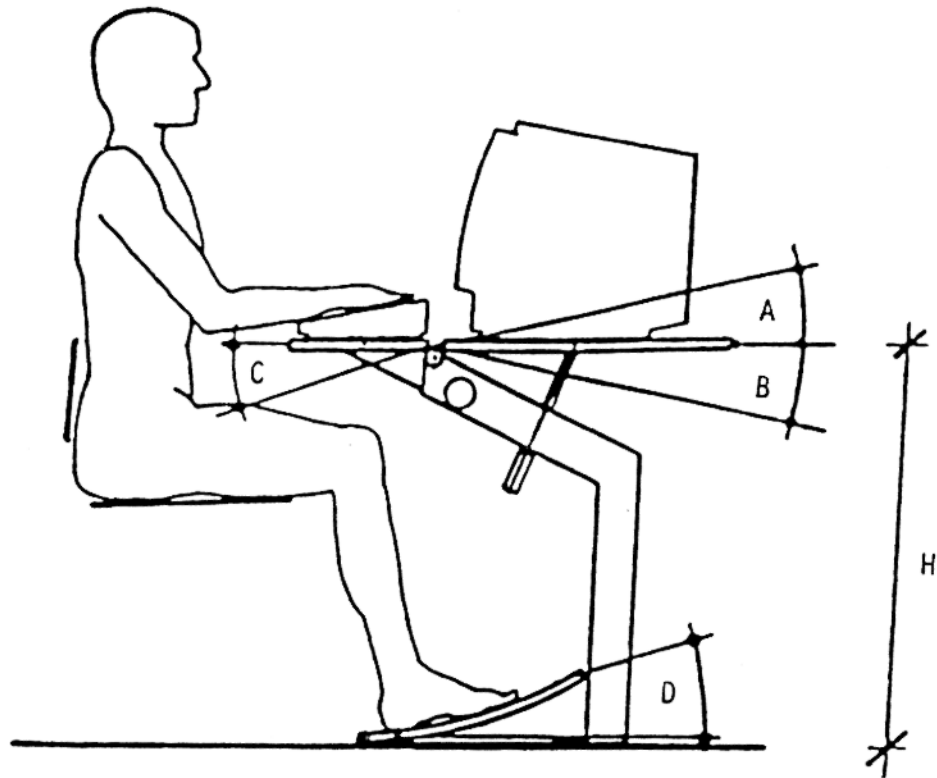


Figure 2. Prototype of a VDT workstation

Source: Bandini Buti, L. et al. In Grandjean, E. and Vigiliani, E. (Eds.) Ergonomic aspects of visual display terminals. London: Taylor and Francis, 1980.

Based on the above discussion and on the recommendations of Armbruster (1983) and Olsen (1981), the author has developed the following set of criteria to design the VDT workstation.

As a matter of convenience the workstation is divided into five components namely, work table, CRT, document holder, keyboard, and chair. The criteria for each component are listed separately.

Criteria for the work table (See Figure 3). The following are the criteria for the work table.

- * An improper work surface height can force the user to adopt positions that produce fatigue. Therefore the work surface should be adjustable in height to accommodate a wide range of users. Proper work surface height should allow the feet to rest flat on the floor and provide adequate thigh clearance. The recommended range of adjustable height is 680 to 760 mm.
- * For a stationary work surface the recommended height is 720 mm.
- * If the work surface height is stationary, a footrest should be provided. Since, for some operators, increasing the seat height to achieve a correct typing and viewing position may result in their feet not resting comfortably on the floor. The footrest should have a range of adjustable height from 40 to 110 mm and a range of adjustable inclination from 5 to 15°.

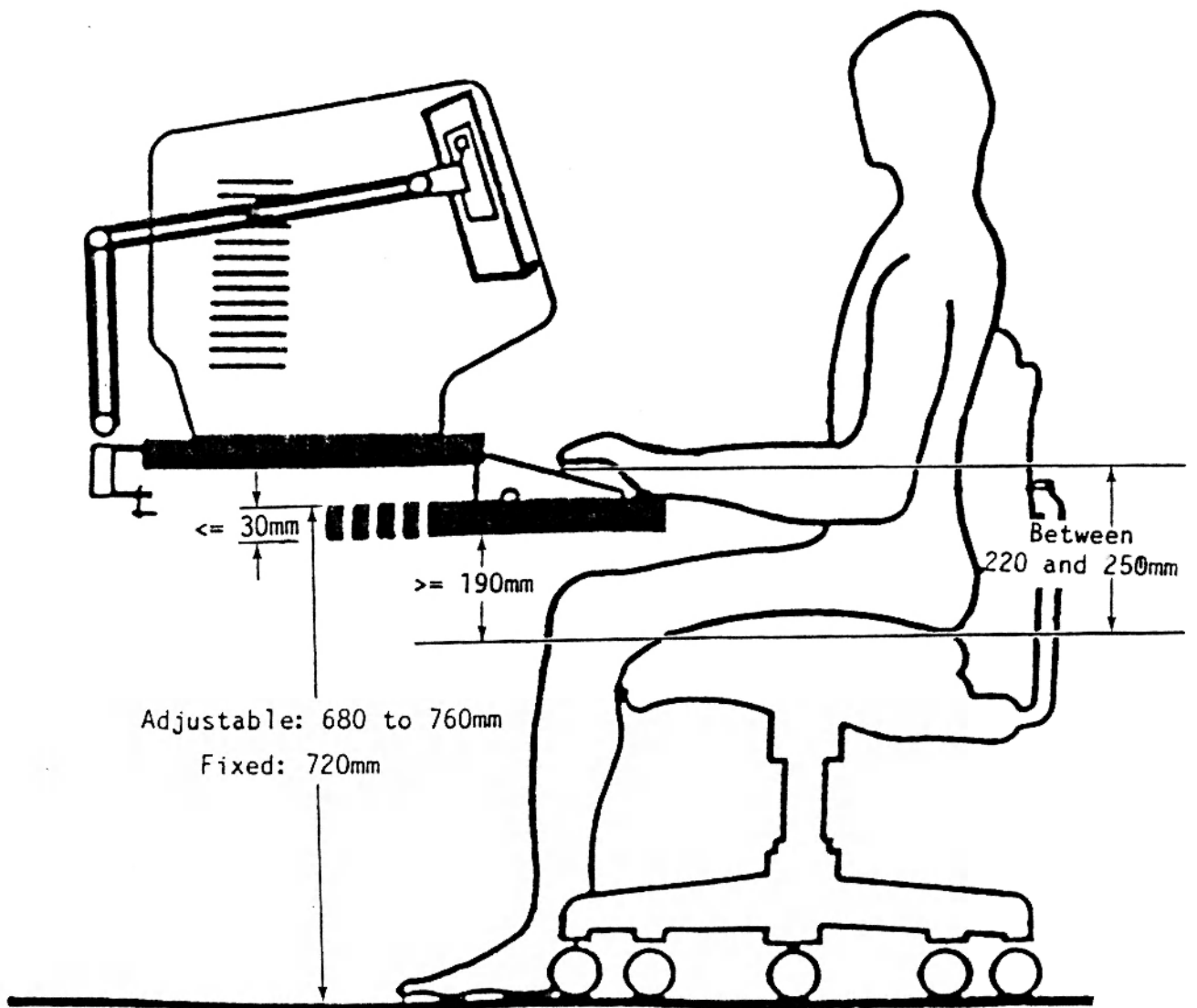


Figure 3. Heights and distances for VDT workstation

Source: Modified from Pulgram, William and Stonis, Richard. Designing the automated office. New York: Whitney library of design, 1984.

