Preliminary Conceptual Study for Safety Parameter Display System of PGSFR

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1. Introduction

A PGSFR (prototype Gen-IV sodium-cooled fast reactor) is under development at KAERI.[1] A safety parameter display system (SPDS) should be designed for licensing the PGSFR in order to cope with the TMI action plan requirements. Thus, a preliminary conceptual study for the SPDS of PGSFR including licensing requirements, intrinsic function and critical variables for the SPDS of the PGSFR is studied on this study.

At first, some documents issued by NRC related to install a SPDS include the following: [2,3,4]

- NUREG-0737, Clarification of TMI Action Plan Requirements
- NUREG-0696, Functional Criteria for Emergency Response Facilities
- NUREG-0835, Human Factors Acceptance Criteria for the Safety Parameter Display System, Draft Report for Comment

2. Functions and Requirements of SPDS

The SPDS of the PGSFR should provide a display of critical plant variables to aid the control room personnel during abnormal and emergency conditions in determining the safety status of the plant and in assessing whether abnormal conditions warrant corrective action by operators to avoid a degraded core.[5]

To effectively achieve the function of the SPDS, some requirements should be met as following:

- Concise display: The basis for the requirement for a concise display stems from the lack of centralized display capability in the TMI-2 control room. In the TMI-2 control room, personnel in the control room could not easily overview plant conditions during accidents because the displays were widely spread out. This design did not help the operators make a decision to cope with the accident. Therefore, the SPDS should be easily accessible to gather the plant status at once through a concise display which can show major safety parameters of the plant without any extra burdens of control room personnel.
- Rapid response: Rapid response means that all information displayed on the SPDS should represent current plant status in real time without missing, masked or lost data by the passage of time. For rapid response, the sampling rate and update rate are important to design the appropriate SPDS of the PGSFR. Also, the information should be displayed in a simple, easy-to-understand format in order to be rapidly comprehended by the control room personnel.
- Convenient location and continuous display: The SPDS should be located convenient to the control room operators and display information from which the plant safety status can be readily and reliably assessed by control room personnel to avoid the degraded and damaged core events.[2] In addition, all critical parameters should continuously displayed because the SPDS affords the operator almost immediate access to the most important information about plant safety. The SPDS should be designed for operators not to need to search among various displays or page through irrelevant information to get a current overview of plant safety status or to be aware that plant status was changing.
- Reliability: The availability of the computer used in the SPDS should be equal to or greater than 99 percent. Also, the data used in the SPDS should be validated to represent an accurate and not to generate false alarms. Since the data validity and system reliability have such a great impact on the usability of the SPDS, these must be carefully considered when designing the SPDS of the PGSFR.
- Conditions when the SPDS should be operational: The SPDS should be designed to operate normal, abnormal and emergency conditions i.e. all operation mode above cold shutdown of the PGSFR.

3. Critical Variables of PGSFR

The minimum critical variables and related alarm legs for PGSFR are as following:

- Reactivity control: power range instrumentation, intermediate range instrumentation, source range instrumentation, control rod bottom contacts.
- Reactor core cooling and heat removal from the primary system: primary pool level, hot pool temperature, core exit temperature, cold pool temperature, PDRC (passive decay heat removal system) flow rate, ADRC (active decay heat removal system) flow rate.
- Reactor coolant system integrity: primary pool level, cover gas pressure, safeguard vessel level, cold pool temperature

- Radiation control: radiation of intermediate heat transfer loop, radiation of containment purge
- Containment condition: containment pressure, containment isolation status

Table 1 shows the comparison of critical variables of PWR, BWR and PGSFR and a preliminary hierarchy of the critical variables for the SPDS of the PGSFR is shown in Fig. 1.

4. Conclusions

The preliminary concept for the SPDS of the PGSFR is studied in this study. On the progress of designing the PGSFR, the studied design concept will be refined and implemented through further studies to acquire the approval of safety analysis report of the PGSFR.

REFERENCES

[1] Y.I. Kim et al, Development of Basic Key Technologies for Gen IV SFR, KAERI/rr-3463/2011, 2012.
[2] NUREG-0737, Clarification of TMI Action Plan Requirements, 1980.
[3] NUREG-0696, Functional Criteria for Emergency Response Facilities, 1981.
[4] NUREG-0835, Human Factors Acceptance Criteria for the Safety Parameter Display System, Draft Report for Comment, 1981.
[5] NUREG-1342, A Status Report Regarding Industry Implementation of Safety Parameter Display Systems, 1989.

Table I: Critical variables of PWR, BWR and SFR

Safety function	Representative Critical Parameters for SPDS	
Reactivity Control	PWR	Power range instrumentation Intermediate range instrumentation Source range instrumentation
	BWR	Average power range monitor Source range monitor
	SFR	Power range instrumentation Intermediate range instrumentation Source range instrumentation Control rod bottom contacts
Reactor core cooling and heat removal	PWR	RCS level Subcooling margin Hot leg temperature Cold leg temperature Core exit temperature S/G pressure Residual heat removal flow
	BWR	Reactor pressure vessel water level Drywell temperature
	SFR	primary pool level hot pool temperature cold pool temperature PDRC (passive decay heat removal system) flow rate ADRC (active decay heat removal system) flow rate
Reactor Coolant	PWR	RCS pressure Cold leg temperature
system Integrity		Containment sump level SG/ pressure S/G level S/G blowdown radiation
	BWR	Reactor pressure vessel pressure
	SFR	primary pool level cover gas pressure safeguard vessel level cold pool temperature
Containment Isolation	PWR	containment pressure containment isolation status
	BWR	Drywell pressure Drywell temperature Suppression pool temperature Suppression pool level containment isolation status Drywell hydrogen concentration Drywell Oxygen concentration
	SFR	containment pressure containment isolation status

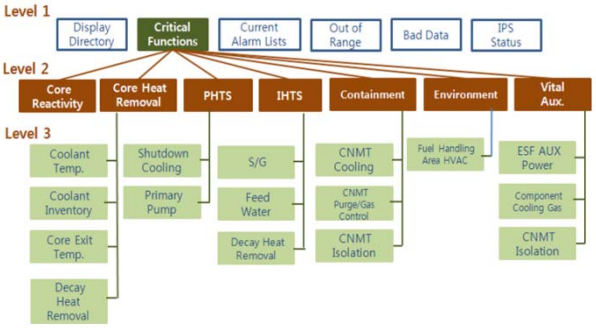

Fig. 1. Preliminary hierarchy of critical variables for SPDS of PGSFR