# BWR OWNERS' GROUP

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Project No. 691

BWROG-02008
February 21, 2002

Mr. Joseph Donoghue,
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U.S. Nuclear Regulatory Commission
Mail Stop O 7E1
Washington, DC 20555-0001.

SUBJECT: **Submission Of NEDC-33046 Report - Technical Justification to Support Risk-Informed Primary Containment Isolation Valve AOT Extensions for BWR Plants For NRC Staff Review**

The BWR Owners' Group (BWROG) is submitting the attached report for NRC Staff review and approval. This report is being submitted as part of the industry Risk Informed Technical Specification Task Force (RITSTF) Initiative 4a, risk informed allowed outage times (AOTs).

This report provides the results of the application of risk informed analyses to identify improvements in AOT specified for primary containment isolation valves (PCIVs) in BWR Technical Specifications. The analyses provide bounding risk assessments of the impact of adopting the proposed AOT change.

The analyses conclude that plant safety and operational improvements can be achieved by extending the AOT for primary containment isolation valves from the current 4, 24, or 72 hours to 7 days in order to perform on-line maintenance, repair, or testing. Justification of this AOT modification is based on an integrated review and assessment of plant operations, deterministic/design basis factors, and plant risk.

The scope of the analysis included all PCIVs except the Main Steam Isolation Valves (MSIVs) and the ones in the Feedwater system. Based on the results of the analysis, the acceptance criteria for AOT extension were not met for the Low Pressure Core spray (LPCS) PCIVs for BWR 5/6 plants and the Shutdown Cooling Suction PCIVs for all BWRs.

The results demonstrate that the risk level associated with the proposed AOT is below the regulatory guidelines set forth in Regulatory Guides 1.174 and 1.177. The proposed change increases the time available to perform on-line PCIV maintenance and reduce the potential for, and associated risks of, unnecessary plant shutdowns

If you have any questions regarding these comments, please contact Don McCamy (TVA), BWROG Risk Informed Technical Specification Committee Chairman at (259) 729-2474 or Rick Hill (GE) Project Manager at (408) 925-5388.

Sincerely,

Original Signed By

J. A. Gray, Jr.
BWR Owners' Group Chairman

Attachment: NEDC-33046

cc: K Putnam, BWROG Vice Chairman
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BWROG RITS Committee
B. Bradley, NEI
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# BWROG SPECIFIC COMMENTS ON RISK-BASED PERFORMANCE INDICATORS: RESULTS OF PHASE-1 DEVELOPMENT

1. Important information that is required to understand the PIs and their thresholds is not included in the body of the report, but is buried in footnotes in the appendices. Sometimes the footnote directly contradicts the information presented in the text. The following are some examples of this:

   Table A.1.1.1-1 – The footnote indicates that BWR general transients do not meet the 1E-6 CCDP criterion for being included in the risk based initiators but are included anyway because their frequency is high. This goes against the text that explains the criteria for including initiating events. This type of information should be included in the text rather than being buried in a footnote in an appendix.

   Page A-9 – A footnote indicates the LOFW and LOHS initiators include loss of offsite power events. This information needs to be included in the body of the report. Loss of offsite power events have very different CCDPs and inpact than LOFW and LOHS events with power available. By combining these initiators, it effectively applies a LOOP CCDP to LOFW and LOHS initiator frequencies. This information should be incorporated into the review of the main document.

   Table A.1.4 series of tables – These tables contain footnotes that indicate general transients include the LOHS and LOFW events. Once again, this effectively applies the higher CCDP from LOHS and LOFW to the higher initiating event frequency of a general transient. This information is essential for the review of the main document. The thresholds in the tables do not make sense without this information.

   Table A.2.4 series of tables contain important information in the footnotes. It states that the unreliability value also includes unavailability. These should not be combined, because these two parameters have different affects on model results. This information is necessary to understand the tables in the main part of the report.

2. On page A-51, one of the LERF multipliers is stated to be 10. This can't be correct since the multipliers must range from 0 to 1.

3. Table A.3.1-1 contains two BWR Mark I rows.

4. On page A-58, the author provides a "reformulation" of LERF. This should not be done in this paper. The reformulation introduces a "large" definition that is different than is typically used at BWRs. Most BWRs use 10% of the CsI

released to the environment as the threshold for "large". It is also different than the definition in the ASME Standard (draft) on PRA applications for both "large" and "early". The standard defines "early" as prior to effective offsite actions. The definition of "early" in this appendix would indicate that TW sequences are early releases. This is not typical. The definition needs to be left to the standard and not reformulated for the PIs.

5. Section B totally mischaracterizes the shutdown risk contributors for BWRs. The risk is high in the first two days of cold shutdown because decay heat is high and the model probably did not credit steam driven systems. It is not directly a result of POS 5 (cold shutdown with the head on). In fact, risk follows decay heat level. If the head is replaced later in the outage, CDF is extremely low due to the long time to boil. Also, if steam driven systems are not properly credited in the model, CDF is over predicted. For POS 5 (as defined in the appendix), it is likely that CDF has a high contribution from loss of AC power events (other initiators tend to be lower). In LOOP events, the reactor can re-pressurize so that high pressure systems can be used for injection. It is suggested that the shutdown PIs be deferred until the risk drivers during shutdown are properly understood and can be reflected appropriately in performance indicators.

6. In the section of fire events, there is an inconsistency with the way plants treat fire mitigating system impairments. Most plants put compensatory measures in place when detection/suppression systems are impaired. In nearly all cases, these measures are just as reliable as the automatic systems, so unavailability has very little meaning as a PI. In addition, many plants' fire systems are only licensed for automatic containment of the fire, rather than suppression. Manual suppression means are typically required even if the automatic systems are available.

7. In many of the sections in Appendix F, the reader is referred to F.6 for the calculation that was performed. F.6 only contains the calculation for one of the PIs. It then says that a later table will cover the others. We could not find this "later" table.

8. The process that was used in Appendix F to create data to validate the thresholds is not valid. Duplicating and recombining existing data points does not create any new information, and cannot be used to increase the statistical significance of that data set. This evaluation needs to be performed by identifying plants that have both good and bad performance, and then taking actual data from those plants

9. Abbreviations and Acronyms – page xix – LPI and LPR are both defined as Low Pressure Injection.

10. Page 2-8 – Fourth paragraph in Step 4, first sentence – It seems like the sentence should read "Some elements under the initiating events cornerstone and mitigating systems cornerstone affect <u>CDF</u> as well as <u>LERF</u>."

11. Paragraph 3.2.2 – Without the benefit of having Appendix B, the methodology in the subject paragraph seems somewhat suspect.

12. The method uses time in a configuration in excess of the baseline as metric of risk. The numerator in the cited equation is ΔCDP threshold. This paragraph states that the thresholds are the standard thresholds for G/W, W/Y, and Y/R. However, the threshold established in Section 2 is based on core damage frequencies per year not changes in core damage probabilities.

13. Configuration CCDF, is assumed to be calculated for each plant. The frequency of the CCDF expressed here is per day. If one assumes the average CDF for operation, 1E-5 per year, the CDF per day is 2.7E-8. This means the outage configuration needs to be 36 times more likely to yield core damage than the normal operating configuration just to have a CCDF of 1E-6, which is low. Using the listed thresholds and CCDFs the threshold Δt's will range from .01 to 100 days. Hence, a color change can occur when .01 of a day is exceeded and when, 0.1 of a day is exceeded, etc. Having short time limits is relatively meaningless since outage delays typically will exceed 2.4 hours.

14. Section 5 Validation and Verification: It appears that V&V is for the data (failure rates) being used. It seems more appropriate to pick a plant with declining performance and apply the RBPI methodology to it to determine if the indicators would predict declining performance.

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NEDC-33046
Class 2
DRF A13-00485-00
February 2002

# Technical Justification to Support Risk-Informed Primary Containment Isolation Valve AOT Extensions for BWR Plants

BWR Owners' Group
Risk-Informed Technical Specification Committee

## IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

**Please Read Carefully**

# ABSTRACT

This document provides the results of the application of risk informed analyses to identify improvements in allowed outage time (AOT) specified for primary containment isolation valves in BWR Technical Specifications (TS). The analyses provide bounding risk assessments of the impact of adopting the proposed AOT change.

The analyses conclude that plant safety and operational improvements can be achieved by extending the AOT for primary containment isolation valves from the current 4, 24, or 72 hours to 7 days in order to perform on-line maintenance, repair, or testing. Justification of this AOT modification is based on an integrated review and assessment of plant operations, deterministic/design basis factors, and plant risk. The results demonstrate that the risk level associated with the proposed AOT is below the regulatory guidelines set forth in Regulatory Guides 1.174 and 1.177. The proposed change increases the time available to perform on-line PCIV maintenance and reduce the potential for, and associated risks of, unnecessary plant shutdowns.

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# ACRONYMS

| | |
|---|---|
| AOT | Allowed Outage Time |
| AOV | Air Operated Valve |
| ASME | American Society of Mechanical Engineers |
| BWR | Boiling Water Reactor |
| BWROG | Boiling Water Reactor Owners' Group |
| CCDP | Conditional Core Damage Probability |
| CDF | Core Damage Frequency |
| CDP | Core Damage Probability |
| CE | Combustion Engineering |
| CEOG | Combustion Engineering Owners' Group |
| CRD | Control Rod Drive |
| CSS | Containment Spray System |
| CST | Condensate Storage Tank |
| CTMT | Containment |
| CV | Check Valve |
| ECCS | Emergency Core Cooling System |
| EFCV | Excess Flow Check Valve |
| ESF | Engineered Safety Feature |
| ESFAS | Engineered Safety Feature Actuation Signals |
| GE | General Electric Company |
| HPCI | High Pressure Coolant Injection |
| HPCS | High Pressure Core spray |
| ICCDP | Incremental Conditional Core Damage Probability |
| ICLERP | Incremental Conditional Large Early Release Probability |
| ISLOCA | Interfacing System LOCA |
| ISTS | Improved Standard Technical Specifications |
| LCO | Limiting Condition of Operation |
| LERF | Large Early Release Frequency |
| LERP | Large Early Release Probability |
| LOCA | Loss-of-Coolant Accident |
| LPCI | Low Pressure Coolant Injection |
| LPCS | Low Pressure Core Spray |

## ACRONYMS (Continued)

| | |
|---|---|
| MOV | Motor Operated Valve |
| MSLB | Main Steam Line Break |
| NOED | Notice of Enforcement Discretion |
| NRC | Nuclear Regulatory Commission |
| NSSS | Nuclear Steam Supply System |
| PCIV | Primary containment Isolation Valve |
| PSA | Probabilistic Safety Analysis |
| PWR | Pressurized Water Reactor |
| RCIC | Reactor Core Isolation Cooling |
| RCS | Reactor Cooling System |
| RHR | Residual Heat Removal |
| RWCU | Reactor Water Cleanup |
| SDC | Shutdown Cooling |
| SI | Safety Injection |
| SLOCA | Small Break LOCA |
| STS | Standard Technical Specifications |
| TCV | Turbine Control Valve |
| TS | Technical Specifications |

# EXECUTIVE SUMMARY

This report provides the technical analysis to support extending the Allowed Outage Time (AOT) for a specific set of primary containment isolation valves (PCIVs) from 4, 24, or 72 hours to 7 days during Modes 1, 2, and 3. This activity is a continuation of the Industry's Risk-Informed Technical Specifications improvement initiatives. This AOT extension is sought to provide flexibility in the performance of surveillance testing, preventive and corrective maintenance of containment isolation/pressure boundary valves during power operation. This will allow allocation of time for on-line maintenance, repair and testing of a PCIV. Justification of this AOT modification was based on an integrated review and assessment of plant operations, deterministic/design basis factors, and plant risk.

The proposed increase in AOT for a particular PCIV was evaluated from the perspective of various risks associated with plant operation. Incorporation of the proposed extension of AOT into the Technical Specifications may result in a negligible to small increase in the "at power" risk, as measured in terms of incremental increase in probabilities for core damage and large early release. The incurred plant risk will be strongly dependent on how the AOT is utilized. It is expected that the primary usage of the proposed extended AOT will involve low risk or risk insignificant maintenance activities associated with preventive maintenance of the subject PCIV.

The inoperability of a PCIV that is in the open position was found to have an insignificant to small risk impact on events that may give rise to large early radionuclide releases. Therefore, any decrease in containment reliability due to the inoperability of a PCIV that is in the open position for the requested TS modifications would result in a negligible impact on the incremental large early release probability for GE BWRs.

The scope of the analysis included all PCIVs except the Main Steam Isolation Valves (MSIVs) and the ones in the Feedwater system. Based on the results of the analysis, the acceptance criteria for AOT extension were not met for the Low Pressure Core spray (LPCS) PCIVs for BWR 5/6 plants and the Shutdown Cooling Suction PCIVs for all BWRs.

In conclusion, the results of this evaluation demonstrate that the proposed AOT extension provides plant operational flexibility while simultaneously allowing plant operation with an acceptable level of risk. The results demonstrate that the risk level associated with the proposed AOT is below the regulatory guidelines set forth in Regulatory Guides 1.174 and 1.177. The proposed change increases the time available to perform on-line PCIV maintenance and reduce the potential for, and associated risks of, unnecessary plant shutdowns.

# 1.0 PURPOSE

The purpose of this report is to provide a risk-informed justification for modifying the Technical Specification allowed outage time (AOT) for many primary containment isolation valves (PCIVs) of units with GE BWR NSSS designs. Specifically, this report provides technical justification for an extension of the AOT for the "Primary Containment Isolation" function from 4, 24, or 72 hours to 7 days. This proposed modification applies to those PCIVs addressed by Conditions A, C, and E of Section 3.6.1.3 of NUREG-1433, Revision 2 (Attachment 1) and Section 3.6.1.3 of NUREG-1434, Revision 2 (Attachment 2). In addition, this report identifies a limited set of valves for which an AOT change is not requested. This report has been prepared in the same format as the Combustion Engineering Owners' Group (CEOG) report for AOT extension of containment isolation valves in CE PWR plants (Reference 11).

Implementation of the described AOT modifications will enhance plant safety by providing flexibility in the performance of preventive and corrective maintenance during power operation. Furthermore, the proposed modifications will also reduce the potential for, and associated risks of, unnecessary plant shutdowns and consequently the need for exigent Notices of Enforcement Discretion (NOEDs).

The described AOT modifications are consistent with the objectives and intent of the Maintenance Rule (Reference 1). The Maintenance Rule controls the actual maintenance cycle by defining annual unavailability goals and assessing instantaneous maintenance risk. The described AOT modifications will support efficient scheduling of maintenance within the boundaries established by implementing the Maintenance Rule. The overall risk of performing maintenance will be controlled according to paragraph (a)(4) of the Maintenance Rule.

In addition, this report evaluates the treatment of the inoperability of dual function valves. These valves provide both containment pressure boundary control function and system accident consequence limiting functions.

# 2.0 SCOPE OF PROPOSED CHANGE TO TECHNICAL SPECIFICATIONS

## 2.1 DEFINITION OF PRIMARY CONTAINMENT ISOLATION VALVE

In describing "primary containment isolation valves" corresponding to LCO 3.6.1.3 in NUREG-1433, Revision 2 (Reference 2) and NUREG-1434, Revision 2 (Reference 3), the Bases Section B.3.6.1.3 states:

> "The OPERABILITY requirements for PCIVs help ensure that an adequate primary containment boundary is maintained during and after an accident by minimizing potential paths to the environment. Therefore, the OPERABILITY requirements provide assurance that primary containment function assumed in the safety analyses will be maintained. These isolation devices are either passive or active (automatic). Manual valves, de-activated automatic valves secured in their closed position (including check valves with flow through the valve secured), blind flanges, and closed systems are considered passive devices."

In the corresponding Action Condition Statements of NUREG-1433/4, Revision 2, the "primary containment isolation valves" as defined in NUREG-1433/4 are divided into the following three categories:

- PCIVs for containment piping penetrations, other than containment purge lines, that have two PCIVs (as defined by NUREG-1433/4) in the associated piping line (Addressed by Conditions A and B of LCO 3.6.1.3 of NUREG 1433/4, Revision 2)
- PCIVs for containment piping penetrations, other than containment purge lines that have one PCIV in the associated piping line. (Addressed by Condition C of LCO 3.6.1.3 of NUREG 1433/4, Revision 2)
- PCIVs associated with the containment penetrations for containment purge lines. (Addressed by Condition E of LCO 3.6.1.3 of NUREG 1433/4, Revision 2)

The Technical Specifications for each GE BWR NSSS unit include Technical Specifications that address these three categories of PCIVs (PCIVs as defined in NUREG 1433/4, Revision 2).

For some GE BWR NSSS units, the specific Technical Specification sections that address these three categories of PCIVs also address "containment pressure boundary" function requirements for valves that serve the piping penetrations of "accident consequence limiting systems." These "accident consequences limiting systems" include (but are not necessarily limited to) Emergency Core Cooling Systems, Reactor Core Isolation Cooling System, Containment Spray, cooling water to Residual Heat Removal System, and the Main Feedwater System. The Technical Specifications of each and every GE BWR NSSS unit includes sections concerning each of the applicable "accident consequence limiting systems.)

This study does not include an evaluation of the AOTs associated with Secondary Containment Isolation Valves.

## 2.2 PROPOSED EXTENSION OF AOTS

For the majority of PCIVs that correspond to either Condition A, Condition C or Condition E of LCO 3.6.1.3 in NUREG 1433/4, this report provides justifications for an extension in the AOT for the applicable Action (Action A.1, C.1, or E.1) from 4, 72 or 24 hours to 7 days. A specific set of valves were excluded from the analysis. The valves in this set include: valves associated with main feedwater systems, and the Main Steam Isolation Valves. In addition, there were two systems identified in the analysis where the acceptance criteria for AOT extension were not met. These include Low Pressure Core Spray PCIVs for BWR 5/6 plants and Shutdown Cooling Suction PCIVs for all BWRs.

## 2.3 CONSIDERATION OF "ACCIDENT CONSEQUENCE LIMITING SYSTEMS"

Valves that have both a "containment pressure boundary" function and a separate accident consequence limiting function were explicitly assessed for the impact of their loss of primary containment isolation function only. The impact of valve inoperability, as it affects the ability of the valve to perform other accident mitigation functions, is considered within the scope of the Technical Specification for the associated inoperable system. This philosophy is consistent with the ISTS approach for assessment of operability of dual function valves.

# 3.0 BACKGROUND

This report provides a risk-informed technical basis for specific changes to Technical Specification Allowed Outage Times (AOTs). The applicable AOTs are those that correspond to the LCO and Conditions of Section 3.6.1.3 of NUREG 1433/4, Revision 2. The primary intent of the proposed changes is to provide for the potential of on-line maintenance, repair and testing of a Primary Containment Isolation Valve (PCIV) that is declared INOPERABLE during operation in the applicable modes (Modes 1, 2, and 3). These changes are warranted based on the low risk associated with the extended AOTs and the relatively greater risk associated with transitioning from the existing Mode to cold shutdown (Mode 4).

This application is being pursued by the BWROG as a risk informed plant modification in accordance with NRC Regulatory Guides 1.174, (Reference 4) and 1.177 (Reference 5). Each utility will assess the risk associated with plant maintenance as part of plant programs(s) to meet paragraph (a)(4) of the Maintenance Rule.

To expedite the review process, this report provides, where appropriate, generic bounding risk assessments of the impact of adopting these TS changes. The risk calculations included in this evaluation consider all significant impacts of PCIV TS modification, including:

- Assessment of the Incremental Conditional Core Damage Probability (ICCDP) and Incremental Conditional Large Early Release Probability (ICLERP) resulting from allowing PCIVs to remain in the OPEN position for the duration of the AOT.
- For systems with PCIVs that are connected to the RCS, ICCDP/ICLERP assessments include consideration of Interfacing System LOCA (ISLOCA).
- Assessment of Incremental Conditional Core Damage Probability (ICCDP) associated with retaining the valves that have a safety function (in addition to primary containment isolation), in the closed position for an extended time.

