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March 14, 2001
CEOG-01-065

NRC Project 692

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

Subject: Transmittal of Approved Topical Report CE NPSD-1168-A, Rev 00

Reference: (1) CEOG Letter, R. Phelps to NRC, Submittal of CE NPSD-1168, "Joint Applications Report for Containment Isolation Valve AOT Extension," CEOG-99-239, 7/27/1999.

Reference (1) submitted Topical Report CE NPSD-1168 for staff review and approval. The staff safety evaluation for this report was issued on December 21, 2000 and is stored in ADAMS under accessions number ML003779518.

The purpose of this letter is to transmit one unbound copy of the approved topical report for entry into the NRC's public records. In addition, three bound copies of the approved report are enclosed for staff use. As requested, a copy of the staff safety evaluation is incorporated into CE NPSD-1168-A. This report is nonproprietary and may be released to the public.

Please do not hesitate to contact me at 623-393-5882 or Gordon Bischoff, CEOG Project Office, at 860-285-5494 if you have any questions.

Sincerely,

Richard A. Bernier

Richard A. Bernier, Chairman
CE Owners Group

Enclosure: as stated
cc: J. S. Cushing w/ 3 copies (NRC)

D047

cc: CE Owners Group
CEOG Licensing and PSA Subcommittees
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CEOG COMBUSTION ENGINEERING OWNERS GROUP

CE NPSD-1168-A, Rev 00

Joint Applications Report for Containment Isolation Valve AOT Extension

CEOG Task 849

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CE NPSD-1168-A, Rev 0

Joint Applications Report for Containment Isolation Valve AOT Extension

CEOG Task 849
Final Report

January 2001

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UNITED STATES
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WASHINGTON, D.C. 20555-0001

December 21, 2000

Mr. Richard Bernier, Chairman
CE Owners Group
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SUBJECT: ACCEPTANCE ERRATA FOR COMBUSTION ENGINEERING OWNERS GROUP CE NPSD-1168, "JOINT APPLICATIONS REPORT FOR CONTAINMENT ISOLATION VALVE AOT EXTENSION" (TAC NO. MA9957)

Dear Mr. Bernier:

CE NPSD-1168, "Joint Applications Report for Containment Isolation Valve AOT [allowed outage time] Extension" provides a risk-informed justification for extending the technical specifications AOT for containment isolation valves from the current value of four hours to seven days. By letter dated June 26, 2000, the staff issued its safety evaluation (SE) accepting the topical report for referencing in licensing applications.

By letters dated September 8 and 18, 2000, you submitted errata to topical report CE NPSD-1168. The errata identified a number of changes that are either editorial or minor numerical changes to the risk numbers. The principle change identified in the errata is that the total conditional core damage probability value changed from 3.73E-3 to 3.75E-3. This change to the total core damage probability propagated into other calculated values in the topical report.

The changes that are editorial in nature do not affect the conclusion reached in the staff's SE dated June 26, 2000. The changes to the risk numbers are not significant and are within the guidelines of Regulatory Guide 1.177, "An Approach for Plant-Specific, Risk-Informed Decisionmaking: Technical Specifications," and do not affect the conclusion reached in the staff's SE dated June 26, 2000.

In accordance with procedures established in NUREG-0390, "Topical Report Review Status," we request that the CEOG publish an accepted version of this topical report within three months of receipt of this letter. The accepted version shall place this letter between the title page and the abstract and replace the incorrect pages of the topical report with the corrected pages. It must be well indexed such that information is readily located. Also, it must contain in appendices historical review information, such as questions and accepted responses, and original report pages that were replaced. The accepted version shall include an "-A" (designating accepted) following the report identification symbol.

Should our criteria or regulations change so that our conclusions as to the acceptability of the report are invalidated, the CEOG and/or the applicants referencing the topical report will be expected to revise and resubmit their respective documentation, or submit justification for the continued applicability of the topical report without revision of their respective documentation.

If you have further questions, you may contact Jack Cushing at 301-415-1424, or on the Internet at jxc9@nrc.gov.

Sincerely,

Stuart A. Richards, Director
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 692

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UNITED STATES
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WASHINGTON, D.C. 20555-0001

June 26, 2000

Mr. Ralph Phelps, Chairman
CE Owners Group
Omaha Public Power District
P.O. Box 399
Ft. Calhoun, NE 68023-0399

SUBJECT: ACCEPTANCE FOR REFERENCING OF COMBUSTION ENGINEERING OWNERS GROUP CE NPSD-1168, "JOINT APPLICATIONS REPORT FOR CONTAINMENT ISOLATION VALVE AOT EXTENSION" (TAC NO. MA6288)

Dear Mr. Phelps:

We have concluded our review of the Joint Applications Report (JAR) "Joint Applications Report for Containment Isolation Valve AOT Extension," dated June 1999, submitted by the Combustion Engineering Owners Group (CEOG). This report provides a risk-informed justification for extending the technical specifications allowed outage time (AOT) for containment isolation valves (CIV) from the current value of four hours to seven days.

The CIV AOT extension to seven days is acceptable for referencing in licensing applications for Combustion Engineering (CE) plants subject to the limitations specified in the report and in the associated NRC safety evaluation, which is enclosed. The evaluation defines the basis for acceptance of the report.

The JAR evaluates the risk of, and requests relaxation of, 14 containment isolation valve configurations common to CE-designed plants. The JAR does not request AOT relaxation for containment sump supply valves for the emergency core cooling system (ECCS), containment spray system (CSS) pumps, valves associated with the main feedwater system, or main steam isolation valves.

We do not intend to repeat our review of the matters described in the report, and found acceptable, when the report appears as a reference in license applications, except to assure that the material presented is applicable to the specific plant involved. Our acceptance applies only to matters approved in the report.

In accordance with procedures established in NUREG-0390, "Topical Report Review Status," we request that the CEOG publish an accepted version of this topical report within 3 months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed safety evaluation between the title page and the abstract. It must be well indexed such that information is readily located. Also, it must contain in appendices historical review information, such as questions and accepted responses, and original report pages that were replaced. The accepted version shall include an "-A" (designating accepted) following the report identification symbol.

Should our criteria or regulations change so that our conclusions as to the acceptability of the report are invalidated, the CEOG and/or the applicants referencing the topical report will be expected to revise and resubmit their respective documentation, or submit justification for the continued applicability of the topical report without revision of their respective documentation.

If you have further questions, you may contact Jack Cushing at 301-415-1424, or on the internet at jxc9@nrc.gov.

Sincerely,

/RA/

Stuart A. Richards, Director
Project Directorate IV & Decommissioning
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Project No. 692

Enclosure: Safety Evaluation

cc w/encl: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO COMBUSTION ENGINEERING OWNERS GROUP

CE NPSD-1168, "JOINT APPLICATIONS REPORT

FOR CONTAINMENT ISOLATION VALVE AOT EXTENSION"

1.0 INTRODUCTION

The Combustion Engineering Owners Group (CEOG) submitted Joint Applications Report (JAR) CE NPSD-1168, dated June 1999, to justify a risk informed change in the technical specifications allowed outage time (AOT) for containment isolation valves (CIVs). The staff has completed its review of this report with the assistance of Scientech, Incorporated. The Scientech technical evaluation report (TER) is attached.

2.0 BACKGROUND

The CEOG conducted a study of the justification for extending the allowed outage time of CIVs from four hours to seven days and documented the results in the Joint Applications Report (JAR) CE NPSD-1168. In particular, the report addresses the case of one CIV inoperable in a penetration with redundant CIVs and the case of an inoperable CIV in a penetration with one CIV which is part of a closed system. The JAR does not address the case of both redundant CIVs in a penetration being inoperable which typically has an AOT of one hour. This requirement will therefore remain unchanged.

The technical analysis used upper-bound values from the set of Combustion Engineering (CE) designed plants. AOT relaxations for containment sump supply valves to the emergency core cooling system (ECCS) and containment spray system (CSS) pumps, valves associated with the main feedwater system, and main steam isolation valves (MSIVs) are not proposed by CE NPSD-1168.

The staff was assisted in this review by Scientech, Incorporated. The results of the Scientech review are documented in SCIE-NRC-394-99, "Technical Evaluation of the CEOG Joint Applications for Containment Isolation Valve Allowed Outage Time Extension," dated December 30, 1999.

The staff has reviewed the evaluation and findings of the Scientech report and agrees with the conclusions of the report. These conclusions are documented in this safety evaluation.

3.0 EVALUATION

3.1 Traditional Engineering Evaluation

CIVs, individually and in combination, control the extent of leakage from the containment following an accident. The proposed AOT extension applies to the reduction in redundancy in the containment isolation function by the CIVs for a limited period of time but should not alter the ability of the plant to meet the overall containment leakage requirements. In developing proposed license amendment requests for extended opening of a CIV, a licensee must confirm that the action of locking open a subject CIV 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 seven day AOT on plant operation with a locked open CIV is discussed below for the various flowpath classes.

Class A Flowpath

The CIVs 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 CIVs associated with these flowpaths have the intended function to isolate in order to minimize the leakage of reactor coolant. For example, failure to isolate letdown will result in additional reactor coolant system (RCS) leakage. The letdown line has three valves capable of isolating the penetration. These valves each receive a signal to close on a safety injection actuation signal and a containment isolation actuation signal. Therefore, the consequences of locking one of the letdown line CIVs 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 CIV or similar valve capable of system isolation is available to provide assurance of containment isolation following an accident.

Class C Flowpaths

The CIVs 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

A Class D piping penetration includes the containment pressure sensor. The CIVs associated with Class D containment piping penetrations are designed to be open during power operation and provide integral input to the engineered safety features actuation system (ESFAS) (or engineered safeguards control system). The CIVs 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 CIVs is not required.

Class E Flowpaths

There are three types of Class E penetrations of interest: (1) penetrations designed to provide safety injection to the RCS (2) penetrations designed to provide makeup flow to the RCS 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 CIVs are also open during power operation to perform normal operational functions. For these penetration flowpaths, locking the CIV 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, and the plant may not be able to operate for an extended period without being forced to shut down. The CIVs that are actuated in an open position or receive a confirmatory open signal following the generation of an ESFAS are the ECCS isolation valves, CSS isolation valves, CIVs contained within the component cooling water system (CCWS) and the auxiliary feedwater (AFW) isolation valves. The JAR did not request AOT relaxations for containment sump supply valves to the ECCS and containment spray system pumps, valves associated with the main feedwater system, and the MSIVs.

<u>ECCS Isolation Valves</u>

In the case of ECCS safety injection (SI) valves, unavailability of one SI injection flowpath [in addition to one which is assumed unavailable during a cold leg loss of coolant accident (LOCA)] 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.

<u>CSS Isolation Valves</u>

Inoperability of the CSS valves that serve a containment isolation function to open will render the associated CSS inoperable. This has minimal impact on the accident mitigation capability of the CSS since the redundant means of spray injection is available. Furthermore, all CE PWRs with the exception of Palo Verde are also equipped with emergency containment fan cooler units which provide a diverse means of containment heat removal.

<u>Cooling Water Isolation Valves for the Containment Fan Cooler Units (CFCUs)</u>

Inability of the cooling water isolation valves of the CFCUs to open will disable one train of containment fan coolers. The loss of a single CFCU will result in marginal impact on containment heat removal since redundant CFCUs are available and containment heat removal may also be accomplished by use of the CSS.

AFW Isolation Valves

The operability issues associated with the AFW isolation valves overlap with AFW system operability. CE technical specifications require AFW operability to include both the valve's ability to open (to satisfy its decay heat removal function) and the ability to remain closed or to close in the event of a feedwater line break or a steam generator tube rupture. Thus, by extending the CIV AOT to seven days, the limiting requirements associated with the CIV in the open position will become those associated with AFW system operability (typically, a 72 hour AOT for one AFW train).

3.2 Probabilistic Risk Assessment Evaluation

3.2.1 Tier One

The risk measures used to assess the impact of the proposed changes are consistent with the measures defined in Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Current Licensing Basis," and Regulatory Guide 1.177, "An Approach for Plant-Specific, Risk-Informed Decision Making: Technical Specifications," with only minor changes. Regulatory Guide 1.177 provides for a three-tiered approach to evaluate the risks associated with the proposed license amendments. The first tier evaluates the PRA model and the impacts of the changes on plant operational risk. The second tier addresses the need to preclude potentially high risk configurations should additional equipment outages occur during the allowed outage time. The third tier evaluates the licensee's configuration risk management program (CRMP) to ensure that the removal of equipment from service immediately prior to or during the proposed AOT will be appropriately assessed from a risk perspective.

The effects of assumed CIV failure are included quantitatively in Table 6 of the attached Scientech TER and are summarized in Table 8 of that report.

On the basis of the staff's review, the findings below pertain to core damage frequency (CDF) and large early release frequency (LERF).

The analyses of the JAR are generic. All cases do not have the same impact on CDF and LERF for the generic study. It will therefore be necessary for individual licensees requesting CIV AOT relaxations to justify the applicability of the JAR results for their particular plant. Thus, plant-specific analyses, original or comparative, should be performed to ensure the applicability of the CE NPSD-1168 results in assessing the impact of the extended AOT for inoperable CIVs. The licensee must also provide information on how external events would impact the analysis and revised technical specifications. In performing the plant-specific analyses, credit for physical barrier integrity outside containment can only be given for seismically qualified piping systems.

Licensees should ensure that the relaxed AOT will only apply to penetrations analyzed to meet the risk guidelines of Regulatory Guide 1.177. The JAR considers 14 containment penetration configurations. Any others must be included in the licensee's plant-specific analysis.

Common-cause failures were not addressed in the JAR. Therefore, common cause failures need to be addressed on a plant-specific basis. In this regard, the operability of the remaining CIV in a penetration flow path needs to be verified before entering the relaxed AOT interval. This action would serve to ensure that defense-in-depth is maintained. Plant-specific submittals should describe how this will be done either based upon technical specifications requirements, the provisions of the CRMP, or on some other acceptable basis.

The JAR assumes that the penetrations remain physically intact so that their integrity is maintained. In instances where corrective or preventive maintenance activities would be performed on penetrations and CIVs while in modes requiring these valves to be operable, it will be necessary to monitor the activities and ensure that the integrity of the penetration is not compromised during the maintenance. Considerations should include, for example, the impact of physical removal of sealing material (packing) and removal of CIV components that would affect penetration integrity. Licensees should describe in their plant-specific applications how the affected penetration will remain physically intact, or state in their plant-specific applications that the penetration will be isolated so as not to permit a release to the outside environment.

The incremental conditional core damage probabilities (ICCDPs) and incremental conditional large early release probabilities (ICLERPs) for 14 CIV flow paths for the bounding values used in the analyses are presented in Table 7 of the Scientech TER. These results are well within the ICCDP guideline of 5.0E-7 and the ICLERP guideline of 5.0E-8.

3.2.2 <u>Tier 2 and Tier 3 Capabilities</u>

Tier 2 Capability

One of the main requirements of the Tier 2 program is to establish whether each licensee is providing reasonable assurance that risk-significant plant equipment outage configurations will not occur when one or more CIVs are out of service. Although the information provided in CE NPSD-1168 is not plant-specific, based on the presentation in Sections 6.6 and 6.7, "Tier 2 Considerations" and "Commitment to Configuration Risk Management Program," respectively, of CE NPSD-1168, licensees of CE-designed plants that endorse CE NPSD-1168 will meet the intent of the Tier 2 program.

Tier 3 Capability

The main criteria of the Tier 3 program are to ensure that licensees have:

- a predetermined knowledge of high risk configurations (e.g., risk matrix, spectrum of PRA analyses, or an on-line safety monitor), or

- the ability to evaluate and compensate for configuration risks as they evolve.

Due to lack of plant-specific data in CE NPSD-1168, licensees should furnish information in individual submittals on how Tier 3 will be implemented.

In this regard, licensees should propose, in a new TS or other administratively controlled document that the staff finds acceptable, a "Configuration Risk Management Program" (CRMP). The CRMP provides a proceduralized risk-informed assessment to manage the risk associated with equipment inoperability. The programs apply to technical specification structures, systems, and components for which a risk-informed allowed outage time has been granted. The term "completion time" is synonymous with "allowed outage time." The proposed programs include the following elements:

a. Provisions for the control and implementation of a Level 1, at power, internal events, PRA-informed methodology. The assessment shall be capable of evaluating the applicable plant configuration.

b. Provisions for performing an assessment prior to entering the limiting condition for operation (LCO) for preplanned activities.

c. Provisions for performing an assessment after entering the LCO for unplanned entry into the LCO.

d. Provisions for assessing the need for additional actions after the discovery of additional equipment out-of-service conditions while in the LCO.

e. Provisions for considering other applicable risk significant contributors such as Level 2 issues and external events, qualitatively or quantitatively.

As stated above, the CRMPs are acceptable in that the programs provide the necessary assurances that appropriate assessments of plant risk configurations using software, matrices, or PRA analyses augmented by appropriate engineering judgment, are sufficient to support the proposed AOT extension requests for CIVs.

In addition, the CRMPs are used to assess changes in core damage frequency resulting from applicable plant configurations. The CRMPs use software, matrices, or if necessary, the full PRA to aid in the risk assessment of online maintenance and to evaluate the change in risk from a component failure.

The CRMP is used when a CIV is intentionally taken out of service for a planned activity excluding short duration activities. In addition, the CRMP is used for unplanned maintenance or repairs of the CIV.

The licensee should commit to implementation of the CRMP as described below.

The CRMP includes the following key elements:

Key Element 1. Implementation of CRMP

The intent of the CRMP is to implement 10 CFR 50.65(a)(3) (maintenance rule) with respect to on-line maintenance for risk-informed technical specifications, with the following additions and clarifications:

a. The scope of the structures, systems and components (SSCs) to be included in the CRMP will be those SSCs modeled in the licensee's plant PRA in addition to those SSCs considered risk significant in accordance with the plant maintenance rule program that are not modeled in the PRA.

b. The CRMP is PRA informed, and may be in the form of either a matrix, an on-line assessment, or a direct PRA assessment.

c. CRMP will be invoked for:

   Risk-Informed Inoperability: A risk assessment shall be performed prior to entering the LCO for preplanned activities. For unplanned entry into the LCO, a risk assessment will be performed in accordance with plant procedures, utilizing the maintenance configuration matrix, augmented by appropriate engineering judgment.

   Additional SSC Inoperability and/or Loss of Functionality: When in the risk-informed completion time, if an additional SSC within the scope of the CRMP becomes inoperable or non-functional, a risk assessment shall be performed in accordance with plant procedures.

d. Tier 2 commitments apply for planned maintenance only, but will be evaluated as part of the Tier 3 assessment for unplanned occurrences.

Key Element 2. Control and Use of the CRMP

a. Plant modifications and procedure changes will be monitored, assessed, and dispositioned as part of the normal PRA update process:

   - Evaluation of changes in plant configuration or PRA model features can be dispositioned by implementing PRA model changes or by the qualitative assessment of the impact of the changes on the CRMP. This qualitative assessment recognizes that changes to the PRA take time to implement and that changes can be effectively compensated for without compromising the ability to make sound engineering judgments.

   - Limitations of the CRMP are identified and understood for each specific completion time extension.

b. Procedures exist for the control and application of CRMP, including description of the process when outside the scope of the CRMP.

Key Element 3. Level 1 Risk-Informed Assessment

The CRMP assessment tool is based on a Level 1, at power, internal events PRA model. The CRMP assessment may use any combination of quantitative and qualitative input. Quantitative assessments can include reference to a risk matrix, pre-existing calculations, or new PRA analyses.

a. Quantitative assessments should be performed whenever necessary for sound decisionmaking.

b. When quantitative assessments are not necessary for sound decisionmaking, qualitative assessments will be performed. Qualitative assessments will consider applicable, existing insights from quantitative assessments previously performed.

Key Element 4. Level 2 Issues/External Events

External events and Level 2 issues are treated qualitatively and/or quantitatively.

Guidance for implementing the CRMP is provided by plant procedures.

The licensee will have the ability to analyze the risk impact of outage configurations in a timely manner using an appropriate risk-informed tool.
If a licensee requests a TS change consistent with this JAR after the revision to the maintenance rule, 10 CFR 50.65 (64 FR 38551, July 19, 1999, and 65 FR 34913, June 1, 2000), becomes effective on November 28, 2000, then implementation of a plant CRMP will not be necessary. The licensee's implementation of the provisions of 10 CFR 50.64(a)(4) will provide adequate configuration risk management.

The staff's third tier evaluation concludes that the risk-informed CRMP proposed by the licensee will satisfactorily assess the risk associated with the removal of equipment from service during the proposed CIV AOT. The program provides the necessary assurances that appropriate assessments of plant risk configurations, including during outage conditions, are sufficient to support the AOT extension request for the CIVs.

3.2.3 PRA Quality

To ensure that specific PRAs are adequate to support the requested TS changes, each licensee should state in its plant-specific application that it has verified acceptable PRA quality as described in RG 1.177, including:

- Assurance that the PRA reflects the as-built, as-operated plant
- Updates of the PRA since the last review cycle, including corrections of weaknesses identified by past reviews
- Details of their peer review process, a summary of the peer review findings, and a discussion of the independence of internal reviews/reviewers
- Description of PRA quality assurance methods
- Results of reviews of pertinent accident sequences and cut sets for modeling adequacy and completeness (with respect to this application)

4.0 CONCLUSION

The AOT extension will allow efficient scheduling of online maintenance within the boundaries established by implementing the maintenance rule.

The staff agrees with the CEOG findings that based on the use of bounding risk parameters for CE-designed plants, the proposed increase in the CIV AOT from four hours to seven days does not alter the ability of the plant to meet the overall containment leakage requirements and does not result in an unacceptable incremental conditional core damage probability or incremental conditional large early release probability according to the guidelines of Regulatory Guide 1.177 when the items discussed in this safety evaluation and identified below are acceptably addressed by individual licensees referencing this report in plant-specific submittals.

Analysis

a. Since the JAR is generic, individual licensees requesting CIV AOT relaxations should state in their plant-specific applications that they have verified that they have justified the applicability of the JAR results to their particular plant. Licensees should ensure that the relaxed AOT will only apply to penetrations analyzed to meet the risk guidelines of Regulatory Guide 1.177. The JAR considers 14 containment penetration configurations. Any other containment isolation valve configurations which were not analyzed in the JAR to which the revised AOT will apply must be included in the licensee's plant-specific analysis.

   In addition, the JAR identified three sets of valves (containment sump supply valves to the ECCS and containment spray system pumps, valves associated with the main feedwater system, and main steam isolation valves), to which the revised AOT will not apply. Licensees' plant-specific technical specification submittals must maintain the current technical specifications AOT value for these valves.

b. Licensees should provide sufficient quantitative or qualitative substantiation to demonstrate that external events will not impact the results of the analysis supporting the revised technical specifications.

c. Licensees should state in their plant-specific applications that they have verified acceptable PRA quality as described in Regulatory Guide 1.177.

Configuration Risk Management Program

a. Licensees must state in their plant-specific applications that a risk-informed plant CRMP to assess the risk associated with the removal of equipment from service during the AOT has been implemented (unless the submittal is made after the revised maintenance rule has become effective). An acceptable CRMP must be incorporated into documents that the staff finds acceptable.

b. Concerns with common-cause failures were not addressed in the JAR. Licensees should require verification of the operability of the remaining CIV(s) in a penetration flow path before entering the relaxed AOT interval for corrective maintenance.

c. The JAR assumes that the penetrations remain physically intact (except following seismic events or spurious lifting of relief valves) while in modes requiring these valves to be operable during corrective or preventive maintenance. Licensees should describe in their plant-specific applications how the affected penetration will remain physically intact, or state in their plant-specific applications that the penetration will be isolated so as not to permit a release to the outside environment.

d. The licensee's CRMP should consider the additive nature of multiple failed CIVs, and the possibility of entering multiple AOTs and verify that these situations will result in risks consistent with the incremental conditional core damage probability and incremental large early release probability guidelines so that defense-in-depth for safety systems will be maintained.

The staff expects the licensees to implement these technical specifications changes and the other administratively controlled documentation in accordance with the three-tiered approach described above. The licensees will monitor CIV performance in relation to the maintenance rule performance criteria. Application of implementation and monitoring strategies will help to ensure that extension of the containment isolation valve AOT, which is the subject of the CE NPSD-1168, will not degrade operational safety over time and that the risk incurred when a CIV train is taken out of service is acceptable.

Attachment: Technical Evaluation Report

Principal Contributors: M. Wohl
R. Lobel

Date: June 26, 2000

Attachment: SCIENTECH Technical Evaluation Report, "Technical Evaluation of the CEOG Joint Applications for Containment Isolation Valve Allowed Outage Time Extension."

SCIE-NRC-394-99

TECHNICAL EVALUATION OF THE CEOG JOINT APPLICATIONS FOR CONTAINMENT ISOLATION VALVE ALLOWED OUTAGE TIME EXTENSION

FINAL REPORT

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December 30, 1999

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Attachment

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EXECUTIVE SUMMARY

This report provides the results of the evaluation performed on the risk-informed application submitted by the Combustion Engineering Owners Group (CEOG) to extend the allowed outage time (AOT) for many containment isolation valves (CIVs) from 4 hours to 7 days in modes 1, 2, 3, and 4. The requested change applies to those CIVs addressed by Condition A and C of Section 3.6.3 of NUREG-1432, Revision 1. The joint applications report (JAR), CE NPSD-1168, cites the need for flexibility in the performance of on-line maintenance and surveillance testing as the primary reason for the requested change. This evaluation focused on the PRA aspects of the joint application in order to determine the degree of departure from the guideline values for the AOT risk as provided in the standard review plan for the technical specifications (Chapter 16.1). The guideline value has been used as a gauge for measuring the risk significance of the limiting condition of operation (LCO) configuration in risk-informed technical specification (TS) evaluations. With respect to core damage, the guideline of 5E-7 is compared with the probability of core damage occurring, while in the LCO configuration during the allowed outage time. This probability, which is referred to as the single AOT risk (SAOT) is obtained by multiplying the increase in the core-damage frequency (CDF) [conditional CDF given one CIV is out, less baseline CDF] by the proposed AOT of 168 hours. Relative to large early release, the guideline for a single AOT risk is 5E-8.

