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 Schedule - **Containment Emergency Procedure Guidelines Issues**

Reference: R. W. Borchardt Letter to J. F. Quirk, "GE ABWR Containment Systems and Severe Accident Review Issues", December 29, 1993

Dear Chet:

This letter responds to the Low-Pressure Venting Item 2 of the subject issues transmitted by the above reference. The item is repeated below followed by the response:

2. Address suppression pool bypass mechanism through interconnection in the atmosphereic control system (ACS) and show the effect on the existing bypass analysis. Ensure that no other bypass pathways exist that have not been accounted for.

   Response:

   See revised Subsections 6.2.1.1.5.3 and 6.2.1.1.5.5 and new Appendix 6E.

Sincerely,

Jack Fox
Advanced Reactor Programs

cc: Joe Quirk (GE)
Alan Beard (GE)
Norman Fletcher (DOE)
Umesh Saxena (GE)

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See attached dist

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M_s = spray flow rate

N_s = spray efficiency

T_c = containment temperature

T_s = spray temperature at the spray nozzles

H_{fg} = latent heat of vaporization of water

C_p = constant pressure specific heat of water

The spray water temperature is calculated from:

$$T_s = T_p - KHX \times [(T_p - T_{sw}) / (M_s \times C_p)]$$

where

T_p = suppression pool temperature

KHX = RHR heat exchanger effectiveness

T_{sw} = service water temperature

Containment sprays have a significant effect on the allowable steam bypass capability. Use of sprays increases the maximum allowable bypass leakage by an order of magnitude and represents an effective backup means of condensing bypass steam. See Appendix 6E for additional bypass considerations.

6.2.1.1.5.5 Suppression Pool Bypass During Severe Accidents

The only mode of suppression pool bypass that presents any significant risk during a severe accident is vacuum breaker leakage. Vacuum breaker leakage results in the passage of gas from the drywell into the wetwell airspace. Vapor suppression and fission product scrubbing by the suppression pool are not available to the gas and vapor which pass through the vacuum breakers. The consequences associated with vacuum breaker leakage can be mitigated by use of containment sprays.

Large amounts of leakage can occur as a result of catastrophic failure of valve components or a valve sticking open. Lesser amounts of leakage can result from normal wear and tear including degradation of the valve seating surfaces. For sufficiently large amounts of leakage during a severe accident without containment heat removal, the time to COPS activation or containment overpressurization can be reduced and the amount of fission products released can be increased.

The probability that the vacuum breakers will leak or stick open will be minimized by using materials selected for wear resistance and using high quality seating surfaces.

$$M_{dot} = . [(A/K)\sqrt{(2g_c(\Delta Pv)/v)}]$$

where

v = drywell steam specific volume, and

K = total loss coefficient of the flow path.

(7) Compute the maximum allowable leakage path area. $A/\sqrt{K}$, as follows:

$$A/\sqrt{K} = [(M_{dot})/\sqrt{(2g_c(\Delta P_V)/v}]$$

$$= [(M_S/\Delta t)/\sqrt{(2g_c(\Delta P_V)/v}]$$

where

Δt = Accident duration

Using the procedure outlined above and assuming an accident duration of 6 hours, the maximum allowable leakage path area under these circumstances is determined to be an effective flow area ($A/\sqrt{K}$) of 5 cm^2 See Appendix 6E for additional bypass considerations.

6.2.1.1.5.4 Bypass Capability With Containment Spray and Heat Sinks

An analysis has been performed which evaluates the bypass capability of the containment for a spectrum of break sizes considering containment sprays and containment structural heat sinks as means of mitigating the effects of steam bypass of the suppression pool.

The containment system design provides two RHR spray loops, and each loop consists of both wetwell and drywell sprays. In operation of RHR in spray mode, the wetwell and drywell sprays activate simultaneously. Per loop, the design flow rate of drywell spray is about 800 m^3/hour, and that of wetwell spray is about 114 m^3/hour. In this analysis it is assumed that spray is to be initiated no sooner than 30 minutes after the wetwell gas space pressure is reached to 1.05 kg/cm^2g. This assumed value of spray initiation pressure set point, which is higher than the EPGs pressure set point of 0.73 kg/cm^2g, is expected to produce slightly conservative results. The suppression pool water passes through the RHR heat exchanger and is then injected into the drywell and wetwell spray headers located respectively in the upper region of drywell and wetwell gas space. The spray will rapidly condense the stratified steam, creating a homogeneous air-steam mixture in the containment. Structural heat sinks (drywell and wetwell boundary surfaces) were considered with variable convective heat transfer coefficients based on Uchida correlation. The reactor vessel shutdown rate was assumed to be 55.6°C/hr, and the maximum design service water temperature was used. This shutdown rate corresponds to the maximum rate which does not thermally cycle the reactor vessel.

