

Integrated Human Factor Program for Nuclear Power Plants

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1. Introduction

Modern life demands that every activity should go well with its environments. Traditionally movies have been called integrated art including film, music, scenario, costume, settings and actors. These days every human activity is not performed by single person or single department, or not guided by single rule. Lots of additional reviews are required by rules. Activities in nuclear power plants are not exceptions. Nuclear activities should be reviewed by interdisciplinary points. Qualification assurance process has been one of the additional areas. Human factor engineering is now also important review point.

NUREG-0711 is useful guidelines to apply human factor engineering for reviewing process. The guideline has been revised 3 times [1]. Construction activities and design change activities are performed via NUREG-0711. NUREG-0711, however, does not specify how sub-activities of constructions can be reviewed. 12 elements of NUREG-0711 should be applied to the sub-activities performed by other organizations.

FSAR is safety analysis document for operating nuclear power plants. It assures safety of operating nuclear power plants. Content of all chapters except human factors are specified in Reg1.70 [2]. Ch.18 for human factors describes evaluation results of human factor activities during construction phase. Is this useful for operating plant? Actually human factor activities during operating plant are different from those of construction phase.

During power operation, nuclear power plants should be evaluated because of aging, design change, procedure revision, organization restructuring and law enforcement such as severe accident. PSR or stress test is one of reviewing process. There is review process for design change too.

Korean nuclear power plants are facing new stage called decommissioning. The process occurs slowly and configuration of MCR changes step by step as process develops. Human factor activities for the process should be described in integrated HFE program.

2. Life Cycle of NPP and its HF activities

Before HFE program is described, life cycle of nuclear power plants is depicted as Fig.1.

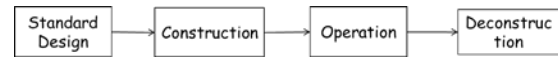


Fig. 1. Life Cycle of NPP

Because constructing a nuclear power plant is challenging project costing lots of resources and time, its standard design should be licensed prior to construction. During the standard design period, advanced concepts to increase safety of NPP can be tried. Especially digital control and communication are big trend in human history. That technique revolutionizes all devices. HFE shall evaluate its effect on nuclear safety and human performance.

Even though standard design is licensed, PSAR should be approved by regulatory organization for construction. This phase covers all design activities from MCR overview design to detail design to build actual plant. Overall MCR is designed by AE engineer, but its systems are designed by other specialized company. KHNP CRI is in charge of CPS(Computerized Procedure System). Once MCR is designed, its design documents are delivered to manufacturing companies. They also design components and fabricate the components. Human factor engineering shall be applied to AE engineers, system design engineers, and component engineers. It is reason why integrated HFE program is needed. NURGE-0711 is defining HFE program as Fig.2.

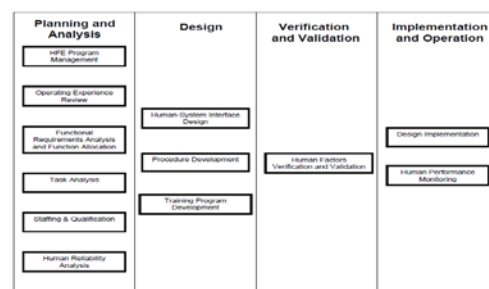


Fig. 2. Human Factors in NUREG-0711

Experience with HFE tells that mechanism to apply HFE to MCR looks like fractal. Recursive application occurs from designing MCR to designing components. Unfortunately, while designing system or designing components, HFE is not tightly controlled. All 12 elements are not applied. HFE program for MCR is partially reflected to HFE program for system or component. Number of staff for MCR might not be the same with number of operators who use CPS. Therefore

staffing for MCR cannot be inherited to CPS directly. CPS designer should reconsider the staffing. Another problem occurs when organizations designing system or component have their own HFE program that might be different from HFE of MCR because component manufactory sells their products in the different market. Thus integrated HFE program should be maintained among all participants.