SCIENTECH has completed its review of the proposal by the CEOG to extend the AOT for inoperable containment isolation valves. The results of this risk-informed evaluation are presented in this report. Overall we believe that the approach has merit with regard to enhancement of on-line valve repair and maintenance activities during plant operations. We agree with the findings of the CEOG that the increase in CIV AOT from 4 hours to 7 days does not result in an unacceptable incremental increase in either CDF or large early release frequency (LERF) and thus, sufficient safety margin is assured. This finding is conditional on satisfying the assumptions of the risk-informed analyses presented herein and in the JAR, and resolution of certain concerns discussed below and in the body of this report. The review of the various containment penetration/isolation valve configurations typical for CE type plants was based upon the guidelines of RG 1.177 - An Approach for Plant-Specific, Risk-Informed Decision-making: Technical Specifications.

The JAR identified certain isolation valves for which justification for the extended AOT has not been pursued. These valves include the containment sump supply valves to the emergency core cooling system (ECCS) and containment spray system (CSS) pumps, valves associated with the main feedwater systems, and main steam isolation valves. Further, while the CEOG/JAR report is generic, it would be necessary for a particular licensee requesting TS changes to verify the applicability of the JAR results for their particular plant application. In addition, the following items were discussed with the CEOG and will either need to be evaluated in individual plant submittals or through revisions to the JAR:

- Concerns with common-cause failures need to be evaluated. In this regard, the operability of the remaining CIV in a penetration flow path needs to be verified before entering the extended AOT interval. This action would serve to ensure that defense-in-depth is maintained.

- In instances where corrective maintenance activities would be performed on penetrations and CIVs, it will be necessary to monitor the activities and ensure that the system remains intact during the maintenance period. Considerations should include the impact of physical removal of CIV components that would affect penetration integrity against the loss of a physical barrier. Such proposed activities should be evaluated against the overall model and assumptions used in the JAR.

- Consideration needs to be given in dealing with the potential for any additive nature of failed CIVs, and entering multiple AOT outages and accumulated risk. Such activities should be within the guidelines of the single AOT risk (both CDF and LERF) and maintain defense-in-depth for the safety systems.

ACRONYMS

ANO-2	Arkansas Nuclear One, Unit 2
AOT	Allowed Outage Time
AOV	Air-Operated Valve
CC	Common Cause
CCDF	Conditional Core Damage Frequency
CDF	Core Damage Frequency
CDP	Core Damage Probability
CE	Combustion Engineering
CEOG	Combustion Engineering Owners Group
CIAS	Containment Isolation Actuation Signal
CIV	Containment Isolation Valve
CLERF	Conditional Large Early Release Frequency
CM	Corrective Maintenance
CRMP	Configuration Risk Management Program
CS	Containment Spray
CSS	Containment Spray System
CVCS	Chemical Volume Control System
DBA	Design Basis Accident
ECCS	Emergency Core Cooling System
ESFAS	Engineered Safety Feature Actuation System
HPSI	High Pressure Safety Injection
ICCDP	Incremental Conditional Core Damage Probability
ICLERP	Incremental Conditional Large Early Release Probability
IPE	Individual Plant Examination
ISLOCA	Interfacing System Loss of Coolant Accident
JAR	Joint Applications Report
LB	Licensing Basis
LCO	Limiting Condition of Operation
LERF	Large Early Release Frequency
LERP	Large Early Release Probability
LLRF	Large Late Release Frequency
LOCA	Loss of Coolant Accident
LPSI	Low Pressure Safety Injection
MOV	Motor-Operated Valve
MR	Maintenance Rule
MSIV	Main Steam Isolation Valve
NRC	U.S. Nuclear Regulatory Commission
PM	Preventive Maintenance
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Assessment
RCP	Reactor Coolant Pump
RCS	Reactor Cooling System
RHR	Residual Heat Removal
RWT	Refueling Water Tank
SAOT	Single AOT Risk
SE	Safety Evaluation
SG	Steam Generator

SGTR	Steam Generator Tube Rupture
SIAS	Safety Injection Actuation Signal
SLOCA	Small Loss of Coolant Accident
SOW	Statement of Work
SRP	Standard Review Plan (NUREG-0800)
SSC	Structure, System and/or Component
STI	Surveillance Test Interval
TER	Technical Evaluation Report
TS	Technical Specifications
VIAS	Ventilation Isolation Actuation Signal

1. INTRODUCTION

1.1 Background

In June 1999 the Combustion Engineering Owners Group (CEOG) submitted, for staff review, a joint applications report (JAR) to modify the technical specifications (TS) for many containment isolation valves (CIVs) [1]. The proposed changes would allow an extension of the allowed outage time (AOT) to 7 days for CIVs addressed by Conditions A and C of Section 3.6.3 of NUREG-1432, Revision 1 [2]. Exceptions cited in the JAR where justification has not been pursued include (1) the containment sump supply valve to the ECCS and CSS pumps; and valves associated with main feedwater systems and main steam isolation valves. The JAR provided risk-informed and deterministic arguments to justify the AOT extension. The risk assessment provided in the JAR is not plant specific and is presented as a bounding analysis. The conclusions drawn in the JAR are considered applicable to all of the CE plants.

The NRC requested SCIENTECH, Inc. to evaluate the joint applications report focusing on the risk-informed analyses performed to support the AOT extension request. This report documents the results of the review activities performed for the risk-informed portion of the submittal. The review activities were based on the requirements of the statement of the work (SOW) [3] and the guidance provided by the NRC staff. The review was also carried out, to the extent consistent with the SOW, in adherence with the guidance contained in standard review plans (SRPs) [4, 5] and regulatory guides [6, 7].

1.2 Compliance of Review Process with SRPs

The general guidance for evaluating the technical bases for a risk-informed modification to a licensing basis (LB) is provided in Chapter 19 of the NRC Standard Review Plan (SRP) [4]. The specific guidance for the evaluation of changes to AOTs and surveillance test intervals (STIs) is contained in Chapter 16.1 of the SRP [5]. Chapter 19 of the SRP requires the review activities to address five key principles that collectively govern the staff's risk-informed decision-making process. These principles are listed below and are depicted in Figure 1.

I. The proposed TS change meets the current regulation.

II. The impact of the proposed TS change is consistent with the defense-in-depth philosophy.

III. The proposed TS change maintains sufficient safety margin.

IV. The incremental risk associated with the proposed change is small and consistent with the intent of the Commission's Safety Goal Policy Statement [8]. (Since the AOTs are entered infrequently and are considered temporary in nature, the SRP for the TS provides specific acceptance guidelines applicable only to AOT risk.)

V. The licensee has the ability to monitor the impact of the proposed change using performance measurement strategies and then commits to such a program.

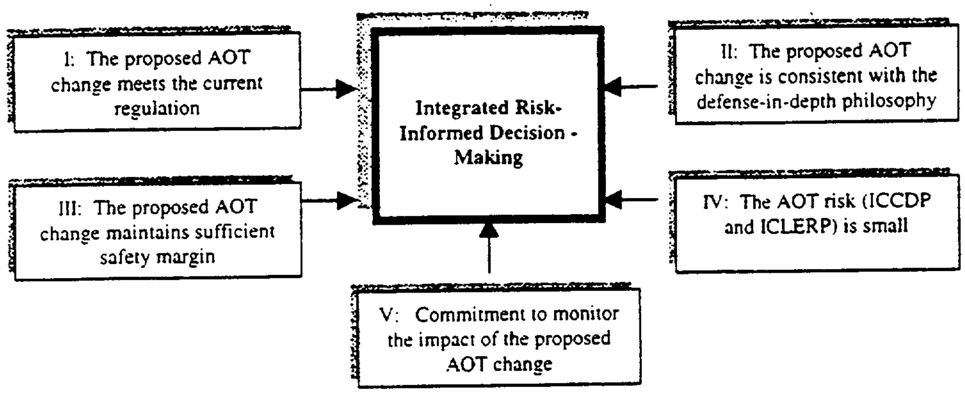

Figure 1: Principles of Risk-Informed Integrated Decision-Making

The staff decision in granting any requested change is guided by a process that requires the determination of whether a licensing basis change meets the set of key principles shown above. In risk-informed TS applications, the intent of Principles II, IV, and V is met by a three-tiered approach [5] as discussed below.

In Tier 1, an individual licensee is expected to determine the change in plant operational risk [specifically with respect to core damage frequency (CDF) and incremental conditional core damage probability (ICCDP)] as a result of the proposed TS modification. In addition, in order to get a better understanding of the impact of the TS change on containment performance, the licensee is expected to perform an analysis of the large early release frequency (LERF) and incremental conditional large early release probability (ICLERP) under the modified TS conditions and then discuss the results. Accordingly, the attributes of Principle IV are met directly by the assessment needs of Tier 1. The evaluation of the probabilistic analyses performed by the CEOG to demonstrate conformance with Principle IV is the focus of this review.

In Tier 2, an individual licensee is expected to evaluate and understand the plant's status with respect to defense-in-depth when proposing an AOT change. The licensee should provide reasonable assurance that risk-significant plant equipment outage configurations will not occur when specific plant equipment is out of service consistent with the proposed TS changes. An effective way to perform such an assessment is to evaluate equipment according to its contribution to plant risk while the equipment covered by the proposed AOT change is out of service. Once plant equipment is so evaluated, an assessment can be made as to whether certain enhancements to the TS or procedures are needed to avoid risk-significant plant configurations. In addition, compensatory actions that can mitigate any corresponding increase in risk should be identified and evaluated. Any changes made to the plant design or operating procedures as a result of such a risk evaluation should be incorporated into the analyses utilized for TS changes under Tier 1. Thus, the Tier 2 evaluation satisfies the intent of Principle II to ensure the proposed change is consistent with the defense-in-depth philosophy. A probabilistic analysis can be used to support and augment traditional engineering evaluations performed to justify conformance with

Principle II[1] (Tier 2). This review process includes an assessment of the responsibilities of individual plants with respect to Tier 2.

In Tier 3, the licensees assure that the risk impact of out-of-service equipment is appropriately evaluated in anticipation of a configuration and in response to an evolving plant condition. This is expected to be an intrinsic part of all maintenance scheduling. Again, Tier 3 generally meets the intent of Principle V. This review evaluates whether the licensees have the ability to predict high-risk configurations, and if so, whether they commit to a risk-informed configuration control system.

Rather than performing a plant specific analysis for each CEOG utility, the JAR performed a bounding analysis primarily based on the risk profile of the Calvert Cliffs plant that has reported the highest core damage frequency among CE plants.

Table 1 delineates the review activities that support principles II, IV, and V. Each review activity is presented in terms of an "issue." For some issues the SRP provides acceptance guidelines. The acceptance guidelines for each issue and the sections of the technical evaluation report (TER) which address the issue are also listed in Table 1.

1.3 Scope and Structure of Report

The purpose of this technical evaluation report (TER) is to establish the validity of the conclusions drawn in the CEOG joint applications report for TS modifications related to CIVs. It provides a technical basis for the NRC staff's safety evaluation (SE) on the joint applications report. This TER primarily addresses the probabilistic analysis of the joint applications report. This TER also addresses the concept of defense-in-depth (Principle II), probabilistically using the AOT risk results and programmatically by determining the licensee's commitment to Tier 2. The individual licensee's commitment to meet Principle V, by committing to a risk configuration control system, is also addressed. Section 2 provides a summary of the proposed TS changes. Section 3 addresses the systems affected by the proposed TS changes. Section 4 summarizes the statement of the need for the AOT extension as presented in the JAR. Section 5 summarizes the general risk-informed strategy employed by the CEOG to justify the TS change. Section 6 provides the AOT risk results and examines the assumptions and calculation methods employed by the CEOG to estimate the CDF-based and LERF-based risk values. Section 7 summarizes the mitigating role of various containment isolation valves in prevention of core damage and large early releases given a core damage has occurred. An evaluation of defense-in-depth is also presented in Section 7. Section 8 addresses the licensees' ability to meet Tier 2 and 3 elements. The Evaluation Summary is presented in Section 9, followed by the References in Section 10.

[1] A probabilistic analysis can also support and augment traditional engineering evaluations performed to justify compliance with Principle III. The SRP [5] only acknowledges the potential use of PRA as a framework in determining the extent of the defense-in-depth philosophy (i.e., Principle II).

Table 1: Review Activities Performed as Guided by the Standard Review Plan

Principle	Area of Review: Issue	Area of Review: Guidelines (if applicable)	Within the Scope of TER/Section No.
I. The proposed AOT change meets the current regulation	Compliance with current regulation		No
	10 CFR 50.36, 10 CFR 50.90		
	58 FR 39132, 60 FR 36953		
II. The impact of the proposed AOT change is consistent with the defense-in-depth philosophy	Traditional engineering evaluations supported by probabilistic analysis		
	Tier 2: Avoidance of risk significant plant configurations	Commitment to Tier 2	7.2
	Impact on the balance among core damage prevention and consequence mitigation	No significant impact on CDF or LERF	7.2
	Over-reliance on programmatic activities	No unrealistic assumption or credit in the PRA	5.2
	Impact on system redundancy and functional availability	Compliance to Tier 2 and MR	5.2
	Impact on defense against common cause failures	No new CC failure modes are introduced	5.2
	Impact on the independence of physical barriers	Independence of barriers is not degraded	5.2
	Impact on the operator response	No new operator error	NA
	Compliance with general design criteria	Compliance to Appendix A of 10 CFR Part 50	No
III. The proposed AOT change maintains sufficient safety margin	Traditional engineering evaluation		No
	Compliance with approved code and standards		
	FSAR assumptions are not violated		
IV. The incremental risk associated with the proposed AOT change is small and consistent with the intent of the Commission's Safety Goal Policy Statement	Probabilistic engineering evaluation		
	The weight of PRA in establishing the basis for TS change	The basis is adequately supported by PRA	5
	Methodology used for assessment of AOT risk	An accepted method (e.g., NUREG/CR-6141) is used	5.2, 6.2
	Consideration of shutdown and transitioning risk	A compelling qualitative or risk-informed argument is presented	5.1
	Validity of PRA	PRA is generally valid for AOT risk calculation	6
	Tier 1: Single AOT risk (ICCDP)	5.0E-7	6.2
	Tier 1: Single AOT risk (ICLERP)	5.0E-8	6.2
V. Commitment to monitor the impact of proposed change using performance measurement strategies	Licensee's Tier 3 Program		8
	Tier 3: Implementation of risk-informed configuration risk management	Commitment to Tier 3	
	Monitoring the impact of the AOT change as part of the MR program	Commitment to monitoring of the impact of the AOT change	

2. CURRENT AND PROPOSED TECHNICAL SPECIFICATIONS

The requested modifications affect the AOT for the containment isolation under conditions shown in Table 2 below. These conditions are applicable to operational modes 1, 2, 3, and 4 for both atmospheric and dual containment designs.

The JAR excluded the following valves from the scope of the requested change.

- The containment sump supply valves to the ECCS and Containment Spray pumps
- Valves associated with main feedwater systems, and
- Main steam isolation valves (MSIVs)

Table 2: Current and Proposed AOT for the Affected CIVs

Containment Penetration Flow Path Equipped with	Condition	Present TS		Requested TS	
		Limit on No. of Penetration Paths that Share the Condition	AOT (hours)	Limit on No. of Penetration Paths that Share the Condition	AOT (hours)
two containment isolation valves	One containment isolation valve is inoperable (Condition A of LCO 3.6.3 in NUREG 1432 [2])	None	4	None	168
only one containment isolation valve and a closed system.	One containment isolation valve is inoperable (Condition C of LCO 3.6.3 in NUREG 1432 [2])	None	4	None	168

Note that the requested change in TS does not affect the existing flexibility in allowing multiple simultaneous entries into the LCO for different containment penetration paths. That is, the TSs remain unchanged relative to lack of any limit on the number of penetration paths that are in Conditions A or C.

3. SYSTEM AFFECTED BY THE PROPOSED TS

Of necessity, there are many pipelines that penetrate the containment wall. The requested change affects the containment isolation valves for containment piping penetrations. The function of containment isolation valves is to prevent the release of radioactive material from the reactor coolant system (RCS) or the containment atmosphere to the outside environment via a containment penetration line. The containment isolation valves also allow the transfer of essential fluid across the containment boundary to support normal operation of the reactor and to support operation of the mitigating systems under accident conditions.

The types of containment isolation valves are:

- Manually operated valves;
- Motor-operated valves (MOVs);
- Air-operated valves (AOVs); and

- Check valves.

For the purpose of assessment, the JAR categorizes the CIVs into several classes based on the following attributes:

- Safety function of the piping flow path
- The nature of interface between the flow path and the RCS
- Normal and post accident valve positions
- Characteristics of the piping flow path (e.g., seismic qualification)

Based on this classification scheme, fourteen piping flow paths are identified in the JAR. These paths are summarized in Table 3 and discussed briefly in the remainder of this section.

<u>*Penetration Path A1:*</u>
CIVs in penetrations connected directly to containment atmosphere and outside environment

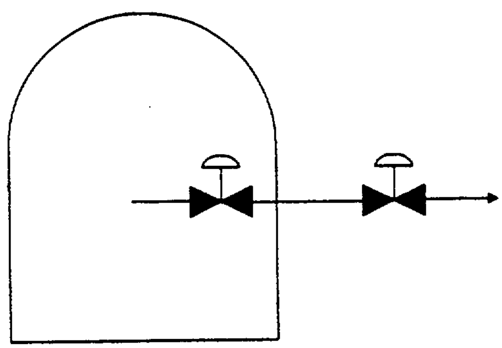

Figure 2: Schematic of Penetration Connected Directly to Containment Atmosphere and Outside Environment -- Penetration Path A1

Figure 2 shows a generic configuration for a containment penetration that is connected directly to the containment atmosphere and directly to the outside environment. The penetration is equipped with two automatic containment isolation valves (CIVs) -- one inside containment and one outside containment. The associated piping downstream of the CIV outside containment is typically non-seismically qualified. This configuration is generally used for venting the containment atmosphere or to provide containment pressure relief. Since the CIVs for this penetration configuration serve as the only barriers between the containment atmosphere and the environment, they are normally closed during normal power operation (Modes 1 – 4). The valves may be cycled during Modes 1, 2, 3, or 4 in order to accomplish their required in-service testing. Following a design basis accident (DBA), the CIVs are designed to close automatically via a safeguard signal such as containment isolation actuation signal (CIAS) or ventilation isolation actuation signal (VIAS). Closure also occurs automatically following the loss of motive or control power to the valve actuator. The passage of fluid into or out of the containment, via this piping configuration, is not needed to accomplish or support any of the safety functions. Examples of piping penetrations that have this configuration are the refueling cavity purification flow inlet line and the station air line.

Table 3: Summary of Penetration Flow Paths

ID	Description of Penetration Flow Path	Closed System		A Representative Configuration Shown in	Normal Position of CIV	Post-accident Position of CIV	Position of Inoperable CIV	Affects	
		Inside Containment	Outside Containment					CDF	LERF
A1	CIVs in penetrations connected directly to containment atmosphere and outside environment	No	No	Figure 2	Closed	Closed	Open		√
A2	CIVs in penetrations connected directly to containment atmosphere and closed loop system outside environment	No	Yes	Figure 3	Open	Closed	Open		√
A3	CIVs in penetrations connected directly to containment atmosphere and open loop system outside environment	No	No	Figure 4	Closed	Closed	Open		√
A4	CIVs in penetrations connected directly to closed loop system inside and outside containment	Yes	Yes	Figure 5	Open	Closed	Open		√
B1	CIVs in penetrations connected to safety injection (SI) line check valve leakage path	Note 1	No	Figure 6	Closed	Closed	Open	√	√
B2	CIVs in penetrations connected to the reactor coolant system (RCS) sample line	Note 1	No	Figure 7	Closed	Closed	Open	√	√
B3	CIVs in penetrations connected to letdown or reactor coolant pump (RCP) bleed-off line	Note 1	No	Figure 8	Open	Closed	Open	√	√
C1	CIVs in penetrations connected to non-essential containment cooling	Yes	Yes	Figure 9	Open	Closed	Open	√	√
C2	CIVs in penetrations connected to secondary side of steam generator	Yes	No	Figure 10	Closed	Closed	Open	√	√
D	CIVs in penetrations connected to containment atmosphere pressure detector	No	Yes	Figure 11	Open	Open	Open		√
E1*	CIVs in penetrations used to support RCS inventory control safety function under accident condition	Note 1	No	Figure 12	Closed	Open	Open	√	√
E2*	CIVs in penetrations used to provide charging under normal condition	Note 1	No	Figure 13	Open	Open	Open	√	√
E3*	CIVs in penetrations used to support containment heat removal function using containment sprays	No	No	Figure 14	Closed	Open	Open	√	√
E4*	CIVs in penetrations used to support containment heat removal function using fan coolers	Yes	Yes	Figure 15	Closed	Open	Open	√	√

Note 1: The piping is directly connected to the RCS inside containment.

*The shaded rows indicate the classes of penetrations for which the CEOG is not requesting an extension of the AOT for the CIV in the closed position.

Penetration Path A2:
CIVs in penetrations connected directly to containment atmosphere and closed loop system outside environment

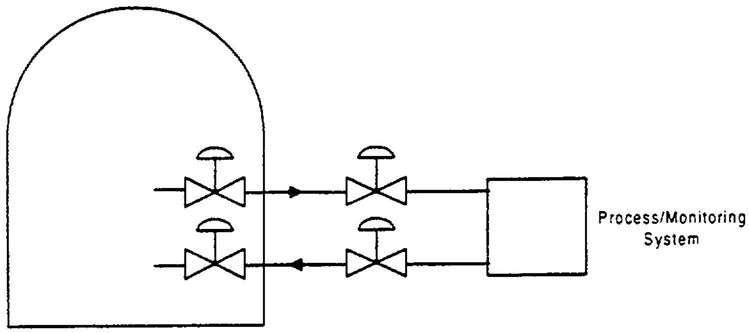

Figure 3: Schematic of Penetration Connected Directly to Containment Atmosphere and a Closed Loop System -- Penetration Path A2

Figure 3 shows a generic configuration for a containment penetration that is connected directly to the containment atmosphere and to a closed loop system outside containment. The piping associated with the closed loop system (outside containment) may or may not be seismically qualified. For purposes of evaluating AOT risk, both conditions are analyzed in the JAR. Each penetration is equipped with two CIVs, one on either side of the containment. These CIVs are typically equipped with either an air operator or a solenoid operator. During normal power operation (Modes 1 – 4), the valves are typically open. Following a design basis accident, the CIVs are designed to close automatically via a safeguard signal such as containment isolation actuation. This closure can be overridden if post-accident monitoring or sampling is required. In order for there to be a release of radioactive material to the environment, both a failure of the CIV to isolate the containment penetration and a breach of the closed loop system must occur following core damage. The passage of fluid into or out of the containment, via this piping configuration, is not needed to accomplish or support any of the safety functions. Examples of piping penetrations that have this configuration are radiation monitoring and hydrogen analysis systems.

Penetration Path A3:
CIVs in penetrations connected directly to containment atmosphere and open loop system outside environment

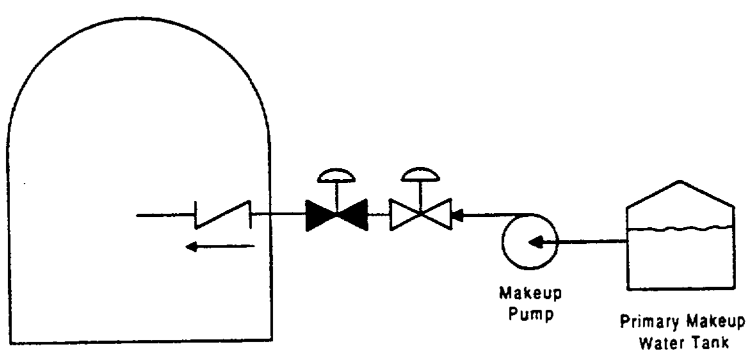

Figure 4: Schematic of Penetration Connected to Containment Atmosphere and an Open Loop System -- Penetration Path A3

Figure 4 shows a generic configuration for a containment penetration that is connected directly to the containment atmosphere and to an open loop system outside containment. The piping associated with the open loop system outside containment is assumed to be non-seismically qualified. The CIVs for the penetration serve as the primary barrier between the containment atmosphere and the outside environment, and therefore, are closed during normal power operation (Modes 1 – 4). The main purpose of the system shown in this configuration is to provide inlet flow of fluids needed to support equipment operability inside containment. The CIV outside containment (typically an air-operated valve (AOV)) is designed to close automatically upon receipt of a CIAS following a DBA. By design, the check valve inside containment closes in the absence of flow through the line. Typical systems that have this configuration are primary makeup or demineralized makeup water, station or instrument air, and refueling cavity purification makeup.

