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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 308 Related to the ESBWR Design Certification – Containment Systems – RAI Number 6.2-148 S01**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) responses to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter No. 308 (Reference 1). GEH's response to RAI Number 6.2-148 S01 is addressed in Enclosure 1. Tier 1 and Tier 2 DCD markups associated with this response are provided in Enclosure 2.

If you have any questions or require additional information, please contact me.

Sincerely,

Lee F. Dougherty for

Richard E. Kingston
Vice President, ESBWR Licensing

Reference:

1. MFN 09-120, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 308 Related To ESBWR Design Certification Application*, dated February 10, 2009

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 308 Related to ESBWR Design Certification Application – Containment Systems – RAI Number 6.2-148 S01
2. Response to Portion of NRC Request for Additional Information Letter No. 308 Related to ESBWR Design Certification Application – Containment Systems – RAI Number 6.2-148 S01 – DCD Tier 1 and Tier 2 Markups

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Enclosure 1

MFN 08-344, Supplement 1

Response to Portion of NRC Request for Additional Information Letter No. 308
Related to the ESBWR Design Certification

Containment Systems

RAI Number 6.2-148 S01

NRC RAI 6.2-148 S01:

In response to RAI 6.2-148, GEH proposed changes to ESBWR DCD Tier 2 Section 6.2.1.1.2, which states that "there are temperature sensors located between the vacuum breaker and the isolation valve. These sensors will detect a rise in temperature due to the hot drywell gas bypass, relative to the wetwell gas, which will generate another control signal to close the isolation valve. The safety-related logic and control of the isolation valve is independent of the safety related Q-DCIS. The isolation valve can also be manually opened or closed. For more discussion on the logic control of the vacuum breaker isolation valves, see Subsection 7.3.6." Section 7.3.6 states that actuation logic for the vacuum breaker isolation valve: "The primary closure demand for the VB isolation valve is based upon a temperature differential between the drywell and wetwell and …" The DCD does not state how the temperature differential is determined, what value of temperature differential is set to activate the sensors, or what is the corresponding limit of bypass leakage.

A. Provide the limit of bypass leakage that activates the sensors to close the vacuum breaker isolation valve.

B. State how the temperature differential is calculated.

C. Provide the value of temperature differential that activates the sensors.

D. Justify that the accuracy of temperature measurement is sufficient to detect the intended temperature differential.

E. Provide the calculation that justifies that the temperature differential setpoint is low enough to limit the vacuum breaker bypass leakage to the intended limit.

F. "The safety-related logic and control of the isolation valve is independent of the safety related Q-DCIS" is an incorrect statement because the safety-related logic and control of the isolation valve is a subset of the safety-related Q-DCIS, and it is inconsistent with other Tier 1 and Tier 2 sections. GEH should correct this statement in the DCD

GEH Response:

Based on additional analysis of the location of the temperature sensors described in DCD Tier 2, Revision 5, Subsection 6.2.1.1.2, the location of the temperature sensors has been moved to the upstream side of the vacuum breaker isolation valve (VBIV) on the wetwell (WW) side of the vacuum breaker penetration. See Figure 1 T_{cavity} location. The relocation provides sufficient margin to detect a leaking vacuum breaker without spuriously actuating a VBIV. The description of the temperature sensor location will be revised in Subsection 6.2.1.1.2 of the DCD.

In order to assure pool swell during a LOCA does not impact the bottom of the structural shield/debris screen, Tier 1, Figure 2.15.1-1 will be revised to increase the minimum distance from the WW ceiling (bottom of diaphragm floor slab) to the WW floor from 9600 mm to 12150 mm.

A. The analytical limit of bypass leakage that activates the sensors to close a VBIV is 0.6 cm^2 (A/√K).

   A vacuum breaker (VB) not fully closing is considered a single-failure. Not fully closing is defined as a bypass leakage area greater than 0.6 cm^2 (A/√K). For a beyond design basis accident scenario of all three vacuum breakers not fully closing, closing each VBIV at 0.6 cm^2 (A/√K) or less assures the analytical limit of 2 cm^2 (A/√K) for total bypass leakage will not be exceeded. The analytical limit is assumed to be a constant bypass leakage in the design basis accident analyses for containment pressurization.

   DCD Tier 1, Table 2.15.1-2, ITAAC 16b will be changed to a type test to detect bypass leakage from 0.3 cm^2 to 0.6 cm^2 (A/√K) using temperature sensors. Detecting leakage starting from 0.3 cm^2 (A/√K) assures the setpoint calculation will have margin to the 0.6 cm^2 (A/√K) analytical limit to close a VBIV.