- * The distance between the underside of the thighs and the palms of the hand on the middle alphabetical row of keys is recommended to be between 220 and 250 mm.
- * The distance between the underside of the thighs and the underside of the table top is recommended to be at least 190 mm (thigh clearance).
- * The operator should have an unobstructed leg area with the following minimum dimensions:
Height : 650 mm
Width : 580 mm.
- * If the work surface is too thick and must be lowered to achieve a comfortable typing position, the thigh and the leg may become cramped. Therefore the thickness of the table top is recommended to be not more than 30 mm.
- * A study conducted by Hunting et al. (1980) revealed that 90% of the operators on "conversational terminals" rested their hands and forearms. Special hand supports were never observed in the study. But it was noted whether hands or forearms were rested on the desks or on the keyboards using them as supports. The results of the study are shown in Figure 4. From these results, the keyboards should be provided with an adequate device giving the operator the opportunity to rest hands and forearms. This recommendation is particularly indicated for conversational terminals where the operator always has short waiting periods according to the response time of the terminal.

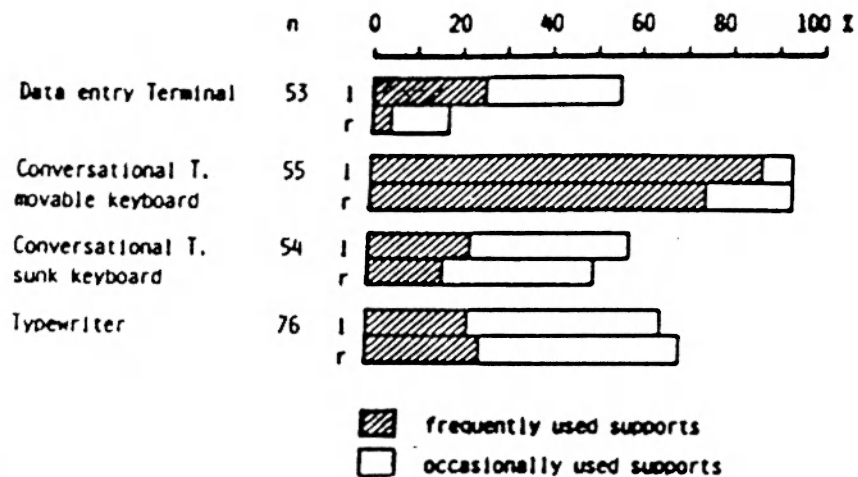


Figure 4. Frequency of hands or forearms rested on desks or on keyboard frames
 l = left side, r = right side

Source: Hunting, W. et al. Constrained postures of VDU operators. In Grandjean, E. and Vigiliani, E. (Eds.) Ergonomic aspects of visual display terminals. London: Taylor and Francis, 1980.

- * The work surface should be matte finished to control reflections and prevent excessive brightness. Excessive luminance from glossy surfaces has been found to produce visual fatigue.

Criteria for the CRT (See Figure 5). The following are the criteria for the CRT.

- * For comfortable viewing of the CRT screen, the line of sight of the operator should be normal to the screen. Therefore, to make the line of sight of different operators normal to the screen, after variations in seat and table heights, it is necessary for the CRT to be tiltable.
- * The CRT should be rotatable to suit the task and glare control needs of the operator.
- * The CRT's support surface should be adjustable in height to suit the wide range of operators.
- * Flexibility in viewing distance is important. Comfortable viewing depends upon the lighting, the user's vision, the quality of display characters, the contrast, color, and flicker. Generally a comfortable viewing distance, to suit a wide range of users, is considered to be from 300 to 550 mm. Therefore the viewing distance should be adjustable over this range.
- * The angle of line of sight to center of the CRT screen below the horizontal plane of the operator's eyes is recommended to be between 0 and 30°.

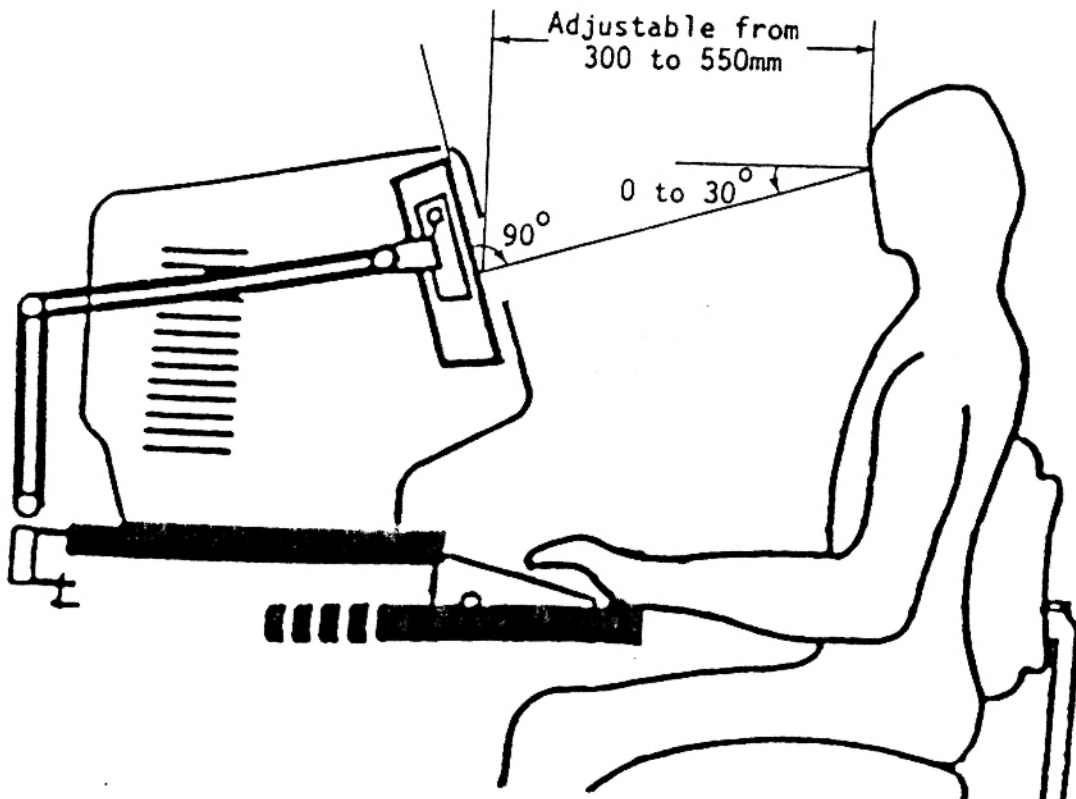


Figure 5. Viewing angles and distance for the CRT

Source: Modified from Pulgram, William and Stonis, Richard. Designing the automated office. New York: Whitney library of design, 1984.

- * The angle between the line of sight and the CRT screen is recommended to be 90° .

Criteria for the Document Holder (See Figure 6). The following are the criteria for the document holder.

- * Concurrent referencing and inputting of data often requires the user to continually shift vision between copy material and the video screen. If the document lies flat on the work surface the head must tilt vertically between screen and the source. If the document is difficult to read body movement also may be required. Unnecessary fatigue can be avoided if the document is placed on a document holder rather than on the work surface.
- * For comfortable viewing of the document, line of sight of the operator must be normal to the display surface of the document holder. Therefore, to make the line of sight of different operators normal to the screen, after variations in seat and table heights, it is necessary for the document holder to be tiltable.
- * The document holder should be rotatable to suit the task and glare control needs of the operator.
- * The document holder's support surface should be adjustable in height to suit a wide range of operators.
- * If the focal distance between the document and the screen is different, the eyes must continually adjust to