Penetration Path A4:
CIVs in penetrations connected directly to closed loop system inside and outside containment

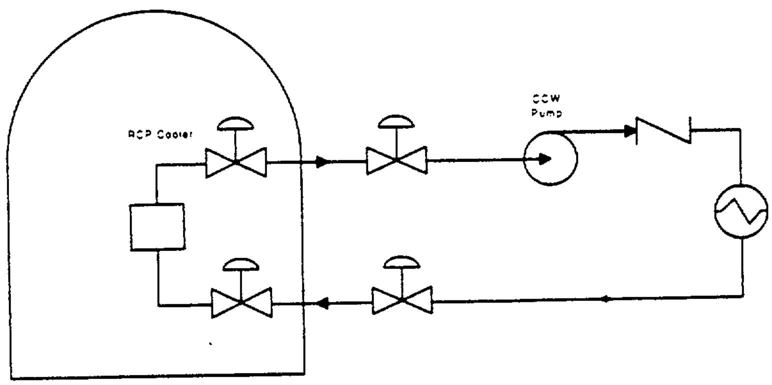

Figure 5: Schematic of Penetration Connected to Closed Loop Inside and Outside Containment -- Penetration Path A4

Figure 5 shows a generic configuration for a containment penetration that is connected directly to a closed loop system inside and outside containment. This penetration is equipped with two CIVs, one on either side of containment. The associated system piping inside and outside containment typically is non-seismically qualified. The CIVs and the closed loop system serve as the main barriers between the containment atmosphere and the outside environment. The main purpose of this configuration is to provide inlet and outlet cooling water flow for heat removal equipment located inside containment. Therefore, during normal power operation (Modes 1 – 4), the CIVs are open. Following a DBA, the CIVs will automatically close upon the receipt of a CIAS. Equipment or systems that typically have this configuration are those that provide heat removal for major equipment such as reactor coolant pump (RCP) seal coolers, or for the containment atmosphere such as non-essential air cooling units.

Penetration Path B1:
CIVs in penetrations connected to safety injection (SI) line check valve leakage path

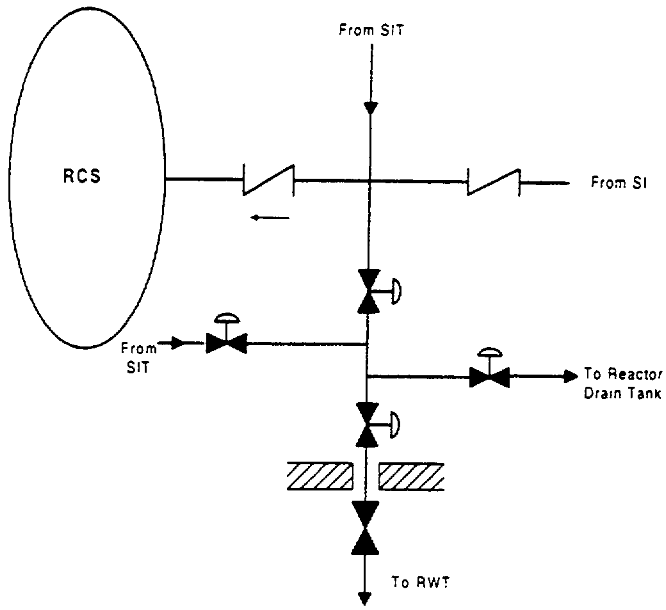

Figure 6: Schematic of Penetration Connected to SI Line Leakage Path -- Penetration Path B1

Figure 6 shows a generic configuration for a containment penetration that is connected to the safety injection tank (SIT) drain and test line that has a flow path to the refueling water tank (RWT). The associated piping outside containment is seismically qualified. During normal power operation (Modes 1 – 4), the automatic CIV inside containment (typically an AOV) is closed, and the manual CIV outside containment is locked closed. The CIVs as well as the check valves provide barriers to an RCS leak path outside containment. According to the CEOG report, four barriers must be breached before the low pressure piping (outside containment) can be exposed to the normal operating conditions of the RCS. The inflow or outflow of fluid through these lines is not needed to accomplish or support any safety function. Therefore, the automatic CIV (inside containment) is designed to close upon receipt of CIAS following a DBA.

Penetration Path B2:
CIVs in penetrations connected to the reactor coolant system (RCS) sample line

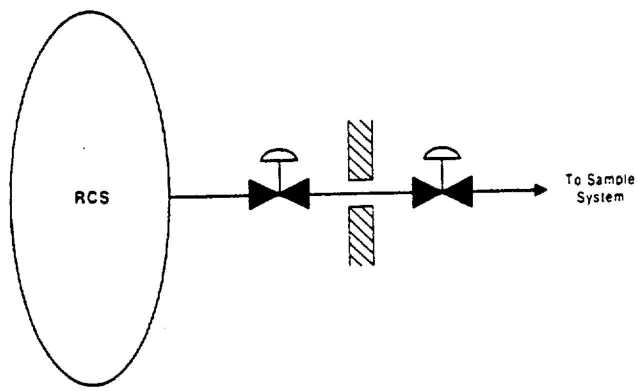

Figure 7: Schematic of Penetration Connected to RCS Sample Line -- Penetration Path B2

Figure 7 shows a generic configuration for a containment penetration that is connected to the RCS and the sample system. The penetration is equipped with two CIVs, one on either side of containment. This configuration is used to obtain samples from various locations in the RCS. RCS sampling occurs on a daily basis during normal power operation (Modes 1 – 4). When samples are not being taken, the CIVs are closed. The piping outside containment is relatively small (< 1" nominal), and is non-seismically qualified. These CIVs are designed to automatically close upon receipt of a CIAS following a DBA. Automatic closure will also occur following the loss of motive or control power to the valve actuator.

Penetration Path B3:
CIVs in penetrations connected to letdown or reactor coolant pump (RCP) bleed-off line

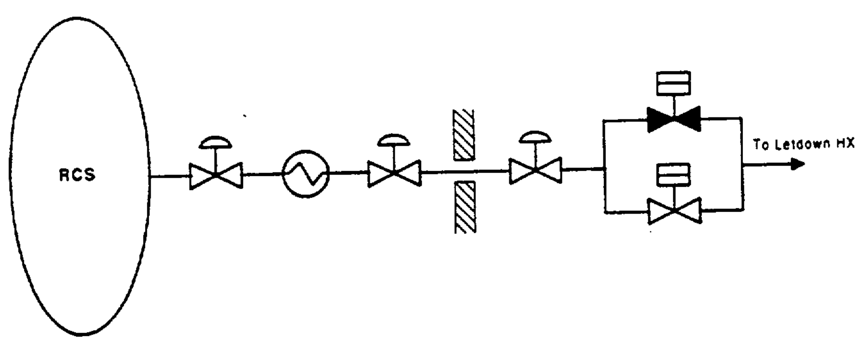

Figure 8: Schematic of Penetration Connected to Letdown Line -- Penetration Path B3

Figure 8 shows a generic configuration for a containment penetration that is connected to the RCS and the chemical and volume control system (CVCS) to provide letdown, or bleedoff from the reactor coolant pumps (RCP). A small portion of reactor coolant is diverted to the CVCS for processing. Bleedoff from the RCPs is also diverted to the CVCS to minimize the amount of makeup required for the RCS. The associated piping outside containment is seismically qualified. Continuous letdown and bleedoff flow is provided during normal power operation (Modes 1 – 4); therefore, the valves are open during power operation. The three valves shown in this configuration are AOVs. and close automatically upon receipt of a CIAS or SIAS following a DBA. Since letdown flow is not needed or required for core damage mitigation, the CIVs in this configuration are typically not included in the probabilistic safety analysis model used to estimate CDF.

Penetration Path C1:
CIVs in penetrations connected to non-essential containment cooling

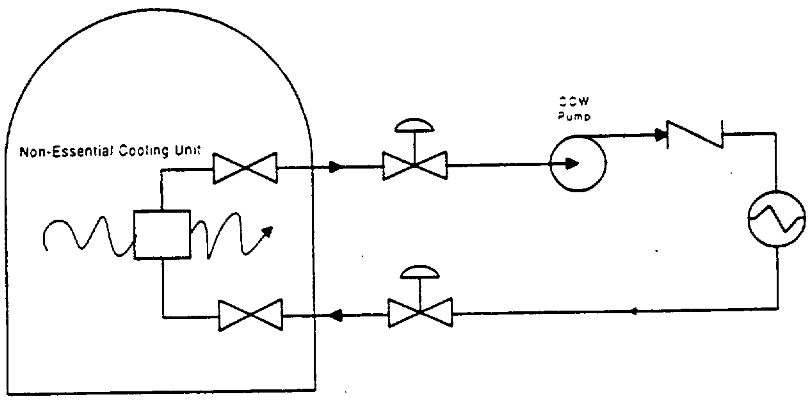

Figure 9: Schematic of Penetration Connected to Non-Essential Cooling Units -- Penetration Path C1

Figure 9 shows a generic configuration for containment penetration that provides inflow and outflow of cooling water to the non-essential containment cooling units. The CIV inside containment is a manual isolation valve, and the CIV outside containment is typically an AOV. The associated piping inside containment is seismically qualified. Since the cooling units are used for containment heat removal during normal power operation (Modes 1 – 4), the valves are normally open. The automatic CIV is designed to close automatically upon receipt of a CIAS or SIAS following a DBA. Containment heat removal by the non-essential cooling units is not required or needed to accomplish or support any of the safety-related functions.

Penetration Path C2:
CIVs in penetrations connected to secondary side of steam generator

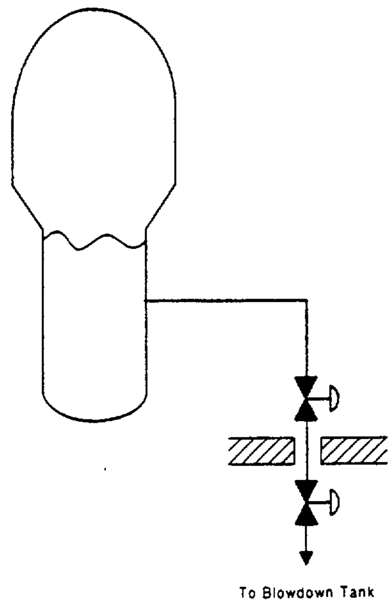

Figure 10: Schematic of Penetration Connected to Steam Generator -- Penetration Path C2

Figure 10 shows a generic configuration for a containment penetration that provides blowdown from the steam generator (SG). As shown, this configuration is equipped with two CIVs, typically AOVs. The associated piping inside containment is seismically qualified, and the piping outside containment is non-seismically qualified. Blowdown from the SGs is discharged to the blowdown tank during normal power operation. Additionally, blowdown samples are taken periodically. Therefore, the CIVs may be open for periods during normal power operation. The CIVs are designed to automatically close upon receipt of a CIAS following a DBA. These CIVs are used to provide containment isolation in the event of a SG tube rupture.

Penetration Path D:
CIVs in penetrations connected to containment atmosphere pressure detector

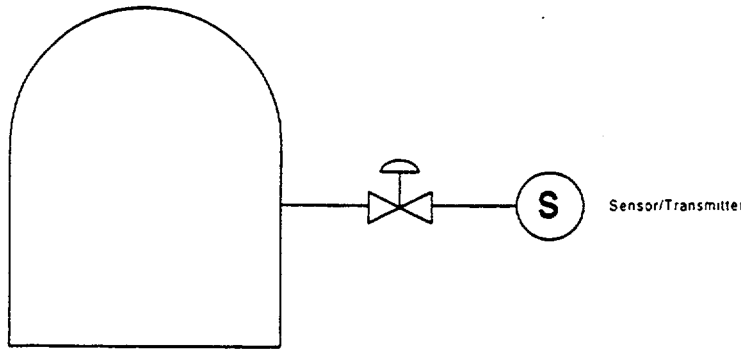

Figure 11: Schematic of Penetration Connected to Containment Instrument Sensor -- Penetration Path D

Figure 11 shows a generic configuration for a containment penetration that is connected to the containment atmosphere and a pressure detector outside containment. This penetration is used for detecting containment pressure and initiating the appropriate plant response. The penetration is equipped with one automatic CIV outside containment. The associated piping is seismically qualified. During normal power operation (Modes 1 – 4), the CIV is open. Since the line is used to detect containment pressure following a DBA, it is open then as well.

Penetration Path E1:
CIVs in penetrations used to support RCS inventory control safety function under accident condition

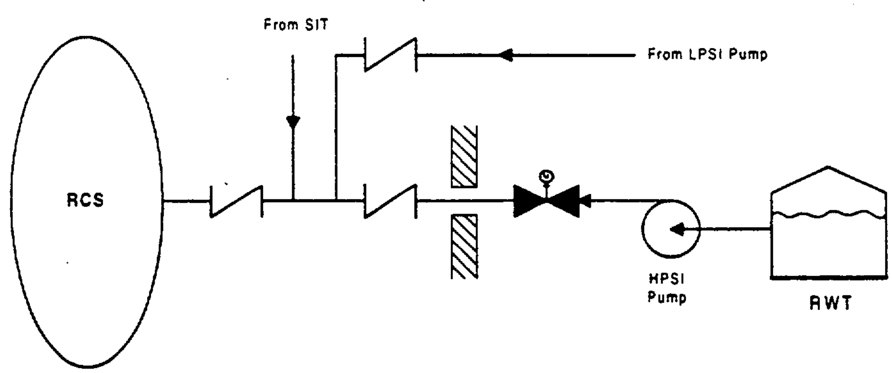

Figure 12: Schematic of Penetration Connected to Safety Injection Line -- Penetration Path E1

Figure 12 shows a generic configuration for a containment penetration that is connected to the RCS (safety injection) inside containment and the high pressure safety injection (HPSI) outside containment. According to the JAR, the low pressure safety injection (LPSI) containment penetration is similar to the HPSI penetration; therefore, the schematic shown is assumed applicable to both penetrations. The penetration is equipped with a motor-operated valve (MOV) outside containment, and multiple check valves inside containment. The associated piping outside containment is seismically qualified. The HPSI and LPSI systems are used to mitigate accidents, and therefore are closed during normal power operation (Modes 1 – 4). Upon receipt of a SIAS, the MOV will automatically open.

Penetration Path E2:
CIVs in penetrations used to provide charging under normal condition

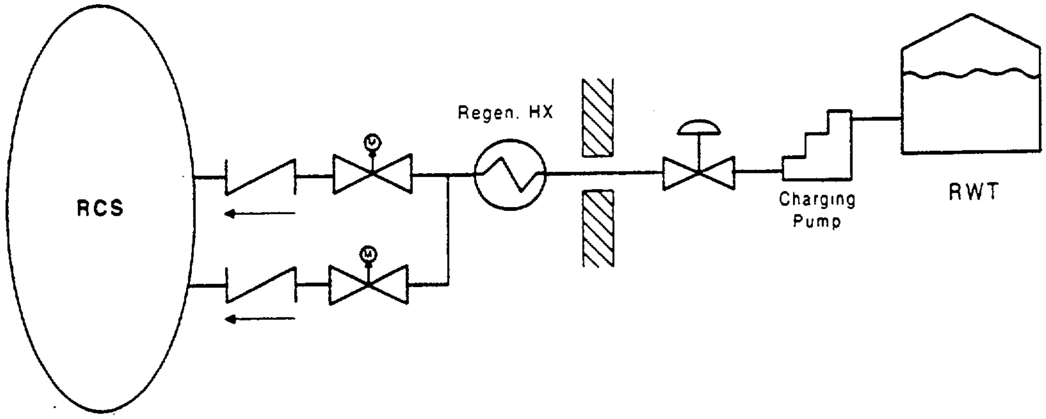

Figure 13: Schematic of Penetration Connected to Charging Line -- Penetration Path E2

Figure 13 shows a generic configuration for a containment penetration connected to the RCS inside containment and the charging line outside containment. The penetration is equipped with an automatic CIV outside containment. and MOVs and check valves inside containment. The associated piping outside containment is seismically qualified. Since the charging line provides RCS makeup during normal power operation, the CIVs are open during Modes 1 - 4. Charging to the RCS is also required following a DBA except in cases when the containment is required to be isolated.

Penetration Path E3:
CIVs in penetrations used to support containment heat removal function using containment sprays

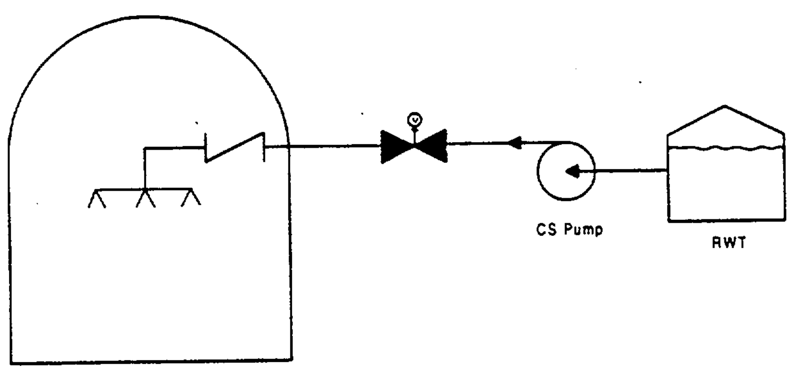

Figure 14: Schematic of Penetration Connected to Containment Spray Line -- Penetration Path E3

Figure 14 shows a generic configuration for a containment penetration that is connected to the containment spray system (CSS) inside and outside containment. The CSS is also used to remove radioactive particulate from the containment atmosphere. The penetration is equipped with two CIVs—an MOV outside containment, and a check valve inside containment. The associated piping outside containment is seismically qualified. During normal power operation (Modes 1 – 4), the MOV is closed. Upon receipt of a containment safeguard actuation signal (CSAS), the valve will automatically open.

Penetration Path E4:
CIVs in penetrations used to support containment heat removal function using fan coolers

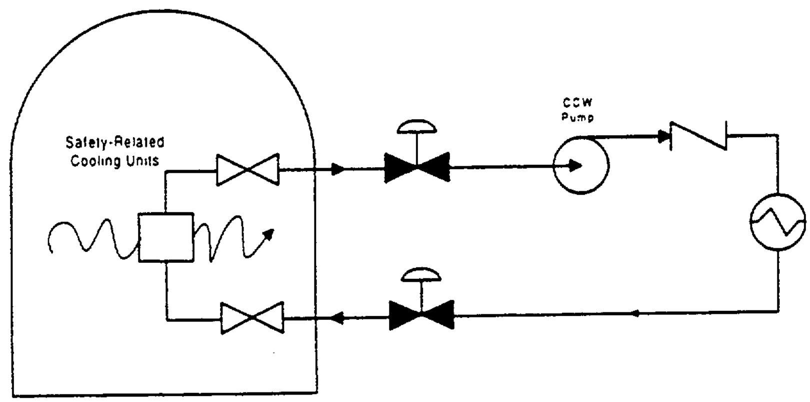

Figure 15: Schematic of Penetration Connected to Safety-Related Cooling Water Line -- Penetration Path E4

Figure 15 shows a generic configuration for containment penetration that is connected to the containment cooling system (CCS) inside and outside containment. The closed loop system is equipped with two CIVs, one on each side of containment in both the supply and return lines. The associated piping outside containment is seismically qualified. The CIV outside containment is typically an MOV, and closed during normal power operation. The CIV inside containment is a manual valve, and is shown in the open position for normal power operation. The MOV is designed to automatically open upon receipt of a safeguard signal following a DBA.

4. STATEMENT OF NEEDS

The JAR states that the proposed AOT extension for the CIVs provides the needed flexibility in the on-line maintenance and surveillance testing of valves. In Section 5.2.2 of the JAR, CEOG argues that many plants are required to enter into the LCO to perform valve testing, and with the current four hour AOT, the corrective maintenance (CM) is not practical if the CIV fails the surveillance test. The JAR cites cases unrelated to CIVs in which the nature of repairs required a longer time period than the existing AOT (currently 4 hours).

5. STRATEGY TO JUSTIFY THE REQUESTED EXTENSION

The JAR identifies a set of generic classes (configurations) for containment penetration flow paths. These generic containment flow paths are briefly described in Section 3 of this TER. Using bounding risk parameters, the impact on plant risk due to the proposed AOT extension is evaluated for each generic penetration flow path once in the LCO. The LCO is defined to be a condition when only one of the two CIVs that serve the containment penetration flow path is inoperable. The JAR provides the following risk information for each generic penetration flow path:

- The CDF-based single AOT risk [incremental conditional core damage probability (ICCDP)] if the LCO affects core damage prevention
- The LERF-based single AOT risk [incremental conditional large early release probability (ICLERP)]

The risk evaluation assumes that once the LCO is entered as a result of a valve failure, there is no potential that the cause of the failure is shared by the redundant CIV. In effect, the JAR assumes that the common cause failure of both valves is absent. In Section 6.3.2 under, Assumption (f), the JAR states

"The unaffected CIV is assumed to be evaluated to ensure that is operable."

The JAR compares the transition risk estimates derived to support a previous submittal [9] with the risk of continued operation with on-line CIV repairs. It claims that these risks are comparable and in some cases the transition risk is higher than the risk of the AOT.

5.1 Consideration of Transition and Shutdown Risk

The JAR takes the position that the risk of AOT should not be viewed in isolation from the risk associated with the transition and shutdown. That is, the risk of transitioning from "at power" to a shutdown mode should be balanced against the risk of continued operation with the inoperable system.

The qualitative argument that AOTs should be extended (during full power operation) to avoid transitioning to shutdown modes and to avoid compromising shutdown safety, has merit only in circumstances when the plant must be shutdown because of unscheduled corrective maintenance (CM). The cause of the forced shutdown could be a failure condition observed during the surveillance tests. In those cases the decision to complete the repair of the affected equipment while remaining at power or forcing the plant to undergo mode changes should include consideration of the transition risk. If, however, the licensee chooses to schedule preventive maintenance (PM) during full power, a practice referred to as "on-line maintenance," then the risk impact of maintenance at full power operation should be compared to that during shutdown (cold shutdown or refueling) without consideration of transition risk. This is because for PM activities, the transition risk is avoidable if the maintenance is properly planned and executed within the AOT window. The transition risk should be factored as a component of the risk tradeoff analysis only in cases where the plant is forced to shutdown as a result of fault discoveries not caused by PM activities. Since many plants are increasingly opting for on-line maintenance, a realistic comparison of the risk impact of PM maintenance at full power versus shutdown risk is possible if two sets of comprehensive risk models are available: full power PRA and shutdown PRA.

For this submittal, the at-power and transition risks are derived using very approximate models. For this reason, this evaluation does not support the quantitative comparison of "at-power" risk with transition risk.

5.2 Methodology Used for Assessment of AOT Risk

The "at power" AOT risk analysis approach employed by the CEOG is generally consistent with the methods described in Reference 10. The SRP for TS provides numerical acceptance guidelines only for the single AOT risk.

In terms of core damage, the single AOT risk is the probability of core damage occurring, while in the LCO configuration during the allowed outage time. For this application, this value is obtained by multiplying the increase in the core-damage frequency (conditional CDF given one valve is inoperable, less baseline CDF) by the proposed AOT of 168 hours. Therefore, the single AOT risk represents the increase in the risk if the entire AOT is consumed.

In the analysis of the AOT risk, the JAR does not distinguish between PM and CM. In this respect, the guidelines of NUREG/CR-6141 [10] relative to common cause failure analysis are not followed. According to the guidelines, if the LCO is entered for CM, the redundant valve should be assigned with the β-factor which is the conditional failure probability given one valve has already failed. The AOT risk of CM, if provided, can provide the upper bound for the AOT risk associated with the LCO configuration.

As stated earlier, the JAR assumes that if the LCO is entered as a result of a valve failure, then there is no potential that the cause of the failure is shared by the redundant CIV. Stated differently, when the LCO Action Statement is prompted by the need for CM (i.e., valve failure), the redundant valve in service can only fail due to causes completely independent of the failed valve. This assumption has merits if each licensee commits to operability test of the redundant valve before entering into the LCO or shortly after the time at which a valve found to be in a failed state and in need of repair. If both valves are found to be in the failed state, then the condition would be governed by a separate LCO, which remains unchanged.

Under Section 5.2 of the JAR entitled "Operating Experience," the type of maintenance performed on CIVs is presented. The purpose of the proposed AOT is to enable a licensee to perform the CM on a CIV found to be inoperable as a result of the surveillance or testing program for this class of valves. Reference 1 defines CM in vague terms that could vary from small stem leakage to debilitating failure of the valve operator. Thus, from a practicable view, when CM is to be performed on a CIV under the proposed AOT, it could include all valve maintenance activities that can be placed into three major groupings, namely:

- ❑ Valve overhaul (repair of all or a portion of the valve's internals)
- ❑ Valve repacking (replacing the sealing material around the valve stem)
- ❑ Repair/replacement of the valve operator (the motive force mechanism acting on the valve stem, typically an air-operated, electric motor-operated, or solenoid-operated valve actuator)

For two out of the three CM activities, the respective system's piping integrity must be broken for a portion or for all of the repair time to accomplish the CM action, specifically for valve overhaul and valve repacking.

The risk assessment presented in the JAR presents cases where there must be a failure of the piping system integrity to obtain a release to the environment. In all cases, it is assumed that the failure of the system integrity is either due to piping failure (rupture or small break) or due to a stuck-open relief valve. However, there may be situations where the CM work package may allow for the system integrity outside the containment to remain broken for a portion if not all of the time period of the CM for those cases of valve overhaul and valve repacking. If this is true, this could increase the AOT risk values by several orders of magnitude by replacing the probability of piping failure to a value of 1.0 since the integrity of the system is broken. Based on the limited information presented in the JAR, it is not possible to evaluate each risk assessment case for the likelihood of this concern and is most likely affected by plant-specific designs. Accordingly, each licensee would need to include specific analyses of such situations or describe how such configurations would be avoided in their submittals for TS change requests for the CIV AOT.

