

Workstation design for VDT (product design project)

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Abstract. Activity and photoergonomic analysis was carried out on 21 VDTs, while the operators were performing usual VDT tasks, at three computer centres in Bombay. Studies confirmed that failure to apply the knowledge of ergonomics to the design of workstations results in unnecessary fatigue and discomfort. Among the various factors which contribute to the efficiency, comfort and well-being of operators, the postural and visual factors are closely related (inseparable) and are important. Document holders, though very important, are not used at all. The aim of the workstation design was to obtain maximum postural/visual efficiency, bearing in mind environmental, manufacturing and marketing constraints.

1. Introduction

Ever since the development of the CRT (cathode ray tube) display terminal more than a decade ago, visual display terminals (VDT), and the computer systems of which they are an integral part, have become increasingly common in offices and other working environments. Not only are they being used regularly by more people than a few years ago, they are being used more intensively. In India the trend is the same as the world over and is reflected by the growth of the computer industry, the value of which has almost doubled from Rs. 18 crores (U.S.\$18 million) in 1975 to 30 crores (U.S.\$30 million) in 1980.

Most of the VDT workstations these days comprise of assorted pieces of furniture which have been brought together, having no relationship with the equipment, the operator or the tasks that are performed on it. A well-integrated furniture system for the VDT workstation has not been conceived as yet.

The VDT operator generally faced with the problem of using heavy and, therefore, more or less fixed equipment invariably tries to move himself to awkward positions (stretching and twisting) to compensate for the incompatibilities of man-machine fit, thus resulting in reduced comfort, strain and excessive fatigue. This reduces operator performance, accuracy and speed. As the operator is a highly paid skilled worker and machine time is very expensive the reduction in performance has far-reaching economical consequences for the user organizations.

1.1. *Design methodology*

A literature survey that dealt with ergonomic requirements and standards for CRT display consoles and typewriters was undertaken. The relationship between the CRT console and the computer with its basic functioning was looked into. Observation and questioning was carried out at the Tata Institute of Fundamental Research, Bombay, the Asian Paints Computer Division, Bombay, and the Indian Institute of Technology Computer Centre, Bombay. Activity analysis and photoergonomic analysis was carried out while the operators were performing usual VDT tasks. An inventory of the objects in the workstation rooms was taken. Details of the layout, the position of the windows, the colours of the walls and draperies, etc., were noted.

In all, 21 VDTs were studied. All were character displays (very few graphic terminals are in use these days).

1.2. Conclusions

The studies confirmed that failure to apply ergonomic knowledge to the design, implementation and, particularly, to the use of VDTs results in unnecessary discomfort and fatigue among operators. This fatigue mostly arises from postural problems due to inadequate workplace design, including the visual aspects of the task.

The position of the keys, the CRT and the copy in the working space form the major elements that decide the operators posture, efficiency and general well-being. There are five major factors which cause or aggravate fatigue and discomfort among VDT operators: postural, visual, environmental, work design and personal. The studies showed that postural and visual factors are very closely related and are inseparable. The item which caused severe postural/visual problems is the document holder (copy holder) or more correctly the lack of it. In none of the workstations that were studied was the document holder used.

The aim of this workstation design was to achieve maximum postural/visual efficiency, which means comfortable working conditions and reduction of fatigue-inducing elements and irritants, bearing in mind manufacturing and marketing constraints.

2. Postural and visual factors

If an operator is comfortable in a work situation, the task can be accomplished efficiently but very few tasks can be accomplished comfortably from restful postures. So comfort, not rest, is the design criterion.

Ideally the *source* (copy document), keyboard and the screen should be all at the same distance from the eyes, if the character, and the character height in each case is same. The right distance at which the screen should be kept for 3 mm character height was found to be 380–400 mm (figure 1).

