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Early Containment Failure Considerations for Brunswick

1. Early containment failure by liner melt-through can be dismissed at Brunswick because of its unique design (full concrete containment that backups up the steel liner). This is consistent with the IPE and IPE SER.

2. Because of the above, the conditional containment failure "factors" provided in Revised Appendix H for a flooded drywell floor can be used as a first approximation. These values represent elimination of the contribution to containment failure from liner melt-through. For a flooded drywell floor, Revised Appendix H indicates factors of 0.6 for sequences with high RCS pressure at vessel breach, and <0.1 for sequences with low RCS pressure.

3. The basis for these Appendix H factors can be further evaluated and modified for Brunswick. The "Basis Document for LERF SDP," NUREG-1765, cites NUREG/CR-6595 as the basis for the 0.6 factor. NUREG/CR-6595, Rev 1, "An Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events" in turn indicates that this value was derived from: (1) NUREG-1560, "IPE Program: Perspectives on Reactor Safety and Plant Performance," and (2) NUREG/CR-4551, Vol. 4, "Evaluation of Severe Accident Risks: Peach Bottom Unit 2." NUREG-1560, Vol. 2 (p-12-18) states that if shell melt-thorough and early containment venting are removed, the early containment failure probability found in the Mark I IPEs varies from 0.01 to 0.3, which even at the high end is less than the factor in Appendix H. NUREG/CR-4551, Vol. 4 (Section 2.5.2.1) describes a sensitivity case showing the impact if drywell melt-through is eliminated. For fast SBO sequences, the early containment failure probability is reduced from 0.33 to 0.08. For slow SBO, the early containment failure probability is reduced from 0.75 to 0.41. The early containment failure probability includes contributions from: (1) venting during core damage, (2) drywell failure resulting from pedestal failure, and (3) over-pressure failure at vessel breach. All of these contributors are not necessarily relevant to LERF for Brunswick. For example, if venting is from the wetwell the fission products will be scrubbed and will not contribute to LERF. Also, the likelihood that reactor vessel pedestal failure leads to drywell failure may be reduced due to the unique containment construction at Brunswick. If these two contributors (as well as drywell melt-through failures) are eliminated, the probability of early containment failure would be about 0.05 and 0.2 for fast SBO and slow SBO sequences respectively (due to containment over-pressure only).

4. The probability of early over-pressure failures of Mark I containments is indicated in NUREG-4551, Vol. 4 (Section 2.5.1.11) to only be significant in those sequences where containment heat removal and venting are failed or inadequate (ATWS) and the suppression pool becomes saturated. This would suggest that in determining whether core damage sequences associated with inspection findings will contribute to LERF in Mark Is, only the subset of high pressure sequences that would have a saturated suppression at vessel breach need to be considered (sequences with a subcooled pool can be screened out as potential LERF contributors.)

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5. A recent RES-sponsored report on direct containment heating in Mark I containments does not fully support the above screening criteria, but indicates that these high pressure sequences can be eliminated from consideration for another reason, i.e., because the RCS will be depressurized as a result of creep rupture of the steam line nozzles. Specifically, ERI/NRC 03-204, "The Probability of High Pressure Melt Ejection-Induced Direct Containment Heating Failure in Boiling Water Reactors with Mark I Design" (page 63) indicates that the conditional containment failure probability for a high pressure vessel failure in a dry drywell would be about 0.4. This is based on pressure loads only and doesn't consider the possibility of liner melt-through by debris that is de-entrained in the drywell and in contact with the steel liner. The report is silent on whether this mechanism would further increase the conditional containment failure probability. The suppression pool temperature in these calculations was about 140F subcooled. This failure probability is higher than the value derived from NUREG/CR-4551 due to containment over-pressure only. However, the ERI report also included a detailed thermal-hydraulic analysis of core melt progression that indicates that there is about a 90% probability that the RCS would be passively depressurized via creep-rupture of the steam line nozzles in both fast SBO and slow SBO events. Thus, even if the probability of early containment failure were in the range of 0.2 to 0.4, the significant probability of RCS depressurization due to creep rupture more than offsets this value, and effectively results in a conditional early containment failure probability of <0.1.

6. In conclusion, for purposes of realistically assessing the contribution to LERF from both high pressure and low pressure core damage sequences at Brunswick, a conditional containment failure factor of 0.1 or less can be justified.