UNIT 8 JOB DESIGN

Objectives

Upon completion of this unit, you should be able to:

- establish the complementary nature of job design to work design
- understand the relevance and importance of ergonomics and human engineering to job design
- realise the need for considering appropriate design considerations for improving productivity
- realise the need for providing a good environment and workplace
- realise the need for interspersing appropriate rest pauses during work hours
- understand the relevance and importance of behavioural dimensions of job design
- identify the need for adopting a socio-technical approach to job design
- appreciate that appropriate work and job design together would go a long way in realising a better quality of life.

Structure

8.1 Introduction to Job Design
8.2 Design Factors
8.3 Environmental Factors
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8.5 Behaviour Dimensions of Job Design
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8.1 INTRODUCTION TO JOB DESIGN

Job design is the consciously planned structuring of work effort performed by an individual or a team of persons. Good job designs must answer the job-related questions such as what work is to be performed, who is to perform the work, where the work is to be done, when the work is to be done, why the job is necessary and how should the work be accomplished. Job designers usually attempt to minimise the amount of physical human effort. Years ago, employers looked for workers with the physical capabilities to suit a given task. Today jobs are designed to suit an average worker and capability distinctions are more likely to be on the basis of education and experience.

For organisational purposes, we divide job design into two basic elements, a human element and a work element. Physiological, social and psychological considerations are important human factors relating to job design. The work element has been considered in detail in the previous unit. We shall, however, include some relevant points that we had deliberately left out while discussing work design. There is increasing evidence that poorly designed jobs are a pervasive societal problem affecting the mental and physical health of the worker both on and off the job. The objective of job design is therefore to develop work assignments that meet the requirements of the organisation and the technology, and at the same time also satisfy the personal and individual requirements of the job holder. The smallest work activities involve various elementary movements called therbligs (Gilbreth spelt backwards), e.g. reach, grasp, position, release, search, select, transport, empty, hold, release, load, inspect, assemble, disassemble, use, plan etc. Micromotions are made of therbligs whereas an element is an aggregation of two or more micrornotions. Two or more elements taken together form a task whereas the set of tasks that must be performed constitute a job the operator is to perform. Job design is a complex function because of the variety of factors that coalesce to create the ultimate job structure.

Degree of Labour Specialisation

Specialisation of labour is the two-edged sword of job design. On the one hand it has made possible high speed and low cost production, and has therefore increased our standard of living. On the other hand. extreme specialisation could lead to adverse effects on the worker, like boredom etc.

Advantages of specaiisation to management are the following:

(i) rapid training of the workforce (ii) ease in recruiting new workers (iii) high output due to simple and repetitive work (iv) low wages due to ease of substitutability of labour and (v) close control over work flow and work loads. As for labour, there is little responsibility for output, little mental effort is required and little or no education is required to obtain work.

There seem to be some disadvantages also. The management may face difficulty in controlling quality since no one person has responsibility for the entire product. Moreover, there could be `hidden' costs of worker dissatisfaction arising from turnover. absenteeism. tardiness, grievances, intentional disruption of production process. Disadvantages to labour could be: (a) boredom stemming from repetitive nature of work (b) little gratification from the work itself because of small contribution to each item (c) little or no control over the work pace leading to frustration and fatigue (d) little opportunity to progress to a better job since significant learning is ready possible on fractionated or .partial work (e) little opportunity to show initiative through developing better methods or tools (f) local muscular fatigue due to use of the same muscles in performing the task and (g) little opportunity for communication with fellow workers due to layout of work area.

As can be seen from the above discussion, disadvantages of specialisation seem to outweigh the advantages. Because of this researchers have cone up with alternative approaches to job design. We now hear of human engineering, ergonomics, work physiology, job enlargement, job enrichment, job rotation, flexiture and socio-technical systems approach, etc.

Ergonomics/Hunan Engineering

Every industrial system consists of some or all of the following components: hardware (the physical aspects), software (non-physical aspects), the physical environment and the organisation. An objective of the designer is to arrange these components to give a harmonious and efficient operation, An objective of ergonomics is to match, or provide the information to match, the various other parts of the system to the characteristics and abilities of the people involved in it. By utilising ergonomics, the designer's opportunities to create a system which reliably achieves its function are improved. Ergonomics is somewhat synonymous with human factors with engineering which is a field of study concerned with the abilities and limitations of human beings in the design of tools, instruments and work places. Let us first discuss Job Design by elaborating on the design, environmental and organisational factors. These can be subsequently complemented by behavioural dimensions and the need for adopting a socio-technical approach.

8.2 DESIGN FACTORS

Layout of Equipment and Seating

Ideally, equipment design should start with the operator. Often a piece of equipment is first designed and then the operator is added as a kind of afterthought w'o has to cope with unsatisfactory arrangements of display and control as best as he can. Quite often, it is assumed that because a machine has always been the way it is, there is no good reason to change it. The attitude is one of `what was good for our grandfathers is good enough for us'. The effects of tradition acting in this way is the rule rather than an exception.

Thus many equipments, though inconvenient, undergo no change for ages owing to this attitude. In some machine, for example, controls may come in a comfortable position for the hand, but the work might be too far away from the eye and as a result the operator has to operate in a bent posture while working on, say, central lathes. Why not think of a tilted centre lathe so that the operator can see without stooping?

Vision of old type of crane cabs was bad. Redesigned crane cabs now provide unrestricted vision that place much less strain on the driver thereby increasing his efficiency.

