ORIGINAL ARTICLE

Evaluation Human Error in Control Room

AMIN BABAEI POUYA[1], SADEGH HAZRATI[2], MEHDI VOSOUGHI[3], *ZEINAB MOSAVIANASL[4], EHSANOLLAH HABIBI[5]**

ABSTRACT

Background: Control room operators in industries are often responsible for expensive equipment and the health and safety of workers. This responsibility leads to stress and the increased likelihood of the occurrence of human error in their performance.

Aim: To evaluate the effective factors on human errors in the control room workers.

Methods: For a task analysis of the control room staff the hierarchical task analysis (HTA) technique is used. Human Error Assessment and Reduction Technique (HEART) are used in seven steps for each task, and the possibility of their human error is estimated.

Results: The most important and the most prone job tasks to "human error are "monitoring and controlling warning symptoms by the operator" and "coordination" to resolve this problem by supervisor".

Conclusion: In normal circumstances, the operators are able to perform multiple tasks simultaneously, but in some cases (emergency situations) that according to the operators' comment, they are forced to do several things simultaneously (more than the individual power), in such a situation there is a need for cooperation between people. In such a situation, the use of the software and to follow the instructions already provided can be useful.

Keywords: Human error, Human Error Assessment and Reduction Technique (HEART), Cement plant control room

INTRODUCTION

The cement industry is as one of the basic industries that plays an important role in the national economy of developing countries. Control room operators in industries are often responsible for expensive equipment and the health and safety of workers. This responsibility leads to stress and the increasing likelihood of the occurrence of human error in their performance. Research has shown that the cause of more than half of the unfortunate events is human error. Today, the factories use the advanced automation and sophisticated control equipment for management of safety and the prevention of the accidents. A total of 88% of accidents occur due to human error, 10% because of factors related to machines, and 2% depend on other factors. Prevention and a reduction in the number of accidents and incidents needs to reduce human error. Hierarchical task analysis (HTA) technique is a type of task analysis that focuses on the overall task of a complex activity. It proceeds to deconstruct the complex activity into subtasks needed to reach the overall goal, and subtasks to those subtask, etc., through multiple iterations down to specific simple tasks or activities. HTAs are often the foundation for more complex analysis, such as human error or situation awareness analysis. For a task analysis of the control room staff, HTA is used[1].

The objective method is to identify and describe the process and the steps to achieve the goals. HTA is a hierarchical analysis method of tasks and subtasks and expresses the relationship between these tasks. Since 1950 the human errors have attracted the attention of studies on the safety of industrial systems. The purpose of the study of human errors is a quantitative assessment of the reliability of human operators. In 1960, the French Academy of Sciences accepted human reliability, as a major belonging in the engineering sciences, and some ways were created to predict human error in 1964.The Human Error Assessment and Reduction Technique (HEART) was first proposed in 1985.The HEART has been proposed as an integrated approach to investigate the accident scenarios and operator error .This technique is systematically developed for risk analysis to identify the factors that have the greatest impact on human performance and increase the probability of human error. The HEART is used for human reliability assessment (HRA). Kirwan compared this technique with THERP and JHEDI methods. HEART earned the highest validity

----

[1,2,3]Department of Occupational Health Engineering, School of Health, Ardabil University of Medical Sciences; Ardabil, Iran
[4]Departments of Occupational Health Engineering, School of Health, Ahvaz University of Medical Sciences; Ahvaz, Iran
[5] Departments of Occupational Health Engineering, School of Health, Isfahan University of Medical Sciences ;Isfahan, Iran
Correspondence to Mr. Amin Babaei Pouya; Email: a.babaei@arums.ac.ir

