Using the 'Balance Model' for Occupational Safety and Health Promotion

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Abstract. The 'balance model' of job design was introduced in 1989 [1] and expanded to the enterprise level later [2 - 7]. The main idea of this model is that various components of the workplace interact to increase and decrease workplace safety and health risk, and that careful 'balancing' of the components can produce reduced risk and improved employee safety and health. In this paper we discuss how the 'balance model' can be used to promote occupational safety and health.

Keywords: balance, design, hazard, health, risk, safety, system, wellness.

1 The Balance Model

Smith and Carayon [1-4], Smith, Karsh, Carayon and Conway [6], Carayon and Smith [5] and Carayon [7, 8] conceptualized the work system as comprised of five interacting components: employees, tasks, technology, work environment, and the organization (corporate processes). The proposition was that each of the components produced risks for employee safety and health; for example the work environment had hazards and the employees engaged in unsafe acts. These risks could be controlled by working with each component to make improvements. In addition there were safety and health risks that occurred because of the interactions among the various components; for example the organizational component's failure to notify employees about the risks of new materials, or the employees' failures to notify the organization about transient and temporary hazards. Smith, Carayon and Karsh [9], Smith, Karsh, Carayon and Conway [6] and Smith and Carayon [4] have discussed various hazards of each component of the work system and some hazards due the interactions among system components. In essence there is a need to be aware of and deal with the hazards that occur within a component and from the interactions among the components.

2 Organizational Considerations

Cohen [10], Smith, Cohen, Cohen and Cleveland [11], Cleveland, Cohen, Smith and Cohen [12] and Cohen and Cleveland [13] found that successful occupational safety program performance occurred in those companies that had a commitment to reducing

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workplace risks, good communication between the workforce and management, good human relations, structured activities for assessing and controlling hazards, and adequate resources for controlling hazards. The "safety culture" of the company has been identified as a critical element in the frequency rate for occupational injuries of a company [14, 15].

This illustrates the essential role that corporate commitment and involvement has in effective occupational safety and health programs. Conversely, without a strong corporate commitment and involvement it would be unlikely that a company would have a good safety record. Corporate (management) commitment and involvement is a foundation upon which effective occupational safety and health promotion is built.

The first element of a corporate commitment is a policy statement in support of occupational safety and health promotion that comes from the top of the company. This statement spells out the roles of each component of the company, the rewards and punishments for performance, and the resources available for achieving good occupational safety and health performance. It provides the "philosophy" of safety and health that promotes active participation by all employees from the top position to the shop floor employees and everyone between. Cleveland, Cohen, Smith and Cohen [12] found that the safest companies had greater participation by all employees and better human resource relations among managers, supervisors, shop floor employees and unions. Top management plays an important role in providing direction (vision) and resources for setting up the systems and processes related to safety and health promotion.

The importance of a strong culture with a corporate commitment to safety and health is in danger of reduced attention to safety and health when the economy becomes weak and a company's profits decline. Reduced attention to safety and health and cut backs in safety and health resources at such times undermine the corporate culture and are likely to increase the risk for greater hazards and subsequent injuries and illnesses among employees. A strong occupational safety and health corporate culture will reduce the likelihood that cut backs in occupational safety and health resources will occur.

Zimolong and Elke [16] concluded from a review of safety management research and theory that there are three consistent factors that emerge for ideal safety management considerations. These are (1) genuine and consistent management commitment to safety, (2) communication about safety issues between management, supervisors and the workforce, and (3) involvement of employees in safety matters.

The second element in corporate commitment is a process to motivate managers and supervisors to become actively involved in occupational safety and health promotion and activities. Many companies have a safety and health review as part of a manager's annual performance rating and for determining pay increases. Some companies have a policy that managers can be discharged for poor work unit safety performance, or if a serious accident occurs. Other companies provide rewards and prizes for work units and managers that have exemplary safety performance. The important point is that corporate policies and actions have to get the attention of company managers and supervisors that occupational safety and health are very important, and that good performance will be rewarded while poor performance will be punished.

The current era (2000-2008) has seen very risky behavior by managers worldwide in stock market funds, mortgage and finance banking, and in insurance investments that have led to a major collapse of many investment funds, banks and insurance companies.