The position of the operator's head in relation to the display, and the posture of the head in relation to the spine and shoulders can greatly affect the incidence of fatigue (figure 2). When seated, the normal sight-line is 15° to the horizontal and if the eyes have to be elevated to read a display above this line, the eyeball must be rotated upwards. If this is a constant or repetitious requirement, it causes an imbalance in normal contraction of the six tiny muscles that control the eye ball within the socket. In particular, the superior rectus muscle will be most affected and will become static loaded if not relieved for reasonable periods. Consequently, poor blood flow and heat transfer can produce discomfort in this area. Therefore, all visual elements should be below the line of 15° for the shortest (i.e. the 5th percentile) operator (figures 3 and 4).

It is generally assumed that seat height should be made variable to accommodate the population between the 5th and the 95th percentile, but variable seat height is not the only way to accommodate the variation in stature. Variable seat height necessitates the use of variable table heights and angular adjustments of the equipment.

In this project some of these problems were circumvented by fixing the seat heights from the ground for the Indian 95th percentile (440 mm) and by providing a discreetly variable footrest, which not only accommodates the different heights but also provides a chance to move the lower limbs to adopt different postures—minor postural changes in the lower limbs of seated person are desirable for better circulation provided no constraint to the tissue of the thigh is offered. This was achieved by making the seat

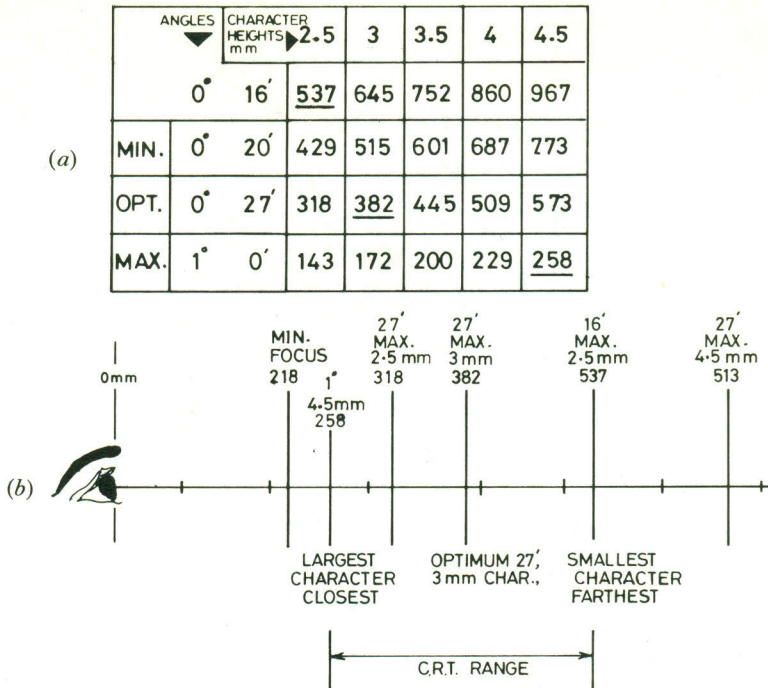


Figure 1. (a) Character heights, angle subtended and maximum viewing distances. (b) Optimum CRT viewing distance depending on character height.

horizontal and rounding down the front edge. Fixed seat height helps in reducing the gap between the eye levels of the 5th and 95th percentiles, allowing the use of fixed angle copy holder and screen positions (see figure 3).