The general assumptions used by the CEOG to estimate the SAOT risk are briefly presented below. If an assumption has a significant impact on the AOT risk calculation, it is underlined. In these cases the text in the parenthesis explains the significance of the assumption.

- The inoperability of one of the CIVs associated with a particular piping penetration is know typically due to inservice testing or other activity that cycles a CIV.
- An assessment is made on the remaining CIV to ensure it is operable so that common cause failure mode can be ruled absent. (The timing of the operability assessment and the method of operability assessment are not specified in the JAR.)
- The "at power" risk caused by the inoperability of two CIVs associated with a particular piping penetration is *not* included in the evaluation. (This TER recognizes that if both valves are found to be inoperable, the LCO configuration is subject to condition B.1 of Section 3.6.3 of NUREG-1432, Revision 1 [2], which is not within the scope of this application. The issue is when an LCO configuration related to conditions A.1 or C.1 are entered, when and how the licensees determine that they are not in Condition B.1. The AOT for Condition B.1 is only one hour.)
- The CIV AOT is 168 hours (7 days) with exception of the containment sump supply valve(s) to the ECCS and CSS pumps AOT which remains unchanged.
- Duration of proposed CIV AOT is assumed adequate for on-line maintenance, risk from forced shutdown is assumed negligible, and the modification of the CIV TS is applicable for on-line maintenance only.
- Failure of the piping in the containment penetration is negligible, as is failure of the penetration.
- The CDF due to bypass is negligible (i.e. set to 0.0).
- Data used for calculating the AOT risk are based on bounding input values.
- Low pressure piping failure probability outside of containment is based on the material and dimensions of the piping. Failure is immediate to high-pressure exposure and core damage eventually occurs.
- Probability of an AOV failing to remain closed is 2.3E-3 during the time period of the proposed CIV AOT. (The analysis effectively assumes that the redundant valve is as same-as-new the moment the LCO is entered. This assumption is only valid if the redundant valve is tested at the time of the LCO entry.)
- Penetrations designed to close automatically by an engineered safety feature actuation system (ESFAS) and do not support a safety function are equipped with AOVs and fail in a safe state (i.e. closed).
- Probability of an AOV failing to operate is 1.55E-3 per demand.
- Non-seismically induced pipe failures are assumed to occur randomly in time at a conservative rate of 5.0E-3 per year and that safety and non-safety grade piping have the same random failure probability.
- Non-seismically qualified piping always fails during a seismic event.
- The potential impact on the average CDF is neglected from increasing a CIV unavailability as a result of AOT extension to 7 days.

6. BASIS OF AOT RISK RESULTS

6.1 Validity of the Risk Parameters Used for AOT Risk

As stated earlier, no plant specific AOT risk calculations were performed in the JAR. Instead, CEOG surveyed the IPE results of CE plants to identify a set of risk parameters that are bounding. The risk parameters selected for use are primarily obtained from the Calvert Cliffs IPE which reported the highest core damage frequency in the CE plant population.

Based on the staff review of the Calvert Cliffs IPE [11], it was determined that the use of the risk parameters of Calvert Cliffs for this application is appropriate and there are no apparent defects in the Calvert Cliffs IPE that make the conclusions of JAR invalid.

Table 4 contains the Risk Parameter Values that were used for evaluation of the bounding AOT risk.

Table 4: Risk Parameter Values Used for Calculating AOT Risk

Parameter	Value	Comments
Total core damage frequency (per year)	2.0E-4	Bounding value based on most limiting CEOG plant CDF value
Large early release frequency (per year)	5.7E-6	Bounding value based on most limiting CEOG plant
Conditional core damage probability due to SLOCA	3.7E-3	Bounding value based on Calvert Cliffs
Conditional core damage probability du to reactor trip	6.1E-6	Bounding value based on Calvert Cliffs
Conditional core damage probability due to SGTR	9.2E-4	Bounding value based on Calvert Cliffs
Core damage frequency due to seismic event (per year)	1.7E-5	Bounding value based on most limiting CEOG plant seismic CDF

For penetration path classes B-1 and E-1, the inoperability of a CIV increases the potential for interfacing system LOCAs (ISLOCA). In these cases rather than maintain consistency in applying a bounding analysis to AOT risk calculation, the JAR presents a complex equation that is also dependent on taking credit for a pressure transducer when determining the ISLOCA frequency. One method to confirm the appropriateness of the analysis presented in the JAR is to examine and compare ISLOCA frequency estimates reported in the IPE of a representative CE plant with those generated by the JAR. The Calvert Cliffs IPE provides a good reference for numerical comparison. This is because the Calvert Cliffs plant is assumed to be the bounding plant in the JAR.

Table 5 provides the frequencies of several representative bypass sequences as reported in the Calvert Cliffs IPE. Depending on the nature of the containment isolation, the frequency ranges between 3E-8/yr to 1E-7/yr. In the JAR the frequency of ISLOCA ranges between 2.2E-8/yr and 8.8E-7/yr. The former frequency applies to penetration class B-1 and the later to penetration class E-1. It is important to note that a basic assumption in any IPE (including the Calvert Cliffs IPE) is that *CIVs* are initially operable. However, the JAR reflects the LCO configuration in which one of the CIVs is inoperable.

Table 5: Frequency of Large ISLOCA as Reported in the Calvert Cliffs IPE

Penetration	Description	RCS Interface	Containment Isolation	Frequency
3	Safety Injection	Open to RCS	3 check valves in series	3.5E-8
4	Safety Injection	Open to RCS	3 check valves in series	3.5E-8
5	Safety Injection	Open to RCS	3 check valves in series	3.5E-8
6	Safety Injection	Open to RCS	3 check valves in series	3.5E-8
41	Shutdown Cooling	Isolated by 2 MOVs	2 MOVs in series	1.06E-7

The JAR values, if they are to be consistent with the IPE values, should be larger than the IPE value by several orders of magnitude (the inverse of CIV failure probability). Based on this observation the reported ISLOCA frequencies in the JAR maybe are underestimated. One of the following conclusions can be drawn:

- The impact of crediting the pressure transducer on the AOT risk results may be significant

<u>or</u>

- The generic penetration classes defined in the JAR may not be applicable to Calvert Cliffs

This TER believes that the credit taken for the pressure transducer is responsible for the discrepancy. Without additional information from the CEOG, this evaluation cannot verify the appropriateness of the JAR modeling assumption relative to this issue.

6.2 Methods Of AOT Risk Calculation And Results

The JAR reported the AOT risk for various penetration paths. Table 6 summarizes the calculation method used for quantification of the AOT risk for each penetration path. Under the column labeled "Comments" the key assumptions made by the JAR for the AOT analysis of each case are listed. Table 7 contains a summary of the risk results as determined by the CEOG for the given penetrations.

Table 6: Summary of Calculation Methods

ID	Description of Penetration Flow Path	Calculation Method	Comment
A1	CIVs in penetrations connected directly to containment atmosphere and outside environment (See Figure 2)	SINCE THE PIPING OUTSIDE CONTAINMENT IS OPEN, NO DIFFERENTIATION IS MADE BETWEEN SEISMIC AND NON-SEISMIC EVENTS $SAOT_{LLRF} = \Delta CDF \bullet P_{CIV} \bullet \frac{AOT}{8760} = 8.8E-9$ where $SAOT_{LLRF}$ = single AOT risk for large early release ΔCDF = change in CDF, baseline CDF assumed to be: 2E-4/yr P_{CIV} = failure probability of unaffected CIV (solenoid type): 2.3E-3 $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumptions: • Inoperability of one CIV is detected during periodic surveillance or cycling of the valve. • The inoperable CIV is in the open position and the other CIV is the only barrier for releases to the environment. • The failure mechanism causing the operable CIV to open also prevents it from closing if a demand occurs. REVIEW COMMENTS: • The unaffected CIV is assumed to be OPERABLE. • It is assumed that the cause of the failure of the affected CIV is not shared by the redundant CIV. That is, common cause failure is absent. • The redundant valve is treated as same-as-new.

ID	Description of Penetration Flow Path	Calculation Method	Comment
A2	CIVs in penetrations connected directly to containment atmosphere and closed loop system outside environment (See Figure 3)	NON-SEISMICALLY INITIATED EVENTS $SAOT_{LERF} = \Delta CDF \bullet P_{CIV} \bullet P_{cl} \frac{AOT}{8760} = 1.5E-12$ where $SAOT_{LERF}$ = single AOT risk for large early release ΔCDF = change in CDF, baseline CDF assumed to be: 2E-4/yr P_{CIV} = failure probability of unaffected CIV (air-operated): 3.85E-3 P_{cl} = probability of a pipe failure in closed loop system: 1E-4 $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year SEISMICALLY INITIATED EVENTS $SAOT_{LERF} = \Delta CDF \bullet P_{CIV} \bullet \frac{AOT}{8760} = 1.3E-9$ where ΔCDF = change in CDF, baseline CDF for seismic assumed to be: 1.75E-4/yr P_{CIV} = same as above $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumptions: • CIVs normally opened and cycled to satisfy in-service testing and TS requirements. • Inoperability of one CIV is detected during periodic surveillance or cycling of the valve and it is secured in open position when found to be inoperable. • CIVs may be either AOVs or solenoid-operated valves. • The inoperable CIV remains open for all conditions and demands. • Conditional failure probability is 1 following a seismic event for non-seismic piping systems. REVIEW COMMENTS: • The unaffected CIV is assumed to be OPERABLE. • Crediting close loop system as a barrier is applicable to cases in which the affected valve (the valve under CM) is intact. If not true, the value of $SAOT_{LERF}$ of 1.5E-12 increases to 1.5E-8.

ID	Description of Penetration Flow Path	Calculation Method	Comment
A3	CIVs in penetrations connected directly to containment atmosphere and open loop system outside environment (See Figure 4)	NON-SEISMICALLY INITIATED EVENTS $SAOT_{LLRF} = \Delta CDF * P_{CK} * P_{B}\frac{AOT}{8760} = 5.83E-13$ where $SAOT_{LLRF}$ = single AOT risk for large early release ΔCDF = change in CDF, baseline CDF assumed to be: 2E-4/yr P_{CK} = failure probability of unaffected CIV (check valve): 1.52E-3 P_{B} = probability of a pipe failure in open loop system: 1E-4 $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year SEISMICALLY INITIATED EVENTS $SAOT_{LLRF} = \Delta CDF * P_{CK} * \frac{AOT}{8760} = 5.1E-10$ where ΔCDF = change in CDF, baseline CDF for seismic assumed to be: 1.75E-4/yr P_{CK} = same as above $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumptions: • CIVs are check valve inside containment and AOV outside containment. Failure of a check valve is 1.52E-3 per demand. • Inoperability of one CIV is detected during periodic surveillance or cycling of the valve and it is secured in open position when found to be inoperable. • For outside containment, there are multiple valves for isolation of a break and failure of multiple valves is assumed to be a low probability event and has no impact. • Pipe break cannot be isolated. • Piping outside the containment is non-seismically qualified and probability of pipe failure after a seismic event is 1.0. REVIEW COMMENTS: • The unaffected CIV is assumed to be OPERABLE. • In this case although the loop is open, the analysis effectively assumes a closed loop system by crediting other means of isolation as shown in term P_B. • As in the case of A2, crediting close loop system as a barrier is applicable to cases in which the affected valve (the valve under CM) is intact.

ID	Description of Penetration Flow Path	Calculation Method	Comment
A4	CIVs in penetrations connected directly to closed loop system inside and outside containment (See Figure 5)	NON-SEISMICALLY INITIATED EVENTS $SAOT_{LERF} = ACDF * P_{CIV} * P_{cII} * P_{cIO} \frac{AOT}{8760} << 2E-13$ where $SAOT_{LERF}$ = single AOT risk for large early release $ACDF$ = change in CDF, baseline CDF assumed to be: 2E-4/yr P_{CIV} = failure probability of unaffected CIV (air-operated): 3.85E-3 P_{cII} = probability of a pipe failure in close loop system inside containment: 1E-4 P_{cIO} =probability of a pipe failure or inadvertent opening of a relief valve in closed loop outside containment: 6E-4 $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year FOR SEISMICALLY INITIATED EVENTS $SAOT_{LERF} = ACDF * P_{CIV} * \frac{AOT}{8760} = 1.3E-9$ where $ACDF$ = change in CDF, baseline CDF for seismic assumed to be: 1.75E-4/yr P_{CIV} = same as above $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumptions: • Inoperability of one CIV is detected during periodic surveillance of the valve and it is secured in open position when found to be inoperable. • Piping (inside and outside) is non-seismically qualified and has a conditional failure probability of 1.0 for seismic events. • A breach in the piping of both inside and outside containment must fail concurrently with failure to isolate the penetration for a pathway to the environment. • Inadvertent opening of a relief valve will also breach the piping outside of containment and is given a probability of 5.0E-4 for the proposed AOT. • AOV failure probability includes failure of the valve to close on demand or to remain closed during the proposed AOT. REVIEW COMMENTS: • The unaffected CIV is assumed to be OPERABLE. • Crediting close loop system outside containment as a barrier is applicable to cases in which the affected valve (the valve under CM) is intact. If not true, the value of $SAOT_{LERF}$ would increase by a factor of 1.0E4.

ID	Description of Penetration Flow Path	Calculation Method	Comment
B1	CIVs in penetrations connected to Safety Injection (SI) line check valve leakage path (See Figure 6)	$ISLOCA = \frac{\lambda_1\lambda_2\lambda_3T^2}{3} + \lambda_1\lambda_2\lambda_{d3}\left[\frac{d_3T+1}{2}\right] + \lambda_1\lambda_{d2}\lambda_3T\left[\frac{d_2T+1}{2}\right]$ $+ 2\lambda_1\lambda_{d2}\lambda_{d3}\left[\frac{d_2T+1}{2}\right]\left[\frac{d_3T+1}{2}\right] = 2.19E-8 \textit{ per year}$ $SAOT_{LERF} = ISLOCA * \frac{AOT}{8760} = 4.19E-10$ where, $SAOT_{LERF}$ = single AOT risk for large early release $ISLOCA$ = frequency of interfacing system LOCA per year: 2.19E-8 per year λ_1 = random leakage rate of SI check valve: 8.76E-4 per year λ_2 = random leakage rate of AOV: 7.0E-3 per year λ_3 = random leakage rate of manually operated valve: 1.68E-3 per year λ_{d2} = probability of the AOV failing to reseat: 1.55E-3 per demand λ_{d3} = probability of the manually operated valve failing to reseat: 3.88E-4 per demand d2 = the number of times the AOV is operated:4 d3 = the number of times the manually operated valve is operated: 4 T = fault exposure time: 1 year $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumptions: • Assumed that penetration has one AOV on inside and one manually operated valve on outside the containment. The inoperability of the AOV is detected during surveillance or cycling of the valve. • The failure mode of manually operated valves is not known but failure to reseat is bounded by a failure on demand of 3.88E-4 per demand. • Average of four in-service tests of the manual CIV per year. • Mean failure rate of an AOV transferring open is 7.98E-7 per hour and a bounding probability to fail on demand of 1.55E-3. • The AOV is cycled once per quarter. • Random leakage of a SI check valve is assumed to be 8.76E-4. • Fault exposure time is equivalent to time that the plant operates in its non-cold shutdown modes, namely one year. • A pressure transmitter can detect a leaking or stuck open SI check valve. REVIEW COMMENTS: • The unaffected CIV is assumed to be OPERABLE. • Without taking credit of the pressure transmitter, the result can change significantly. • It appears that the expression used to estimate ISLOCA frequency is unnecessary complex. Verification of the correctness of the equation was not performed. It is recommended that the applicant fully derive the equation presented and provide additional discussion. • The expression used in the JAR does not account for common cause failure of redundant valves.

ID	Description of Penetration Flow Path	Calculation Method	Comment
B2	CIVs in penetrations connected to the reactor coolant system (RCS) sample line (See Figure 7)	$SAOT_{LERF} = CCDP_{SL} * F_P * P_{TRC} * \frac{AOT}{8760} = 8.23E-10$ where, $SAOT_{LERF}$ = single AOT risk for large early release $CCDP_{SL}$ = total conditional core damage probability given the interaction of a small LOCA: 3.73E-3 F_P = frequency of a random pipe failure occurring in the sample system creates a small LOCA: 5.0E-3 per year P_{TRC} = probability of the operable CIV failing to remain closed during the proposed AOT: 2.3E-3 $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year FOR SEISMIC EVENTS: $SAOT_{LERF} = 6.57E-10$	Specific Assumptions: • Both CIVs are AOVs. • CIVs assumed to be cycled daily and initially closed. Probability to remain closed is more conservative than failing to close on demand. • The same failure mechanism causing the CIV to transfer open prevents it from closing on demand. • Pipe failure due to exposure to high RCS temperature and pressure is negligible. • A break in the sample system can be compensated by charging system or ECCS and the plant can be shutdown in a timely manner so it will not lead to core damage. • Note: $CCDP_{SL} * F_P$ is equivalent to core damage frequency associated with a sample system pipe failure (1.9E-5). • Assumed exposure time used for P_{TRC} is equal to AOT. This assumption is not conservative. The exposure time should be the time between the last test to the end of AOT. REVIEW COMMENTS: • The unaffected CIV is assumed to be OPERABLE. • It is assumed that the cause of the failure of the affected CIV is not shared by the redundant CIV. That is, common cause failure is absent. • The redundant valve is treated as same-as-new.

ID	Description of Penetration Flow Path	Calculation Method	Comment
B3	CIVs in penetrations connected to Letdown or reactor coolant pump (RCP) bleed-off line (See Figure 8)	BREAK INSIDE CONTAINMENT: $SAOT_{LERF} = ICCDP * P_{FTC}$ $= \left[CCDP_{SL} * F_P * P_{FTC} * \frac{AOT}{8760} \right] * P_{FTC}$ $= (5.54E-10) * (1.55E-3) = 8.59E-13$ BREAK OUTSIDE CONTAINMENT: $SAOT_{LERF} = ICCDP = F_P * P_S * \frac{AOT}{8760}$ $= 7.82E-9$ where $SAOT_{LERF}$ = single AOT risk for large early release $ICCDP$ = incremental conditional core damage probability $CCDP_{SL}$ = total conditional core damage probability given the interaction of a small LOCA: 3.73E-3 F_P = frequency of a random pipe failure occurring in the letdown line inside or outside containment: 5.0E-3/yr for inside and 2.63E-3/yr for outside P_{FTC} = probability of the remaining CIVs failing to closed by common cause during the proposed AOT: 1.55E-3 P_S = probability of both CIVs failing to closed during the proposed AOT: 1.55E-4 $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumption: • All valves are AOVs and AOV failure to close is 1.55E-3. • Failure of the actuation signal to close the AOV is negligible when compared with hardware failures. • Inoperability of one CIV can be detected and secured in open position. The two other AOVs can isolate the containment. • Break is assumed between the two CIVs inside containment and the one downstream of the regenerative heat exchanger is inoperable and in the open position. • Breach in outside line is downstream of the outside CIV from piping failure or failure of a relief valve (probability of 2.13E-2 per year). • The probability of both operable CIVs failing to close is dominated by common cause failure for a probability of 1.55E-4. REVIEW COMMENTS: • In the text, the equation for a break outside containment has CLERP not ICLERP. This is assumed to be a typo. • The unaffected CIV is assumed to be OPERABLE. • For this situation, the licensee may be able to enter the LCO by removing two CIVs. It is recommended that guidance be provided that only one CIV of a pair could be removed at a time.

ID	Description of Penetration Flow Path	Calculation Method	Comment
C1	CIVs in penetrations connected to non-essential containment cooling (See Figure 9)	CASE INVOLVING A RANDOM PIPE FAILURE AND CAUSING REACTOR SCRAM: $SAOT_{CDF} = ICCDP = CCDP_t * F_P * \frac{AOT}{8760}$ $= 3.07E-9$ $SAOT_{LERF} = ICCDP * P_B$ $= 1.84E-12$ (without P_t) CASE INVOLVING A PIPE FAILURE CONCURRENT WITH CORE DAMAGE: $SAOT_{LERF} = ACDF * P_t * P_B * \frac{AOT}{8760}$ $= 2.30E-13$ where $SAOT_{CDF}$ = single AOT risk for core damage $SAOT_{LERF}$ = single AOT risk for large early release $CCDP_t$ = conditional core damage probability due to reactor trip: 6.08E-6 $ICCDP$ = incremental conditional core damage probability $ACDF$ = change in CDF, baseline CDF assumed to be: 2E-4/yr F_P = frequency of breaching a closed loop system outside the containment: 2.63E-2 per year P_F = probability of a pipe failure in the closed loop system inside the containment: 1.0E-4 P_B = probability of a pipe failure in the closed loop system outside the containment: 6.0E-4 $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumptions: • One AOV per penetration and is open during normal operation • Inadvertent opening of a relief valve will also breach the piping outside of containment and is given a probability of 5.0E-4 for the proposed AOT. The combination of relief and piping failure yield a probability of 6.0E-4. • A breach in the piping of both inside and outside containment must fail for a pathway to the environment. REVIEW COMMENTS: • The equation for the case involving a pipe failure and causing reactor scram may need to have a probability for pipe failure outside containment to complete the pathway to the environment (P_t). • The unaffected CIV is assumed to be OPERABLE. • A breach in the closed loop system during power operation is assumed to cause an uncomplicated reactor trip. • The presented analysis is valid if the breach does not impact the CCW function.

ID	Description of Penetration Flow Path	Calculation Method	Comment
C2	CIVs in penetrations connected to secondary side of steam generator (See Figure 10)	$SAOT_{LERF} = CCDP_{SGTR} * P_{TRC} * F_B * \frac{AOT}{8760}$ $= 2.02E-10$ where $SAOT_{LERF}$ = single AOT risk for large early release $CCDP_{SGTR}$ = conditional core damage probability due to SGTR: 9.16E-4 P_{TRC} = probability of the operable CIV failing to remain closed during the proposed AOT: 2.3E-3 F_B = random pipe failure of blowdown piping outside the containment: 5.0E-3 per year $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumptions: • A penetration has two closed AOVs and once one is determined inoperable, it is secured open. • For a path to the environment, a SGTR event must also occur concurrently with a transfer opening of the closed CIV. • The piping outside of the containment is non-seismically qualified. REVIEW COMMENTS: • The unaffected CIV is assumed to be OPERABLE. • It is assumed that the cause of the failure of the affected CIV is not shared by the redundant CIV. That is, common cause failure is absent. • The redundant valve is treated as same-as-new.

ID	Description of Penetration Flow Path	Calculation Method	Comment
D	CIVs in penetrations connected to containment atmosphere pressure detector (See Figure 11)	No equations, qualitative assessment	Proposed by CEOG to be negligible and well below acceptance criteria of 5.0E-7 and 5.0E-8 for ICCDP and ICERLP respectively.
E1	CIVs in penetrations used to support RCS inventory control safety function under accident condition (See Figure 12)	HPSI/LPSI LINE: $ISLOCA = \frac{\lambda^2 T}{2} + \lambda\lambda_d\left[\frac{dT+1}{2}\right]$ $SOAT_{LLRF} = ISLP = ISLOCA * P_C * \frac{AOT}{8760}$ $= 1.68E-9$ where $SAOT_{LLRF}$ = single AOT risk for large early release $ISLP$ = incremental conditional ISLOCA probability $ISLOCA$ = frequency of interfacing system LOCA per year: 8.76E-7 λ = random leakage rate of SI check valve: 8.76E-4 per year λ_d = probability of the second check valve failing to reseat: 2.81E-4 per demand d = the number of times the check valve is operated: 3 P_C = conditional probability of pipe failure following exposure to RCS pressure: 0.1 T = fault exposure time: 1 year $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours[1]) to a year	Specific Assumptions: • Assumed that penetration has two check valves on inside and one MOV on outside the containment. The inoperability of the MOV is detected during surveillance or cycling of the valve. • Piping upstream of the MOV can fail if exposed to RCS pressure with a conditional probability of 0.1. • A pressure transmitter can detect a leaking or stuck open SI check valve. • Random leakage of a SI check valve is assumed to be 8.76E-4. • Average of three cold-shutdowns per year where the SI check valves are operated. • Fault exposure time is equivalent to time that the plant operates in its non-cold shutdown modes, namely one year. REVIEW COMMENTS: • Without taking credit of the pressure transmitter, the result can change significantly. • It appears that the expression used to estimate ISLOCA frequency is unnecessary complex. Verification of the correctness of the equation was not performed. It is recommended that the applicant fully derive the equation presented and provide additional discussion. • In this case although the loop is open, the analysis effectively assumes a closed loop system by crediting other means of isolation as shown in term P_C. • Crediting close loop system as a barrier is applicable to cases in which the affected valve (the valve under CM) is intact.

[1] The AOT value used in the calculation (i.e., 168 hours) may not be consistent with the current AOT for the ECCS system in NUREG-1432, Revision 1 [Note: The current permissible AOT for the ECCS system is 72 hours.]

