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Lessons learned from Appling Human Factor Engineering Program

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1. Introduction

Most commercial products are chosen by customers considering their functions at the earlier life cycle. Once they are mature in the life cycle, they are chosen by user interface. These principles are also applied to nuclear power plants.

Human factor engineering (HFE) program is process to develop smart user interface. The program covers functional requirement analysis and procedure development as in Fig.1[1]

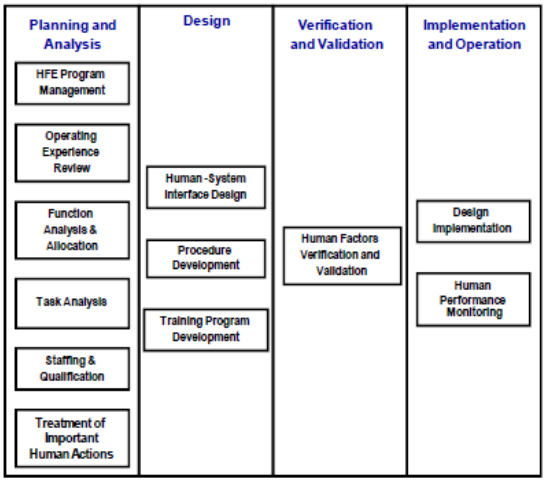

Fig 1 Elements of HFE Program

Development of products requires lots of activities such as requirements analysis, risk management, available technology, quality management, V&V, human resources management, configuration management. HFE program and qualification program are one of them. Some activities are covered by both HFE and QA programs. Therefore some nuclear power plants have a team to handle both HFE and QA, and other nuclear power plants separate teams.

HFE program has been applied to construction nuclear power plants. Each element of HFE program is planned and implemented with report. Due to this effort Korean engineers have considered HFE as useful process.

It is, however, needed to improve HFE program to be more useful to user interfaces. NPIC&HMIT2015 conference treated this topic within a special session. This paper mentions present HFE program and its weakness, and suggest how to elaborate the HFE elements.

2. HFE Program result to FSAR

FSAR is final safety analysis report. FSAR Ch.7 deals with I&C systems, whereas FSAR Ch.18 deals with MCR and HFE. FSAR must be a living document as change whenever human factor related elements such as MCR is modified. Impact on safety due to modification must be reanalyzed. Present FSAR Ch.18 was described during construction phase, and rarely updated with modification.

Both MCR and local control panels are continuously modified during commercial operation. The modification process must comply with HFE program established since construction phase, and its result must be reflected to FSAR as construction phase. HFE program needs to be revised to consider FSAR.

3. Decoupling among human factor elements

NUREG-0711 elements have their own characteristics that can be performed independently. Even though individual result can be input to other human factor elements, NUREG-0711 requires too strong coupling among 12 human factor elements. The interface requirements demand lots of efforts but benefits are so small. Elements for HFE program should not be defined just referring to the other elements.

4. HFE Program for both construction and commercial operation.

Every process has PDCA(Plan-Do-Check-Action) type. SW development process, QA process, and HFE program have PDCA type. The 12 elements of HFE program is detail process of PDCA. Therefore HFE program can be applied to both construction and operation phase.

NUREG-0711 is typical example of HFE program. According to NUREG-0711, element “Design Implementation” deal with design change process during power operation. It says that design change must be carried out with HFE program. This is wrong description because HFE program is basically applied to both construction and operation.

Element “design implementation” must address human factor issue while manufacturing user interface. Potential human factor issues are review of manufacturing document in order to check consistence with designer’s document. Factory acceptance test can be one of human factor issues. Design implementation of HFE must be interpreted in the same level as other process such as SW development process.

5. Practical Functional Allocation and Task Analysis.

Nuclear powers plants generate electric power in constraint of non-violating safety criteria. In order to fulfill these requirements, SSC (Structure, System Component) functions almost 90 % of requirements. 10 % of the requirements are scope of human in MCR. SSC forms basic infrastructure of NPP, and MCR is interface with SSC through I&C and MCR.

HFE program, however is a program applied to MCR rather than SSC. But present FA and TA in NURG-0711 are focusing on SSC functions such as reactivity control, inventory controls. Even though advanced MCR have been introduced, functions of SSC do not change significantly. Therefore result of FA and TA are same for all nuclear power plants. This looks strange because FA and TA is important element for MCR design. How do the same TA and FA results make MCR different?

Tasks are generally categorized as primary task and secondary task. The secondary tasks are related to navigation to find information. While designing SSC, the primary tasks should be analyzed, whereas designing MCR should be focused on the secondary task. Without secondary tasks, advanced MCR could be developed. Therefore element FA and TA must include the secondary tasks significantly.

6. Human Factor Verification and Validation.

V&V is activity to accept designed MCR without scarifying safety. SSC is generally accepted through deterministic safety analysis or probability safety analysis. However human factors cannot use such a quantitative method. HFE is a sort of qualitative process.

V&V is also activities to be performed whenever design change occurs. So there could not be a final HFE V&V as described in NUREG-0711. V&V should be performed repeatedly during power generation phase and its result should be reflected in FSAR if necessary.

V&V also means component based V&V, system based V&V, and integrated system based V&V. It is not a good idea that unit based test should be distinguished from HFE V&V as the present NUREG-0711. HFE program should comply with program convention applied to other industrial fields.

V&V can be performed anytime during design phase. Initial design can be V&Ved and its result can be reflected to design. As-built design can be V&Ved and its result can be accepted for licensing. V&V activities must be performed if necessary.

V&V can be performed in view of availability, suitability, and usability [2]. As design goes on, these types of V&V can be performed partially or fully as Fig.2

	1st V&V	Component V&V	System V&V	2nd V&V	3rd V&V	V&V during Operation
Availability	O	X	X	O	O	X
Suitability	O	O	O	O	O	O
Usability	X	X	O	O	O	O

Fig 2 V&V types through plant life cyle

7. Facility for V&V.

V&V activities are usually performed by reviewing document, calculating design data, observing and interviewing operators, and measuring performance index on V&V facility. For example, availability and suitability can be checked by reviewing document and drawing. Usability can be rated on the V&V facility.

HED results from V&V covers items on procedure, environments, MMI, and staffing. Ideally V&V facility should be the same as real plant. Ideal V&V facility cannot be built, but equivalence can be achieved. The same facility requirement is too strict and easy-going altitude for human factors. Practically V&V facility should have enough fidelity to test human factor issues. How is enough fidelity achieved? The answer depends on HED derived. For example, typical HED on CPS is presentation of procedure. This HED can be evaluated at FPD with CPS, without full scope simulator.

8. Conclusions

NUREG-0711 has been applied to constructing nuclear power plants. Advantages of NUREG-0711 are to create a common framework for human factor activities, and to provide method to apply human factors. These days there are movement to revise the guideline. At NPIC&HMIT2015 conference, there was a special session for revision, especially on integrated system validation. This paper suggests area for improvement in NUREG-0711.

REFERENCES

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[2] IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities, IEEE Std 1023, 2004