at 78% level. For a quantitative assessment of human errors, the HEART is used. The features of this technique include: It is simple and easy; it requires quantitative information resources; it offers useful suggestions for reducing errors; it provides the possibility of cost-benefit analysis. The HEART is highly capable of evaluating human errors and has the ability to determine the environmental conditions affecting the occurrence of errors, so it is helpful in redesigning or changing environmental conditions. Some advantages of this technique can be the quantitative output of human error probability and the identification of factors affecting human error. By applying the HEART, the type of possible human errors can be predicted based Model SRK (Slips-Rules-Knowledge; Rasmussen, 1986).The status of the system possible errors in the current situation can be checked, and to reduce or eliminate these errors the necessary training, technical and management planning can be provided. In the HEART, nine general task groups are identified and a range as human uncertainty is assigned to it. These nine groups are together with 38 error producing conditions (EPCs). In the end, a set of error reduction strategies is presented to deal with any EPCs that have the most impact. After identifying the EPCs, the analyzer assigns a numeric value between 0 and 1, and then all values are set in a formula and the amount of the of human error probability is determined. The aim of this study was the hierarchical task analysis of cement plant control room staff as task and subtask and then the assessment of human errors with HEART[2,3].

MATERIAL AND METHODS

In this case study, the chief engineer, supervisor and shift operator of the control room were studied. With the help of the shift supervisor, the direct observation of operators' activity, the study of the daily reports, the list of events and events that occurred, the entire tasks and the entire sub-tasks of the operator were identified. Hierarchical task analysis (HTA) is the most famous method of task analysis. The human error assessment and reduction technique assumes that human reliability essentially depends on the nature of the task that a person performs. To assess human errors and Human Reliability Assessment (HRA), HEART was performed according to the following steps:

Step 1: Determination of the task under analysis: The first step in a HEART analysis is to select an appropriate set of tasks for the system under analysis. In order to ensure that the analysis is as exhaustive as possible, it is recommended that the analyst selects a set of tasks that are as representative of the system under analysis as possible.

Step 2: Conducting an HTA for the task under analysis: Once the tasks under analysis are defined clearly, the next step involves describing the tasks. It is recommended that an HTA is used for this purpose. A number of data collection techniques may be used in order to gather the information required in the HTA

Step 3: Conduct HEART Screening Process: The HEART uses a screening process, in the form of a set of guidelines that allows the analyst to identify the likely classes, the sources, and strengths of human error for the scenario under analysis.

Step 4: Generic Task Unreliability Classification: Once the screening process has been conducted, the analyst must define the proposed nominal level of human unreliability associated with the task under analysis. Generic Task Unreliability Classify the task in terms of its generic human unreliability into one of the 8 generic HEART task types

Step5: Identification of EPCs (error producing conditions): The next stage of a HEART analysis is the identification of EPCs associated with the task under analysis. To do this, the analyst uses the associated HEART EPCs to identify any EPCs that are applicable to the task under analysis

Step 6: Assessed Proportion of Effect: Once the analyst has identified any EPCs associated with the task under analysis, the next step involves determining the assessed proportion of the effect of each of the EPCs identified. This involves providing a rating between 0 and 1 (0=low, 1=high) for each EPC. The rating offered are based upon the subjective judgment of the analyst involved.

Step 7: Assessed impact value: Assessed Effect: Calculate the 'assessed impact' for each EPC, according to the formula:

(EPCs −1) Assessed Proportion of Effect) +1

Step 8: Overall probability of failure: Human Error Probability: Calculate the overall probability of failure of task based on the formula:

Generic Task Unreliability ×Assessed impact 1× Assessed Impact2… etc.

In order to achieve the study objectives, the implementation technique, the number and probability of errors were estimated (4-5).

RESULTS

After analyzing the job and identifying the error in the relevant tasks, the number and probability of errors for the various tasks are determined and calculated. The findings from the HTA technique include 20 main tasks and 77 subtasks, which the investigated jobs' tasks separately are as follows:

1. Shift Chief-Engineer: eight main tasks and 29 sub-task.
2. Shift Supervisor: six main tasks and 25 divisions.
3. Central Control Room Operator: six tasks and 23 sub- tasks.

The number of the detected human errors was 80. During the shift chief engineer's tasks, the most common cause of the error incidence was "incidence of disease during work", "the existence of low morale among the workforce" and the "sense of meaninglessness of duty". In shift supervisor's duties, the greatest cause of the error was "the normal sleep cycle disorient (fatigue)," " A typical sleep disorder (fatigue) disorder, poor quality of information transmitted by the instructions, and person-to-person "and" incidence of disease during work" .In the control room operator's tasks, the most common cause of the error was "the typical sleep disorder (fatigue) disorder ", "the existence of low morale among the workforce," the sense of meaninglessness of duty, and the "incidence of work-related disease".

