HITACHI

**GE Hitachi Nuclear Energy**

James C. Kinsey
Vice President, ESBWR Licensing

PO Box 780 M/C A-55
Wilmington, NC 28402-0780
USA

T 910 675 5057
F 910 362 5057
jim.kinsey@ge.com

MFN 06-466, Supplement 4

Docket No. 52-010

March 8, 2008

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 116 Related to ESBWR Design Certification Application, RAI Number 6.2-102 S02**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter dated November 15, 2007 (Reference 1). Previous RAIs and responses were transmitted in References 2 thru 4. The GEH response to RAI Number 6.2-102 S02 is in Enclosure 1.

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

Sincerely,

James C. Kinsey
James C. Kinsey
Vice President, ESBWR Licensing

D068
NRO

References:

1. MFN 07-632, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 116 Related to ESBWR Design Certification Application*, November 15, 2007

2. MFN 06-393, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 79 Related to ESBWR Design Certification Application*, October 11, 2006

3. MFN 06-466. *Response to Portion of NRC Request for Additional Information Letter No. 79 - Containment Systems – RAI Numbers 6.2-102, 6.2-103 and 6.2-122,* November 21, 2006

4. MFN 06-466. *Response to Portion of NRC Request for Additional Information Letter No. 79 Related to ESBWR Design Certification Application- Passive Containment Cooling System – RAI 6.2-102 S01*, August 17, 2007

Enclosure:

1. Response to Portion of NRC Request for Additional Information Letter No. 116 Related to ESBWR Design Certification Application Passive Containment Cooling System RAI Number 6.2-102 S02

| | | |
|---|---|---|
| cc: | AE Cubbage | USNRC (with enclosure) |
| | GB Stramback | GEH/San Jose (with enclosure) |
| | RE Brown | GEH/Wilmington (with enclosure) |
| | DH Hinds | GEH/Wilmington (with enclosure) |
| | eDRF | 0000-0079-5781 |

# Enclosure 1

# MFN 06-466, Supplement 4

# Response to Portion of NRC Request for

# Additional Information Letter No. 116

# Related to ESBWR Design Certification Application

# Passive Containment Cooling System

# RAI Number 6.2-102 S02

## NRC RAI 6.2-102

*DCD Tier 2, Revision 1, Sections 6.2.4.3.2.1 and 6.2.4.3.2.2, state that the passive containment cooling system (PCCS) has no containment isolation valves (CIVs). This is contrary to the explicit requirements of General Design Criterion (GDC) 56, which state that such lines require a CIV inside containment and another outside containment. It is also inconsistent with the guidance of Standard Review Plan (SRP), Section 6.2.4, Rev. 2, June 1996, Regulatory Guide (RG) 1.141 as well as the national standard ANS-56.2/ANSI N271-1976 on the implementation of the statement in GDC 56. This standard allows other isolation provisions if it can be demonstrated that the containment isolation provisions for a specific class of lines are acceptable on some other defined basis.*

*The heat exchanger modules and piping of the PCCS outside containment, form closed systems. As the justification for having no CIVs, the DCD states that the heat exchanger modules and piping are designed as extensions of the safety-related containment, and that the design pressure of the PCCS is greater than twice the containment design pressure and the design temperature is the same as the drywell design temperature.*

*This clearly does not satisfy the explicit requirements of GDC 56 of 10 CFR Part 50,Appendix A, for two CIVs per penetration. However, GDC 56 also allows other isolation provisions if it can be demonstrated that the containment isolation provisions for a specific class of lines are acceptable on some other defined basis.*

*Regulatory guidance on the implementation of the "other defined basis" provision is found in SRP 6.2.4, Rev. 2, and RG 1.141, "Containment Isolation Provisions for Fluid Systems," dated April 1978, which endorses ANS-56.2/ANSI N271-1976, "Containment Isolation Provisions for Fluid Systems." These documents contain two pertinent discussions: 1) Necessary design provisions of a closed system outside containment, and 2) Allowable containment isolation provisions for a closed system outside containment.*

***(1) Necessary design provisions of a closed system outside containment***

*SRP 6.2.4, Rev. 2, "Containment Isolation System," section II, "Acceptance Criteria," states, under heading e., that a closed system outside containment should have, among other things, "... a design temperature and pressure rating at least equal to that for the containment."*

*ANS-56.2/ANSI N271-1976, section 3.6.7, "Criteria for Closed Systems Outside Containment," is consistent: "(3) Withstand temperature and internal pressure equal to the containment design conditions."*