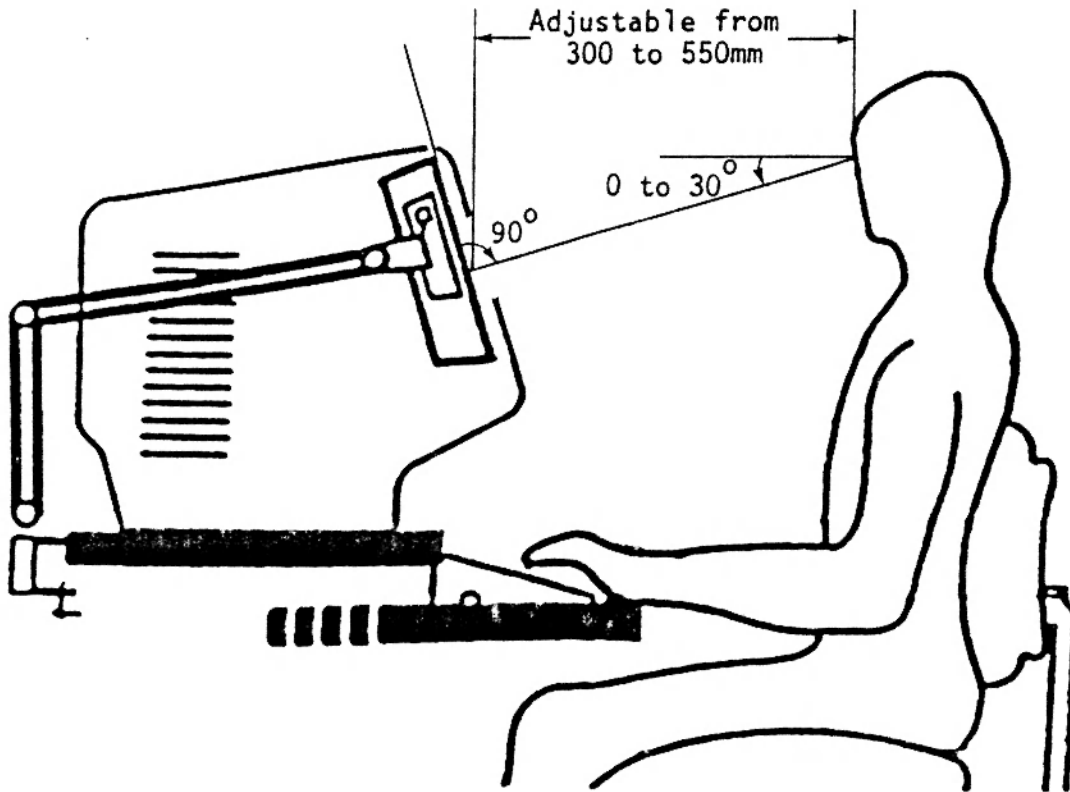


Figure 6. Viewing angles and distance for the document holder

Source: Modified from Pulgram, William and Stonis, Richard. Designing the automated office. New York: Whitney library of design, 1984.

accommodate. Obviously, economy of movement and time as well as reduced body and eye strain can be achieved by using a document holder that places the document on the same plane as that of the CRT screen. Therefore the viewing distance from eye to document must roughly equal the viewing distance from eye to CRT screen.

- * The angle of the line of sight to center of the document holder's display surface below the horizontal plane of operator's eyes is recommended to be between 0 and 30°.
- * The angle between the line of sight and the display surface of the document holder is recommended to be 90°.

Criteria for the Keyboard (See Figure 7). The following are the criteria for the keyboard.

- * The keyboard and the CRT must be in separate housings such that they can be adjusted independently.
- * The keyboard's position must be adjustable in the fore and aft directions to match user needs.
- * The keyboard must be tiltable to adjust the angle of the keyboard to match the user needs.
- * The keyboard support surface must be adjustable in height to match user and seat variations.
- * The angle of the keyboard is recommended to be not more than 15° to avoid an excessive load on the hands and arms.
- * The height of middle row of alphabetic keys is recommended to be not more than 30 mm.

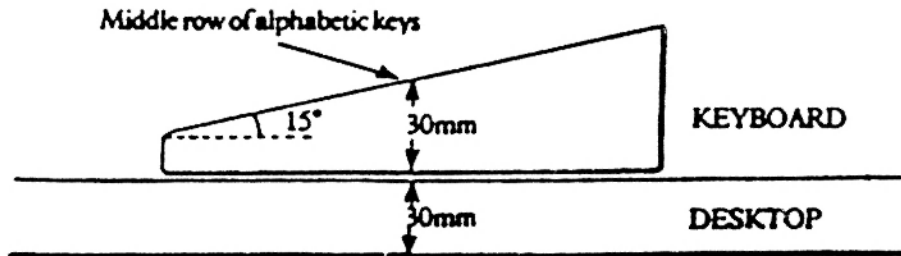


Figure 7. Preferable dimensions for keyboard and desk top

Source: Armbruster, Albert. Ergonomic requirements. In Harry J. Otway and Malcolm Pelta (Eds.) New office technology: Human and organizational aspects. Great Britain: Albex, 1983.

Criteria for the Chair. The following are the criteria for the chair.

- * Chair height must be adjustable to suit the different operators and their seat height variations.
- * Chair backrest must be adjustable in height and in the fore-aft directions to suit the different operators and their seat variations.
- * The front edge of the seat must be rounded so that it does not cut into the back of the operator's legs. The seat cushion should be padded and constructed using a material that "breathes" to avoid trapping body heat and perspiration.
- * The chair should have good stability and maneuverability and should typically be provided with a five point base with castors.

Illumination

The most common problems experienced by the VDT operators due to illumination is either a too low or too high level of illumination and/or the glare caused by the illumination sources.

Glare causes visual discomfort that can lead to poor operating efficiency and under severe conditions to visual impairment. Glare associated with displays is mainly caused by unwanted light reflected on the display which reduces contrast of the display.

Light contrast between the display and its surroundings

is also known to cause glare. However, an acceptable ratio for the contrast between the display and the surroundings has not yet been established.

Criteria for illumination. The following are the criteria for illumination.

- * The recommended level of room illumination is between 300 and 700 lx.
- * In most cases glare can be controlled by manipulating the relative location of the light sources and the display, the type of light sources and by manipulating the level of illumination. Glare also can be controlled by having an anti-reflective coating on the screen or by installing other glare control aids such as screen filters, micromesh filters or tube shields. Screen filters and micromesh filters are additional screens that are placed directly on the CRT screen. Tube shields are shields which are fitted around the CRT screen to prevent light from falling directly on the CRT screen and create reflections. However, it is desirable to control glare through judicious choice of the location and the type of light sources rather than by using tube shields or filters as tube shields tend to interfere with the viewing field of the operator and filters always tend to lower the quality of display and may cause additional visual strain on the operator.

VDT WORKSTATION EVALUATION FORM

Following is the VDT workstation evaluation form containing the criteria which were developed based on the previously discussed design considerations.

VDT WORKSTATION EVALUATION

Location of workstation : _____

Type of terminal : _____

Name of evaluator : _____

Date of evaluation : _____

Name of operator : _____

Profession : _____

Sex : _____

Height : _____

* Make linear measurements in millimeters, angles in degrees, and illumination in lux.

* If a condition is not applicable, mark an "X" under existing condition.

POSTURE

| | CONDITION | EXISTING | DESIRED |
|----|---|----------|--------------------|
| P1 | Heels can touch the floor or footrest (yes/no) | | YES |
| P2 | Seat of the chair not too deep as to touch the calves (yes/no) | | YES |
| P3 | Backrest supports back when operator's spine is vertical, slightly arched forward, and when slightly arched backward (yes/no) | | YES |
| P4 | Head not tilted awkwardly to avoid glare on the CRT screen or on the document (yes/no) | | YES |
| P5 | Angle between forearm and upperarm | | 90° |
| P6 | Angle of forearm to the keyboard below the keyboard | | Between 0° and 30° |

WORKSTATION

Work Table :

| | CONDITION | EXISTING | DESIRED |
|----|---|----------|------------------------|
| W1 | a) Table or keyboard support surface height is adjustable (yes/no) | _____ | YES |
| | b) If YES, Range of adjustable height | _____ | From 680 to 760 mm |
| | c) If NO, Fixed height of the table or the keyboard support surface | _____ | 720 mm |
| W2 | a) Footrest is provided (yes/no) | _____ | YES |
| | If YES, b) Range of adjustable height of footrest | _____ | From 40 to 110 mm |
| | c) Range of angle of inclination of footrest | _____ | From 5 to 15° |
| W3 | The distance between the underside of thighs and the palms of the hand on the middle alphabetical row of keys | | Between 220 and 250 mm |
| W4 | The distance between the underside of thighs and underside of the table top or keyboard support surface | | At least 190 mm |
| W5 | Dimensions of the leg area: | | |
| | a) Height | _____ | At least 650 mm |
| | b) Width | _____ | At least 580 mm |
| W6 | Thickness of table top or keyboard support surface | | Not more than 30 mm |
| W7 | Wrist supports provided near keyboard for momentary resting (yes/no) | | YES |
| W8 | Work surface is finished in matte | | YES |

