GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

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Chet Poslusny, Senior Project Manager
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of the Nuclear Reactor Regulation

Subject: Submittal Supporting Accelerated ABWR Review Schedule - **"Insights" Examples**

Dear Chet:

Enclosed is information which compares the "Insights" examples that were provided by Carol Buchholz (GE) to the NRC February 16, 1993 with the examples sent by Bob Palla (NRC) to GE on March 24, 1993. This information may be useful to the NRC in preparation for the GE/NRC April 26, 1993 meeting.

Please provide a copy of this transmittal to Bob Palla.

Sincerely,

Jack Fox

Jack Fox
Advanced Reactor Programs

cc: Carol Buchholz (GE)
Jack Duncan (GE)
Norman Fletcher (DOE)

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Drywell/Wetwell Vacuum Breakers

Staff: Reliable wetwell/drywell vacuum breaker operation is very important to reducing the consequences of an accident. This is because suppression pool function (severe accident progression and fission product removal) can be compromised in the ABWR design by a single failure of a wetwell/drywell vacuum breaker (i.e., a stuck open vacuum breaker), or by excessive leakage of one or more vacuum breakers. In the ABWR design there is only a single vacuum breaker in each path in operating BWRs. Periodic surveillance and testing of the vacuum breaker valves and their associated position indicators will be crucial to minimizing this risk.

The vacuum breakers and their position indication switches are very important in reducing the chances of suppression pool bypass. GE has taken credit (reduction of suppression pool bypass from 18% to 2% for cases in which releases are into the drywell) for aerosol plugging to reduce the significance of vacuum breaker leakage. The PRA assumes that (1) each vacuum breaker will be equipped with a position indication switch that will indicate the valve to be open should the gap between the disk and seating surface exceed 0.9 cm, and (2) normal operating procedures will call for the operators to periodically confirm that all vacuum breakers are closed.

GE: The ABWR contains eight 20-inch diameter vacuum breakers which provide positive position indication in the control room. They have also been located high in the wetwell to reduce potential loads occurring during pool swell. The result of the vacuum breaker design in the ABWR is to reduce the potential for suppression pool bypass.

Conclusion: GE/Staff agree on what is important. Staff's items (1) and (2) could be included. Reference to PRA results not necessary.

Passive Flooder

Staff: The passive flooder system provides a passive means of adding water to the lower drywell following reactor vessel breach. This water would cover the core debris, thereby enhancing debris coolability, cooling the drywell, and providing fission product scrubbing. The passive flooder is a backup to other means of lower drywell water addition in the ABWR. PRA-based sensitivity studies indicate that the incremental risk reduction offered by the passive flooder is system is minimal. This is because of credit taken in the ABWR for water addition using the ACIWA mode of RHR.

GE: The lower drywell flooder system has been included in the ABWR design to provide alternate cavity flooding in the event of core debris discharge from the reactor vessel and failure of the firewater addition system. This system is actuated from the melting of a fusible plug. The temperature set point for the plug is 533 K. The system consists of ten 4 inch diameter lines located about 4 m below the normal suppression pool water level discharging into the lower drywell about 1 m above the floor. Assuming only 9 of the 10 flooders open, the total flooder flow would be 97 kg/s. By flooding after the introduction of core material, the potential for energetic core-water interactions during debris discharge is minimized. The flooder will cover the core debris with water providing for debris cooling and scrubbing any fission products released from the debris due to core-concrete interactions.

Conclusion: GE text provides more details of system. Staff's mention of PRA sensitivity studies not pertinent to the discussion.

COPS

Staff: The pressure at which the COPS system vents is important to safety. The COPS system provides for a scrubbed release path in the event that pressure in the containment cannot be maintained below the structural limit of the containment. COPS provides significant benefit to Class II sequences and seismic events. Two competing goals were considered in establishing the pressure relief setpoint, specifically, minimizing the probability of drywell failure prior to COPS actuation, while maximizing the time before fission product release to the environment. As such, the tolerance in the pressure at which the system actuates is an important aspect of the design. The ABWR PRA assumes the following system parameters: (1) rupture disk actuation at a pressure of 90 psig, with atmospheric pressure on the downstream side of the disk, (2) reliability of the system actuation within +/- 5% of the mean value, (3) upstream and downstream isolation valves maintained normally open.

GE: The COPS is part of the atmospheric control system and consists of two 8-inch diameter overpressure relief rupture disks mounted in series on a 14-inch line which connects the wetwell airspace to the stack. This system will provide for a scrubbed release path in the event that pressure in the containment cannot be maintained below the structural limit. This controlled release will occur at a containment pressure of 0.72 MPa (90 psig). This system is beneficial for several of the severe accident issues. In cases with continued core-concrete attack, or those with no containment heat removal operational, the containment will pressurize. The COPS provides a controlled release path which will mitigate the fission product releases. This is an example of how uncertainties in severe accident behavior, i.e. debris coolability, are addressed by the ABWR design.

Conclusion: GE/Staff agree on what is important. Could include competing goals discussion and (2) and (3) from above.

Sprays

Staff: Wetwell/drywell sprays provide significant benefit for mitigation of severe accidents. In the event of a stuck open vacuum breaker, excessive vacuum breaker leakage, or other bypass leakage to the wetwell airspace, the wetwell and/or drywell sprays provide a backup means of containment pressure and fission product control.