*Thus, the DCD's justification statement indicates only that the PCCS meets one of the criteria for a closed system outside containment. It is not sufficient to justify having no CIVs.*

***(2) Allowable containment isolation provisions for a closed system outside containment***

*SRP 6.2.4, Rev. 2, "Containment Isolation System," section II, "Acceptance Criteria," states ,under heading e.:*

> *Containment isolation provisions for lines in engineered safety feature or engineered safety feature-related systems normally consist of two isolation valves in series. A single isolation valve will be acceptable if it can be shown that the system reliability is greater with only one isolation valve in the line, the system is closed outside containment, and a single active failure can be accommodated with only one isolation valve in the line. The*

> *closed system outside containment should be protected from missiles, designed to seismic Category I standards, classified Safety Class 2 (Ref. 9), and should have a design temperature and pressure rating at least equal to that for the containment. The closed system outside containment should be leak tested, unless it can be shown that the system integrity is being maintained during normal plant operations. For this type of isolation valve arrangement the valve is located outside containment, and the piping between the containment and the valve should be enclosed in a leak tight or controlled leakage housing. If, in lieu of a housing, conservative design of the piping and valve is assumed to preclude a breach of piping integrity, the design should conform to the requirements of SRP Section 3.6.2. Design of the valve and/or the piping compartment should provide the capability to detect leakage from the valve shaft and/or bonnet seals and terminate the leakage.*

*ANS-56.2/ANSI N271-1976, section 3.6.4, "Single Valve and Closed System Both Outside Containment," contains consistent criteria:*

> *For the isolation function of an engineered safety feature or system required to test an engineered safety feature, one barrier is required after the occurrence of a single active failure. Normally, this is accomplished by providing two isolation valves in series. If it is not practical to locate a valve inside containment and if it can be shown that a single active failure can be accommodated with only one valve in the line and that fluid system reliability is enhanced by the single valve over two valves in series while still maintaining at least a single mechanical barrier, and* ***if the closed system outside containment is treated as an extension of containment****, [emphasis added] then one valve is acceptable. The closed system shall be leak tested in accordance with 5.3 of this Standard unless it can be shown by inspection that system integrity is being maintained for those systems operating during normal plant operation at a pressure equal to or above the containment design pressure.*
>
> *The single valve and piping between the containment and the valve shall be enclosed in a protective leak tight or controlled leakage housing to prevent leakage to the atmosphere.*

*In other words, if the PCCS satisfies the criteria for a closed system outside containment, it needs one CIV per penetration, located outside containment. The justification provided in the DCD that the closed system is treated as an extension of containment does not, per the ANS standard, eliminate the need for one CIV; it is, in fact, necessary to justify having only one CIV instead of two.*

*Revise the DCD to provide a design which is consistent with the staff's regulatory position as detailed in SRP 6.2.4 and RG 1.141, or provide additional justification for maintaining the current design.*

**GE Response (original)**

As described in the DCD, the passive containment cooling system (PCCS) contains no containment penetrations, but is instead considered an extension of the containment boundary. This is an acceptable justification for the absence of containment isolation valves because as an extension of containment, the PCCS does not fall under the scope of GDC 56, SRP 6.2.4 Rev. 2 (July 1981), ANS-56.2/ANSI N271-1976, or RG 1.141. Rather, the PCCS is designed in accordance with SRP 6.2.1.1.C Rev. 6 (August 1984), which is the guideline for pressure suppression type BWR containments.

The classification of PCCS components as an extension of containment is justified by the description provided in DCD Tier 2, Section 6.2.2.3. This section contains a detailed explanation of all the requirements that shall be met by the PCCS as an extension of containment. As described in this section, the PCCS components located above the drywell shall be designed in accordance with GDC 2, 4, 16, 38, 39, 40, 51, 52, and 53. Compliance with SRP 6.2.1.1.C also requires that GDC 50 be satisfied, therefore a statement to this effect will be added to DCD Section 6.2.2.3.

**DCD Impact**

DCD Section 6.2.2.3 will be modified as shown in the attached markup.