Yet in the wake of this disaster it is astounding that many of the managers that made very risky and poor decisions received huge bonuses even though the results were poor. Such a reward structure encourages managers to take risks that can lead to unfavorable outcomes. This type of risk management reward process is not what we want to have as a motivational tool for managers in the arena of occupational safety and health. We want managers to be rewarded for reducing the risk of accidents, injuries and illnesses, and for the support they provide to employees to be involved in occupational safety and health efforts.

The third element of corporate commitment and responsibility is the promotion of good communications among all levels of the organization to ensure a knowledgeable workforce. The flow of information must be bi-directional, that is upward as well as downward. One approach for dealing with safety communications is to establish communication networks. These are formal structures to ensure that information gets to the people who need to know the message(s) in a timely way. These networks are designed to control the amount of information flow to guard against information overload, misinformation, or a lack of needed information. Such networks have to be tailored to the specific needs of an organization. They are vital for hazard awareness and general health and safety information. For instance, in a multi-shift plant, information on a critical hazardous condition can be passed from shift to shift so that workers can be alerted to the hazard. Without a communication network, this vital information may not get to all affected workers and an avoidable exposure or accident could occur. This is especially important in work settings where changes can occur very rapidly and, therefore, working conditions may produce new hazards that every worker should be aware of as soon as possible.

The fourth element of corporate commitment is providing the resources necessary to support occupational safety and health efforts. This could include expertise in safety and health participating in facility design, the purchasing of equipment, materials and supplies, training for managers, supervisors and employees, and in carrying out safety and health program activities. At the center of corporate commitment is a structured program of hazard detection, evaluation, analysis and control. This is a visible demonstration to managers, supervisors and employees that safety and health are important and need to be taken seriously. In addition, it is important to recognize that occupational safety and health issues need to be considered whenever changes in technologies and production methods are implemented.

A critical element of corporate commitment is the use of metrics to evaluate the successes and failures of safety and health efforts. Various measurements have been used such as property damage costs, injury costs, insurance premiums, injury frequency rates, employee lost days from work, and production costs of downtime due to accidents and illnesses. The purpose of the metrics is to provide assessment of progress and to pinpoint areas in need of attention. Such metrics are best used at an aggregate level that provides a sufficient number of exposed employees that will allow for reasonable trend analysis. These metrics are seldom useful for detecting trends at the individual department or supervisor level.

Metrics at the department or supervisor level could include the extent of employee training achieved, the number of serious hazards identified and resolved, the number of employee safety contacts, and/or the number of safety meetings in a given period of time.

It has been suggested that the development of Total Quality Management approaches may produce some positive results with regard to occupational safety and health [17]. Power and Fallon [18] have proposed TQM as a framework for integration of health and safety activities with other functions. They argue that the practice of safety management should include the following TQM principles: management commitment to occupational safety and health objectives, plans and policies; development of a health and safety culture; employee involvement in safety activities, such as risk assessment and training of new employees; measurement and monitoring of health and safety performance; and continuous improvement.

K.U. Smith [19] and T.J. Smith [20] have proposed a model for integrating ergonomics, safety and quality based on behavioral cybernetics theory. From a behavioral cybernetics perspective, participatory ergonomics and safety and quality management are effective because they enable workers to control sensory feedback from job-related decisions or working conditions that affect them, and in turn to generate sensory feedback for the control and benefit of other workers. Worker involvement in decision-making, worker control over the production process, and job enrichment enhance the overall level of worker self-control. Use of workers as resource specialists and emphasis on skill development can benefit the integration of ergonomics, safety management, and quality management of the organization. This should lead to quicker discovery and identification of hazards, as well as improved mechanisms for communicating hazard-related information that can be used to improve work systems and processes.

3 The Human Factor

At the center of the work system is the employee who carries out job tasks under the direction of the organization (policies, managers, resources, rewards). There are many theories and concepts that address how employee behavior creates risks for accidents and injuries. Some focus on the characteristics of an employee or the workforce and how these characteristics can lead to risky employee behavior. Others focus on the misfits between the employee and the workplace that lead to employee errors (See Smith and Carayon, 2003 for a discussion of some of these theories). KU Smith [19] proposed that the employee was a critical point of control of hazards, and that this role was much more important in promoting occupational safety and health than the concerns about unsafe acts of employees. He proposed a series of 'behavioral safety codes' that can lead to improved employee behavior and enhanced safety and health.