GE: This system not only can play an important role in preventing core damage, it is the primary source of water for flooding the lower drywell should the core become damaged and relocate into the containment. The drywell spray mode of this system not only provides for debris cooling, but it is capable of directly cooling the upper drywell atmosphere and scrubbing airborne fission products. This system has sufficient capacity to cover the core debris ex-vessel and provide debris cooling and scrub fission products released as a result of continued core-concrete interactions.

The firewater addition system operating in the drywell spray mode will also reduce the consequences of a suppression pool bypass or containment isolation failure. This is due to the fission product removal function performed by this mode of operation. Fission products will be scrubbed by the sprays prior to leaving the containment.

The firewater addition system has been sized to optimize the containment pressure response. The system is capable of delivering water to the containment up to the setpoint pressure of the COPS system. The flow rate, nominally 0.055 m^3/sec at runout and 0.044 m^3/sec at the COPS setpoint, is sufficient to allow cooling of the core debris, while maximizing the time until the water level reaches the bottom of the vessel, at which point it is turned off.

Conclusion: GE/Staff agree on what is important. GE discussion is more comprehensive.

Inerted Containment

Staff: Because the ABWR containment is inerted during normal operation, containment failure as a result of hydrogen combustion is not considered important for power operation, and was not modelled in the PRA.

GE: One of the important severe accident consequences is the generation of combustible gasses. Combustion of these gasses could increase the containment temperature and pressure. The ABWR containment will be operated inerted to minimize the impact from the generation of these gasses.

Conclusion: GE/Staff agree on what is important.

Vessel Depressurization

Staff: ADS plays a major role in reducing the frequency of containment failure from direct containment heating (DCH). As a result of ADS, the fraction of reactor vessel failures at high pressure are reduced to about 30 percent. The staff has estimated the containment failure probability for DCH to be about 5%, conditional upon reactor vessel failure at high pressure. This results in a very low absolute frequency of a core damage event leading to containment failure from DCH (2.3E-9 per year).

GE: The ABWR reactor vessel is designed with a highly reliable depressurization system. This system plays a major role in preventing core damage, however, even in the event of a severe accident, the RPV depressurization system can minimize the affects of high pressure melt ejection. If the reactor vessel would fail at an elevated pressure, fragmented core debris could be transported into the upper drywell. The resulting heatup of the upper drywell could pressurize and fail the drywell. Parametric analyses performed in Section 19AE of the ABWR SSAR indicate that even in the event of direct containment heating, the probability of early drywell failure is quite low. The RPV depressurization system further decreases the probability of this failure mechanism.

Conclusion: GE does not agree that PRA results are important here.

Lower Drywell Design (CCI)

Staff: The contribution of core concrete interactions (CCI) to risk has been minimized in the ABWR design by the inclusion of the following design features: (1) a _____ m thick reactor pedestal capable of withstanding approximately _____ m of erosion from CCI without loss of structural integrity, and (2) the use of basaltic concrete in the floor of the lower drywell.

GE: The details of the lower drywell design are important in the response of the ABWR containment to a severe accident. Six key features are described below.

Sacrificial Concrete

The floor and walls of the ABWR lower drywell include a 1.5 meter layer of concrete above the containment liner. This is to insure that debris will not come in direct contact with the containment boundary upon discharge from the reactor vessel. This added layer of concrete will protect the containment from possible early failure.

Basaltic Concrete

The sacrificial concrete in the lower drywell of the ABWR has been constructed of low gas content concrete. The selection of concrete type is yet another example of how the ABWR design has striven not only to provide severe accident mitigation, but to also address potential uncertainties in severe accident phenomenon. Here, the uncertainty is whether or not the core can be cooled by flooding the lower drywell. For scenarios in which the lower drywell flooder is unable to cool the core debris, the concrete type selected will result in a very low gas generation rate. This translates into a long time to pressurize the containment. This is important because time is one of the key factors in aerosol removal.

Conclusion: GE/Staff agree on what is important. GE agrees to address pedestal erosion capability.

Lower Drywell Design

Staff: It is important that the as-built plant have (1) a lack of any direct pathways by which water from the upper drywell (e.g., from drywell sprays) can drain to the lower drywell, other than by overflow of the suppression pool, (2) negligible probability of premature or spurious actuation of the passive flooder valves at temperatures less than 500 F or under differential pressures associated with reactor blowdown and pool hydrodynamic loads, (3) a capability to accommodate approximately _____ cubic meters of water in the suppression pool before the pool overflows into the lower drywell, and (4) a reactor pedestal capable of withstanding an impulse loading of ______ without loss of integrity. This is important because the contribution of fuel-coolant interactions or steam explosions is considered negligible in the ABWR design due to two factors: (1) a very low probability that the lower drywell will be flooded at the time of reactor vessel failure (0.3%), and (2) the capability of the ABWR reactor pedestal to withstand the loads associated with an ex-vessel steam explosion.

GE: Developed based on "features" that are important to severe accident response:

(1) Solid vessel skirt
(2) Flooder design

Conclusions: GE could include discussion of overflow volume. GE does not agree that discussion of maximum pedestal loading is important. Resolution of FCI issue is needed before insights can be developed. PRA results not pertinent to discussion.

Lower Drywell Design (Sump)

Staff: As part of the resolution of the issue of CCI, GE proposed a sump shield to prevent core debris from entering the lower drywell sump. The impact of lower drywell sumps or sump shields on severe accident progression was not considered in the PRA.

GE: The lower drywell sumps are protected such that a substantial amount of core debris will not enter. This maximizes the upper surface area between the debris and the water and maximizes the potential to quench the core debris.

Conclusion: GE could include that the failure of the sump shield was not considered in the PRA. However, we believe that the shift in focus from the features to PRA is not desired.