**NRC RAI 6.2-102 S01(email):**

*DCD Tier 2, Revision 3, Sections 6.2.4.3.2.1 and 6.2.4.3.2.2, state that the passive containment cooling system (PCCS) has no containment isolation valves (CIVs). The heat exchanger modules and piping of the PCCS, outside containment, form closed systems. As the justification for having no CIVs, the DCD states that the PCCS does not penetrate containment, because the heat exchanger modules and piping are designed as extensions of the safety-related containment, and that the design pressure of the PCCS is greater than twice the containment design pressure and the design temperature is the same as the drywell design temperature.*

*In RAI 6.2-102, the staff stated that the PCCS must have CIVs, and, supported its position with extensive citations from the regulations (10 CFR Part 50, Appendix A, General Design Criterion 56) and the applicable official NRC guidance (Standard Review Plan 6.2.4, Rev. 2, "Containment Isolation System," and Regulatory Guide 1.141, "Containment Isolation Provisions for Fluid Systems," dated April 1978, which endorses national standard ANS-56.2/ANSI N271-1976, "Containment Isolation Provisions for Fluid Systems" (national standard)). Staff provided a quotation from the national standard that stated that even if the closed system outside containment is treated as an extension of containment, at least one CIV per line is still necessary.*

*GE's response, MFN 06-466, was a reiteration of their position that the system is considered an extension of the containment boundary, meaning that there are no containment penetrations in the PCCS, and therefore GDC 56, the SRP, the RG, and the national standard do not apply. The applicant cites several documents (other SRPs and GDC) which contain design provisions for the containment boundary, and states that the PCCS satisfies these provisions and so is an extension of containment.*

*Staff's Review of GE's Response:*

*(1) Staff's review found that the documents cited by the applicant only address design provisions for the containment in general such as for the walls and roof. The documents cited do not address any situation which is like the applicant's design (that is, a piping system outside of containment) or explain why no CIVs are needed in such a design. On the other hand, the guidance documents cited by the staff do specifically address designs like the PCCS.*

*(2) Staff understand that there is no explicit definition of "containment penetration" in the documents cited in staff's original RAI. Perhaps the authors felt that, when a pipe passes through the containment wall or roof (like the PCCS does), that this was obviously a containment piping penetration. However, there is the following definition in the national standard, in section 2, "Definitions and Terminology":*

> *Penetration assembly. An assembly that allows fluid lines or electrical circuits to pass through a single aperture (nozzle or other opening) in the containment.*

*Also, the national standard begins as follows:*

> *1. Purpose and Scope*
>
> *The primary purposes of this Standard are to specify minimum design, testing and maintenance requirements for the isolation of fluid systems which penetrate the primary containment of light water reactors. These fluid systems include piping*

*systems (including instrumentation and control) for all fluids entering or leaving the containment.*

*When applying the definitions of the national standard, it can reasonable be interpreted that the PCCS design does indeed have containment penetrations thus requiring CIVs.*

*(3) Even within the DCD, there is contradiction as to whether the PCCS has containment penetrations. Revision 3 of the DCD contains a new table, 6.2-47, titled "Containment Penetrations Subject to Type A, B, and C Testing." This table lists 18 containment penetrations in the PCCS, numbered T15-MPEN-0001 through T15-MPEN-0018.*

*Staff agrees that the portion of the PCCS outside of containment is considered to be an extension of containment. However, the applicant concludes without sufficient justification that this inherently means there are no containment penetrations and thus no requirement for any CIVs. The applicant has not provided precedents, regulations, guidance documents, or any other reference to support this conclusion.*

*Alternatively, staff has cited a national standard endorsed by Regulatory Guide 1.141 which specifically address the case of a closed system outside of containment which is considered to be an extension of containment. This national standard states that there must be at least one CIV in each line.*

*Provide additional justification for the current design of the PCCS, or revise the DCD with a redesign of the system to include CIVs, per the NRC's applicable regulatory position.*

**GEH Response (Supplement 1):**

GEH understands the position taken by the NRC in RAI 6.2-102 and its supplement, and agrees that the DCD is in need of clarification in areas that describe the ESBWR Passive Containment Cooling System (PCCS) design.

As stated in the RAI supplement, there is no explicit definition for several terms including "extension of containment", and GEH's use of these terms is necessarily different from that of several regulations that require isolation valves for pipelines of separate external cooling systems. Therefore, it is GEH's intention to provide a more explicit and specific description of the ESBWR containment's passive cooling in the DCD so it is better understood how the function is an integral part of the containment and structural boundary. This design approach is diametrically opposite of a traditional extension or closed system that provides the cooling function from outside of containment.

