Human Factor Design Requirements for the Emergency Headquarter in the Nuclear Facility

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1. Introduction

The need for the Emergency Headquarter in the nuclear power plant site is raised from lessons learnt from the Fukushima accident and emotional dislike to the EOF (emergency operation facility) location. The Emergency Headquarter in the Fukushima Daiichi nuclear site is called the Seismic Isolated Building which is a base-isolated building a few hundred meters away from the unit #1 reactor building.

As an onsite response measure, the Emergency Headquarter covers the roles of TSC (technical support center) and EOF under radiation emergency, DEC and even severe accidents. USNRC and KINS require taking human factors into account for designing and operating ERF (emergency response facility) including TSC and EOF, thus it is necessary that the Emergency Headquarter also apply human factors principles, standard, and guidelines to its development for the safe and efficient operation.

For the Emergency Headquarter of Korean nuclear power plant sites, the high-level human factors design requirements are described in this paper.

2. Methods and Results

The Seismic Isolated Building (SIB) in Japan should be implemented within the nuclear power plant site to cope with nuclear accidents following earthquakes. Japanese regulation body recommended its implementation after Kashiwazaki Kariwa nuclear accident (quake, fire, and release) in 2007, and regulated the SIB as the Emergency Headquarter after the Fukushima accident in 2012.

Because of no beyond design basis accidents in Korean nuclear facilities, Fukushima's Emergency Headquarter (E-H) and other Japan power company's SIBs are the reference facilities. To develop the high-level HF design requirements, the following activities were carried out: data collection from TEPCO and other Japanese power companies, the review of accident analysis reports from several organizations (Japanese Diet, Japanese government, etc.), availability evaluation on HF design guidelines.

2.1 Considerations

The following characteristics are considered to develop the high-level HF design requirements.

-Personnel Safety
-DEC (design extension condition) and severe accident
-Multiple units and different reactor types
-High stress and fatigue level
-Long-term utilization
-Information demand
-Reliability
-Maintenance
-Support systems

The high-level HF design requirements are being developed at this time and major requirements are presented herein.

2.2 Requirements for Personnel Safety

The design should minimize the potential risk to human workers. Critical risks are radiation, quake, fire, flooding, stress and fatigue.

Personnel safety should be addressed more than efficiency in the design.

Response manuals for critical risks should be prepared and trained periodically.

The design should provide means for minimizing personnel exposure to radiation during their stay in the site.

2.3 Requirements for Performance

The design should be developed according to the procedural process including HF team coordination, operation concept definition, user and scenario specification, design issue management, iterative implementation.

The E-H organization should be functionally grouped and its ordering/reporting system should be effective and efficient.

Plant states which the design covers should range from AOO (anticipated operational occurrence) to severe accident. It includes DBAs and beyond DBAs. The design should prepare operation reaction beyond procedures, ie. knowledge-based operation as well as rule-based operation.

The design should have a capability of managing multi-unit accidents as well as single unit accidents. Consideration for various reactor types should be also taken for the design. Effective and reliable means for deliver various types of information to human workers should be provided.

Displays used for decision making should be designed by considering cognitive performance

enhancement so that effective mitigation tactics and strategies are easily developed under highly stressed condition.

Staffing should be assumed in the early design stage and defined in the later design stage.

The location of the SIB should be determined to facilitate ease of access and minimum dose level.

The design should provide sufficient space for workers, equipment, and expansion. Layout building inside should be functionally grouped to ensure efficient cooperation and communication within group and between groups.

2.3 Requirements for work

The design should consider the characteristics of long-term usage of building, equipment, and staffing. The design should allocate dedicated spaces at least for:

- meeting
- surveillance (monitoring) and control
- resting/stand-by
- maintenance/storage
- decontamination
- radiation expose management
- habitability control
- waste management.

Environmental factors such as noise, illumination, HVAC, color, etc should be designed and controlled by human factors standards/guidelines and local condition.

The design should provide the management system for control worker stress and fatigue. Personnel work should be scheduled by considering stress and fatigue level as well as dose level.

2.4 Requirements for Information Demand

Human-Machine Interfaces (HMIs) should be designed by postulated scenario definition, functional requirements analysis, and task analysis with staffing assumption.

Information to be shared within organization, function units, and work group should be independently determined through systematic analyses.

Information sharing display should be installed at the effective location where target population can get information easily and accurately.

Surveillance displays should be provided for effective situation assessment and decision support. Sufficient expandability for new/additional configurations of nuclear installation should be provided in the HMI design.

Alerting structure should be defined in s systematic manner. Hierarchical, reaction-triggering and informative alerting message delivering should be guaranteed.

The design should provide communication facilities for internal and external message transmission.

2.4 Requirements for Reliability

The design process should be systematically managed and iterative.

The design should be verified and validated by effective evaluation methods such as checklist, experiment, expert judgment, etc.

2.4 Requirements for Maintenance

Information gathered in the SIB should be stored and managed to enable to retrieve specific data later.

2.4 Requirements for Support System

The design should consider application of already-developed support systems. Functional requirement analyses for adopting support systems should be carried out in the early stage of design process.

The design should integrate selected support systems rather than simply add-up to maintain interface consistency and enhance human performance.

Integrated system should be compatible and consistent with the rest of whole system in the SIB and tested in aspect of system performance and human performance.

3. Conclusions

A human machine system should be developed through thorough analysis, effective design, and reliable test/evaluation. This HF design requirement is the starting point at the overall system development process.

The high-level HF design requirements will provide the basis for further detail HF design requirements. Industrial and nuclear domain HF design principles, standards, and guidelines can be used for the detail design requirements.

These requirements are expected to provide the basis for the Emergency Headquarter development without trial and errors.

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