ID	Description of Penetration Flow Path	Calculation Method	Comment
E2	CIVs in penetrations used to provide charging under normal condition (See Figure 13)	No equations, qualitative assessment	Proposed by CEOG to be negligible and well below acceptance criteria of 5.0E-7 and 5.0E-8 for ICCDP and ICERLP respectively.
E3	CIVs in penetrations used to support containment heat removal function using containment sprays (See Figure 14)	$SAOT_{LERF} = \Delta CDF * P_{CK} * P_{B} * \frac{AOT}{8760}$ $= 5.83E-13$ where $SAOT_{LERF}$ = single AOT risk for large early release ΔCDF = change in CDF, baseline CDF assumed to be: 2E-4/yr P_{CK} = probability of a pipe failing to isolate the associated containment penetration: 1.52E-3 P_{B} = probability of a pipe failure in the open loop system outside the containment: 1.0E-4 $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumptions: • The containment penetration has one MOV outside and a check valve inside the containment where the MOV is the CIV that fails and is secured in the open position. • Based on the previous assumption, a redundant means of isolating the containment will be lost during the AOT of 7 days. • Random pipe failure outside the containment leads to the unavailability of the affected train of containment spray and a potential pathway to the environment. • Mean probability of a check valve to close is 1.52E-3. REVIEW COMMENTS: • In this case although the loop is open, the analysis effectively assumes a closed loop system by crediting other means of isolation as shown in term P_B. • As in the case of E1, crediting close loop system as a barrier is applicable to cases in which the affected valve (the valve under CM) is intact.

ID	Description of Penetration Flow Path	Calculation Method	Comment
E4	CIVs in penetrations used to support containment heat removal function using fan coolers (See Figure 15)	$SAOT_{LLRF} = \Delta CDF * P_f * P_B * \frac{AOT}{8760}$ $= 2.30E-13$ *for closed loop* $= 3.84E-10$ *for open loop* where $SAOT_{LLRF}$ = single AOT risk for large early release ΔCDF = change in CDF, baseline CDF assumed to be: 2E-4/yr P_f = probability of a pipe failing to isolate the associated containment penetration: 1.0E-4 P_B = probability of a pipe failure in the closed loop system outside the containment: 6.0E-4 (closed loop), or 1.0 (open loop) $\frac{AOT}{8760}$ = fraction of full duration of AOT (i.e., 168 hours) to a year	Specific Assumptions: • The containment penetration has a MOV on the outside and a normally open manually operated valve inside the containment where the MOV is the CIV that fails and is secured in the open position. • Only a random piping failure can establish a pathway from containment to the environment with a conditional probability of 1.0E-4 during the proposed AOT. • Inadvertent opening of a relief valve will also breach the piping outside of containment and is given a probability of 5.0E-4 for the proposed AOT. • A breach in the piping of both inside and outside containment must fail for a pathway to the environment. • Securing the MOV in the closed position will result in an action per TS. The proposed AOT for an inoperable CCS cooling water line CIV is 7 days. REVIEW COMMENTS: • The unaffected CIV is assumed to be OPERABLE. • Crediting close loop system outside containment as a barrier is applicable to cases in which the affected valve (the valve under CM) is intact. If not true, the value of $SAOT_{LLRF}$ would increase by approximately three orders of magnitude.

Table 7: Summary of Risk Results (Reproduced from CEOG Report)

ID	Description of Penetration Flow Path	Seismic Effect on Piping		CDF-based Single AOT Risk (ICCDP)	LERF-based Single AOT Risk (ICLERP)
		N	Y		
A1	CIVs in penetrations connected directly to containment atmosphere and outside environment	Note 1		0	8.82E-9
A2	CIVs in penetrations connected directly to containment atmosphere and closed loop system outside environment	√		0	1.48E-12
			√	0	1.29E-9
A3	CIVs in penetrations connected directly to containment atmosphere and open loop system outside environment	√		0	5.83E-13
			√	0	5.10E-10
A4	CIVs in penetrations connected directly to closed loop system inside and outside containment	√		0	<<2.00E-13
			√	0	1.29E-9
B1	CIVs in penetrations connected to safety injection (SI) line check valve leakage path	Note 2		4.19E-10	4.19E-10
B2	CIVs in penetrations connected to the reactor coolant system (RCS) sample line	√		8.23E-10	8.23E-10
			√	6.57E-10	6.57E-10
B3	CIVs in penetrations connected to letdown or reactor coolant pump (RCP) bleed-off line	Notes 2 & 3		5.54E-10	7.82E-9
C1	CIVs in penetrations connected to non-essential containment cooling	Notes 4 & 5		3.07E-9	1.84E-12
C2	CIVs in penetrations connected to secondary side of steam generator	√		0	2.02E-10
			√	0	Negligible
D	CIVs in penetrations connected to containment atmosphere pressure detector	Note 2		Negligible	Negligible
E1	CIVs in penetrations used to support RCS inventory control safety function under accident condition	Note 2		1.68E-9	1.68E-9
E2	CIVs in penetrations used to provide charging under normal condition	Note 2		0	Negligible
E3	CIVs in penetrations used to support containment heat removal function using containment sprays	Note 2		2.0E-8	5.83E-13
E4	CIVs in penetrations used to support containment heat removal function using fan coolers	Notes 2 & 6		2.0E-8	3.84E-10

Notes for Table 7 (Reproduced from Table 6.3-3 of CEOG Report):

1. The associated piping located downstream of the CIV 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 containment is seismically qualified.
3. CCDP is bounded by letdown pipe break inside containment; ICLERP is bounded by letdown pipe break outside containment.
4. Associated piping inside containment is seismically qualified.
5. CCDP and ICLERP are bounded by pipe failure causing reactor trip.
6. ICLERP is bounded by penetration connected to an open loop cooling water system.

7. IMPACT ON CDF AND LERF

7.1 CIVs Role in Preventing Core Damage and Large Early Releases

A summary of the risk-informed assessment pertaining to the effects of CIV failure and the extended AOT is given in the following table. These results reflect the 14 containment penetration configurations given in the CEOG JAR for the five classes of flow paths and in Figures 2 through 15 of this report. The CIVs are either part of the safety systems or involved with plant operations. The effects of assumed CIV failure in either the open or closed positions as they pertain to CDF and LERF are evaluated quantitatively in earlier sections of this report and are summarized below in Table 8. On the basis of this review, the following findings pertaining to CDF and LERF are given below:

- Credit for physical barrier integrity outside containment can only be afforded for seismically qualified piping systems. In addition, any maintenance operations should not result in an open system that would lead to a loss of a physical barrier during an extended AOT.

- The effects of common cause failure for CIVs needs to be addressed by individual licensees for plant specific containment penetration configurations to ensure remaining CIVs are operable based upon the provisions of the configuration management plan.

- Not all cases studied impact CDF, and all cases do not have the same impact on LERF for the generic study. Accordingly, plant specific analyses should be performed to assure the applicability of the CEOG JAR results in assessing the impact of the extended AOT for inoperable CIVs.

7.2 Evaluation of Defense-in-Depth with the Tier 2 Program

<u>With the Commitment to a Tier 2 Program, Defense-in-Depth is Preserved</u>

If the licensee adheres to an effective Tier 2 or equivalent program, there will be no further degradation of the plant's mitigation capabilities, as a result of licensee action, while in the LCO condition. Tier 2 is intended to prevent high-risk configurations from emerging while the plant is in the LCO condition. The licensee accomplishes this by having a *qualitative* understanding of what configurations must be prevented, by knowing how close any given configuration is to an undesirable condition, and by knowing what elements of the current configuration must be maintained to prevent undesirable configurations. This knowledge will be the basis upon which contingency plans and compensatory measures should be developed.

Table 8: Summary of Effects of CIV Failure Modes on CDF and LERF

ID	Description of Penetration Flow Path	Failure Mode	CDF Impact	LERF Impact
A1	CIVs associated with these flow paths isolate the containment in the event of an accident. CIVs in penetrations connected directly to containment atmosphere and outside environment. (See Figure 2)	Inoperable or open CIV following an accident could result in a direct pathway to the environment (containment bypass).	Since there is no direct effect on core cooling , a failed CIV in this configuration would have no impact on CDF.	A failed CIV could create a containment bypass path and would contribute to an early large release of radioactive materials to the environs.
A2	CIVs associated with these flow paths isolate the containment in the event of an accident. CIVs in penetrations connected directly to containment atmosphere and closed loop system outside environment. (See Figure 3)	Inoperable or open CIV following an accident could result in a direct pathway to the environment (containment bypass) for failed non-seismically qualified piping in a closed-loop cooling system outside containment.	Same as A1 above.	Failure of non-seismically qualified piping outside containment with a failed or inoperable CIV would contribute to an early large release of radioactive materials to the environs.
A3	CIVs associated with these flow paths isolate the containment in the event of an accident. CIVs in penetrations connected directly to containment atmosphere and open loop system outside environment. (See Figure 4)	A pipe break in an open-loop concurrent with a failure to isolate the containment penetration would establish a direct pathway to the environment (containment bypass).	Same as A1 above.	Failure of non-seismically qualified piping in the open-loop concurrent with an open CIV leads to containment bypass.
A4	CIVs associated with these flow paths isolate the containment in the event of an accident. CIVs in penetrations connected directly to closed loop system inside and outside containment. (See Figure 5)	A pipe break in a closed-loop system both inside and outside containment with failure to isolate the penetration would result in a direct pathway to the environment (containment bypass).	Same as A1 above.	Failure of non-seismically qualified piping in a closed-loop system both inside and outside containment concurrent with an open CIV leads to containment bypass.
B1	CIVs associated with these flow paths isolate the containment in order to minimize the leakage of reactor coolant. CIVs in penetrations connected to safety injection (SI) line check valve leakage path. (See Figure 6)	Failure of multiple barriers would result in over-pressurization of low pressure piping outside containment. Over-pressurization could lead to an interfacing system LOCA. A failed CIV inside containment reduces the number of barriers to protect the low pressure system.	The loss of reactor coolant to the low pressure piping outside containment impacts the effectiveness of ECCS.	Failure of the low pressure piping outside containment creates a direct leakage path for radioactive materials to the environs (containment bypass).
B2	CIVs associated with these flow paths isolate the containment in order to minimize the leakage of reactor coolant. CIVs in penetrations connected to the reactor coolant system (RCS) sample line. (See Figure 7)	CIV failure mode could lead to discharge of reactor coolant given a failure of non-seismically qualified piping outside containment.	Small impact expected for this event due to line size and ECCS make-up capability.	An inoperable and open CIV in conjunction with non-seismic piping failure would lead to a direct leakage path for radioactive materials to the environs.

ID	Description of Penetration Flow Path	Failure Mode	CDF Impact	LERF Impact
B3	CIVs associated with these flow paths isolate the containment in order to minimize the leakage of reactor coolant. CIVs in penetrations connected to letdown or reactor coolant pump (RCP) bleed-off line. (See Figure 8)	Piping failure inside containment between CIVs or outside containment downstream of the CIV with an inoperable CIV leads to a non-isolatable containment penetration.	A break inside containment between the two CIVs is considered to be a small break LOCA. A break outside containment is similar in consequence. However, loss of coolant inventory would not be available for long-term make-up and heat removal and impact CDF.	Either failure mode with an open CIV in conjunction with a postulated piping break leads to a direct release path for radioactive materials to the environs (containment bypass).
C1	CIVs associated with these flow paths isolate the containment in the event of an accident. CIVs in penetrations connected to non-essential containment cooling. (See Figure 9)	An open CIV leads to a direct pathway from the containment to the environs in the event of a break in a closed-loop system inside and outside the containment.	Little impact would be expected for an open CIV and a failed closed cooling system. An inadvertent opening of a relief valve or break in a closed loop system during power operation would result in a reactor trip with a small impact on CDF.	In this event, the inability to provide containment isolation would lead to a direct release pathway for radioactive materials to the environs (containment bypass).
C2	CIVs associated with these flow paths isolate the containment in the event of an accident. CIVs in penetrations connected to secondary side of steam generator. (See Figure 10)	Failed CIV to isolate a steam generator with a ruptured steam generator tube allows a release of reactor coolant outside containment through failed non-seismically qualified piping or an open safety-relief valve.	An open CIV in this case has the potential to impact CDF due to loss of coolant outside containment.	Direct pathway to environs would be created in the event of a CIV in the open position and a SG tube rupture event.
D	CIVs in these flow paths are designed to open during power operation and provide input to ESFS; designed to open during post accident conditions. CIVs in penetrations connected to containment atmosphere pressure detector. (See Figure 11)	CIV failure in the open position in a containment sensor line would create a direct path to the environs (containment bypass) should the sensor also fail.	No impact on CDF would result with a failed or open CIV.	An accident occurring with a failed or open CIV would not of itself create bypass leakage path to the environs. However, in conjunction with a concurrent failed sensor, a direct leakage path to the environs (containment bypass) would be created.
E1	CIVs in these flow paths have varied functions: (1) safety injection, (2) make-up to RCS, and (3) support post accident heat removal. The penetrations are designed to be open in the event of an accident and some may be opened during normal plant operations. CIVs in penetrations used to support RCS inventory control safety function under accident conditions. (See Figure 12)	Concern over failure of low pressure portion of HPSI/LPSI piping upstream of header CIVs (charging line is not of consequence here because it is designed to full system pressure). HPSI/LPSI with CIV secured in either the closed or open position.	CIV in closed position results in CDF impact due to loss of system operability. On the other hand, CIV in secured open position would allow system operability but with reduced number of barriers present.	No pathway bypassing containment would occur for the secured closed CIV. On the other hand, a secured open CIV with failure of low pressure piping would result in a bypass pathway for release of radioactive materials.

ID	Description of Penetration Flow Path	Failure Mode	CDF Impact	LERF Impact
E2	CIVs in these flow paths have varied functions: (1) safety injection, (2) make-up to RCS, and (3) support post accident heat removal. The penetrations are designed to be open in the event of an accident and some may be opened during normal plant operations. CIVs in penetrations used to provide charging under normal conditions. (See Figure 13)	Same as E1 above, except for the charging system (all high pressure). CIVs considered in either closed or open position.	CIV in the closed position removes system operability. However, the charging system is not always required for heat removal. In the open position, there would be little or no impact on CDF.	In the closed position, CIV would fulfill containment isolation function. In the open position because of high pressure design, there would be little or no impact on LERF.
E3	CIVs in these flow paths have varied functions: (1) safety injection, (2) make-up to RCS, and (3) support post accident heat removal. The penetrations are designed to be open in the event of an accident and some may be opened during normal plant operations. CIVs in penetrations used to support containment heat removal function using containment sprays. (See Figure 14)	CIVs in this system provide for containment spray function. CSS – MOV secured in the open position allows for system operation. However, failure of outside piping could lead to containment bypass. Close position renders system inoperable.	There should be little or no impact on CDF for this CIV failure mode in either the secured open or closed position.	With failure of the outside piping with a secured open CIV, containment bypass would occur contributing to the release of radioactive materials.
E4	CIVs in these flow paths have varied functions: (1) safety injection, (2) make-up to RCS, and (3) support post accident heat removal. The penetrations are designed to be open in the event of an accident and some may be opened during normal plant operations. CIVs in penetrations used to support containment heat removal function using fan coolers. (See Figure 15)	CIVs in this system provide for containment cooling function. CCS – CIV secured in closed position renders system inoperable for cooling. In the open position a barrier loss results, and impacts the protection against containment bypass.	CIV in closed position renders system inoperable for cooling and would impact the CDF through reduced cooling capability. On the other hand, a secured open CIV leads to the loss of one barrier.	A secured closed CIV would impact LERF due to reduced heat removal capability affecting long term containment integrity. On the other hand, a CIV in the secured open position would lead to a containment bypass path contributing to the release of radioactive materials.

The most immediate part of this process is for the licensee to ensure that, while in the LCO condition, no actions will be taken (no additional equipment will be taken out of service) that could impair the plant in responding to conditions requiring the functioning of the inoperable system causing the LCO condition. Any time the licensee enters an LCO by removing a piece of equipment for which the risk model credits the use of the equipment, the success paths should be identified. The latter success paths comprise the plant response until the down equipment is returned to service. Part of the intent of the Tier 2 evaluation is to preserve the functionality of these success paths. This requires the identification of the following:

- Initiating events that challenge the down equipment
- Functional role that the down equipment would normally play in the mitigation of initiating events
- Equipment that is potentially available and is credited as functionally redundant to the down equipment, and the context (success paths) in which this equipment can perform its intended function
- Procedures to restore the functionality of the down equipment.

Once these success paths have been identified, the following conditions exist for the management of plant configurations.

The licensee should ensure that no action or maintenance practices will be performed that:

1. increase the likelihood of the occurrence of any of the initiating events identified above

   or

2. involve the removal of or jeopardize any equipment that is redundant in functionality to the down equipment (i.e., redundant CIV)

   or

3. involve the removal of or jeopardize any equipment that supports the systems appearing in any of the success paths identified above

How the CEOG Intends to Evaluate Defense-in-Depth When in an LCO Condition Related to the CIVs

The JAR claims that no loss of containment isolation function will emerge because TS 3.6.3 prohibits simultaneous removal of two redundant CIVs in the same penetration line. As stated earlier, the estimates provided for single AOT risk credits the operability of the redundant CIV while in the LCO. The JAR does not however, provide any indication on how the operability of the redundant CIV is established when entering into the LCO. The most significant compensatory measure committed by CEOG, as stated in Section 6.7 of the JAR deals with meeting cumulative unavailability targets for individual CIVs. It states the following:

"In conformance with Regulatory Guide 1.177, the CEOG member utilities commit to the use of a risk-informed configuration risk management program. This program will assess the risk associated with plant maintenance activities and may be included within the plant program(s) to meet paragraph A.4 of the proposed revision to the Maintenance Rule. Risk informed cumulative unavailability targets for CIVs are already being established within the scope of the current Maintenance Rule."

8. TIER 2 AND 3 CAPABILITIES

Tier 2 Capability

The main requirement of the Tier 2 program is to establish whether each licensee is evaluating defense-in-depth when entering an LCO condition. Although the information provided in the JAR are not plant specific, based on the representation made under Section 6.6 and Section 6.7 of the JAR "Tier 2 Considerations" and "Commitment to Configuration Risk Management Program" respectively, it appears that all licensees are meeting the intent of the Tier 2 program.

Tier 3 Capability

The main requirement of the Tier 3 program is to establish whether the licensees have:

1) a predetermined knowledge of high risk configurations (e.g., risk matrix or an online risk monitor) and
2) the ability to evaluate the risk of LCO conditions as they evolve.

Due to lack of plant specific data in the JAR, this TER cannot determine the extent of each licensee's ability to meet the Tier 3 requirements.

9. EVALUATION SUMMARY

We have identified the important modeling assumptions that affected the AOT risks in the JAR. On the basis of this review, the following findings or recommendations are given below:

- In Section 6.3.2.1 of the CEOG JAR, one general assumption is that the unaffected CIV is evaluated to ensure that it is OPERABLE. However, it is unclear as to when the evaluation is performed. Therefore, we recommend that licensees be required to submit a plan to show what their practice is for determining which TS is applicable, i.e., if TS 3.6.3 applies to the situation. Additionally, we recommend that a licensee be required to perform an operability determination of the unaffected valve shortly after the affected CIV has been determined to be inoperable, i.e., within 4 hours of discovery.

- NUREG-1432, Rev. 1, Section 3.6.3, Action 2, states that, "Separate Condition entry is allowed for each penetration flow path." Additionally, there is no restriction in the CEOG JAR to prevent removal of a valve body during the AOT, thereby creating a potential for an "OPEN system." As such, if multiple entries into the LCO are made, the potential exists to summarily exceed the AOT risk guideline values. Therefore, we recommend that licensees utilize their configuration risk management program (CRMP) to determine if multiple entries into the LCO are consistent with the AOT risk guidelines, i.e., the summation of SAOT risk values for multiple entries should be less than the RG 1.177 guideline value. For plants that do not have plant-specific risk models, use of generic penetration model(s) presented in the JAR is acceptable for estimating AOT risk. However, it is expected that each generic penetration model will be adapted to reflect the specificity of the outage.

- In instances where CM activities would be performed on penetrations and CIVs, it will be necessary to monitor the activities and ensure that the system remains intact during the maintenance period. Considerations should include the impact of physical removal of CIV components that would affect penetration integrity against the loss of a physical barrier. Such proposed activities should be evaluated against the overall model and assumptions of the JAR with the recognition that the JAR results may not be applicable.

- Not all cases studied impact CDF and all cases do not have the same impact on LERF for the generic study. Accordingly, plant specific analyses should be performed to assure the applicability of the JAR results in assessing the impact of the extended AOT for inoperable CIVs. This is especially true for outages that increase the potential for interfacing system LOCAs.

10. REFERENCES

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4 US NRC, Chapter 19 of the Standard Review Plan, "Use of Probabilistic Risk Assessment in Plant-Specific, Risk-Informed Decision-Making: General Guidance," NUREG-0800.

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LIST OF ACRONYMS

AOT	Allowed Outage Time
AOV	Air-operated Valve
CCS	Containment Cooling System
CDF	Core Damage Frequency
CE	Combustion Engineering
CEOG	Combustion Engineering Owners Group
CFCU	Containment Fan Cooler Unit
CHR	Containment Heat Removal
CIAS	Containment Isolation Actuation Signal
CIV	Containment Isolation Valve
CRMP	Configuration Risk Management Program
CSS	Containment Spray System
CT	Completion Time
CVCS	Chemical and Volume Control System
ECCS	Emergency Core Cooling System
ESF	Engineered Safety Feature
ESFAS	Emergency Safeguards Features Actuation System
ESCS	Engineered Safeguard and Control System
HPSI	High Pressure Safety Injection
ICCDP	Incremental Conditional Core Damage Probability
ICLERP	Incremental Conditional Large Early Release Probability
ISLOCA	Interfacing System Loss of Coolant Accident
ISTS	Improved Standard Technical Specifications
LCO	Limiting Condition for Operation
LERF	Large Early Release Frequency
LOCA	Loss of Coolant Accident
LPSI	Low Pressure Safety Injection
MOV	Motor-operated Valve
NOED	Notice of Enforcement Discretion
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
PSA	Probabilistic Safety Assessment
PWR	Pressurized Water Reactor
RCS	Reactor Coolant System
RDT	Reactor Drain Tank
RWT	Refueling Water Tank
SDC	Shutdown Cooling
SI	Safety Injection
SIAS	Safety Injection Actuation Signal
SIRWT	Safety Injection Refueling Water Tank
SIT	Safety Injection Tank
SG	Steam Generator
STS	Standard Technical Specifications
TS	Technical Specification
VIAS	Ventilation Isolation Actuation Signal

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1.0 PURPOSE

The purpose of this report is to provide a risk-informed justification for modifying the Technical Specification allowed outage times (AOTs)/Completion Times (CTs) for many containment isolation valves (CIVs) of units with CE NSSS designs. Specifically, this report provides technical justification for an extension of the AOT/CT for the "Containment Isolation" function from 4 hours to 7 days. This proposed modification applies to those CIVs addressed by Conditions A and C of Section 3.6.3 of NUREG-1432, Revision 1 (Attachment 1). In addition, this report identifies a limited set of valves for which an AOT/CT change is not requested.

Implementation of the described AOT/CT modifications will enhance plant safety by providing flexibility in the performance of preventative 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 NOEDs.

The described AOT/CT 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/CT 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 via implementation of a configuration risk management program (CRMP) consistent with the guidance set forth in Regulatory Guide 1.177 (Reference 9).

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.

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2.0 SCOPE OF PROPOSED CHANGE TO TECHNICAL SPECIFICATION

2.1 Definition of Containment Isolation Valve

In describing "containment isolation valves" corresponding to LCO 3.6.3 in NUREG-1432, the Bases Section B.3.6.3 of NUREG-1432, Revision 1 (Reference 3) states:

> "The containment isolation valves form part of the containment pressure boundary and provide a means for fluid penetrations **not serving accident consequence limiting systems** to be provided with **two isolation barriers** that are closed on an automatic isolation signal. 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." [Note: "Bolding" in the quotation has been added for emphasis.]

In the corresponding Action Condition Statements of NUREG 1432, Revision 01, the "containment isolation valves" as defined in NUREG-1432 are divided into the following three categories that are common to both atmospheric containment design and dual containment design:

- CIVs for containment piping penetrations, other than containment purge lines, that have two CIVs (as defined by NUREG-1432) in the associated piping line (Addressed by Conditions A and B of LCO 3.6.3 of NUREG 1432, Revision 1)
- CIVs for containment piping penetrations, other than containment purge lines that have one CIV and a closed system corresponding to the associated piping line. (Addressed by Condition C of LCO 3.6.3 of NUREG 1432, Revision 1)
- CIVs associated with the containment penetrations for containment purge lines. (Addressed by Condition E of LCO 3.6.3 of NUREG 1432, Revision 1)

The Technical Specifications for each CE NSSS unit include Technical Specifications that address these three categories of CIVs (CIVs as defined in NUREG 1432, Revision 1).

For <u>some</u> CE NSSS units, the specific Technical Specification sections that address these three categories of CIVs 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 (including charging pump injection in some cases), Containment Spray, cooling water to Emergency Containment Cooling Units, and the Auxiliary Feedwater System. (The Technical Specifications of each and every CE NSSS unit includes sections concerning each of the applicable "accident consequence limiting systems.")

2.2 Proposed Extension of AOTs/CTs

For the majority of CIVs that correspond to either Condition A or Condition C of LCO 3.6.3 in NUREG 1432, this report provides justifications for an extension in the AOT/CT for the applicable Action (Action A.1 or Action C.1) from 4 hours to 7 days. Additionally, the report identifies a specific set of valves for which the justifications have not been pursued. Valves in this identified set include: (i) the containment sump supply valves to the ECCS and Containment Spray pumps, (ii) valves associated with main feedwater systems, and (iii) Main Steam Isolation Valves.

