Human Error Probability Estimate from the Stress on the RPVI Dismantling Work

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1. Introduction

In the previous study, refinement Performance Shaping Factors (PSFs) for Reactor Pressure Vessel Internal (RPVI) dismantling work has been derived[1]. In this study, a formula has been developed to find the effects of stress on the dismantling work, which is one of the PSFs for the dismantling work. Then, using the developed expression, the probability of human error due to the stress of the worker is obtained during the dismantling work.

2. Stress Effects on RPVI Dismantling Worker

2.1. Stress

The Stress in RPVI dismantling work are defined as “time stress”, which requires the task to be performed within a planned period, and “cognitive and physical workload stress” for the amount of work to be performed, work intensity, and complexity. Since stress is a subjective concept, it is difficult to evaluate it directly. However, it was judged that the stress in the dismantling work is closely related to fatigue. Therefore, the formula to be applied to stress was the same of the fatigue – related contents. Various literature evaluates that fatigue increases exponentially over time. As a result, the formula of the change in fatigue level with time in the production process was confirmed. Since the dismantling work is also performed repeatedly with a certain strength or higher, this was applied to the stress caused by the RPVI dismantling work [2].

2.2. Stress due to performing work

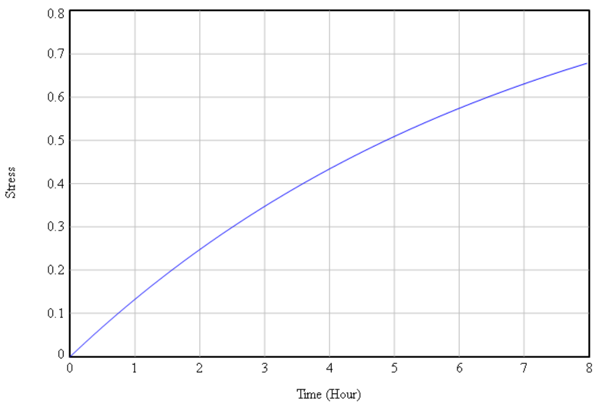
The formula of the stress related with time during the working process is as described in formulas (1) and (2).

$$S(t_i) = R(t_{i-1}) + \left(1 - R(t_{i-1})\right)(1 - \exp(-\lambda t_i)) \quad (1)$$

$$R(t_i) = S(t_{i-1}) \exp(-\mu \tau_i) \quad (2)$$

$S(t_i)$ means stress due to work performed time, and $R(t_i)$ means rest stress relieved by rest. λ means the stress index which is the worker stress value of the nuclear power plant worker[4], and μ means the rest index which is the relief rate value of the worker stress associated with the work. t_i and τ_i mean 2 hours of work time based on task analysis of RPVI dismantling work, and break time and lunch break in the middle or work, respectively. Using the above formula, derived the graph for stress when the stress relief rate is 0%, as shown in [Figure 1].

Figure 1. Worker stress according to RPVI dismantling work



3. Human error probability result from the worker stress

3.1. Probability density function

A continuous random variable means that it can be counted even if the number of possible values of the random variable for a specific probability that a certain event appears is infinite. The probability density function is a function that makes it possible to calculate the probability for an interval for an infinitely large number of values within a certain range. The formula for the probability density function of such a normal distribution is as shown in formula (3).

$$f(x) = \frac{1}{\sqrt{2\pi} \cdot \sigma} exp\left\{-\frac{(x-\mu)^2}{2\sigma^2}\right\} \quad (3)$$

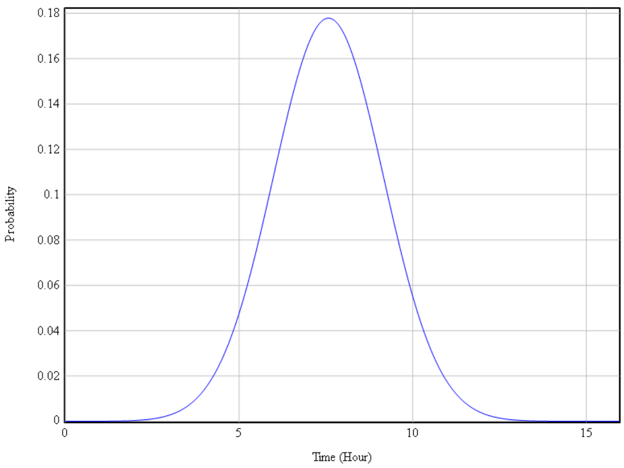
Through literature review, confirmed the example such as human error probability estimation in the

SLOCA situation using the probability density function[5]. Therefore, based on these methods, the probability density function was applied to the stress on the dismantling work to estimate the human error probability.

3.2. Estimating error probability

The stress value of the worker due to the work derived by the above formula was applied to the probability density function. Then, the error probability due to the stress of the worker was estimated from this. The worker's stress is affected by the stress relief rate over the break time, but the most conservative value is derived, which is estimated to result in an error probability of up to 0.177906 during 7.57422 hours with 0% relief rate, as shown in the graph [Figure 2].

Figure 2. Probability density functional graphs of stress for tasks



4. Conclusion

In this study, the stress with the working time is derived through the worker stress formula. Then, the human error probability per the stress, which is derived form the probability density function is estimated to be about 18% during the working time of 8 hours without any rest. Based on this, the future research is to estimate the human error probability due to the other PSFs for the dismantling work with the similar method in this paper. All together with the human error probability per all PSFs will be used to develop an integrated human error simulation model that can be utilized to estimate the overall human error probability for the dismantling work. Through this, it is judged that it can be used to reduce the human error probability to cause incidents and/or accidents by identifying and managing various human error factors in advance.

Acknowledgement

This work was supported by the National Research Foundation of Korea(NRF), granted financial resource from the Ministry of Science and ICT(NRF-2016M2B2B1945084), Republic of Korea.

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