Risk evaluations also include explicit consideration of incremental risks associated with PCIVs connected to systems containing non-seismically qualified piping. All risk assessments consider the impact of maintaining the PCIV in an open position.

In accordance with Regulatory Guide 1.177, Single AOT risks are evaluated against the "very small risk" metrics of 5.0E-7 for ICCDP and 5.0E-8 for ICLERP. The cumulative impact of multiple simultaneous and sequential entries into the TS is also considered

The supporting/analytical material contained within the document is considered applicable to all GE BWR NSSS designed units of the BWROG member utilities regardless of the category of their Plant Technical Specifications, and regardless of the valve actuators.

# 4.0 SUMMARY OF APPLICABLE TECHNICAL SPECIFICATIONS

There are three distinct categories of Technical Specifications at GE BWR NSSS units.

The first category concerns Technical Specifications (TSs) that reference the Improved Standard Technical Specifications (ISTS) guidance provided in NUREG-1433/4 (Revision 2, dated April 2001). Most GE BWR NSSS units have either completed the conversion to the ISTS or are in process.

The second category concerns Technical Specifications in the format of the original Standard Technical Specifications (STS). A few plants have approved STS and have not converted to the ISTS.

The third category includes those Technical Specifications that have structures other than those that are outlined in either the ISTS or the STS. These TSs are generally referred to as "customized" technical specifications and are associated with the early GE BWR designs.

Each of these categories of Technical Specifications include operating requirements for Primary Containment Isolation Valves (PCIVs) corresponding to the PCIVs addressed in NUREG-1433/4 LCO 3.6.1.3.

Additionally, as stated in Section 2, for some GE BWR NSSS units, the specific Technical Specification sections that address these three categories of PCIVs also address "containment pressure boundary" function requirements for valves that serve the piping penetrations of "accident consequence limiting systems." These "accident consequence limiting systems" include (but are not necessarily limited to) Emergency Core Cooling Systems, Reactor Core Isolation Cooling System, Containment Spray, cooling water to Residual Heat Removal System, and the Main Feedwater System. (The Technical Specifications of each and every GE BWR NSSS unit includes sections concerning each of the applicable "accident consequence limiting systems.")

## 4.1 IMPROVED STANDARD TECHNICAL SPECIFICATIONS GUIDANCE

As discussed in Section 2, Section 3.6.1.3 of NUREG-1433/4, Revision 2 describes LCO requirements, required action requirements, and corresponding AOT requirements for three categories of containment isolation valves (PCIVs). Section 2 of this report also provides a description of the NUREG-1433/4 definitions of these three categories of PCIVs.

This report provides risk-informed justifications for AOT extensions corresponding to the actions in response to either Condition A, Condition C, or Condition E as defined in NUREG-1433/4. These Conditions and the existing corresponding required actions and AOTs are:

*CONDITION A APPLICABILITY: Penetration Flow Paths with Two PCIVs with One PCIV Inoperable (except for purge valve leakage not within limit).*

When in CONDITION A, one PCIV in the affected penetration flow path is INOPERABLE. The Allowed Outage Time (AOT) for the required action is 4 hours. The required action is isolation of the affected penetration by use of at least one closed and de-activated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

*CONDITION C APPLICABILITY: Penetration Flow Paths with One PCIV with One PCIV Inoperable.*

When in CONDITION C, the single PCIV in the penetration flow path is INOPERABLE. The AOT for the inoperable PCIV is 4 hours except for excess flow check valves (EFCVs) and penetrations with a closed system. The AOT for an inoperable EFCV or a PCIV in a closed system is 72 hours. The required action in both cases is isolation of the affected penetration by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange.

*CONDITION E APPLICABILITY: One or More Penetration Flow Paths With One or More Containment Purge Valves Not Within Purge Valve Leakage Limits.*

When in Condition E, one or more containment purge valves in the affected flow path are not within leakage limits. The AOT for the required action is 24 hours. The required action is isolation of the affected penetration by use of at least one closed and de-activated valve, closed manual valve, or blind flange.

For each of the GE BWR NSSS units with Technical Specifications referencing ISTS guidance, the described guidance of NUREG-1433/4, Revision 2 (including the AOT for 4 hours, 24 hours, and 72 hours) is fully integrated into the corresponding applicable "PCIV" Technical Specification.

For each of the GE BWR NSSS units with Technical Specifications with STS format or "customized" Technical Specifications, there are corresponding Technical Specifications with AOTs of no greater than 4 hours, 24 hours, or 72 hours.

## 4.2 VALVES SUPPORTING ACCIDENT CONSEQUENCE LIMITING SYSTEMS

For some GE BWR NSSS units, the specific Technical Specification sections that address the three categories of PCIVs NUREG-1433/4 Section 3.6.1.3 also addresses the "containment pressure boundary" function requirements for valves that serve the piping penetrations of "accident consequence limiting systems."

# 5.0 SYSTEM DESCRIPTION AND OPERATING EXPERIENCE

## 5.1 SYSTEM DESCRIPTION

The primary function of primary containment isolation valves is to prevent the release of radioactive material from either the primary containment atmosphere or the reactor coolant system to the outside environment via a containment penetration. At the same time, primary containment isolation valves must function to allow the passage of essential fluids across the containment boundary to support the safe operation of the reactor and to support the design features that mitigate the consequences of an accident.

As a result of the wide range of affected systems and functions, plants utilize various types of primary containment isolation valves including: (a) manually-operated valves, (b) motor-operated valves, (c) air-operated valves, and (d) check valves. Some primary containment isolation valves are automatically actuated to a closed position by one or more Engineered Safety Feature Actuation Signals (ESFAS), such as Primary Containment Isolation System as defined in NUREG-1433/4.

Some other primary containment isolation valves are automatically actuated to an open position by a LOCA Signal. These primary containment isolation valves include valves that are components of ECCS, Containment Spray System (CSS), or cooling water for containment heat removal.

There are also containment penetrations that have either associated primary containment isolation valves that are only manually-operated or installed blind flanges.

For purposes of this assessment, the types of containment piping flow paths are categorized into five general classes (A through E), with Classes A, B, C and E further subdivided in Section 6.3. These flow path classes reflect the (1) safety function of the flow path, and (2) the manner in which the flow path communicates between the Reactor Coolant and the environment. Through a survey of operating BWR plants, it was concluded that the above flow path classes, with the conservative assumptions made in the analysis, envelope all the PCIV configurations in these plants.

Characterization of Primary Containment Isolation Valve Flow Paths

**Class A**

This type of containment flow path connects the containment atmosphere to the environment, or connects to non-seismically qualified piping that interfaces with containment atmosphere. The PCIVs and/or piping or ductwork represent the only barriers between the containment atmosphere and the outside environment. A typical example of this type of piping penetration is the station air line to containment.

**Class B**

This type of containment piping flow path connects directly to the Reactor Coolant Pressure Boundary (Reactor Coolant). With the loss of containment isolation, a pathway may be established from the Reactor Coolant to the environment. The PCIVs and/or piping represent the only barriers between the reactor coolant and reactor coolant exposed systems outside the containment. An example of a reactor coolant exposed system is Reactor Water Cleanup (RWCU).

**Class C**

This type of containment piping flowpath is connected to a closed loop system inside the containment. These closed loop systems are designed to withstand a higher pressure than the containment design pressure. As a result, failure of the closed loop piping is deemed insignificant. A typical example of this type of containment piping penetration is Reactor Building Component Cooling Water (RBCCW) supply and return lines.

**Class D**

This type of containment piping penetration is used for measuring containment pressure. Typically, a closed PCIV and a closed piping system outside the containment represent the only barriers between the containment atmosphere and the outside environment. An example of this piping penetration is the containment pressure sensing line.

**Class E**

This type of containment piping penetration is designed to open during a design basis event. Consequently, the PCIVs associated with this type of piping penetration do not provide a barrier against the release of radioactivity during Engineered Safety feature (ESF) system operation. During ESF system operation, containment integrity is maintained by a water seal established by the flow of water into containment and the volume of water in the suppression pool.

A typical example of this type of piping penetration is the Low Pressure Coolant Injection (LPCI) line.

## 5.2 OPERATING EXPERIENCE

### 5.2.1 Preventive Maintenance

In light of the current 4, 24, and 72 hour AOTs, on-line scheduled preventive maintenance of PCIVs is rare. A limited amount of surveillance testing is performed.

Maintenance activities associated with PCIVs include:

- valve overhaul
- valve repacking
- power supply/air supply support, plant specific

Typically, PCIV maintenance requires more time than is currently allowed via the technical specification.

### 5.2.2 Surveillance/Testing of PCIVs

Testing of PCIVs (Motor-operated valves, Air-operated valves and Check Valves) occurs as a result of post-maintenance testing and in-service inspections. The scopes of these tests vary based on the type of valve, specific activity and utility procedures. The interval for in-service testing is defined via the Technical Specifications and Section XI of ASME Boiler and Pressure Vessel Code. This testing may be performed either at power or during a plant shutdown. In the case of dynamic testing of the MOVs at power, it is required that the MOV stroke time be within a specified band and that the valve operator performance be within defined limits. Testing times for a single MOV can vary from under one hour to more than 8 hours. (Failure of tested valves to meet dynamic response

criteria can result in considerably longer inoperabilities for the valves.) For the majority of plants, the test is conducted so as to not disable the valve's ability to receive and respond to an Engineered Safety Features Actuation Signal, and for all plants the actual time interval that the tested valve is either not functional, or in its design-base event response position, is small.

At many plants, valve testing requires system tagout and entry into the LCO ACTION STATEMENT. An extended AOT is necessary to provide adequate time to properly identify and correct any problems found as a result of any particular surveillance and/or dynamic test. The extended AOT will increase the potential for on-line valve repair or repositioning.

### 5.2.3 Corrective Maintenance

Corrective maintenance for PCIV involves valve repair. In practice, the term corrective maintenance is typically used for the repair of a valve resulting from an observable malfunction that may or may not compromise the ability of the affected PCIV to perform its safety function. This terminology typically places corrective maintenance on PCIVs due to small stem leakage (which does not necessarily impair valve function) into the same category as more extreme failures such as a debilitating failure of the valve operator. The terminology also includes the repairs performed in response to conditions observed during the surveillance tests that were discussed in the previous section of this report. The extended AOT will increase the potential for on-line valve repair or repositioning.

As previously discussed in, Section 5.2.2, during MOV dynamic testing, the applicable system train is "INOPERABLE" by definition, and the associated system AOT is applicable. In order for the tested valve and the system to be returned to an OPERABLE condition, the valve characteristics must be measured to be within a specified band of torque and flow. If these parameters fall outside the defined bands during testing, the MOV and the system remain INOPERABLE. The remainder of the system AOT can be used to perform corrective maintenance and retesting to return the valve and the system to an OPERABLE condition. An inability to complete this corrective maintenance and determination of the OPERABILITY of the valve within the remainder of the AOT would result in the applicability of other Technical Specification requirements to bring the plant to a mode where the affected valve does not need to be OPERABLE.

# 6.0 TECHNICAL JUSTIFICATION FOR PCIV AOT EXTENSION

This section presents an integrated assessment of the proposed AOT extensions. The assessment includes discussion of: (a) motivation and need for technical specification change, (b) the impact of the change on the plant design basis and (c) probabilistic risk assessment of the proposed change.

Section 6.1 presents a summary statement of the need for the AOT extension (the supporting information for this section has been previously presented in Section 5). Section 6.2 provides an assessment of deterministic factors, particularly those associated with the plant design basis. The following sections generally follow the NRC guidance set forth in Reference 5 for risk informed changes to Technical Specifications. The probabilistic risk assessment for this AOT extension is contained in Section 6.3.

The considerations of multiple AOT entries and accumulated risk are addressed in Section 6.4. The risk of mode transition and plant shutdown is provided in Section 6.5. Tier 2 considerations and programs(s) to meet paragraph (a)(4) of the Maintenance Rule are provided in Sections 6.6 and 6.7, respectively.

## 6.1 STATEMENT OF NEED

The OPERABILITY requirements for PCIVs help ensure that the accident analysis assumptions concerning the release of radiological releases remain valid.

The containment isolation valve LCO was derived from the assumptions related to minimizing the loss of reactor coolant inventory and establishing the containment boundary during a major accident. The design basis accidents that potentially result in a release of radioactive material within containment are a Loss-of-Coolant Accident (LOCA) and a Main Steam Line Break (MSLB). In the analysis for each of these accidents, it is assumed that containment isolation valves are either closed or function to close within the required isolation time following event initiation.

Extending the AOT from the current 4, 24, and 72 hours to 7 days would provide sufficient margin to effect most anticipated preventive, and corrective maintenance activities (including "on-line" valve surveillance testing). It is currently recommended that the 7 day AOT would apply to all PCIVs included within Condition A, C and E of the current Technical Specifications.

## 6.2 ASSESSMENT OF DETERMINISTIC FACTORS

Technical Specification 3.6.1.3 governs the time that PCIVs may remain INOPERABLE for all plant operating modes above cold shutdown (Mode 4). Individually and in combination, the PCIV controls the extent of leakage from the containment following an accident. This technical specification modification is applicable to the reduction in the redundancy in the containment isolation for a limited time period and should not alter the ability of the plant to meet the overall containment leakage technical specification (corresponding to NUREG-1433/4, Revision 2 Section 3.6.1.1). In developing proposed license amendments for extended opening of a PCIV, a licensee must confirm that the action of locking open a subject PCIV will not result in the design basis technical specification containment leakage being exceeded. This confirmation will demonstrate capability to support accident analysis assumptions.

The design basis impact of the 7 day AOT on plant operation with a locked OPEN PCIV is discussed below for the various flowpath classes defined in Section 5.1.

**Class A Flowpaths**

The PCIVs associated with these flowpaths have no design basis function other than to isolate the containment in the event of an accident.

**Class B Flowpaths**

The PCIVs associated with these flowpaths have the intended function to isolate in order to minimize the leakage of reactor coolant. For example, failure to isolate RWCU will result in an additional Reactor Coolant leakage. The RWCU line has 2 valves capable of isolating the penetration. These valves each receive a signal to close on LOCA. Therefore, the consequence of locking one of the RWCU line PCIVs in the OPEN position will have no impact on the ability of the system to perform its design basis function. The remaining valves in this category are typically within small diameter sampling lines. Typically a redundant PCIV or similar valve capable of system isolation is available to provide assurance of containment isolation following an accident.

**Class C Flowpaths**

The PCIVs associated with these flowpaths have no design basis safety function other than to isolate the containment in the event of an accident.

**Class D Flowpaths**

The class D piping penetration includes the containment pressure sensor. The PCIVs associated with Class D containment piping penetrations are designed to be open during power operation and provide integral input to the Engineered Safety Features Instrumentation System. The PCIVs are designed to be open during post-accident conditions. These lines are of very small diameter and/or contain flow limiters in the sensing line so that isolation of the PCIVs is not required.

**Class E Flowpaths**

There are three types of Class E penetrations of interest: (1) penetrations designed to provide coolant injection to the Reactor, (2) penetrations designed to provide makeup flow to the Reactor, and (3) penetrations designed to support post-accident heat removal. These penetrations are designed to be open in the event of an accident. In some instances these PCIVs are also open during power operation to perform normal operational functions. For these penetration flowpaths locking the PCIV in the OPEN position satisfies the accident mitigation safety function. Locking the valve CLOSED will satisfy the containment isolation safety function but jeopardize and/or impair the ability to meet the mitigation function associated with the specific system, and the plant may not be able to operate for an extended period without being forced to shut down. The PCIVs that are actuated in an open position or receive a confirmatory open signal are the ECCS isolation valves, Containment Spray System (CSS) isolation valves, and the RCIC isolation valves.

<u>ECCS Isolation Valves</u>

In the case of ECCS Safety Injection (SI) isolation valves (LPCI/HPCS(HPCI)/LPCS isolation valves), the unavailability of one SI flowpath will not compromise the ability of

the ECCS to mitigate a LOCA. Thus, while inoperability of a single SI isolation valve to open may render the system technically INOPERABLE, the system remains fully capable of meeting the intent of LOCA event mitigation (that is, the system remains functional).

CSS Isolation Valves

Inoperability of those CSS valves that serve a containment isolation function to open will render the associated containment spray system INOPERABLE. This has minimal impact on the accident mitigation capability of the CSS since the redundant means of spray injection is available (via a second spray train).

RCIC Isolation Valves

The operability issues associated with the RCIC Isolation valves overlap with RCIC operability. BWR Technical Specifications (References 2 and 3) require RCIC operability to include both its ability to open (to satisfy its decay heat removal function) and the ability to remain closed or to close in the event of a steam supply line break. Thus by extending the PCIV AOT to 7 days, the limiting LCO associated with the PCIV in the open position will become the one associated with RCIC operability.

## 6.3 ASSESSMENT OF RISK

### 6.3.1 Overview

The purpose of this analysis is to provide an integrated assessment of the overall plant risk associated with the adoption of the proposed Allowed Outage Time (AOT) extension from 4, 24, or 72 hours to 7 days for the Containment Isolation Valves (PCIVs). The methodology used to evaluate the PCIV AOT extension was based in part on the guidance provided in Regulatory Guide 1.174 (Reference 4) and Regulatory Guide 1.177 (Reference 5). These Regulatory Guides outline criteria for the acceptability of a Technical Specification modification.

Regulatory Guide 1.177 provides the acceptance guidelines that are specific to AOT changes. The extracted guidelines from this Regulatory Guide are as follows:

- The licensee has demonstrated that the Technical Specification (TS) AOT change has only a small quantitative impact on plant risk. An Incremental Conditional Core Damage Probability (ICCDP) of less than 5.0E-7 is considered small for a single TS AOT change. An Incremental Conditional Large Early Release Probability (ICLERP) of 5.0E-8 or less is also considered small. Also, the ICCDP contribution should be distributed in time such that any increase in the associated conditional risk is small and within the normal operating background (risk fluctuations) of the plant (Tier 1).
- The licensee has demonstrated that there are appropriate restrictions on dominant risk-significant configurations associated with the change (Tier 2).
- The licensee has implemented a risk-informed plant configuration control program. The licensee has implemented procedures to utilize, maintain, and control such a program (Tier 3).

Section 6.3.2 provides a risk assessment of the PCIV AOT extension with respect to consideration of the associated "at power" risks only.

### 6.3.2 Assessment of "At Power" Risk

The BWROG has developed a process for evaluating plant risk associated with the proposed changes to the PCIV TS AOT. The process involves grouping the various containment penetrations into defined classes. For each class, the containment penetrations are further sub-divided into generic type of configurations. An evaluation is then performed for each of the generic configurations of containment penetration to assess the impact on plant risk due to the proposed AOT extension of the associated PCIVs. The evaluation of the impact on plant risk determines the change in core damage frequency (ΔCDF), the incremental conditional core damage probability (ICCDP), the change in large early release frequency (ΔLERF) and the incremental conditional large early release probability (ICLERP). For the assessment provided herein, it is assumed that the inoperability of one of the PCIVs associated with a particular piping penetration is known. Typically this awareness of the PCIV inoperability will develop as a consequence of in-service testing, (or other activity requiring cycling of PCIVs. It is further assumed that an assessment is conducted to ensure the remaining PCIV is operable [that is common cause failure mode is absent]). The "at power" risk caused by the inoperability of two PCIVs associated with a particular piping penetration is not included in this evaluation.

The general assumptions/input used in assessing the plant risk due to the proposed PCIV AOT extension is provided below. The classes of containment penetrations and estimates the plant risk associated with the generic configurations within each of the classes are described following the general assumptions.

