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Result of Methodology Application for ISLOCA Frequency Reduction

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1. Introduction

The frequency of Interfacing System Loss of Coolant Accident (ISLOCA) was not significant since the frequency was low enough and not recognized as important initial event. However, reducing the ISLOCA frequency began to be recognized as a very important initial event with Nuclear Safety Law after the Fukushima nuclear accident in June 2011.

In order to reduce the frequency of ISLOCA, the design change of nuclear plant was attempted, including the installation of the relief valve, but the plan fell through due to management problems and plant conditions. Therefore, it is necessary to reduce the frequency of ISLOCA by applying the new analysis methodologies.

The purpose of this paper is to reduce the ISLOCA frequency by applying analysis methodologies such as NUREG/CR-5102, the newest data application and NRC DC Screening criteria. And ultimately, the above methodologies could be applied to the AMP PSA model to meet the safety goal.

2. Analysis Methodologies for ISLOCA Frequency

2.1 NUREG/CR-5102 methodology

The ISLOCA frequency according to NUREG/CR-5102 is to calculate the D (diameter)/t (thickness) of the target pipe designed with low-pressure and apply the corresponding pipe rupture probability value to the ISLOCA frequency. This is a methodology that can significantly reduce the ISLOCA frequency by applying rupture probability value instead of the conservatively applied rupture probability value "1" before.

2.2 Application of NRC DC Screening Criteria

Applying the NRC DC ISLOCA screening criteria instead of the existing ISLOCA screening criteria NUREG/CR-5102, NUREG/CR-5745 has Differences like Table 2.1 below. Especially, criteria 1 and 3 are different each other. The reason why application of the NRC DC screening criteria is necessary is that there are different target lines for ISLOCA in spite of same kind reactor. Therefore, making the target lines same for ISLOCA is necessary for PSA analysis consistency.

2.3 Application of NUREG/CR-6928 (2015) data

The newest data is from NUREG/CR-6928 (2015) instead of NUREG/CR-6928 (2007). The applied data is valve operated with motor (MOV) and failure mode is Internal Rupture (ILL).

Table 2.1 Differences between NUREG/CR-5102, NUREG/CR-5745 and NRC DC

Screening Criteria	NUREG/CR-5102 NUREG/CR-5745	NRC DC
Criteria 1	*The line does not connect to the RCS*	*The line does not connect directly to the RCS*
Criteria 2	*The line has a diameter ≤ ⅜"*	*The line has a diameter ≤ ⅜"*
Criteria 3	*Design pressure of the path is larger than RCS pressure*	*The path could not be overpressurized by RCS pressure*
Criteria 4	*Systems whose low-pressure portions are isolated from RCS pressure by four or more normally closed valves or periodically leak-tested check valves in series are eliminated from further consideration.*	*Systems whose low-pressure portions are isolated from RCS pressure by four or more normally closed valves or periodically leak-tested check valves in series are eliminated from further consideration.*

3. Application

Considering the pipe rupture probability designed with low-pressure is too positive since valves installed behind of target pipe should be survived with high-pressure. Therefore, Thermal Hydraulic (TH) analysis is necessary and that will be performed in detail analysis later. Thus, application of both NRC DC screening criteria and newest data will be below only.

3.1 NRC DC Screening Criteria

Reference plant has been applied with NRC DC screening criteria like above table 2.1. Table 3.1 shows that shutdown cooling line is remained only as analysis target. This is because the CCW supply and return line is a pipe not directly connected to the RCS (according to criteria 1), and the CVCS Letdown Line is not overpressure by RCS pressure leakage (according to criteria 3). The NRC DC screening criteria could be applied to operating and construction reactor as well since consistency is necessary for all PSA model which are operating and construction reactor.

3.2 NUREG/CR-6928 (2015) data

Data difference between NUREG/CR-6928 (2015) and NUREG/CR-6928 (2007) is showed in Table 3.2. Decrement is -55% compared with previous data.

Table 3.1 Analysis target by NRC DC screening criteria

Screening Criteria	NUREG/CR-5102 NUREG/CR-5745	NRC DC
Analysis Target Lines	*Shutdown Cooling Line*	*Shutdown Cooling Line*
	CVCS Letdown Line	
	CCW Supply and Return Line to RCP High Pressure Cooler	

Table 3.2 Decrease Proportion of the Newest Data Application

	NUREG/CR-6928 (2007)	***NUREG/CR-6928 (2015)***
Failure Mode	*MOV-ILL(Internal Rupture)*	
Reduction Effect (%)	*-55(%)*	

4. Result

4.1 Applying NRC DC Screening Criteria and the NUREG/CR-6928(2015) Data

As a result of applying NRC DC's screening criteria, the ISLOCA analysis target is only shutdown cooling line. Further, the latest data from NUREG/CR-6928 (2015) is applied to MOV internal rupture and frequency is calculated like below. Calculation result is shown in Table 4.1.

ISLOCA Frequency of Shutdown Cooling Line
= {(MOV1 internal rupture)×(MOV2 internal rupture) + Var(internal rupture)}× Number of lines
= {MOV1 internal rupture rate/hr × MOV2 internal rupture rate/hr + Var (internal rupture)/hr²}×T1×T2×2
※ Var (internal rupture)= α / β^2

Table 4.1 Reduction Effect of CDF by Screening Criteria and the Newest Data

Analysis Target Line	Reduction Effect of CDF (%)
Shutdown Cooling Line	***-79.4(%)***

5. Conclusion

The ISLOCA frequency according to rupture probability of pipe designed with low-pressure, it is necessary to assume that integrity of valve at the rear of the target pipe could be maintained when exposed to high pressure. However, this is too optimistic, that is why it is difficult to apply.

However, application of NRC DC screening criteria is necessary since target lines for ISLOCA are different in spite of same kind reactors. Therefore, making the target line same in same kind reactor should be performed for PSA model consistency. Also, applying the newest data which is NUREG/CR-6928 (2015) should be carried out for PSA model revision.

REFERENCES

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