B. The temperature differential will be calculated using the cavity temperature and the WW temperature; see Figure 1 for approximate temperature sensor locations. The WW temperature is subtracted from the cavity temperature and compared to the drywell (DW) minus WW temperature difference. When the cavity-WW difference exceeds a fraction of the DW-WW difference the VBIV will be signaled to close.

C. The temperature difference value that will activate the sensors will be dependent on the final location of the temperature sensors, the instrument accuracy of the temperature sensors, and the height of the vacuum breaker seat from the diaphragm floor, which is dependent on the end-to-end dimension of the VBIV. Part E discusses approximate values that will be seen by these sensors from a leaking vacuum breaker and shows that the temperature difference varies as a function of distance from the vacuum breaker seat.

   Setpoint calculations are a part of the detailed design process and have not been completed. The setpoint to control the VBIV will be implemented and confirmed during the DAC and ITAAC process.

   DCD Tier 1, Section 2.2.15, Instrumentation & Control Compliance With IEEE Std. 603 provides DAC's and ITAAC's for safety-related functions, including the Vacuum Breaker Isolation Function, that verify automatic control of safety-related functions and the associated safety-related setpoints. In Table 2.2.15-2, ITAAC's 16a and 16b cover automatic control and ITAAC's 21a and 21b ensure safety-related setpoints are defined, determined and implemented using a defined setpoint methodology. These DAC's and ITAAC's were added in response to RAI's contained in MFN 09-089 letter dated February 19, 2009.

D. As discussed in the response to Part E, the difference between the temperature corresponding to 0.3 cm^2 and the temperature corresponding to 0.6 cm^2 is 7.7 ^oC at location 1 and 9.1 ^oC at location 2, for a DW temperature 166 ^oC and WW temperature of 99 ^oC. The trigger value will vary depending on the temperature ^oC measurement uncertainty.

Conventional measurement uncertainty is $\pm$ 2.5 ^{o}C for this application. Therefore, the temperature measurement accuracy is sufficient to detect a leak at the analytical limit assumed in the LOCA analysis (2.0 cm^2 ($A/\sqrt{K}$) in total, 0.6 cm^2 ($A/\sqrt{K}$) per VB) while avoiding closure of the VBIVs with leakage less than the Technical Specification Surveillance Requirement (SR) 3.6.1.1.3 (0.3 cm^2 ($A/\sqrt{K}$)).

The total number of temperature sensors required is discussed in DCD Tier 2, Subsection 7.3.6.2. The instrument specification will be written to meet the requirements of the setpoint analysis.

E. A simple 1-D vacuum breaker component is modeled in TRACG, based on the geometry shown in Figure 1, to calculate the temperatures at different leak rates. It should be noted that a VB extension section in the WW gas space allows the sensors in the extension section to accurately capture the temperature rise due to the DW-WW leakage through the VB.

The leakage area is modeled as an orifice flow area at the top of the VB cavity. The DW and WW thermodynamic conditions (pressures and temperatures) after the first cycle of VB actuation are obtained from the main steam line break LOCA and are used as the VB exterior boundary conditions. The radial heat conduction through the VB pipe wall from the WW is also modeled. The natural convection heat transfer is considered outside of the VB pipe wall. No insulation is applied on the VB pipe. Two cases are analyzed; one for a leakage area of 0.3 cm^2 ($A/\sqrt{K}$), which represents the Technical Specification SR 3.6.1.1.3, above which the VBIV must be closed; the other for a leakage area of 0.6 cm^2 ($A/\sqrt{K}$), which represents the upper analytical limit of the VB bypass leakage. The calculation results are summarized in Table 1. Location 1 and location 2 analyzed are located in the middle of the extension section and close to the exit of the extension, respectively (See Figure 1, T_{cavity}).

Table 1 shows the TRACG temperature results for the two leakage areas at the two locations without insulation on the VB/VBIV assembly and penetration.

For the temperature differential setpoint approximately between 37.4 C and 46.5 ^{o}C, considering the temperature measurement uncertainty discussed in Part D, the above calculation provides an example to justify that the temperature differential setpoint will be able to discriminate vacuum breaker leakage, which requires isolation from allowable leakage.

In addition, as shown in the table, the difference between the temperature corresponding to 0.3 cm^2 and the temperature corresponding to 0.6 cm^2 is 7.7 ^{o}C at location 1, and 9.1 ^{o}C at location 2. Considering the temperature measurement uncertainty discussed in Part D, this calculation shows that a temperature differential setpoint that will limit the vacuum breaker bypass leakage to the intended limit can be set.