CRT :

| | CONDITION | EXISTING | DESIRED |
|-----|--|----------|-------------------|
| W9 | CRT tiltable to make line of sight normal to the screen (yes/no) | | YES |
| W10 | CRT can be rotated to fit task and glare control needs (yes/no) | | YES |
| W11 | CRT support surface adjustable in height to match user and seat variations (yes/no) | | YES |
| W12 | Distance from eye to CRT screen can be adjusted from 300 to 550 mm (yes/no) | | YES |
| W13 | Distance between eye and CRT screen maintained by the operator | | 400 mm |
| W14 | Angle of line of sight to center of CRT screen below the horizontal plane of operator's eyes | | Between 0 and 30° |
| W15 | Angle between line of sight and CRT screen | | 90° |

Document Holder :

| | CONDITION | EXISTING | DESIRED |
|-----|---|----------|-------------------|
| W16 | Workstation equipped with document holder (yes/no) | | YES |
| W17 | Document holder tiltable to match user needs (yes/no) | | YES |
| W18 | Document holder can be rotated to match user needs (yes/no) | | YES |
| W19 | Document holder adjustable in height to match user and seat variations (yes/no) | | YES |
| W20 | Distance from eye to document holder's display surface can be adjusted from 300 to 550 mm (yes/no) | | YES |
| W21 | Distance between eye and document holder's display surface maintained by the operator | | 400 mm |
| W22 | Angle of line of sight to center of document holder display surface below the horizontal plane of the operator's eyes | | Between 0 and 30° |
| W23 | Angle between line of sight and document holder's display surface | | 90° |

Keyboard :

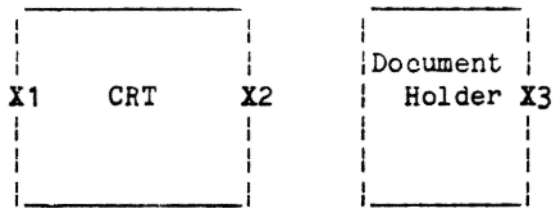
| | CONDITION | EXISTING | DESIRED |
|-----|--|----------|---------------------|
| W24 | Keyboard detached from CRT (yes/no) | | YES |
| W25 | Keyboard position on surface can be adjusted fore and aft (yes/no) | | YES |
| W26 | Keyboard can be tilted to suit the operator (yes/no) | | YES |
| W27 | Keyboard support surface adjustable in height to match user and seat variations (yes/no) | | YES |
| W28 | Angle of keyboard | | Not more than 15° |
| W29 | Height of middle row of alphabetic keys from the base of the keyboard | | Not more than 30 mm |

Chair :

| | CONDITION | EXISTING | DESIRED |
|-----|--|----------|---------|
| W30 | Chair height adjustable to match user needs (yes/no) | | YES |
| W31 | Chair backrest adjustable in height (yes/no) | | YES |
| W32 | Chair backrest adjustable in fore - aft directions (yes/no) | | YES |
| W33 | Rounded seat front edge and padded seat surface with cloth covering (yes/no) | | YES |
| W34 | Chair has five point base with castors | | YES |

ILLUMINATION

| | CONDITION | EXISTING | DESIRED |
|----|---|----------|---------------------------|
| I1 | Average level of illumination at the immediate surrounding (See Figure 8 for computation) | | Between 300 and 700 lx |
| I2 | Glare on CRT screen is a) None b) Slight c) Moderate d) Severe | | NONE |



Illumination at X1 (left border of the screen) in lx _____

Illumination at X2 (right border of the screen) in lx _____

Illumination at X3 (right border of the document) in lx _____

Average illumination at the immediate surrounding

$$= \frac{X1+X2+X3}{3} = \text{_____ lx}$$

FIGURE 8. Average illumination

RESULTS

A survey of 35 VDT workstations located on the Kansas State University campus was carried out in which each workstation was evaluated using the above mentioned evaluation form. The results of the survey are presented in Table 2. The criteria in Table 2 are numbered the same as the criteria in the previously shown evaluation form. The raw data gathered during the survey are shown in Tables 3 and 4.

The locations of the workstations were Durland, Seaton Hall, Cardwell, Dickens, and Fairchild Hall.

The types of terminals: IBM Pc, Zenith, Apple, Courier, Selanair, Televideo, WYSE, Perkin Elmer, Digital, SOROC, Heathkit, CIT- 101e, and ESP 6110.

Name of the evaluator: Narendra Munireddy

Period of evaluation: July, August 1985.

Professions of operators: 7 secretaries and 28 students.

Sex of operators: 26 male and 9 female.

Average height of operators: 172.5 cm.

TABLE 2

Results of the survey

| <u>Sl. no.</u> | <u>CONDITION</u> | <u>EXISTING</u> | <u>DESIRED</u> |
|----------------|---|-------------------------------------|-------------------|
| P1 | Heels can touch the floor or footrest (yes/no) | n = 35 YES = 100% NO = 0% | YES |
| P2 | Seat of the chair not too deep as to touch the calves (yes/no) | n = 35 YES = 97.1% NO = 2.9% | YES |
| P3 | Backrest supports back when operator's spine is vertical, slightly arched forward, and when slightly arched backward (yes/no) | n = 35 YES = 85.7% NO = 14.3% | YES |
| P4 | Head not tilted awkwardly to avoid glare on the CRT screen or on the document (yes/no) | n = 35 YES = 85.7% NO = 14.3% | YES |
| P5 | Angle between forearm and upperarm | n = 35 Av. = 97.5° SE = 3.0° | 90° |
| P6 | Angle of forearm to the keyboard below the keyboard | n = 35 Av. = 11.7° SE = 1.5° | Between 0 and 30° |

TABLE 2 Continued

| <u>Sl. no.</u> | <u>CONDITION</u> | <u>EXISTING</u> | <u>DESIRED</u> |
|----------------|---|--|------------------------|
| W1 | a) Table or keyboard support surface height is adjustable (yes/no) | n = 35 YES = 0% NO = 100% | YES |
| | b) If YES, Range of adjustable height | ---- | From 680 to 760 mm |
| | c) If NO, fixed height of the table or the keyboard support surface | n = 35 Av. = 704.3 mm SE = 11.1 mm | 720 mm |
| W2 | a) Footrest is provided (yes/no) | n = 35 YES = 0% NO = 100% | YES |
| | b) If YES, Range of adjustable height of footrest | ---- | From 40 to 110 mm |
| | c) Range of angle of inclination of footrest | ---- | From 5 to 15° |
| W3 | The distance between the underside of thighs and the palms of the hand on the middle alphabetical row of keys | n = 35 Av. = 306.0 mm SE = 10.5 mm | Between 220 and 250 mm |
| W4 | The distance between the underside of thighs and underside of the table top or keyboard support surface | n = 35 Av. = 194.4 mm SE = 5.9 mm | At least 190 mm |
| W5 | Dimensions of the leg area: | n = 35 | |
| | a) Height | Av. = 646.0 mm SE = 6.9 mm | At least 650 mm |
| | b) Width | Av. = 736.4 mm SE = 15.7 mm | At least 580 mm |