For good design, the designer ought to start out with the operator by laying out the areas for vision, for controls, for sitting, for leg room etc. by taking note of standard anthropometric data of men and women, as the case may be lob design should consider whether the job is to be done standing or sitting or in both the ways. You would probably observe that people leave their work places after regular intervals in order to obtain a change of posture. It is not very surprising to note that workers find it necessary to stand up from time to time probably because the seats provided are probably too uncomfortable to be sat upon for wore than a limited period.

It is the requirement of good seating that the person while sitting should be able to maintain a good posture which will not cause overstrain of any particular group of muscles. The use of a well designed and positioned back rest may relieve the back muscles of a good deal of postural strain. Moreover, the seat should not press unduly on the tissues of buttocks. The pressure will restrict the blood flow which may cause pressure on the nerve trunk which runs on the underside of the thigh and will cause discomfort which could also sometimes cause the need to go to sleep' and induce numbness. A well designed seat should therefore bear the weight of the body in a good posture on the hips and not on the thighs. The elements of good seating will depend on the length, width and shape of the seat; material of which the seat is made; the shape and height of the backrest and the height of the seat above the floor. When high chairs are used at work benches, there will have to be some type of footrest which should preferably be a flat surface rather than a bar which causes fatigue by forcing the operator to keep the foot in a fixed position. Sometimes it maybe useful to provide some standing supports or `rump rests'. In contrast to the work situations, seats which will be used for relaxation can he somewhat lower than office and factory chairs.

On the contrary, there are quite a few advantages in working at floor level. This is popular amongst workers of many categories such as cobblers, tailors, etc. Workers have greater freedom to move their legs and bodies. Sometimes consultants might provide operators with some sort of a stool or a bench out of human considerations. It is usually seen that such aids are not used subsequently for sitting purposes; rather the operators would place their tiffin boxes, small bags, shawls etc. on these stools.

However, when benches are laid out for assembly work or when controls are positioned, the general principles of motion economy as laid down by Gilbreth should be taken as a guideline. It is now being realised that reducing movements too much could cause local muscular fatigue which will not be present if the actions are spread over more muscles in the body. Accurate positioning of manipulative movements should be made near the body and controls which need fine adjustment should be placed close to and opposite the hand which will operate them. In case a worker is to operate a foot pedal, the return spring pressure on the pedal should be sufficient to support the weight of the foot or of the leg as the case may be; otherwise very tiring static work will have to be done to maintain either a foot or a leg in the `off' position. In extreme cases, muscular damage can be caused by pedals with insufficient pressure operat for a long period of time.

In case of controls, information should preferably be given to the operators in a binary form of `yes-no' type. Alternative lights like green-red can be used. Where quantitative information has to be given, digital presentation should be used in preference to the reading of graduated scales. Important control panel instruments should have preferably a combination of auditory (sound) and a visual warning signal scheme. Care should be taken to see that visual warning should be quite evident and not misleading. Lights or blinkers that are 30° from the centre of vision will be noticed more slowly than lights that are centrally located.

Layout design of the equipments, control panels etc. should also keep in mind the need for their subsequent maintenance and repair in the beginning itself. Certain points which require regular maintenance should not be placed at inaccessible places. Diagnostic studies might have to be conducted to isolate causes of failure. Rectification would be done accordingly. Ergonomics considerations need to be kept in mind at various design stages.

Instrument Display Design

We can think of display as any device or event which gives information about a situation which is occurring or has occurred. Where this information cannot be obtained by seeing or hearing directly, we might have to resort to the use of instruments, like pressure gauge for instance, which reveal the conditions of a piece of equipment or instrumental displays which could be primarily of auditory or visual type.

Visual dial displays could have a graduated scale on which the indication of a value is given by means of a pointer. There could be `off-on' lights knows as **indicators, warning devices** and numerically displayed information counters. Dials and counters may be used for quantitative and qualitative reading, and to check reading for comparison in visual displays without controls. As for the case when displays are used with controls, dials and counters may be used for check controlling, setting and tracking. Warning and indicator devices are used in both cases.Visual displays could be of different kinds like (i) moving index with a fixed legend (moving index display), (ii) fixed index with a moving legend (fixed index display), (iii) open window display, (iv) counters, (v) shutters, lights etc. Dials could be of shapes varying from circular to linear forms.

Studies conducted have shown that counters which give the value directly in numerals are far more superior than others for quantitative reading. The design of the actual scale on a dial, in case of a graduated scale, has far greater influence on accurate reading than its shape. Moving index displays are found to be superior to fixed index displays probably because additional information is given by the position of the index.

It has further been observed that vertical straight dials are better than circular dials because an upward movement of the pointer will always indicate an increase in value. However, for recording a rate of change, a circular dial is preferred because the angle of the pointer rapidly conveys the relevant information. Circular dials also find favour when comparisons need to be made. However, it has been suggested by various workers that moving pointer instruments are most suited for check reading. Horizontal straight dials can be used for setting machines more quickly as compared to other varieties.However, when dials are mounted in panels with associated controls; it is probable that both circular and vertical straight dials may be used with reasonable confidence. There seem to be no definite conclusions about the variety of dials best suited for indication and warning purposes.