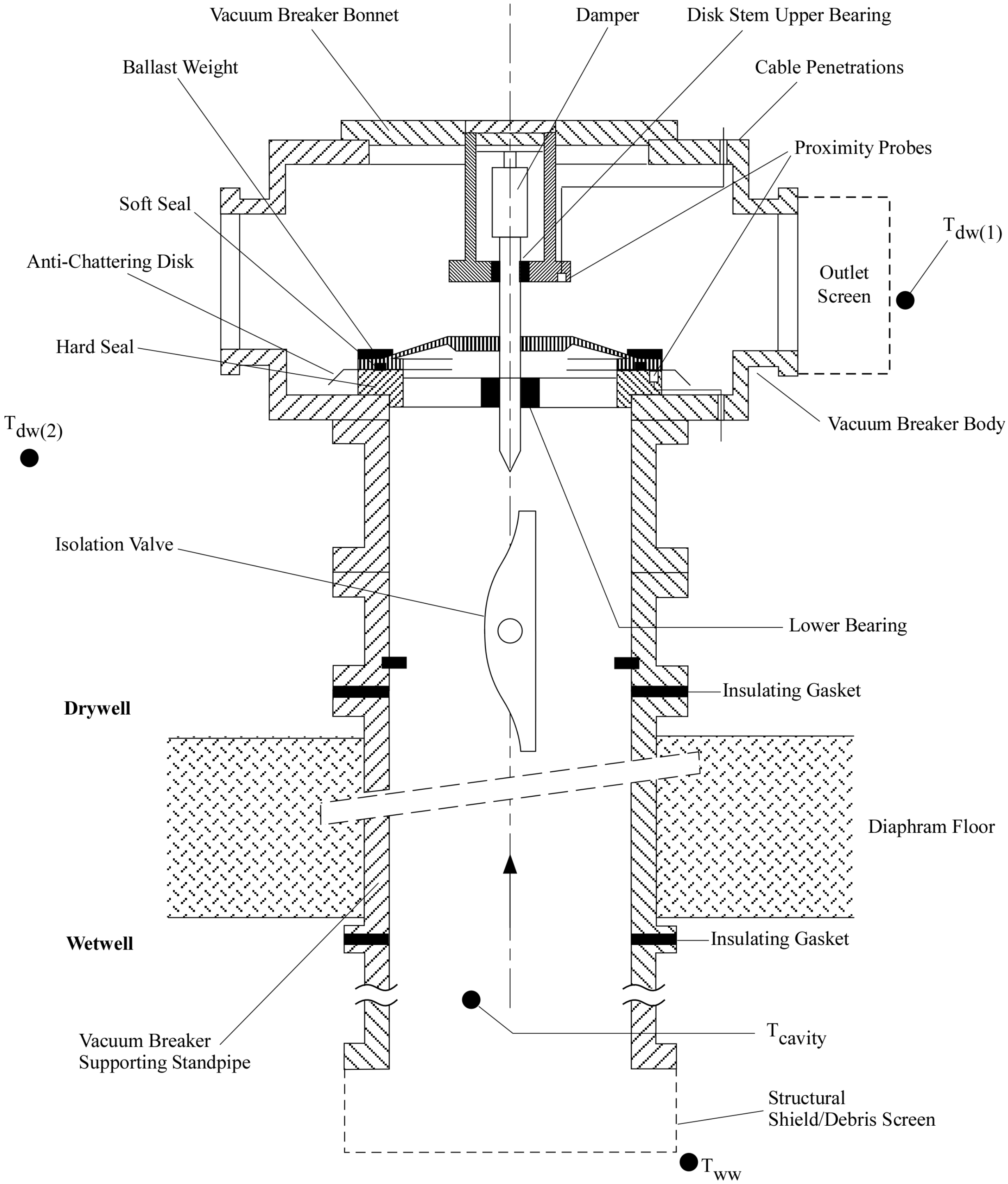
F. This statement is incorrect and has been removed from DCD Tier 2, Section 6.2.1.1.2 in response to RAI 7.1-110 (MFN 08-920, dated 12/12/2008).

<u>DCD Impact</u>:

DCD Tier 2, Section 6.2.1.1.2, Section 7.3.6.2, and Figure 6.2-28 and Tier 1 Table 2.15.1-2 and Figure 2.15.1-1 will be revised as noted in the attached markups.

Table 1

Location	**Final Steady State Temperature Differential (^oC)**		
	Leakage Area (A/√K)		Difference, 0.6 cm^2 - 0.3 cm^2 leakage area (A/√K)
	0.3 cm^2	0.6 cm^2	
Location 1	45.6	53.3	7.7
Location 2	37.4	46.5	9.1
Available Measurement Accuracy	--	--	2.5



Legend

T	–	Gas Temperature
dw	–	Drywell
ww	–	Wetwell
●	–	Approximate Location(s) of Temperature Measurement

Figure 1

Enclosure 2

MFN 08-344, Supplement 1

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DCD Tier 1 and Tier 2 Markups

assigned to a separate division. Each of the four groups provides temperature values for separate drywell and wetwell locations.