The employee is the point of interaction with the hazards (physical, chemical, radiation, biological, behavioral) that produce injuries. S/he is the point where energy or toxins are released that can damage property or persons. How the employee interacts with the technology, materials and environment in carrying out tasks affects the risk potential of work activities. Smith and Carayon [3] showed how the nature of this interaction could lead to errors that produce accidents, and that the design of tasks, technology, management and environmental factors often play a significant role in causing employee errors and unsafe behaviors.

Companies can take actions to enhance occupational safety and health promotion among employees. The first action is to provide opportunities for employees to be

active in managing the risks of their own work tasks. Employees can be empowered to identify hazards and report them to supervisors. Many hazards are "transient" in that they come and go depending on the circumstances of the tasks, technology and environment. Encouraging employees to immediately report significant hazards to supervisors can lead to quick resolution of the risk. This supposes that supervisors and employees have an open communication channel, good relations and respect for each other. The greater the employee participation and open communication afforded by the company culture, then the greater the probability that employee hazard awareness and hazard reporting will occur; this will then lead to actual changes in work systems and processes that can either eliminate hazards or reduce their potential impact. This process is similar to a participatory ergonomics process in which employees are involved in the redesign of some element of their work systems [21].

A second action is to provide ongoing training for employees in hazard awareness and recognition. Cohen and Colligan [22] found that safety and health training was effective in reducing employee risk. Hazard knowledge is a strong tool that leads to early detection and resolution of risks. Training also keeps employees aware of the need to be alert to hazards, and to behave in ways that reduce rather than increase risk. Several safety and health standards require periodic employee training to keep their knowledge and skills in hazard recognition and avoidance current and at the front of their awareness. Beyond these requirements companies can provide additional training to further reinforce the need for employees to be alert, aware and knowledgeable on how to respond to hazards.

Many theories of accident causation have defined employee unsafe acts or behaviors as the major factor in the cause of accidents. Other theories define human error or employee unintentional or intentional behavior as a primary cause of accidents. Still other theories have proposed that system design flaws and improper management lead to human error that causes accidents. At the heart of all of these theories is the belief that improper employee behavior, whatever its cause, is central to accident causation. If this belief is conceded, then it makes sense to take actions that promote proper employee behavior when confronted with risks or hazards. The probability of proper behavior is increased under the following conditions: (1) employees recognize the risk and know what to do when confronted with the risk, (2) employees have the knowledge, skills and capacity to act properly when confronted with risks, (3) employees are motivated to respond properly to the risks, and (4) action is taken by management (or employees) to control the risks.

A large number of the hazards in the workplace are produced by the interaction between employees and their tools and environment. Some of these hazards cannot be completely controlled through hazard inspection and engineering controls. An ancillary way they can be controlled is by increasing employee recognition of the hazards and by proper and safe employee behavior when confronted with the hazards. Such behavior may be the use of safe work procedures to ensure that hazards will not occur, taking an evasive action to avoid a hazard when the hazard does occur, or informing supervision of the hazards so that appropriate action can be taken. There are very few hazard control efforts that are not in some way dependent on the proper behavior of employees. But, increasing employees' awareness of hazards is meaningless if employees do not behave in a proper and safe way by using their hazard awareness and knowledge.

Conard [23] defined work practices as employee behaviors that can be simple or complex, which are related to reducing a hazardous situation in occupational activities. There are a series of steps that can be used in developing and implementing work practices for eliminating occupational hazards: (a) the definition of hazardous work practices; (b) the definition of new work practices to reduce the hazards; (c) training employees in the desired work practices; (d) testing the new work practices in the job setting; (e) installing the new work practices using motivators; (f) monitoring the effectiveness of the new work practices; (g) redefining the new work practices as needed; and (h) maintaining proper employee habits regarding work practices. Hopkins, Conard and Smith [24] demonstrated the efficacy of this approach for decreasing risky workplace behavior and increasing proper work practices that reduced employee exposures to hazardous chemicals.