Readings `at a glance' used in connection with quantitative reading implies a reading time of 1.0 to 2.0 seconds whereas check reading at a glance may be as short as 0.5 seconds.If x' is the percentage tolerance and an instrument is to be read to 100th of its maximum scale value (m.s.v.) and if a scale division is to be read to fifths,the optimum number of scale divisions in a whole scale would be (100/5x).

Activity A

Determine the optimum number of scale of divisions if a reading tolerance of 1% is required. Do you get 20 as your answer? Yet another relationship between reading distance (D) and scale base length (L) can be expressed as :(D =1.2 L)when `D' is expressed in feet and ‘is’ expressed in inches.

In general, the following formulae would prove to be useful for design of instrumental displays for calculating relevant parameters.

$m = n/(c \times i)$

$c = nt/100$

$L = (0.06944\ D)/t$

Where D=reading distance(in cms)

scale base length(in cms)

L=scale range

n= number of units

c= 1 m 2 or 5(or decimal multiple)

i= number of parts into which a scale division is to be divided by eye.

t=tolerance(%)

m=number of scale divisions

$(c \times i)$number of units in scale division

Instruments and counters could be used for various purposes. It seems that when check reading alone is required, the shape of the instrument is not of vital importance. However, if a control movement is also involved, as in check controlling, then the movement of the instrument should be compatible with that of the control.

Displays could be pictorial when we wish to disseminate primarily qualitative information about a situation. These displays could include not only instruments but tables, graphic presentations and even pictorial panels. Today computer graphics is assuming great importance.

There could yet be another way of communicating information namely by auditory displays.The simplest use of auditory signals is for providing warnings of the `yes-no' type. Yet another form of auditory display in addition to the above information gives some quantitative information, e.g. a chiming clock. To be effective the sound intensity of a warning device should be at least 10 decibels (dB) above the background noise. Intermittent sound catches attention more readily than continuous sound.

Compatibility

Now you will notice that there are quite a few natural movements. One usually turns a knob in a clockwise rotary direction or from left to right so as to switch on an instrument or equipment. Such natural movements need to be kept in mind while designing instrument knobs. Learning times for the operation of equipment on which controls are compatible with natural movements are much shorter than if the controls are incompatible. There will be greater risk of accidents in case of incompatibility. Performance deteriorates on equipments with incompatible control movements.

While designing the control knobs, either have all of them compatible or all of them incompatible with the natural movements. Where controls are associated with dials in a panel, the dials and controls should be laid out with the same spatial relationship, e.g. the left hand dial should be operated by the left hand controls and so on. It is also important to know the preferred hand of an operator.Unfortunately, most of the researches and recommendations have been made for the right handers only.

Control Design Characteristics

In the absence of a computer, controls are the normal way in which an operator conveys his instructions to a machine. It is therefore important to take note of the shape, size, inertia, friction characteristics of controls. The anatomy of the limbs used in operation could be considered while determining the best type of control for different uses.

Control used for continuous adjustment could be rotary or reciprocating in form. Cranks, handwheels and knobs are of the rotary type while `joysticks' and levers are of the reciprocating form. Levers usually give control in one dimension and joysticks in two dimensions but both types of controls do give speed and accuracy. Controls required for discrete movement will usually be of some `off-on' type of mechanism.

Let us now discuss some of these control mechanisms and their utilities.

Crank is a control in which the handle is offset from and parallel to the shaft. Cranks are used when high turning speeds are required upto 200 r.p.m. (revolutions per minute), when rapid complete turns are required and when heavy loads have to be moved manually.

Handwheel is a circular control gripped by the rim, preferably with both hands. Handwheels should be used when turning speeds are low (1 r.p.m. or less), when very accurate partial turns are required and when torque required is above 15 inch lbs. Handwheels are best used when the amount of turn required does not exceed 90° for fine positioning movement.

A **knob** is a rotary control that can be operated freely by gripping it on both sides with the fingers of one hand. Knobs may be used for making fine adjustments when loads are light, upto 22 inch. lbs., or as rotary selector switches for switching operations.

A **lever** is a hand-operated rod-like control working in one dimension about a fulcrum. A lever should be used when the effective travel is small, when fast movement without great accuracy is required and when there is e medium to heavy load.

Toggle switches are miniature levers used as selector switches. However, they should not be used for more than three switching positions, and there should be between 30° and 40° of movement on either side of the central position. Toggle switches should not be used for making discrete adjustments.

A joystick is a lever working in two dimensions. Joysticks should be used when continuous simultaneous control is required in two dimensions or for rapid multiple switching operations.

A **rotary lever** is a lever attached to a shaft so as to permit a complete turn. It is used when a fairly high force is required over a long range of movement with fairly accurate end control.

A **pedal handgrip** is a rotary lever with a limited area of movement which is gripped close to the shaft rather than by its end. Handgrips are used for rotary multiple switching. They should not be used for continuous control.

A **pedal** is a reciprocating control operated by one foot acting independently. Pedals should be used when a very powerful force has to be applied or for continuous controlling when accuracy is not of a high order or for on/off or start/stop switching.

A **rudder ba**r is a reciprocating control pivoted about its centre and operated by the foot in line with the lower leg. A treadle is a reciprocating control pivoted at or near its centre which is operated by the movement of the ankle. Rudder bars are used when accurate control is very important but the amount of force required is very small.

A **push-button** is a reciprocating control, small in size which has a positive action in one direction only. Push button should be used for switching in one or two senses only.