The most important factors in the incidence of human error were" the normal sleep cycle disorder (fatigue)," "the incidence of the disease while working, especially fever", "low morale among the workforce" and" the sense of meaninglessness of the detected duty ".

The most important and the most prone to job duties to the occurrence of the detected human error was "monitoring and control (operator)", "warning control symptoms (operator)" and "coordination to resolve this problem (supervisor)".

The most likely human error was related to "controlling warning signs (Operator)" with 0.416 and the lowest probability was related to "Attend meetings (Chief-Engineer)," "Shift Reports (Chief-Engineer)"," Organizing the educational affairs (Chief-Engineer)" and " Study of Unit Circumstance (Chief-Engineer)" with 0.022.

Most likely an error was related to the control room operator's duty and the lowest probability was shifted chief engineer's task.

DISCUSSION

Under normal conditions, operators have the ability to perform multiple tasks simultaneously, but there are some cases (emergencies) that, according to operators' statements, they have to do several things simultaneously (over individual power), in such situations, there is a need for collaboration between people. In such a situation, the use of pre-ordered instructions can be beneficial.

Instructions are the core of every operation. There are three types of instructions: operational, emergency and maintenance. Effective guidelines are usually the most important tool for increasing safety, reducing environmental impacts and ensuring product quality. The lack or absence of instructions for doing things cause people to rely on the training they have spent, and as a result of this, they create differences in how the work is done and cause the work to not be done properly and properly. And there may be an error and an incident that may occur.

Operators are a regular eight-hour work shift in four 4-day working shifts (an at rest shift) from morning to night. Except for the shift worker who is day shift worker, but for reasons such as overtime or duty, instead of a partner during the month, several occasions occur where an operator operates more than one shift per day, which is actually an irregular shift worker. Therefore, in order to avoid irregular work shifts, it is necessary to pay attention to the design of the work shift program[6].

Provided training courses should have a knowledge level that will enhance their knowledge, and these training courses will be held in good time. Therefore, attention to training is essential and the relevant authorities should pay special attention to this. In addition, they should formulate and implement plans and scheduled scheduling for training and/or retraining and recall of training courses in accordance with occupational needs (or assigned duties), in order to prevent some of the possible mistakes in the implementation of the professional duties of the operators. Training is an initial source of information for employees in improving their job skills. The effectiveness of training with exercises can help to reduce errors in how to do the instructions by increasing the skills of the staff. The purpose of any training program should be to increase skills and knowledge and to integrate how the instructions are handled, along with the reduction of the time that educators need to learn skills, knowledge, and instructions. An effective educational system utilizes human factors to ensure that a training program is carried out in accordance with the duties, educates workers with specific skills and knowledge, and measures the effectiveness of the training. Without training and sufficient training, workers will not be able to upgrade from a beginner to a level of specialized performance[7].

The exchange of information required for system operations between people is verbal, mechanical or electrical, which is the most widely used in communication systems is wireless. There are two important things about wireless; first, that the sound quality of this kind of communication device is not desirable, and in cases where the person wants to repeat the story stated; and secondly, there is the lateral sound control room related to the sound of the field of the data processing devices, and the interpersonal discourse that in turn affects the comprehension of the received message. Therefore, the wireless system should be optimized and the sound of the field should be standardized.

Performing a predetermined program or work depends on the level of experience and skill of the person on how to run the operation. Therefore, attention to training is essential and the relevant authorities have to pay special attention to it and have planned and scheduled programming for training and retraining and to develop and implement training courses in accordance with job requirements or tasks, in order to prevent the occurrence of possible errors in the implementation of the professional duties of the operators. The system should also be designed in such a way that it can prevent the operator from doing dangerous work, and the job structure should be set as easily as possible to prevent stress on individuals.

A study by Srinivasan et al. in the control room showed that preventing cognitive failures can prevent human error[8,9].

Kim's study in the control room of nuclear power plants (NPPs) showed that "training how to work", method of performance " and "time opportunity to do the intervention " in critical situations are very important .

Lee emphasized that most of human errors can be improved by the human error prevention techniques such as self-checking, peer-checking, concurrent verification and etc.

