Consideration of Human Factors in Industrial Safety

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ABSTRACT

As modern industrial technologies progress, critical incidents (both conventional and new) occur as well. Although majority of these safety incidents are human-related, or human factors problems, industrial systems and/or occupational safety operations are often designed without seriously considering important roles of human factors in industrial safety. The purpose of this paper is to show how a human factors approach can contribute to industrial safety. The paper introduces a systems safety concept with some useful analysis techniques for proactively preventing human-related safety problems. A behavior-based safety analysis approach to modify human behavior is suggested to reduce unsafe behavior and promote safe behavior. Finally, a sound human factors/ergonomics program is recommended for management to establish a hazard-free work environment. Some current and future research issues are discussed.

INTRODUCTION

With rapid technological and economic development for last few decades, quality of life in Korea has been generally upgraded. However, the other side of a coin was bad news: more accidents, occupational deaths and injuries, and so on. According to the official statistics (Labor Department of Korea , 1993), the number of accidental work-related deaths and the amount of workers' compensation cost paid have been significantly increased for the last three decades in Korea. In 1993 alone, 2,429 occupational deaths were reported, and more than 931 billion Korean wons were legally paid for workers' compensation.

The after-the-fact safety analysis reveals that various industrial accidents are human-oriented, or human factors problems; however, the practice of worker protection is characterized by a set of conditions which are lacking in human factors/behavioral orientation. Accident research and practical safety work in factories and workshops has so far primarily been conducted from an engineering point of view. That is, psychological and organizational problems (which are important to accident histories) are not fully taken into consideration. For instance, too little information to be able to work safely, limits to the human capacities for perception and information processing, etc. These human factors issues can not be overlooked when work on safety is being. This leads to a serious consideration of human factors toward effective design and management of industrial safety systems.

A HUMAN FACTORS APPROACH TO SAFETY

Safety conditions can be controlled and improved by ergonomic, organizational, and personal factors. Examples of control/improvement by ergonomic factors include optimizing the physical work environment, such as illumination, noise and vibration, heat toxic material control; and design of tools/machinery and workplaces, and man-machine interfaces. Organizational factors can improve safety conditions in allocation, sequencing/scheduling of tasks, work, and shift cycles; and improving organizational attitudes and goals with respect to safety performance. Personal factors may also promote safety conditions by improving physiological and psychological conditions such as vision, audition, information processing, skill level, and motor performance. Therefore, a place in the practice of accident prevention and the promotion of industrial safety is assigned to human factors and behavioral sciences.

The potential contributions of human factors to industrial safety. can be assessed by means of orientation toward tasks set by the behavioral sciences, that is, description and explanation of phenomena, and the modification of environment and human behavior. Human factors professionals mostly deal with phenomena which they themselves have not observed. The data on which accident/safety reports are often scanty. Only minimal efforts have been made to classify unsafe behavior, derived from the practical work situation. Behavioral sciences can make valuable contributions to the improvement of essential descriptions and to solving the problems involved in collecting data.

Today, hazards in modern industrial settings, more frequently than before, are hidden hazards which cannot be directly perceived. Dangers arise in the course of performing the work task itself and as the result of surrounding influences. To analyze, describe, and diagnose these dangers, new, more behavior-oriented methods should be developed and implemented.

Another important contribution of the human factors approach is in its capability to provide non-technical explanations for safety problems which can be localized in the environment or in a person. That is, explanations for the occurrence of human errors or of accidents which have or have almost taken place. Critical sequence of incidents which can lead to an accident usually results only when technical processes and human behavior come together. Explanations must never be sought in human behavior alone nor by purely technically orient accident research.

Human factors in industrial safety means that conditions have to be changed. Literature on safety (e.g., Park, 1993) includes several promising attempts to implement techniques of modifying behavior to reduce unsafe behavior and promote safe behavior. The effectiveness of such intervention measures can be highly valued. However, the scarcity of evaluation studies indicates that more systematic human factors research on this area is required. A further discussion of this issue is presented later in the BEHAVIOR-BASED SAFETY ANALYSIS section.

SYSTEM SAFETY CONCEPT

The system safety approach is a thorough and systematic means of addressing workplace hazards. It is the concept of *forward-looking* identification and control of hazards throughout the life cycle of a program.

Traditional safety programs were usually established, based on an *after-the-fact* (or so-called "fly-fix-fly") philosophy of accident prevention. On the other hand, the system safety involves a planned, systematically organized *before-the-fact* process characterized as the *identify-analyze-control* method of

safety (Roland and Moriaty, 1990). Thus, the system safety emphasizes *proactive,* or *preventive* measures of safety, in addition to *reactive*, or *corrective* measures of safety.