#### 6.3.2.1 General Assumptions/Input

The following general assumptions/input were made or used in estimating the plant risk due to the proposed PCIV AOT extension. The values used in the calculations are not plant specific and are intended to be bounding for the BWROG member utilities.

a. The PCIV AOT is assumed to increase from its current duration of 4, 24, or 72 hours to a proposed duration 168 hours for all PCIVs with the exception of Main Steam and Feedwater.

b. The duration of the proposed PCIV AOT is assumed to be adequate for performing the majority of PCIV on-line maintenance. Consequently, shutting down the plant due to the inoperability of a single PCIV is assumed to be unlikely. That is, when considering the extended AOT, the added risk of core damage or large early release resulting from forced shutdown of the plant due to exceeding the AOT for PCIV TS Action statement is assumed to be negligible.

c. It is assumed the likelihood of piping failure during the proposed AOT associated with a specific piping penetration of containment is negligible. The length of piping associated with the penetration is small in comparison to the total length of the run of corresponding piping. Additionally, the associated piping penetrating

conforms to design criteria intended to minimize failure of both the penetration and the piping within the penetration.

d. Because of the bounding nature of the calculations provided herein, it is conservatively assumed that CDF due to bypass events (those core damage events that bypass the containment) is negligible in comparison to the overall average CDF. For this evaluation, a value of zero is conservatively assumed in assessing the incremental impact of the overall PCIV AOT extension plant risk events.

e. Data used for calculating the ICCDP and ICLERP are based on bounding input values. These values are summarized in Table 6.3-1. A comparison of these values for various BWROG member utilities is presented in Table 6.3-2.

**Table 6.3-1: Risk Parameter Values Used for Calculating ICCDP and ICLERP**

| Parameter[1] | Value | Comments |
|---|---|---|
| Plant core damage frequency (per year) | 5.56E-5 | Bounding value based on most limiting BWROG plant CDF value from Table 6.3-2 |
| Large early release frequency (per year) | 4.27E-6 | Bounding value based on most limiting BWROG plant LERF value from Table 6.3-2 |
| Conditional core damage probability due to SLOCA | 9.00E-5 | Bounding value – See Table 6.3-2 |
| Conditional core damage probability due to Intermediate LOCA | 5.50E-3 | Bounding value – See Table 6.3-2 |
| Conditional core damage probability due to turbine trip | 8.93E-6 | Bounding value – See Table 6.3-2 |
| Core damage frequency due to seismic event (per year) | 2.10 E-5 | Bounding value based on most limiting BWROG plant Seismic CDF – See Table 6.3-2 |
| Core damage frequency due to seismic SLOCA event (per year) | 2.31 E-7 | Bounding value based on most limiting BWROG plant Seismic CDF – See Table 6.3-2 |
| Core damage frequency due to seismic MLOCA event (per year) | 1.0 E-7 | Bounding value based on most limiting BWROG plant Seismic CDF – See Table 6.3-2 |

Note for Table 6.3-1

1. Conditional core damage probability is defined as the core damage frequency for the initiator of concern divided by the corresponding initiating event frequency.

**Table 6.3-2: Comparison of Key Risk Parameters**

| BWROG PLANTS | Risk Parameter | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Core Damage Frequency (per year) | Conditional Core Damage Probability due to SLOCA | Conditional Core Damage Probability due to Intermediate LOCA | Conditional Core Damage Probability due to Turbine Trip | Core Damage Frequency due to Seismic Event (/yr) | Core Damage Frequency due to Seismic SLOCA | Core Damage Frequency due to Seismic Intermediate LOCA | Large Early Release Frequency (/yr) |
| Plant A | 1.24E-05 | 3.16E-06 | **5.50E-03** | 8.85E-07 | N/A | N/A | N/A | 2.2E-06 |
| Plant B | Similar unit to Plants C and D | | | | | | | |
| Plant C | 1.05E-06 | 2.14E-06 | 5.10E-04 | 1.01E-07 | N/A | N/A | N/A | 1.35E-07 |
| Plant D | 1.90E-06 | 1.79E-06 | 5.18E-04 | 1.87E-07 | N/A | N/A | N/A | 2.08E-07 |
| Plant E | 2.44E-06 | <8.13E-06 | <8.13E-05 | 1.04E-07 | N/A | N/A | N/A | 6.62E-07 |
| Plant F | 7.13E-06 | 3.49E-06 | 9.73E-5 (Note 3) | 2.74E-06 | N/A | N/A | N/A | 1.18E-06 |
| Plant G | 5.5E-06 | 1.30E-06 | 8.67E-04 | 7.57E-08 | N/A | N/A | N/A | N/A |
| Plant H | 8.66E-06 | 8.62E-05 | 1.83E-04 | 8.39E-07 | 4.70E-06 | 2.5E-10 | N/A | 1.00E-06 |
| Plant I | 2.61E-06 | 5.83E-07 | 3.12E-04 | 5.23E-07 | N/A | N/A | N/A | 1.44E-06 |
| Plant J | 4.60E-06 | 8.00E-06 | 3.53E-04 | 4.506E-07 | N/A | N/A | N/A | 3.10E-06 |
| Plant K | 1.30E-5 | **9.00E-05** | 4.9E-04 | 5.71E-07 | 1.30E-06 | 3.60E-08 | N/A | 1.40E-06 |
| Plant L | 4.80E-05 | 9.75E-06 | 2.27E-04 | 1.2E-06 | 6.30E-07 | N/A | N/A | 9.70E-07 |
| Plant M | 2.24E-05 | 5.25E-07 | 3.80E-05 | 1.12E-06 | **2.10E-05** | **2.31E-07** | **<1.0E-07** | 1.33E-06 |
| Plant N | 1.22E-05 | 4.87E-06 | 6.1E-05 | 9.54E-07 | N/A | N/A | N/A | 1.43E-07 |
| Plant O | 8.58E-06 | 6.25E-06 | 2.78E-04 | 8.47E-07 | 6.00E-07 | 6.50E-08 | 2.6E-09 | 1.50E-06 |

Notes for Table 6.3-2

1. Conditional core damage probability is defined as the core damage frequency for the initiator of concern divided by the corresponding initiating event frequency
2. Bold face values indicate those used in the evaluation.
3. Combined Intermediate and Large LOCA CCDP for Plant F.

<table>
<tr><th colspan="9">Table 6.3-2 (Continued): Comparison of Key Risk Parameters</th></tr>
<tr><th rowspan="2">BWROG PLANTS</th><th colspan="8">Risk Parameter</th></tr>
<tr><th>Core Damage Frequency (per year)</th><th>Conditional Core Damage Probability due to SLOCA</th><th>Conditional Core Damage Probability due to Intermediate LOCA</th><th>Conditional Core Damage Probability due to Turbine Trip</th><th>Core Damage Frequency due to Seismic Event (/yr)</th><th>Core Damage Frequency due to Seismic SLOCA</th><th>Core Damage Frequency due to Seismic Intermediate LOCA</th><th>Large Early Release Frequency (/yr)</th></tr>
<tr><td>Plant P</td><td>5.56E-5</td><td rowspan="2"><7.27E-5</td><td rowspan="2"><3.33E-4</td><td rowspan="2">8.93E-6</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td rowspan="2">4.27E-6</td></tr>
<tr><td>Plant Q</td><td>5.49E-5</td></tr>
<tr><td>Plant R</td><td>5.0E-06</td><td>8.79E-06</td><td>3.33E-04</td><td>2.09E-07</td><td>N/A</td><td>N/A</td><td>N/A</td><td>6.0E-08</td></tr>
<tr><td>Plant S</td><td>4.0E-06</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>6.0E-08</td></tr>
<tr><td>Plant T</td><td>3.0E-06</td><td>5.09E-07</td><td>9.40E-06</td><td>5.58E-07</td><td>N/A</td><td>N/A</td><td>N/A</td><td>2.0E-08</td></tr>
<tr><td>Plant U</td><td>4.0E-06</td><td>N/A</td><td>N/A</td><td>5.80E-07</td><td>N/A</td><td>N/A</td><td>N/A</td><td>7.0E-07</td></tr>
<tr><td>Plant V</td><td>2.7 E-7</td><td>1.5 E-6</td><td>3 E-7</td><td>5.8 E-8</td><td>N/A</td><td>N/A</td><td>N/A</td><td>8.5 E-10</td></tr>
<tr><td>Plant W</td><td>2.7 E-7</td><td>1.5 E-6</td><td>3 E-7</td><td>5.8 E-8</td><td>N/A</td><td>N/A</td><td>N/A</td><td>8.5 E-10</td></tr>
<tr><td>Plant X</td><td>1.52 E-5</td><td>2.6 E-6</td><td>1.3 E-4</td><td>9.0 E-7</td><td>N/A</td><td>N/A</td><td>N/A</td><td>5.5 E-7</td></tr>
<tr><td>Plant Y</td><td>2.84E-5</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>

Notes for Table 6.3-2

1. Conditional core damage probability is defined as the core damage frequency for the initiator of concern divided by the corresponding initiating event frequency
2. Bold face values indicate those used in the evaluation.

f. The inoperability of one PCIV associated with a particular piping penetration is assumed to be detected during surveillance or cycling of the affected valve. The affected PCIV is assumed to be in the open position and on-line maintenance is performed within the proposed AOT to restore the valve to operability. The unaffected PCIV is assumed to be evaluated to ensure that it is OPERABLE.

g. The inoperability of both PCIVs for the associated penetration is not considered in this evaluation. This condition is governed by a separate Limiting Condition of Operation (LCO), which remains unchanged.

h. For penetrations with associated piping that are connected to the reactor coolant, it is assumed that the interfacing system low pressure piping, which is located outside the containment, has a rupture failure probability based on the pipe material, thickness, temperature and reactor pressure. Failure is assumed to occur upon exposure to reactor pressure during power operation with a pipe break probability (Reference 6). Once the pipe rupture occurs, reactor coolant inventory is lost outside the containment and core damage eventually occurs.

i. Based on information provided in Reference 7, Table 3, the failure rates of various automatically operated valves are shown in the table below. The probability of a valve failing to remain closed during the proposed AOT of 7 days (hourly failure rate times 168 hours) is also shown. For purposes of this analysis, the maximum failure rate and failure probability were used in the calculations. This is to ensure that the analyses cover all different valve types.

| **Valve Type** | **Failure to Close (/demand)** | **Failure to Remain Closed (/hour)** | **Failure Probability During AOT** |
|---|---|---|---|
| Air-Operated | 2.00E-03 | 1.40E-05 | 2.35E-03 |
| Motor-Operated | **2.70E-03** | 7.70E-07 | 1.29E-04 |
| Solenoid Valve | 1.10E-03 | **1.70E-05** | **2.86E-03** |
| Check Valve | 1.20E-03 | 2.40E-06 | 4.03E-04 |
| Pressure Relief | N/A | 2.20E-06 | 3.70E-04 |

Note: Bold face values indicate those used in the evaluation.

j. Non-seismically induced pipe failures are assumed to occur randomly in time. Three references were reviewed to determine the failure probability of random pipe failure. NUREG/CR-4407 determined the frequency of a pipe break to be 3.2E-02 per year (Reference 8, pg 23). The probability during the proposed AOT duration of 7 days using this value would be 6.14E-04. A random pipe failure rate of 1.00E-9 per section-hour is assumed in WASH-1400 (Reference 9, Appendix III, Table 2-1). It is conservatively assumed that there are approximately 100 sections included in the run of piping under consideration.

Based on the number of pipe sections, the estimated probability of a random pipe failure during the proposed AOT duration of 7 days is 1.68E-5. The BWR ISLOCA Study also determined the probability of pipe failure without ISLOCA over-pressurization (Reference 6, pg. E-8). That probability is estimated at 5.4E-04 for A106 Grade B Carbon Steel piping. For conservatism, the highest failure probability of these three is used in the calculations (6.14E-04).

It is further assumed that both safety and non-safety grade piping have the same random pipe failure probability.

k. Piping that is not seismically qualified is assumed to fail during a seismic event with a probability of one.

l. Due to the bounding nature of the calculations provided herein, the increase in a PCIV unavailability due to test or maintenance as a result of AOT extension to 7 days and its potential impact on the average CDF for the plant is neglected.

m. The penetration is assumed to remain physically intact during the proposed AOT.

n. Maintenance on a PCIV is assumed to not break the pressure boundary for more than the currently allowed AOT. Breach of the pressure boundary is assumed to be controlled by Maintenance Rule (a)(4).

o. Postulated releases through penetrations originating from the wetwell airspace benefit from suppression pool scrubbing of the radioactive release. Therefore, such a release does not actually constitute a Large Early Release. However, no credit for this scrubbing effect is used in this analysis.

p. Unless otherwise specified for open piping systems outside containment, it is assumed that there are multiple valves in the flow path that can be credited for isolating the pathway to the environment. Failure of multiple valves in this pathway is assumed to be a low probability event and has no impact on ICLERP.

q. Pipe breaks outside of primary containment are assumed to occur downstream of the PCIVs unless noted otherwise.

As discussed above, the acceptance criteria for ICCDP and ICLERP, which are based on the recommended values of Regulatory Guide 1.177, are 5.0E-7 and 5.0E-8, respectively.

#### 6.3.2.2 Risk Assessment of AOT Extension for Class A Containment Penetrations

The function of PCIVs contained within Class A containment piping is to maintain containment isolation following the receipt of a containment isolation signal. A Class A containment piping penetration is connected directly to the containment atmosphere, or connected to non-seismically qualified piping that interfaces with the containment atmosphere. The associated PCIVs and/or piping or ductwork represent the only barriers between the containment atmosphere and the outside environment. These penetrations are open directly to the containment atmosphere and connected to non-seismic piping or ductwork outside the containment. Penetrations that are connected to non-seismic piping or both sides of the containment are also included in this class of containment penetrations. Depending on the function of the penetration, the associated PCIVs are

either normally open (or may be opened) during power operation, or are normally closed and not opened during power operation.

Based on the function of the containment penetration the following potential LERF flowpaths were identified.

1) Penetrations Connected Directly to Containment Atmosphere and Outside Environment
2) Penetrations Connected Directly to Containment Atmosphere and a Closed Loop System Outside Containment
3) Penetrations Connected Directly to Containment Atmosphere and an Open Loop System Outside Containment

The above configurations for Class A containment piping penetrations are described below:

#### 6.3.2.2.1 Case A-1: Penetrations Connected Directly to Containment Atmosphere and Outside Environment

This generic configuration for Class A containment penetration is connected directly to the containment atmosphere and directly to the outside environment. The associated PCIVs for the penetration are the only barriers between the containment atmosphere and the environment. Typical systems where this configuration is used are given below.

- Purge and Vent Air Supply and Exhaust
- Tip Purge
- Sample and Other Small Lines
- Instrumentation Lines

The associated piping downstream of the PCIV outside containment is typically not seismically qualified. A typical schematic for this configuration is shown in Figure 6.3-1 for a Mark III containment design. This representation also applies to the Mark I and II containment designs. As shown, the penetration is equipped with two PCIVs, one on either side of the containment.

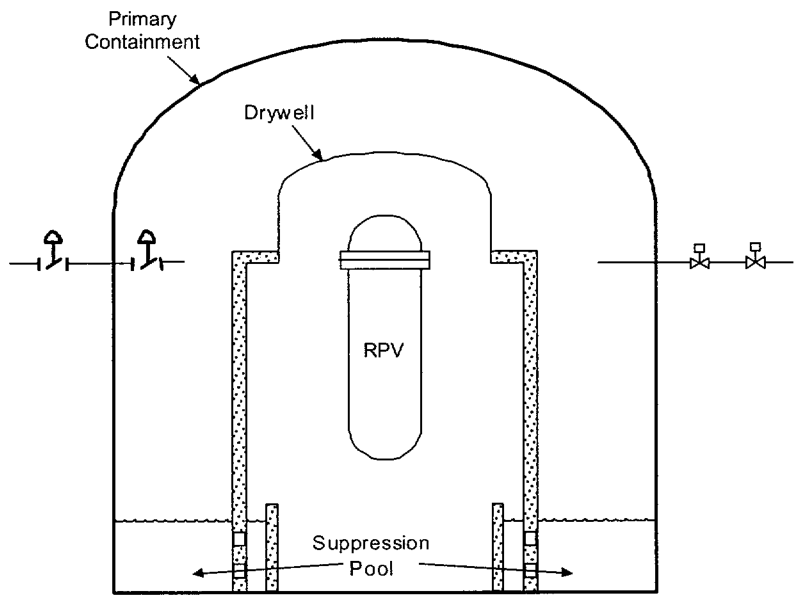


**Figure 6.3-1**
**Case A-1: Schematic of Penetration Connected Directly to Containment Atmosphere and Outside Environment**

The valves are normally in the closed position during normal power operation. The failure of both PCIVs to remain closed if initially closed or failure of both PCIVs to close if initially open creates a direct path to the environment. The passage of fluid into or out of the containment is not needed in order to accomplish or support any of the safety functions following an accident. Therefore, the associated PCIVs are either (a) normally locked closed in MODES 1 through 3, or (b) designed to close automatically following a design basis event.

The PCIVs for this configuration are generally not included in the PSA model(s) used for estimating core damage frequency (CDF) because the passage of fluid through the penetration is not needed for accident mitigation.[1] The inoperability of any PCIV, causing the affected valve to be secured in the open or closed position, will have no impact on CDF. Closure of at least one of the PCIVs following a design basis event will satisfy the containment isolation function. An inoperable and open PCIV reduces the reliability of isolating the penetration following an accident and thus has the potential of impacting LERF. The potential impact is assessed by estimating the incremental conditional early release probability (ICLERP) due to the proposed AOT for the PCIVs.

[1] For containment vent line PCIVs, the inoperability of a PCIV has a potential effect on the decay heat removal function which impacts the CDF if the valve is secured in the closed position. However, an inoperable PCIV will be secured in the open position per General Assumption f (Case A-1 Assumption b). With the inoperable PCIV secured in the open position, the inoperability will have no impact on CDF.

In addition to the general assumptions/input, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed AOT for the PCIVs.

a. The PCIVs are normally closed and are cycled during MODES 1, 2, and 3 in order to accomplish their required in-service testing or design function. Surveillance of the PCIVs is assumed on a periodic basis. The inoperability of one PCIV is assumed to be detected during periodic surveillance or cycling of the valve.

b. The inoperable PCIV is in the open position. Thus for this configuration of containment penetration, the "OPERABLE" PCIV provides the only remaining barrier to guard against the release of radioactive to the environment following core damage.

c. The failure mechanism that causes the "OPERABLE" PCIV to transfer open during the proposed AOT will also prevent the valve from closing when commanded by the safeguard signal following an accident.

#### 6.3.2.2.1.1 Impact on CDF/ICCDP

The inoperability of one PCIV has no impact on CDF because the system associated with this configuration for containment penetration is not required for core damage mitigation.

#### 6.3.2.2.1.2 Impact on LERF/ICLERP

The following expression was used to estimate the impact on ICLERP due to the proposed PCIV AOT.

$$ICLERP = (CDF_{base} - CDF_{byp})\, P_{civ} \left[\frac{AOT}{8760}\right] \qquad (1)$$

where,

| | | |
|---|---|---|
| ICLERP | = | the incremental large early release probability |
| $CDF_{base}$ | = | the total average core damage frequency [5.56E-05 per year – Assumption e] |
| $CDF_{byp}$ | = | the core damage frequency (per year) due to bypass events [0.0 – Assumption d] |
| $P_{CIV}$ | = | the probability of failing to isolate the containment penetration by crediting the unaffected PCIV [2.86E-3 – Highest of values in Assumption i.] |
| AOT | = | the proposed allowed outage time [168 hours – Assumption a.] |

Substituting the above values in Equation 1 yields:

ICLERP = [5.56E-5 – 0.0] * [2.86E-3] * [168/8760]

= 3.05E-9

This indicates that the level of risk associated with large early releases due to the proposed PCIV AOT extension is below the acceptance criterion of 5.0E-8.