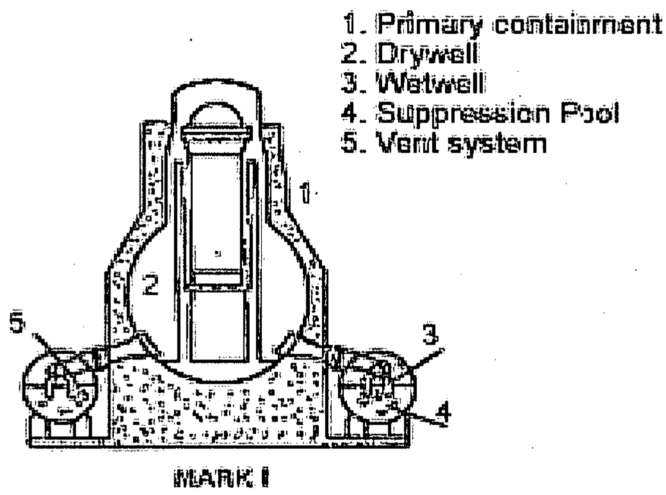
The original response to the RAI indicated the ESBWR containment cooling would be designed with consideration given to Standard Review Plan (SRP) 6.2.1.1.C instead of the documents listed by the staff (10 CFR 50, Appendix A, GDC 56; SRP 6.2.4, Revision 2; ANS-56.2/ANSI N271-1976; and Regulatory Guide 1.141). It was by no means GEH's intention that SRP 6.2.1.1.C would be the only guidance considered in the design of the PCCS.

PCCS provides a functional feature of the ESBWR primary containment that assures cooling in the event of a design basis accident (DBA) or anticipated operational occurrence (AOO), the result of which is a loss of normal containment cooling. PCCS is an inherent capability designed into the containment structure, and is not intrinsically a separate fluid process system. This is a specific departure from the past BWR plant designs including the ABWR. All past BWR containment designs have relied upon an external active safety-related fluid heat exchange system to provide containment cooling in response to DBA and AOO instrumentation and control (I&C) indications and control room operator response actions. To provide a safer and more reliable containment cooling function, PCCS negates the need for a separate active safety-related cooling system, and thus eliminates the need for fluid piping penetrations.

The ESBWR containment is designed under the scope of ASME Section III, Division 2, Article CC-1000. Within this article is Paragraph CC-1120, General Requirements, which states "The rules of Division I shall apply as required in this Subsection for parts and appurtenances not backed by structural concrete for load carrying purposes". As an integral part of the containment structural boundary not backed by concrete, PCCS is under the scope of ASME Section III, Division 1, NE-1130(a), which covers "the containment vessel."

In addition, as described in the original response to the RAI, the PCCS must be designed in accordance with GDC 2, 4, 16, 38, 39, 40, 50, 51, 52, and 53. The PCCS, therefore, does not fall under the scope of GDC 56.

Regulatory documents such as SRP 6.2.1.1.C are not limited to a simple wall and roof style containment, and the design of the ESBWR containment cooling function does have precedent. As an example, consider the Mark I style containment, shown below, which is included in the scope of SRP 6.2.1.1.C.




In a Mark I containment, the "light-bulb" shaped drywell is connected through a reinforced concrete barrier by a series of metal ducts to the wetwell metal torus. This wetwell design is a contiguous part of the containment (not an extension or closed system outside of containment). This design contains many features that are similar to the ESBWR, including the vent duct connections between the drywell and torus, which is a structural containment barrier that is not reinforced by concrete. The ESBWR containment can be understood as an extrapolation beginning from the Mark I containment.

Thus, the ESBWR containment design is an evolution, built on GEH's experience with previous containments, and specifically designed to incorporate the safety-related function of containment cooling directly into the containment structure. Accordingly, GEH has pursued following a design development that satisfies the applicable ASME Code requirements for Class CC and Class MC containment vessel design and construction.

The national standard definition of "penetration assembly" does not apply to the ESBWR PCCS function because the PCCS does not require fluid piping to "pass through a single aperture (nozzle or other opening) in the containment." By definition, a system that forms an integral part of the containment boundary cannot do this.

GEH understands that the DCD contains numerous inconsistencies regarding this topic. In some places, the PCCS is correctly described as function built into the containment boundary. In other places it is incorrectly described as if it were an extension of containment or a closed system outside containment.

An extensive review of the DCD has been performed to standardize the description of the PCCS as being an integral part of the containment boundary. These descriptions will be revised in both DCD Tier 1 and DCD Tier 2 to correct all inconsistencies.

