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# A Study on the Operator Performance to the drastic change of Illumination of MCR in NPP

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## 1. The Importance of Lighting Control at a Nuclear Power Plant

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. In this study, how to respond to visual problems of an operator in a main control room of a nuclear power plant in emergency as well as human error causing dangers was investigated while experimentations on changes of visual working performances were carried out which would occur by a sharp change of intensity illumination.

## 2. Changes of Intensity Illumination and Visual Working Performances

### 2.1 Standards of lighting environment and emergency review

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].

As long as the intensity illumination of MCR keeps properly, there would not be a problem in performing a visual work. However, not a single thorough review on how the working performance would change when the normal lighting is suddenly converted into emergency lighting because of power loss accident such as SBO has been conducted. Even though the intensity illumination meets the minimum limit by law, an operator can still get troubled by a change in a visual environment in which the intensity illumination drops below 10%. Again, problems expected to the operator and changes of working performances by both biological and psychological changes have not been fully understood.

For a common biological symptom in an intensity illumination loss situation is dark adaptation which is a process that a person's eyes try to adapt themselves into darkness while working on a role reversal of cones and rods.

In addition, the loss of intensity illumination leads an operator to changes of psychology. The existing researches discovered that the intensity illumination level controls a communication, which would change an operator's psychological condition. However, since the psychological condition determines an operator's behaviors in a specific situation, it is necessary to conduct a study on a possible situation that would trigger a psychological burden of an operator, such as an emergency in a nuclear power plant. Considering this, the study aimed to provide ways to handle such biological and psychological changes by measuring an operator's working performances in a situation of the loss of the intensity illumination.

### 2.2 Experimentation on measuring of working performance changes based on changes of intensity illumination

In this study, effects of a rapid loss of the intensity illumination on a visual working performance was analyzed. For an experimentation, four different intensity illumination levels were selected. To begin with, it was a general intensity illumination level (750lx and 1200lx), which is a general intensity illumination of MCR in a nuclear power plant and the maximum intensity illumination level of an operator's desk. Second, it was an emergency intensity illumination level (100lx and 20lx), and it was a level which would be required for the minimum intensity illumination and dark adaptation in case of an emergency.

For an experimental function, a working process in which SRO and RO would perform EOP in an emergency situation was designed as in Picture 2, and the performance was observed. Figure 1 is a description of a process which Experimenter A requests Experimenter B for a measurement of a concerned gauge according to procedures. After a request for the measurement is made, Experimenter B check the number of the gauge and reports it to Experimenter A. Experimenter A keeps conducting the experimental function based on the procedures.

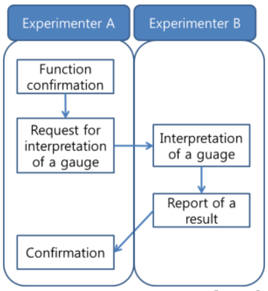


Figure 1. Experimental Task

After the experimentation, the burden on the experiment was evaluated by NASA-TLX. Moreover, for hazards which would affect the working process by causing human errors such as fatigue and stress, subjective opinions were collected

## 3. Results and Experimental Evaluation of Visual Working Performances according to Changes of Intensity Illumination

### 3.1 Change of visual working performances according to changes of intensity illumination

The changes of working performances gained via this study are as in Figure 2. Even though the performances appeared to a bit interrupted by changes of the intensity illumination, from a aspect of statistics, not a significant difference was discovered. There occurred a little interruption in the performance measuring by a rapid changes of the intensity illumination but still, effects of vision loss based on the dark adaptation effects were not found either. These results might have been gained from a simple working process in an experimental environment but since the experimentation was carried out in the same situation of MCR in a nuclear power plant, it would be right to say that chances of human errors in the visual working process will not change that much regardless of a sharp change of intensity illumination in a nuclear power plant.

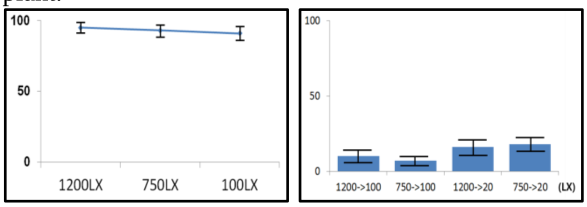


Figure 2. Changes of working performances according to the level of intensity illumination(left) and Effects of the intensity illumination loss level on the working performances(right)

### 3.2 Subjective burdens and difficulties according to changes of intensity illumination

Certain changes of subjective burdens according to a rapid change of the intensity illumination have been observed. Based on the results of the study, it is possible to expect how an operator would get changed psychologically, when the rapid change happens in a MCR of a real nuclear power plant. Add to this, from the experimenter, chances of various visual problems and human errors were gathered. The study came up with a conclusion via a few experimentations that in case of intensity illumination loss which would bring about insufficient visual conditions, an operator would be exposed to psychological burdens and this will cause human errors which are rarely happened in an ordinary situation.

## 4. Conclusion and further research

In this study, how a sharp change of the intensity illumination would affect the visual working process was analyzed to find out ways to help an operator control the visual environment.

According to the results of the experimentations, the working performances did not appear to have a significant relation with changes of intensity illumination level. However, since securing of the intensity illumination level and the minimum intensity level is not the only sufficient condition, it is likely that hazards of various visual errors would occur as a difficulty in a working process in a field. Even though there have not been found any differences in the performances, changes of dangerous human errors could not be ignored, which, as a result, would need to conduct a study on detailed complementary measures. To prevent the hazards from happening, it is suggested to develop procedures in consideration of visual features as many as possible and try to reduce the errors in a working situation. Besides this, the human errors also can be prevented as the decrease of the visual working performances is fixed by 3-way communication or a check with colleagues. In particular, for the psychological burdens of an operator which this study has not considered enough, a very conservative approach should be conducted.

When a visual awareness is secure, lighting rarely has an influence on the working process. However, for a nuclear power plant in which the safety is all about, a study not only just to prevent human errors but also to investigate details of lighting environment and visual characteristics of functions should be carried out in a more precise manner. Particularly, in order to avoid human errors caused by an extremely low or rapidly-changing intensity illumination 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.

## REFERENCES

[1] Shin. K. H, Lee. Y. H., An Ergonomic Evaluation of the Illumination Level and the Management Plan to Improve the Working Environment of Nuclear Power Plants, Transactions of the Korean Nuclear Society fall Meeting, 2011.

[2] Park, et al., Effects of Illumination and Target Size on Time-To-Detect while Recovering Dark Adaptation, Journal of the Ergonomics Society of Korea, Vol.28, No.4 pp.71-76, November, 2009.

[3] Kim. Y. G., A Study of a Decay Parameter for the Dark Adaptation Function on the retina, Journal of Korean Ophthalmic Optics Society, Vol.5, No.2, 2000

[4] Lighting and Human PerformanceⅡ, EPRI 1006415, 2001