8.3 ENVIRONMENTAL FACTORS

Temperature and Humidity

Let us now discuss the effect of temperature and humidity on the performance of workers. Studies have been conducted both in laboratory settings as well as industrial settings yielding quite a bit of statistical data on accidents. In an investigation into loading of coal tubs in coal mining the results revealed that there was a slow but steady increase in the loading time (minutes) as the effective temperature increased from 19°C (66°F) to 28°C (82°F) as shown in Figure I.

Moreover, the time taken for resting (minutes per hour) also increased rapidly for temperatures above 24° C (75° F) as can be seen in Figure II. The working efficiency at the higher temperature was about 41% less than that at the lower.

Some studies were conducted in a weaving shed also. The average per hour output by `pick count' on 44 looms fell from 7163 to 6832 when relative humidity (r.h.) of 77.5% to 77.9% rose to 82.5% to 84.9%. There, however, seem to be hardly any studies conducted on the performance of workers when temperatures are reduced.

Some data on accidents in relation to temperature reveal a rather strange phenomenon. The studies conducted show an increase in accidents both with decrease and increase of temperature from an optimum of 65°F-69°F, the increase with cold being somewhat the greater as can be seen in Figure III.

Also, some studies were conducted on people with different ages to investigate the relative effect of temperature on efficiency. Now accidents could easily reflect, in some way, the effect of temperature on efficiency. As can be seen from Figure IV, older men are adversely affected by higher temperatures.

Having noted the effects of temperature and humidity on performance, one should seriously consider providing an environment conducive to the worker so that he could perform effectively and efficiently. The body attempts to maintain a heat balance and a constant body temperature. This can be done as long as the regulating body mechanism is working within its capacity, and heat gains or losses are not excessive.