TABLE 2 Continued

| <u>Sl. No.</u> | <u>CONDITION</u> | <u>EXISTING</u> | <u>DESIRED</u> |
|----------------|--|--|---------------------|
| W6 | Thickness of table top or keyboard support surface | n = 35 Av. = 78.5 mm SE = 8.0 mm | Not more than 30 mm |
| W7 | Wrist supports provided near keyboard for momentary resting (yes/no) | n = 35 YES = 0% NO = 100% | YES |
| W8 | Work surface is finished in matte | n = 35 YES = 82.9% NO = 17.1% | YES |
| W9 | CRT tiltable to make line of sight normal to the screen (yes/no) | n = 35 YES = 14.3% NO = 85.7% | YES |
| W10 | CRT can be rotated to fit task and glare control needs (yes/no) | n = 35 YES = 100% NO = 0% | YES |
| W11 | CRT support surface adjustable in height to match user and seat variations (yes/no) | n = 35 YES = 0% NO = 100% | YES |
| W12 | Distance from eye to CRT screen can be adjusted from 300 to 550mm(yes/no) | n = 35 YES = 97.1% NO = 2.9% | YES |
| W13 | Distance between eye and CRT screen maintained by the operator | n = 35 Av. = 533.8 mm SE = 17.3 mm | 400 mm |
| W14 | Angle of line of sight to center of CRT screen below the horizontal plane of operator's eyes | n = 35 Av. = 12.8° SE = 1.3° | Between 0 and 30° |
| W15 | Angle between line of sight and CRT screen | n = 35 Av. = 84.6° SE = 1.0° | 90° |

TABLE 2 Continued

| <u>Sl. no.</u> | <u>CONDITION</u> | <u>EXISTING</u> | <u>DESIRED</u> |
|----------------|---|--|-------------------|
| W16 | Workstation equipped with document holder (yes/no) | n = 35 YES = 14.3% NO = 85.7% | YES |
| W17 | Document holder tiltable to match user needs (yes/no) | n = 5 YES = 80% NO = 20% | YES |
| W18 | Document holder can be rotated to match user needs (yes/no) | n = 5 YES = 100% NO = 0% | YES |
| W19 | Document holder adjustable in height to match user and seat variations (yes/no) | n = 5 YES = 80% NO = 20% | YES |
| W20 | Distance from eye to document holder's display surface can be adjusted from 300 to 550 mm (yes/no) | n = 5 YES = 100% NO = 0% | YES |
| W21 | Distance between eye and document holder's display surface maintained by the operator | n = 5 Av. = 509.0 mm SE = 5.6 mm | 400 mm |
| W22 | Angle of line of sight to center of document holder display surface below the horizontal plane of the operator's eyes | n = 5 Av. = 27.4° SE = 3.9° | Between 0 and 30° |
| W23 | Angle between line of sight and document holder's display surface | n = 5 Av. = 76.0° SE = 4.5° | 90° |
| W24 | Keyboard detached from CRT (yes/no) | n = 35 YES = 74.3% NO = 25.7% | YES |

TABLE 2 Continued

| <u>Sl. no.</u> | <u>CONDITION</u> | <u>EXISTING</u> | <u>DESIRED</u> |
|----------------|--|--|---------------------|
| W25 | Keyboard position on surface can be adjusted fore and aft (yes/no) | n = 35 YES = 94.3% NO = 5.7% | YES |
| W26 | Keyboard can be tilted to suit the operator (yes/no) | n = 35 YES = 54.7% NO = 45.3% | YES |
| W27 | Keyboard support surface adjustable in height to match user and seat variations (yes/no) | n = 35 YES = 0% NO = 100% | YES |
| W28 | Angle of keyboard | n = 35 Av. = 12.3° SE = 0.8° | Not more than 15° |
| W29 | Height of middle row of alphabetic keys from base of the keyboard | n = 35 Av. = 49.1 mm SE = 3.6 mm | Not more than 30 mm |
| W30 | Chair height adjustable to match user needs (yes/no) | n = 35 YES = 34.3% NO = 65.7% | YES |
| W31 | Chair backrest adjustable in height (yes/no) | n = 35 YES = 22.9% NO = 77.1% | YES |
| W32 | Chair backrest adjustable in fore - aft directions (yes/no) | n = 35 YES = 22.9% NO = 77.1% | YES |
| W33 | Rounded seat front edge and padded seat surface with cloth covering (yes/no) | n = 35 YES = 37.1% NO = 62.9% | YES |
| W34 | Chair has five point base with castors | n = 35 YES = 2.9% NO = 97.1% | YES |

TABLE 2 Continued

| Sl. no. | <u>CONDITION</u> | <u>EXISTING</u> | <u>DESIRED</u> |
|------------|---|--|---------------------------|
| I1 | Average level of illumination at the immediate surrounding | n = 35 Av. = 348.6 lx SE = 23.4 lx | Between 300 and 700 lx |
| I2 | Glare on CRT screen is | n = 35 | |
| | a) None | 22.86% | NONE |
| | b) Slight | 48.57% | |
| | c) Moderate | 22.86% | |
| | d) Severe | 5.71% | |

