ENCLOSURE 1

MFN 06-032

Framework for ESBWR Licensing Topical Report

Related to ESBWR Fission Product Removal

and Related DCD Revisions

Framework for ESBWR Fission Product Removal Licensing Topical Report, and Related DCD Revisions

Estimation and modeling of effective fission product decontamination factor for ESBWR containment

GE provided a DCD revision [1] , which provided additional details of the leakage path through the PCCS condenser and out. It documented fission product removal mechanism and aerosol characteristics in the main steam lines, including or referencing the technical information required by 10 CFR 52.47, 10 CFR 50.34(a)(I), and the applicable requirements of 10 CFR 100.21. The seismic qualification of the condenser was discussed in this submittal. This part of the DCD analysis is similar to analyses currently applied in operating BWRs.

In the DCD off site dose assessment, a fission product decontamination factor (DF) is reported, and applied to the removal of aerosols and iodine. This decontamination factor physically represents fission product removal mechanisms in the Passive Containment Cooling System (PCCS) heat exchanger, the PCCS condensate flow path (through the Gravity Driven Cooling System (GDCS) pool to the reactor vessel), the PCCS vent flow path, and suppression flow main vent flow path. The Power's aerosol model was applied in RADTRAD (NUREG/CR-6189) to model aerosol removal in the containment on the walls, floor and ceiling.

The fission product decontamination factor applied in the Rev 0 DCD is based on a MELCOR evaluation of a preliminary ESBWR design [2]. The existing ESBWR MELCOR input [2] will be updated to the latest MELCOR version (Version 1.8.6). For the draft licensing topical report (LTR) the implementation of one plant modification: GDCS airspace being vented to the drywell (DW) will be implemented to the MELCOR 1.8.6 input. For the final LTR the MELCOR 1.8.6 input will be updated to incorporate the other ESBWR design parameters.

GE will also calculate the thermal-hydraulic conditions in the containment (including the inlet and outlet flows and boundary conditions for PCC Heat Exchanger, both condensate and vent outlets, and Suppression Pool Main Vents) in a fuel failure/alternate source term scenario which produces degraded core cooling and fuel failure through the time period specified in NUREG-1465, using the TRACG model applied in Chapter 6 for LOCA analysis. Subsequent to the postulated fuel failure, an in-vessel recovery will be modeled, with passive system function as defined in the Chapter 6 loss-of-coolant accident (LOCA) analysis, considering single failures. After 72 hours the function of a minimal number of non-passive components will be credited, e.g. Fuel and Auxiliary Pools Cooling System (FAPCS) to refill the PCC/Isolation Condenser (IC) pool, buffer the suppression pool and spray the DW. Note the FAPCS loop which services the PCC/IC pool is a physically separate FAPCS loop which services the GDCS and suppression pool.

Application of PCCS fission product removal test results

The removal of fission product aerosol particles by the PCCS tubes will be quantified. The relevant mechanisms for particle retention considered in this study are gravity, Brownian diffusion, diffusiophoresis and thermophoresis. Diffusiophoresis, the phenomenon of aerosol

movement in condensing vapor, will drive the aerosol particles to condensate film on the PCCS tube inner wall. In addition to condensation, some fraction of the airborne activity may also plate out in the PCCS. The PCCS effectiveness in removing aerosols has been demonstrated in third party tests. For example, in "Investigation on Aerosol Deposition in a Heat Exchanger Tube" [3], a short length of PCC tube was capable of removing a significant portion of in-flowing aerosols, and removing them with the condensate flow. References [4] and [5] also document aerosol behavior in the PCCS tubes, and will be utilized in developing inputs for fission product removal the MELCOR model. The study will include estimation of the change in the removal efficiency as a function of time. The parameters affecting the removal efficiency are the water level in the PCCS pool, the temperature of the gas at the inlet of the tubes and fraction of non-condensable gases in the flow.

