A Study of Time Response for Safety-Related Operator Actions in Non-LOCA Safety Analysis

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1. Introduction

The classification of initiating events for safety analysis report (SAR) chapter 15 is categorized into moderate frequency events (MF), infrequent events (IF), and limiting faults (LF) depending on the frequency of its occurrence. For the non-LOCA safety analysis with the purpose to get construction or operation license, however, it is assumed that the operator response action to mitigate the events starts at 30 minutes after the initiation of the transient regardless of the event categorization. Such an assumption of corresponding operator response time may have over conservatism with the MF and IF events and results in a decrease in the safety margin compared to its acceptance criteria. In this paper, the plant conditions (PC) are categorized with the definitions in SAR 15 and ANS 51.1. Then, the consequence of response for safety-related operator action time is determined based on the PC in ANSI 58.8. The operator response time for safety analysis regarding PC are reviewed and suggested.

2. Analysis Methods

2.1 Classifying the Plant Conditions of the Event

The concept of PC is developed that includes individual process conditions, combinations of process conditions, and the combinations of process conditions and external hazards that could result in simultaneous effects on plant equipment. However, the probability of occurrence is the unifying basis for the categorization of PC. The best-estimate frequency of occurrence of an event shall be determined and the appropriate PC is assigned as shown in Table Ⅰ [1].

Table Ⅰ: Categorization of Plant Conditions

Plant Condition		Best Estimate Frequency of Occurrence (F) per Reactor Year
PC-1	Normal	Normal Operations
PC-2	Moderate Frequent Incidents	$F \geq 10^{-1}$
PC-3	Infrequent Incidents	$10^{-1} > F \geq 10^{-2}$
PC-4	Limiting Faults	$10^{-2} > F \geq 10^{-6}$

2.2 Time Response of Operator Action for the Events

Based on each PC in previous subsection, the response time embodied in ANS 58.8 criteria is used in the analysis to cope with the transients in pressurized water reactor (PWR) and is based on empirical simulator measurements under sponsorship of the EPRI and by Westinghouse Electric Corporation in 1984.

The symptom-based operating procedures and guidelines provide a structure for crew diagnoses and actions during transient scenarios. The operator response structures are proposed in Fig. 1 for the purpose of breaking down the sequence of events in terms of various time intervals. The time points and intervals involved in an event analysis are as follows; [2]

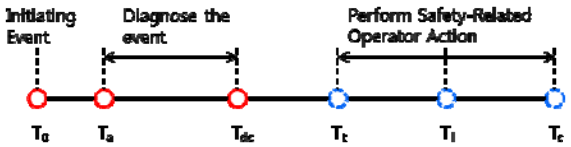

Fig. 1 Definition of Time Points and Intervals

T_0 = Initiating event/disturbances
T_a = Event alarm
T_{dc} = End of event diagnose
T_t = Step in procedure to trigger operator first significant response
T_i = Initiate first significant response/action
T_c = Complete response/action

The time between T_{dc} - T_a represents the time required to diagnose the event and is the interval of the event alarm and the operator decision to take an event-specific part of procedures. The time between T_c - T_t stands for the operator from triggering the first step into the safety-related action to completing end of the relevant action.

According to the ANSI 58.8, Table Ⅱ shows the operator response times for the occurrence of transient of MF, IF and LF. The results in Table Ⅱ represent the data from various scenarios for a given plant conditions and are aggregated in the 95% probability level estimates on operator responses. Also, the data are for

Table Ⅱ: The Time Intervals for Each PC

Plant Condition		Diagnose (minutes)	Operator Action to be taken* (minutes)
PC-2	Moderate Frequent Incidents	5	1 + n
PC-3	Infrequent Incidents	10	3 + n
PC-4	Limiting Faults	20	5 + n

* n signifies the number of discrete manipulations to complete a specific, single operator action

the various PWR plants pooled together for similar tasks.

2.3 The Example of Determining Operator Time Response

The NRC accepts application of ANSI 58.8 to determine the time response of operator action for the transient based on NUREG/CR-5973 [3]. According to ANSI 58.8, the total safety-related operator response time depends on the number of action needed to deal with the corresponding transients in MF, IF and LF. However, it is assumed here that the single action is required to terminate the transients.

The letdown line break (LDLB) event is chosen as an example for the application of ANSI 58.8 because the difference in categorization is found in the same type of reactor and consequent time at which operator action begins.

The LDLB event is classified with MF in SAR chapter 15 for KSNPs. Currently it is assumed that the operator takes action to terminate the event after 30 minutes into the transient. On the other hand, CE System 80 plant, the reference plant of KSNPs, defines LDLB event as an IF and NRC permits credit of operator action after 10 minutes from the start to terminate the event.

If the LDLB event is classified in MF or IF, it will be mitigated by the operator action soon after minimum 7 minutes and 14 minutes from the start of the transient, respectively.

Table Ⅲ: Classification and Operator Response Time of LDLB Event

	Classification of Event	Operator Action
CE System 80, Reference Plant of KSNPs	IF (PC-3)	10 minutes
YGN 3,4	MF (PC-2)	30 minutes
UCN 3,4	MF (PC-2)	30 minutes
SKN 1,2	MF (PC-2)	30 minutes

The summary of classification and the corresponding operator response times of LDLB event are shown in Table Ⅲ.

3. Results and Discussion

From the example above, it is found that various classification with the same transient and corresponding operator response time may defined according to the level of conservative assumptions. However, it is concerned that 30 minutes of operator response time includes too much conservatism and results in severe consequences than using the time standard represented in ANSI 58.8.

It is shown that the application of ANSI 58.8 provides reasonable reduction in the operator response time and relevant consequences which could provide additional margins in safety analysis to comply with the acceptance criteria.

However, even if it is proven that the empirical history of operator response times are shorter compared to the recommended in ANSI 58.8, the verifying process is required whether applying ANSI 58.8 to the operating KSNPs is appropriate. In addition, the clarification of operator action steps is needed in alarm response procedure while mitigating the transient to reduce operator response time, determine operator response time, when the relevant alarms are on.

4. Conclusions

The time response for safety-related operator action is reviewed herein based on ANSI 58.8.

From the results, it is reasonable to assume that operator action could start at minimum 7 minutes, 14 minutes and 26 minutes from the initiation of MF, IF and LF events, respectively, if a single operator action is assumed.

The clarifying alarm response procedure would be required for the guideline to reduce the operator response time when the alarms indicate the occurrence of the transient.

REFERENCES

[1] American National Standard Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants, ANSI/ANS 51.1, 1983

[2] American Nuclear Society Time Response Design Criteria for Safety-Related Operator Actions, ANSI/ANS 58.8, 1994

[3] J. R, Nickolaus, K.L. Bohlander, Codes and Standards and Other Guidance Cited in Regulatory Documents, NUREG/CR-5973, 1996