Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 12-13, 2016

A Stencil to Develop an EOG for a Research Reactor

Hyeonil Kim [a*], Soo-been Yum [b], Youn-Gyu Jung [b], Byeonghee Lee [b], In Sub Jun [b], Su-Ki Park [b]
[a]*Research Reactor Technical Management, Korea Atomic Energy Research Institute, 989-111 Daedeok-daero., Yuseong, Daejeon, 34057*

[b]*Research Reactor Safety Analysis, Korea Atomic Energy Research Institute, 989-111 Daedeok-daero., Yuseong, Daejeon, 34057*
[*]*Corresponding author: hyeonilkim@kaeri.re.kr*

1. Introduction

Following the Three Mile Island Unit 2 (TMI-2) accident, the United States Nuclear Regulatory Commission (NRC) established the sets of requirements addressing their objective to improve the quality of operational information for dealing with emergency events in nuclear power plants. [1][2][3][4]

The Emergency Operating Guidelines (EOG) should be presented to provide technical information to prepare reactor-specific Emergency Operating Procedures (EOP) which cover operation during emergency events.

Applicants for operating license and licensees of reactors under construction are required to:

- Perform analyses of transients and accidents including multiple failures
- Prepare emergency operating guidelines

All assumptions made in the EOP, which relate to safety analysis, must be verified to be true and appropriate for each user by each user. Furthermore, a set of EOP shall be developed for all safety related operations that may be conducted over the lifetime of the facility by international standards, Safety of Research Reactors (IAEA NS-R-4) [5][6]): 7.51 (g) the reactor operator's response to anticipated operational occurrences and DBAs and, to the extent feasible, to BDBAs.

In this paper, it is described about a development and a revision of a set of EOG for a research reactor.

2. Development of an EOG

2.1 Requirements on an EOG

A goal of the EOG is to provide the best available technical information to be used for developing reactor-specific EOP. The content and scope of the EOP developed from EOG should be designed to interface with, but neither overlap nor duplicate, reactor procedures.

2.2 Interfaces and Structures of EOG systems

An understanding of what constitutes an emergency is a prerequisite to deciding what information is to be collected and in which format that information is to be arranged. For the purpose of the EOG, an emergency event is distinguished from other off-normal reactor operations by virtue of its severity; it is sufficiently severe that a reactor trip is either activated automatically or required to be manually initiated to mitigate the event. FIG. 1 depicts the distinction between emergency operating procedures based on these guidelines and other off-normal procedures.

EOG must provide guidance for both classes of emergencies. Thus, when a reactor trip occurs or should occur, the operators can refer to guidance which will provide a safe response whether or not a symptom set is identified: EOG written to treat specific symptoms are called event-based recovery guidelines (ERG); the EOG which provides guidance for undiagnosed events for which a reactor trip is required is called the Symptom-based Recovery Guidelines (SRGs).

2.3 Safety Functions
2.3.1 The Concept of Safety Functions

The concept of safety functions introduces a systematic approach to reactor operations based on a hierarchy of protective actions. The protective actions are directed at mitigating the consequences of an event and, once fulfilled, ensure proper control of the event in progress. A safety function is defined as a condition or action that prevents core damage or minimizes radiation release to the public. A complete set of safety functions needs to be fulfilled to ensure proper operator control of the event and public safety.

The actions which ensure fulfillment of a safety function may result from automatic or manual actuation of systems, from passive system performance, from natural feedback inherent in the reactor design, or when the operator follows guidance established in an event-based recovery guideline. The operator does not have to know what event has occurred but does have to know what success paths are being utilized and what acceptance criteria must be satisfied.