- Proximity switches on each VB body give positive indication of fully open or fully closed positions.
- The thermocouples are located in the:
  - Wetwell (on or adjacent to the VB debris screen);
  - Wetwell cavity (in the pipe cavity between the VB isolation valve and the end of the VB penetration on the wetwell sideisolation valve);
  - Drywell (1) (on or near the outlet of the VB isolation valve); and
  - Drywell (2) (inside the drywell separate from the VB/VB isolation valve assembly).
- Each VB isolation function ATWS/SLC division can be placed into manual bypass status that is automatically indicated in the MCR.

7.3.6.3 Safety Evaluation

Section 6.2 evaluates the VB isolation function and shows that for the entire range of nuclear process system pipe break sizes, the opening of a single VB ensures containment structure functional integrity.

Table 7.1-1 identifies the VB isolation function and the associated codes and standards applied, in accordance with the SRP. This subsection addresses I&C systems conformance to regulatory requirements, guidelines, and industry standards.

7.3.6.3.1 Code of Federal Regulations

10 CFR 50.55a(a)(1), Quality Standards for Systems Important to Safety:

- Conformance: The VB isolation function design complies with these standards.

10 CFR 50.55a(h), Protection and Safety Systems, compliance with IEEE Std. 603:

- Conformance: Safety-related systems are in conformance with RG 1.153 and IEEE Std. 603. Separation and isolation is preserved both mechanically and electrically in accordance with IEEE Std. 603, Section 5.6 and RG 1.75. The VB isolation function is divisionalized and designed with redundancy so failure of any instrument will not prevent the system operation. Electrical separation is maintained between the redundant divisions.The VB isolation function conforms to IEEE Std. 603. Conformance information is found in Subsection 7.1.6.6.1 through 7.1.6.6.1.27. Additional information concerning how the VB isolation function conforms to IEEE Std. 603 is discussed below.

- Section 4.2 (Safety-Related Function): See Subsection 7.3.6.1.
- Section 4.3 (Permissive Conditions for Operating Bypasses): Permissive conditions for operating bypasses are not applicable for the VB isolation function.
- Section 4.6 (Spatially Dependent Variables): See the Actuation Logic section of Subsection 7.3.6.2 & Subsection 6.2.1.1.5.5.1.

isare required to perform vacuum relief function. The third vacuum breaker provides redundancy while the second vacuum breaker provides single failure protection for opening. On the upstream side of each vacuum breaker, pneumatically operated fail-as-is safety-related isolation valves are provided to isolate a leaking (not fully closed) or stuck open vacuum breaker. During a LOCA, when the vacuum breaker opens and allows the flow of gas from WW to DW to equalize the DW and WW pressure and subsequently does not completely fully close as detected by the proximity sensors, a control signal closes the upstream isolation valve to prevent bypass leakage through the vacuum breaker and therefore maintain the pressure suppression capability of the containment.