#### 6.3.2.2.2 Case A-2: Penetrations Connected Directly to Containment Atmosphere and a Closed Loop System

This generic configuration for Class A containment penetration is connected directly to the containment atmosphere and to a closed loop system outside the containment. The associated PCIVs for the penetration and the piping for the closed loop system provide two diverse barriers between the containment atmosphere and the outside environment. Failure to isolate the containment penetration and breach of the closed loop system must occur in order to establish a path for the release of radioactive materials following core damage. Typical systems where this configuration is used are given below.

- Upper Pool to Fuel Pool Cooling and RWST
- Sample and Other Small Lines
- Instrumentation Lines

Depending on the function that is performed, the piping in the closed loop system may or may not be seismically qualified. A typical schematic of this configuration is shown in Figure 6.3-2 for a Mark III containment design. This representation also applies to the Mark I and II containment designs.

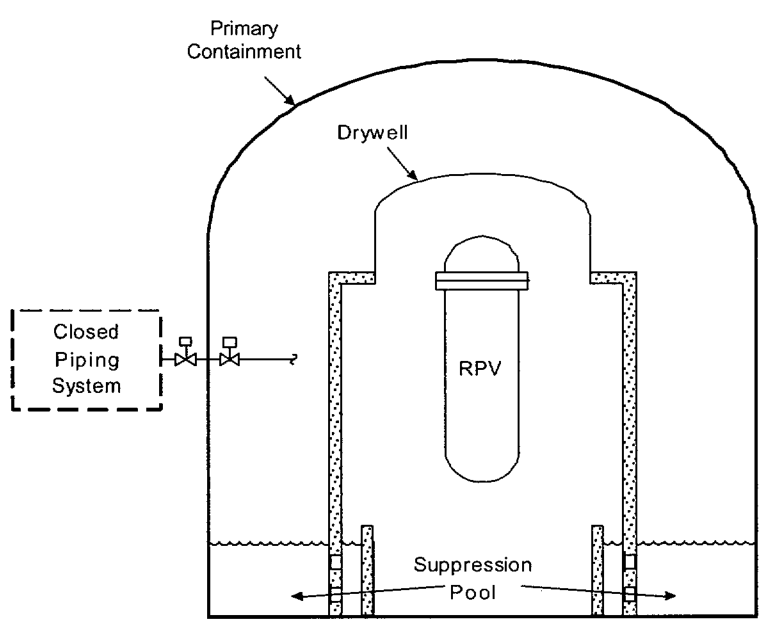


**Figure 6.3-2**
**Case A-2: Schematic of Penetration Connected Directly to Containment Atmosphere and a Closed Loop System**

As shown in Figure 6.3-2, the penetration is equipped with two PCIVs, one on either side of the containment. The valves are shown in the open position during normal power operation. The passage of fluid into or out of the containment is not needed in order to accomplish or support any of the safety functions to prevent core damage. Therefore, the associated PCIVs are designed to close automatically following a design basis event. Closure of the PCIVs can be overridden if post-accident monitoring or sampling is required.

In addition to the general assumptions/input, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed AOT for the PCIVs.

a. The PCIVs are normally open, as shown in Figure 6.3-2, and are cycled during MODES 1, 2, and 3 in order to satisfy both in-service testing requirements and Technical Specification surveillance requirements.

b. The inoperability of one PCIV is assumed to be detected during periodic surveillance or cycling of the valves. The inoperable PCIV is secured in the open position. For this configuration, the unaffected PCIV is available for isolating the containment penetration.

c. Since the penetration may be equipped with MOVs, AOVs, solenoid-operated valves, or manual valves, the valve type associated with the most conservative failure probability was assumed and used in the calculation.

d. The inoperable PCIV is secured in the open position, and will fail to close when commanded by the safeguard signal.

#### 6.3.2.2.2.1 Impact on CDF/ICCDP

The PCIVs for this penetration are generally not included in the PSA model(s) used for estimating CDF because the passage of fluid through the penetration is not needed for core damage mitigation. The inoperability of any PCIV for this penetration, causing the affected valve to be secured in the open or closed position, will have no impact on CDF.

#### 6.3.2.2.2.2 Impact on LERF/ICLERP

Closure of at least one of the PCIVs will satisfy the containment isolation function. An inoperable and open PCIV reduces the reliability of isolating the penetration following a design basis event and thus has the potential of impacting LERF. The potential impact is assessed by estimating the ICLERP due to the proposed AOT for the PCIVs. Since one of the PCIVs is secured open, failure of the remaining operable PCIV to operate (i.e., close) when demanded prevents the containment penetration from being isolated. Failure to isolate the containment penetration must occur concurrent with a breach in the closed loop system outside the containment in order to establish a pathway for the release of radioactive materials following core damage.

The following expression was used to estimate the impact on ICLERP due to the proposed PCIV AOT.

$$ICLERP = (CDF_{base} - CDF_{byp})\, P_{civ}\; P_{pc} \left[\frac{AOT}{8760}\right] \qquad (2)$$

where,

| | | |
|---|---|---|
| ICLERP | = | the incremental large early release probability |
| $CDF_{base}$ | = | the total average core damage frequency [5.56E-05 per year – Assumption e] |
| $CDF_{byp}$ | = | the core damage frequency (per year) due to bypass events [0.0 – Assumption d] |
| $P_{civ}$ | = | the probability of failing to isolate the containment penetration by crediting the unaffected PCIV [2.86E-3 – Highest of values in Assumption i.] |
| $P_{pc}$ | = | the probability of a pipe failure [6.14E-4 – Assumption j] |
| AOT | = | the proposed allowed outage time [168 hours – Assumption a] |

Substituting the above values in Equation 2 yields:

ICLERP = [5.56E-05 – 0.0] * [2.86E-3] * [6.14E-4) * [168/8760]

= 1.87E-12 (seismically qualified piping)

The impact on LERF can be assessed for non-seismically qualified piping in the closed loop system by substituting the appropriate values in Equation 2 to reflect a seismically initiated event. This is accomplished by replacing the value of $CDF_{base}$ with a value of 2.1E-5 for the yearly core damage frequency due to a seismic event, $CDF_{seismic}$. The conditional pipe failure probability is also replaced with a value of 1.0. After making the substitutions in Equation 2, the estimated ICLERP due to seismic event is 1.15E-9.

The calculated conditional probabilities for both the seismically and non-seismically qualified piping for this penetration indicate that the level of risk associated with large early releases due to the proposed PCIV AOT extension is significantly below the acceptance criteria value of 5.0E-8.

#### 6.3.2.2.3 Case A-3: Penetrations Connected to Containment Atmosphere and an Open Loop System

This generic configuration for Class A penetrations describes the containment penetrations that are connected to the containment with associated piping connected to an open loop system outside the containment. The associated PCIVs for the penetration provide the main barrier between the containment atmosphere and the outside environment. Other valves in the open loop system can provide a secondary barrier to guard against the release of radioactive materials outside the containment following core damage. Typical systems where this configuration is used are given below.

- Service and Instrument Air/Gas
- Drywell and Equipment Drain Sumps
- RWST to Upper Pool
- Condensate Supply to Containment

- Upper Pool to the Drain Tank
- Combustible Gas Air Purge Supply
- Purge Radiation Detector
- Instrument air to ADS Receivers
- Demineralized Water Supply
- TIP Drive
- Recirculation Pump Seal Purge
- Wetwell and Drywell Sample

A typical schematic of this configuration is shown in Figure 6.3-3 for a Mark III containment design. This representation also applies to the Mark I and II containment designs. As shown, the penetration is equipped with one check valve, AOV, MOV, or manual valve that provides the containment isolation function inside the containment and one AOV, MOV, or manual valve that provide the containment isolation function outside the containment. The PCIVs for this configuration are shown in the open position during normal power operation.

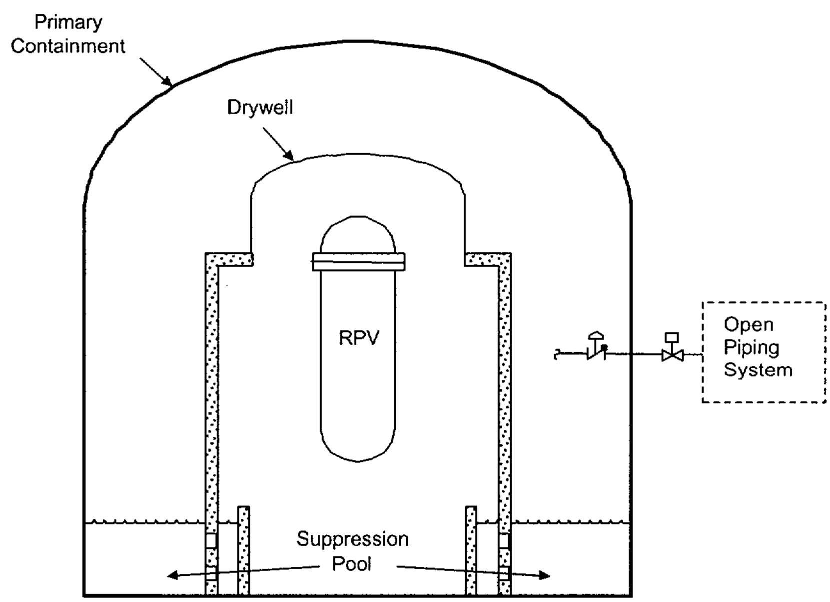


**Figure 6.3-3**
**Case A-3: Schematic of Penetration Connected to Containment Atmosphere and Open Loop System**

Therefore, the PCIV outside the containment is designed to close automatically following a design basis event. By design, the check valve inside the containment reverts to the closed position in the absence of flow through the line.

In addition to the general assumptions/input, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed AOT for the PCIVs.

a. For this configuration, it is assumed that the penetration is equipped with one solenoid-operated valve inside and outside the containment (conservative assumption).

b. The inoperability of the valve outside containment is assumed to be detected during cycling or surveillance of the valve. The inoperable valve is in the open position and the inboard valve is available for isolating the containment penetration.

c. Although the associated piping for the penetration is connected to an open loop system outside the containment, there are multiple valves in the flow path that can be credited for isolating the pathway to the environment. Failure of multiple valves in this pathway is assumed to be a low probability event and has no impact on ICLERP.

d. A pipe break in the open loop system concurrent with failure to isolate the containment penetration will establish a pathway to the environment. The pipe break is assumed to occur in a strategic location within the open loop system that prevents the break from being isolated. This location is assumed to be immediately outboard of the outside PCIV.

e. The associated piping for this configuration outside the containment is assumed to be non-seismically qualified. For non-seismically qualified piping, the probability of pipe failure following a seismic event is assumed to be 1.0.

#### 6.3.2.2.3.1 Impact on CDF/ICCDP

The PCIVs for this penetration are generally not included in the PSA model(s) used for estimating CDF because the passage of fluid into the containment is not needed or required for core damage mitigation. An inoperable PCIV (i.e., in the open position) for this penetration, will not have an impact on CDF.

#### 6.3.2.2.3.2 Impact on LERF/ICLERP

Closure of the operable PCIV will satisfy the containment isolation function. Securing the inoperable valve in the open position reduces the reliability of isolating the penetration following a design basis event. The reduced reliability has the potential of impacting LERF. The potential impact is assessed by estimating the ICLERF due to the proposed AOT for the PCIVs. Since the outboard valve is secured open, a failure of the inboard valve to close when demanded prevents the containment penetration from being isolated. Failure to isolate the containment penetration must occur concurrent with a breach of the piping outside the containment in order to establish a pathway for the release of radioactive materials following core damage (Specific Assumptions c & d).

The following expression was used to estimate the impact on ICLERP due to the proposed PCIV AOT.

$$ICLERP = (CDF_{base} - CDF_{byp})\,P_{civ}\;P_{pc}\left[\frac{AOT}{8760}\right] \text{ (non-seismic events)} \qquad (3)$$

where,

ICLERP = the incremental large early release probability

$CDF_{base}$ = the total average core damage frequency [5.56E-05 per year – Assumption e]

$CDF_{byp}$ = the core damage frequency (per year) due to bypass events [0.0 – Assumption d]

$P_{civ}$ = the probability of failing to isolate the containment penetration by crediting the unaffected PCIV [2.86E-3 – Highest of values in Assumption i.]

$P_{pc}$ = the probability of a pipe failure [6.14E-4 – Assumption j]

AOT = the proposed allowed outage time [168 hours – Assumption a]

Substituting the above values in Equation 3 yields:

ICLERP = [5.56E-05 – 0.0] * [2.86E-3] * [6.14E-4) * [168/8760]

= 1.87E-12 (seismically qualified piping)

The impact on LERF can be assessed for a seismic event by substituting the appropriate values in Equation 3. This is accomplished by replacing the value of $CDF_{base}$ with a value of 2.1E-5 for the yearly core damage frequency due to a seismic event, $CDF_{seismic}$. The conditional pipe failure probability is also replaced with a value of 1.0. After making the substitutions in Equation 3, the estimated ICLERP due to seismic event is 1.15E-9.

The calculated conditional probabilities for both the seismically and non-seismically qualified piping for this penetration indicate that the level of risk associated with large early releases due to the proposed PCIV AOT extension is significantly below the acceptance criteria value of 5.0E-8.

#### 6.3.2.3 Risk Assessment of AOT Extension for Class B Containment Penetrations

A Class B containment piping penetration is connected to the Reactor Coolant System (RCS). The inflow or outflow of fluid through these penetrations is generally not required to accomplish or support any of the safety functions. The PCIV for this type of penetration and the associated piping represent the barriers between the reactor coolant and the reactor coolant exposed systems outside the containment. The reactor coolant exposed systems include Reactor Water Cleanup, and Sample systems. Depending on the function of the penetration, the associated PCIVs are either normally open (or may be opened) during power operation, or are normally closed and not opened during power operation. The passage of fluid through a Class B penetration is generally not needed for core damage mitigation, except the Shutdown Cooling suction line penetration(s). The PCIVs associated with the Shutdown Cooling suction lines are manually opened to establish long term decay heat removal.

Based on the function of the containment penetrations and the definition provided above, the following two generic configurations for Class B piping penetrations were identified for GE BWRs.

1) Penetrations Used to Obtain Samples from the Reactor Coolant
2) Penetrations Used to Provide RWCU Flow

The above configurations for Class B containment penetration are described in the following subsections.

#### 6.3.2.3.1 Case B-1: Penetrations Connected to the Reactor Coolant Sample System

This generic configuration for Class B penetrations represents the containment penetrations with associated piping connected to the reactor coolant system and the sample system. This penetration is used to obtain samples from various locations in the Reactor Coolant. Sampling of the Reactor Coolant is performed on a daily basis during normal power operation. The piping outside the containment that is associated with the penetration is non-seismically qualified and is relatively small. Equipment is provided in the sample system for reducing the Reactor Coolant temperature and pressure before the sample is processed. Typical systems where this configuration is used are given below.

- Sample and Other Small Lines
- Instrumentation Lines

A schematic representation for this configuration is shown in Figure 6.3-4 for a Mark III containment design. This representation also applies to the Mark I and II containment designs. As shown, the penetration is equipped with two PCIVs for providing the isolation function. One PCIV is located inside the containment and the other PCIV is located outside the containment. Sampling of the Reactor Coolant via this penetration is not required or needed in order to support or accomplish any of the safety function for core damage mitigation. Therefore, the associated PCIVs are designed to close automatically following a design basis event. Closure of the PCIVs also occurs automatically following the loss of motive or control power to the valve actuator.

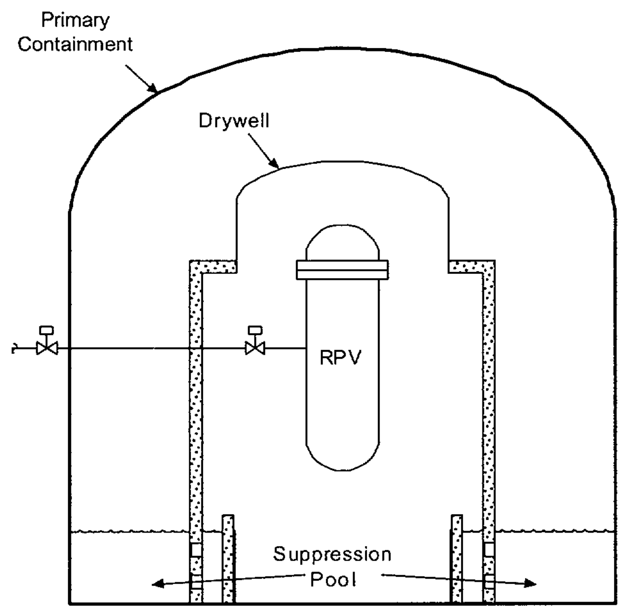


**Figure 6.3-4**
**Case B-1: Schematic of Penetration Connected to Reactor Coolant Sample Line**

The PCIVs for this configuration are generally not included in the PSA model(s) used for estimating CDF because the passage of fluid through the penetration is not needed for core damage mitigation. Closure of at least one PCIV will satisfy the containment isolation function. An inoperable and open PCIV reduces the reliability of isolating the penetration following a design basis event and thus has the potential of impacting LERF. The potential impact is assessed by estimating the ICCDP and ICLERP due to the proposed AOT extension for the PCIVs.

In addition to the general assumptions/input, the following configuration specific assumptions were made in estimating the ICLERP.

a. For this configuration, it is assumed that both PCIVs are solenoid valves, one valve is located inside the containment and the other valve is located outside the containment. The PCIVs are designed to close automatically upon generation of a safeguard signal to isolate the containment.

b. The PCIVs are assumed to be cycled on a daily basis to obtain the necessary samples from the RCS. For the calculations performed for this configuration, it is assumed that the valves are initially closed. The probability of a PCIV failing to remain closed during the proposed AOT is more conservative than the probability of a PCIV failing to close on demand.

c. The failure mechanism that causes the PCIV to transfer open during the proposed AOT will also prevent it from closing when commanded by the isolation signal following a design basis event.

d. A consequential pipe failure in the sample system due to the exposure to high Reactor Coolant temperature and pressure is assumed to be negligible. Equipment is provided in the sample system for reducing the Reactor Coolant temperature and pressure at normal power operation before processing the sample.

e. The nominal size of the sample line is less than one inch. The discharge of reactor coolant outside the containment via a break in the sample line can be mitigated by the feedwater or CRD system or an emergency core cooling system. Plant shutdown is assumed to occur before the inventory in the CST is depleted. The discharge of reactor coolant through the break will not lead to core damage by itself.

The inoperability of one of the PCIVs may impact CDF. The inoperable PCIV is secured in the open position, thus reducing the number of valves available for isolating reactor coolant through this penetration. The impact on CDF or LERF is assessed by estimating the incremental change in core damage and large early release probabilities due to the proposed PCIV AOT extension. To assess the significance of the AOT extension, the discharge of reactor coolant via the penetration is postulated. The discharge of reactor coolant may occur as a result of a breach in the sample line outside containment concurrent with the "OPERABLE" PCIV transferring open within the duration of the AOT. Since the size of the breach is very small (i.e., nominal pipe size is less than one inch), the plant response to this event would be equivalent to a small LOCA, which can be mitigated by the ECCS and in some instances, the feedwater system. Failure to mitigate the event will eventually lead to core damage and the release of radioactive materials to the environment via this pathway. The following expression is therefore used to estimate the potential impact on CDF or LERF.

$$ICCDP = ICLERP = (CCDP)_{sloca}\, F_{pc}\, P_{civ} \left[\frac{AOT}{8760}\right] \quad (4)$$

where,

ICCDP = the incremental conditional core damage probability

ICLERP = the incremental conditional large early release probability

$CCDP_{sloca}$ = the total conditional core damage probability due to a small LOCA [9.00E-5 – Assumption e]

$P_{civ}$ = the probability of failing to isolate the containment penetration by crediting the unaffected PCIV [2.86E-3 – Highest of values in Assumption i.]

$F_{pc}$ = the frequency of a pipe failure [3.2E-2 – Assumption j]

AOT = the proposed allowed outage time [168 hours – Assumption a]

Substituting the above values in Equation 4 yields.