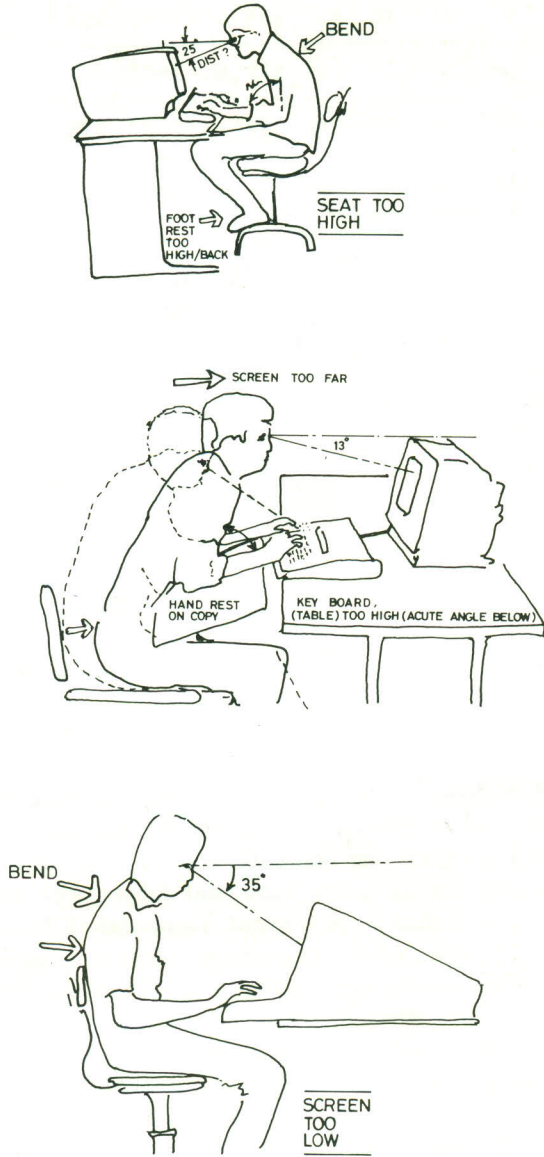
Another consideration for adopting fixed seat height was that not all VDT operators are sensitive or skilled in equipment manipulation to suit their anthropometric requirements. The probability of creating ergonomic misfit by the operator himself is quite high as the questionnaire studies showed that operators did not even realize that they were adopting wrong postures while working. It is felt that variability is more often than not used as a sales gimmick or as an excuse for not being able to take a firm decision regarding the dimensions of the equipment.

Possibilities of posture changes in the upper part of the body (trunk) were incorporated by giving a pivoted backrest. The pivot position was derived by a trial and error method. It allows the body to lean back for a rest pause after a bout of continuous work.

The support surface for the video unit and copy holder has been made angular so that the units (video and copy holder), when aligned to the edges, adapt to the ergonomic requirements (figure 5). The support surface for the key unit is made at a lower level and inclined to 10° for proper and relaxed posture of the arms and hands.

3. Environmental factors

Apart from the usual recommendation regarding the recommended illuminance of 300–500 lx on the desk surface, *visual relief* areas should be included in the lighting and



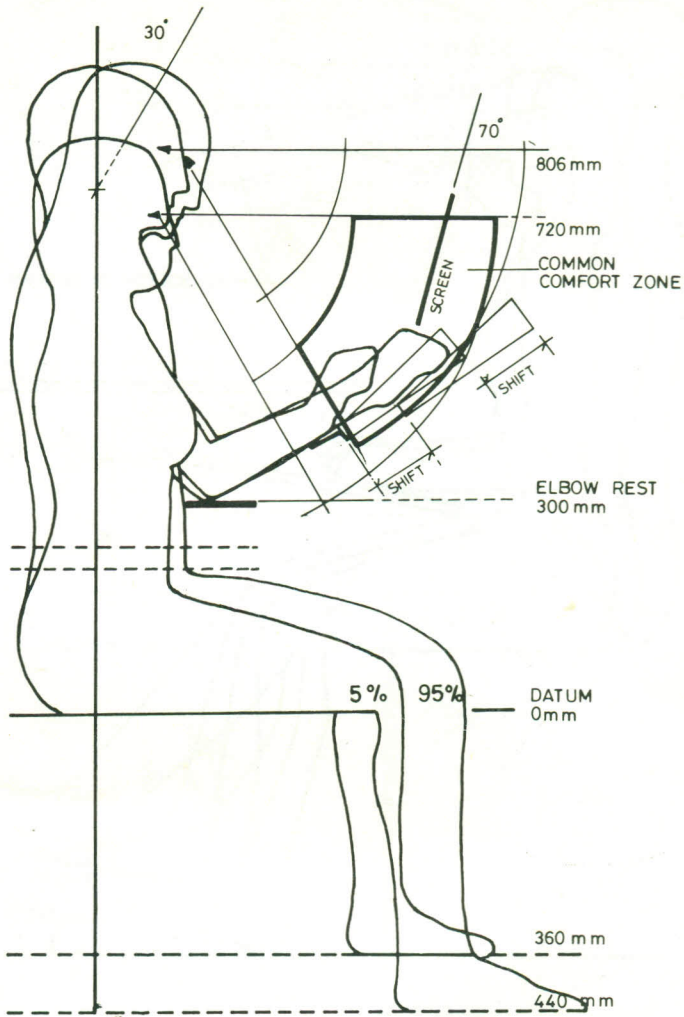


Figure 3. The concept initially chosen.