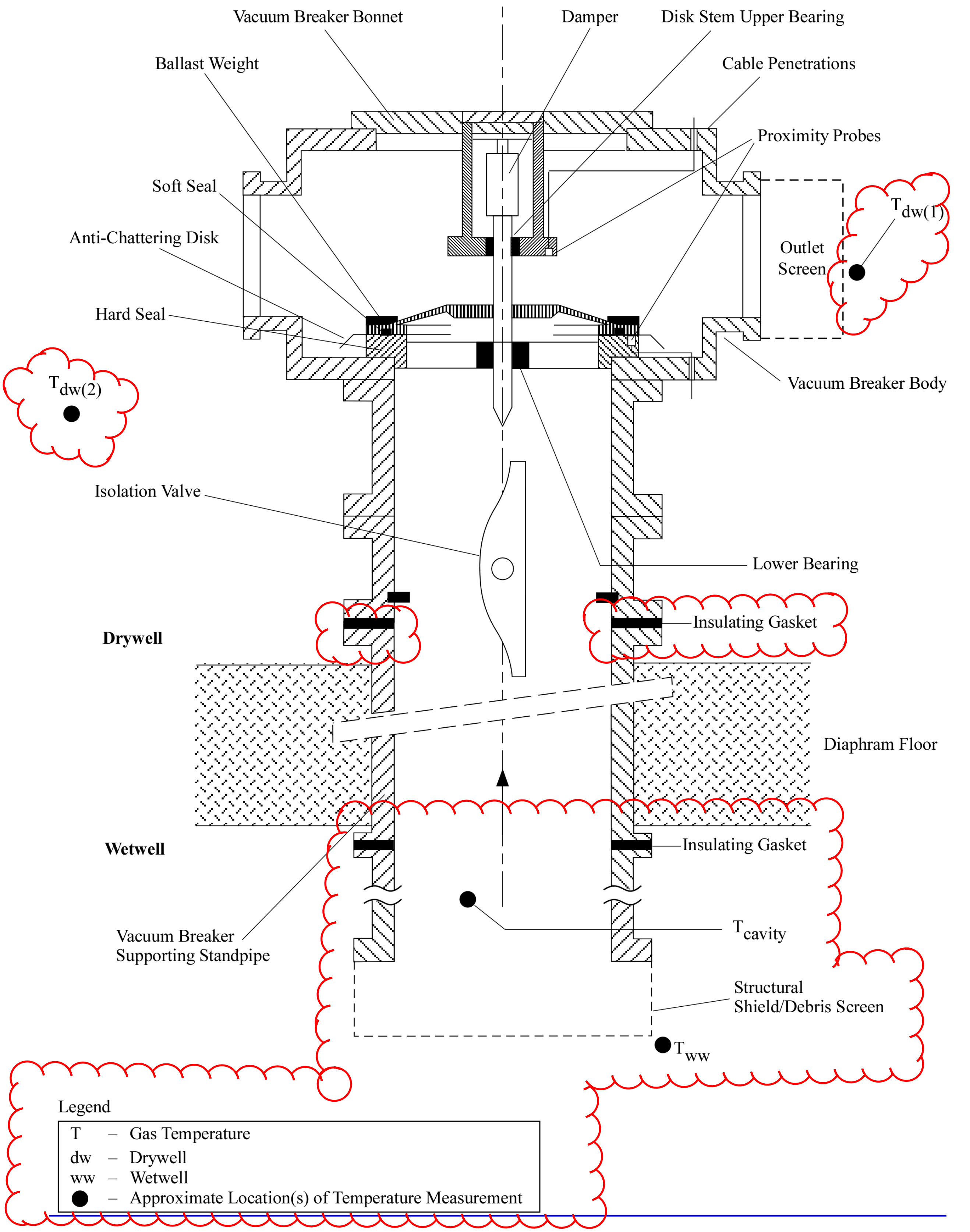
In addition to the proximity sensors, there are temperature sensors located on and in between the vacuum breaker/vacuum breaker isolation valve assemblyand the . See Figure 6.2-28 for approximate temperature sensor locations and sensor terminologyisolation valve. These sensors will detect a rise in temperature between the vacuum breaker and the end of the penetration on the wetwell side due to the hot DW gas leaking past a not fully closed vacuum breaker.bypass, relative to the WW gas When the difference between the cavity temperature, T_{cavity}, and the wetwell temperature, T_{ww}, exceeds a fraction of the difference between the drywell temperature, T_{dw1}, and wetwell temperature, T_{ww}, a signal is sent to the vacuum breaker isolation valve to close.which generates another control signal to close the isolation valve. The bulk drywell temperature, T_{dw2}, (Figure 6.2-28) is measured separately from the vacuum breaker/vacuum breaker isolation valve assembly and is used to detect LOCA conditions and acts as a permissive to allow the vacuum breaker isolation valve logic to function. The safety-related logic and control of the isolation valve is independent of the safety-related Safety-Related Distributed Control and Information System (Q-DCIS).

The corresponding bypass leakage area that the temperature sensors will detect to close a vacuum breaker isolation valve is a maximum analytical limit of 0.6 cm^2 ($A/\sqrt{K}$). Closing each vacuum breaker isolation valve at this bypass leakage assures the analytical limit of 2 cm^2 ($A/\sqrt{K}$) of total bypass leakage will not be exceeded in the unlikely scenario of three vacuum breakers not fully closing. This scenario assumes more than one single failure will occur which is beyond design basis accident requirements.

Each vacuum breaker isolation valve logic subsystem is located in physically separate divisional rooms or compartments that have appropriate fire barriers between them. The isolation valve can also be manually opened or closed. For more discussion on the logic control of the vacuum breaker isolation valves, see Subsection 7.3.6. The design WW-to-DW pressure difference and the vacuum breaker opening differential pressure are given in Table 6.2-1.

The vacuum breaker and vacuum breaker isolation valves are protected from pool swell loads by structural shielding/debris screen designed for pool swell loads determined based on the Mark II/III containment design. Both valves are located in the DW and connected to the WW gas space by a penetration through the diaphragm floor. The structural shielding/debris screen is located in the WW gas space at the inlet side of the penetration.