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 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 generally 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)/Action Completion Times (CTs). The applicable AOTs and completion times are those that correspond to the LCO and Conditions of Section 3.6.3 of NUREG 1432, Revision 1. The primary intent of the proposed changes is to provide for the potential of on-line maintenance, repair and testing of a Containment Isolation Valve (CIV) that is declared INOPERABLE during operation in the applicable modes (Modes 1, 2, 3 and 4). 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 5).

This application is being pursued by the CEOG as a risk informed plant modification in accordance with NRC Regulatory Guides 1.174, (Reference 8) and 1.177 (Reference 9). As required by Reference 9 all plants that adopt these changes will implement a Configuration Risk Management Program to provide PSA informed maintenance controls.

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 CIV TS modification, including:

- Assessment of the Incremental Conditional Core Damage Probability (ICCDP) and Incremental Conditional Large Early Release Probability (ICLERP) resulting from allowing CIVs to remain in the OPEN position for the duration of the AOT/Action Completion Time.

- For systems with CIVs 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 valves, which have a safety function (in addition to containment isolation), in the closed position for an extended time.

Risk evaluations also include explicit consideration of incremental risks associated with CIVs connected to systems containing non-seismically qualified piping. All risk assessments consider the impact of maintaining the CIV 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 CE NSSS designed units of the CEOG member utilities regardless of the category of their Plant Technical Specifications, and regardless of the details of the valve actuators.

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4.0 SUMMARY OF APPLICABLE TECHNICAL SPECIFICATIONS

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

The first category concerns Technical Specifications in the format of the Standard Technical Specifications. Through May 1999, NUREG-0212, Revision 03, commonly referred to as "Standard Technical Specifications (STS)," has provided a model for the general structure and content of the approved technical specifications for several of the domestic CE NSSS plants. The CE NSSS units with current, approved Technical Specifications in the STS format are: Millstone Unit 2, St. Lucie 1, St. Lucie 2, Arkansas Nuclear One – Unit 2, and Waterford Unit 3.

The second category concerns Technical Specifications that reference the Improved Standard Technical Specifications (ISTS) guidance provided in NUREG-1432 (Revision 0, dated September 1992 and Revision 1, dated April 1995). The CE NSSS units with current, approved Technical Specifications that reference ISTS guidance are: (a) San Onofre Unit 2, (b) San Onofre Unit 3, and (c) Palo Verde Units 1, 2 and 3, and (d) Calvert Cliffs Units 1 and 2.

The third category includes those Technical Specifications (TSs) that have structures other than those that are outlined in either NUREG-0212 (Reference 2) or NUREG-1432 (Reference 3). These TSs are generally referred to as "customized" technical specifications; and they are associated with the early CE PWR designs. The CE units that (a) have, current, and approved "customized" technical specifications and (b) do not have an on-going decommissioning plan are: Palisades Nuclear Generating Station and Fort. Calhoun Nuclear Generating Station. (Note: At the Palisades Station, there is an on-going program for conversion to Technical Specifications that reference ISTS guidance.)

Each of these categories of Technical Specifications include operating requirements for Containment Isolation Valves (CIVs) corresponding to the CIVs addressed in NUREG-1432 LCO 3.3.6.

Additionally, as stated in Section 2, for <u>some</u> CE NSSS units, the specific Technical Specification sections that address these three categories of CIVs 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 (including charging pump injection in some cases), Containment Spray, cooling water to Emergency Containment Cooling Units, and the Auxiliary Feedwater System. (The Technical Specifications of each and every CE NSSS unit includes sections concerning each of the applicable "accident consequence limiting systems.")

4.1 Improved Standard Technical Specification Guidance

As discussed in Section 2, Section 3.6.3 of NUREG-1432, Revision 1 describes LCO requirements, required action requirements, and corresponding completion time requirements for three categories of containment isolation valves (CIVs). Section 2 of this report also provides a description of the NUREG 1432 definitions of these three categories of CIVs.

This report provides risk-informed justifications for AOT/CT extensions corresponding to the actions in response to either Condition A or Condition C as defined in NUREG-1432. These Conditions and the existing corresponding required actions and completion times are:

CONDITION A APPLICABILITY: Penetration Flow Paths with Two CIVs

When in CONDITION A, one CIV in the affected penetration flow path is INOPERABLE. The completion time or 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 CIV and a Closed System

When in CONDITION C, the single CIV in the penetration flow path is INOPERABLE. The AOT for the inoperable CIV 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, or blind flange.

For each of the CE NSSS units with Technical Specifications referencing ISTS guidance, the described guidance of NUREG-1432 (including the AOT/CT of 4 hours) is fully integrated into the corresponding applicable "CIV" Technical Specification.

For each of the CE NSSS units with either Technical Specifications with STS format or "customized" Technical Specifications, there are corresponding Technical Specifications with AOTs of no greater than 4 hours. As an example, in the existing, approved "customized" Technical Specifications of Fort Calhoun Station, at least one isolation valve must be maintained operable in the affected penetration and either:

a. Restore the inoperable valves to OPERABLE status within 4 hours; or

b. Isolate each affected penetration within 4 hours by use of at least one closed and de-activated automatic valve, closed manual valve or blind flange.

4.2 Valves Supporting Accident Consequence Limiting Systems

For <u>some</u> CE NSSS units, the specific Technical Specification sections that address the three categories of CIVs from NUREG-1432 Section 3.6.3 also addresses the "containment pressure boundary" function requirements for valves that serve the piping penetrations of "accident consequence limiting systems."

The existing Technical Specifications for San Onofre Units 2 and 3 provide examples. Unique among approved, implemented Technical Specifications of CE NSSS units that reference ISTS guidance, Technical Specification Section 3.6.3 for each of these two units includes additional Conditions and action statements concerning sets of valves associated with "accident consequence limiting systems." Currently, the NRC is considering specific potential license amendments for these two units. These specific, proposed amendments would revise the Completion Time corresponding to these additional conditions to be in general accordance with the ISTS.

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5.0 SYSTEM DESCRIPTION AND OPERATING EXPERIENCE

5.1 System Description

The primary function of containment isolation valves is to prevent the release of radioactive material from either the containment atmosphere or the reactor coolant system to the outside environment via a containment penetration. At the same time, 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 containment isolation valves including: (a) manually-operated valves, (b) motor-operated valves, (c) air-operated valves, and (d) check valves. Some containment isolation valves are automatically actuated to a closed position by one or more Engineered Safety Feature Actuation Signals (ESFAS), such as a Containment Isolation Actuation Signal (CIAS) as defined in NUREG-1432.

Some other containment isolation valves are automatically actuated to an open position by a Safety Injection Actuation Signal (SIAS). These containment isolation valves include valves that are components of ECCS, containment spray system, or cooling water for containment heat removal.

There are also containment penetrations that have either associated 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 two classes (Classes A and B) being further subdivided. These flow path classes reflect the (1) safety function of the flow path, (2) the manner in which the flow path communicates between the RCS and the environment and (3) the characteristics of the flowpaths (e.g. normal valve position, connection to a closed system, seismic qualification of flow path piping, etc.)

Characterization of Containment Isolation Valve Flow Paths

Class A1
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 CIVs and/or piping or ductwork represent the only barriers between the containment atmosphere and the outside environment. For this type of penetration, the associated CIVs are **normally open**, or may be opened, during power operation. Typical examples of this type of piping penetration include the containment vacuum relief line and the containment radiation monitor supply and return lines.

Class A2
This type of containment flow path is similar to Class A1 described above. However, the associated CIVs are **normally closed**, and are not opened during power operation. Typical examples of this type of piping penetration include the refueling cavity purification flow inlet line and the station air line.

Class B1
This type of containment piping flow path connects directly to the Reactor Coolant System (RCS). With the loss of containment isolation, a pathway may be established from the RCS to the environment. The CIVs and/or piping represent the only barriers between the reactor coolant and reactor coolant exposed systems outside the containment. The reactor coolant exposed systems include Chemical and Volume Control System (CVCS) and the Reactor Coolant Sample System. For this type of penetration, the associated CIVs are **normally open**, or may be opened, during power operation. Typical examples of Class B1 type piping penetration include the CVCS letdown line, SIT sample lines and the RCS sample lines. (Note: During Mode 4 operations with shutdown cooling in service, shutdown cooling section isolation valves are in this category.)

Class B2
This type of containment piping penetration is also connected directly to the reactor coolant and the CIVs and/or piping represent the only barriers between the reactor coolant and reactor coolant exposed systems outside the containment. However, the associated CIVs are normally closed, and are not opened during power operation. Typical examples of Class B2 type piping penetration include the shutdown cooling line(s), hot leg injection lines, and SIT test lines.

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. Typical examples of this type of containment piping penetration include non-safety related component cooling supply and return lines, containment chiller normal chiller supply and return lines.

Class D
This type of containment piping penetration is used for measuring containment pressure. Typically, a closed CIV and a closed piping system outside the containment represent the only barriers between the containment atmosphere and the outside environment. Examples of this piping penetration include the containment pressure sensing lines.

Class E
This type of containment piping penetration is designed to open during a design basis event. Consequently, the CIVs 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 collected in the containment sump.

Typical examples of this type of piping penetration include the low pressure safety injection lines and the high pressure safety injection lines.

The key characteristics of these classifications are summarized in Table 5.1-1.

Table 5.1-1
Comparison of Characteristics of Containment Flow Paths

Class	FLOW PATH			Closed System inside CTMT	Closed System outside CTMT	Seismic Qualified Piping	EXAMPLES
	CTMT/ RCS	Normal Operating Position of CIV	Post-Accident Position of CIV				
A1	CTMT	Note (Note 3)	Closed	No	(Notes 1)	(Note 1)	Containment vacuum relief, radiation monitor lines
A2	CTMT	Closed	Closed (Note 5)	No	(Note 1)	No	Station air and refueling cavity purification lines
B1	RCS	Open	Closed	N/A	Yes	Partial (Note 4)	CVCS Letdown line, SIT and RCS sample lines
B2	RCS	Closed	(Notes 1 & 2)	N/A	Yes	Yes	SDC Cooling suction lines, hot leg injection lines, SIT test lines
C	CTMT	Open	Closed	Yes	Yes	Partial (Note 4)	Non-essential Component cooling units
D	CTMT	Open	Open	No	Yes	Yes	Containment pressure sensor
E	CTMT & RCS	Closed (Note 7)	Open	(Note 6)	Yes	Yes	Containment sump isolation valve and LPSI/HPSI system isolation

Notes for Table 5.1-1:

1. Component specific.
2. SIT test lines will likely be closed during an accident, while SDC suction/discharge hotleg injection lines will be open.
3. Open or cycling conditions possible.
4. Piping from RCS to containment penetration is seismically qualified.
5. Open for cold shutdown/refueling.
6. Class E valves are used for accident mitigation. Water sources include RWST and Containment Sump.
7. Charging and emergency fan coolers that are also used for normal HVAC will have open CIVs during power operation.

5.2 Operating Experience

5.2.1 Preventive Maintenance

In light of the current 4 hour AOT, on-line scheduled preventive maintenance of CIVs is rare. A limited amount of surveillance testing is performed.

Maintenance activities associated with CIVs include:

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

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

5.2.2 Surveillance/Testing of CIVs

Testing of CIVs (Motor-operated valves, Air-operated valves and Check Valves) occurs as a result of post-maintenance testing and in-service inspections. The scope 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 (e.g. MOVAT testing). The extended AOT will increase the potential for on-line valve repair or repositioning.

5.2.3 Corrective Maintenance

Corrective maintenance for CIV involves valve repair. In practice, the term corrective maintenance is typically used for the repair of a valve resulting from an observable malfunction which may or may not compromise the ability of the affected CIV to perform its safety function. This terminology typically places corrective maintenance on CIVs 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.

In at least one case at a CE NSSS unit, the combination of on-line dynamic testing following corrective maintenance for such an MOV resulted in restoration of system OPERABILITY within only one hour of the expiration of a system 72 hour AOT. In another recent instance a Combustion Engineering PWR was required to shutdown due to the inability to repair an MOV in the required 72 hour completion time (Reference 5). These examples illustrate the need for a longer AOT.

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6.0 TECHNICAL JUSTIFICATION FOR CIV 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 9 for risk informed changes to Technical Specifications. The probabilistic risk assessment for this AOT extension is contained in Section 6.3, including consideration of risks of mode transition and plant shutdown.

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 commitment to Configuration Risk Management Program are provided in Sections 6.6 and 6.7, respectively.

6.1 Statement of Need

The OPERABILITY requirements for CIVs help ensure that 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), RCP seized rotor event, and a control element assembly ejection accident. 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.

Based on a review of the maintenance requirements on the CIVs for Combustion Engineering PWRs, it was determined that extending the AOT from the current 4 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 CIVs included within Condition A and C of the current Technical Specifications, with the exception of the containment sump isolation valves (for which the existing AOT will be retained).

6.2 Assessment of Deterministic Factors

Technical Specification 3.6.3 governs the time that CIVs may remain INOPERABLE for all plant operating modes above cold shutdown (Mode 5 in the STS and ISTS). Individually and in combination, the CIV 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-1432, Revision 1 Section 3.6.1). In developing proposed license amendments for extended opening of a CIV, a licensee must confirm that the action of locking open a subject CIV 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 CIV is discussed below for the various flowpath classes defined in Section 5.1.

Class A flowpath
The CIVs 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 CIVs associated with these flowpaths have the intended function to isolate in order to minimize the leakage of reactor coolant. For example, failure to isolate letdown will result in an additional RCS leakage. The letdown line has 3 valves capable of isolating the penetration (typically 3 AOVs). These valves each receive a signal to close on SIAS and CIAS. Therefore, the consequence of locking one of the letdown line CIVs 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 CIV or similar valve capable of system isolation is available to provide assurance of containment isolation following an accident.

Class C flowpaths
The CIVs 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
A class D piping penetration includes the containment pressure sensor. The CIVs associated with Class D containment piping penetrations are designed to be open during power operation and provide integral input to the Engineered Safety Features Actuation System (or Engineered Safeguards Control System). The CIVs 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 CIVs is not required.

Class E flowpaths

There are three types of Class E penetrations of interest: (1) Penetrations designed to provide safety injection to the RCS (2) penetrations designed to provide makeup flow to the RCS and (3) penetration designed to support post-accident heat removal. These penetrations are designed to be open in the event of accident. In some instances these CIVs are also open during power operation to perform normal operational functions. For these penetration flowpaths locking the CIV 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 CIVs that are actuated in an open position or receive a confirmatory open signal following the generation of an ESFAS are the ECCS isolation valves, CSS isolation valves, CIVs contained within the component cooling water system (CCWS) and the AFW isolation valves.

ECCS Isolation Valves

In the case of ECCS Safety Injection (SI) valves, unavailability of one SI injection flowpath (in addition to one which is assumed unavailable during a cold leg LOCA) 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). Furthermore, all CE PWRs with the exception of Palo Verde are also equipped with emergency containment fan cooler units which provide a diverse means of containment heat removal.

Cooling Water Isolation Valves for the Containment Fan Cooler Units (CFCUs)

Inability of the cooling water isolation valves of the CFCUs to open will disable one train of containment fan coolers. As discussed above, the loss of a single CFCU will result in marginal impact on containment heat removal since redundant CFCUs are available and CHR may also be accomplished via use of the CSS.

AFW isolation valves

The operability issues associated with the AFW Isolation valves overlap with AFWS operability. CE Technical Specifications require AFW 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 feedwater line break or a steam generator tube rupture. Thus by extending the CIV AOT to 7 days, the limiting LCO associated with the CIV in the open position will become the one associated with the AFWS operability.

6.3 Assessment of Risk

6.3.1 Overview

The purpose of this section is to provide an integrated assessment of the overall plant risk associated with the adoption of the proposed AOT extension for the CIVs. The methodology used to evaluate the CIV AOT extension was based in part on the guidance provided in Regulatory Guide 1.174 (Reference 8) and Regulatory Guide 1.177 (Reference 9). 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 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 CIV AOT extension with respect to consideration of the associated "at power" risks only. Section 6.5 provides an estimate of the transition risk that would be incurred when a plant shutdown is required. As will be discussed in that section, transition risks arise as a consequence of mode changes. TS defined ACTIONS that require plant shutdown (e.g. entry into Mode 5) offset the risk associated with continued plant operation and repairing the component (in this case, a CIV) while the plant remains at power. In the case of CIV repair, for most CIVs repairing an INOPERABLE CIV (unable to close) while the valve is in the OPEN position would incur a very small increment in LERF. On the other hand, the transition risk associated with a short duration increases the plant core damage probability (as well as LERP) in the process shutting down the plant. Section 6.3.2 addresses only the incremental risks associated with continuing plant operation during repair of a CIV place in a position so as not to satisfy TS 3.6.3.

6.3.2 Assessment of "At Power" Risk

The CEOG has developed a process for evaluating plant risk associated with the proposed changes to the CIV Technical Specification 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 for the associated CIVs. 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 CIVs associated with a particular piping penetration is known. Typically this awareness of the CIV inoperability will develop as a consequence of inservice testing, (or other activity requiring cycling of CIVs. It is further assumed that an assessment is conducted to ensure the remaining CIV is operable [that is common cause failure mode is absent]). The "at power" risk caused by the inoperability of two CIVs 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 CIV AOT extension is provided in Section 6.3.2.1. The remaining sub-sections (i.e. 6.3.2.2 through 6.3.2.6) describe the classes of containment penetrations and estimate the plant risk associated with the generic configurations within each of the classes.

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 CIV AOT extension. The values used in the calculations are not plant specific and are intended to be bounding for the CEOG member utilities.

a. The CIV AOT is assumed to increase from its current duration of 4 hours to a proposed duration of 7 days (or 168 hours) for all CIVs with the exception of the ECCS sump CIV (which will be retained at its current value).

b. The duration of the proposed CIV AOT is assumed to be adequate for performing the majority of CIV on-line maintenance. Consequently, shutting down the plant due to the inoperability of a single CIV 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 CT for CIV TS Action statement is assumed to be negligible. The modification of the CIV Technical Specification is applicable for on-line maintenance only.

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 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 CIV 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 the various CEOG 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
Total core damage frequency [per year]	2.00E-4	Bounding value based on most limiting CEOG plant CDF value includes internal fire, seismic and external events.
Large early release frequency [per year]	5.7E-6	Bounding value based on most limiting CEOG plant (Reference 16)
Conditional core damage probability due to SLOCA	3.75E-3	Bounding value - See Table 6.3-2
Conditional core damage probability due to reactor trip	6.08E-6	Bounding value - See Table 6.3-2
Conditional core damage probability due to SGTR	9.16E-4	Bounding value - See Table 6.3-2
Core damage frequency due to seismic event [per year]	1.75E-5	Bounding value based on most limiting CEOG plant Seismic CDF (Reference 19)

Note for Table 6.3-1

1. Conditional core damage probability is defined as the ratio of the core damage frequency for the initiator of concern and the initiating event frequency.

Table 6.3-2
Comparison of Key Risk Parameters

Risk Parameter	CEOG Plants									
	ANO-2	CC	FCS	MP2	PAL	PVNGS	SONGS	SL1	SL2	WSES
Core damage frequency [per year]	2.08E-5	**2.00E-4**	1.40E-5	3.42E-5	5.15E-5	5.10E-5	1.88E-5	1.33E-5	1.20E-5	1.69E-5
Conditional core damage probability due to SLOCA	3.42E-4	**3.75E-3**	1.02E-3	7.24E-4	2.48E-3	5.79E-4	2.90E-3	3.94E-4	5.20E-4	7.63E-4
Conditional core damage probability due to reactor trip	2.95E-6	**6.08E-6**	5.00E-7	1.61E-6	2.16E-6	2.37E-6	3.42E-7	1.46E-7	7.29E-7	7.08E-8
Conditional core damage probability due to SGTR	9.73E-6	**9.16E-4**	7.38E-6	2.37E-5	3.55E-5	6.52E-5	7.40E-5	8.44E-5	9.19E-5	9.70E-5
Core damage frequency due to seismic event [per year]	N/A	1.50E-5	N/A	N/A	8.88E-6	N/A	**1.75E-5**	N/A	N/A	N/A
Large early release frequency [per year]	2.00E-6	(Note 4)	2.00E-6	2.83E-7	5.00E-6	2.13E-6	4.30E-7	2.90E-6	**3.80E-6**	1.80E-6

Notes for Table 6.3-2

1. Conditional core damage probability is defined as the ratio of the core damage frequency for the initiator of concern and the initiating event frequency.
2. Bounding values for the CEOG utilities are shown in bold face type.
3. Seismic CDF quantification was not performed.
4. LERF is not current available.

f. The inoperability of one CIV associated with a particular piping penetration is assumed to be detected during surveillance or cycling of the affected valve. The affected CIV 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 CIV is assumed to be evaluated to ensure that it is OPERABLE.

g. The inoperability of both CIVs 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 RCS, 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 RCS pressure. Failure is assumed to occur immediately upon exposure to RCS pressure during power operation. Once the pipe rupture occurs, RCS inventory is lost outside the containment and core damage eventually occurs.

i. It is assumed that the probability of an AOV failing to remain closed during the proposed AOT is 2.3E-3 (See assumption k). This is based on a failure rate of 1.36E-5 per hour (Reference 10) for spurious transfer opening of the AOV and an exposure time of 7 days (or 168 hours).

j. For the majority of CE PWRs, containment penetrations designed to close automatically by an engineering safeguard signal and are not needed to support any of the safety functions following an accident are typically equipped with AOVs. These CIVs are designed to fail in a safe state (i.e. closed) so that isolation of the associated containment penetration can be accomplished. Closure of the automatically actuated AOVs also occurs following loss of motive or control power to the valve actuator.

k. Based on information provided in Reference 10, the probability of an AOV failing to operate (i.e. closed) is 1.55E-3 per demand. This reference also indicates that the failure rate of an AOV spuriously transferring open is 1.36E-5 per hour. The probability of a normally closed AOV transferring open during the proposed AOT of 7 days (or 168 hours) is therefore estimated as 2.3E-3. (See assumption i)

l. Non-seismically induced pipe failures are assumed to occur randomly in time. A random pipe failure rate of 1.17E-9 per section-hour (Reference 11) is assumed. It is also assumed that there are approximately 100 sections included in the run of piping under consideration. Based on the number of pipe sections, the estimated frequency of a random pipe failure is 1.17E-7 per hour (or 1.02E-3 per year). For conservatism, the failure frequency used in the calculations was increased by a factor of 5 (i.e. 5.0E-3 per year).

The probability of a non-seismically induced pipe failure occurring during the proposed AOT is estimated as the product of the random failure rate and the duration of the AOT. For the proposed AOT duration of 7 days (or 168 hrs), the estimated probability is 1.0E-4. It is further assumed that both safety and non-safety grade piping have the same random pipe failure probability.

m. Piping that is not seismically qualified is assumed to fail during a seismic event.

n. Due to the bounding nature of the calculations provided herein, the increase in a CIV 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 based on results of representative plant evaluations.

As discussed in Section 6.3.1 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 CIVs contained within Class A containment piping is to maintain containment isolation following the receipt of a CIAS or SIAS. 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 CIVs 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 on both sides of the containment are also included in this class of containment penetration. Depending on the function of the penetration, the associated CIVs 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.

- Penetrations Connected Directly to Containment Atmosphere and Outside Environment
- Penetrations Connected Directly to Containment Atmosphere and a Closed Loop System outside Containment
- Penetrations Connected to Containment Atmosphere and an Open Loop System Outside Containment
- Penetrations Connected to a Closed Loop System Inside and Outside the Containment

The above configurations for Class A containment piping penetration are described in subsections 6.3.2.2.1 through 6.3.2.2.4.

6.3.2.2.1 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 CIVs for the penetration are the only barriers between the containment atmosphere and the environment. This configuration is generally used for venting the containment atmosphere or containment pressure relief. The associated piping downstream of the CIV outside containment is typically not seismically qualified. A typical schematic for this configuration is shown in Figure 1. As shown, the penetration is equipped with two CIVs, one on either side of the containment. The valves are shown in the closed position during normal power operation. The failure of both CIVs to remain closed if initially closed or failure of both CIVs 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 CIVs are either (a) normally locked closed in MODES 1 through 4, or (b) designed to close automatically following a design basis event. This is accomplished by the generation of a safeguard signal such as Containment Isolation Actuation Signal (CIAS) or Ventilation Isolation Actuation Signal (VIAS). Closure of the automatically actuated CIVs also occurs automatically following the loss of motive or control power to the valve actuator.

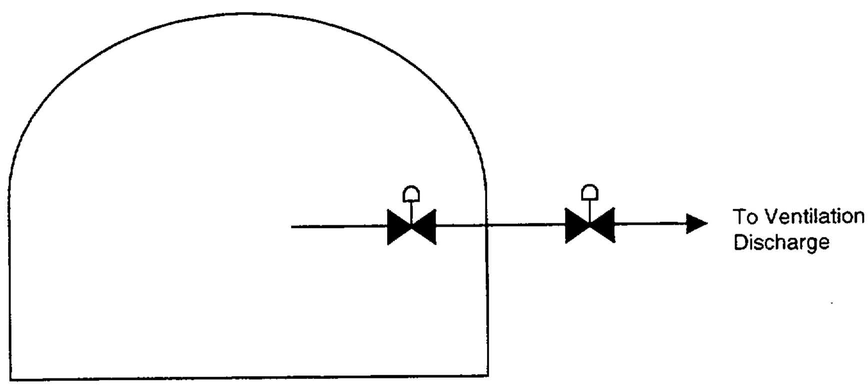

Figure 1
Schematic of Penetration Connected Directly to Containment Atmosphere and Outside Environment

The CIVs 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. The inoperability of any CIV, 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 CIVs following a design basis event will satisfy the containment isolation function. An inoperable and open CIV 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 CIVs.

