Questions on WOG LBLOCA Redefinition Program

Feasibility of LBLOCA Redefinition

Whether or not the NRC decides to focus exclusively on large break loss-of-coolant accident (LBLOCA) redefinition depends on the feasibility of this approach. Clearly the owner's groups believe this approach is feasible (i.e., doable, practical, cost-beneficial, etc.). The following questions indicate some of the current NRC concerns regarding the feasibility of this approach.

1. The staff has examined the proposal presented by the Westinghouse Owners Group (WOG) to redefine the size of pipe break to be considered when evaluating the LBLOCA scenario for ECCS requirement and/or containment and EQ requirements. The staff understands that a probabilistic fracture mechanics (PFM) approach is being pursued by the WOG as a method to demonstrate the likelihood of double-ended guillotine pipe breaks or partial pipe breaks up to a specified size. Please explain how (e.g., computer codes or models used, inputs, assumptions) the WOG PFM approach addresses each of the following issues (note, additional issues may come up as the staff gains a more detailed understanding of the WOG PFM approach). For any of the issues below which are not addressed by your PFM approach, please provide justification as to why your approach is adequate for redefining the LBLOCA size.
   a. The potential for and significance of primary water stress corrosion cracking in the piping systems being analyzed
   b. The potential for and significance of cracking due to mechanical fatigue in the piping systems being analyzed
   c. The potential for and significance of cracking due to thermal fatigue in the piping systems being analyzed
   d. The potential for and significance of non-planar flaws (e.g., wall thinning in ferritic piping) in the piping systems being analyzed
   e. As-built weld geometries and the history of fabrication problems (e.g., repair welds, fit-up problems, etc.) and techniques utilized by each architect engineer (AE) firm/vendor
   f. The definition of an initial flaw distribution considering pre-service and in-service inspection programs
   g. The determination of piping system material properties, included aging effects on stainless steel pipe welds and cast stainless steel components

   This list is not intended to be exhaustive, however, the aforementioned items must be considered for each line, AE firm, vendor, reactor design, etc., which is to be covered under the proposed LBLOCA redefinition.

2. The objective of the current leak-before-break (LBB) approach being used to exclude the dynamic effects of LOCAs is to demonstrate that the detection of a through-wall crack and the subsequent mitigation is assured long before the cracks can become unstable under all possible design basis loads (including seismic loads) and grow to large break areas. To account for a number of uncertainties, the detectable crack size in a LBB analysis is to be set to ten times the crack size required to provided the leakage that can be measured by the leak detection systems at a plant.

   Based on Figure 2-3 of WCAP-14572, Revision 1, Supplement 1, a sampled crack growth calculation is stopped when (1) the pipe fails (ruptures), (2) a disabling leak rate is

achieved, or (3) a detectable leak rate is achieved. It appears that the time between when a detectable leak rate is achieved and the time the crack becomes unstable under all loads (i.e., the time available to take action to mitigate the leak) is not modeled. Is this a correct understanding? Can the Westinghouse PMF code be used to determine the probability distribution for the time between when the crack would be detected by leak detection systems (incorporating the factor of 10 required to account for uncertainty) and the time when the crack becomes unstable (accounting for all possible design basis loads including SSE loads) and grows to a disabling leak rate or rupture? If such information is available for the analyses presented at the last public meeting, please provide a discussion of this information. Please discuss the sensitivity of the predicted growth time probability distributions to the detectable leak rate.

3. Information in WCAP-14572, Revision 1, Supplement 1 implies that in-service inspection (ISI) information is used to set up a PMF calculation. Specifically, the crack inspection interval and accuracy appear to be input parameters. Are there other ISI related input parameters, and if so, please identify them? Please describe the sensitivity of predicted disabling leak frequencies to inputs regarding ISI frequency, accuracy, and other identified parameters. Please identify and describe any changes in ISI frequency, accuracy, or other requirements required to support the conclusions of the fracture mechanics analyses being used to redefine the LBLOCA size.