To reiterate, proper employee behavior has as its foundation a corporate culture that promotes and rewards the proper behavior, well trained and knowledgeable employees, supervision and management that responds to employee identification of risks, and work systems and processes that promote safe behaviors. In essence the best way to get proper employee behavior is to make it part of the corporate safety and health culture.

4 Task Factors

Work task design is a significant consideration for controlling safety hazards, and management is responsible to ensure proper task design [1-4]. The demands of a work activity and the way in which work is conducted can influence the probability of an exposure to a hazard or an accident. In addition, the influence of the work activity on employee attention, satisfaction, and motivation can affect behavior patterns that increase exposure and accident risk. Task design has to be based on considerations that will enhance worker attention and motivation. Work task considerations can be broken into the physical requirements, mental requirements, and psychological considerations. The physical requirements influence the amount of energy expenditure necessary to carry out a task. Excessive physical requirements can lead to fatigue, both physiological and mental, which can reduce worker capabilities to recognize and respond to workplace hazards. Mental overload and underload can take employee attention away from risks while doing tasks. The use of work design principles to meet the physical, mental and psychological needs of employees will lead to better employee hazard awareness and safer behavior.

Other task considerations include the pace or rate of work, the amount of repetition in task activities, and work pressure due to production demands [1]. Task activities, that are highly repetitive and paced by machinery rather than employee paced, tend to be stressful. Such conditions diminish an employee's attention to hazards and his/her capability to recognize and respond to a hazard. Tasks with relatively low workload and energy expenditure can be very hazardous due to boredom that leads to employee inattention to hazards [1].

Psychological task content considerations, such as satisfaction with job tasks, the amount of control over the work process, participation in decision making, the ability to use knowledge and skills, the amount of esteem associated with the job and the

ability to identify with the end products of the task activity can influence employee attention and motivation [1-2]. They also can cause job stress [1]. Job stress can affect employee ability to attend to, recognize, and respond to hazards, as well as the motivation needed to be concerned with personal health and safety considerations. Negative influences can bring about emotional disturbances that limit the employee's capabilities and motivation to respond.

Scientific work design principles can be applied for developing tasks that have proper content to eliminate overload and underload, and will enhance the employee's physical and mental state [1-3]. Work tasks should be under the control of the employee and repetition should be avoided if possible [3]. This latter requirement is sometimes hard to achieve. When work tasks have to be repetitious then providing the worker with some control over the pacing of the task reduces stress associated with such repetition. Employee concentration and attention can be enhanced by providing frequent breaks from the repetitious activity to do alternate tasks or take a rest [3, 6, 9].

Training employees about proper work procedures provides direction that will help employees avoid hazards or to more effectively deal with hazards. The basis of good instruction and training is the job analysis which provides detailed information on the job tasks, environment, tools, and materials used. The job analysis will identify high risk situations. Based on verification of the information in the job analysis, a set of instructions on how to avoid hazardous situations can be developed. The implementation of such instructions as employee behavior will be covered in the next section under training and safe behavior improvement.

5 Technology and Materials Factors

The relationship between the controls of a machine and the subsequent action of that machine dictates the level of skill necessary to perform a task. The action of the controls and the subsequent reaction of the machinery must be compatible with basic human perceptual/motor patterns [6, 9, 19]. If there is incompatibility, then significant interference with performance can occur which may lead to improper responses that can cause errors and accidents [3]. The adequacy of feedback about the reaction of the machine to the control action affects the performance efficiency that can be achieved, and the potential for an operational error. Equipment must conform to principles of proper engineering and human factors design so that the controls that activate the machine, the displays that provide feedback of machine action, and the safeguards to protect workers from the action of the machine are compliant with worker skills and expectations. The action of the machine must be compliant with the action of the controls in temporal, spatial and force characteristics.

The hazard characteristics of materials will affect exposure and risk [4, 6, 9]. More hazardous materials inherently have a greater probability of adverse safety and health outcomes. Sometimes employees will be more careful when using materials that they know have a high hazard potential. But this can only be true when employees are knowledgeable of the materials' hazard level and they know how to respond to the risks posed.

Ensuring that machines are designed properly and that employees are aware of the risks of the materials they work with is the responsibility of management. These issues

are part of a comprehensive and effective safety and health program; see discussion above on organizational considerations.