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed AOT for the CIVs.

a. The CIVs are normally closed, as shown in Figure 1, and are cycled during MODES 1, 2, 3 and 4 in order to accomplish their required in-service testing or design function. Surveillance of the CIVs is assumed on a periodic basis. The inoperability of one CIV is assumed to be detected during periodic surveillance or cycling of the valve.

b. The inoperable CIV is in the open position. Thus for this configuration of containment penetration, the "OPERABLE" CIV 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" CIV 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 CIV 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 CIV AOT.

$$ICLERP = (CDF_T - CDF_{BY})\, P_{FRC} \left[\frac{AOT}{8760}\right] \qquad (6\text{-}1)$$

where,

ICLERP	=	the incremental large early release probability
CDF_T	=	the total average core damage frequency [2.00E-4 per year - Section 6.3.2.1(e)]
CDF_{BY}	=	the core damage frequency (per year) due to bypass events [0.0 - Section 6.3.2.1(d)]
P_{FRC}	=	the probability of failing to isolate the containment penetration by crediting the unaffected CIV [2.3E-3 - Section 6.3.2.1 (k)]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values in Equation 6-1 yields:

$$ICLERP = [2.00E-4 - 0.0] * [2.3E-3] * [168 / 8760]$$

$$= 8.82E-9$$

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

6.3.2.2.2 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 CIVs 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. This configuration is generally used for monitoring or processing containment atmosphere (i.e. radiation monitoring or hydrogen analysis). 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 2.

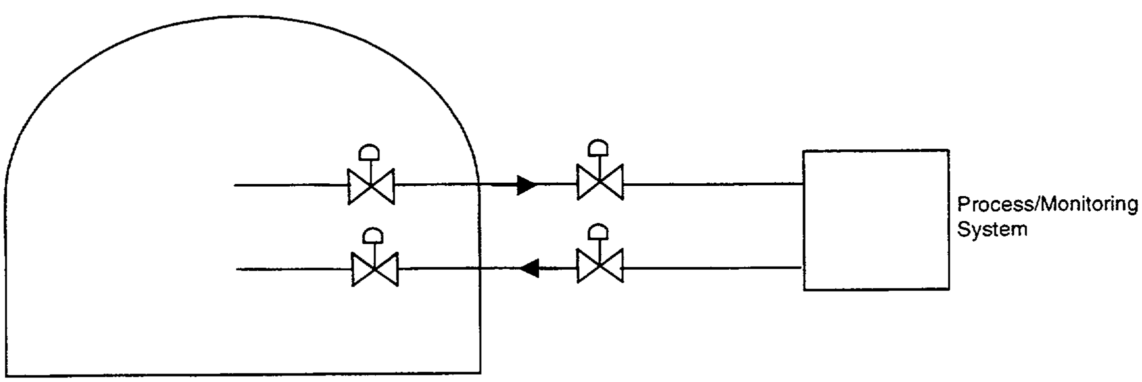

Figure 2
Schematic of Penetration Connected Directly to Containment Atmosphere and a Closed Loop System

As shown in Figure 2, the penetration is equipped with two CIVs, one on either side of the containment. A survey of this configuration for the CEOG members show that the associated penetration may be equipped with either AOVs or solenoid-operated valves. 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 CIVs are designed to close automatically following a design basis event. This is accomplished by the generation of a safeguard signal such as CIAS. Closure of the CIVs can be overridden if post-accident monitoring or sampling is required.

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed AOT for the CIVs.

a. The CIVs are normally open, as shown in Figure 2, 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 CIV is assumed to be detected during periodic surveillance or cycling of the valves. The inoperable CIV is secured in the open position. For this configuration, the unaffected CIV is available for isolating the containment penetration.

c. Since the penetration may be equipped with either AOVs or solenoid-operated valves, the valve type associated with the more conservative failure probability was assumed and used in the calculation. The probability includes failure of the valve to close on demand and failure of the valve to remain closed during the AOT. Based on information provided in Reference 10, the overall failure probability of an AOV (i.e. 3.85E-3) is more conservative as shown below and is therefore used in the assessment.

	Air Operated Valve	Solenoid Operated Valve
Failure to close on demand	1.55×10^{-3}	2.05×10^{-3}
Failure to operate during AOT (i.e. 7 days)	2.30×10^{-3}	2.82×10^{-4}
Overall failure probability	3.85×10^{-3}	2.33×10^{-3}

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

e. The conditional failure probability for non-seismically qualified piping is assumed to be 1.0 following a seismic event.

6.3.2.2.2.1 Impact on CDF/ICCDP

The CIVs 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 CIV for this penetration, causing the affected valve to be secured in the open or closed, will have no impact on CDF.

6.3.2.2.2.2 Impact on LERF/ICLERP

Closure of at least one of the CIVs will satisfy the containment isolation function. An inoperable and open CIV 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 CIVs. Since one of the CIVs is secured open, failure of the remaining operable CIV 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 CIV AOT.

$$ICLERP = (CDF_T - CDF_{BY})\, P_{FTC}\, P_B \left[\frac{AOT}{8760}\right] \qquad (6\text{-}2)$$

where,

ICLERP	=	the incremental large early release probability
CDF_T	=	the total average core damage frequency [2.00E-4 per year - Section 6.3.2.1(e)] (assumed non-seismic CDF)
CDF_{BY}	=	the core damage frequency (per year) due to bypass events [0.0 - Section 6.3.2.1(d)]
P_{FTC}	=	the conditional probability of failing to isolate the containment penetration by crediting the operable CIV [3.85E-3 - Assumption /Input (c)]
P_B	=	the probability of a pipe failure in the closed loop system outside the containment with seismically qualified piping [1.0E-4 - Section 6.3.2.1 (l)]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values into Equation 6-2 yields:

ICLERP = [2.00E-4 – 0.0] * [3.85E-3] * [1.0E-4] * [168 / 8760]

= 1.48E-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 6-2 to reflect a seismically initiated event. This is accomplished by replacing the value of CDF_T with a value of 1.75E-5 for the yearly core damage frequency due to a seismic event, CDF_{SEIS}. The conditional pipe failure probability is also replaced with a value of 1.0. After making the substitutions in Equation 6-2, the estimated ICLERP due to seismic event is 1.29E-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 CIV AOT extension is significantly below the acceptance criterion value of 5.0E-8.

6.3.2.2.3 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 CIVs 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. This configuration is generally used to provide inlet flow of fluids needed to support equipment operability inside the containment. Such fluids include primary makeup or demineralized makeup water, station or instrument air, and refueling cavity purification makeup. A typical schematic of this configuration is shown in Figure 3. As shown, the penetration is equipped with one check valve that provides the containment isolation function inside the containment and one AOV that provide the containment isolation function outside the containment. The CIVs for this configuration are shown in the closed position during normal power operation.

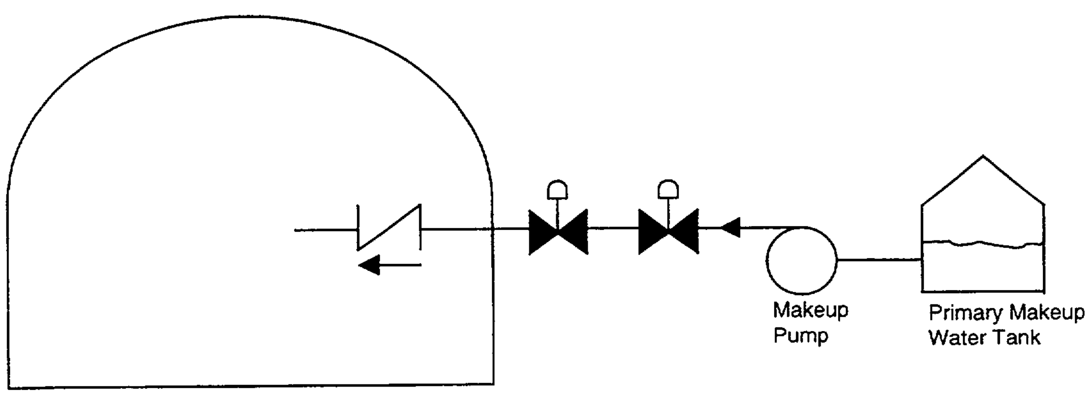

Figure 3
Schematic of Penetration Connected to Containment Atmosphere and an Open Loop System

Therefore, the CIV outside the containment is designed to close automatically by CIAS 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 provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed AOT for the CIVs.

a. For this configuration, it is assumed that the penetration is equipped with one check valve inside the containment and one AOV outside the containment. Based on the information provided in Reference 10, the mean probability of a check valve failing to close is 1.52E-3 per demand.

b. The inoperability of the AOV outside containment is assumed to be detected during cycling or surveillance of the valve. The inoperable AOV is in the open position and the check 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 upstream of the outside CIV.

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 CIVs 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 AOV (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 check valve will satisfy the containment isolation function. Securing the inoperable AOV 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 ICLERP due to the proposed AOT for the CIVs. Since the AOV is secured open, a failure of the check 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.

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

$$ICLERP = \left(CDF_T - CDF_{BY}\right) P_{CK}\ P_B \left[\frac{AOT}{8760}\right] \quad \text{(non-seismic events)} \qquad (6\text{-}3)$$

where,

ICLERP	=	the incremental large early release probability
CDF_T	=	the total average core damage frequency [2.00E-4 per year - Section 6.3.2.1(e)] (for non-seismic events)
CDF_{BY}	=	the core damage frequency (per year) due to bypass events [0.0 - Section 6.3.2.1(d)]
P_{CK}	=	the probability of a check valve failing to isolate the associated containment penetration [1.52E-3 - Assumption /Input (a)]
P_B	=	the probability of a pipe failure in the open loop system outside the containment [1.0E-4 - Section 6.3.2.1 (l)]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values into Equation 6-3 yields:

ICLERP = [2.00E-4 – 0.0] * [1.52E-3] * [1.0E-4] * [168 / 8760]

= 5.83E-13

The impact on LERF can be assessed for a seismic event by substituting the appropriate values in Equation 6-3. This is accomplished by replacing the value of CDF_T with a value of 1.75E-5 for the yearly core damage frequency due to a seismic event, CDF_{SEIS}. The conditional pipe failure probability is also replaced with a value of 1.0. After making the substitutions in Equation 6-3, the estimated ICLERP due to seismic event is 5.10E-10.

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 CIV AOT extension is significantly below the acceptance criterion value of 5.0E-8.

6.3.2.2.4 Penetrations Connected to Closed Loop System Inside and Outside Containment

This generic configuration for Class A penetrations describes the containment penetrations that are connected to closed loop piping inside and outside the containment. The closed loop system and the CIVs 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 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 (i.e. RCP seal coolers) or for the containment atmosphere (i.e. non-essential air cooling units) during normal power operation. A typical schematic for this configuration is shown in Figure 4.

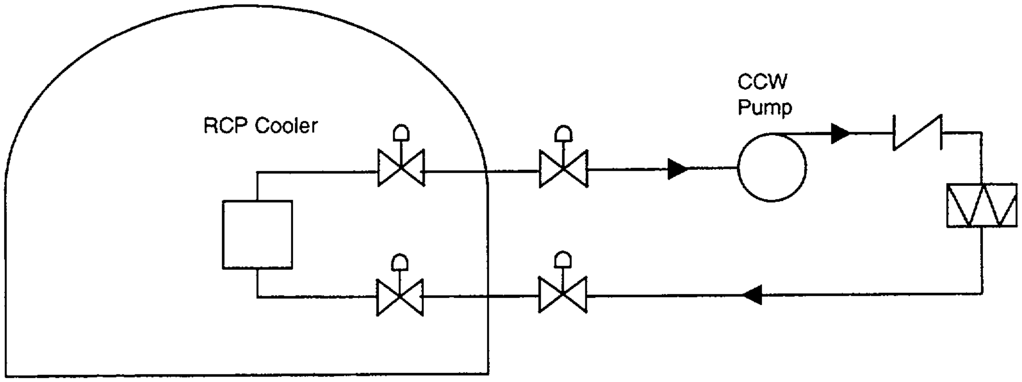

Figure 4
Schematic of Penetration Connected to Closed Loop Inside and Outside Containment

As shown in Figure 4, the penetration is equipped with two CIVs, one AOV on either side of the containment. The valves are shown in the open position during normal power operation. The flow of cooling water through the penetrations for this configuration is not required to accomplish or support any of the safety functions for preventing core damage. Therefore, the CIVs for this configuration are designed to close automatically by CIAS following a design basis event.

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed AOT.

a. The inoperability of one of the CIVs is assumed to be detected during surveillance of the valves. The inoperable AOV is secured in the open position and the remaining CIV 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. Because the associated piping for the penetration is connected to a closed loop system, pressure relief (i.e. relief valve) protection is provided outside the containment. In addition to a pipe failure, inadvertent opening of a relief valve will also breach the closed loop system outside the containment. An estimated probability of 5.0E-4 is assumed and used for inadvertent opening of a relief valve within the proposed AOT of 168 hours. The probability value is based on a mean failure rate of 2.43E-6 per hour (Reference 10) for inadvertent opening of a relief valve and the AOT. [The product of these values (i.e. 4.08E-4 = 2.43E-6 * 168) was rounded up to 5.0E-4.]

e. The AOV failure probaiblity includes failure of the valve to close on damand or failure of the valve to remain closed during the AOT. Based on information provided in Reference 10, the overall failure probability is 3.85E-3 [see Sections 6.3.2.1(i) and 6.3.2.1(k)].

6.3.2.2.4.1 Impact on CDF/ICCDP

The CIVs for this configuration are generally not included in the PSA model(s) used for estimating CDF because the cooling water is used to remove heat from non-essential equipment, which is not needed for core damage mitigation. The inoperability of one of the AOVs, causing the affected valve to be secured in the open position, will have no impact on CDF.

6.3.2.2.4.2 Impact on LERF/ICLERP

Securing the inoperable AOV 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 ICLERP due to the proposed AOT for the CIVs.

Since the inoperable CIV is secured in the open position, a failure of the remaining CIV prevents the containment penetration from being isolated. Failure of the containment penetration must occur concurrent with a breach in the closed loop system inside and 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 CIV AOT for this configuration.

$$ICLERP = (CDF_T - CDF_{BY})\, P_{FTC}\; P_B\; P_{RV} \left[\frac{AOT}{8760}\right] \qquad (6\text{-}4)$$

where,

ICLERP	=	the incremental large early release probability
CDF_T	=	the total average core damage frequency [2.00E-4 per year - Section 6.3.2.1(e)]
CDF_{BY}	=	the core damage frequency (per year) due to bypass events [0.0 - Section 6.3.2.1(d)]
P_B	=	the probability of a pipe failure in the closed loop system inside the containment [1.0E-4 - Section 6.3.2.1 (l)]
P_{RV}	=	the probability of inadvertent opening of a relief valve [5.0E-4 - Assumption/Input (d) above] or the probability of pipe failure outside containment [1.0E-4 –Section 6.3.2.1 (l)]. This results in a value of 6.0E-4.
P_{FTC}	=	the conditional probability of failing to isolate the containment penetration by crediting the operable CIV [3.85E-3 - Assumption /Input (e)]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values into Equation 6-4 (not crediting the conditional probability for isolating the containment penetration, P_{FTC}) yields:

$$ICLERP = [2.00E\text{-}4 - 0.0] * [3.85E\text{-}3] * [1.0E\text{-}4] * [6.0E\text{-}4] * [168 / 8760]$$

$$<< 2. E\text{-}13$$

The impact on LERF can be assessed for a seismic event by substituting the appropriate values in Equation 6-4. This is accomplished by replacing the value of CDF_T with a value of 1.75E-5 for the yearly core damage frequency due to a seismic event, CDF_{SEIS}. The piping in the closed loop system for this configuration is non-seismically qualified. The conditional pipe failure probability (for both inside and outside the containment) is also replaced with a value of 1.0. After making the substitutions in Equation 6-4, the estimated ICLERP due to seismic event is 1.29E-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 CIV AOT extension is significantly below the acceptance criterion 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 are generally not required or needed to accomplish or support any of the safety functions. The CIV for this type of penetration and the associating piping represent the barriers between the reactor coolant and the reactor coolant exposed systems outside the containment. The reactor exposed systems include Chemical and Volume Control, Safety Injection, Shutdown Cooling, and Sample systems. Depending on the function of the penetration, the associated CIVs 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 CIVs 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 three generic configurations for Class B piping penetrations were identified for the CE PWRs.

- Penetrations Connected to the Safety Injection Line Check Valve Leakage Path
- Penetrations Used to Obtain Samples from the RCS
- Penetrations Used to Provide RCS Letdown or Bleedoff Flow

The above configurations for Class B containment penetration are described in subsection 6.3.2.3.1 through 6.3.2.3.3.

6.3.2.3.1 Penetrations Connected to the SI Line Check Valve Leakage Path

This generic configuration concerns the containment penetration for the Safety Injection Tank (SIT) drain and test line that has a flow path to the Refueling Water Tank (RWT). In compliance with 10CFR General Design Criteria 55, this line includes an automatic actuated CIV inside containment and a normally locked-closed manual CIV outside containment. During normal operations at power, both of these CIVs are in the closed position. In addition to these CIVs, check valves in the passive injection line of each SIT provide additional barriers to an RCS leak path outside containment via the SIT drain and test line. Figure 5 provides a schematic of this typical penetration configuration.

In the event of the failure of each of these barriers during operations in any of operating Modes 1 through 4, the low pressure rated piping outside the containment would be exposed to the relatively higher pressures and temperatures of the reactor coolant.

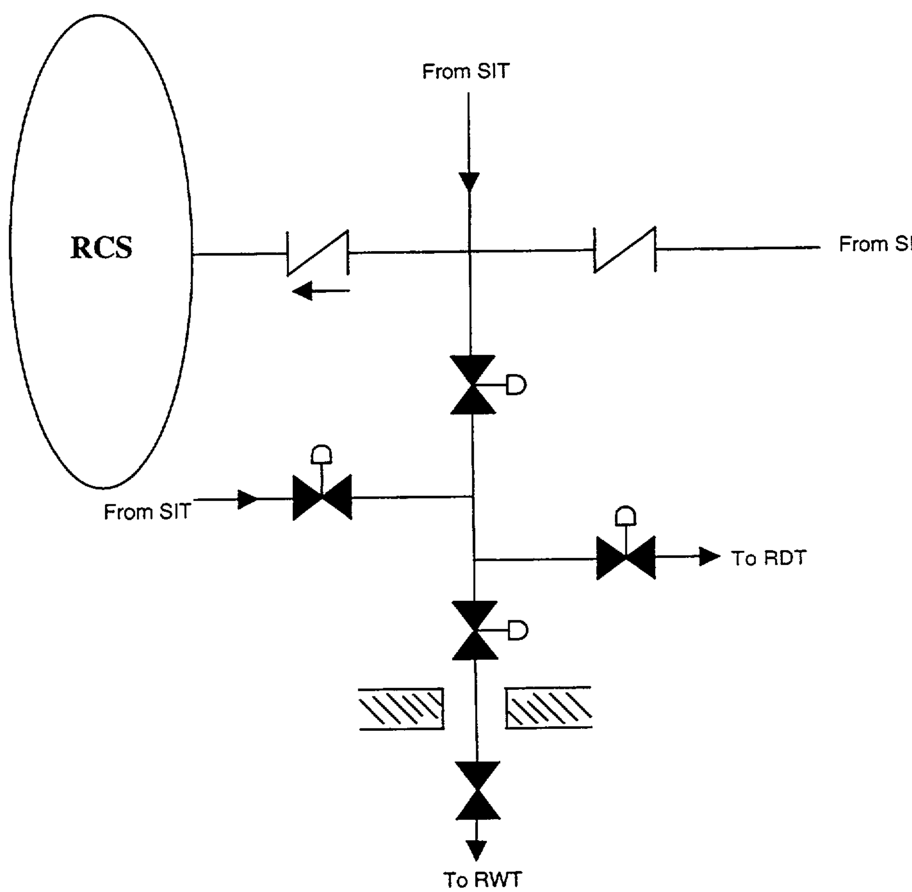

Figure 5
Schematic of Penetration Connected to SI Line Leakage Path

The CIVs for this configuration of Class B penetrations are usually considered in the identification of the various pathways that could lead to an interfacing system LOCA and the assessment of the associated frequencies of ISLOCA. Considering the pathway from the RCS to the low pressure piping outside the containment (See Figure 5), there are four barriers that must be breached before the low pressure piping can be exposed to normal operating conditions of the RCS. This pathway would most likely be screened from further evaluation because the failure of multiple barriers must occur. The frequency of such failures is an insignificant contributor to the overall ISLOCA frequency. The inoperability of the CIV (i.e. AOV) inside the containment, causing it to be secured in the open position, reduces the number of available barriers to guard against an ISLOCA. The reduction in barriers has the potential for impacting ISLOCA. The potential impact is assessed by estimating the ICLERP due to the proposed AOT for the CIVs.

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed extension AOT for the CIVs.

a. For this configuration, it is assumed that the penetration is equipped with one AOV located inside the containment and one manually operated valve located outside the containment. The inoperability of the AOV is assumed to be detected during cycling or surveillance of the valve. The inoperable AOV is secured in the open position and is not available to provide containment isolation during the proposed AOT. Containment isolation is provided by the manually-operated valve.

b. Based on the information provided in Reference 10, the mean failure rate of a manual valve transferring open is 1.92E-7 per hour (or 1.68E-3 per year). The failure mode involving a manual valve failing to properly reseat is not explicitly identified in Reference 10. It is therefore assumed that the probability this failure mode is bounded by the probability of failing to operate on demand (i.e. 3.88E-4 per demand).

c. It is assumed that there is an average of four in-service tests of the manual CIV per year for each of the CE PWRs.

d. Based on the information provided in Reference 10, the mean failure rate of an AOV transferring open is 7.98E-7 per hour (or 7.00E-3 per year). The failure mode involving an AOV failing to properly reseat is not explicitly identified in Reference 10. It is therefore assumed that the probability this failure mode is bounded by the probability of failing to operate on demand (i.e. 1.55E-3 per demand).

e. The AOV in the leakage path is assumed to be cycled in accordance with the plant's inservice testing program of once per quarter. This valve is therefore assumed to be operated four (4) times during the fault exposure time (see item h below).

f. The random leakage rate for the SI check valve is assumed to be 8.76E-4 per year (Reference 13).

g. The fault exposure time for the valves in this configuration is equivalent to time that the plant operates in its non-cold shutdown modes. For this configuration the fault exposure time is assumed to be one year.

h. A pressure transmitter is located upstream of the SI check valve. The effect of the transmitter is that a leaking (or stuck open) SI check valve would be detected followed by appropriate corrective action(s).

With the inoperable CIV inside the containment secured in the open position, there is one less barrier available to protect the low pressure piping from being exposed to high RCS pressure. The reduction in the number of barriers has the potential for impacting both CDF and LERF due to ISLOCA. The potential impact was assessed by estimating the ICCDP/ICLERP for this configuration of Class B penetrations.

The methodology described in Reference 13 was used to estimate the frequency for ISLOCA. By securing the CIV open, the configuration becomes a "three series valve system" to guard against an ISLOCA. No attempt was made in this report to develop the ISLOCA frequency expression for this system. Rather, the expressions already developed in Reference 13 were used, and the appropriate values were substituted in order to estimate the ISLOCA frequency. The expression for the average frequency of coincident failure of the SI check valve, the AOV, and the manually operated valve over time period T is as follows:

$$ISLOCA = \frac{\lambda_1 \lambda_2 \lambda_3 T^2}{3} + \lambda_1 \lambda_2 \lambda_{d3} T \left[\frac{d_3 T + 1}{2}\right] + \lambda_1 \lambda_{d2} \lambda_3 T \left[\frac{d_2 T + 1}{2}\right] + 2\lambda_1 \lambda_{d2} \lambda_{d3} \left[\frac{d_2 T + 1}{2}\right]\left[\frac{d_3 T + 1}{2}\right] \quad (6\text{-}5)$$

where,

ISLOCA	=	Frequency of ISLOCA (per year)
λ_1	=	Random leakage rate of SI check valve [8.76E-4 per year - Assumption (f) above]
λ_2	=	Random leakage rate of AOV [7.00E-3 per year - Assumption (d) above]
λ_3	=	Random leakage rate of manually-operated valve [1.68E-3 per year - Assumption (b) above]
λ_{d2}	=	The probability of the AOV failing to reseat [1.55E-3 per demand - Assumption (d) above]
λ_{d3}	=	The probability of the manually-operated valve failing to reseat [3.88E-4 per demand - Assumption (b) above]
d_2	=	The number of times the AOV is operated [4 - Assumption (e) above]
d_3	=	The number of times the manually-operated valve is operated [4 - Assumption (c) above]
T	=	Fault exposure time [1 year - Assumption (g) above]

By crediting the pressure transmitter in the SI line, the terms in Equation 19 of Reference 13 involving failure of the SI check valve to reseat were eliminated because they are no longer applicable. The elimination of these terms is reflected in Equation 6-5. The first term on the right of Equation 6-5 represents random leakage of all three valves during the fault exposure time. The second term in the equation represents random leakage of the SI check valve and the

AOV concurrent with failure of the manually operated valve to reseat after opening. The third term in the equation represents random leakage of the SI check valve and the manually operated valve concurrent with failure of the AOV to reseat after opening. The fourth term represents random leakage of the SI check valve and failure of both the AOV and manually operated valves to reseat after opening.