4. In order to assess the potential benefit which could result from redefining the limiting size of the LBLOCA event, please describe the potential benefits that would be achieved (specifically what aspects of what regulations would be modified) if the double-ended guillotine break (DEGB) of the main coolant loop were reduced to each of the following:
   a. A break size equivalent to the DEGB of a 14-inch diameter auxiliary line
   b. A break size equivalent to the DEGB of a 12-inch diameter auxiliary line
   c. A break size equivalent to the DEGB of a 10-inch diameter auxiliary line
   d. A break size equivalent to the DEGB of a 8-inch diameter auxiliary line
   e. A break size equivalent to the DEGB of a 6-inch diameter auxiliary line

Implementation Guidance

5. At the 16Nov00 meeting, industry representatives mentioned that various types of plant-specific analyses may be called for as part of the industry implementation methodology for LBLOCA redefinition. Please provide a list of, and briefly discuss, the types of plant-specific analyses envisioned. Indicate, in particular, those analyses that industry believes will require NRC review and approval.

Containment, Equipment Qualification (EQ), and Other Special Treatment

6. The NRC is considering options to assure that LBLOCA redefinition would not result in risk-significant deterioration of containment performance. These options include:
   a. Requiring that the containment design pressure not be decreased and that containment ultimate capacity and fission product removal capability not be compromised as a result of LBLOCA redefinition
   b. Requiring licensees who opt for LBLOCA redefinition to demonstrate the capability of their containments (and containment ESFs) to withstand a specified severe accident for 24 hours

c. Requiring a demonstration (most likely plant-specific) that the impact of LBLOCA redefinition on large release frequencies would be small compared to the Option 3 Framework guidelines

Do the owner's groups have comments or preferences regarding these options? What are the bases for the preferences?

7. What excess burden do the owner's groups perceive are associated with LBLOCA requirements for (a) containment and (b) equipment qualification? Please provide specific examples of relief that could be obtained by LBLOCA redefinition. Identification of the regulations and implementing documents associated with each example is requested.

8. Would LBLOCA redefinition significantly impact current EQ envelopes? If so, how would the risk-significance of changing EQ envelopes be assessed?

9. How would LBLOCA redefinition impact other special treatment requirements?

<u>Need for Alternative DBAs for ECCS and/or EQ</u>

10. In addition to addressing the potential for pipe ruptures, if the limiting LBLOCA is to be reduced from the DEGB of the main coolant loop, other potential breaches of the primary system must also be evaluated. This includes, *but is not limited to*, the following:
    a. The potential for SG manway cover failure
    b. The potential for valve bonnet/body failure
    c. The potential for pump casing failure
    d. The potential for a draindown event during refueling
    e. The potential for indirect breach of the primary system (e.g., load drop accident during shutdown)

    Do the owner's groups have feedback on the list of potential LOCA initiating events provided by NRC at the last public meeting (attached here as Table 1)? Specifically, what is the position of the owner's groups on the need for alternative DBAs for ECCS or EQ as part of LBLOCA redefinition. The potential concerns should also be considered for each AE firm, vendor, reactor design, etc., which is to be covered under the proposed rule change.

Based on the above questions, it would probably be beneficial to have available at the January 11, 2000, public working meeting individuals knowledgeable in the following areas:

- Fracture mechanics
- WOG PFM approach
- In-service inspection
- Licensing
- Containment
- Equipment qualification
- Thermal-hydraulics
- Level-1 and Level-2 risk analysis