Heat could be gained by the body through convection (C), radiation (R) and the

Figure I: Effect of Temperature on Loading Time

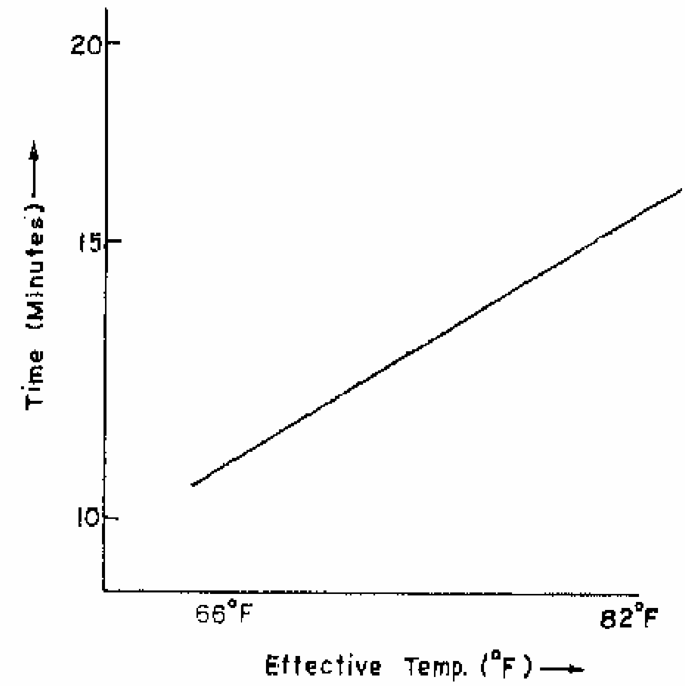


Figure II: Effect of Temperature on Duration of Rest

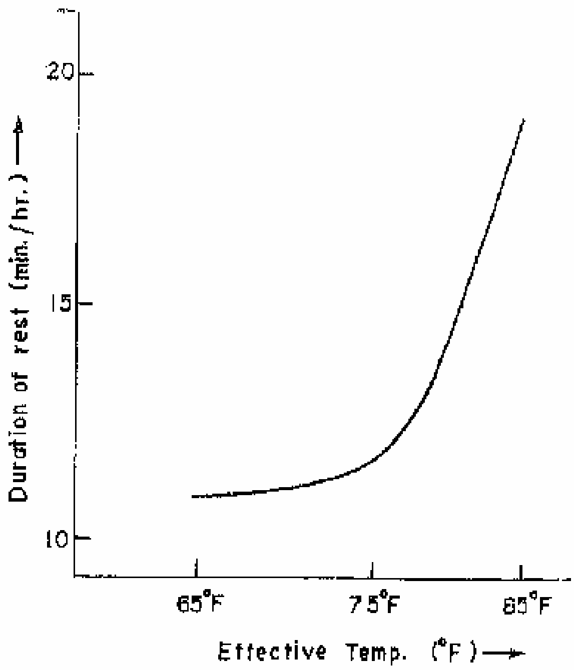


Figure III: Effect of Temperature on Relative Frequency of Accidents

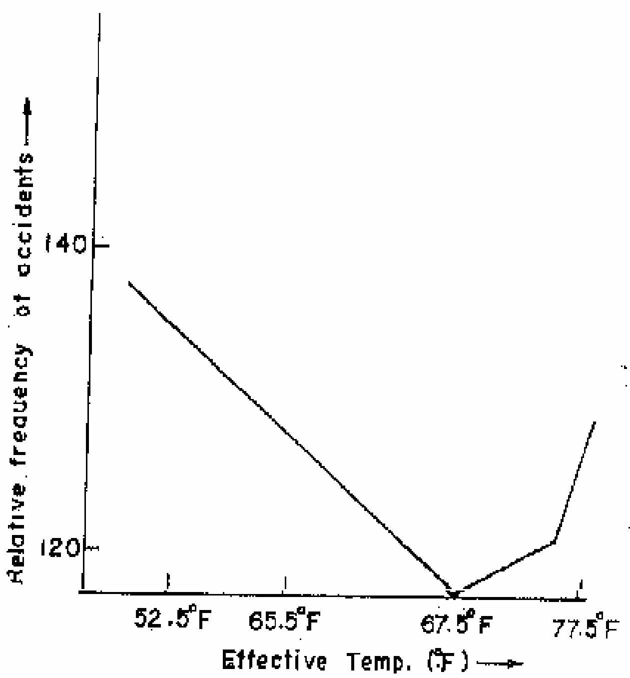
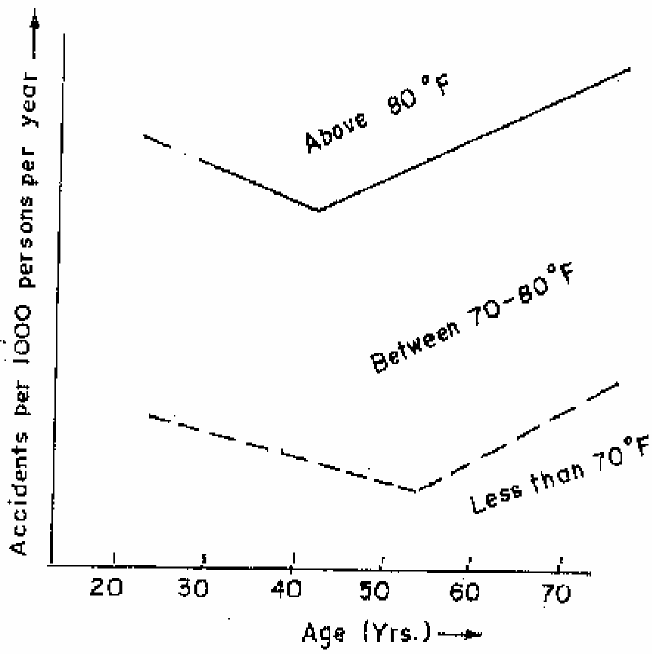


Figure IV: Effect of Age on Accident Rates



production of body heat through muscular activity and basal metabolism (M). Similarly, heat is lost through evaporation (E), convection and radiation. Therefore, the heat balance equation may be expressed as

M±R± E =0

orE=M±R±C

Now the rate of evaporation depends upon the sweating mechanism of the body and upon the relative humidity or water pressure of the environment in which the individual is working.

Should the body be gaining heat greater than it can lose by evaporation, then a maximum body temperature rise is about 1°C (or 2°F); otherwise severe heat stress could lead to heat stroke. It is possible, however, that man's tolerance to heat increases gradually with the passage of time.

Heat may be troublesome under two conditions: warm-moist and hot-dry. Warm-dry conditions do not pose a problem whereas in hot-moist climate it would be impossible to survive. In a warm-moist environment, heat is mainly convected. Work becomes difficult because of the high humidity which reduces evaporation of sweat though proper ventilation and air-conditioning can help in improving this situation. However, where heat is radiated, amelioration of this condition will depend on preventing the heat from falling on the body or, where this is impossible, removing the workman from the environment at appropriate times to allow him/her to cool off.

Vibration

During work, a person could be frequently subjected to vibration from various resources. The effects of movement and vibration upon the person may range from motion sickness through slight discomfort to physical damage. Some studies have been conducted which reveal a relationship at the tolerable limit between the amplitude (A) and frequency (F) of a vibration as follows:

-AF^3 = 2 for low frequency vibration 1 to 6 cycles per second

- AF^2 = 1/3 for medium frequency vibration 6 to 60 cycles per second.

- and AF = 1/60 for high frequency vibration above 60 cycles per second.

Vibration which is at or near the tolerable comfort limit may be experienced for long periods without causing any harm, although it may interfere with a person's efficiency as an operator and produce sensations of fatigue. However, it should be noted that most of the experimental work on subjective tolerance to vibration have been of compaiatively short exposure durations rarely more than about half an hour. Excessive vibration of amplitudes of the order of 0.2 at frequencies of about 10 to 20 cycles per second has been shown to cause damage to the lungs, rectal bleeding, blood in the urine and constipation in some cases. In some studies of injuries due to use of hand-held vibrating tools or pneumatic drills, instances have been reported of white fingers', `dead hand' or 'Raymonds phenomenon'. However, it is difficult to make specific design recommendations which will ensure that the effects of vibration on efficiency are minimal. Not much attention is given to vibration because even the people/operators themselves feel that they are paid, in part at least, to tolerate discomfort (which can include that due to vibration). It appears most operators accept vibration provided it does not cause actual physical damage.

Noise

Let us now discuss yet another important environmental factor, namely, noise which can best be described as unwanted sound. Noise could be a frequent cause of fatigue and irritation resulting in loss of output. The ear is quite sensitive. The risk of damage to the ear appears to be greatest from frequency of sounds between 2,400 to 4,800 cycles per second. Hearing losses may increase with age. For instance, at the age of 50 years, a hearing loss of 40 decibles might be expected above 12,000 cycles per second and 5 decibels at 125 cycles per second compared with the hearing of an individual of the age of 20.