TABLE 3

Data on the ergonomic conditions at the workstations

| Workstation number | P1 | P2 | P3 | P4 | P5 | P6 | W1a | W1b | W1c | W2a | W2b | W2c | W3 | W4 | W5 | W6 | W7 | W8 | W9 | W10 | W11 | W12 | W13 | W14 | W15 | W16 | W17 | W18 | W19 | W20 | W21 | W22 | W23 | W24 | W25 | W26 | W27 | W28 | W29 | W30 | W31 | W32 | W33 | W34 | I1 | I2 |
|-----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------|------|--------|
| 1 | YES | YES | NO | YES | 85 | 15 | NO | _ | 645 | NO | _ | _ | 240 | 205 | 645 | _ | NO | YES | NO | YES | NO | YES | 530 | 16 | 85 | NO | _ | _ | _ | _ | _ | _ | _ | YES | YES | YES | NO | 17 | 27 | NO | NO | NO | YES | NO | 430 | NONE |
| 2 | YES | YES | NO | YES | 90 | 15 | NO | _ | 660 | NO | _ | _ | 290 | 210 | 625 | 35 | NO | NO | NO | YES | NO | YES | 560 | 12 | 87 | NO | _ | _ | _ | _ | _ | _ | YES | YES | NO | NO | 15 | 70 | NO | NO | NO | YES | NO | 242 | NONE | |
| 3 | YES | YES | NO | NO | 90 | 12 | NO | _ | 660 | NO | _ | _ | 270 | 210 | 625 | 35 | NO | NO | YES | YES | NO | YES | 540 | 22 | 88 | NO | _ | _ | _ | _ | _ | YES | YES | YES | NO | 13 | 40 | NO | NO | NO | YES | NO | 430 | SLIGHT | | |
| 4 | YES | YES | NO | YES | 90 | 5 | NO | _ | 635 | NO | _ | _ | 230 | 210 | 635 | _ | NO | YES | NO | YES | NO | YES | 530 | 8 | 88 | NO | _ | _ | _ | _ | _ | YES | YES | YES | NO | 16 | 30 | NO | NO | NO | YES | NO | 323 | MODERATE | | |
| 5 | YES | YES | NO | YES | 89 | 9 | NO | _ | 635 | NO | _ | _ | 250 | 205 | 635 | _ | NO | YES | NO | YES | NO | YES | 510 | 8 | 90 | NO | _ | _ | _ | _ | _ | YES | YES | YES | NO | 17 | 27 | NO | NO | NO | YES | NO | 253 | SEVERE | | |
| 6 | YES | YES | NO | YES | 90 | 20 | NO | _ | 705 | NO | _ | _ | 280 | 165 | 630 | 75 | NO | YES | NO | YES | NO | YES | 740 | 3 | 90 | NO | _ | _ | _ | _ | _ | YES | YES | YES | NO | 10 | 30 | NO | NO | NO | NO | NO | 538 | MODERATE | | |
| 7 | YES | YES | YES | NO | 127 | 9 | NO | _ | 745 | NO | _ | _ | 345 | 165 | 630 | 115 | NO | YES | NO | YES | NO | YES | 700 | 12 | 80 | NO | _ | _ | _ | _ | _ | YES | YES | NO | NO | 12 | 70 | YES | YES | YES | NO | NO | 350 | MODERATE | | |
| 8 | YES | YES | NO | YES | 87 | 17 | NO | _ | 700 | NO | _ | _ | 310 | 210 | 550 | 150 | NO | NO | NO | YES | NO | YES | 520 | 0 | 90 | NO | _ | _ | _ | _ | _ | YES | YES | NO | NO | 12 | 70 | NO | NO | NO | NO | NO | 592 | SLIGHT | | |
| 9 | YES | YES | YES | YES | 90 | 1 | NO | _ | 650 | NO | _ | _ | 250 | 165 | 595 | 55 | NO | YES | NO | YES | NO | YES | 520 | 17 | 78 | YES | YES | YES | NO | YES | 560 | 42 | 62 | YES | YES | YES | NO | 10 | 30 | YES | YES | YES | YES | NO | 538 | NONE |
| 10 | YES | YES | NO | NO | 88 | 24 | NO | _ | 745 | NO | _ | _ | 335 | 200 | 635 | 110 | NO | NO | NO | YES | NO | YES | 520 | 10 | 87 | NO | _ | _ | _ | _ | _ | YES | YES | NO | NO | 11 | 65 | NO | NO | NO | NO | NO | 285 | MODERATE | | |
| 11 | YES | YES | NO | YES | 82 | 12 | NO | _ | 745 | NO | _ | _ | 345 | 200 | 635 | 110 | NO | NO | NO | YES | NO | YES | 410 | 15 | 85 | NO | _ | _ | _ | _ | _ | YES | YES | NO | NO | 11 | 65 | NO | NO | NO | NO | NO | 339 | SLIGHT | | |
| 12 | YES | YES | YES | YES | 90 | 15 | NO | _ | 730 | NO | _ | _ | 330 | 275 | 700 | 30 | NO | YES | NO | YES | NO | YES | 540 | 17 | 84 | NO | _ | _ | _ | _ | _ | YES | YES | NO | NO | 11 | 65 | YES | NO | YES | NO | NO | 204 | SLIGHT | | |
| 13 | YES | YES | YES | YES | 88 | 12 | NO | _ | 650 | NO | _ | _ | 290 | 225 | 600 | 50 | NO | YES | NO | YES | NO | YES | 400 | 15 | 80 | YES | YES | YES | YES | YES | 500 | 25 | 75 | NO | NO | NO | NO | 13 | 80 | YES | YES | YES | YES | NO | 316 | SLIGHT |
| 14 | YES | YES | NO | YES | 90 | 5 | NO | _ | 625 | NO | _ | _ | 210 | 165 | 625 | _ | NO | YES | NO | YES | NO | YES | 510 | 8 | 90 | YES | YES | YES | YES | YES | 475 | 19 | 90 | YES | YES | YES | NO | 20 | 30 | YES | NO | NO | YES | NO | 646 | SLIGHT |
| 15 | YES | YES | NO | YES | 140 | 6 | NO | _ | 660 | NO | _ | _ | 195 | 140 | 630 | 30 | NO | YES | NO | YES | NO | YES | 640 | 15 | 83 | YES | YES | YES | YES | YES | 520 | 26 | 78 | YES | YES | YES | NO | 10 | 30 | YES | NO | NO | YES | NO | 430 | SLIGHT |
| 16 | YES | YES | NO | YES | 90 | 3 | NO | _ | 625 | NO | _ | _ | 220 | 170 | 625 | _ | NO | YES | NO | YES | NO | YES | 515 | 11 | 85 | NO | _ | _ | _ | _ | _ | YES | YES | YES | NO | 20 | 30 | NO | NO | NO | NO | NO | 312 | MODERATE | | |
| 17 | YES | YES | NO | YES | 90 | 8 | NO | _ | 625 | NO | _ | _ | 215 | 175 | 625 | _ | NO | YES | NO | YES | NO | YES | 440 | 11 | 85 | NO | _ | _ | _ | _ | _ | YES | YES | YES | NO | 20 | 30 | NO | NO | NO | NO | NO | 269 | SLIGHT | | |
| 18 | YES | YES | YES | NO | 90 | 18 | NO | _ | 680 | NO | _ | _ | 290 | 150 | 610 | 70 | NO | YES | NO | YES | NO | YES | 465 | 26 | 80 | YES | NO | YES | YES | YES | 490 | 25 | 75 | NO | YES | NO | NO | 10 | 80 | YES | YES | YES | YES | YES | 344 | NONE |
| 19 | YES | YES | NO | YES | 135 | 10 | NO | _ | 750 | NO | _ | _ | 405 | 250 | 690 | 60 | NO | YES | NO | YES | NO | NO | 490 | 10 | 80 | NO | _ | _ | _ | _ | _ | NO | NO | NO | NO | 13 | 72 | NO | NO | NO | NO | NO | 97 | SLIGHT | | |
| 20 | YES | YES | NO | YES | 100 | -12 | NO | _ | 615 | NO | _ | _ | 220 | 175 | 615 | _ | NO | YES | NO | YES | NO | YES | 455 | 16 | 84 | NO | _ | _ | _ | _ | _ | YES | YES | YES | NO | 23 | 30 | NO | NO | NO | NO | NO | 355 | NONE | | |