ICCDP = ICLERP = [9.00E-5] * [2.86E-3] * [3.2E-2] * [168/8760]

= 1.58E-10

Since the piping outside the containment in the sample system is non-seismically qualified, a failure in this section of piping is assumed following a seismic event. For a seismic event, the impact on ICCDP and ICLERP can be assessed by substituting the appropriate values in Equation 4.

This is accomplished by replacing the product of (CCDP) and $F_{pc}$ with the CDF of a seismic induced small LOCA. As indicated in Table 6.3-2, the CDF due to a seismic induced small LOCA is 2.31 E-07. After making the substitutions in Equation 4, the estimated incremental probability for both core damage and large early release is 1.27E-11. For seismic ICLERP a sensitivity case was calculated using total seismic CDF rather than just seismically induced small LOCA CDF, and the result still meets the criteria.

The calculated conditional probabilities for both seismic and non-seismic initiated event indicate that the level of risk due to the proposed PCIV AOT extension is below the acceptance criterion value of 5.0E-7 and 5.0E-8 for the incremental conditional probability of core damage and large early release, respectively.

#### 6.3.2.3.2 Case B-2: Penetrations Connected to the RWCU and CRD Systems

This generic configuration for Class B penetrations represents the containment penetrations with associated piping connected to the Reactor Coolant to support systems, such as, the RWCU and CRD. A small portion of reactor coolant is diverted to the RWCU for processing in order to remove suspended solids and impurities from the coolant. Continuous RWCU and CRD flow is provided during normal power operation.

A typical schematic for this configuration is shown in Figure 6.3-5 for a Mark III containment design. This representation also applies to the Mark I and II containment designs. As shown, the flow path is equipped with two normally open MOVs. One of the valves is located inside the containment. The other valve is located outside the containment. Closure of these valves for an extended period will terminate RWCU flow and force a plant shutdown. The valves are closed automatically following a design basis event to terminate the flow of reactor coolant outside the containment following the associated design basis events. RWCU normally re-enters the reactor via the feedwater system but can be directed to the reactor via the alternate RWCU return line via two manual valves. The analyzed configuration bounds that penetration configuration.

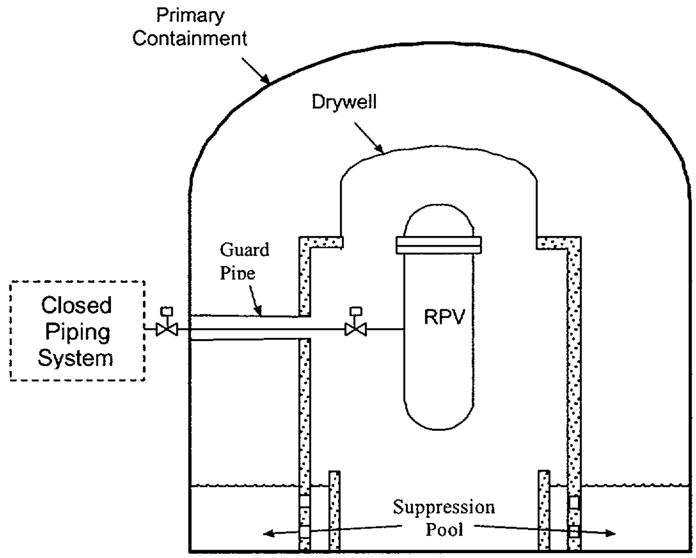


**Figure 6.3-5**
**Case B-2: Schematic of Penetration Connected to RWCU Line**

Because RWCU flow is continuous during normal power operation, a breach in the RWCU line will initiate a plant response similar to an intermediate LOCA. An inoperable and open PCIV reduces the reliability of isolating the penetration following an intermediate LOCA and thus has the potential of impacting LERF. The potential impact is assessed by estimating the ICCDP and ICLERP due to the proposed AOT extension for the PCIVs.

In addition to the general assumptions/input, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed AOT for the PCIVs.

a. The PCIVs are normally open, as shown in Figure 6.3-5, and are cycled during MODES 1, 2, 3 and 4 in order to satisfy both in-service testing requirements and Technical Specification surveillance requirements.

b. The inoperability of one PCIV is assumed to be detected during periodic surveillance or cycling of the valves. The inoperable PCIV is secured in the open position. For this configuration, the unaffected PCIV is available for isolating the containment penetration.

c. Since the penetration is equipped with MOVs, the failure probability assumed for an MOV valve type was used in the calculation.

d. The inoperable PCIV is secured in the open position, and will fail to close when commanded by the isolation signal.

The inoperability of one of the PCIVs may impact CDF. The inoperable PCIV is secured in the open position, thus reducing the number of valves available for isolating reactor coolant through this penetration. The impact on CDF or LERF is assessed by estimating

the incremental change in core damage and large early release probabilities due to the proposed PCIV AOT extension. To assess the significance of the AOT extension, the discharge of reactor coolant via the penetration is postulated.[2] The discharge of reactor coolant may occur as a result of a breach in the RWCU line outside containment concurrent with the "OPERABLE" PCIV failing to close when receiving the isolation signal. The plant response to this event would be equivalent to an intermediate LOCA, which can be mitigated by the ECCS. Failure to mitigate the event will eventually lead to core damage and the release of radioactive materials to the environment via this pathway. The following expression is therefore used to estimate the potential impact on CDF or LERF.

$$ICCDP = ICLERP = (CCDP)_{mloca}\, F_{pc}\, P_{mov} \left[\frac{AOT}{8760}\right] \quad (5)$$

where,

ICCDP = the incremental conditional core damage probability

ICLERP = the incremental conditional large early release probability

$CCDP_{mloca}$ = the total conditional core damage probability due to an intermediate LOCA [5.50E-3 – Assumption e]

$P_{mov}$ = the probability of failing to isolate the containment penetration by crediting the unaffected PCIV [2.70E-3 – Assumption i, MOV fails to close on demand.]

$F_{pc}$ = the frequency of a pipe failure [3.2E-2 – Assumption j]

AOT = the proposed allowed outage time [168 hours – Assumption a]

Substituting the above values in Equation 5 yields.

ICCDP = ICLERP = [5.50E-3] * [2.70E-3] * [3.2E-2] * [168/8760]

= 9.11E-9

Since the piping outside the containment in the RWCU system is non-seismically qualified, a failure in this section of piping is assumed following a seismic event. For a seismic event, the impact on ICCDP and ICLERP can be assessed by substituting the appropriate values in Equation 5.

This is accomplished by replacing the product of (CCDP) and $F_{pc}$ with the CDF of a seismic induced intermediate LOCA. As indicated in Table 6.3-2, the CDF due to a seismic induced intermediate LOCA event is 1.0 E-07. After making the substitutions in Equation 5, the estimated incremental probability for both core damage and large early release is 5.18E-12. For seismic ICLERP a sensitivity case was calculated using total seismic CDF rather than just seismically induced small LOCA CDF, and the result still meets the criteria.

[2] In some plants, failure to isolate RWCU during ATWS events could result in core damage due to SLC carry-over after injection. The CDF due to this failure under ATWS conditions is bounded by the dominant intermediate LOCA event analyzed.

The calculated conditional probabilities for both seismic and non-seismic initiated event indicate that the level of risk due to the proposed PCIV AOT extension is below the acceptance criterion value of 5.0E-7 and 5.0E-8 for the incremental conditional probability of core damage and large early release, respectively.

#### 6.3.2.4 Risk Assessment of AOT Extension for Class C Containment Penetrations

A Class C containment penetration is connected to closed loop piping inside and outside the containment. The closed loop system and the PCIVs for the penetration represent the barriers between the containment atmosphere and the outside environment. Closed loop systems inside the containment that function as a containment barrier are seismically qualified and include component cooling water, main steam, and feedwater. Portions of the main steam system inside the containment are considered to be closed for all events except a main steam line break. A forced plant shutdown usually occurs when a PCIV associated with penetrations in the main steam and feedwater systems becomes inoperable. The proposed PCIV AOT extension considered in this report is not applicable to PCIVs in the main steam and feedwater systems. Based on the functions of the remaining penetrations, the following two generic configurations for Class C penetrations were identified for GE BWRs.

1) Penetrations Connected to the Non-Essential Containment Cooling Units (PCIVs outside Containment and closed loop inside Containment)

2) Penetrations Connected to the Non-Essential Containment Cooling Units (PCIVs inside and outside Containment)

The above configurations for Class C containment penetrations are described below.

##### 6.3.2.4.1 Case C-1: Penetrations Connected to the Non-Essential Containment Cooling Units (PCIVs Outside Containment and Closed Loop Inside Containment)

This generic configuration for Class C penetrations represents the containment piping penetrations that provide inflow and outflow of cooling water to the non-essential containment cooling units. These cooling units are used for containment heat removal and recirculation pump cooling during normal power operation. Typical systems where this configuration is used are given below.

- Recirculation Pump Cooling
- Chilled Water

This configuration is equipped with two types of barriers between the containment atmosphere and the outside environment, at least one active and one passive barrier. The closed loop piping inside the containment provides a passive barrier for the containment atmosphere, and the PCIV provides an active barrier. A typical schematic for this configuration is shown in Figure 6.3-6 for a Mark I containment design. As shown, the

penetration is equipped with a MOV outside the containment. Containment heat removal by the non-essential cooling units is not required or needed to accomplish or support any of the safety functions for preventing core damage.

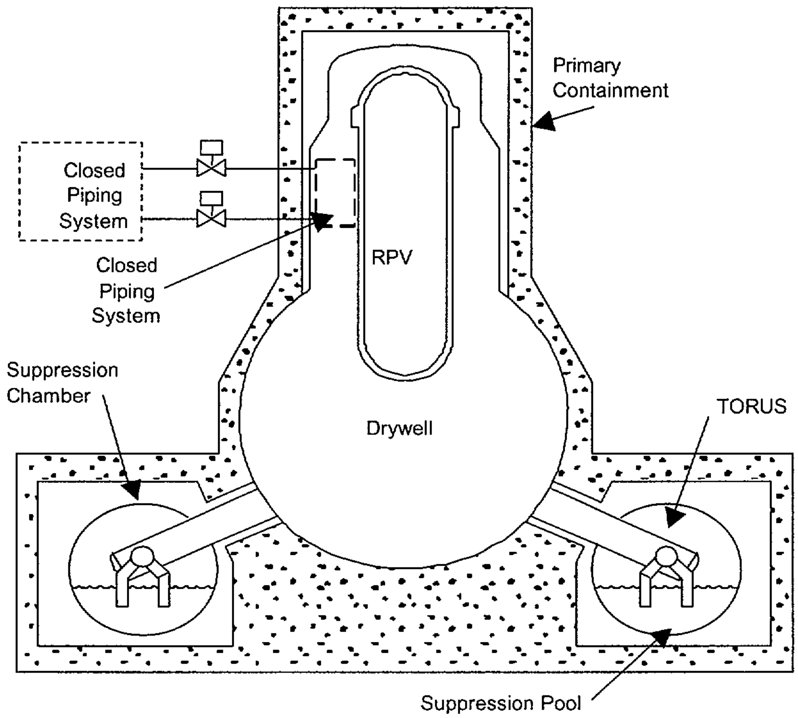


**Figure 6.3-6**
**Case C-1: Schematic of Penetration Connected to Non-Essential Cooling Units**

The PCIV for this configuration of Class C penetrations is generally not included in the PSA model(s) because the non-essential cooling units are not credited for core damage mitigation. Securing the PCIV in the open position eliminates the active barrier for containment isolation. For this condition, a pathway from the containment atmosphere to the environment is established by breaching the closed loop system inside and outside the containment. The inability to provide containment isolation has the potential of impacting LERF. The potential impact is assessed by estimating the ICLERP due to the proposed AOT for the PCIVs.

In addition to the general assumptions/input, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed PCIV AOT extension.

a. For this configuration, it is assumed that the penetration is equipped with one PCIV, which is located outside the containment. The PCIV is open during normal power operation. Because the PCIV is determined to be inoperable it is secured in the open position, which makes it unavailable for isolating the penetration.

b. A breach in the closed loop system both inside and outside the containment must occur in order to establish a pathway from the containment atmosphere to the environment.

c. Insufficient containment heat removal during normal power operation will lead to a forced plant shutdown. Therefore, a breach in the closed loop system during power operation is assumed to cause an uncomplicated turbine trip. An estimated frequency of 1.93E-2/yr is assumed and used for inadvertent opening of a relief valve. The frequency value is based on a mean failure rate of 2.2E-6 per hour (General Assumption i) for inadvertent opening or leak of a relief valve. When combined with the random frequency of a pipe failure (3.2E-2/yr - General Assumption j), the overall frequency of breaching the closed loop system is 5.13E-2/yr.

d. The piping associated with the closed loop system outside the containment is assumed to be non-seismically qualified. A conditional failure probability of 1.0 is assumed for such piping following a seismic event.

#### 6.3.2.4.1.1 Impact on CDF/ICCDP

A breach in the closed loop system during normal power operation has the potential for impacting CDF. It is postulated that the plant will respond to the breach in a manner similar to an uncomplicated turbine trip. The following expression is therefore used to estimate the potential impact on the conditional change in core damage probability due to the CIV AOT extension for this configuration.

$$ICCDP = F_P \ (CCDP)_T \left[\frac{AOT}{8760}\right] \qquad (6a)$$

where,

ICCDP = the incremental conditional core damage probability

$CCDP_T$ = the conditional core damage probability due to turbine trip [8.93E-6 – Section 6.3.2.1, General Assumption (e)]

$F_P$ = the frequency of breaching a closed loop system due to a pipe break or relief valve failure [5.13E-2 per year – Assumption (c) above]

AOT = the proposed allowed outage time [168 hours – Section 6.3.2.1(a)]

Substituting the above values in Equation 6a yields:

ICCDP = [5.13E-2] * [8.93E-6] * [168/8760]

= 8.79E-9

#### 6.3.2.4.1.2 Impact on LERF/ICLERP

A pathway from the containment atmosphere to the environment is established if a breach occurs in the closed loop system both inside and outside the containment. As stated in Assumption c of this case, a breach in the closed loop system on either side of the containment will lead to a plant shutdown. If the shutdown leads to core damage, and

there is a second breach on the other side of the containment, the accident will result in release of radioactive material to the environment. The following expression is therefore used to estimate the impact on the probability of large early release.

$$ICLERP = F_P \ (CCDP)_T \ P_{pc}\left[\frac{AOT}{8760}\right] \qquad (6b)$$

where,

ICLERP = the incremental large early release probability

$CCDP_T$ = the conditional core damage probability due to turbine trip [8.93E-6 – Section 6.3.2.1, General Assumption e]

$F_P$ = the frequency of breaching a closed loop system due to a pipe break or relief valve failure [5.13E-2 per year – Assumption (c) above]

$P_{pc}$ = the probability of a pipe failure [6.14E-4 – Section 6.3.2.1(j)]

AOT = the proposed allowed outage time [168 hours – Section 6.3.2.1(a)]

Substituting the above values into Equation 6b yields.

ICLERP = [5.13E-2] * [8.93E-6] * [6.14E-4] * [168/8760]

= 5.39E-12

The piping in the closed loop system outside containment for this configuration is non-seismically qualified. The impact on LERF can be assessed for a seismic event by using Equation 6c.

$$ICLERP = (CDF_{seismic}) \ P_{pc}\left[\frac{AOT}{8760}\right] \qquad (6c)$$

where,

ICLERP = the incremental large early release probability

$CDF_{seismic}$ = the core damage frequency due to a seismic event [2.1E-5 – Section 6.3.2.1(e)]

$P_{pc}$ = the probability of a pipe failure inside the containment [6.14E-4 – Section 6.3.2.1(j)]

AOT = the proposed allowed outage time [168 hours – Section 6.3.2.1(a)]

Substituting the above values into Equation 6c yields.

ICLERP = [2.1E-5] * [6.14E-4] * [168/8760]

= 2.47E-10

The calculated incremental conditional probabilities for core damage and large early release indicate that the level of risk due to the proposed PCIV AOT extension is well below the acceptance criteria of 5.0E-7 and 5.0E-8, respectively.

#### 6.3.2.4.2 Case C-2: Penetrations Connected to the Non-Essential Containment Cooling Units (PCIVs Inside and Outside Containment)

This generic configuration for Class C penetrations describes the containment penetrations that are connected to closed loop piping inside and outside the containment. The closed loop system and the PCIVs provide the main barriers between the containment atmosphere and the outside environment following core damage. The associated closed loop piping, both inside and outside the containment, is assumed to be non-seismically qualified. This configuration is generally used to provide inlet and outlet cooling water flow for heat removal equipment located inside the containment. Heat removal is provided for major equipment or for the containment atmosphere during normal power operation. Typical systems where this configuration is used are given below.

- Drywell Chilled Water
- Plant Chilled Water
- RBCCW
- Standby Service Water

A typical schematic for this configuration is shown in Figure 6.3-7 for a Mark III containment design. This representation also applies to the Mark II containment design.

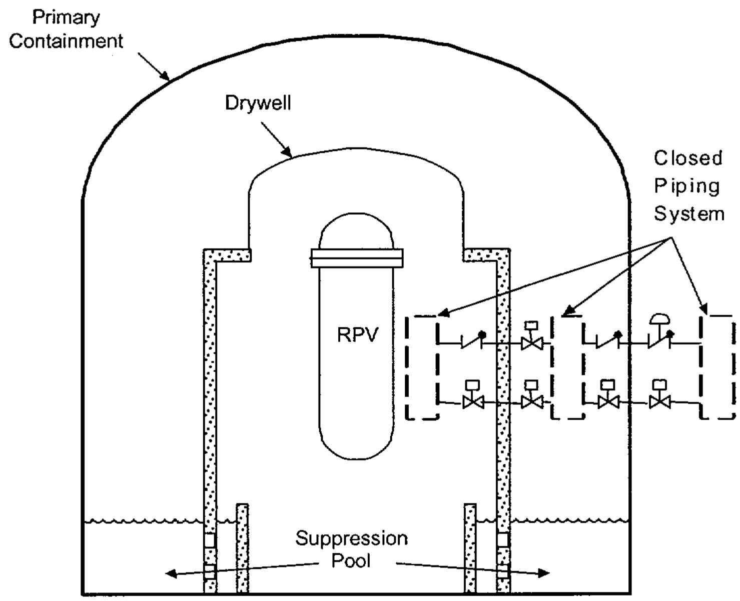


**Figure 6.3-7**
**Case C-2: Schematic of Penetration Connected to Closed Loop Inside and Outside Containment**

The penetration is equipped with one PCIV (CV, TCV, AOV, or MOV) on either side of the containment. The valves are shown in the open position during normal power operation.

In addition to the general assumptions/input the following configuration specific assumptions were made in estimating the ICLERP due to the proposed AOT.

a. The inoperability of the PCIV is assumed to be detected during surveillance of the valves. The inoperable valve is secured in the open position and the remaining PCIV is available for isolating the associated containment penetration.

b. The piping associated with the closed loop system inside and outside the containment is assumed to be non-seismically qualified. A conditional failure probability of 1.0 is assumed for such piping following a seismic event.

c. A breach in the closed loop system both inside and outside the containment must occur concurrent with failure to isolate the penetration in order to establish a pathway from the containment atmosphere to the environment.

d. Insufficient containment heat removal during normal power operation will lead to a forced plant shutdown. Therefore, a breach in the closed loop system during power operation is assumed to cause an uncomplicated turbine trip. An estimated frequency of 1.93E-2/yr is assumed and used for inadvertent opening of a relief valve. The frequency value is based on a mean failure rate of 2.2E-6 per hour (General Assumption i) for inadvertent opening or leak of a relief valve. When combined with the random frequency of a pipe failure (3.2E-2/yr - General

Assumption j), the overall frequency of breaching the closed loop system is 5.13E-2/yr.