FSAR Ch18 is added chapter as TMI accident actions. Nonetheless content of Ch18 is not specified in other NRC documents [2]. Korean nuclear power plants decided to divide the chapter into 3 sections; HFE program and its results, MCR design, and RSR design. FSAR is a living document describing the present MCR and RSR, and evaluation document for present MCR and RSR. The milestone of constructed plant or activities for construction cannot satisfy requirement of living document. HFE evaluation section resulted from HFE program should be summarized in FSAR in order to demonstrate safety of MCR or RSR. The detail description of HFE result should be submitted in another report. When FSAR is revised due to design change during power operation, the detail result of FSAR is hard to revise.

FSAR Ch18 should be revised to be HFE guideline document for operating nuclear plants. Most part of FSAR Ch18 is written by MCR designer who does not have experience of operation. The most valuable area of HFE is human error prevent tools to reduce human error. Neither FSAR nor NUREG-0711 describes the right activities in Fig.3.

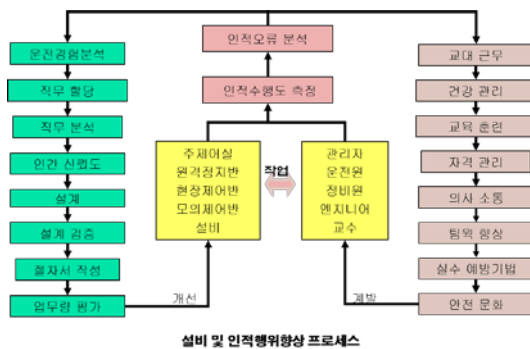


Fig. 3. Human Factor Activities in HFE

FSAR Ch13 is handling the right most part of Fig.3. This chapter is written by personnel who had experienced operation. Staffing, training, and procedure are common elements of both Ch.13 and NUREG-0711. In order to describe those sections in view of HFE, HFE program for Ch.18 should be integrated considering Ch.13.

During plant operation, plant organization tried to reduce human error and reactor trip with lots of management tools. Actually HFE can greatly contribute to better plant performance and better human performance. There are lots of procedures to detect

human error precursors in the plant. Unfortunately FSAR Ch.18 does not have guideline on this subject. Furthermore Korean regulatory body introduced PSR 17 years ago. PSR is extensive and periodic evaluation process including HFE. There is degradation in MCR due to aging or improvement due to design change. Evaluation of MCR in PSR is judged by 3 elements called inventory, suitability, and usefulness. On the other hand evaluation of MCR in FSAR is judged by PV(Preliminary Validation) and ISV(Integrated System Validation). The judgement criteria should be identical.

There are temporal activities demanding HFE efforts. Stress test or accident management program are typical examples. This evaluation is handling beyond design basis events and demands lots of participants from NPP. The severe accident is not covered by simulators. It is difficult to judge that plant has adequate capability to manage beyond design basis events. NASA-TLX measure which was used for construction phase is not suitable for stress test where operators are threatened by radioactive materials. Integrated HFE program should mention these kinds of issues.

Kori-1 Nuclear power plant entered decommissioning stage. After shutdown the reactor, indicators or controller not used in MCR are tagged as “permanent shutdown”. This tagging convention has been adopted in US nuclear plants. However it has human factor issues whether all signals going to the indicators are removed, or tagging makes human operator confusing. Furthermore during decommissioning stage, indicator or controllers will be removed from MCR step by step. Must the shortly living-MCR be evaluated even without fuel loading. Integrated HFE program mentions on this subject too.

3. Conclusions

Human factor engineering program has been well applied to design, construction, operation, and decommissioning separately. Their guidelines and evaluators are different from stage to stage. It is time to integrate HFE program to improve plant and human performance.

Integrated HFE is not only scope of nuclear power plants, but also scope of other organization. Elements of integrated HFE shall be shared among the organizations.

REFERENCES

- [1] NUREG 0711, NRC, Human Factor Engineering Program review Model, 2012.
- [2] Reg. 1.70, NRC, Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants, 1978.