6 The Work Environment

The work environment can expose employees to materials, chemicals, radiation, biological agents and physical agents that can cause harm or injury if the exposure exceeds safe limits [4, 6, 9]. Such exposures vary widely from industry to industry, from job to job, and from task to task. Hazard exposures in the work environment influence the probability for an accident, injury or illness, and the extent of exposure often determines the seriousness of an injury. The hazard potential of different environmental factors can be evaluated using various federal, state and local codes and standards for worker protection, and limits established by scientific and professional groups. A comprehensive safety and health program can be very effective in defining and controlling workplace hazard exposures. Providing a proper work environment that is free of hazards, has adequate sensory requirements, and permits smooth work flow is the responsibility of management. Ensuring that the work environment remains clean and uncluttered is an important issue for good safety performance [10, 11].

A formalized approach to hazard control often includes an inspection system to define workplace hazards, accident investigations, record keeping, a preventive maintenance program, a machine guarding program, review of new purchases to ensure compliance with safety guidelines, materials safety data sheets, and good housekeeping requirements [4, 6, 9]. The effectiveness of specific aspects of such a formalized hazard control approach has been debated [10, 11], but it is clear that structured programs are a good idea [4, 6, 9, 11]. Cohen [10] indicated that more frequent informal inspections may be more effective than more formalized approaches. This may be because the informal programs often involve workers in defining the hazards. However, the significance of formalized hazard control programs is that they establish the groundwork for other programs such as work practice improvement and training. In essence, they are the foundation for other safety approaches.

7 Conclusions

The Balance Theory was created as an attempt to develop a more realistic approach to the design of the work system. It provides an integrated, holistic approach to identifying elements of the work system, as well as a set of principles for the design or redesign of work systems. Consistent with an integrated approach that bridges various areas (job/organizational design, job stress, and human factors and ergonomics), the outcomes of interest of the 'Balance Theory' are diverse and include job satisfaction and stress, and worker health, safety and well-being [7]. The broader work system model encompasses psychosocial, cognitive and physical aspects of work that can create psychosocial, cognitive and/or physical demands and loads on the individual. For instance, the tasks performed by the individual have psychosocial dimensions such as control over work pace, cognitive dimensions such as information overload, and physical dimensions such as repetitiveness. These psychosocial, cognitive and

physical loads created by the work system interact with each other and have various impacts on the individual's ability to respond appropriately to risk.

The core principles of work system design of the 'Balance Theory' are:

1. to eliminate negative aspects of each work system model. This requires knowledge in the areas of job/organizational design, job stress, and human factors and ergonomics.
2. to balance the work system. Because it may not be possible or practical to eliminate all negative aspects of the work system, the entire work system needs to be balanced so that the overall impact on the individual is high performance, low job stress, good health, and high safety and well-being. The balance can be achieved by identifying aspects of the work system that can be used to compensate for the negative aspects. Another method for achieving the balance is overall system balance where there are sufficient significant positive aspects that balance out for the negative aspects of work [7, 8].

Carayon and Smith [5] and Carayon [8] have described an expansion of the 'balanced work system' and proposed the 'balanced organization'. The organization is conceptualized as being a collection of work systems that are interconnected; the elements of the organization include: people, strategy, structure, rewards and processes. The work system model can also be expanded to describe phenomena at the team level: a team is comprised of individuals who perform tasks using tools and technologies; the work of the team occurs in a physical environment and is influenced by various organizational factors. This expanded model provides an improved concept for promoting safety, health and wellbeing at the workplace.

References

1. Smith, M.J., Carayon-Sainfort, P.: A balance theory of job design and for stress reduction. International Journal of Industrial Ergonomics 4, 67–79 (1989)
2. Smith, M.J., Carayon, P.: New technology, automation, and work organization: Stress problems and improved technology implementation strategies. The International Journal of Human Factors in Manufacturing 5(1), 99–116 (1995)
3. Smith, M.J., Carayon, P.: Examining the Entire Work System to Better Understand Human Error in Occupational Accidents. In: Proceedings of Human Error in Occupational Safety Symposium, Peachtree City, GA, March 13-14, 2003, pp. 33–53. American Society of Safety Engineers, Des Plains (2003)
4. Smith, M.J., Carayon, P.: Controlling Occupational Safety and Health Hazards. In: Tetrick, L.E., Quick, J.C. (eds.) Handbook of Occupational Health Psychology. American Psychological Association, Washington (in press, 2009)
5. Carayon, P., Smith, M.J.: Work organization and ergonomics. Applied Ergonomics 31, 649–662 (2000)
6. Smith, M.J., Karsh, B.-T., Carayon, P., Conway, F.T.: Controlling Occupational Safety and Health Hazards. In: Quick, J.C., Tetrick, L.E. (eds.) Handbook of Occupational Health Psychology, pp. 35–68. American Psychological Association, Washington (2003)
7. Carayon, P.: Human factors of complex sociotechnical systems. Applied Ergonomics 37, 525–535 (2006)