Moreover, it has long been recognised that individuals who have been exposed to high noise levels over a long period of time will suffer a hearing loss. It is thought that people get used to noise without realising the long term impact. Still, quite a few noises produced intermittently could be very irritating and harmful. Any intermittent noise which approaches the damage risk level should be considered a potential hazard. In a number of countries abroad, deafness due to noise has come to be recognised as a compensatabl industrial disability.

Protection against unavoidable noise may be provided by some form of earplugs, or simple cotton wool which might be a cheap and effective preventive remedy. It has been observed that noise above 90 decibels can induce the commission of errors in those who are normally accustomed to noise Under certain circumstances, some individuals may become irritated by certain types of noises which in turn may have an effect on their work. High pitched noises of a frequency of above 1500 cycles per second appear to be more annoying than lower pitched noises of equal intensity. Relating a subjective feeling such as annoyance to an objective measure of performance is as difficult as trying to relate, say, boredom to performance.

However, at times noise could be made meaningful in some cases. It may be necessary to introduce sound artificially into quiet working places in order to act as a barrier between one worker and another. Some companies think of introducing music-while-you-work so as to increase output and to improve the workers' feeling of satisfaction in the job. However, it is possible that while some like music, there are others who do not like it and treat it as noise and hence show an adverse impact on productivity. Also superimposing music on an already high noise level in the work place and its environment could render the general noise level dangerous. Noise may also interfere with oral communication between persons. Shouting will permit communication at higher noise levels, but it could be very strenuous. Noise can also interfere with communication between man and his equipment by masking the sound of warning signals or bells. Where this is likely to happen, auxiliary visual signals should be considered.

There are various ways of reducing noise. Probably the most important method is the reduction of noise at the source itself. You could also think of isolating the equipment from the surrounding structure or its total enclosure to prevent the noise spreading, or by mounting noisy machines on resilient bases. Sometimes noise is produced by resonance when, for instance, parts are being ground or when office machinery is mounted in sheet steel cabinets. Suitable damping devices can often be attached to parts which are likely to resonate. Alternatively, damping material can be applied to the inner surface of the sheet metal. If however all this has been tried to prevent production and distribution of noise from the source and the noise level remains still too high, some acoustic absorption will be necessary. Quite often residents staying close to some industries may find the noise very irritating. To absorb such noise, and also to reduce pollution, it is advisable to plant trees, which also add to the scenic and aesthetic view of the factory.

Visual Environment

The majority of industrial tasks will depend for their efficiency on adequate vision and, therefore, lighting arrangements may play an important role in determining the efficiency with which tasks are carried out. The standards of lighting and recommended levels of illumination at work place are good aids for work and job designers. It is said that at normal levels of illumination, the ability to see increases in proportion to the logarithm of the illumination (given in lumens per square foot, lm/ft^2). This implies that from a practical and economic aspect, a point is reached at which large increases in illumination will produce relatively small increases in efficiency or output. One such study, conducted for a task requiring speed and precision, revealed that there was a significant decrease in errors when the illumination was increased from L to 50 lm/ft^2. When the illumination was further increased to 150 lm/ft^2, there was only a slight non-significant decrease in errors. However, the above study was conducted under certain conditions and the results just cannot be extended to all types of activity.

Apart from direct lighting standards, there are some other important factors which can affect performance. The contrasts between the surroundings and the task being performed, the colour schemes and the presence or absence of glare could greatly influence th6 overall efficiency and effectiveness of the work. For reading, high-contrast or well printed material in areas not involved in critical or prolonged seeing e.g., for conferring, interviewing etc., the recommended illumination is 10 lm/ft^2. Recommended illumination is 100 lm/ft^2 for regular office work, reading good reproductions, reading or transcribing handwriting in pencil on poor paper, sorting notes, etc. Fine bench work and machine work require 70 lm/ft^2 and 500 lm/ft^2, and rough bench work and machine work 15 lm/ft^2 and 50 $lmlft^2$ as recommended by Illuminating Engineering Societies (IES). However, people can adapt themselves to a variety of conditions so that they can work quite satisfactorily in conditions worse than those thought to be ideal. Sometimes level of illumination may be generally appropriate, the relative location of jobs, (e.g. overhang of press and position of the operation in relation to a luminaire) may be such that the light actually falling on the task may be quite inadequate.

The amount of light required for the performance of a visual task is influenced by four factors which are inter-dependent. These are (a) the size of the object, (b) the contrast between the object and its immediate surrounding, (c) the reflectivity of the immediate surroundings, and (d) time allowed for seeing. However, with the steady increase in the number and brightness of lighting fixtures these days, the problem of

Work and Job Design glare is causing concern. There could be a discomforting glare which produces a feeling of strain due to the worrying effects of sources of brightness. On the other hand, there could be disability glare which could cause a diminished ability to see. The effect of both types of glare may cause distraction by drawing the eyes away from the visual task. Reflections could be from paper surfaces, cover glasses over dials or shiny panel surfaces. Table 1 shows some recommended maximum brightness ratios and reflectance values.