**DCD Impact:**

The following sections of DCD, Tier 1, and DCD, Tier 2, will be revised as shown in the attached markups: *[Note: Refer to MFN 06-466, Supplement 1 dated August 17, 2007 for the 60 pages of markup pages].*

- Tier 1, Subsection 2.15.4
- Tier 1, Table 2.15.4-1
- Tier 1, Figure 2.15.4-1
- Tier 2, Figure 1.1-2
- Tier 2, Subsection 1.2.2.15.4
- Tier 2, Table 1.3-2
- Tier 2, Sections 3.1 and 3.8
- Tier 2, Table 3.2-1
- Tier 2, Subsection 3.9.3
- Tier 2, Section 6.2 and Subsection 6.6.1
- Tier 2, Tables 6.2-10 and 6.2-47
- Tier 2, Figures 6.2-1, 6.2-15, and 6.2-16
- Tier 2, Subsections 7.1.5 and 7.3.2
- Tier 2, Subsections 9.1.6 and 9.2.5
- Tier 2, Subsection 15.5.6
- Tier 2, Subsection 16.3.6.1.7, 16B.3.6.1.7, and 16B.3.7.1

**NRC RAI 6.2-102 S02**

*In RAI 6.2-102, Supplemental No. 1, Staff had restated the original RAI 6.2-102 and position:*

*"In RAI 6.2-102, the staff stated that the PCCS must have CIVs, and, supported its position with extensive citations from the regulations (10 CFR Part 50, Appendix A, General Design Criterion 56) and the applicable official NRC guidance (Standard Review Plan 6.2.4, Rev. 2, "Containment Isolation System, " and Regulatory Guide 1.141, "Containment Isolation Provisions for Fluid Systems," dated April 1978, which endorses nationals standard ANS-56.2/ANSI N271-1976, "Containment Isolation Provisions for Fluid Systems" (national standard)). Staff provided a quotation from the national standard that stated that even if the closed system outside containment is treated as an extension of containment, at least one CIV per line is still necessary."*

*GEH's response to Supplement No. 1 clarified and corrected many discrepancies in the DCD to support their original position that the system is considered an extension of the containment boundary, meaning that there are no containment penetrations in the PCCS, and therefore GDC 56, the SRP, the RG, and the national standard do not apply. The applicant uses the Mark I containment as a precedent example for which the wetwell design is a contiguous part of the containment (not an extension or closed system outside of containment.). GEH states that "the ESBWR containment can be understood as an extrapolation beginning from the Mark 1 containment."*

*In a conference call, dated October 19, 2007, Staff restated its position that the national standard applies to the PCCS design and that GEH did not provide sufficient justification to deviate from the National Standard as endorsed in RG 1.141.*

*During the conference call, GEH responded with new information. GEH stated that from a risk perspective, it was safer not to have CIVs in the PCCS.*

*Please provide the risk analysis performed to support GEH's conclusion that from a risk perspective it is safer not to have CIV's in the PCCS. Include a comparison of the probability of CIV failure to the probability of a leak in the PCCS.*

**GEH Response**

The probability of the PCCS condensers leaking is assumed to be conservatively bounded by generic data for a "general use heat exchanger leaks during operation". Taken from EPRI ALWR URD (PRA Reference 5-1, Table A2-1, Survey Entry 53), this failure rate is 1.0E-6/hr. Failure probabilities are then:

- 24 hour mission time = 2.4E-5
- 72 hour mission time = 7.2E-5

The sum of all the Level 1 PRA core damage cutsets that would survive truncation when ANDED with the 72-hour PCCS leak probability is 5.81E-9/yr. Accordingly, with no containment isolation valves on the PCCS and assuming a conservative leakage probability, the probability of a PCCS leak over 72 hours coincident with core damage is (5.81E-9/yr)*(7.2E-5) = 4E-13/yr. Considering that total release frequency is currently 9.62E-10/yr, the unisolated PCCS leakage scenario is not considered risk-significant. In addition, the source term from hypothetical cracking in the PCCS piping would likely be small in the Level 2 PRA.

To evaluate the risk associated with PCCS isolation valves, the following assumptions were made:

1) Isolation valves would be actuated automatically by Q-DCIS on high radiation in the PCCS pools (same as the ICS high-radiation isolation)
2) The common cause failure of safety-related software would isolate the PCCS
3) Each penetration has one isolation valve
4) The spurious Q-DCIS software failure probability is 1E-4

As only 4/6 PCCS loops are required for successful containment heat removal, the only significant failure mode emerged to be inadvertent actuation of the isolation valves by the Q-DCIS. That is, individual spurious valve closure did not contribute to increased risk. Effectively, the model change required to simulate the containment isolation valves involved changing top gate "WP-TOPDHR" for PCCS from an "EQU" gate to an "OR" gate with two inputs:

- T15-3/6 LOOPS: "Loss of three out of six PCCS loops" (from the current PRA model)
- C63-CCFSOFTWARE_S: "Common cause failure of software, for spurious"

The actual fault tree modification is shown in Figure 1.