The system safety approach to the safe design and operation of potentially hazardous processes can be discussed by a system that allows for equipment, human, and environment interactions. Safety personnel try to identify hazards in that system that could result from equipment failure, human error, environmental conditions, or a combination of these effects. After the hazards (physical, chemical, biological, and/or ergonomic) are identified within the system, the risks associated with the hazards should be determined. The next step is to decide whether the risks are acceptable or not (as with the loss or damage of human life). In the case of unacceptable risks, the safety personnel and engineers are required to determine at what cost the risks can be eliminated or reduced, etc.

System Safety Analysis Techniques

Several hazard evaluation procedures have been developed, when applied properly to a given system, can identify hidden system failure modes and recommend procedures for their rectification. These procedures should be an integral part of different phases of process development from conceptual design to installation, operation, and maintenance of the system under consideration. Some effective hazard evaluation procedures, particularly useful in the preliminary and detailed stages of the design process, include: preliminary hazard analysis (PHA), failure mode and effects analysis (FMEA), fault tree analysis (FTA), event tree analysis (ETA). Detailed discussion of these analysis techniques can be found in Stephenson (1993).

BEHAVIOR-BASED SAFETY ANALYSIS

The behavioral approach to safety analysis applies principles of behavioral science. Behavioral analysis helps the organization to assess the factors that are really driving its safety efforts. The rationale for applying behavioral analysis to industrial safety is to prevent safety hazards before they occur by providing management and safety personnel with preventive thinking and decision making.

The basic tool of behavioral analysis is known as so-called ABC *(Antecedent-Behavior-Consequence)* analysis. An *antecedent* is an event which triggers an observable *behavior*. A *consequence* is any event that follows from that *behavior*. ABC analysis involves the following principles: 1) *antecedents* control behavior *indirectly* (predicting consequences) and 2) *consequences* control behavior *directly* (powerfully). For example, to motivate the *use of hearing protectors in the field (behavior)*, certain *antecedents*, such as *education, reminders/prompters*, may be used to increase the occurrence of desired behaviors. Any *consequences*, including *rewards or punishments*, can be powerful addition to antecedents to help individuals to change behavior (e.g., wearing hearing protectors in this case) because some antecedents are usually not sufficient for motivational change. Park (1993) presented a detailed discussion for application of an ABC model to motivate the use of personal protective equipment, along with some related intervention strategies.

A general procedure of ABC analysis has three steps: 1) analyze the unsafe behavior, 2) analyze the safe behavior, and 3) draft the action plan. A step-wise example procedure of ABC analysis of "Failure to wear hearing protectors" is illustrated in Krause, Hidley, and Hodson (1990).

AN EFFECTIVE HUMAN FACTORS PROGRAM

To be effective in an organization, a sound human factors/ergonomics program should be applied not only by safety and health professionals but also in all areas within an organization in their design and operations. Management is recommended to use a proactive approach to prevent those safety problems from occurring.

The implementation of an effective ergonomics program should include a visible commitment by top management so that all employees can understand that the company is serious about the program. A sound ergonomics program, with a team approach, includes 1) elimination of ergonomic hazards, 2) a safety policy with the same importance level as production, 3) commitment to assign and communicate responsibility for various aspects of the ergonomics program, and 4) commitment to provide adequate authority and resources to all responsible parties

Being encouraged by the employer, employees should involve in the ergonomics program as follows: 1) Employees need to bring their concerns to management and to provide feedback, 2) safety/health committees that receive information on ergonomic problem areas, analyze the data, and make recommendations for corrective action, and 3) ergonomic teams with the required skills to identify and analyze jobs for ergonomic stress and to recommend solutions.

An effective human factors program must include the following elements: 1) work-site analysis, 2) hazard prevention and control, 3) medical management, and training and education. In addition, written programs and regular review and evaluation can help to ensure achievement of company goals.

CONCLUSION

The major purpose of human factors/ergonomics is to design a workplace or any human-machine system that is compatible with the limitations and capabilities of workers. Evaluating industrial safety systems reveals that the safety conditions are often lacking human factors, though there exist several important human factors/behavioral science contributions to industrial safety.

It is important to motivate workers to behave safely and to develop a positive attitude toward safety matters. In addition, safe behavior always involves the appropriate and successful training of operators who deal with dangerous situations. Work settings must also be designed and/or reorganized so that safety will increase. These safety-oriented approaches need to be designed with higher productivity and more workers' satisfaction. A sound human factors/ergonomics program should be developed and committed in all areas of the organization, with strong support from top management.

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