### 6.3.2.4.2.1 Impact on CDF/ICCDP

A breach in the closed loop system during normal power operation has the potential for impacting CDF. It is postulated that the plant will respond to the breach in a manner similar to an uncomplicated turbine trip. The following expression is therefore used to estimate the potential impact on the conditional change in core damage probability due to the CIV AOT extension for this configuration.

$$ICCDP = F_P \ (CCDP)_T \left[\frac{AOT}{8760}\right] \quad (7a)$$

where,

ICCDP = the incremental conditional core damage probability

$CCDP_T$ = the conditional core damage probability due to turbine trip [8.93E-6 – Section 6.3.2.1, General Assumption e]

$F_P$ = the frequency of breaching a closed loop system due to a pipe break or relief valve failure [5.13E-2 per year – Assumption (d) above]

AOT = the proposed allowed outage time [168 hours – Section 6.3.2.1(a)]

Substituting the above values in Equation 7a yields:

ICCDP = [5.13E-2] * [8.93E-6] * [168/8760]

= 8.79E-9.

### 6.3.2.4.2.2 Impact on LERF/ICLERP

A pathway from the containment atmosphere to the environment is established if a breach occurs in the closed loop system both inside and outside the containment, and the operable PCIV fails open.

As stated in Assumption d of this case, a breach in the closed loop system on either side of the containment will lead to a plant shutdown. If the shutdown leads to core damage, and there is a second breach on the other side of the containment while the operable PCIV is failed open, the accident will result in release of radioactive material to the environment. The following expression is therefore used to estimate the impact on the probability of large early release.

$$ICLERP = F_P \ (CCDP)_T \ P_{pc} P_{civ} \left[\frac{AOT}{8760}\right] \quad (7b)$$

where,

ICLERP = the incremental large early release probability

$CCDP_T$ = the conditional core damage probability due to turbine trip [8.93E-6 – Section 6.3.2.1, General Assumption e]

$F_P$ = the frequency of breaching a closed loop system due to a pipe break or relief valve failure [5.13E-2 per year – Assumption (d) above]

$P_{pc}$ = the probability of a pipe failure [6.14E-4 – Section 6.3.2.1(j)]

$P_{CIV}$ = the probability of failing to isolate the containment penetration by crediting the unaffected PCIV [2.86E-3 – Highest of values in Section 6.3.2.1(i)]

AOT = the proposed allowed outage time [168 hours – Section 6.3.2.1(a)]

Substituting the above values into Equation 7b yields.

ICLERP = [5.13E-2] * [8.93E-6] * [6.14E-4] * [2.86E-3] * [168/8760]

= 1.54E-14

For this configuration, the piping in the closed loop system inside and outside the containment is non-seismically qualified. Per Assumption b of this case, it is assumed that following a seismic event the only remaining barrier in the release path is the operable PCIV. Therefore, the impact on LERF can be assessed for a seismic event by using Equation 7c.

$$ICLERP = (CDF_{seismic})\ P_{civ}\left[\frac{AOT}{8760}\right] \qquad (7c)$$

where,

ICLERP = the incremental large early release probability

$CDF_{seismic}$ = the core damage frequency due to a seismic event [2.1E-5 – Section 6.3.2.1(e)]

$P_{CIV}$ = the probability of failing to isolate the containment penetration by crediting the unaffected PCIV [2.86E-3 – Highest of values in Section 6.3.2.1(i)]

AOT = the proposed allowed outage time [168 hours – Section 6.3.2.1(a)]

Substituting the above values into Equation 7c yields.

ICLERP = [2.1E-5] * [2.86E-3] * [168/8760]

= 1.15E-9

The calculated conditional probabilities for both seismic and non-seismic event initiators indicate that the level of risk associated with large early releases due to the proposed PCIV AOT extension is significantly below the acceptance criteria value of 5.0E-8.

### 6.3.2.5 Risk Assessment of AOT Extension for Class D Containment Penetrations

A Class D containment penetration is connected to the containment atmosphere and a detector outside the containment. This type of penetration is used for detecting containment atmospheric conditions and initiating the necessary plant response. For this type of penetration, a single isolation valve and a closed piping system outside the containment represent the barriers between the containment atmosphere and the outside environment. The containment detector line is open to the containment atmosphere and a single isolation valve is provided outside the containment. The detector line is seismically qualified and designed for higher pressure than the containment design pressure. An orifice or other flow-restricting device is provided in the containment pressure detector line to limit the release of radioactive materials for design basis events to less than the acceptable limits. A typical schematic for this containment is shown in Figure 6.3-8 for a Mark III containment design. This representation also applies to the Mark I and II containment designs. This figure shows a penetration that is equipped with an isolation valve outside the containment. The PCIV is shown in the open position during normal power operation. The detection of containment pressure is provided during normal power operation as well as during post-accident conditions. Therefore, the PCIVs for Class D penetrations do not receive a safeguard signal following a design basis event.

In addition to detectors that monitor containment atmosphere, there are similar detector lines connected to the vessel that monitor reactor conditions. A typical schematic for this type of detector line is also shown in Figure 6.3-8.

Typical systems where this configuration is used are given below.

- Sample Lines
- Air and Instrumentation Lines

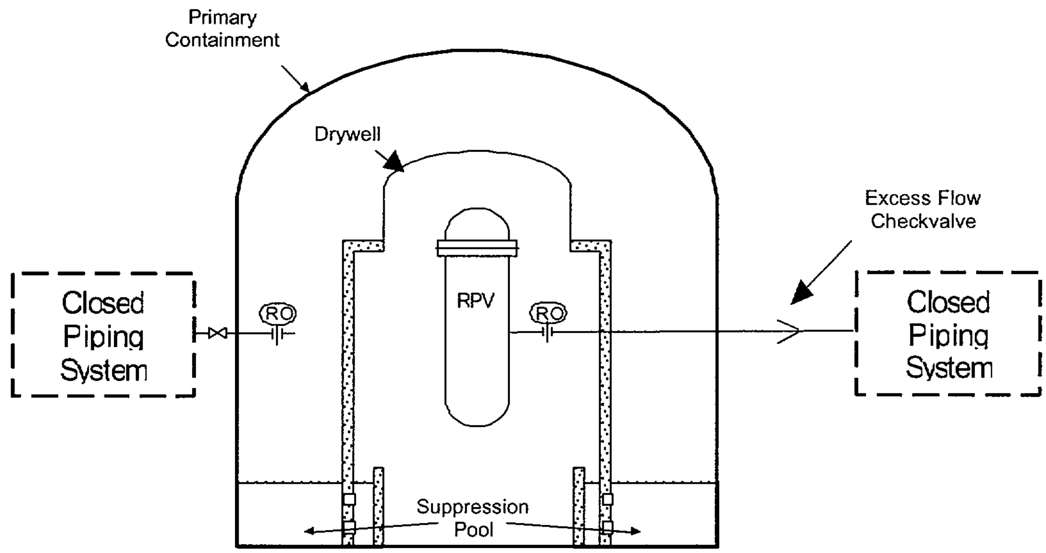


**Figure 6.3-8**
**Case D: Schematic of Penetration Connected to Containment Instrument Sensor**

An inoperable PCIV for Class D penetration that is secured in the open position has no impact on CDF because instrument lines are sized and orificed to limit the rate and extent of any coolant loss to a small amount relative to the reactor coolant makeup capability. A rupture in the containment or reactor pressure detector line outside the containment may establish a pathway to the environment. However, the risk of a significant release of radioactive material or coolant via the affected penetration is insignificant since the line is not capable of passing enough flow to exceed the acceptable limits.

For Class D penetrations, the incremental conditional probabilities for core damage and large early release due to the PCIV AOT extension are qualitatively assessed to be negligible and well below the acceptance criteria of 5.0E-7 and 5.0E-8, respectively.

### 6.3.2.6 Risk Assessment of AOT Extension for Class E Containment Penetrations

A Class E containment penetration is designed to open during a design basis event. Consequently, the PCIVs associated with Class E penetrations are required to open automatically or receive confirmatory signal to open by an actuation signal. Based on their functions, the following generic configurations of Class E penetrations were identified for GE BWRs.

1) Penetrations Used to Support Reactor Coolant Inventory Control Safety Function
2) Penetrations Used to Support Containment Heat Removal Safety Function
3) PCIVs in penetrations connected to the Suppression Pool

The above generic configurations for Class E penetrations with an associated PCIV secured in the open position are analyzed in the following subsections.

Since the PCIVs associated with Class E penetrations provide containment isolation and are also required to be open for accident mitigation, an inoperable PCIV in either the open or closed position will have an impact on both CDF and LERF. An inoperable Class E PCIV in the closed position will impact the ability of the associated system in performing its mitigating function. The intent of the risk assessment provided in this report is to evaluate the impact of extending the AOT for restoring an INOPERABLE PCIV to operability for satisfying the containment isolation function. Additionally, the following paragraph provides qualitative assessment on risk impact for securing an INOPERABLE Class E PCIV in the closed position.

This information is provided for purposes of completeness. This report is not requesting an extension of the AOT for the Class E valve to be in the closed position. This discussion does however support the ISTS general philosophy of associating the inoperability of their valves to open within the system AOT. Retaining an INOPERABLE Class E PCIV for an associated containment piping penetration in the closed position may impact CDF and LERF. The magnitude of the impact depends on the associated system and the type of mitigating function it performs and the impact of the valve closure on the system mitigating capability. The impact of a closed PCIV may be sufficient to cause the complete loss of a system train (e.g., closure of PCIV in containment spray line) or may be minimal and have no significant effect on system.

#### 6.3.2.6.1 Case E-1: Penetrations Used to Support Reactor Control Safety Functions

This type of Class E penetrations is used to provide makeup of lost reactor coolant and to maintain and control Reactor Coolant inventory. Typical systems where this configuration is used are given below.

- RHR Shutdown Cooling (SDC)
- RHR Low Pressure Coolant Injection (LPCI)
- RHR and RCIC Head Spray
- Low Pressure Core Spray (LPCS)

- High Pressure Core Spray (HPCS)
- Standby Liquid Control (SLC)
- Steam to RCIC and HPCI
- Main Steam Line Drain
- CS Discharge
- Shutdown Cooling Return to RPV

The LPCS and LPCI lines upstream of the injection valves are equipped with low-pressure piping. Such piping is susceptible to over-pressurization failure (i.e., rupture) if exposed to the normal operating temperature and pressure of the reactor coolant. The HPCS/HPCI and RCIC systems are equipped with high-pressure piping and are susceptible to over-pressurization failure only if the suction piping is exposed to high pressure. The piping in all of these systems, therefore, may be susceptible to over-pressurization failure.

The lines enter the containment via separate penetrations. The configurations for the HPCS, RCIC head spray, LPCS and LPCI penetrations are similar, and because of the similarity only the description and assessment of a typical LPCI line penetration is provided. A typical schematic of a LPCI line penetration is shown in Figure 6.3-9 for a Mark III containment design. This representation also applies to the Mark I and II containment designs. The figure shows that a typical LPCI line includes a motor-operated valve and a testable check valve for protecting the low pressure piping from being exposed to the normal operating temperature and pressure of the reactor. The motor-operated valve, which is located outside the containment, is normally closed and opens automatically. There is a testable check valve inside the containment that is used for pressure isolation.

The Standby Liquid Control System, steam to RCIC and HPCI, and shutdown cooling configurations are similar to the above-described systems except the PCIVs are typically check valves or MOVs which have lower failure probabilities. Because of this similarity, the LPCI PCIV configuration analyzed in this section bounds the Standby Liquid Control configuration.

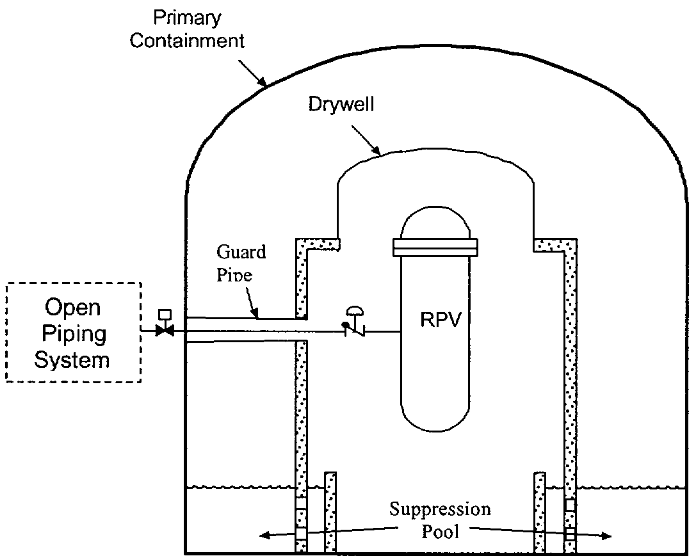


**Figure 6.3-9**
**Case E-1: Schematic of Penetration Connected to LPCI Line**

The LPCI line motor-operated PCIV is credited in the PSA model(s). The inoperability of a PCIV has the potential for impacting CDF and LERF, regardless of whether the affected valve is secured in the open or closed position. The potential impact on CDF associated with securing the motor-operated PCIV in the closed position is qualitatively assessed above. In this section, the impact on CDF and LERF is assessed by estimating ICCDP and ICLERP for the valve in the open position for the proposed AOT. Retaining the inoperable motor-operated valve in the LPCI line in the closed position will satisfy the containment isolation function for the associated penetration.

In addition to the general assumptions/input, the following configuration specific assumptions were made in estimating the impact on CDF and LERF due to the proposed PCIV AOT extension.

1. For this configuration, it is assumed that the piping associated with the penetration is equipped with one testable check valve inside the containment and one motor-operated valve that is located outside the containment.
2. In some cases, the piping outboard of the motor-operated valve is not designed to accommodate full Reactor Coolant pressure. Exposure of the low pressure piping to normal operating Reactor Coolant pressure may cause an over-pressurization failure of the low-pressure piping and lead to an Interfacing System LOCA (ISLOCA).

**6.3.2.6.1.1 Impact on ISLOCA for Securing a PCIV in Locked Open Position**

Securing the motor-operated PCIV in a LPCS line in the open position will not degrade the operability of the LPCS system in performing its mitigating function.

However, the number of barriers in place to protect the low pressure piping from being exposed to normal operating temperature and pressure of the Reactor Coolant will be reduced. The reduction in the number of barriers increases the potential for a catastrophic failure of the low-pressure piping and a resulting ISLOCA. Because the ISLOCA analysis methods and results vary from plant to plant, the methodology and values described in Reference 6 were used to estimate the conditional ISLOCA frequency.

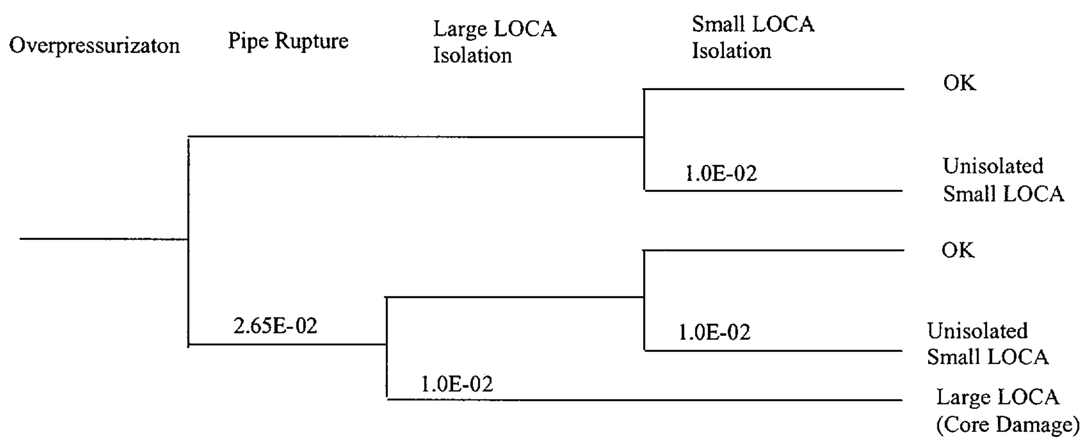


**Figure 6.3-10**
**Event Tree for Conditional Probability of LOCAs Resulting From an Overpressurization (ISLOCA)**

Figure 6.3-10 illustrates the event tree used in Reference 6 to determine the conditional probability of various sized LOCAs given that the low pressure piping has been over-pressurized. Overpressurization occurs because the valves that isolate the high pressure portion of the system from the low pressure portion of the system have failed, allowing high pressure fluid into the low pressure piping. Given that an overpressurization occurs, the probability that a pipe rupture occurs was analyzed in Reference 6. The highest (most conservative) value was 2.65E-02. Reference 6 used the probability of 0.01 for isolating the rupture. If a rupture does not occur, or if it is isolated, then a small LOCA may occur resulting from open relief valves and failed gaskets with a probability of 0.01. If the rupture occurs and is not isolable, a Large LOCA results. As assumed in Reference 6, this LOCA leads to core damage because other means of injecting water into the core are also lost due to the ISLOCA. The resulting CCDP given a small LOCA from Reference 6, Table 4.5, is 5.36E-03 and the CCDP given a large LOCA is 1.0. These values are the highest, most conservative CCDP values used or calculated in Reference 6.

Using the above event tree in Figure 6.3-10, the conditional probabilities of small ($P_{SLOCA}$) and large ($P_{LLOCA}$) ISLOCAs, given an overpressurization of low pressure piping are:

$$P_{SLOCA} = [(1\text{-}2.65E\text{-}02) * 1.0E\text{-}02] + [2.65E\text{-}02 * (1\text{-}1.0E\text{-}02) * 1.0E\text{-}02]$$
$$= 1.0E\text{-}02$$

$$P_{LLOCA} = 2.65E\text{-}02 * 1.0E\text{-}02$$
$$= 2.65E\text{-}04$$

The following expression is used to estimate the potential impact on CDF and LERF:

$$ICCDP = ICLERP = F_{op}\ (P_{SLOCA} * CCDP_{SLOCA} + P_{LLOCA} * CCDP_{LLOCA}) \left[\frac{AOT}{8760}\right] \quad (9)$$

where,

| | | |
|---|---|---|
| ICCDP | = | the incremental conditional core damage probability |
| ICLERP | = | the incremental large early release probability |
| $F_{op}$ | = | the frequency of overpressurization or the product of the frequency of failure of the check valve inside containment times the probability of failure of any other high pressure isolation valves |
| $P_{SLOCA}$ | = | Conditional probability of a small LOCA given overpressurization of low pressure piping [1.0E-02, calculated above]. |
| $CCDP_{SLOCA}$ | = | Conditional Core Damage Probability given an Interfacing System Small LOCA [5.36E-3 - Reference 6, Table 4.5] |
| $P_{LLOCA}$ | = | Conditional probability of a large LOCA given overpressurization of low pressure piping [2.65E-04, calculated above]. |
| $CCDP_{LLOCA}$ | = | Conditional Core Damage Probability given an Interfacing System Large LOCA [Assumed 1.0 based on Reference 6] |
| AOT | = | The proposed allowed outage time [168 hours – Section 6.3.2.1, Assumption a] |

Substituting the above values in Equation 9 yields:

$$ICCDP = ICLERP = F_{op} * [1.0E\text{-}02*5.36E\text{-}3 + 2.65E\text{-}04*1.0] * [168/8760]$$

$$= F_{op} * [6.11E\text{-}6] \quad (10)$$

Some systems in this class have three valves available to isolate the high pressure fluid from the low pressure piping, 2 of those valves being PCIVs. For these systems the $F_{op}$ is

evaluated as the product of the frequency of a check valve leak times the probability of an MOV failure to isolate.

$$F_{op} = F_{cv} * P_{mov} \quad (11)$$

where,

$F_{cv}$ = The frequency of a check valve leak [2.4E-06*8760 = 2.10E-02/yr - Assumption i]

$P_{mov}$ = The probability of a MOV failing to remain closed during the proposed AOT [7.70E-7 * 168 = 1.29E-4 - Assumption i]

Substituting the above values in Equation 11 yields:

$$F_{op} = [2.1E-2] * [1.29E-4] = 2.7E-6$$

Substituting the above value in Equation 10 yields:

ICCDP = ICLERP = [2.7E-6] * [6.11E-6] = 1.66E-11

The resulting CCDP and ICLERP for penetrations in this class that have three high pressure valves is well below the acceptance criteria of 5E-07 and 5E-08, respectively. Penetrations with three high pressure valves are:

- Steam to HPCI, RCIC and RHR
- LPCI Injection
- HPCI Injection
- HPCS Injection
- RCIC Injection
- Core Spray Injection (BWR3/4)
- Head Spray

For systems with only 2 isolation valves in the high pressure piping, both of which are PCIVs, the $F_{op}$ is the frequency of a check valve leak only [2.4E-06*8760 = 2.10E-02/yr]. The resulting CCDP and ICLERP is 1.28E-07. This configuration DOES NOT MEET either acceptance criteria; therefore a Technical Specification Change is NOT requested for systems in this class with only 2 high pressure isolation valves. Systems with only 2 high pressure isolation valves are:

- LPCS (BWR5/6)
- Shutdown Cooling Suction

### 6.3.2.6.2 Case E-2: Penetrations Used for Containment Heat Removal

This type of Class E penetrations is used to provide containment pressure control and containment heat removal. The Containment Spray Sub-System of the RHR System is used to perform this function. The penetrations associated with the system are connected directly to the containment atmosphere. The PCIVs installed in the penetrations for the system design are described below.