All safety functions are directed at mitigating an event and containing and/or controlling radioactivity releases. These safety functions can be grouped into four major classes as follows:

1. Anti-core melt safety functions
   A. Reactivity Control (RC)
   B. Pool Water Inventory Control (IC)
   C. Core Heat Removal (CHR)
2. Confinement isolation safety functions
3. Maintenance of vital auxiliaries needed to support the other safety functions

2.3.2 Safety Function Hierarchy

The safety function concept incorporates a principle of safety function hierarchy. Some safety functions have precedence over others concerning their sequence of implementation during an event. The hierarchy of safety functions is summarized as standardized in this EOG guidance:

1. Reactivity Control
2. Maintenance of Vital Auxiliaries (AC and DC Power)
3. Reactor Pool Water Inventory Control
4. Core Heat Removal
5. Confinement Isolation

Reactivity control is the most important safety function since it responds most quickly to changes in reactor conditions. Similarly, Reactor Pool Water Inventory Control (IC) must be satisfied before core heat removal can be effected (i.e., there must be a medium to remove heat). This hierarchy concept is important in the design of systems used to fulfill each function and has also been employed in developing the EOG. All of the EOG identify each of the 5 safety functions (in the hierarchy presented previously) and the acceptance criteria which reflect accomplishment of each of the safety functions. The safety functions are provided as a complete set so that the operator can monitor and control the reactor to protect the health and safety of the public.

Application of the concept of safety functions in a restructured format is acceptable as long as: (1) the representation contains actions and acceptance criteria necessary to control and fulfill the five individual safety functions; (2) it is consistent with the safety function hierarchy of this EOG; and (3) the ultimate goal of protecting the health and safety of the public is preserved.

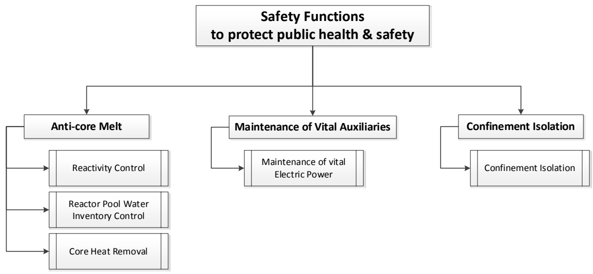

FIG. 2 Safety Functions Classification

Each level, consisting of a rearrangement or combination of safety functions can achieve the same goal as the set which contains each safety function individually. This safety function subset or rearrangement may be enhanced by use of a particular control room operator aid, etc.

2.4. A stencil to gather information related to safety/safety-related function

In order to develop a set of EOG/EOP, the information about the system should be identified in a comprehensive way and the procedure should be prioritized in a systematic way.
Here a conceptual system architecture is assumed as in fig. 3. This is a generic, straightforward structure to realize a research reactor. Depending on the safety function, several physical variables should be measured to identify the status of the reactor, success of the safety function. The measured variables may be processed through a series of systems, operator action can be inserted through buttons or panels in systems, the whole information should be monitored in a display panel or computers, and the whole processes must be supported by auxiliary systems such as electric power supply systems, compressed air systems, hydraulic systems, and so forth. The system, structure, components consisting of the reactor will be classified in a different way considering the performance and safety of the reactor. Fig. 3 represents a comprehensive, systematic, prioritized way of understanding the reactor architecture to incorporate the safety function of a reactor.

After identifying the architecture of the reactor, operator action should be verified to be effective. A hierarchy in fig. 4 can be idealized in a systematic way such that the priorities of operator actions is emphasized in order to give an intuitive to the reactor architecture.