8. Carayon, P.: The balance theory and work systems model -— twenty years later. International Journal of Human-Computer Interaction (in press, 2009)
9. Smith, M.J., Carayon, P., Karsh, B.-T.: Design for Occupational Safety and Health. In: Salvendy, G. (ed.) Handbook of Industrial Engineering: Technology and Operations Management, pp. 1156–1191. John Wiley and Sons, New York (2001)
10. Cohen, A.: Factors in successful occupational safety programs. Journal of Safety Research 9, 168–178 (1977)
11. Smith, M.J., Cohen, H.H., Cohen, A., Cleveland, R.: Characteristics of successful safety programs. Journal of Safety Research 10, 5–15 (1978)
12. Cleveland, R., Cohen, H., Smith, M.J., Cohen, A.: Safety Program Practices in Record-Holding Plants, U.S. Dept. of Health, Education, and Welfare Publication No (NIOSH), pp. 79–136. Government Printing Office, Washington (1979)
13. Cohen, H.H., Cleveland, R.J.: Safety program practices in record-holding plants. In: Professional Safety (March 1983)
14. Zohar, D.: Safety climate in industrial organizations: Theoretical and applied implications. Applied Psychology 65, 96–102 (1980)
15. Zohar, D.: A group-level model of safety climate: Testing the effect of group climate on micro-accidents in manufacturing jobs. Applied Psychology 85, 587–596 (2000)
16. Zimolong, B.M., Elke, G.: Occupational Health and Safety Management. In: Salvendy, G. (ed.) Handbook of Human Factors and Ergonomics, 3rd edn., pp. 673–707. John Wiley & Sons, Inc., Hoboken (2006)
17. Zink, K.: Human Factors and Business Excellence. In: Axelsson, J., Bergman, B., Eklund, J. (eds.) Proceedings of the International Conference on TQM and Human Factors-Towards Successful Integration, vol. 1, pp. 9–27. Centre for Studies of Humans, Technology and Organization, Linkoping, Sweden (1999)
18. Power, F.P., Fallon, E.F.: Integrating Occupational Health and Safety Activities with Total Quality Management. In: Axelsson, J., Bergman, B., Eklund, J. (eds.) Proceedings of the International Conference on TQM and Human Factors-Towards Successful Integration, vol. 1, pp. 445–450. Centre for Studies of Humans, Technology and Organization, Linkoping, Sweden (1999)
19. Smith, K.U.: Performance Safety Codes and Standards for Industry: The Cybernetic Basis of the Systems Approach to Accident Prevention. In: Widner, J.T. (ed.) Selected Readings in Safety. Academy Press, Macon (1973)
20. Smith, T.J.: Synergism of ergonomics, safety and quality – A behavioral cybernetic analysis. International Journal of Occupational Safety and Ergonomics 5(2), 247–278 (1999)
21. Wilson, J.R., Haines, H.M.: Participatory ergonomics. In: Salvendy, G. (ed.) Handbook of Human Factors and Ergonomics, pp. 490–513. John Wiley & Sons, New York (1997)
22. Cohen, A., Colligan, M.J.: Assessing Occupational Safety and Health Training: A literature Review. National Institute for Occupational Safety and Health, Cincinnati (1998)
23. Conard, R.: Employee Work Practices. National Institute for Occupational Safety and Health, Cincinnati (1983)
24. Hopkins, B.L., Conard, R.J., Smith, M.J.: Effective and reliable behavioral control technology. American Industrial Hygiene Association Journal 47(12), 785–791 (1986)