Table 1: Recommended Brightness Ratios and Reflectance values

Maximum Brightness Ratios		
Between jobs and adjacent surroundings		5 to 1
Between jobs and more remote surfaces		20 to 1
Between light sources (or sky) and surfaces adjacent to them		40 to 1
Any where within the environment of the worker		
Reflectance values		
Type of surface	Reflectance value	
Ceiling	80	
Walls	60	
Desk and bench tops	35	
Machines and Equipment	25 to 30	
Floors	Not less than 15	

Yet another important factor that could effect worker's performance is the colour scheme. It is often said that warm saturated colours such as yellows and reds tend to give a sense of warmth and an advancing effect. Conversely, cool shades of blues, greens and greys tend to give a sense of coldness and recession. Long narrow rooms may be made to appear wider by using `cool' colours on the side walls and `warm' colours on the ends. Light of special colour may with advantage be used to improve visibility by a selective darkening of parts of the task. Moreover, a light source should not keep flickering. Flickering lights could be a source of irritation and watering of the eyes and may produce sensations of muscle twitching such as eye blinking and facial twitching, sensations relating to other parts of the body such as 'funny' feelings in the stomach, headache, nausea, chill and tense muscles etc. Hand-eye coordination is significantly impaired by flickering light to the tune of about 10 flashes/sec.

Planning for visual efficiency should start at an early stage in job planning. As a general rule, sunlight is preferable to artificial lighting. Apart from the work place, suitable lighting should also be provided in all important stairways, exits from work places and passages to these. A great deal can be achieved by good lighting, the use of colour, by the manipulation of contrasts to make a work place in the factory or office, a pleasant place where people will be happy to work and perhaps become more effective and efficient. The money, time and thought devoted to acheving good visual conditions at a place of work is certain to yield good dividends in the long run.

8.4 ORGANISATIONAL FACTORS

The problem of when to give a `break' or `rest pause' to an operator has been engaging the attention of researchers for many years. Work measurement techniques are important, some of which were discussed in the previous unit. Heavy work can be measured by means of energy expenditure. Researchers have arrived at a reasonable estimate for the calorie expenditure of an `average man' employed in different types of occupation. It has been estimated that the light work clerks expend about 2,800 K. cal per day whereas coalfield miners expend about 3,600 K. cal per day. On an average the person working over an extended period should not expend over 3,200 K.cal per day. If heavier work is undertaken, the daily expenditure will rise. Work physiologists seem to agree that over a period of time, the calorie output of a normal man in good health should not exceed 4800 Kcal. per day. The whole day's activites are divided broadly in three stages, namely, time spent in (i) bed (ii) work activity and (iii) non-work activity. As such, it is estimated that about 2000 K. cal could be used for a normal days work. A value of 5 K.cal/minute seems to be acceptable to workers and work physiologists. The approximate number of calories required per minute for activities is shown in Table 2.

Table 2: Expenditure in Cals/min for various activities

Type of activity	Energy expended cals/min	Type of activity	Energy Expended cals/min.
Sitting at rest	1.7	Ironing	4.4
Writing	2.0	Heavy assembly	5.1
Typing	2.3	Chopping wood	7.5
Medium Assembly	2.9	Digging	8.9
Shoe repair	3.0	Tending furnace	12.0
Machinery	3.3	Walling upstairs	12.0

Table 3 is a rough grading of work difficulty in terms of calories and heart rate.

Table 3: Grading of work on physiological considerations

Work load	Energy expenditure cals/min	Heart rate beats/min.
Very light	Less than 2.5	Less than 75
Light	2.5-5.0	75-100
Moderate	5.0 - 7.5	100-125
Very hard	7.5 -10.00	125-150
Extremely hard	10.0-12.5	150-175

The optimum arrangement for work and rest is that work should cease at the point in time at which lactic acid (responsible for muscle fatigue) starts to accumulate in the body; rest taken at this time will be minimal. When a substantial part of the work is carried out at a rate exceeding 5 K. cal/min, the cycle of work should be organised into periods of about 10 minutes activity and 7 minutes rest if the optimum output and minimum fatigue are to result. The working hours need to be interspersed with some pauses, rest period, meal breaks etc. which would, however, otherwise be taken, by 'clever' operators.

Thus far we have discussed fatiguing in case of heavy work. In the case of light but repetitive work, the operator's work may lead to boredom instead of fatigue. In such cases, to motivate the operator one might have to redesign the jobs and think in terms of job enrichment and `job enlargement'. Let us now look at some bahavioural dimensions of job design.

8.5 BEHAVIOURAL DIMENSIONS OF JOB DESIGN

Traditionally, jobs have been designed to minimise immediate cost and maximise immediate productivity. We agree that economic criteria are still paramount. We must not forget that behavioural implications in job design can and do influence performance. With this goal in mind, let us examine the behavioural ideas of job enlargement, job enrichinent, job rotation and participative job design.

Jobs are a set of tasks, easy ask-being associated with a set of stimuli-auditory, visual and/or tactile. A job consists g of varied tasks provides varied stimuli; a job with routine repetitive tasks usually provides few stimuli.

Job Enlargement

If jobs become too specialised, workers perceive their job to be monotonous and boring, and this leads to job dissatisfaction. Many workers become alienated and the result is high levels of tardiness, absenteeism and turnover. Under such situations we should think of **job enlargement**. An enlarged job would offer the employees opportunities such as (i) a larger variety and hence the opportunity to use a variety of skills (ii) autonomy, the opportunity to exercise control over how and when the work is completed, (iii) task identity, the opportunity to be responsible for an entire piece or programme of work and (iv) feedback, the opportunity to receive on line information. Thus job enlargement is the procedure of redesigning jobs or modifying work so that employees can feel more involved in and responsible for what they do.