An evaluation model for the removal of airborne fission products from the containment atmosphere and aerosol transport and behavior mechanisms in the containment following a LOCA will be developed. This will be accomplished by the following:

The contribution to the draft LTR will contain a compilation of the empirical test data, conclusions based on the experimental work and description of the modeling principles. Test reports that will be used in the verification of the PCCS retention model will be indicated. Uncertainties related to the experiments will be discussed.

The final LTR will include all results from the modeling calculations and a function for DF that can be applied in MELCOR. The model for particle retention will be validated using results from empirical tests conducted with PCC heat exchanger tubes. Fission product retention calculations will use thermal-hydraulic conditions as input. Effective decontamination factors for the PCCS will be obtained as the end result of the modeling work.

The MELCOR model will assess pH in containment water pools taking into account the injections of buffering solutions according to the defined accident management measures (injection of sodium pentaborate into the reactor pressure vessel (RPV) at 1.5 hours into the accident, followed by injection of trisodium phosphate into the suppression pool and RPV at 72 hours into the accident). The water pool masses and flow rates between the pools are obtained with the MELCOR 1.8.6 code.

An effective fission product containment decontamination factor will be determined from the MELCOR 1.8.6 analysis that takes into account the abovementioned items.

<u>Estimation and modeling of fission product release rates from the reactor building to the environment</u>

The fission product release rates from the reactor building to environment will be calculated using the MELCOR 1.8.6 code. Different leak paths from the reactor building will be investigated, including limiting release paths using the MELCOR 1.8.6 code. MELCOR 1.8.6 analyses give a release estimate with the (lumped parameter) assumption of complete and instantaneous mixing in a control volume. Various flow paths will be investigated.

<u>Comparison to off-site dose calculation</u>

The GE RADTRAD assumptions will be compared to the MELCOR evaluation to confirm the DCD off-site dose calculation bounds the MELCOR evaluation.

<u>Miscellaneous DCD revisions</u>

In DCD section 6.2.1.1.10.2 "ESBWR Design Features for Severe Accident Control, GE will clarify or change the statement in item 4) which implies the PCCS is 100% efficient in removing aerosols, and will replace the reference in item 8) to an "intermediate holding tank", with "GDCS pool".

GE will provide the FAPCS lineup post accident to document the isolation of the radioactivity from discharge into the PCC/IC pool and GDCS pools.

GE will clarify or change the apparently inconsistent statements in section 6.2.3 "Reactor Building Functional Design" regarding the applicability of GDC 16. GE will confirm or revise if necessary the statement in 6.2.3.1 regarding the capability of the Reactor building to undergo periodic leak rate testing, and confirm that the containment and associated system leak rate applied in the off site dose calculation meets the leak tight criteria of GDC 16.

References

[1] MFN 05-111, Letter from David H. Hinds to U. S. Nuclear Regulatory Commission, *GE Response to Results of NRC Acceptance Review for ESBWR Design Certification Application – Item 4 (TAC # MC8168)*, October 22, 2005

[2] "Fission Product Retention Within the ESBWR Containment," Woudstra, A., ECN Nuclear Energy Report ECN-CX-96-124, December 1996. (To be provided separately)

[3] "Investigation on Aerosol Deposition in a Heat Exchanger Tube," Hokkinen, J., Auvinen, A., Renvall, T., Ludwig, W. and Jokiniemi, J., VTT Energy Report ENE53/46/2000, January 2001. (Attached)

[4] "Experimental Results on Aerosol Deposition in a Heat Exchanger Tube," Hokkinen, J., Jokiniemi, J., Auvinen, A., Makynen J., VTT Energy Report ENE25/5/99, December 1999. (Attached)

[5] "CFD Simulation on Aerosol Impaction and Deposition Analysis in a Passive Containment Condenser," Ludwig, W., Lehtinen, K., Pyykonen, J., Brown, D, Paraled, J, Jokiniemi, J., Gamble, R., ICONE8, April 2000.