TABLE 3 Continued

| Workstation number | P1 | P2 | P3 | P4 | P5 | P6 | W1a | W1b | W1c | W2a | W2b | W2c | W3 | W4 | W5 | W6 | W7 | W8 | W9 | W10 | W11 | W12 | W13 | W14 | W15 | W16 | W17 | W18 | W19 | W20 | W21 | W22 | W23 | W24 | W25 | W26 | W27 | W28 | W29 | W30 | W31 | W32 | W33 | W34 | I1 | I2 | |
|--------------------|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|----------|----------|--------|
| 21 | YES | YES | NO | YES | 125 | -2 | NO | _ | 685 | NO | _ | _ | 310 | 205 | 655 | 30 | NO | YES | NO | YES | NO | YES | 610 | 15 | 83 | NO | _ | _ | _ | _ | _ | _ | _ | _ | NO | YES | NO | NO | 10 | 60 | YES | NO | NO | NO | NO | 291 | SLIGHT |
| 22 | YES | YES | NO | YES | 80 | 21 | NO | _ | 865 | NO | _ | _ | 415 | 225 | 750 | 115 | NO | YES | NO | YES | NO | YES | 280 | 37 | 59 | NO | _ | _ | _ | _ | _ | _ | _ | NO | YES | NO | NO | 13 | 65 | NO | NO | NO | NO | NO | 118 | MODERATE | |
| 23 | YES | YES | NO | YES | 132 | 2 | NO | _ | 685 | NO | _ | _ | 260 | 150 | 620 | 65 | NO | YES | YES | YES | NO | YES | 730 | 26 | 81 | NO | _ | _ | _ | _ | _ | _ | YES | YES | YES | NO | 4 | 30 | NO | NO | NO | NO | NO | 312 | SLIGHT | | |
| 24 | YES | YES | NO | YES | 130 | 5 | NO | _ | 685 | NO | _ | _ | 270 | 160 | 620 | 65 | NO | YES | YES | YES | NO | YES | 755 | 15 | 90 | NO | _ | _ | _ | _ | _ | _ | YES | YES | YES | NO | 4 | 30 | NO | NO | NO | NO | NO | 247 | SLIGHT | | |
| 25 | YES | NO | YES | YES | 73 | 25 | NO | _ | 775 | NO | _ | _ | 345 | 180 | 645 | 130 | NO | YES | NO | YES | NO | YES | 580 | 0 | 94 | NO | _ | _ | _ | _ | _ | _ | YES | YES | YES | NO | 10 | 30 | YES | YES | YES | YES | NO | 215 | NONE | | |
| 26 | YES | YES | NO | YES | 82 | 30 | NO | _ | 905 | NO | _ | _ | 420 | 230 | 760 | 145 | NO | YES | YES | YES | NO | YES | 420 | 8 | 86 | NO | _ | _ | _ | _ | _ | _ | YES | YES | YES | NO | 5 | 30 | NO | NO | NO | NO | NO | 323 | SLIGHT | | |
| 27 | YES | YES | NO | YES | 128 | 0 | NO | _ | 735 | NO | _ | _ | 340 | 240 | 675 | 60 | NO | YES | NO | YES | NO | YES | 700 | 11 | 88 | NO | _ | _ | _ | _ | _ | _ | YES | YES | YES | NO | 10 | 30 | NO | NO | NO | NO | NO | 183 | SLIGHT | | |
| 28 | YES | YES | NO | YES | 90 | 15 | NO | _ | 735 | NO | _ | _ | 335 | 225 | 675 | 60 | NO | YES | NO | YES | NO | YES | 530 | 5 | 90 | NO | _ | _ | _ | _ | _ | _ | YES | YES | YES | NO | 10 | 30 | NO | NO | NO | NO | NO | 334 | SLIGHT | | |
| 29 | YES | YES | NO | YES | 100 | 11 | NO | _ | 735 | NO | _ | _ | 340 | 260 | 685 | 50 | NO | NO | YES | YES | NO | YES | 495 | 23 | 79 | NO | _ | _ | _ | _ | _ | _ | YES | YES | YES | NO | 6 | 30 | NO | NO | NO | NO | NO | 592 | NONE | | |
| 30 | YES | YES | NO | YES | 90 | 22 | NO | _ | 740 | NO | _ | _ | 345 | 210 | 675 | 65 | NO | YES | NO | YES | NO | YES | 540 | 9 | 85 | NO | _ | _ | _ | _ | _ | _ | NO | YES | NO | NO | 12 | 80 | NO | NO | NO | NO | NO | 387 | MODERATE | | |
| 31 | YES | YES | NO | YES | 100 | 10 | NO | _ | 735 | NO | _ | _ | 370 | 185 | 625 | 110 | NO | YES | NO | YES | NO | YES | 500 | 10 | 86 | NO | _ | _ | _ | _ | _ | _ | NO | YES | NO | NO | 12 | 80 | NO | NO | NO | NO | NO | 387 | MODERATE | | |
| 32 | YES | YES | YES | NO | 90 | 8 | NO | _ | 680 | NO | _ | _ | 380 | 150 | 640 | 40 | NO | YES | NO | YES | NO | YES | 520 | 8 | 84 | NO | _ | _ | _ | _ | _ | _ | NO | YES | NO | NO | 12 | 75 | YES | YES | YES | YES | NO | 334 | SEVERE | | |
| 33 | YES | YES | YES | YES | 90 | 15 | NO | _ | 675 | NO | _ | _ | 320 | 215 | 646 | 29 | NO | YES | NO | YES | NO | YES | 410 | 15 | 80 | NO | _ | _ | _ | _ | _ | NO | YES | NO | NO | 12 | 75 | YES | YES | YES | YES | NO | 355 | NONE | | | |
| 34 | YES | YES | NO | YES | 90 | 24 | NO | _ | 775 | NO | _ | _ | 340 | 150 | 635 | 140 | NO | YES | NO | YES | NO | YES | 550 | 4 | 90 | NO | _ | _ | _ | _ | _ | _ | YES | YES | YES | NO | 10 | 30 | NO | NO | NO | NO | NO | 183 | SLIGHT | | |
| 35 | YES | YES | YES | YES | 90 | 19 | NO | _ | 760 | NO | _ | _ | 400 | 150 | 590 | 170 | NO | YES | NO | YES | NO | YES | 530 | 11 | 82 | NO | _ | _ | _ | _ | _ | _ | YES | YES | NO | NO | 18 | 73 | YES | YES | YES | NO | NO | 646 | SLIGHT | | |

TABLE 4

Data on the workstation, equipment and the operator

| Workstation number | Name of evaluator | Date of evaluation | Location of workstation | Type of terminal | Name of operator | Profession of operator | Sex of operator | Height of operator in cm. |
|--------------------|--------------------|--------------------|-------------------------|----------------------------|--------------------|------------------------|-----------------|---------------------------|
| 1 | Narendra Munireddy | 07-02-1985 | DU 210 | IBM Pc | Max Atwood | student | male | 195.6 |
| 2 | Narendra Munireddy | 07-10-1985 | DU 209 | COURIER | Stephan Ferrell | student | male | 177.8 |
| 3 | Narendra Munireddy | 07-15-1985 | DU 209 | SELANAIR | Hurriet Aydogan | student | male | 177.8 |
| 4 | Narendra Munireddy | 07-17-1985 | DU 209 | IBM Pc | Nesbie Bolden | student | male | 167.6 |
| 5 | Narendra Munireddy | 08-05-1985 | DU 210 | IBM Pc | Dan Mcnarney | student | male | 177.8 |
| 6 | Narendra Munireddy | 08-05-1985 | DU 140 | ZENITH 150 | Chetan Mehta | student | male | 172.7 |
| 7 | Narendra Munireddy | 08-05-1985 | DU 140 | COURIER | Sujeet Shenoy | student | male | 182.9 |
| 8 | Narendra Munireddy | 08-05-1985 | DU 140 | DIGITAL | Mahendra Ghorpuray | student | male | 167.6 |
| 9 | Narendra Munireddy | 08-05-1985 | DU 237 | ZENITH 150 | Fern Miller | secretary | female | 165.1 |
| 10 | Narendra Munireddy | 08-05-1985 | Dickens 3 | TELEVIDEO | Jennifer Kendal | student | female | 157.4 |
| 11 | Narendra Munireddy | 08-05-1985 | Dickens 3 | TELEVIDEO | Wongo | student | male | 172.7 |
| 12 | Narendra Munireddy | 08-05-1985 | Dickens 3 | TELEVIDEO | Richard | student | male | 175.3 |
| 13 | Narendra Munireddy | 08-06-1985 | DU 261 | ZENITH 150 | Vicky Anderson | secretary | female | 167.6 |
| 14 | Narendra Munireddy | 08-06-1985 | DU 105 | ZENITH 150 (ANDEK monitor) | Kelly Swenson | secretary | female | 165.1 |
| 15 | Narendra Munireddy | 08-06-1985 | DU 105 | ZENITH 150 | Susan Rolfs | secretary | female | 170.2 |
| 16 | Narendra Munireddy | 08-06-1985 | DU 128 | Zenith 150 | Jon Cramer | student | male | 180.3 |
| 17 | Narendra Munireddy | 08-06-1985 | DU 128 | Zenith 150 | Chris Loehr | student | male | 177.8 |
| 18 | Narendra Munireddy | 08-06-1985 | DU 207 | SOROC | Joyce Martin | secretary | female | 165.1 |
| 19 | Narendra Munireddy | 08-06-1985 | DU 246 | APPLE IIc | Song-Tien Chou | student | male | 165.1 |
| 20 | Narendra Munireddy | 08-07-1985 | DU 128 | IBM Pc (ANDEK monitor) | Nagashima | student | male | 167.6 |