The results of the PCCS isolation valve study are shown below; all calculations were done with a truncation of 1E-13/yr:

- The CDF increased from 1.066E-8/yr to 8.076E-7/yr
- Non-TSL (nTSL) release frequency increased from 8.64E-10/yr to 8.00E-7/yr (note that the 9.62E-10/yr quoted above is a result of 1E-15/yr truncation)
- Conditional Containment Failure Probability (CCFP) increased from 0.079 to 0.991

The CDF rises noticeably with the addition of PCCS isolation valves, but the significant result is the increase in CCFP to almost 1.0. Introducing the spurious software failure as a failure mode to PCCS significantly reduces its reliability and places more importance on other methods of containment heat removal. A summary of the probability that the containment isolation valves fails PCCS versus the probability of a PCCS leak is provided in Table 1.

The installation of containment isolation valves that are subject to spurious closure by software error increases the CDF by almost two orders of magnitude, the nTSL frequency by three orders, and increases the conditional containment failure probability to approximately 1.0.

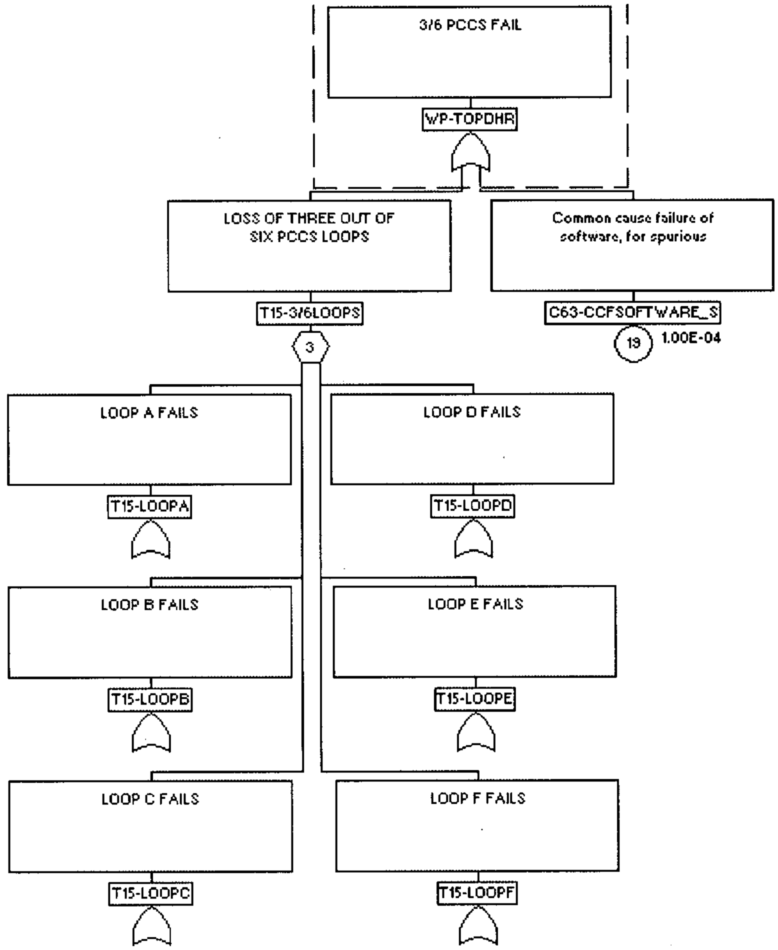



*Figure 1 – PCCS Fault Tree Modification (WP-TOPDHR was an EQU Gate)*

| Event | Probability |
|---|---|
| PCCS Containment Isolation Valves Fail the PCCS by Inadvertent Actuation Signal via Q-DCIS | 1E-4 |
| A PCCS Condenser Leaks Coincident with Core Damage, Requiring Isolation | 4E-13/yr |

*Table 1 – Probabilistic Cost/Benefit Comparison for PCCS Isolation Valves*

**DCD Impact**

No DCD changes will be made in response to this RAI.

NEDO-33201 Section 11 will be updated to include this sensitivity study.