Containment Spray Lines

Containment Spray is in the standby mode during normal power operation. The system is actuated automatically in order to perform its functions. A typical schematic of a Containment Spray line penetration is shown in Figure 6.3-11 for a Mark I containment design. This schematic shows that two PCIVs are installed in the line.

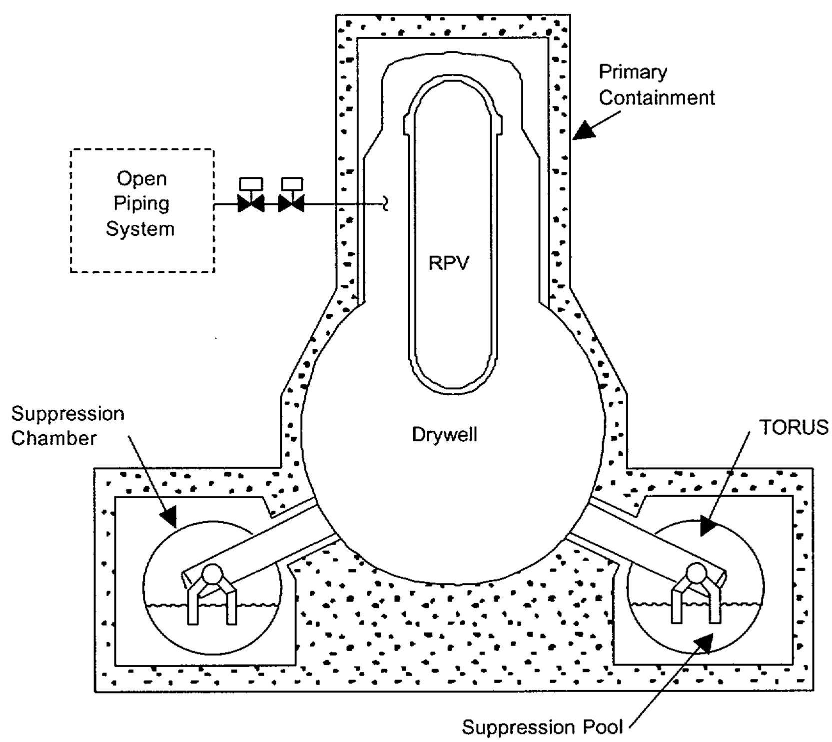


**Figure 6.3-11**
**Case E-2: Schematic of Penetration Connected to Containment Spray Line**

The line is equipped with a motor-operated valve (MOV), which is located outside the containment, and a second MOV that is located either outside or inside the containment. Containment Spray is credited in the PSA for long-term heat removal. Securing a PCIV associated with the Containment Spray line in the closed position will impact the potential for core damage and large early release.

The following example penetration configurations are considered bounded by this class:

- Containment Spray Lines
- Drywell Sump Discharge

In addition to the general assumptions/input, the following configuration specific assumptions were made in estimating the potential impact on core damage and large early release due to the proposed PCIV AOT extension.

1. For this configuration, it is assumed that the Containment Spray system containment penetration is equipped with one MOV that is located outside the containment and a second MOV either inside or outside containment. One MOV is secured in the open position in order to assess its potential impact on risk due to the proposed PCIV AOT extension.
2. Securing the PCIV in the open position will satisfy the mitigating function for the Containment Spray System in the affected train. For this condition, the redundant means of isolating the containment will be lost during the AOT. The AOT for this inoperable position is governed by the PCIV Technical Specification and the proposed duration is 7 days.
3. A random pipe failure in the CSS line outside the containment leads to the unavailability of the affected train of containment spray and a potential pathway for the release of radioactive materials to the environment.
4. The entire Containment Spray System is assumed to be seismically qualified

Securing the motor-operated PCIV in a containment spray line in the open position will not prevent the affected train of containment spray to perform its safety-related function following a design basis accident. However, the number of barriers available for isolating the affected containment penetration will be reduced. With the motor-operated PCIV secured in the open position, a pathway for the release of radioactive motor following core damage may be established if the second valve fails to close concurrent with a random pipe failure in the associated spray line outside containment. The following expression is therefore used to estimate the change in large early release probability.

$$ICLERP = (CDF_{base} - CDF_{byp})\ P_{mov}\ P_{pc} \left[\frac{AOT}{8760}\right] \qquad (12)$$

where,

ICLERP = the incremental conditional large early release probability

$CDF_{base}$ =the total average core damage frequency [5.56E-5 per year – Assumption e]

$CDF_{byp}$ =the core damage frequency (per year) due to bypass events [0.0 – Assumption d]

$P_{mov}$ = the probability of failing to isolate the containment penetration by crediting the unaffected PCIV [2.7E-3 –Assumption i.]

$P_{pc}$ = the probability of a pipe failure [6.14E-4 – Assumption j]

AOT = the proposed allowed outage time [168 hours – Assumption a]

Substituting the above values in Equation 12 yields.

ICLERP = [5.56E-5 – 0.0] * [2.7E-3] * [6.14E-4] * [168/8760]

= 1.77E-12

The incremental change in probability for large early release demonstrates that the level of risk associated with the proposed PCIV AOT is well below the acceptance criterion of 5.0E-8.

#### 6.3.2.6.3 Case E-3: Penetrations Connected to the Suppression Pool

This generic configuration for Class E penetrations represents the containment piping penetrations that either take suction from or discharge to the Suppression Pool. Typical systems where this configuration is used are given below.

- RHR, HPCI, HPCS, RCIC, CS, LPCS suction from the Suppression Pool
- RHR, HPCI, HPCS, RCIC, CS, LPCS test or Min Flow to Suppression Pool
- Containment to RCIC Steam Discharge Line
- Suppression Pool Spray
- Suppression Pool Cleanup
- RCIC and HPCI Exhaust
- RCIC Vacuum Pump Discharge
- LPCS and RHR Relief
- Sample and Other Small Lines
- Air and Instrumentation Lines
- Drywell Purge Supply
- Drywell Purge Exhaust
- Suppression Pool Purge Supply
- Suppression Pool Purge Exhaust
- HPCI and RCIC Vacuum Relief
- Upper Pool to FPC

These lines terminate under water in the Suppression pool and the water seal provides one of the isolation means. The piping inside the containment provides a passive barrier for the containment atmosphere, and the PCIV outside the containment provides an active barrier. A typical schematic for this configuration is shown in Figure 6.3-12 for a Mark

III containment design. This representation also applies to the Mark I and II containment designs. As shown, the penetration is equipped with a MOV outside the containment. All of these lines are assumed to be required following an accident.

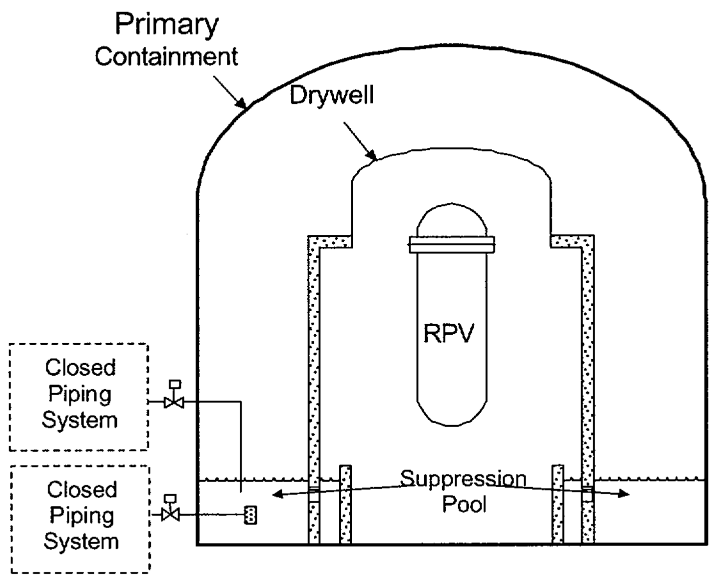


**Figure 6.3-12**
**Case E-3: Schematic of Penetration Connected to the Suppression Pool**

These PCIVs are credited in the PSA model(s). The inoperability of a PCIV has the potential for impacting CDF and LERF, regardless of whether the affected valve is secured in the open or closed position. The potential impact on CDF associated with securing the motor-operated PCIV in the closed position is qualitatively assessed above for all Class E PCIVs. In this section, the impact on LERF is assessed by estimating ICLERP for the valve in the open position for the proposed AOT. Retaining the inoperable PCIV in the closed position will satisfy the containment isolation function for the associated penetration. However, the accident mitigating function that the valve is required to perform will not be accomplished.

In addition to the general assumptions/input, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed PCIV AOT extension.

a. For this configuration, it is assumed that the penetration is equipped with one PCIV, which is located outside the containment. The PCIV is open during normal power operation. Because the PCIV is determined to be inoperable it is secured in the open position, which makes it unavailable for isolating the penetration.

b. A breach in the system outside the containment must occur in order to establish a pathway from the containment atmosphere to the environment. The passive barrier inside the containment is conservatively not credited

c. The piping both inside and outside containment is assumed to be seismically qualified.

#### 6.3.2.6.3.1 Impact on CDF/ICCDP

Securing the PCIV in the open position will not prevent the affected system to perform its safety-related function following a design basis accident. Therefore securing the PCIV in the open position will have no impact on CDF.

#### 6.3.2.6.3.2 Impact on LERF/ICLERP

In the calculations that follow, the case involving a pipe failure that occurs concurrent with core damage is examined to assess the impact on large early release probability. For this case, the assumed inoperable PCIV is secured in the open position and has no impact on CDF. When the PCIV is in the open position it becomes unavailable for isolating the configuration penetration. A pathway from the containment atmosphere to the environment is established if the breach occurs in the piping both inside and outside the containment. The following expression is therefore used to estimate the impact on the probability of large early release.

$$ICLERP = (CDF_{base} - CDF_{byp})\ P_{pc}\left[\frac{AOT}{8760}\right] \tag{13}$$

where,

| | | |
|---|---|---|
| ICLERP | = | the incremental large early release probability |
| $CDF_{base}$ | = | the total average core damage frequency [5.56E-5 per year – Assumption e] |
| $CDF_{byp}$ | = | the core damage frequency (per year) due to bypass events [0.0 – Assumption d] |
| $P_{pc}$ | = | the probability of a pipe failure [6.14E-4 – Assumption j] |
| AOT | = | the proposed allowed outage time [168 hours – Assumption a] |

Substituting the above values into Equation 13 yields.

ICLERP = [5.56E-5 – 0.0] * [6.14E-4] *[168/8760]

= 6.55E-10

The calculated incremental conditional probabilities for core damage and large early release indicate that the level of risk due to the proposed PCIV AOT extension is well below the acceptance criteria of 5.0E-7 and 5.0E-8, respectively.

### 6.3.3 Summary of Single AOT Risks

Table 6.3-3 summarizes the "risk" impact of extending the PCIV AOTs for the various types of containment penetrations for the full AOT duration. The risk ratios included in the last two columns of Table 4 represent the ratio of the incremental risk to the NRC's regulatory guidelines for ICCDP of 5.0E-7 and ICLERP of 5.0E-8. As demonstrated by the risk ratios (last two columns of Table 6.3-3), the risk level associated with an

INOPERABLE PCIV for any particular containment penetration configuration is less than the regulatory guidelines and in most instances are orders of magnitude lower.

Penetrations for Low Pressure Core Spray (BWR5/6 only) and Shutdown Cooling suction piping do not meet either acceptance criteria; therefore a Technical Specification Change is NOT requested for these PCIVs.

**Table 6.3-3**
**Summary of Plant Risk for Proposed PCIV AOT Extension**

| Class | Description | Seismic Effect on Piping Y | Seismic Effect on Piping N | Position of INOPERABLE PCIV | Proposed AOT (Days) | ICCDP | ICLERP | ICCDP Risk Ratio (Note 4) | ICLERP Risk Ratio (Note 5) |
|---|---|---|---|---|---|---|---|---|---|
| A | 1. PCIVs in penetrations connected directly to containment atmosphere and outside environment | (Note 1) | | OPEN | 7 | 0 | 3.05E-9 | 0 | 1.08E-02 |
| | 2. PCIVs in penetration connected directly to containment atmosphere and closed loop system outside containment | √ | | OPEN | 7 | 0 | 1.87E-12 | 0 | 4.74E-03 |
| | | | √ | OPEN | 7 | 0 | 1.15E-9 | 0 | 6.64E-06 |
| | 3. PCIVs in penetrations connected to containment atmosphere and open loop system outside containment | √ | | OPEN | 7 | 0 | 1.87E-12 | 0 | 4.74E-03 |
| | | | √ | OPEN | 7 | 0 | 1.15E-9 | 0 | 6.64E-06 |
| B | 1. PCIVs in penetrations connected to Reactor Coolant sample lines | √ | | OPEN | 7 | 1.58E-10 | 1.58E-10 | 5.21E-06 | 5.21E-05 |
| | | | √ | OPEN | 7 | 1.27E-11 | 1.27E-11 | 1.28E-06 | 1.28E-05 |
| | 2. PCIVs in penetrations conneced to RWCU (Note 3) | √ | | OPEN | 7 | 9.11E-9 | 9.11E-9 | 2.17E-04 | 2.17E-03 |
| | | | √ | OPEN | | 5.18E-12 | 5.18E-12 | 3.04E-07 | 3.04E-06 |
| C | 1. PCIVs in penetrations connected containment cooling units (PCIVs outside and closed loop inside) | √ | | OPEN | 7 | 8.79E-9 | 5.39E-12 | 0 | 4.94E-03 |
| | | | √ | OPEN | 7 | | 2.47E-10 | 7.21E-03 | 1.64E-05 |
| | 2. PCIVs in penetrations connected containment cooling units (PCIVs inside and outside) | √ | | OPEN | 7 | 8.79E-9 | 1.54E-14 | 0 | 4.74E-03 |
| | | | √ | OPEN | 7 | | 1.15E-9 | 7.21E-03 | 9.66E-09 |
| D | PCIVs in penetrations connected to containment atmosphere pressure detector | (Note 2) | | OPEN | 7 | Neg | Neg | Neg | Neg |
| E | 1. PCIVs in penetrations used to support Reactor Coolant Inventory Control Safety Function – coolant injection | (Note 2) | | OPEN | 7 | 1.66E-11 | 1.66E-11 | 9.58E-03 | 9.58E-02 |
| | 2. PCIVs in penetrations used to support Containment Heat Removal safety function using containment sprays | (Note 2) | | OPEN | 7 | 0 | 1.77E-12 | 0 | 3.04E-06 |
| | 3. PCIVs in penetrations connected to the Suppression Pool | (Note 2) | | OPEN | 7 | 0 | 6.55E-10 | 0 | 6.93E-06 |

Notes for Table 6.3-3:

1. The associated piping located downstream of the PCIV outside Containment is open to the environment. The associated plant risk for this penetration is not impacted by a seismic event.
2. Associated piping outside the containment is seismically qualified.
3. ICLERP is bounded by penetration connected to an open loop cooling water system.
4. ICCDP risk ratio is defined as the ratio of the estimated ICCDP to RG 1.177 acceptance criteria of 5.0E-7.
5. ICLERP risk ratio is defined as the ratio of the estimated ICLERP to RG 1.177 acceptance criteria of 5.0E-8.

## 6.4 CONSIDERATION OF MULTIPLE AOT ENTRIES AND ACCUMULATED RISK

As identified in Section 3.6.1.3 of the ISTS, multiple simultaneous entries are allowed for this TS. The action statement for multiple simultaneous entries into the LCO for the same path is not considered within CONDITIONS A and C in Section 3.6.1.3 of the ISTS. Therefore all entries into the LCO which result in opening a primary containment isolation valve may be considered independent and therefore would have an additive impact on the accumulated incremental CDP or LERP. Based on the low level of risk identified in Table 6.3-3, entry into a reasonable number of multiple cases (say 5 to 10), simultaneous activities is not expected to result in ICLERP in excess of 5E-8.

## 6.5 TRANSITION RISK CONSIDERATIONS

The extension of AOT to one week has the potential to reduce the number of plant shutdown associated with the current lower AOT values. For any given AOT extension, there is an "at power" increase in risk associated with it. In Section 6.3, single "at power" AOT risks were evaluated against very small ICCDP and ICLERP risks metrics. The proposed change increases the time available to perform on-line PCIV maintenance and repair, resulting in potentially fewer shutdowns and associated transition risk.

## 6.6 TIER 2 CONSIDERATIONS

Regarding multiple unavailabilities of PCIVs for performing their containment isolation function, no Tier 2 conditions were noted that were not already prohibited by TS 3.6.1.3 (that is, 2 PCIVs inoperable in the same line, loss of function, etc.). The plant implementation of paragraph (a)(4) of the Maintenance Rule will limit the overall risk of PCIV maintenance for valves in this class by controlling the cumulative and simultaneous unavailabilities of PCIVs and associated system pressure boundary valves.

## 6.7 COMMITMENT TO PARAGRAPH (a)(4) OF THE MAINTENANCE RULE

In conformance with Regulatory Guide 1.177, the BWROG member utilities will commit to assess the risk associated with plant maintenance activities and will be included within the plant program(s) to meet paragraph (a)(4) of the Maintenance Rule (10 CFR 50.65). Risk informed cumulative unavailability targets for PCIVs are already being established within the scope of the Maintenance Rule.

# 7.0 SUMMARY AND CONCLUSIONS

A technical basis has been provided in the previous sections for extending the Allowed Outage Time (AOT) for a specific set of PCIVs from 4, 24, or 72 hours to 7 days during Modes 1, 2, and 3. The specific set of PCIVs is addressed by Conditions A, C and E of Section 3.6.1.3 of NUREG-1433/4, Revision 2 (Attachment 1 and 2).

The results of this evaluation demonstrate that the proposed AOT extension provides plant operational flexibility while simultaneously allowing plant operation with an acceptable level of risk. The results demonstrate that the risk level associated with the proposed AOT is below the regulatory guidelines set forth in Regulatory Guides 1.174 and 1.177.

## 8.0 REFERENCES


1. 10 CFR 50.65, Appendix A, "The Maintenance Rule."

2. NRC, "Standard Technical Specifications: General Electric Plants, BWR/4," NUREG-1433, Revision 2, June 2001.

3. NRC, "Standard Technical Specifications: General Electric Plants, BWR/6" NUREG-1434, Revision 2, June 2001.

4. NRC Regulatory Guide, "An Approach for Using Probabilistic Risk Assessment In Risk-Informed Decisions On Plant-Specific Changes to the Licensing Basis," RG 1.174, July 1998.

