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Figure 3-31: Pressures in steam generators for the PRA sequence of large break LOCA (LLOCA-C04-NOECSBS-MCCI)

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Figure 3-32: Water levels in steam generators for the PRA sequence of large break LOCA (LLOCA-C04-NOECSBS-MCCI)

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Figure 3-33: Masses in the core, lower plenum and reactor cavity for the PRA sequence of large break LOCA (LLOCA-C04-NOECSBS-MCCI)

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Figure 3-34: Ablation depth in floor and sidewall for the PRA sequence of large break LOCA (LLOCA-C04-NOECSBS-MCCI)

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Figure 3-35: Pressure in containment dome for the PRA sequence of large break LOCA (LLOCA-C04-NOECSBS-MCCI)

4.0 CONCLUSIONS

Potential threat to containment integrity due to MCCI was studied for the APR1400 plant. The postulated severe accident scenarios are the so-called “wet” cases, where the containment flooding system (CFS) is assumed available to flood the reactor cavity following reactor core damage.

The computational tool used for this study is the severe accident code MAAP 4.0.8. Review of the modeling features of this code indicates that two modeling parameters, FCHF and ENT0C, must be calibrated against more sophisticated MCCI codes to achieve conservative predictions of key variables important to containment integrity, including concrete ablation depth and containment pressure. The MCCI code CORQUENCH 3.03 was selected as the basis of the calibration process, given its detailed modeling features of corium-water interaction and melt eruption. Based on the results of this code, the ablation depth of a Limestone Common-sand (LCS) concrete floor is about 27 cm for the bounding large LOCA scenario. This result is considered conservative because it ignores initial molten corium jet breakup. If this effect was considered, the ablation depth would have been much smaller. The MAAP 4.0.8 input value of FCHF is calibrated to be 0.0235, which leads to an even more conservative result of 36 cm of ablation into the concrete floor, compared to the ablation depth predicted by CORQUENCH for the chosen bounding scenario. This ablation depth is much smaller than the depth of containment liner (about 90 cm). Therefore, release of fission products from containment due to ablation damage is unlikely. The value of ENT0C, which is the entrainment coefficient in the initial jet breakup model, is set to a very small number, which is equivalent to ignoring the effect of jet breakup. It is conservative with respect to concrete ablation, because ignoring the jet breakup will generate a high temperature corium pool. The impact of this small value of ENT0C on containment pressurization has also been assessed and found consistent with modeling expectations.

The five severe accident scenarios were selected based on their core damage frequencies from Level I PRA analyses and potential bounding features, including such sequences as: loss of essential service water, loss of AC power with failure of auxiliary feedwater, medium break LOCA, and large break LOCA. Table 4-1 lists the identifiers of the scenarios along with brief scenario descriptions. For each scenario, up to 24 hours of the transient was simulated. The modeling parameter FCHF was set to 0.0235 and ENT0C was set to 1×10^{-5}, as specified in the previous section.

Figure 4-1 and Figure 4-2 show the ablation depths and containment pressures of the scenarios for the first 24 hours. The large break LOCA is the most bounding scenario and it produces the maximum ablation depth and containment pressure, about 24 cm and 7.4 bar respectively. According to SECY 93-087 (Reference 12), the containment liner must be protected during MCCI, and the pressure resulting from MCCI should not exceed the FLC (Factored Load Category) pressure within 24 hours. The depth where the liner is located in APR1400 cavity is about 0.9 m, and the FLC pressure is about 8.5 bar. It can be seen that the ablation depth and containment pressure resulting from MCCI do not exceed the limits even for the most bounding scenario. MAAP4.0.8 results are based on the assumption that the cavity floor is a flat surface without a sump. When a cavity sump is considered, CORQUENCH shows that the corium in the sump is quenched before the ablation depth reaches the containment liner, given a cavity floor made of LCS concrete.

Table 4-1 Selected Severe Accident Scenarios for MCCI Analyses for the APR1400 Plant TS

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Figure 4-1 Ablation Depths within 24 Hours for Different Severe Accident Scenarios for the APR1400 Plant

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Figure 4-2 Containment Pressures within 24 Hours for Different Severe Accident Scenarios for the APR1400 Plant

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