A safety-related PCCS is incorporated into the design of the containment to remove decay heat from DW following a LOCA. The PCCS uses six elevated heat exchangers (condensers) that are an integral part of the containment boundary located in large pools of water outside the containment at atmospheric pressure to condense steam that has been released to the DW following a LOCA. This steam is channeled to each of the condenser tube-side heat transfer


Vacuum Breaker Bonnet
Damper
Disk Stem Upper Bearing
Ballast Weight
Cable Penetrations
Proximity Probes
Soft Seal
Tdw(1)
Outlet
Screen
Anti-Chattering Disk
Hard Seal
Vacuum Breaker Body
Tdw(2)
Isolation Valve
Lower Bearing
Insulating Gasket
Drywell
Diaphram Floor
Wetwell
Insulating Gasket
Vacuum Breaker
Supporting Standpipe
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T – Gas Temperature
dw – Drywell
ww – Wetwell
– Approximate Location(s) of Temperature Measurement

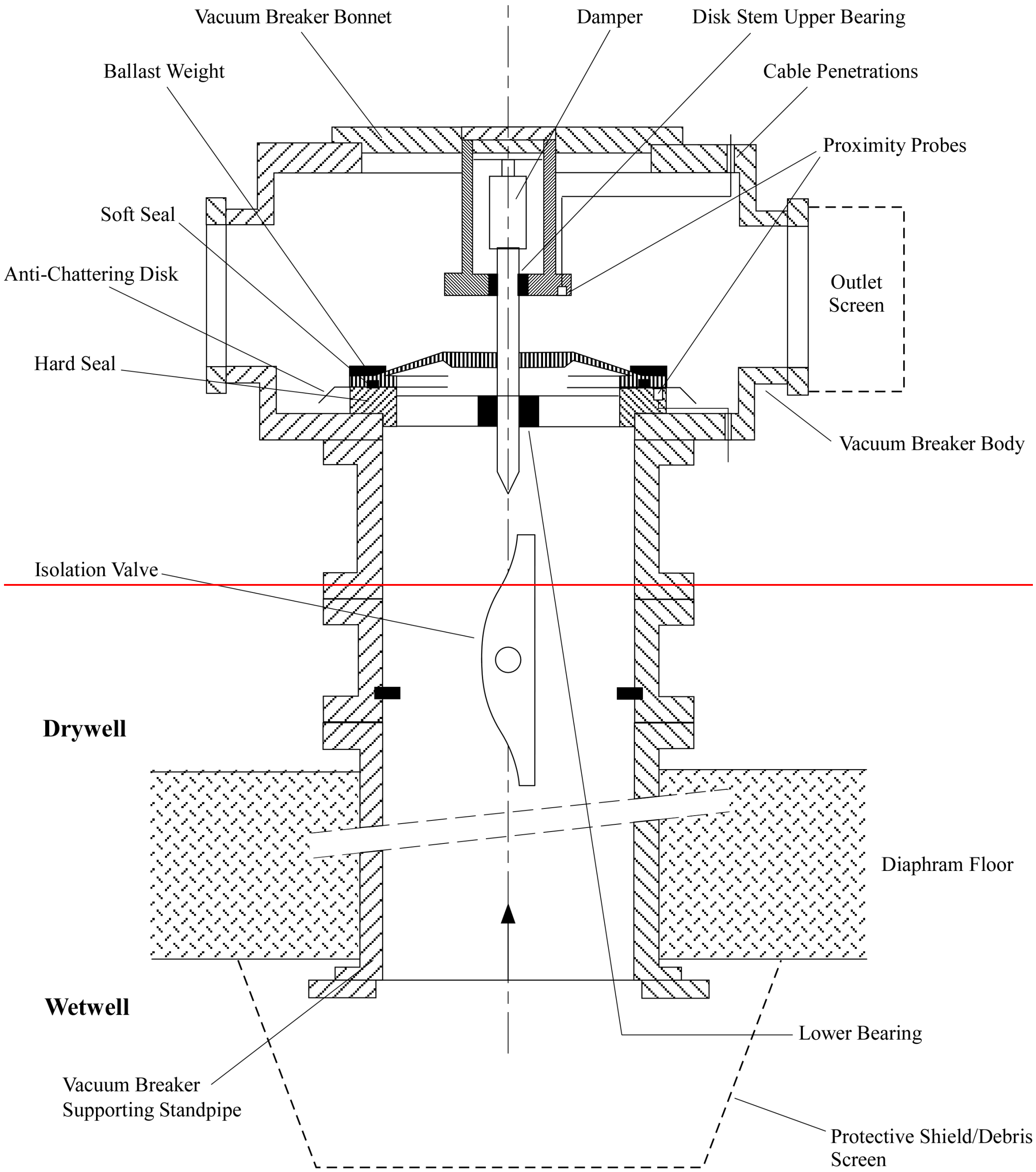
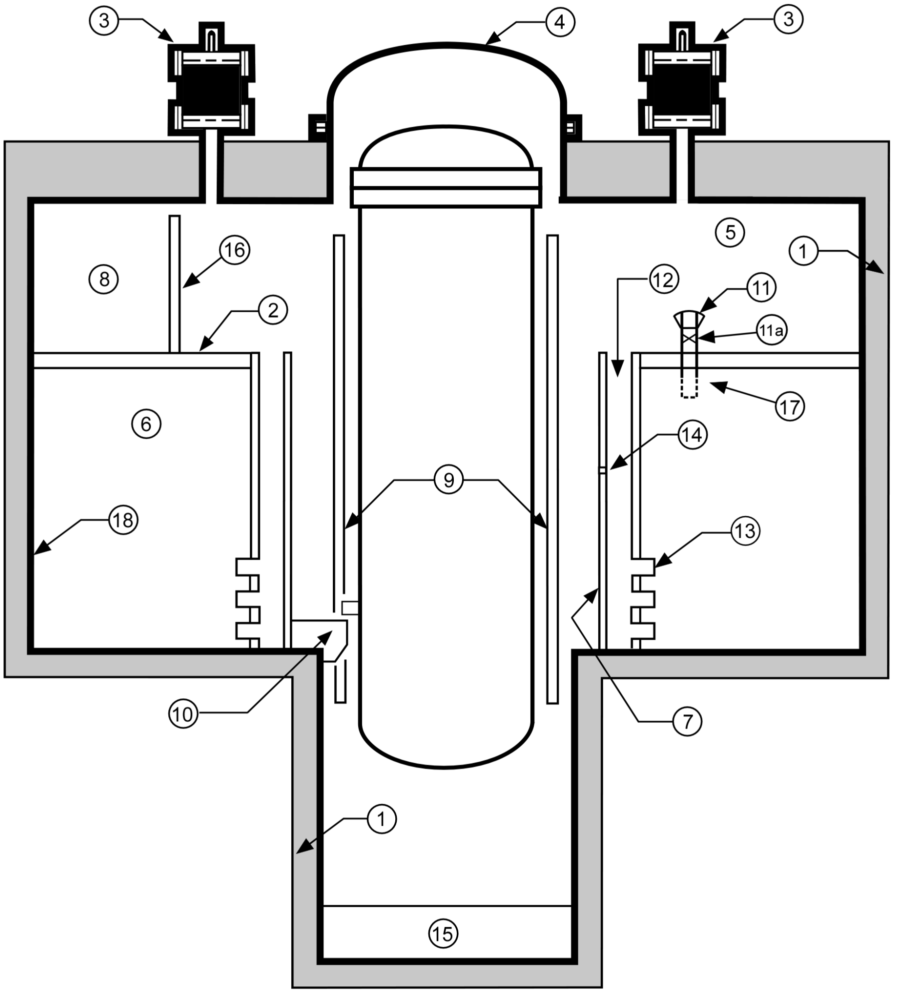