TABLE 4 Continued

| Workstation number | Name of evaluator | Date of evaluation | Location of workstation | Type of terminal | Name of operator | Profession of operator | Sex of operator | Height of operator in cm. |
|--------------------|--------------------|--------------------|-------------------------|------------------|------------------|------------------------|-----------------|---------------------------|
| 21 | Narendra Munireddy | 08-07-1985 | DU 31 | PERKIN-ELMER 550 | Ravi Pragasa | student | male | 165.1 |
| 22 | Narendra Munireddy | 08-07-1985 | DU 37 | HEATHKIT | Nora Mortensen | student | male | 177.8 |
| 23 | Narendra Munireddy | 08-08-1985 | CW Basement | WYSE | Gerard Wall | student | male | 181.6 |
| 24 | Narendra Munireddy | 08-08-1985 | CW Basement | WYSE | R. Lapitan | student | male | 167.6 |
| 25 | Narendra Munireddy | 08-08-1985 | CW 303 | Zenith 150 | Venkataraman | student | male | 170.2 |
| 26 | Narendra Munireddy | 08-08-1985 | CW 313 | CIT-101e | Ajit Bhat | student | male | 175.3 |
| 27 | Narendra Munireddy | 08-08-1985 | F 5 | ZENITH 150 | Wei Lee | student | male | 170.2 |
| 28 | Narendra Munireddy | 08-08-1985 | F 5 | ZENITH 150 | Shun Jane Lin | student | female | 160.0 |
| 29 | Narendra Munireddy | 08-08-1985 | F 14-C | ESP 6110 | Bob Clark | student | male | 188.0 |
| 30 | Narendra Munireddy | 08-09-1985 | S 126 | ZENITH 100 | David Murdock | student | male | 190.5 |
| 31 | Narendra Munireddy | 08-09-1985 | S 126 | ZENITH 100 | Mohammed Nai | student | male | 167.6 |
| 32 | Narendra Munireddy | 08-09-1985 | S 115 | ZENITH 100 | Darlene Axelton | secretary | female | 163.8 |
| 33 | Narendra Munireddy | 08-09-1985 | DU 261 | ZENITH 100 | Orlene Sherwood | secretary | female | 161.9 |
| 34 | Narendra Munireddy | 08-12-1985 | DU 52 | ZENITH 150 | Venkatesh | student | male | 172.7 |
| 35 | Narendra Munireddy | 08-12-1985 | S 21 | COURIER | Frank Hwang | student | male | 170.2 |

DISCUSSION

Posture (refer to criteria P1 through P6 in Table 2)

The postural aspects of most of the VDT operators mostly conformed to the desired conditions and standards. The only nonconformity of significance was that some of the operators' backs was not being supported by the chairs' backrest (P3). This will be discussed under the chair's characteristics.

Workstation

Work table (refer to criteria W1 through W8 in Table 2).

All the workstations evaluated had tables only with fixed height (W1). This reduced the possibility of adjusting the work surface height and also other relative heights such as the distance between the underside of thighs and the palms of the hand on the middle alphabetical row of keys (W3), the distance between the underside of thighs and the underside of the table top (W4), etc.

The average distance between the underside of thighs and the palms of the hand on the middle alphabetical row of keys (W3) was found to be 306 mm against a desired distance of 200 to 250 mm. This increase in distance could be due to the following reasons.

Nearly 66% of the chairs (W30) and all of the work tables (W1) were of fixed height. Hence the distance was mostly predetermined and could not be adjusted to obtain the desired distance.

Even in cases of chairs with adjustable height, the adjustability could not be fully utilized because footrests were not provided in any of the workstations (W3). Therefore, in some cases increasing the chair height would have resulted in some of the operator's feet not resting on any firm support.

Some of the table tops were also much thicker than desired (W7). This prevented the operators from increasing the chair height without reducing the distance between the underside of thigh and underside of table top (W5) to less than the desired minimum of 190 mm.

Also, none of the 35 workstations evaluated was equipped with wrist supports (W7).

CRT (refer to criteria W9 through W15 in Table 2). Only about 14% of the CRTs were tiltable (W9). Hence most of the operators could not tilt the CRT to make their line of sight normal to the screen. This could be the reason for the slightly lower average angle of 84.6° between the line of sight of the operator and the CRT screen against the desired angle of 90° (W15).

Document holder (refer to criteria W10 through W16 in Table 2). Nearly 86% of the workstations were not equipped with document holders. Among the workstations equipped with document holders, about 20% of the document holders could not be adjusted for tilt (W17). Hence the operator could not tilt the document holder's display surface to make their line of

sight normal to the display surface. This could be the reason for the decreased angle of 76° between the line of sight of the operator and the display surface against the desired angle of 90° (W23).

Also, only about 20% of the document holders could be adjusted in height (W19). This adjustment in height is mainly considered necessary to facilitate the user to adjust the angle of line of sight to the center of the document holder's display surface (W22). Since this angle averaged about 27° against the desired angle of 0 to 30° , the lack of height adjustment in some of the document holders did not seem to have affected much.

Keyboard (refer to criteria W24 through W29 in Table 2).
About 26% of the keyboards were attached to the CRT (W24). This prevented the operators from moving the keyboard back and forth and positioning it according to their convenience without altering the position of the CRT.

None of the keyboard support surfaces were adjustable in height (W27). This prevented the operators from setting their own keyboard height and other relative heights.

The average height of the middle row of alphabetic keys from the base of the keyboard (W29) was much higher than desired. This also seems to have contributed to the increase in the distance between the palms of the hand on the middle alphabetical row of keys and the underside of thighs (W3).

Chair (refer to criteria W30 through W34 in Table 2).

Nearly 66% of the chairs were of fixed height (W30). This, coupled with the fixed height of the work tables and keyboard support surfaces, almost totally prevented the operators from adjusting any of the heights as desired.

Only 23% of the chairs had backrests adjustable in height and in fore-aft directions (W31 and W32). This probably is the reason for some of the operator's back not being supported by the backrest (P3).

Nearly 66% of the chairs did not have a rounded front edge and padded seat surface or were not covered with cloth (W35). Only 3% of the chairs had a five point base with castors (W36).

Illumination (refer to criteria I1 and I2 in Table 2)

The average level of illumination of 349 lx was within the desired limits of 300 to 700 lx (I1). However, regarding the glare on the CRT screen (I2), only about 23% of the CRT screens had no glare, nearly half of the CRT screens had slight glare and the rest had moderate to severe glare.

RECOMMENDATIONS

The following are the recommendations to correct the major problems observed during the survey.

1. For the CRTs having glare, relocate the CRTs or the illumination sources such that the glare on the CRT is reduced to a minimum or is completely eliminated.
2. Provide all workstations with document holders. The document holders should be adjustable in height, and be tiltable and rotatable to match the user needs. The document holder should be placed in the plane of the CRT.
3. Provide all workstations with chairs having the following characteristics. The chairs should be adjustable in height. The chair's backrest should be adjustable in height and in fore-aft directions. The chair should have a rounded front edge and padded seat surface with cloth covering. The chair should have a five point base with castors.
4. Replace all the worktables having table tops of more than 30 mm thickness with tables having table tops of 30 mm or less thickness.
5. Provide all the workstations with footrests that are adjustable in height and in inclination.
6. Provide wrist supports at all the workstations.
7. For the CRTs which cannot be tilted, provide pivoting monitor stands or stands that can be adjusted for tilt.

8. Make the CRT support surface adjustable in height either by placing them on tables with adjustable height or by providing spacers to increase and decrease the height.
9. Make the keyboard support surface adjustable in height either by placing them on tables with adjustable height or by providing spacers to increase and decrease the height.

The above recommendations are for the major problems observed during the survey. However, it should also be noted that not only is the proper design of the VDT workstation important but it is also important to acquaint the user with the capabilities of the workstation and to educate him/her in its proper use. Because, regardless of how carefully a workstation is designed, it is useless without the proper education of the end user.

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VDT WORKSTATION EVALUATION

by

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AN ABSTRACT OF A MASTER'S REPORT

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ABSTRACT

Electronic equipment is fast replacing traditional office equipment. The use of video display terminals (VDTs) is becoming more and more widespread. With this change in the nature of the equipment and the work methods it has become necessary to examine the ergonomic aspects associated with these new equipments and work methods and design the workstations accordingly.

In recent years, after research on the ergonomic aspects of VDT workstations, some countries have developed ergonomic standards relating to VDT workstations. These standards are either general and qualitative or very detailed and quantitative. Based on these standards the author has developed a set of standards which are neither all qualitative nor all quantitative. These standards are discussed in detail as the design considerations for the VDT workstation and then are presented in the form of a VDT workstation evaluation form.

In a survey conducted by the author, 35 VDT workstations located on the Kansas State University campus were evaluated using the above mentioned evaluation form. The results of the survey and how well the conditions at these workstations relate to the standards are reported and discussed. Also, appropriate recommendations have been made to overcome the major problems observed during the survey.