decorative scheme, i.e. if VDT characters are green, the objects of complementary colours, i.e. red flowers in the flower pot or red patterned drapes and/or a painting predominantly red, can provide relief to the eyes from after images—and make the environment more relaxing and comfortable. Touches of red in this case can provide warmth in an environment which is rather cool (air-conditioning requirements of computers). If the characters are blue, touches of orange in drapes, flowers, carpets or paintings can provide relief from after images. The preferred colour for VDT screens was green. It was considered soothing and believed by the operators to be less harmful to the eyes than other colours.

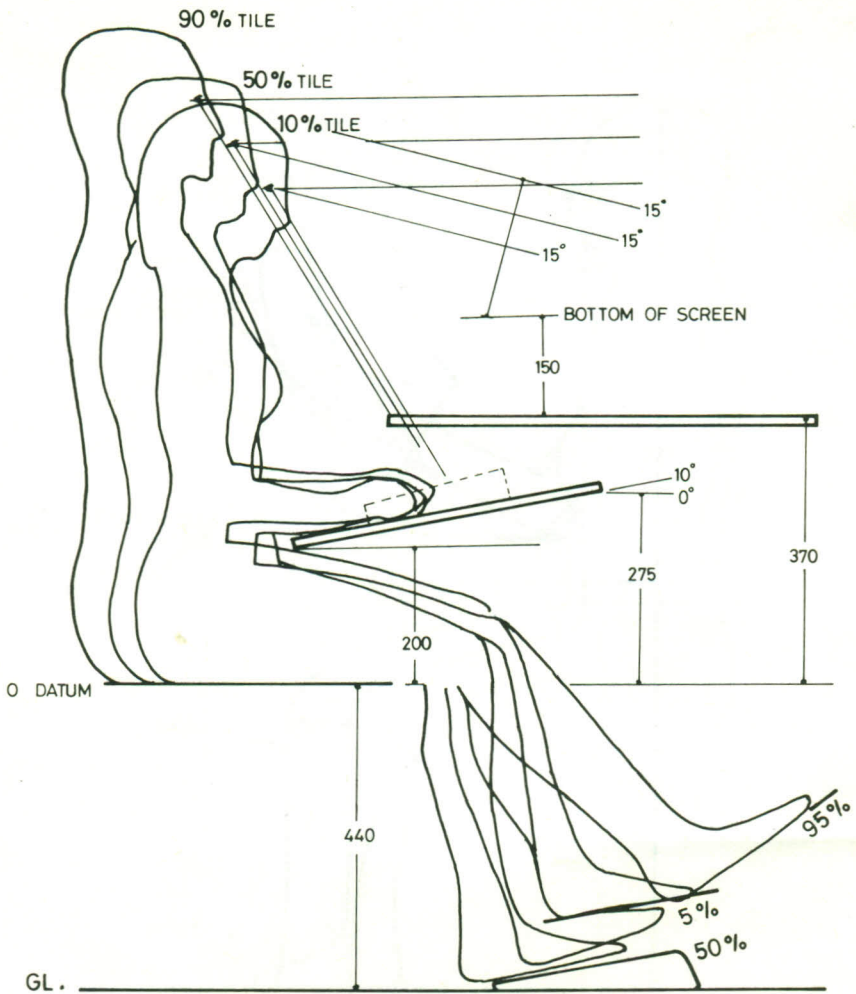


Figure 4. The ergonomic solution.

