Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 25-26, 2007

A Study on a Workload assessment for Periodic Safety Reviews in Korean Nuclear Power Plants

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1. Introduction

According to the article 19-2 of enforcement regulations of the atomic energy act in which details of a periodic safety review (PSR) are enshrined, Korea Hydro & Nuclear Power (KHNP) have to analyze human information requirements and a workload to confirm a management status of various human factors that may affect the safe operation of reactor facilities. In the PSR, task information requirement and workload have been analyzed for each Korean nuclear power plant.

However there are several problems in a workload assessment. Although information requirements are obtained and it is judged whether these requirements are satisfied or not by the PSRs, workload levels cannot be identified. Also there are limitations on achieving influence factors because it is difficult to eliminate individual, job and reactor unit differences. In addition, the results of workload assessments cannot verify objectively if criteria for a workload are met but make only a relative comparison among tasks possible.

This paper investigates general workload assessments which include physical aspects and mental aspects and the limitation of an application caused by properties of tasks in NPPs and problems of PSR execution. We also offer applicable workload assessments by considering various properties in NPPs.

2. Methods and Technical Considerations

2.1 General Workload Assessments in Human Factors

In this section, various methods for workload assessments used in pervious studies are discussed. Workload assessments have been divided into two parts: the first is for physical workload which is caused by demand of physical activities; the second is for the mental workload which is affected by motivation, atmosphere, status, and experienced workload that operators feel during task performance. A classification of workload assessments is shown in Table. 1 [1].

Table 1. Classification of workload assessments

Mental Workload Assessment Methods	Physical workload Assessment Methods
Subjective rating - OW, Primary and Secondary Task Performance Measures, Physiological Measures, NASA TLX, MCH, SWAT, SWORD, DRAWS **Physiological measures** - EEG, Evoked brain potentials, Pupil diameter, Heart-rate variability **Performance-based measures** - Primary task measures, Secondary task methods	**Epidemiological Approach** - DMQ **Biomechanical Approach** - Measures of Work posture and Biomechanics Strain: OWAS Work Posture, Strain Index, RULA, REBA, Measures in Manual Materials Handling, 3DSSPP **Subjective rating** - Borg's Scale **Physiological measures** - Heart rate, EMG, Oxygen consumption, EEPP

2.2 General characteristics of NPP tasks

Tasks in NPPs have general characteristics like the following:

- Consideration of radioactivity related hazards
- System-level safety
- Proof-of-criteria-tight-coupled technical tasks
- Tasks based on written procedures
- Fragmentation problems without overall status of system operation
- Mainly risky in sense of system safety not risky to workers' physical safety

2.3 Factors influencing Workload Tasks in NPP

Table 2 represents the factors influencing a mental workload. These divisions were also based on ISO 10075-2 [2].

Table 2. Stress-strain relationship in mental workload

Classification	Types	Influencing factors
Cause	situational influences on mental stress	Task requirements, Physical conditions, Social and organizational factors, Societal factors(external to the organization)
	individual characteristics	Level of aspiration, Motivation, Skill, Experience, Health, Physical constitution etc.
Effects	Facilitating effects	Warming-up effect, Activation
	Impairing effects	Mental fatigue, Fatigue-like states(Monotony, Reduced vigilance, Mental satiation)
	Other effect	Practice effect

Also, Table 3 represents factors influencing a workload. If the factors in Table 2 are not considered adequately in a workload assessment of a task, the result from this assessment cannot be representative for tasks similar to the task for which a workload is assessed.

Table 3. Factors influencing workload assessment

Classification	Influencing factors
Environmental Factors	Temperature, Humidity, Wind, Long Wave Radiation, Solar Radiation, Dust, Aerosols, Gases, Fumes, Barometric Pressure, clothing
Personal Factors	Age, Sex, Physical Fitness, Body Build, Health, Acclimatization, Nutrition &Hydration, Motivation, Training, Physical capabilities, Mental Capabilities, Emotional Stability, Ethnic Characteristics
Job Factors	complexity of Task, Duration of Task, Physical Load, Mental Load, Perceptia1-motor Load, Sensorimotor Load, Skill Required

2.3 Limitations in the PSRs

The PSR which is a legal requirement is very restrictive in using techniques due to time limitations. In the case of a physical workload assessment, a lot of time is required for the measurement, and the application of assessment techniques without analyses on work activities in NPPs is unreasonable. Also, in the case of mental workload assessments, it is difficult to eliminate individual differences, and the representativeness of assessment results is hard to achieve because comparisons with the other sites are difficult actually.