6E Additional Bypass Leakage Considerations

6E.1 Bypass Mechanism through ACS Interconnection

In accordance with the ABWR design, the ACS is provided to establish and maintain an inert atmosphere within the primary containment during all plant operating modes, except during shutdown for refueling or equipment maintenance or access for inspection at low reactor power. The ACS also maintains a slightly positive inert gas pressure in the primary containment during normal, abnormal and accident conditions to prevent air (oxygen) leakage into the inerted volumes from the secondary containment.

Isolation valves F040 and F041 (see Figure 6.2-39), which are normally open, make a direct flow path connection between the drywell and the wetwell air space. Therefore, in the event of a pipe break inside the drywell, this direct flow path will become an additional steam bypass leakage path. However, this additional bypass leakage path will close in few seconds, because of automatic closure of these valves upon receipt of a LOCA signal. These isolation valves are designed to close automatically within 15 seconds after receiving a high drywell pressure (2 psig) signal.

<u>Valves Fail to Close</u>

Failure of the above two isolation valves to close, which may result in a continuous bypass pathway, is highly unlikely. Division II is the power source for these two valves, and they are fail-to-close safe. Four independent sensors (one in each electrical division) detect high pressure in the drywell. Isolation system uses reverse logic (i.e., valve in open position with a low drywell pressure signal), and the isolation signal uses two-out-of-four logic. A loss of signal will de-energize the solenoid resulting in valve closure.

6E.2 Other Bypass Pathways

All containment systems which communicate with the drywell and/or wetwell air space were examined for any potential steam bypass pathways during LOCA events. A careful review of their P&IDs revealed no additionall bypass pathways.

6E.3 *Effect on Existing Bypass Analyses*

The ACS interconnection, as described above, will become a bypass pathway during LOCA. This pathway will introduce steam bypass leakage area, in addition to the bypass leakage area considered and analyzed in the existing bypass analyses (SSAR Subsections 6.2.1.1.5.3, and 6.2.1.1.5.4). Simple engineering analyses were performed to assess effect of this additional bypass leakage area on the these two existing bypass analyses.

6E.3.1 Estimate of Effective Bypass Leakage Area ($A/\sqrt{K}$)

The flow area, A, through the ACS interconnection is determined by the 2-in piping of Sch 80, which is about 0.02 ft^2. In determining the total loss coefficient, only local flow losses were considered. Pipe friction losses were ignored for conservatism. A total flow loss coefficient of 11.5 was determined, which comprises of the following:

a.	Standard entrance loss coefficient:	0.5
b.	Flow loss coefficient for two standard globe valves in series:	8.0
c.	Flow loss coefficient for two standard elbows in series:	2.0
d.	Standard exit loss coefficient:	1.0

The effective bypass leakage area, $A/\sqrt{K}$, is approximately 0.006 ft^2.

6E.3.2 Duration of Bypass Flow

Bypass flow through this additional bypass pathway will terminate upon closure of the isolation valves. As noted above, these valves will close within 15 seconds after receiving a high drywell pressure (2 psig) signal. It was determined that the drywell pressure for a small (0.02 ft^2) steam break LOCA will reach to 2 psig in about 20 seconds after LOCA. Allowing for the 15 seconds of valve closure time, this additional bypass pathway will be active for first 35 seconds only. For assessment purposes, a continuous effective flow area of 0.006 ft^2 during first 35 seconds was assumed. Decrease in flow area during the valve closure period was ignored for conservatism.

6E.3.3 Effect on Existing Bypass Analyses

a. Bypass Capability Without Sprays and Heat Sinks (6.2.1.1.5.3)

This analysis, which assumes continuous steam bypass leakage over 6-hr period, determined an acceptable effective flow area of 0.005 ft^2 (or 5 cm^2). In this analysis, a stratified atmosphere model, which assumed steam only flow through the leakage path, was assumed to ensure conservative results.

It was estimated that this additional bypass leakage area of 0.006 ft^2 will result in a total flow of about 10 lb of steam over the 35-sec period. This additional flow of 10 lb of steam is about 0.1% (which is almost negligible) of the total flow of steam over the 6-hr period in the existing analysis.

Given inherent conservatism in the analysis assumption, it is concluded that this ACS interconnection bypass pathway will havea negligible effect on the existing analysis results.

b. Bypass Capability with Sprays and Heat Sinks

This analysis, which takes credit for heat sinks as well as manual actuation of sprays 30 minutes after the wetwell airspace pressure reaches to 15 psig (or 1.05 cm^2 g), determined an acceptable effective bypass leakage area of 50 cm^2.

Given manual actuation of sprays as defined abo /e, it is concluded that this ACS interconnection bypass pathway should have no impact on this bypass capability analysis.

6E.4 Conclusion

In view of the above results, it is concluded that the suppression pool bypass mechanism through interconnection in the atmospheric control system (ACS) will have no effect on the existing bypass leakage analyses in SSAR Subsections 6.2.1.1.5.3 and 6.2.1.1.5.4