Figure 6.2-28. Wetwell-to-Drywell Vacuum Breaker

Table 2.15.1-2

ITAAC For The Containment System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
15. Each vacuum breaker isolation valve automatically closes if the vacuum breaker does not fully close when required.	A test will be performed by providing a simulated or real not-fully closed vacuum breaker signal originating from the closed position proximity sensor and temperature sensors to close the associated vacuum breaker isolation valve.	A report demonstrates exists and concludes that each as-built vacuum breaker isolation valve automatically closes when a simulated or real not-fully closed signal is provided from the closed position proximity sensor of its associated vacuum breaker.
16a. Each vacuum breaker has proximity sensors to detect open/close position. This indication is available in the main control room.	Testing will be performed with each as-built vacuum breaker to demonstrate that the proximity sensors indicate open and closed position.	Test report(s) demonstrate exist and conclud that each as-built vacuum breaker proximity sensor indicates an open position with the vacuum breaker open and indicates a closed position when the vacuum breaker is in the fully closed position. The open and closed position indications of the as-built vacuum breakers are available in the main control room.
16b. Each vacuum breaker has temperature sensors to detect bypass leakage. This indication is available in the main control room.	A type test will be performed on a vacuum breaker to detect bypass leakage at design basis accident conditions.	Test report(s) exist and conclude vacuum breaker temperature sensors discriminate within the range of ≥ 0.3 cm^2 and ≤ 0.6 cm^2 (A/√K) of bypass leakage area at design basis accident conditions.Records of test conclude vacuum breaker temperature sensors detect bypass leakage.

