Development of a HRA method based on Human Factor Issues for advanced NPP

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1. Introduction

A design of instrumentation and control (I&C) systems for various plant systems including nuclear power plants (NPPs) is rapidly moving toward fully digital I&C and modern computer techniques have been gradually introduced into the design of advanced main control room (MCR). In advanced MCR, computer-based Human-System Interfaces (HSIs) such as CRT based displays, large display panels (LDP), advanced information system, soft control and computerized procedure system (CPS) are applied in advanced MCR.

Human operators in an advanced MCR still play an important role. However, various research and experiences from NPPs with an advanced MCR show that characteristics of human operators' task would be changed due to the use of inexperienced HSIs.

This gives implications to the PSFs (Performance Shaping Factors) in HRA (Human Reliability Analysis). PSF in HRA is an aspect of the human's individual characteristics, environment, organization, or task that specifically decrements or improves human performance resulting in increasing or decreasing the likelihood of human error[1].

These PSFs have been suggested in various ways depending on the HRA methods used. In most HRA methods, however, there is a lack of inconsistency for the derivation of the PSFs and a lack of considerations of how the changes implemented in advanced MCR give impact on the operators' task.

In this study, a framework for the derivation of and evaluation in the PSFs to be used in HRA for advanced NPPs is suggested.

2. Derivation of PSFs

2.1 Review of the PSFs in various HRA methods

HRA methods are usually divided into the 1st and 2nd generation methods. A major difference between these two generations can be simply stated as the consideration of impact of PSFs on operators. PSFs in the 1st generation HRA methods more focus on the environmental effect on operator whereas 2nd generation HRA methods more focus on the cognitive aspect of the operator. In this study, PSFs in various HRA methods in these two generations are reviewed to derive the PSFs which are considered important in common.

110 PSFs from the 1st generation HRA methods such as THERP[2], INTENT[3] and etc. and 49 PSFs from 2nd generation HRA methods such as CREAM[4], HRMS[5], IDAC[6] and etc. are collected and reviewed. Further, overall 159 PSFs are grouped into 9 important PSF categories; *stress level, action type, experience, time constraints, places where operator action taken, procedure, training, HSI, team factor.*

2.2 Deriving PSFs with a consideration of features in advanced MCR

In order for these 9 PSF categories to be verified important PSFs and used in HRA for advanced NPPs, there needs a concrete framework.

Human factor engineering program review model (HFEPRM)[2] shows that the PSFs in HRA can acquire feedback from human factors analysis. In short, since human factor(HF) issues can affect human performance, HF issues in advanced MCR should be identified at first.

For the identification of HF issues, scopes of the HSIs are limited to the CPS, soft control, advanced information system and their related training. As stated above, remaining issues from conventional NPPs regardless of the implementation of computer-based HSIs and new issues occurring with computer-based HSIs are identified.

There were 12, 10, 10 and 13 major HF issues identified with CPS, training, advanced information system and soft control, respectively. For the verification of the importance of the PSFs, an analysis of the relevance between identified major HF issues and 9 PSF categories were performed and an example showing the relevance between CPS and 9 PSF categories are listed in Table1.

2.3 Evaluating the PSFs

For the HRA methods using PSFs, some of them use as set of PSFs in adjusting the basic HEP(Human Error Probability) such as THERP, HEART, CREAM and others in producing HEP by rating and integrating PSFs such as SLIM, STAHR, etc.

For the evaluation of 9 PSF categories derived in this study, major HF issues are used. Major HF issues derived in this study are expected to cover broad ranges of HF issues which can affect human performance, however, there can be specific situations which can mitigate these HF issues. In this case, HF issues can be removed from the HF issues.

After the verification of the importance of the PSFs, impact of the PSFs should be evaluated. In this study, a term severity is used to represent the impact of the HF issues on performance. Severity is divided in 3 categories; *Severe, Moderate, Weak*

Table I: Evaluation criteria for PSF

HF issues \ PSFs	Stress level - Action type - Experience	Places where operator action taken	Time Constraints	Procedure	Training	HSI	Team Work
Problem inherent in CPS design				V		V	
Degradation of team performance due to the reduction of operator's reporting	V			V	V		
Difficulty in situation awareness due to the complexity		V	V	V	V	V	V
Function allocation problem between operator and CPS due to the increased level of automation	V		V	V		V	V
Keyhole effect and difficulty of managing the CPS in individual monitor	V		V	V	V	V	
Increase of operator's cognitive load with failure of CPS in complex situation	V	V	V	V	V		V
Problem with insufficient experience in hybrid procedure				V	V		V
Decrease of legibility with CPS format						V	
Problem with a level of operator's reliance about CPS			V	V		V	V
Increase of operator's cognitive load due to the inconsistencies between CPS and other HIS	V		V		V	V	
Training					V		V
Maintaining the technical accuracy of CPS				V			

Range of severity can be either selected from range of PSFs which has similar characteristics in THERP or by expert judgment.

Since the impacts of the HF issues on human performance can be different, a term weighting factors is used to represent the difference. These weighting factors can be given to the HF issues with normalization. After deciding the severity and weighting factors of the PSFs, importance of the PSFs can be derived by summing the value of severity multiplied by their weighting factors. Whole processes stated above are briefly explained in figure 1.

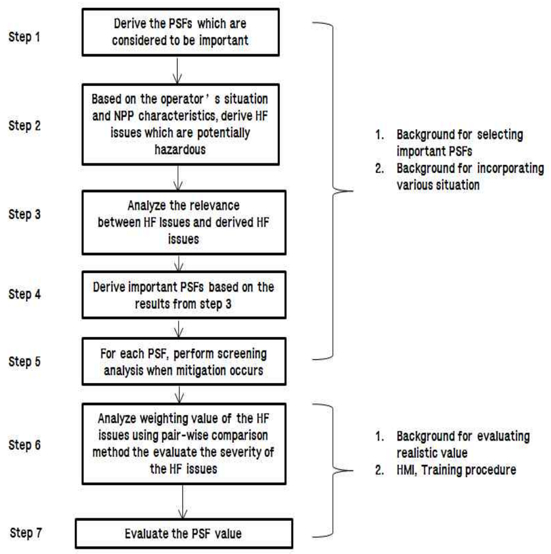

Fig 1. Process for the derivation of and evaluation in the PSFs

3. Conclusions

In this study, a framework for the derivation of and evaluation in PSFs which can consider the new features in an advanced MCR is suggested. It is expected that PSFs can be derived in more consistent way since relevancies between the HF issues and PSFs can be used as evaluation criteria.

Moreover, this framework can give more accuracy in evaluating the PSFs since a range of these PSFs can be divided into at least 3^n cases according to this framework.

In conclusion, PSFs derived with this framework not only provides HRA practitioners with more options to select and decide the importance of PSFs but also contribute to the reduction of the conservatism in HRA. Also, HF issues not screened by specific mitigations could be the items for improving the design of the HSIs and training.

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