

AN ANALYSIS OF RISK REDUCTION METHODS FOR INTERFACING SYSTEM LOCAs AT PWRs*

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Interfacing system loss-of-coolant accidents (ISLs) refers to events where the integrity of the Reactor Coolant System (RCS) pressure boundary is breached through failure of isolation valves which separate a support system of lower design pressure. The overpressurization of the support system will affect its availability and may further affect the availability of various safety systems required to mitigate the accident. In addition, it may result in a scenario where primary coolant is directly discharged into the outside environment bypassing the containment.

The Reactor Safety Study (WASH-1400) predicted that ISL events were significant contributors to risk even though they were calculated to be relatively low frequency events. However, there are substantial uncertainties involved in determining the probability and consequences of the ISL sequences. For example, the assumed valve failure modes, common cause contributions and the location of the break/leak are all uncertain and can significantly influence the predicted risk from ISL events.

The present study was performed to investigate the vulnerability of pressurized water reactor designs to ISLs and identify any improvements that could significantly reduce the frequency of these events.

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The operators of commercial nuclear power plants are, in most cases, required to perform periodic tests on the pressure isolation devices that separate the RCS from interfacing safety systems. Three different PWR designs were analyzed in detail and the core damage frequency (CDF) resulting from ISLs was calculated based on plant specific test and maintenance practices.

Periodic testing requirements are not uniformly applied across the PWR population, i.e., older plants are not required to test the structural and leak-tight integrity of the isolation components. Based on these differences, two separate groups of actions were considered to determine effective methods of reducing the risks due to ISLs. First, for plants with no present requirement for any leak testing, the effect of leak testing as a basic requirement was analyzed with respect to test frequency and placement of testing. In the other group, corrective actions such as additional leak testing, continuous leak monitoring, improved operator training and refueling water storage tank (RWST) makeup procedural changes were examined for their potential to enhance the effectiveness of an already instituted test program.

In order to judge the effectiveness of any corrective action the additional costs incurred due to its application were also considered.

In order to provide a range of alternatives within the study, four models including three actual plants were investigated. All of the three reference plants perform some level of leak testing for their pressure isolation valves. The fourth plant model, representing a specific base case was also studied to focus on the cost-benefit consideration of the effects of placing leak testing requirements on plants that do not currently perform these tests.

The generic base case was developed by selecting and modifying one of the specific plant models to remove the credit given for the current leak testing provisions. For the generic model, three cases were evaluated, the first was to perform leak testing every nine months and the second was every refueling period (~18 months). Both of these cases included the requirement to perform the leak testing in the critical path (extending the length of the outage). A third case was also analyzed where leak testing would be performed in each refueling outage, but not in the critical path, greatly increasing the effectiveness from cost considerations.

The results, listed in Table 1, indicate that the leak testing programs are capable of reducing the CDF due to ISLs by two orders of magnitude depending on the specific test arrangements. It is important to note that the difference between the 18 months (Case C) and the nine months critical path testing (Case B) is only about a factor of ~4 suggesting that a program with 18 months test frequency may be almost as effective in reducing the CDF as a program with more frequent tests. In addition, substantial cost savings may be achieved by performing the leak test during descent from power without significantly increasing the risk of an ISL event (only a factor of ~2 difference between Case C and D).

Table 1 also lists the results of a plant specific analysis for the second group of corrective actions, which may increase the effectiveness of an already established testing program. Corrective actions such as increased frequency of valve leak testing and application of continuous leak monitoring devices are capable of reducing the CDF due to ISLs by a factor of ~2-5 depending on plant-specific arrangements. These reductions are rendered largely

ineffective when the corresponding cost considerations are also included in the analysis. The corrective actions involving improved training and RWST procedural changes are ineffective, primarily because the dominant sequences for ISLs represent unisolable large pipe breaks preventing effective operator interventions.

In summary, the present analysis suggests that the most cost-effective method to reduce the risk due to ISLs is, as a minimum, to perform leak testing of the pressure isolation valves at each refueling and after specific valve maintenance. The tests may be performed during descent from power without significantly increasing the risk of an ISL event.

Table 1
Reduction in CDF - Generic Model

Corrective Actions					
Cases (CDF)	Group 1			Group 2	
	CDF Reduc- tion Factor (Relative to Case A)	Benefit/Cost Ratio*		Cases	Reduction Factor (Rel- ative to Pre- sent Practice)
		Nonsub- merged Release	Sub- merged Release		
A-Base Case w/o Leak Test (3.26-04)	----	---	---	1-Leak Test After Each Cold Shut- down	-1-6
B-Leak Test Every Nine Months/ Critical Path (8.42-07)	-400	1.7	1.0	2-Continuous Leak Monitoring	-1-2
C-Leak Test Every 18 Months/ Critical Path (3.28-06)	-100	3.3	1.9	3-Improved Operator Training	-1
D-Leak Test Every 18 Months/Not in Critical Path (6.11-06)	-55	78.2	46.0	4-RWST Makeup Procedure	-1-2

*In order to bound the benefit calculation, two sets of source terms were used. One source term representing a reduction factor associated with a submerged release and the other representing a nonsubmerged release.

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