Job Enrichment

Alternatively we could think of job enrichment. It presumes that many jobs are so highly specialised that operative workers can no longer visualise how their work contributes to the organisation's goals. The worker tightening a nut on a bolt all day long loses sight of the fact that this nut helps hold a wheel on a new automobile and thereby provides safety for some new owner. Job enrichment is a procedure of redesigning work content to make the job more meaningful and enjoyable by involving employees in planning, organising and controlling their work. Management must suply information on goals and performance that previously was not available to the workers. A proper organisational climate has to be established for success. For some workers, enrichment might reduce social interaction. Many employees prefer a low level of required competency, high security and relative independence to the increased responsibility and growth that job enrichment implies.

Job Rotation

Yet another way to approach jobs that cannot be designed or automated to eliminate undesirable features is to move or rotate employees into the job for a short period of time and then move them out again. This **job rotation** technique seems to be working well in a large number of situations that seem to defy job enrichment and/or

enlargement.

However, one very important fact overlooked by designers is the person/operator who performs the job. If the ultimate beneficiary, the person/operator could be involved in a participatory design procedure, there would be greater success in implementing any changes that need to be done in the organisation.

8.6 SOCIO-TECHNICAL APPROACH TO JOB DESIGN

The consideration of both the technology of production and the social aspects of the work environment is called the socio-technical approach to job design. What is sought, is a design that provides for high levels of productivity and quality and at the same time ensures a satisfying job and work environment. The socio-economic approach emphasises the need for integrating the social consequences of work with the traditional cost versus quantity considerations of production. The concept of socio-technical systems was first elucidated by Eric Trist and his colleagues at the Tavistock Institute of Social Research in London.

On the basis of studies carried out at the Tavistock Institute, the following guidelines for job design are offered at the level of the individual:

1 optimum variety of tasks within the job.

2 A meaningful pattern of tasks that gives each job a semblance of a single, overall task.

3 Optimum length of work cycle.

4 Some scope for setting standards of quantity and quality of production and a suitable feedback of knowledge of results.

5 Inclusion in the job of some. of the auxiliary and preparatory tasks.

6 Inclusion in the job of some degree of care, skill, knowledge or effort that is worthy of respect in the community.

7 Perceivable contribution of the job to the utility of the product for the consumer.

Some group level guidelines are:

8 Providing for `interlocking' tasks, job rotation or physical proximity where

- a) there is a necessary inter-dependence of jobs for technical or psychological reasons.
- b) the individual jobs entail a relatively high degree of stress.
- c) the individual jobs do not make obvious, perceivable contribution to the utility of the end product..

9 If a number of jobs are linked together by interlocking tasks or job rotation, they should, as a group, have some:

- a) semblance of an overall task that makes a contribution to the utility of the product,
- b) scope for setting standards and receiving knowledge results, and
- c) control over the `boundary tasks':

Some caution is, however, needed in implementing the above guidelines. For example, a `loose rein' situation of forming and functioning of autonomous groups might not be tolerated by certain job designers. Sufficient amount of top management support might be needed to make traditional job designers `toe the line' of a socio-technical perspective.

8.7 SUMMARY

A key function in production and operation management is organising work. This is essentially work and job design. In the previous unit we discussed work design whereas in the current unit we have examined a number of important issues regarding the design of jobs and have developed certain useful tools of job analysis and productivity improvement. In considering the role of people in work, operation managers must take a socio-technical approach; that is, they must consider not only the technical aspects but also the social atmosphere of the job. In addition to work design methods, human engineering/ergonomic considerations need to be kept in mind while examining the physical workplace, the physical environment and the social environment. All these must come together to create an effective job that will meet the organisational objectives of low cost, high productivity and worker satisfaction towards a better quality of work life, higher standard of living and ultimately a better quality of life itself.

8.8 KEY WORDS

Anthropometric data: Data regarding physical characteristics of human beings.

Job: Group of related tasks or activities that need to be performed to meet organisational objectives.,

Job Design: The determination of specific job tasks and responsibilities, the work environment and work methods.

Job Enlargement: Procedure of redesigning jobs or modifying work content to provide greater stimulus variety, autonomy, task identity and feedback for the worker.

Job Enrichment: Procedure of redesigning work content to give more meaning and enjoyment to the job by involving employees in the planning, organisation and control of their work.

Job Rotation: Movement of employees into a job for a short period of time and then out again.

Human factors engineering/Ergonomics: A field of study concerned with the abilities and limitations of human beings in the design of tools and work places.

Principles of Motion Economy: General statements focusing on work arrangement, the use of human hands and body, and the use of tools.

Therblig: One of 17 elementary human motions such as grasp, select, assemble and so on so forth.

8.9 SELF-ASSESSMENT EXERCISES

1. Define job design. How has management viewed job design since the industria: revolution?
2. List the important factors that must be addressed in job design and briefly discuss the importance of each one.
3. Discuss, some of the aspects involved in designing a workplace.
4. Contrast job enlargement and job enrichment. Are they mutually exclusive?
5. Each of us realises that such environmental variables as temperature and noise affect our work. What empirical evidence can you cite that supports the impact such environmental variables have on output?

6. What do you understand by the term `a socio-technical system'? Can you give some socio-technical guidelines for job design?
7. Discuss some principles of motion economy and their relevance to job design.

8.10 FURTHER READINGS

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