According to Sharma's research in the control room, the importance of the operator's ability of learning and awareness in various circumstances is very important.

The results of the research by Park on the factors influencing the operation of the control room operator indicate that the operator's experience is effective in overall performance. The complexity of the work affects the activity and the subsequent situation[10,11,12,13].

The following materials are suggested to reduce the risk of human error in the control room:

1. Designing and operating guidelines for emergency and operational work to ensure safe operation and the avoidance of incidents for the use of control room operators.
2. Holding training courses tailored to the needs of the control room operators.
3. Holding training courses using the simulator system for employee skills and assessing their performance in critical situations in the system.
4. Optimizing the system's internal communication system and the use of the highest quality wireless system.
5. Use of two types of the communication system when performing operations on the site (wireless and mobile phone).
6. Preparation and compilation of the checklist for the inspection, and monitoring control equipment of control room.
7. Reducing the of the control room's background sound and bringing it to the standard level.
8. Making the necessary changes in the unit control software to prevent the occurrence of the human error during process control.
9. Writing important figures and figures that need to be addressed with a distinctive color in the Log Sheet.
10. Environmental and ergonomic inspection of the control room and attention to equipment placement.
11. The use of regular work shifts
12. Compiling the programs for reducing stress and other psychological problems in order to avoid absenteeism

Conflicts of interest: The authors declare no conflict of interest.

Acknowledgments: This article was extracted from the thesis written by Amin Babaei Pouya, a M.Sc. Occupational Health Engineering and was financially supported by the University of Medical Sciences, Ardabil, Iran.

REFERENCE

1. El-Taher A, Makhluf S, Nossair A, Halim AA. Assessment of natural radioactivity levels and radiation hazards due to cement industry. Applied Radiation and Isotopes. 2010;68(1):169-74.
2. Kodappully M, Srinivasan B, Srinivasan R. Towards predicting human error: Eye gaze analysis for identification of cognitive steps performed by control room operators. Journal of Loss Prevention in the Process Industries. 2016;42:35-46.
3. Baysari MT, Caponecchia C, McIntosh AS, Wilson JR. Classification of errors contributing to rail incidents and accidents: A comparison of two human error identification techniques. Safety Science. 2009;47(7):948-57.
4. Williams J, editor HEART—a proposed method for achieving high reliability in process operation by means of human factors engineering technology. Safety and Reliability; 2015: Taylor & Francis.
5. Castiglia F, Giardina M, Tomarchio E. THERP and HEART integrated methodology for human error assessment. Radiation Physics and Chemistry. 2015;116:262-6.
6. Williams JC, Bell JL, editors. Consolidation of the Error Producing Conditions Used in the Human Error Assessment and Reduction Technique (Heart). Safety and Reliability; 2015: Taylor & Francis.

7. Carnahan BJ, Maghsoodloo S, Flynn EA, Barker KN. Geometric probability distribution for modeling of error risk during prescription dispensing. American journal of health-system pharmacy. 2006;63(11).
8. Kumar AM, Rajakarunakaran S, Prabhu VA. Application of Fuzzy HEART and expert elicitation for quantifying human error probabilities in LPG refuelling station. Journal of Loss Prevention in the Process Industries. 2017;48:186-98.
9. Iqbal MU. An experimental strategy to mesure control room operator performance and analyze human failure probability: Indian Institute of Technology Gandhinagar; 2016.
10. Monazzam MR, Hosseini M, Matin LF, Aghaei HA, Khosroabadi H, Hesami A. Sleep quality and general health status of employees exposed to extremely low frequency magnetic fields in a petrochemical complex. Journal of Environmental Health Science and Engineering. 2014;12(1):78.
11. Deng H, Zhou D, editors. Main Control Room Design of Advanced Nuclear Reactor. International Confernece Pacific Basin Nuclear Conference; 2016: Springer.
12. Sharma C, Bhavsar P, Srinivasan B, Srinivasan R. Eye gaze movement studies of control room operators: A novel approach to improve process safety. Computers & Chemical Engineering. 2016;85:43-57
13. Pouya AB, Habibi E. using CREAM techniques for investigating human error with cognative ergonomics approach in the control room of cement industry. International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS) 2015;4(3):1480-1484.