4. Aesthetic factors

The supporting surface for the copy holder and video unit was made angular, with an angle of 150° (ergonomic requirement), and manoeuvrable footrests were also made at the same angle, with central column support to make the structure light and the whole unit less bulky.

The colours chosen for the table-top surface and the structure were matt light beige and coffee brown, respectively. The corrected effective temperature (CET) of Indians being about 2°C higher than that of Europeans, the warm colours on the equipment are believed to offset the chilly atmosphere inside the VDT rooms, at least psychologically, as the temperature and humidity considerations in these rooms are mainly dictated by machine requirements. The table edges were in wood (wood-grain finish) to accentuate

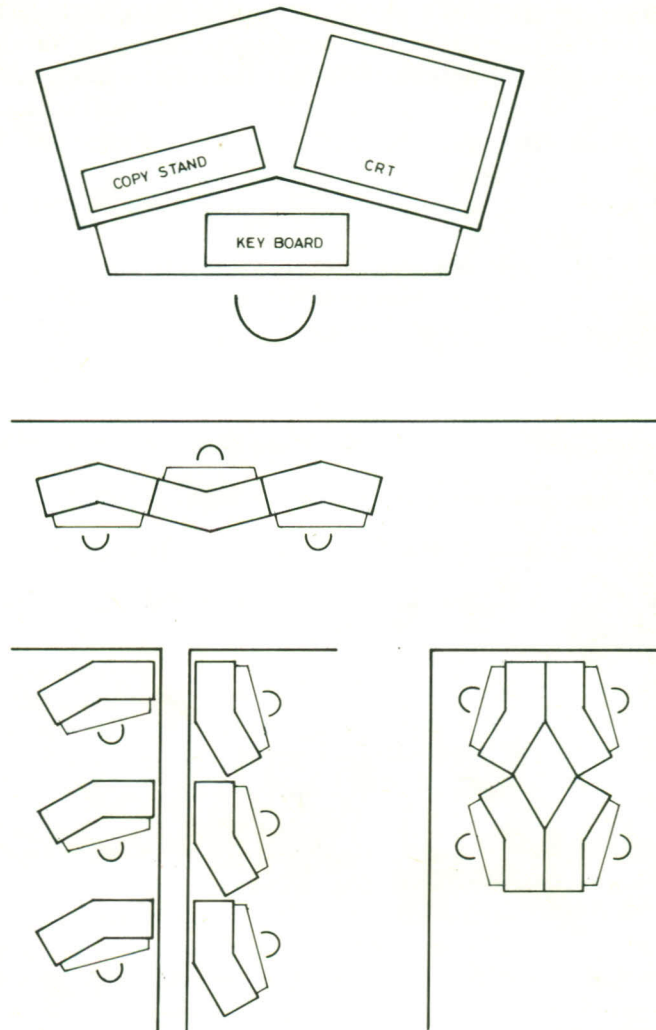


Figure 5. Layout configurations.

the warm feeling and the thickness at the edges was added to make it look strong and less sharp.

The unit can be used singly or in groups and because of its angular configuration has the possibility of producing interesting and efficient layout arrangements of working spaces. Even if laid out closely it cannot create claustrophobic conditions because of its light (visually) construction.

5. Marketing and distribution factors

The unit has been designed so that it can be erected or assembled from parts that are not awkwardly large or inconvenient to handle or assemble. Dismembered parts are packed and delivered to the customer, who can either assemble it as per the instructions or a dealers' representative can assemble it easily.

The unassembled unit can be transported over greater distances (India being a vast country) at relatively cheaper cost, with low incidence of damage in transit. The parts can be sent separately to the distributors, who can then offer a choice of colours and finishes, thus avoiding the setting up of the assembly line at the manufacturers.

The whole operation can be easily handled by a marketing organization if vendors are employed to produce parts strictly according to the specifications and a quality-control check is made at the vendors premises. This can reduce costs and thereby increase acceptability of the product.

The possibility of concealed wiring has been incorporated as a feature, and specialized tooling has been kept to a minimum, bearing in mind the reluctance of Indian manufacturers to invest in high-cost tooling.

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