Therefore, we cannot present assessment results in numerical values at present but only compare workload in tasks relatively. In previous assessments, they are focused on a comparison between an objective workload measured from the amount of information required when workers perform corresponding tasks and a subjective workload measured from the degree of satisfaction in performing tasks.

3. Proposition for new approach

3.1 Methods for workload assessment in NPP

The purpose of a workload assessment in PSR is to eliminate the probability of human errors in NPPs. So, the previous assessments are focused on a balancing between information required and degrees of satisfaction in performing tasks. However, because the results showed that it was difficult to present criteria in current PSRs by an absolute index, the results are nothing but comments for improving the workload management in NPPs. Furthermore, PSRs assume that information requirements are obtained by performing a task analysis. To establish the items required in performing tasks, we have to perform task analyses for all the tasks performed in NPPs. There are many methods available for task analysis such as Hierarchical Task Analysis (HTA), Goals, Operators, Methods and Selection Rules (GOMS), Sub-Goal Template Method (SGT), Cognitive Task Analysis Methods, Cognitive Work Analysis (CWA), Cognitive Walkthrough, etc [4]. However, task analyses have been performed independently for workload assessments in previous studies. Recently, we have tried a workload assessment through task analyses based on DGOMS and CWA for one NPP in Korea [3].

Workload assessment techniques have to be able to consider unique characteristics of NPP tasks in order to estimate a workload used in assessment techniques. Especially, in order to verify a workload assessment method, we have to find out items required in performing tasks and items making assessment results be different due to differences in individual workers. Also, in order to acquire representativeness of the results, we should compare tasks in different plants where all work conditions are very similar to each other, for example, in twin units of NPPs. So, a company which performs PSRs has to research and develop factors which influence a job, an individual, or a reactor unit.

To complement a relative comparison for the workload of tasks, workload assessment techniques should be an absolute evaluation which can express results numerically. Especially, we need to establish criteria which are recognized officially and compare them with other industrial areas in order to verify the criteria of a physical workload and mental workload. Previous researches have tried to estimate a workload using a quantitative analysis for a physical workload assessment.

3.2 Approach

Figure 1 represents the process of establishing the new workload management. This process is based on Human Factors Management Program (HFMP) [4].

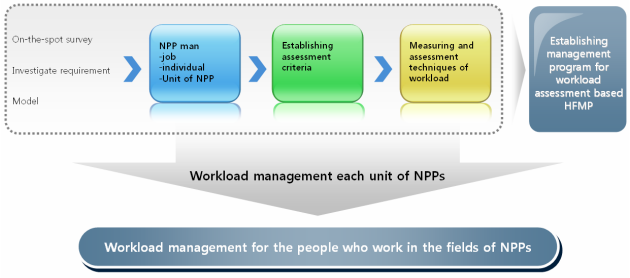

Figure 1. Process of establishing the workload management

REFERENCES

[1] J. K. Park, Y. H. Lee, A Physical Workload Assessment using the classification of job activity in nuclear power plants, Proceedings of the 2006 Fall Conference of the Ergonomics Society of Korea, pp.484-488, 2006.

[2] ISO (International Organization for Standardization): ISO 10075-2: Ergonomic principles related to mental work-load - Part 2: Design principles, 1996.

[3] J. K. Park, Y. H. Lee, D. H. Kim, T. I. Jang, A Workload Assessment Based on DGOMS in Nuclear Power Plants, 12th International Conference on Human-Computer Interaction, 2007.

[4] Y. H. Lee, A Development of Human Factors Management Program(HFMP) for the Continuous Operation of KORI Unit #1, IAEA Tech. Mtg. on Use of Advanced Safety Assessment Methods for Evaluation of NPP Upgrades including Control Room Modernization with Consideration of Human-System Issues, 2006.