Table 1
Potential Causes and Frequencies of Loss of Primary Coolant

Source of Loss of Coolant	Frequency Estimates	References	Comments
Reactor Vessel			
Vessel rupture	3E-7/yr	WASH-1400	
CRDH housing failure	-		No frequency estimate available. Too small for LBLOCA.
Head closure seal leakage rupture	9E-5/yr 9E-7/yr	EGG-SSRE-9639 WSRC-TR-93-262	Reflects flange/gasket failure estimates. A rupture could be a LBLOCA.
Failure of instrumentation penetrations	-		No frequency estimate available. Too small for LBLOCA.
Inadvertently-open head vent valve	9E-4/yr	NUREG/CR-4550	Frequency of spuriously-open MOV, two valves may have to open. Too small for LBLOCA.
Pressurizer			
Shell leakage rupture	9E-5/yr 9E-7/yr	EGG-SSRE-9639	Reflects data recommended for a pressurized tank. Estimated based on 12 leakage events (1 in the PCS) and 2 rupture events (0 in PCS). A rupture could be a LBLOCA.
Surge line rupture	-		Assumed included in other PCS piping failure frequency.
Pressurizer spray line rupture	-		Assumed included in other PCS piping failure frequency.
Inadvertently-open PORV	1E-3/yr	NUREG/CR-5750	Too small for LBLOCA.
Stuck-open safety valves 1 SORV (BWR) 1 SORV (PWR) 2 or more SORVs	 5E-3/yr 4.6E-2/yr 3.2E-4/yr	NUREG/CR-5750	Three SORVs would be a LBLOCA.
Failure of instrumentation penetrations	-		No frequency estimate available. Too small for LBLOCA.

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Potential Causes and Frequencies of Loss of Primary Coolant

Source of Loss of Coolant	Frequency Estimates	References	Comments
Steam Generator			
Single tube rupture Multiple tube ruptures	7E-3/yr -	NUREG/CR-5750	Based on 3 reported events. Multiple SGTRs would result in a LBLOCA. No frequency estimate identified.
Shell leakage rupture	9E-5/yr 9E-7/yr	EGG-SSRE-9639	Reflects estimates for heat exchangers. Estimates based on 2 leakage events and 0 rupture events in non-PCS HTXs. A rupture could be a LBLOCA.
Manway failure	-		No frequency estimate available.
Failure of instrumentation penetrations	-		No frequency estimate available. Too small for LBLOCA.
Reactor Coolant Loops			
Pump casing leakage rupture	3E-4/yr 3E-6/yr	EGG-SSRE-9639	Based on 50 reported incidences of external leakage (4 in PCS) and 2 rupture events (0 in PCS). A rupture could be a LBLOCA.
RCS pump seal failure	2.5E-3/yr	NUREG/CR-5750	Too small for LBLOCA.
Valve body leakage rupture	9E-5/yr 9E-7/yr	EGG-SSRE-9639	Estimated based on 170 incidences of reported leakage (29 in PCS) and 7 rupture events (none in the PCS). A rupture could be a LBLOCA.
Large pipe rupture BWR PWR	 2E-5/yr 4E-6/yr	NUREG/CR-5750	Frequencies are for BWR pipe sizes >5 inches in diameter and PWR pipe sizes >6 inches in diameter.
Accumulator leakage rupture	9E-5/yr 9E-7/yr	EGG-SSRE-9639	Reflects data recommended for a pressurized tank. Estimated based on 12 leakage events (1 in the PCS) and 2 rupture events (0 in PCS). Valve failures would also have to occur to result in loss of primary coolant.
Failure of instrumentation penetrations	-		No frequency estimate available. Too small for LBLOCA.

Table 1
Potential Causes and Frequencies of Loss of Primary Coolant

Source of Loss of Coolant	Frequency Estimates	References	Comments
Interfacing System LOCAs			
BWRs	9.6E-4/yr	NUREG/CR-5750	This is the mean CDF of the distribution of IPE point estimates. Not all ISLOCAs may be LBLOCAs.
PWRs	5.1E-5/yr	NUREG/CR-5750	This is the mean CDF of the distribution of IPE point estimates. Not all ISLOCAs may be LBLOCAs.
Low Power/Shutdown Events			
Draindown events	6.1E-2/yr	NUREG/CR-5593	Frequency is for a BWR. The frequency does not include the fraction of time the plant is shutdown.
Inadvertent overpressurization (makeup greater than letdown or spurious ECCS actuation)	1.6E-3/yr 1.4E-2/yr	NUREG/CR-5593	Frequency is for a BWR. Applicable for cold shutdown only. The frequency does not include the fraction of time the plant is in cold shutdown.
ISLOCA (RHR)	1.6E-2/yr	NUREG/CR-5593	Frequency is for a BWR. The frequency does not include the fraction of time the plant is shutdown.