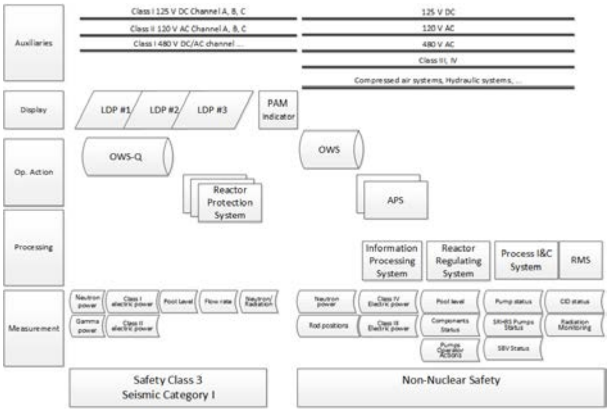

FIG. 3 System architecture related to safety/safety-related functions

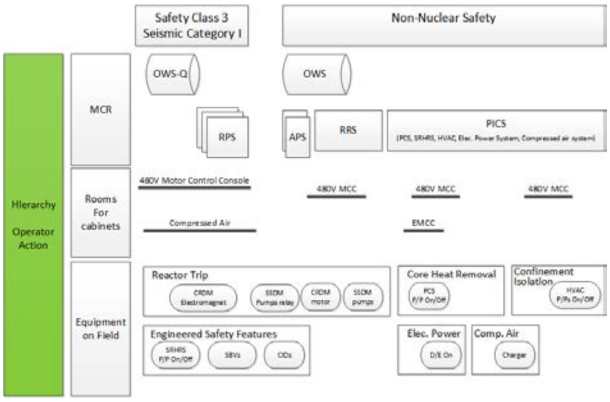

FIG. 4 Hierarchy of operator action related to safety/safety-related functions

Finally the whole system information should be gathered in an easy-following way. A stencil as in fig. 5 is proposed for putting all the design information together in single sheet by reflecting the conceptual architecture and hierarchy. With concept of safety functions, the stencil will be able to give a strong but very easy, straightforward, systematic, comprehensive tool to analyze the architecture of the reactor, to cover the whole SSC information.

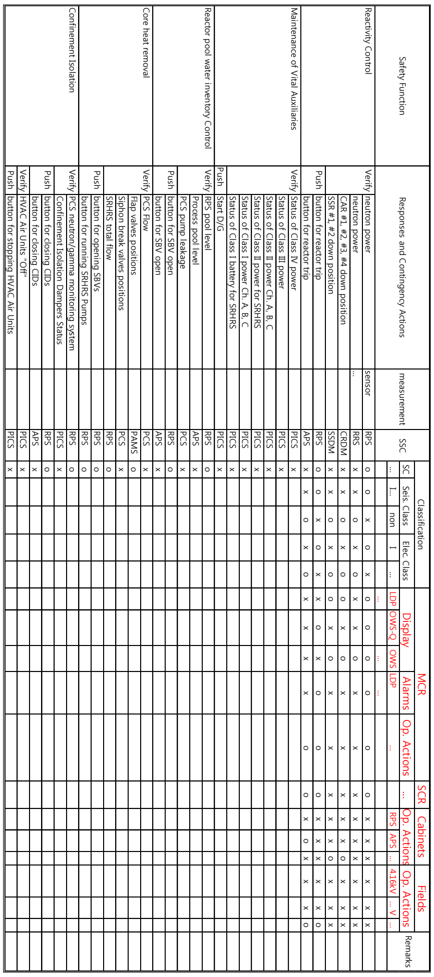

FIG. 5 Stencil to gather information related to safety/safety-related functions

3. Conclusions

For helping to design and develop a set of EOG/EOP, a stencil in a sheet was proposed as an easy and intuitive tool to gather information of a research reactor related to safety/safety-related functions.

Acknowledgement

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST) (NRF-2012M2C1A1026916).

REFERENCES

[1] NUREG-0578, TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations, U.S. NRC, July 1979.
[2] NUREG-0585, TMI-2 Lessons Learned Task Force Final Report.
[3] NUREG-0660, Action Plan Developed as a Result of the TMI-2 Accident.
[4] NUREG-0899, Guidelines for the Preparation of Emergency Operating Procedures, 1982.
[5] Nuclear Safety Act, 2011.

[6] Regulation of NSSC, No. 2, Enforcement Regulation of Nuclear Safety Act, 2011.
[7] Regulation of NSSC, No. 3, Regulation on Technical Criteria for Nuclear Reactor Facilities, 2011.
[8] Notice of NSSC No. 2012-27, Regulation on Technical Specifications of Construction and Operation Capabilities for Nuclear Reactor Facilities, 2012.
[9] Safety Requirements, NS-R-4, Safety of Research Reactors, 2005.
[10] Safety Guide, NS-G-4.4, Operational Limits and Conditions and Operating Procedures for Research Reactors, 2008.
[11] Safety Report Series No. 48, Development and Review of Reactor Specific Emergency Operating Procedures, 2006.1515