5. NRC Regulatory Guide, "An Approach for Plant-Specific, Risk-Informed Decisionmaking: Technical Specifications," RG 1.177, August 1998.

6. "Interfacing Systems LOCA: Boiling Water Reactors", NUREG/CR-5124, Brookhaven National Laboratory, May 1987.

7. "Component Failure Data Handbook", Idaho National Engineering Laboratory, EGG-EAST-8563, April 1991

8. "Pipe Break Frequency Estimation for Nuclear Power Plants", NUREG/CR-4407, Idaho National Engineering Laboratory, February 1989.

9. "Reactor Safety Study", Appendix 2, Table 2-1, WASH 1400

10. "EPRI ALWR Utility Requirements Document", Volume II, ALWR Evolutionary Plant, Chapter 1, Appendix A

11. CE Owners Group report, "Joint Application Report for Containment Isolation Valve AOT Extension", CE NPSD-1168, June 1999.

# Attachment 1

**NUREG-1433, Volume 1, Revision 2 (June 2001), Section 3.6.1.3**

**(Pages 3.6.1.3-1 through 3.6.1.3-11)**

## 3.6 CONTAINMENT SYSTEMS

### 3.6.1.3 Primary Containment Isolation Valves (PCIVs)

LCO 3.6.1.3 Each PCIV, except reactor building-to-suppression chamber vacuum breakers, shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3,
When associated instrumentation is required to be OPERABLE per LCO 3.3.6.1, "Primary Containment Isolation Instrumentation."

ACTIONS

- NOTES –

1. Penetration flow paths [except for purge valve penetration flow paths] may be unisolated intermittently under administrative controls.
2. Separate Condition entry is allowed for each penetration flow path.
3. Enter applicable Conditions and Required Actions for systems made inoperable by PCIVs.
4. Enter applicable Conditions and Required Actions of LCO 3.6.1.1, "Primary Containment," when PCIV leakage results in exceeding overall containment leakage rate acceptance criteria in MODES 1, 2, and 3.

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| A. **- NOTE -** Only applicable to penetration flow paths with two [or more] PCIVs.<br><br>One or more penetration flow paths with one PCIV inoperable [for reasons other than Condition[s] D [and E]]. | A.1<br><br>AND | Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured. | 4 hours except for main steam line<br><br>AND<br><br>8 hours for main steam line |

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| | A.2 --------------- - NOTES - 1. Isolation devices in high radiation areas may be verified by use of administrative means. 2. Isolation devices that are locked, sealed, or otherwise secured may be verified by use of administrative means. --------------- Verify the affected penetration flow path is isolated. | Once per 31 days for isolation devices outside primary containment <br> AND <br> Prior to entering MODE 2 or 3 from MODE 4, if primary containment was de-inerted while in MODE 4, if not performed within the previous 92 days, for isolation devices inside primary containment |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| B. ---------------<br>**- NOTE -**<br>Only applicable to penetration flow paths with two [or more] PCIVs.<br>---------------<br><br>One or more penetration flow paths with two [or more] PCIVs inoperable [for reasons other than Condition[s] D [and E]]. | B.1 | Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange. | 1 hour |
| C. ---------------<br>**- NOTE -**<br>Only applicable to penetration flow paths with only one PCIV.<br>---------------<br><br>One or more penetration flow paths with one PCIV inoperable [for reasons other than Condition[s] D [and E]]. | C.1<br><br><br><br><br><br><br><br><br>AND | Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange. | [4] hours except for excess flow check valves (EFCVs) and penetrations with a closed system<br><br>AND<br><br>72 hours for EFCVs and penetrations with a closed system |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| | C.2 | ---------------<br>**- NOTES -**<br>1. Isolation devices in high radiation areas may be verified by use of administrative means.<br><br>2. Isolation devices that are locked, sealed, or otherwise secured may be verified by use of administrative means.<br>--------------- | |
| | | Verify the affected penetration flow path is isolated. | Once per 31 days |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| D. [ One or more [secondary containment bypass leakage rate,] [MSIV leakage rate,] [purge valve leakage rate,] [hydrostatically tested line leakage rate,] [or] [EFCV leakage rate] not within limit. | D.1 | Restore leakage rate to within limit. | [4 hours for hydrostatically tested line leakage [not on a closed system]]<br><br><u>AND</u><br><br>[4 hours for secondary containment bypass leakage]<br><br><u>AND</u><br><br>[8 hours for MSIV leakage]<br><br><u>AND</u><br><br>[24 hours for purge valve leakage]<br><br><u>AND</u><br><br>[72 hours for hydrostatically tested line leakage [on a closed system] [and EFCV leakage] ] |
| E. [ One or more penetration flow paths with one or more containment purge valves not within purge valve leakage limits. | E.1 | Isolate the affected penetration flow path by use of at least one [closed and de-activated automatic valve, closed manual valve, or blind flange]. | 24 hours |
| | <u>AND</u> | | |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| | E.2 | ---------------<br>**- NOTES -**<br>1. Isolation devices in high radiation areas may be verified by use of administrative means.<br><br>2. Isolation devices that are locked, sealed, or otherwise secured may be verified by use of administrative means.<br>---------------<br>Verify the affected penetration flow path is isolated. | Once per 31 days for isolation devices outside containment<br><br><u>AND</u><br><br>Prior to entering MODE 2 or 3 from MODE 4 if not performed within the previous 92 days for isolation devices inside containment |
| | <u>AND</u> | | |
| | E.3 | Perform SR 3.6.1.3.7 for the resilient seal purge valves closed to comply with Required Action E.1. | Once per [92] days ] |
| F. Required Action and associated Completion Time of Condition A, B, C, D, or E not met in MODE 1, 2, or 3. | F.1 | Be in MODE 3. | 12 hours |
| | <u>AND</u> | | |
| | F.2 | Be in MODE 4. | 36 hours |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| G. [ Required Action and associated Completion Time of Condition A, B, C, D, or E not met for PCIV(s) required to be OPERABLE during movement of [recently] irradiated fuel assemblies in [secondary] containment. | G.1 | -------------------------------- - NOTE - LCO 3.0.3 is not applicable. -------------------------------- Suspend movement of [recently] irradiated fuel assemblies in [secondary] containment. | Immediately ] |
| H. [ Required Action and associated Completion Time of Condition A, B, C, D, or E not met for PCIV(s) required to be OPERABLE during MODE 4 or 5 or during operations with a potential for draining the reactor vessel (OPDRVs). | H.1 | Initiate action to suspend OPDRVs. | Immediately |
| | <u>OR</u> | | |
| | H.2 | Initiate action to restore valve(s) to OPERABLE status. | Immediately ] |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.6.1.3.1 | - NOTE -<br>[ [Only required to be met in MODES 1, 2, and 3.]<br><br>Verify each [18] inch primary containment purge valve is sealed closed except for one purge valve in a penetration flow path while in Condition E of this LCO. | 31 days ] |
| SR 3.6.1.3.2 | - NOTES -<br>[ 1. [Only required to be met in MODES 1, 2, and 3.]<br><br>2. Not required to be met when the [18] inch primary containment purge valves are open for inerting, de-inerting, pressure control, ALARA or air quality considerations for personnel entry, or Surveillances that require the valves to be open.<br><br>Verify each [18] inch primary containment purge valve is closed. | 31 days ] |
| SR 3.6.1.3.3 | - NOTES -<br>1. Valves and blind flanges in high radiation areas may be verified by use of administrative means.<br><br>2. Not required to be met for PCIVs that are open under administrative controls.<br><br>Verify each primary containment isolation manual valve and blind flange that is located outside primary containment and not locked, sealed, or otherwise secured and is required to be closed during accident conditions is closed. | 31 days |

SURVEILLANCE REQUIREMENTS (continue)

| | SURVEILLANCE | FREQUENCY |
|---|---|---|
| SR 3.6.1.3.4 | ------------------------------------<br>**- NOTES -**<br>1. Valves and blind flanges in high radiation areas may be verified by use of administrative means.<br>2. Not required to be met for PCIVs that are open under administrative controls.<br>------------------------------------<br>Verify each primary containment manual isolation valve and blind flange that is located inside primary containment and not locked, sealed, or otherwise secured and is required to be closed during accident conditions is closed. | Prior to entering MODE 2 or 3 from MODE 4 if primary containment was de-inerted while in MODE 4, if not performed within the previous 92 days |
| SR 3.6.1.3.5 | Verify continuity of the traversing incore probe (TIP) shear isolation valve explosive charge. | 31 days |
| SR 3.6.1.3.6 | Verify the isolation time of each power operated automatic PCIV, [except for MSIVs], is within limits. | [In accordance with the Inservice Testing Program or 92 days] |
| SR 3.6.1.3.7 | ------------------------------------<br>**- NOTE -**<br>[ [Only required to be met in MODES 1, 2 and 3.]<br>Perform leakage rate testing for each primary containment purge valve with resilient seals.<br>------------------------------------ | 184 days<br>AND<br>Once within 92 days after opening the valve ] |

SURVEILLANCE REQUIREMENTS (continue)

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.6.1.3.8 | Verify the isolation time of each MSIV is ≥ [2] seconds and ≤ [8] seconds. | [In accordance with the Inservice Testing Program or 18 months] |
| SR 3.6.1.3.9 | Verify each automatic PCIV actuates to the isolation position on an actual or simulated isolation signal. | [18] months |
| | ---------- **- REVIEWER'S NOTE –** The bracketed portions of the SR apply to the representative sample as discussed in NEDO-32977-A. ---------- | |
| SR 3.6.1.3.10 | Verify each [a representative sample of] reactor instrumentation line EFCV actuates [on a simulated instrument line break to restrict flow to ≤ 1 gph]. | [18] months |
| SR 3.6.1.3.11 | Remove and test the explosive squib from each shear isolation valve of the TIP System. | [18] months on a STAGGERED TEST BASIS |
| SR 3.6.1.3.12 | ---------- **- NOTE -** [ [Only required to be met in MODES 1, 2, and 3.] ---------- Verify the combined leakage rate for all secondary containment bypass leakage paths is ≤ [ ] $L_a$ when pressurized to ≥ [ ] psig. | In accordance with the Primary Containment Leakage Rate Testing Program ] |
| SR 3.6.1.3.13 | ---------- **- NOTE -** [Only required to be met in MODES 1, 2, and 3.] ---------- Verify leakage rate through each MSIV is ≤ [11.5] scfh when tested at ≥ [28.8] psig. | [In accordance with the Primary Containment Leakage Rate Testing Program] |

SURVEILLANCE REQUIREMENTS (continue)

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.6.1.3.14 | - NOTE -<br>[Only required to be met in MODES 1, 2 and 3.]<br><br>Verify combined leakage rate through hydrostatically tested lines that penetrate the primary containment is within limits. | In accordance with the Primary Containment Leakage Rate Testing Program |
| SR 3.6.1.3.15 | - NOTE -<br>[ [Only required to be met in MODES 1, 2, and 3.]<br><br>Verify each [ ] inch primary containment purge valve is blocked to restrict the valve from opening > [50]%. | [18] months ] |

# Attachment 2

**NUREG-1434, Volume 1, Revision 2 (June 2001), Section 3.6.1.3**

**(Pages 3.6.1.3-1 through 3.6.1.3-9)**

## 3.6 CONTAINMENT SYSTEMS

### 3.6.1.3 Primary Containment Isolation Valves (PCIVs)

LCO 3.6.1.3 Each PCIV shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3,
When associated instrumentation is required to be OPERABLE per LCO 3.3.6.1, "Primary Containment Isolation Instrumentation."

ACTIONS

- NOTES –

1. Penetration flow paths [ ] [except for [ ] inch purge valve penetration flow paths] may be unisolated intermittently under administrative controls.
2. Separate Condition entry is allowed for each penetration flow path.
3. Enter applicable Conditions and Required Actions for systems made inoperable by PCIVs.
4. Enter applicable Conditions and Required Actions of LCO 3.6.1.1, "Primary Containment," when PCIV leakage results in exceeding overall containment leakage rate acceptance criteria in MODES 1, 2, and 3.

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| A. ---------------- **- NOTE -** Only applicable to penetration flow paths with two [or more] PCIVs. ---------------- One or more penetration flow paths with one PCIV inoperable [for reasons other than Condition[s] D [and E]]. | A.1<br><br>AND | Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured. | 4 hours except for main steam line<br><br>AND<br><br>8 hours for main steam line |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| | A.2 ---------------NOTES---------------<br>1. Isolation devices in high radiation areas may be verified by use of administrative means.<br><br>2. Isolation devices that are locked, sealed, or otherwise secured may be verified by use of administrative means.<br>-------------------------------------<br><br>Verify the affected penetration flow path is isolated. | Once per 31 days for isolation devices outside primary containment, drywell, and steam tunnel<br><br>AND<br><br>Prior to entering MODE 2 or 3 from MODE 4, if not performed within the previous 92 days, for isolation devices inside primary containment, drywell, or steam tunnel |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| B. ---------------<br>**- NOTE -**<br>Only applicable to penetration flow paths with two [or more] PCIVs.<br>---------------<br>One or more penetration flow paths with two [or more] PCIVs inoperable [for reasons other than Condition[s] D [and E]]. | B.1 | Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange. | 1 hour |
| C. ---------------<br>**- NOTE -**<br>Only applicable to penetration flow paths with only one PCIV.<br>---------------<br>One or more penetration flow paths with one PCIV inoperable [for reasons other than Condition[s] D [and E]]. | C.1 | Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange. | [4] hours except for penetrations with a closed system<br><br><u>AND</u><br><br>72 hours for penetrations with a closed system |
| | <u>AND</u> | | |
| | C.2 | ---------------<br>**- NOTES -**<br>1. Isolation devices in high radiation areas may be verified by use of administrative means.<br><br>2. Isolation devices that are locked, sealed, or otherwise secured may be verified by use of administrative means.<br>---------------<br>Verify the affected penetration flow path is isolated. | Once per 31 days |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| D. [ One or more [secondary containment bypass leakage rate,] [MSIV leakage rate,] [purge valve leakage rate,] [or] [hydrostatically tested line leakage rate] not within limit. | D.1 | Restore leakage rate to within limit. | [4 hours for hydrostatically tested line leakage [not on a closed system]]<br><br>AND<br><br>[4 hours for secondary containment bypass leakage]<br><br>AND<br><br>[8 hours for MSIV leakage]<br><br>AND<br><br>[24 hours for purge valve leakage]<br><br>AND<br><br>[72 hours for hydrostatically tested line leakage [on a closed system] ] |
| E. [ One or more penetration flow paths with one or more containment purge valves not within purge valve leakage limits. | E.1 | Isolate the affected penetration flow path by use of at least one [closed and de-activated automatic valve, closed manual valve, or blind flange]. | 24 hours |
| | AND | | |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| | E.2 | ---------------<br>**- NOTES -**<br>1. Isolation devices in high radiation areas may be verified by use of administrative means.<br><br>2. Isolation devices that are locked, sealed, or otherwise secured may be verified by use of administrative means.<br>---------------<br>Verify the affected penetration flow path is isolated. | Once per 31 days for isolation devices outside containment<br><br><u>AND</u><br><br>Prior to entering MODE 2 or 3 from MODE 4 if not performed within the previous 92 days for isolation devices inside containment |
| | <u>AND</u> | | |
| | E.3 | Perform SR 3.6.1.3.7 for the resilient seal purge valves closed to comply with Required Action E.1. | Once per [92] days ] |
| F. Required Action and associated Completion Time of Condition A, B, C, D, or E not met in MODE 1, 2, or 3. | F.1 | Be in MODE 3. | 12 hours |
| | <u>AND</u> | | |
| | F.2 | Be in MODE 4. | 36 hours |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| G. [ Required Action and associated Completion Time of Condition A, B, C, D, or E not met for PCIV(s) required to be OPERABLE during movement of [recently] irradiated fuel assemblies in the [primary or [secondary] containment. | G.1 ----- **- NOTE -** LCO 3.0.3 is not applicable. ----- Suspend movement of [recently] irradiated fuel assemblies in [primary and secondary containment | Immediately ] |
| H. [ Required Action and Associated Completion Time of Condition A, B, C, D, or E not met for PCIV(s) required to be OPERABLE during MODE 4 or 5 or during operations with a potential for draining the reactor vessel (OPDRVs). | H.1 Initiate action to suspend OPDRVs. | Immediately |
| | OR | |
| | H.2 Initiate action to restore valve(s) to OPERABLE status. | Immediately ] |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.6.1.3.1 | ----- **- NOTE -** [ [Only required to be met in MODES 1, 2, and 3.] ----- Verify each [ ] inch primary containment purge valve is sealed closed except for one purge valve in a penetration flow path while in Condition E of this LCO. | 31 days ] |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.6.1.3.2 | - NOTES -<br>[ 1. [Only required to be met in MODES 1, 2, and 3.]<br>2. Not required to be met when the [20] inch primary containment purge valves are open for pressure control, ALARA or air quality considerations for personnel entry, or Surveillances that require the valves to be open, provided the drywell [purge supply and exhaust] lines are isolated.<br><br>Verify each [20] inch primary containment purge valve is closed. | 31 days ] |
| SR 3.6.1.3.3 | - NOTES -<br>1. Valves and blind flanges in high radiation areas may be verified by use of administrative means.<br>2. Not required to be met for PCIVs that are open under administrative controls.<br><br>Verify each primary containment isolation manual valve and blind flange that is located outside primary containment, drywell, and steam tunnel and not locked, sealed, or otherwise secured and is required to be closed during accident conditions is closed. | 31 days |

SURVEILLANCE REQUIREMENTS (continue)

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.6.1.3.4 | - NOTES -<br>1. Valves and blind flanges in high radiation areas may be verified by use of administrative means.<br>2. Not required to be met for PCIVs that are open under administrative controls.<br><br>Verify each primary containment isolation manual valve and blind flange that is located inside primary containment, drywell, or steam tunnel and not locked, sealed, or otherwise secured and is required to be closed during accident conditions is closed. | Prior to entering MODE 2 or 3 from MODE 4 if not performed within the previous 92 days |
| SR 3.6.1.3.5 | Verify the isolation time of each power operated, automatic PCIV[, except MSIVs,] is within limits. | [In accordance with the Inservice Testing Program or 92 days] |
| SR 3.6.1.3.6 | - NOTE -<br>[ [Only required to be met in MODES 1, 2, and 3.]<br><br>Perform leakage rate testing for each primary containment purge valve with resilient seals. | 184 days<br><br><u>AND</u><br><br>Once within 92 days after opening the valve ] |
| SR 3.6.1.3.7 | Verify the isolation time of each MSIV is ≥ [3] seconds and ≤ [5] seconds. | [In accordance with the Inservice Testing Program or [18] months] |
| SR 3.6.1.3.8 | Verify each automatic PCIV actuates to the isolation position on an actual or simulated isolation signal. | [18] months |

SURVEILLANCE REQUIREMENTS (continue)

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.6.1.3.9 | - NOTE - [ [Only required to be met in MODES 1, 2, and 3.]<br><br>Verify the combined leakage rate for all secondary containment bypass leakage paths is ≤ [ ] $L_a$ when pressurized to ≥ [ ] psig. | In accordance with the Primary Containment Leakage Rate Testing Program ] |
| SR 3.6.1.3.10 | - NOTE - [Only required to be met in MODES 1, 2, and 3.]<br><br>Verify leakage rate through all four main steam lines is ≤ [100] scfh when tested at ≥ [11.5] psig. | [In accordance with the Primary Containment Leakage Rate Testing Program] |
| SR 3.6.1.3.11 | - NOTE - [Only required to be met in MODES 1, 2, and 3.]<br><br>Verify combined leakage rate through hydrostatically tested lines that penetrate the primary containment is within limits. | In accordance with the Primary Containment Leakage Rate Testing Program |
| SR 3.6.1.3.12 | - NOTE - [ [Only required to be met in MODES 1, 2, and 3.]<br><br>Verify each [ ] inch primary containment purge valve is blocked to restrict the valve from opening > [50]%. | [18] months ] |