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Introduction of developing a list of MSO generic scenarios for PHWR

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1. Introduction

According to NEI 00-01, it provides a methodology for addressing Multiple Spurious Operation(MSO) in Post-fire safe shutdown analysis of Pressurized Water Reactor(PWR) and Boiling Water Reactor(BWR). MSO scenarios should contain scenarios threatening Post-fire safe shutdown function by MSO of Safe Shutdown Equipments(SSEs) as well as Non-SSEs.

The list of MSO generic scenarios(NEI 00-01, Appendix G) was developed by industrial survey. Although not all scenarios of the list of MSO generic scenarios(NEI 00-01, Appendix G) are considered applicable to every reactor type, this list provides an input about MSO identification and treatment process. If NEI 00-01 is applied to other reactor type, analyst should review applicability of the list of generic scenarios(NEI 00-01, Appendix G) and consider potential MSO scenarios undescribed in the list of MSO generic scenarios(NEI 00-01, Appendix G). Table I is scope of industrial survey.

Especially, in PHWR case, there is no list of MSO generic scenarios in Canada or internationally. There are substantial physical variations between NPPs. So some generic scenarios(NEI 00-01, Appendix G) would need validation. Nevertheless, industrial stakeholder have not did any MSO work until now.

In this paper, results of first stage research that develop the list of MSO generic scenarios for pressurized heavy water reactor(PHWR) is introduced.

2. Necessity of generic MSO scenario for PHWR

In PHWR case, reactor design, structure of heat sink, system configuration, operation mode and procedure are different from PWR and BWR. Thus, specific review of the list of MSO generic scenarios(NEI 00-01, Appendix G) is required such as how it applies to PHWR.

The list of MSO generic scenarios(NEI 00-01, Appendix G) is classified as specific function as follows : RCS inventory control/RCS integrity, decay heat removal, RCS pressure control, reactivity control, support functions and other scenario. It is not different with required function classification of post-fire safe shutdown analysis that has being analyzed so far. also, It is not significantly different with PHWR. But specific details of an accident leading to each scenario is far different.

For example, analysis object of scenario related inventory control can be selected chemical and volume control system in PWR, pressure & inventory control system and D_2O purification system in PHWR. There are difference of operation condition and system design & structure. In special case, it might require success criteria by thermal hydraulic analysis.

Table I: Scope of industrial survey(NEI 00-01).

Reactor type		Characteristics	Related NPP
Boiling water reactor (BWR)		Mark I	Browns Ferry
		Mark II	Columbia
		Mark III	Perry
		PREMOD	Pathfinder
Pressurized water reactor (PWR)	Bobcook & wilcox	Two once through SGs	Arkansas unit 1
	Combustion Engineering	Two SGs, Four RCPs	Arkansas unit 2
	Westinghouse	2-Loops	Ginna
		3-Loops	Surry
		4-Loops	Callaway

3. Establishment of criteria for review

In this research, criteria for review of applicability of the list of MSO generic scenario(NEI 00-01, Appendix G) in PHWR is established. Criteria is as the following.

3.1 Applicable scenario

A scenario that was evaluated as any generic scenarios(NEI 00-01, Appendix G) can be applied, for example, systems and equipments of scenario are same as PHWR's one or simply systems and equipments name of scenario are not same as PHWR's one, is defined 'Available'. Example of applicable scenario is illustrated in the following table.

Table II: Example of the generic scenario #4

Generic list (NEI 00-01)	PHWR Applicability
Loss of all seal cooling to any RCP(s). See scenario 1&2	Loss of all seal cooling to any HTS pump(s). See scenario 1&2
AND	AND
Fire prevents tripping, or spuriously starts, RCP(s)	Fire prevents tripping, or spuriously starts, HTS pump(s).

3.2 Scenario required modification

A scenario that is evaluated as any generic scenarios(NEI 00-01, Appendix G) which can be applied after details of the scenario is modified, for example, although systems and equipments of the scenario are not same as PHWR's one, accident consequence caused by MSO impact to any systems and equipments in PHWR, is same as the scenario and detail of an accident is similar to the scenario, is defined 'not available' and should be modified. Example of the scenario required modification is illustrated in the following table.

Table III: Example of the generic scenario #21

Generic list (NEI 00-01)	PHWR Applicability
Spurious starting of additional high head charging pump(s).	Not available
AND	-
Spurious opening of additional RCS makeup flow paths.	Spurious opening of P&IC system feed line level control valve(s)

3.3 Scenario required reestablishment

A scenario that was evaluated as any generic scenarios(NEI 00-01, Appendix G) which can be applied after the scenario is reestablished, for example, although systems and equipments of the scenario are not same as PHWR's one, accident consequence caused by MSO impact to any systems and equipments in PHWR is same as the scenario and details of an accident is not similar to the scenario, is defined 'Not available' and should be reestablished. Example of scenario required reestablishment is illustrated in the following table.

Table IV: Example of the generic scenario #1

Generic list (NEI 00-01)	PHWR Applicability
Spurious isolation of seal injection header flow	Not available
AND	
Spurious isolation of CCW flow to thermal barrier heat exchanger.	
Not available	Spurious isolation of seal injection return line flow
	OR
	Spurious isolation of RCW flow to heat exchanger of heat transfer system
	OR
	Spurious isolation of RCW flow to heat exchanger of D2O purification system

3.4 Unapplicable scenario

A scenario that was evaluated as any generic scenarios(NEI 00-01, Appendix G) can't be applied, for example, there is no occurrence of the scenario because of plant specific difference or even if scenario occur, no effect to post-fire safe shutdown function, is defined 'Unavailable scenario'.

In a case of scenario #5(RCP seal No. 2 failure), it is unavailable scenario. Because there is no equipment that lead to increase RCP seal leakage in PHWR.

4. Conclusions

According to the review results, specific review of the list of MSO generic scenarios(NEI 00-01, Appendix G) is required such as how it applies to PHWR. And criteria was established for review of availability of the list of generic scenarios(NEI 00-01, Appendix G). However there are still many tasks such as potential scenario review, risk model review and expert panel review.

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