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PEOPLE: THEIR CAPACITIES, LIMITATIONS, AND EXPECTATIONS IN PHARMACEUTICAL INDUSTRY

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ABSTRACT

This paper considers the human capacities and limitations of people performing industrial tasks. Using the Human Factors techniques of work physiology, anthropometry, and psychology, the worker's capacity for physical work is determined, his body dimension characteristics are considered, and his psychological expectations associated with the equipment are noted.

INTRODUCTION

Industrial efforts to meet employee needs generally are concentrated in the area of human relations and fringe benefits. Eli Lilly has adopted a more encompassing approach where special attention is directed to the human aspects of work. Practices that embraced the assumption "people will adapt if given time" are discarded to favor operations that recognize human factors. Employees' capacities and limitations now are considered in job designs. Jobs are being revamped to fit the employee rather than forcing the individual to adapt to an incompatible job.

The company's Human Factors Department is designed to recognize the human elements in various jobs and how these relate to the job and employee. "Optimal matching" is the group's byword. Its goals simply extend Lilly philosophy--a philosophy that is quite people oriented. The ambitions of this department briefly may be stated as:

> "The engineering of the employee's environment in such a way that fatigue, discomfort, job dissatisfaction, and error provocative features of his equipment are reduced, thereby hopefully effecting an improvement in quality, productivity, comfort, health, and safety."

To determine how much matching is necessary, studies are conducted in our Human Factors Laboratory and at the job site. Examples of some studies are presented in this paper and the human variables in question are explained. Hopefully, the principles and techniques presented here will serve to expand awareness of the human side of industrial operations. The techniques employed in these studies may serve as useful tools for those interested in initiating such programs.

WORKER CAPACITY AND JOB HEAVINESS

Although automation characterizes many of today's industrial jobs, there are still jobs requiring physical effort. Using the human factors approach, we tend to view such jobs on a sort of "scales-of-justice" type balance. On one side, we place the employee's capacity for expending physical energy. On the other side, we place the physical demands of the job. If the scales balance, the employee is supposedly matched with the job demands. The same holds true if the scales are heavy on the capacity side. But if the scales tip toward the job demands end and the demands are expected to continue over an extended period of time, this is unacceptable. Something must be done to equalize the scales.

A review of our job studies and techniques may illustrate how we determine worker capacities and job demands.

FUNCTIONAL CAPACITY ASSESSMENT PROCEDURE

Selection - Employees are selected for study on a strictly voluntary basis from the population of workers typically assigned to the job under investigation. Volunteers then are screened to represent the population in terms of factors critically linked to the job (e.g., height, weight, age, experience, etc.)

Health Check - Participating employees then are given a complete medical examination to insure that they will be exhibiting healthy responses during the testing. If the employee passes the medical check, he undergoes a Functional Capacity Assessment (FCA) in the Human Factors laboratory.

A Standardized Sub-maximal Task - The FCA is a sub-maximal walking exercise on a treadmill that changes speeds and elevations according to a standardized program. Prior to and during the FCA, the individuals' heart rates and oxygen consumption levels are measured, using an E&M Biomedical Telemetry system (FM-100-E2) in conjunction with a Physiograph (Type DMP-4A) paper chart recording device and accessories. The individual also breathes into a face mask connected to a Max Planck Gasometer. Oxygen consumption data then is mathematically derived from the oxygen (O_2) content of the subject's expired air. The O_2 content of the expired air is determined by a Beckman O_2 Oxygen Analyzer.

The physiological parameters of heart rates and oxygen consumption then are used to estimate the subject's capacity for performing physical work. This capacity is expressed in caloric amounts (Kcal/min), which are determined from oxygen consumption data. This defines the energy expenditure levels a person healthfully can sustain over long periods of time (work career). Foı example, a person having an "outstanding" occupational work capacity would be able to expend 5.0 Kcal/min over an eight hour work period without undue physiological strain. Such a person could complete a "heavy" job without impairing his long term health.

Work Heaviness Determination - After individual capacities have been determined, the subjects then are tested at a later date while performing the task in question. The employee wears the same telemetry system throughout the entire work day and continuous heart rates are recorded. On a sporadic basis, O_2 data also are collected using the Max Planck Gasometer with arm strap attachments, face mask, hose, and bladder collection bag. STandard techniques for computing oxygen consumption levels from air volumes and expired oxygen levels then are used. Heart rates and corresponding O_2 consumption levels are plotted as each subject responds to different levels of work on the job. Using the mean heart rate for each subject's workday, a caloric cost of the job can be determined. By converting the job demands to energy expenditure terms (Kcal/min), a comparison can be made to the employee's capacity for work since it is expressed in such terms (Kcal/min).

As an example, a study involving a laundry job indicated the physical demands to be "heavy" (6.4 Kcal/min). Since these demands were greater than our recommended maximum for most employees, material handling aids were suggested as one method to reduce the heaviness. In addition, it was recommended that the employee's daily schedule be changed whereby he would rotate to other laundry jobs of "moderate" heaviness. This mixing of "heavy" and "moderately heavy" tasks helps to reduce the overall physical demands.

By changing the daily schedule, the heaviness of this task was dissipated over several jobs. This change was particularly important when viewing specific employee capacities, for one subject was assessed to have a 4.0 Kcal/min capacity. For this employee, the revamped work load brought the job within closer range of his capacity. The likelihood of physiological strain to him was thereby reduced.

Studies of this nature often lead to job design changes, (e.g., different work-rest cycles, material handling aids, and rotation of personnel). Likewise, the studies may indicate that some employees are not suited for particular jobs because of lower capacities than the job requies. Through the objective assessment of the worker's capacity and job demands we are better able to make recommendations to supervision and engineers regarding optimal matching between the worker and his job.