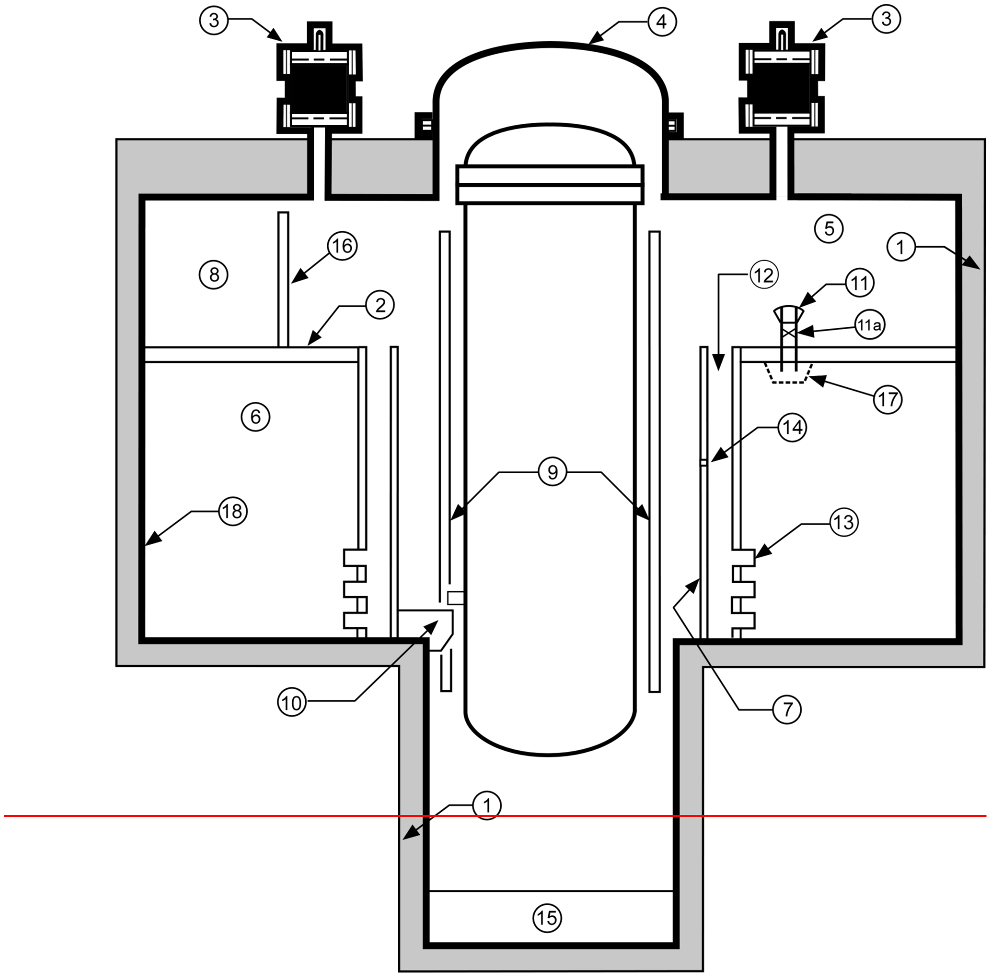


LEGEND

1. Reinforced Concrete Containment Vessel (RCCV)
2. Diaphram Floor Slab, Distance from bottom of slab to the Wetwell Floor > 12150 mm
3. (6) Passive Containment Cooling System (PCCS)
4. Drywell Head
5. Drywell
6. Wetwell
7. Vent Wall
8. (3) GDCS Pools
9. Reactor Shield Wall
10. (8) RPV Support Brackets
11. (3) Vacuum Breakers, ≥ 0.0967 m^2 (1.041 ft^2) Each

11a. (3) Vacuum Breaker Isolation Valves, ≥ 0.0967 m^2 (1.041 ft^2) Each

12. (12) Vertical Vents, ≥ 13.6 m^2 (146 ft^2) Total
13. (36) Horizontal Vents, ≥ 0.7 m (2.30 ft) I. D.
    - Top Row (centerline) 3.5 m (11.48 ft) above wetwell floor
    - Middle Row (centerline) 2.13 m (6.99 ft) above wetwell floor
    - Bottom Row (centerline) 4.69 m (2.49 ft) above wetwell floor
14. (12) Spillover Holes, 200 mm (8 inch) Nominal Diameter, Elevation 12370 mm
15. BiMAC
16. GDCS Pool Wall (Typical)
17. Protective Shield/Debris Screen
18. Suppression Pool Stainless Steel Liner



LEGEND
1. Reinforced Concrete Containment Vessel (RCCV)
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5. Drywell
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Figure 2.15.1-1. Containment System