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ATTACHMENT E

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Progression of Severe Accidents in the U. S. EPR™ [1]

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INTRODUCTION

U.S. EPR™ is a light water cooled and moderated plant designed by AREVA NP. This reactor is currently undergoing design certification review by the Nuclear Regulatory Commission (NRC). The nuclear steam supply system is a four-loop pressurized water reactor with four inverted U-tube steam generators. The containment is a large-dry design and includes a number of unique severe accident mitigation features including an In-containment Refueling Water Storage Tank (IRWST); a Severe Accident Heat Removal System; and a core catcher with features designed to spread, flood, and cool the core debris ex-vessel on the containment floor.

This paper focuses on assessment of the response of the U.S. EPR™ reactor, containment, and associated systems to selected severe accident scenarios, including comparisons of MELCOR predictions of selected accident signatures and radiological releases to those of AREVA using MAAP4.

DESCRIPTION OF WORK

The analyses have been performed based on a relatively detailed model using MELCOR 1.8.6 computer code. The MELCOR model consists of a detailed representation of the reactor pressure vessel internals, the reactor coolant system (RCS) including the potential for in-vessel and hot-leg/steam generator tube counter-current natural circulation, the impact of failure of in-core instrumentation tubes on accident progression, lower head failure, melt behavior inside the reactor cavity, melt-plug failure, debris relocation onto the spreading floor, and coolability. Other modeling features include distribution of gases inside containment, passive autocatalytic recombiners, and fission product release and evolution.

RESULTS

Figure 1 shows comparisons of MELCOR- and MAAP-predicted RCS pressure for a station blackout accident scenario. It is noted that MELCOR and MAAP prediction of in-vessel accident progression are generally consistent, except that MAAP-predicted event progression is faster, resulting in earlier time of vessel breach as shown by the sharp drop in RCS pressure in Figure 1. Generally, MAAP-predicted in-vessel hydrogen generation was found to be higher than the MELCOR prediction. This is due to a conservative enhancement of the oxidation rate as modeled by AREVA. The confirmatory analyses have shown that over the range of parametric values investigated to date, the induced Steam Generator Tube Rupture (SGTR) appears to be less likely than other induced RCS failures (consistent with MAAP). In addition, the impact of failure of instrument tubes on natural circulation is not as pronounced as for other existing pressurized water reactors that have been studied [1], nonetheless, the trends are similar.

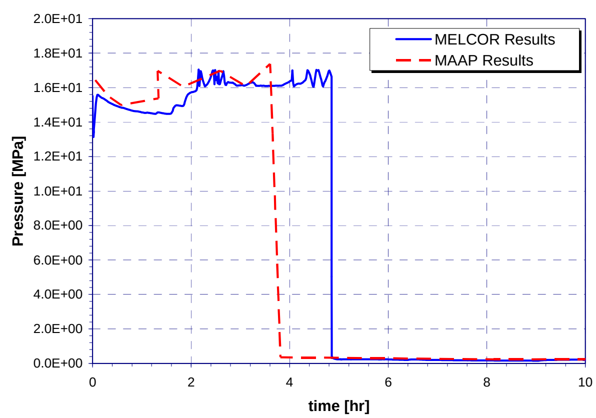

Fig. 1. RCS pressure

The largest differences exist in the behavior of core debris inside the reactor cavity following vessel breach,

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[1] Work performed under the auspices of the U.S. Nuclear Regulatory Commission

where even though the MELCOR-calculated debris temperature is lower than that predicted by MAAP, the cavity melt plug failure (a special feature in U.S. EPR™ to enable melt stabilization before relocation to a region where core debris is expected to be cooled by another engineered cooling system) occurs later in MAAP as compared to MELCOR. There are several parameters that can potentially have a strong impact on the melt retention time. These include the total mass of corium in the reactor cavity, the amount of metal assumed to be in the pool layer in contact with the concrete, and the corium temperature. There are also differences in the modeling of molten core concrete interactions between MELCOR and MAAP that influence the calculated melt retention period. Nonetheless, these differences are considered significant in so far as overall progression of the accident is concerned.

Provided uniform spreading of molten core debris material on the specially designed spreading floor occurs, passive flooding of IRWST water onto the containment spreading room results in melt cooling and stabilization for the accident scenarios that have been examined. The debris cool-down rate has been calculated to be faster in MELCOR as compared with the AREVA MAAP predictions.

Both MAAP and MELCOR results show that hydrogen concentration in containment remains below significant combustion limits under severe accident conditions (due to effective recombination by passive autocatalytic recombiners). The impact of reduced effectiveness of passive autocatalytic recombiners as a result of severe accident environment (i.e., poisoning or coking) on hydrogen behavior inside containment has been examined through a parametric approach.

In general, the calculated rate and magnitude of containment pressurization was found to be higher in the MAAP calculations. Finally, MAAP- and MELCOR-predicted fission product releases for scenarios involving intact or partially intact containment were found to be in reasonable agreement. However, significantly higher releases of volatile fission products were calculated by MELCOR for accidents involving containment bypass (e.g., due to steam generator tube rupture).

REFERENCES

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