A Review of Various Performance Shaping Factors for Use in Advanced Control Rooms

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1. Introduction

Human reliability analysis(HRA) has been performed as part of the probabilistic risk assessment to identify and quantify human actions and the associated impacts on structures, systems and components for a complex facility.[1]

Currently, representative HRA methods such as THERP, ASEP HRA and HCR are being used in Korea. In performing HRA, such conditions that influence human performances have been represented via several context factors. These context factors are referred to by different terms according to method:PSF(Performance Shaping Factors), PIF(Performance Influencing Factors), PAF(Performance Affecting Factors, EPC(Error Producing Conditions), CPC(Common Performance Conditions), and so on.[2] These context factors which will be called PSFs in this study are used in adjusting the basic human error probability(BHEP) .

However, these PSFs need to be re-assessed since the context is expected to change due to the implementation of computer technologies in NPP.

In this study, various PSFs used in different HRA methods are reviewed and PSFs which are frequently mentioned as important factors are derived. Also, HF(Human Factor) issues with one of the design characteristics of advanced NPP are identified.

2. A Review of various PSFs used in HRA Methods

THERP, CREAM, SPAR-H and IDAC are reviewed for colleting the set of PSFs. In THERP, PSFs are defined as factors that influence human performance. 67 PSFs are provided and grouped into three groups, i.e. external PSFs, stressor PSFs, and internal PSFs. Again, the external PSFs group consists of three subgroups: 'situational characteristics', 'job and task instructions' and 'task and equipment characteristics', the stressors PSF group is divided into 'psychological stressors' and 'physiological stressors' and internal PSFs includes 'organismic factors'.[3]

In CREAM, nine context factors named CPCs(Common Performance Conditions) are provided and there is difference in meaning between conventional PSFs and CPCs in that the former is used to adjust or produce the HEP, however, the latter is used for the overall assessment of task situation as well as the quantification of HEP.[4]

In SPAR-H(Standardized Plant Analysis Risk-Human Reliability Analysis), eight PSFs are provided and it describes PSFs in a similar way of THERP.[5]

In IDAC, 48 PSFs are provided and grouped into eleven groups, i.e cognitive modes and tendencies, emotional arousal, strains and feelings, perception and appraisal, memorized information, intrinsic characteristic, environmental factor, conditioning events, organizational factors and team related factors. PSFs in IDAC focus on the factors affecting information process of human.[6]

Thus, 132 PSFs are collected and grouped into 9 categories which were frequently mentioned as important factors; stress level, action type, experience, time constraints, places where operator action taken, procedure, training, HSI(Human System Interface), team factor.

3. Developing Evaluation Criteria for Use in ACR

Modern computer techniques have been gradually introduced into the design of ACR. A design of I&C systems for various plant systems is also rapidly moving toward fully digital I&C. For example, CRT based displays, large display panels, soft controls, a CPS(computerized procedure system), and an advanced alarm system are planned to be applied in advanced NPP[7].

In this study, CPS is selected for developing sub-items for evaluation criteria of PSFs. It is expected that CPS can provide various advantages to operator. For example, operator performs a task with VDU(Video Display Unit) in individual work station and directly observes the parameter from VDU, secondary task such as reporting to other operator can be lessened.

Operator can easily navigate to the information and use place-keeping function to prevent loss of operator's position. Also, information provided to operator can be flexibly managed according to the experience level of operator.

However, unexpected human factor issues in the designing step of CPS can occur and affect operator performance. These human factor issues need to be carefully considered since it could affect the operator's context.

Several issues with CPS are identified from reviewing reported HF issues. These HF issues are listed as follows.

-Problem inherent in CPS design
-Degradation of team performance due to the reduction of operator's reporting
-Difficulty in situation awareness due to the complexity
-Function allocation problem between operator and CPS due to the increased level of automation
-Keyhole effect and difficulty of managing the CPS in individual monitor
-Increase of operator's cognitive load with failure of CPS in complex situation
-Problem with insufficient experience in hybrid procedure
-Decrease of legibility with CPS format
- Problem with a level of operator's reliance about CPS
-Increase of operator's cognitive load due to the inconsistencies between CPS and other HSI
-Training
-Maintaining the technical accuracy of CPS

4. Sub-items for Developing Evaluation Criteria for PSFs

In performing HRA for ACR, some evaluation criteria available for derived PSFs can be used. However, more sub-items should be considered for developing evaluation criteria.

Thus, relevance between identified human factor issues with CPS and derived nine PSFs are assessed and listed Table 1. Each sub-items can be further grouped into categories and used as input data for developing evaluation criteria.

5. Conclusions

In this study, various PSFs used in different HRA methods are reviewed and nine important PSFs are identified. Changes in operator action due to design characteristics of advanced NPP and its relevant human factor issues are identified. Also correlation between nine PSFs and HF issues with CPS are assessed. It is expected that the result from this study can be used as input data for developing evaluation criteria for each PSFs for performing HRA for ACR.

However, there needs to be more collection of PSFs in other HRA methods or review of HRA methods in other fields. Also this evaluation criteria table needs to be further verified by experts and issues with other design characteristics need to be identified.

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Table 1 Evaluation criteria for PSF

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