

An Empirical Study on Human Performance according to the Physical Environment (Potential Human Error Hazard) in Nuclear Power Plants

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1. The Physical Environment at a Nuclear Power Plant

Since the advent of the industrial revolution, physical environment has been a significant source of physical and psychological stress and workload. Physical environment, which consists of luminance, noise, vibration, temperature and humidity, in nuclear power plants have been managed according to detail standards. In operation for a nuclear power plant, physical environment is external factors of PSF and affects task behavior and performance for PSR. Although the technical standards were satisfied to the occupation safety and health acts and the atomic energy law, skilled operators raised safety questions of work environment since Fukushima accident. And they present the review the management standard and criteria about physical environment in NPPs. The physical environmental factors effects to improve human performance to operators but affects efficiency and causes human error which is a trivial matter or critical problem. To prevent human error, there continue their unremitting exertions to maintain the optimum conditions of human performance through periodic assessment on the influence and compatibility of the physical environment.

1.1 Lighting Control for Visual working performance

Lighting has been an essential material at a nuclear power plant, which is very much need for working process of a worker. Intensity illumination, brightness, contrast and glare are all found to have a direct influence on visual working process and, designing and managing of such factors are considered important [1,2,3]. As long as it satisfies the minimum visual requirements, lighting would directly affect changes of a worker's moves by about 1~3% [4]. However, for factors with indirect influences are psychological and biological states of an individual worker and, these have been playing a significant role in deciding moves of the worker. For this reason, control of a proper lighting environment is definitely an important part in designing and managing of a nuclear power plant.

The control standard which is being applied at present to keep this important lighting for a nuclear power plant at a proper level is a limit of the intensity illumination. The ergonomic intensity illumination standard of MCR is required to be approximately 500-

1000LX and 100LX at least in each of a normal situation and an emergency situation (NUREG-0700, EPRI NP-3659) [1]. These measures are higher than the ones of a general industry of other near works and it is because a nuclear power plant which is supposed to consider the safety the top priority needs to prevent ergonomic dangers of visual works from happening as much as possible, which would occur by a low intensity illumination [3].

Fig. 1 shows a conceptual framework for considering the factors that influence progress down each three route and the interaction between them.

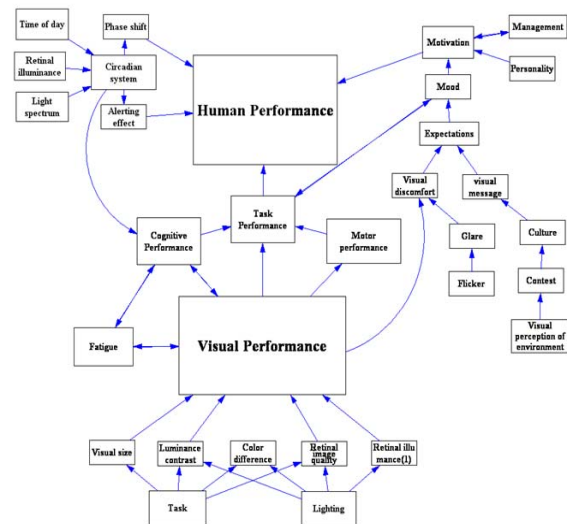


Fig. 1. A conceptual framework setting on the three routes whereby lighting conditions can influence human performance.

1.2 Noise effects on communicative human performance

Noise has broad effects, ranging from interference with cognitive processing to detrimental effects on mental and physical health. Sound can be noise by subjectivity according to physical and psychological conditions. It can cause a hearing loss as well as physiology and psychology effects. If operators expose strong impact noise and continuous background noise, it causes negative stress, uneasiness, headache, and gastro-enteric trouble etc. An alternative explanation underlying noise effects is based on the fact that noise has been found to increase the mental workload imposed by a given task environment, thereby reducing the cognitive resources available for allocation to task performance[5]. The study that the noise interferes with the human performance has been a long time,

Poulton(1979) described the reason that noise delay inner speech, interferes with the demonstration process, and reduces the amount of required information[6]. Broadbent and Eschenbrenner presented that irregularity and intermittent noise is related with to dropping off the human performance.

Fig. 2 shows the comparison of noise exposure standards set by different organizations. Also, NRC give advices technical standard such as white noise, distractions, reverberation, related with noise for applying in a NPP at NUREG-0700.

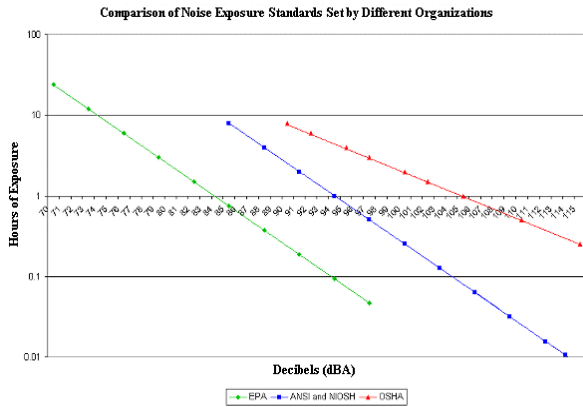


Fig. 2. Comparison of noise exposure standards set by different organizations

2. The potential hazard factors related with error on physical environment

The management of the physical environment is required throughout the life cycle in a nuclear power plant. The design phase applies appropriate design criteria for working environment and considers the environmental factors related to equipment and installation in the construction. And In the operation, it is periodically evaluated and maintained associated with the task.

The physical environmental factors are managed as one of the compulsory minimum levels of provision for the safety assessment within the design criteria. Although the physical environment is maintained within the reference value, it can lead to human error because of combination situations according to organization and personnel aspects. Especially visual performances and behaviors of operators in a nuclear power plant are significantly related with the physical environment.

This study defined the potential hazard factors related with human performance and error on physical environment and proposed the countermeasure to reduce human error in a nuclear power plant. To define the potential hazard factors we performed four processes at fig. 3. Through four steps, this study found the impact structure that the physical environment affect the human performance and rare event related to error. At the first step, we compared with standards and then reviewed the accident to find

the effects of human performance and human error. After evaluation, this study proposed scenarios about expected human performance due to the physical environment to get highly provability. And then it was verified from expert review and interview of operators.



Fig. 3. The definition process of potential hazard factors

3. Conclusions

The management of the physical environment should be controlled through a legal requirement in a nuclear power plant. In other industry, the management of the physical environment for safety is more effective than a nuclear industry. Despite the physical environment such as lighting, noise satisfy with management standards, it can be background factors may cause human error and affect human performance. Because the consequence of extremely human error and human performance is high according to the physical environment, requirement standard could be covered with specific criteria. Particularly, in order to avoid human errors caused by an extremely low or rapidly-changing intensity illumination and masking effect such as power disconnection, plans for better visual environment and better function performances should be made as a careful study on efficient ways to manage and continue the better conditions is conducted.

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