EQUIPMENT DESIGN AND WORKER EXPECTATIONS

It should be realized that operators think equipment controls behave in a predictable manner. That is, through prior experience with specifically designed equipment, they expect certain things to occur. For example, an increase (speed, flow, or quantity) would be expected if the control is moved forward, upward, to the right, or clockwise, depending of course on the location of the control and the operator's orientation. If the resulting movement contradicts the operator's expectations, he makes an error in operations. Such errors can be critical, causing injury, equipment damage, product loss, or delays in processing.

In the pharmaceutical industry training includes the orientation to such expectations. For example, when a valve handle is at 90^{o} to the transport line, it is said to be "closed". Likewise, when the valve is in alignment with the chemical line it is in the "open" position. When a valve is reversed during installation, accidental opening is possible.

Imagine an operator loading a centrifuge at a slow rate. The valve in the drop line for some reason has been installed to operate in reverse. The operator notices that the centrifuge is nearly full and quickly moves the valve to the "closed" position. Error! He mistakenly turned the valve to its most "open" position. The intermediate, which was precipitated with acid, now is wildly splashing from the centrifuge. Product escapes around the basket. The centrifuge lists from side to side out of balance. Was anyone injured? Any acid burns? How much product lost? Will the filtrate have to be recycled? Standardize controls that are similar, and honor the "expectations" that have become associated with them. Remember, people are only human.

Look-alike controls with different functions also are likely to cause errors. Suppose the agitator and light switch on a pressure reactor are quite similar in appearance. Inadvertent activation of the agitator may cause an undesirable acceleration of reaction. Undesirable consequences may result. Use controls that are easily distinguished from one another.

The location of controls also can be critical. For example, suppose it is necessary to enter one of two brine pots located side-by-side. Following good practices, the agitator will first be locked out. The electrical power cut-off switches are positioned away from the vessels. Does the right-hand switch cut out the right-hand vessel? This is another "expectation" of man. There should be a logical link between the control and its associated equipment. This not only will facilitate learning during training, but also will pay off during emergency situations.

THE WORKPLACE AND WORKER BODY DIMENSIONS

When planning the physical design of any workplace, the anthropometry of employees should receive adequate attention. An individual's body measurements should be an important consideration in designing workplace arrangements if he is expected to operate the equipment or inhabit the workplace area. For instance, certain principles should be observed if an operator must extend his arm to reach a control, or if he is expected to work below equipment with adequate freedom of movement, or if he is required to perform repetitive physical motions. The design should accomodate most of the workers who will be part of the system. Will the shortest worker be able to reach the control? Will the tallest worker have proper head clearance under the equipment? Will the repetitive motions cause early fatigue or medical problems?

To illustrate the importance of anthropometric considerations in designs, these three examples will be elaborated. The Human Factors principle for such instance will be stated and examples of possible consequences of principle violations also will be presented.

When designing for reach, design for the fifth percentile individual, or, consider the shortest reaching workers. If they can reach it, then chances are 95 percent or more of all employees will be accommodated.

It is quite easy to spot inadequate reach designs, for operators may be seen stretching, climbing, or precariously balancing themselves in some manner to allow them to reach a valve or a control.

Valve extensions or other remote control devices could be added to accommodate the shortest-reaching person in the area (at least for the fifth percentile individual). To do so hopefully would eliminate slips, falls, and accidental or uncontrolled activation of controls. Visualize a bank of solvent headers with the valves located a bit too high for some operators. Imagine the tip-toe stance a short operator assumes when reaching for the valve. He needs only a small quantity for the job, but when he loses his balance and accidentally trips the valve completely open, a surge of solvent is delivered suddenly and unexpectedly. The outcome? The operator's partner at the other end of the line may have received a face full of solvent. Or maybe it only was a small solvent loss, or just a little time lost in cleanup. The outcome likely will be undesirable regardless of what it is.

When designing for clearance, design for the 95th percentile individual, or consider the head-bumping potential of the tallest worker. If he is considered, all others will be accommodated. The consequences of a design violation in this instance likely would be personal injury and even possibly equipment damage.

BIOMECHANICAL DESIGNS

Good biomechanical designs provide more efficient utilization of man-machine systems. Three general principles should be considered when developing a system that requires operators' body movements. These principles are:

A. Static loading of muscles should be avoided.

B. Large muscle groups should be utilized when the job design includes heavy work.

C. Required body movements should be kept well within comfortable limits.

The natural dynamics of body movements should receive adequate attention in equipment design, for efficiency decreases if the operator reaches or is beyond comfortable limits. Static loading of muscles will cause early discomfort and fatigue and this reduces efficiency. When small-muscle groups are used for heavy work they will fatigue early. Physical strains or sprains may follow. Scooping from centrifuges into containers is an example of a poor biomechanical design. The operator is seen bending and stretching down into the centrifuge basket, making many repetitive motions with small muscle groups.

SUMMARY

Techniques and principles are available for optimizing man-machine systems in industry. The integral part that man plays in the industrial scene is quite important, yet sometimes ignored. Man's importance in man-machine systems inadvertently is subordinated due to lack of consideration he sometimes is given in the design of equipment and workplaces. To utilize people more efficiently, their capacities and limitations must be given adequate attention. With such consideration, industrial goals of improved quality, productivity, and employee well-being may be enhanced. It may be said that the pharmaceutical industry has traditionally been people-oriented due to the nature of their products. The consideration of the people making these products deserves no less attention.

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