Substituting the above values in Equation 6-5 yields:

ISLOCA = 2.17E-08 per year

Based on the above ISLOCA frequency, the incremental conditional core damage probability or incremental conditional large early release probability is estimated based on a 168 hours exposure (one AOT) as follows:

$$ICCDP = ICLERP = ISLOCA \left[\frac{AOT}{8760}\right]$$

$$= 2.17E-08 \left[\frac{168}{8760}\right]$$

$$= 4.16E-10$$

The calculated conditional probabilities indicate that the level of risk associated with the configuration for Class B penetrations due to the proposed CIV AOT extension is significantly lower than the acceptance criteria of 5.0E-7 and 5.0E-8 for ICCDP and ICLERP, respectively.

6.3.2.3.2 Penetrations Connected to the RCS Sample System

This generic configuration for Class B penetrations represents the containment penetrations with associated piping connected to the RCS and the sample system. This penetration is used to obtain samples from various locations in the RCS. Sampling of the RCS 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 are relatively small (i.e. less than 1" nominal diameter). Equipment is provided in the sample system for reducing the RCS temperature and pressure before the sample is processed. A typical schematic for this configuration is shown in Figure 6. As shown, the penetration is equipped with two CIVs for providing the isolation function. One CIV is located inside the containment and the other CIV is located outside the containment. Sampling of the RCS 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 CIVs are designed to close automatically following a design basis event. This is accomplished by the generation of CIAS. Closure of the CIVs also occurs automatically following the loss of motive or control power to the valve actuator.

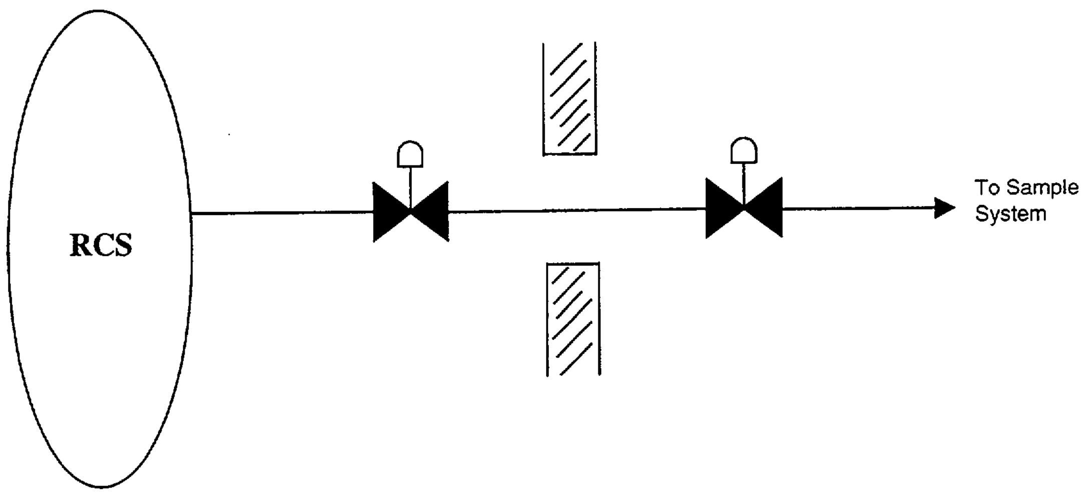

Figure 6
Schematic of Penetration Connected to RCS Sample Line

The CIVs 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. The inoperability of any of the CIVs, causing the affected valve to be secured in the closed position, may impact CDF. Closure of at least one CIV will satisfy the containment isolation function. An inoperable and open CIV 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 CIVs.

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the ICLERP.

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

b. The CIVs 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 CIV failing to remain closed during the proposed AOT is more conservative than the probability of a CIV failing to close on demand.

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

d. A consequential pipe failure in the sample system due to the exposure to high RCS temperature and pressure is assumed to be negligible. Equipment is provided in the sample system for reducing the RCS 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 charging system or the emergency core cooling system. Plant shutdown is assumed to occur before the inventory in the RWT (SIRWT) is depleted. The discharge of reactor coolant through the break will not lead to core damage by itself.

The inoperability of one of the CIVs may impact CDF. The inoperable CIV 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 CIV 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" CIV 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 very small LOCA, which can be mitigated by the ECCS and in some instances, the charging 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.

$$ICCDP = ICLERP = (CCDP)_{SL}\ F_P\ P_{FRC}\left[\frac{AOT}{8760}\right] \qquad (6\text{-}6)$$

where,

ICCDP	=	the incremental conditional core damage probability
ICLERP	=	the incremental conditional large early release probability
$CCDP_{SL}$	=	the total conditional core damage probability given a small LOCA [3.75E-3 - Section 6.3.2.1(e)]
F_P	=	the frequency of a random pipe failure occurring in the sample system creates a small LOCA [5.0E-3 - Section 6.3.2.1 (l)]
P_{FRC}	=	the probability of the operable CIV failing to remain closed during the proposed AOT [2.3E-3 - Section 6.3.2.1 (k)]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values in Equation 6-6 yields:

$$ICCDP = ICLERP = [3.75E-3] * [5.0E-3] * [2.3E-3] * [168 / 8760]$$

$$= 8.27E-10$$

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 6-6.

This is accomplished by replacing the product of $CCDP_{SL}$ and F_P with the frequency of a seismic induced small LOCA. As indicated in Table 6.3-2, the CDF due to a seismic event at San Onofre was used as the bounding value in the calculations. Based on the information provided in Table 3.6-7 of the San Onofre IPEEE (Reference 19), the frequency of a seismic induced small LOCA is 1.49E-5 per year. After making the substitutions in Equation 6-6, the estimated incremental probability for both core damage and large early release is 6.57E-10.

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

6.3.2.3.3. Penetrations Connected to the Letdown or RCP Bleedoff Lines

This generic configuration for Class B penetrations represents the containment penetrations with associated piping connected to the RCS and the CVCS to provide letdown or bleedoff from the reactor coolant pumps. A small portion of reactor coolant is diverted to the CVCS for processing in order to remove suspended solids and impurities from the coolant. Bleedoff from the reactor coolant pumps is also diverted to the CVCS to minimize the amount of makeup required for the RCS. Continuous letdown and bleedoff flow is provided during normal power operation. The RCS temperature and pressure is reduced to prevent the relatively low pressure and temperature components of the CVCS from being exposed to normal operating temperature and pressure of the RCS. The nominal pipe size for the letdown line is two inches, which is much larger than the nominal pipe size for the bleedoff line (i.e. 3/4 of an inch). Isolation failure of the larger piping penetration is bounding and is assessed for this configuration. A typical schematic for this configuration is shown in Figure 7. As shown, the flow path is equipped with three valves. Two of the valves are located inside the containment, one upstream and the other downstream of the regenerative heat exchanger. Both valves provide a redundant means of providing inside containment isolation. The third valve is located outside the containment. These valves are normally open during normal power operation and may not be closed for an extended period without forcing a plant shutdown. Closure of any of these valves for an extended period will terminate letdown flow and force a plant shutdown. The valves are closed automatically by CIAS or SIAS following a design basis event to terminate the flow of reactor coolant outside the containment following the associated design basis events.

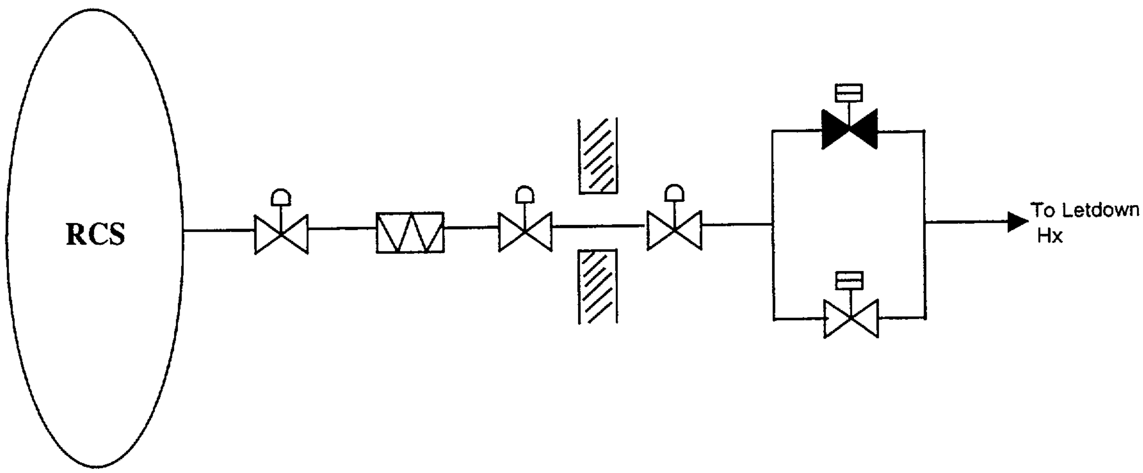

Figure 7
Schematic of Penetration Connected to Letdown Line

The valves for this configuration are generally not included in the PSA model(s) used for estimating CDF because letdown flow is not required or needed for core damage mitigation. Because letdown flow is continuous during normal power operation, a breach in the letdown line will initiate a plant response similar to a small LOCA. Two pipe break locations in the letdown line, which are not included as part of the typical small LOCA event, are examined. The first location involves a break inside the containment between the two valves, and the second location involves a break downstream of the CIV outside the containment.

In assessing the impact of the break locations, the following configuration specific assumptions/ input were made in addition to those identified in Section 6.3.2.1.

a. For this configuration, it is assumed that all three valves are AOVs. These valves are designed to close automatically upon the generation of either SIAS or CIAS. Based on the information provided in Reference 10, the mean probability of an AOV failing to close is 1.55E-3.

b. It is assumed that failure of the actuation signal to close the AOV is a negligible contributor to the overall failure probability of the valve when compared with contributions from hardware failures. The actuation signal to close the valve is generated automatically by the Engineered Safety Features Actuation System. Manual actuation of the signal is included as a backup if automatic actuation of the signal should fail.

c. The inoperability of one CIV is assumed to be detected, thus resulting in the affected valve being secured in the open position. The two remaining valves are available for isolating the containment penetration to prevent the flow reactor coolant outside the containment.

d. A break is assumed to occur in the piping located between the two valves inside the containment. The CIV immediately downstream of the regenerative heat exchanger is assumed to be inoperable and secured in the open position. The inoperable CIV is unavailable for isolating the containment penetration.

e. A breach in the letdown line outside the containment is assumed to occur downstream of the CIV located outside the containment. The breach may result from a random pipe failure or inadvertent opening of a relief valve during the proposed AOT. The mean failure rate for inadvertent opening of a relief valve is 2.13E-2 per year (or 2.43E-6 per hour) (Reference 10). When combined with the random frequency of a pipe failure, the overall frequency of breaching the letdown line outside the containment is 2.63E-2 per year.

f. The probability that both CIVs fail to close is dominated by common cause failure of these valves. The probability is estimated as the product of the demand failure probability and the common cause beta factor. The probability that the valve fails to close is 1.55E-3 [see item (a) above], and the beta factor is 0.1 (Reference 14) is assumed and used. This common cause beta factor is considered to be very conservative. The product of these two numbers yields a common cause probability of 1.55E-4.

The impact of a postulated break inside or outside the containment is assessed below.

Break Inside Containment

A pipe break that occurs between the two valves inside the containment will initiate a loss of reactor coolant and a plant response similar to a small LOCA event. The lost coolant collects in the containment sump and is available for long term heat removal. A break in this location can be mitigated by closing the upstream valve or by making up the lost reactor coolant via the ECCS. Failure to mitigate this event would eventually lead to core damage. The following expression is therefore used to estimate the incremental increase in core damage probability.

$$ICCDP = F_P\,(CCDP)_{SL}\;P_{FTC}\left[\frac{AOT}{8760}\right] \tag{6-7}$$

where,

ICCDP	=	the incremental conditional core damage probability
$CCDP_{SL}$	=	the total average core damage probability [3.75E-3 - Section 6.3.2.1(e)]
F_P	=	the frequency of a random pipe failure occurring in the letdown line [5.00E-3 per year - Section 6.3.2.1 (l)]
P_{FTC}	=	the probability of the operable CIV failing to close [1.55E-3 - Section 6.3.2.1 (k)]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values in Equation 6-7 yields:

$$ICCDP = [5.0E\text{-}3] * [1.55E\text{-}3] * [3.75E\text{-}3] * [168 / 8760]$$

$$= 5.57E\text{-}10$$

The incremental increase in conditional core damage probability would also lead to an incremental increase in large early release probability. Since the CIV that is closest to the inside containment is assumed to be in the open position, the outside CIV is the only valve that is relied on for isolating the containment penetration. Other letdown valves (i.e. the letdown control valves) may be used to isolate the path. Credit for such valves is not included in the calculation. The following expression is used to bound the estimated probability for large early releases.

$$ICLERP = ICCDP\ P_{FTC}$$

$$= (5.57E\text{-}10)\ (1.55E\text{-}3)$$

$$= 8.63E\text{-}13$$

Break Outside Containment

A breach that occurs downstream of the CIV outside the containment will cause a loss of reactor coolant, and a plant response similar to a small LOCA event will be initiated. The lost coolant will not be available for long term RCS inventory control and heat removal. A breach in this location can be mitigated by closing the operable valves. Failure to mitigate this event will eventually lead to an ISLOCA. The following expression is used for estimating the ICCDP or ICLERP due to the proposed AOT for the CIVs.

$$ICCDP = ICLERP = F_P\ P_S \left[\frac{AOT}{8760}\right] \quad (6\text{-}8)$$

where,

- ICCDP = the incremental conditional core damage probability
- ICLERP = the incremental conditional large early release probability
- F_P = the frequency of breaching the letdown line outside the containment [2.63E-3 per year - Assumption (e) above]
- P_S = the probability of both CIVs failing to close [1.55E-4 - Assumption (f) above]
- AOT = the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values in Equation 6-8 yields:

$$ICCDP = ICLERP = [2.63E\text{-}3] * [1.55E\text{-}4] * [168 / 8760]$$

$$= 7.82E\text{-}09$$

For the two break locations considered, the calculated incremental conditional probabilities for core damage and large early release indicate that the level of risk due to the proposed CIV AOT extension is below the acceptance criteria of 5.0E-7 and 5.0E-8, respectively.

6.3.2.4 Risk Assessment of AOT Extension for Class C Containment Penetrations

A Class C containment penetration is connected to a seismically qualified closed loop piping inside the containment. The closed loop system and the CIVs 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 included component cooling water, main steam, feedwater, and steam generator blowdown. Portions of the main steam and blowdown systems inside the containment are considered to be closed for all events except a main steam line break or a steam generator tube rupture. A forced plant shutdown usually occurs when a CIV associated with penetrations in the main steam and feedwater systems becomes inoperable. The proposed CIV AOT extension considered in this report is not applicable to CIVs 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 the CE PWRs.

- Penetrations Connected to the Non-Essential Containment Cooling Units
- Penetrations Connected to the Secondary Side of the Steam Generators

The above configurations for Class C containment penetrations are described below in subsections 6.3.2.4.1 and 6.3.2.4.2.

6.3.2.4.1 Penetrations Connected to Non-Essential Containment Cooling Units

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 during normal power operation. This configuration is equipped with two types of barriers between the containment atmosphere and the outside environment, at lease one active and one passive barrier. The closed loop piping inside the containment provides a passive barrier for the containment atmosphere, and the CIVs provide an active barrier. A typical schematic for this configuration is shown in Figure 8. As shown, the penetration is equipped with an AOV outside the containment. A manually operated valve is shown inside the containment. Both CIVs are shown in their open position during normal power operation. 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. At least one of the CIVs for this configuration is designed to close automatically by SIAS or CIAS following a design basis event.

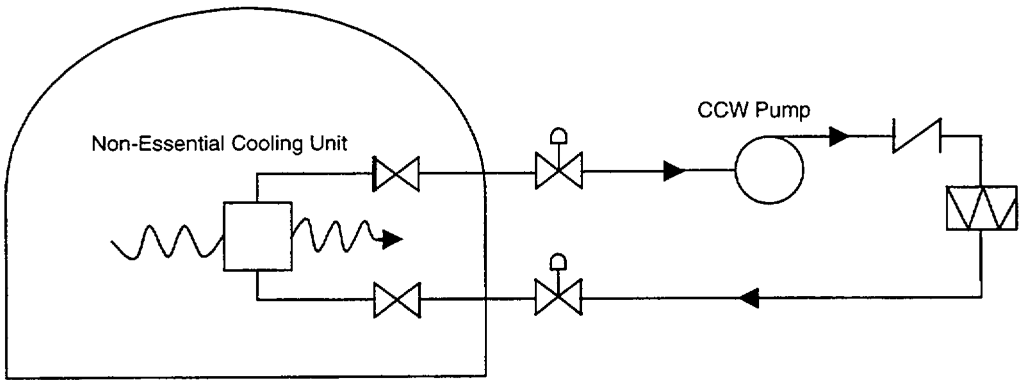

Figure 8
Schematic of Penetration Connected to Non-Essential Cooling Units

The CIVs for this configuration of Class C penetrations are generally not included in the PSA model(s) because the non-essential cooling units are not credited for core damage mitigation. The inoperability of any CIV, causing the affected valve to be secured in the open position, will have not impact on CDF. Securing the CIV 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 CIVs.

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed CIV AOT extension.

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

b. Pressure relief (i.e. relief valve) protection is provided for the closed loop system outside the containment. In addition to a pipe failure, inadvertent opening of a relief valve will also breach the closed loop system outside the containment. An estimated probability of 5.0E-4 is assumed and used for inadvertent opening of a relief valve within the proposed AOT of 168 hours. The probability is based on a mean failure rate of 2.43E-6 per hour (Reference 10) for inadvertent opening of a relief valve. The product of the failure rate and AOT (i.e. 4.08E-4 = 2.34E-6 * 168) was rounded up to 5.0E-4. The overall probability of 6.0E-4 for breaching the closed loop system outside the containment includes a pipe failure or inadvertent opening of a relief valve.

c. 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.

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 reactor trip. The breach may result from a random pipe failure or inadvertent opening of a relief valve during the proposed AOT. The mean failure rate for inadvertent opening of a relief valve is 2.13E-2 per year (or 2.43E-6 per hour) (Reference 10). When combined with the random frequency of a pipe failure, the overall frequency of breaching the line outside the containment is 2.63E-2 per year.

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 reactor 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.

$$ICCDP = F_P\,(CCDP)_T \left[\frac{AOT}{8760}\right] \qquad (6\text{-}9)$$

where,

ICCDP	=	the incremental conditional core damage probability
$CCDP_T$	=	the conditional core damage probability due to reactor trip [6.08E-6 - Section 6.3.2.1(e)]
F_P	=	the frequency of breaching a closed loop system outside the containment [2.63E-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 6-9 yields:

ICCDP = [2.63E-2] * [6.08E-6] * [168 / 8760]

= 3.07E-9

The impact on the large early release probability (i.e. ICLERP) caused by the impact on CCDP is estimated as the product of the incremental conditional core damage probability and the probability [i.e. 6.0E-4 - assumption (b) above] of breaching the closed loop outside the containment. The product of these probabilities yields a value of 1.84E-12 for ICLERP.

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

6.3.2.4.1.2 Impact on LERF/ICLERP

The calculations in Section 6.3.2.4.1.1 for this configuration consider the case involving a random pipe failure in the closed loop system occurring within the AOT and causing a reactor trip. In the calculations that follows, 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 CIV is secured in the open position and has no impact on CDF. When the CIV is in the open position it becomes unavailable for isolating the containment penetration. A pathway from the containment atmosphere to the environment is established if the breach occurs in the closed loop system both inside and outside the containment. The following expression is therefore used to estimate the impact on the probability of large early release.

$$ICLERP = (CDF_T - CDF_{BY})\, P_F \; P_B \left[\frac{AOT}{8760}\right] \qquad (6\text{-}10)$$

where,

ICLERP	=	the incremental large early release probability
CDF_T	=	the total average core damage frequency [2.00E-4 per year - Section 6.3.2.1(e)]
CDF_{BY}	=	the core damage frequency (per year) due to bypass events [0.0 - Section 6.3.2.1(d), conservatively neglected]
P_F	=	the probability of a pipe failure in the closed loop system inside the containment [1.0E-4 - Section 6.3.2.1(l)]
P_B	=	the probability of breaching the closed loop system outside the containment [6.0E-4 - Assumption/Input (b) above]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values into Equation 6-10 yields:

ICLERP = [2.00E-4 - 0.0] * [1.0E-4] * [6.0E-4] * [168 / 8760]
= 2.30E-13

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

6.3.2.4.2 Penetrations Connected to the Secondary Side of the Steam Generators

This generic configuration for Class C penetrations represents the containment piping penetrations that provide blowdown from the steam generators. Blowdown from the steam generators is discharged to the blowdown tank in a controlled manner during normal power operation. Blowdown samples from the steam generators are also obtained periodically during normal power operation. Except for the Palo Verde Units, the nominal size of the blowdown line is three inches, which is significantly larger than the nominal pipe size for the blowdown sample line (i.e. ⅜ of an inch). For the Palo Verde Units, the CIVs in the blowdown lines are normally open for continuous blowdown during power operation, and the nominal size of a blowdown line is six inches. The consequences of failing to isolate the large piping penetration are more adverse and are assessed for this configuration. A typical schematic for this configuration is shown in Figure 9. As shown, the penetration is equipped with two AOVs. One of the AOV is located outside the containment and the other AOV is located inside the containment. The associated piping outside the containment is non-seismically qualified. There is no need for continuous blowdown (except for the Palo Verde Units), thus CIVs for this configuration may be closed during normal power operation. Even though the valves are closed they receive a confirmatory safeguard signal (i.e. CIAS) to close following the associated design basis events.

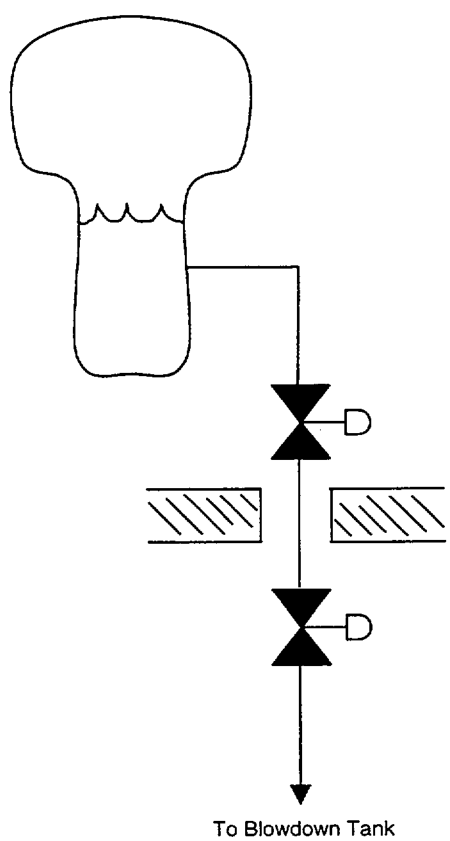

Figure 9
Schematic of Penetration Connected to SG

The CIVs for this configuration are generally included in the PSA model(s) used for estimating CDF. These CIVs are credited for isolating the ruptured steam generator in order to mitigate core damage. Securing one of the CIVs in the open position, after being detected to be inoperable, has the potential of impacting CDF and LERF. The potential impact is assessed by estimating the incremental probabilities for core damage and large early release.

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the ICLERP due to the proposed CIV AOT extension.

a. For this configuration, it is assumed that the penetration is equipped with two AOVs. One AOV is located outside the containment and the other AOV is located inside the containment. One of the AOV is determined to be inoperable and is secured in the open position. The other AOV is initially closed.

b. The transfer opening of the initially closed CIV is conservatively assume to establish a pathway from the release of radioactive materials following core damage due to a SGTR event.

c. The associated piping for the penetration, which is located outside the containment, is non-seismically qualified.

6.3.2.4.2.1 Impact on CDF/ICCDP

Following a steam generator tube rupture event, the CIVs in the blowdown lines are closed or verified to be closed in order to isolate the ruptured steam generator. Failure to isolate the blowdown line associated with the ruptured steam generator may establish a path for the release of radioactive materials to the environment.

Failure to isolate the blowdown line may be caused by either operator error or hardware failure of the associated CIVs. The limiting human error probability used by the CEOG member utilities for failure to isolate the ruptured steam generator is 1.0E-2. With both CIVs available for isolating the associated blowdown line piping penetration, the isolation failure probability is of the order of 2.0E-4. This value is dominated by common (hardware) failure of both CIVs. It includes hardware failure probability of approximately 2.0E-3 and an assumed beta factor of 0.1. With both CIVs available, the overall probability of failing to isolate the blowdown line is 1.02E-2, which is dominated by human error probability. For a configuration where one CIV is inoperable and secured in the open position, the human error probability of failing to isolate the blowdown line would still be the same as the configuration for two CIVs. However, hardware failure probability of the available CIV that prevents the blowdown line from being isolated would no longer be dominated by common cause failure, but rather by independent failure of the CIV (~ 2.0E-3). After combining the human error and hardware failure probabilities, the overall probability for this configuration (i.e. one CIV secured in the open position) is 1.2E-2. Even though the redundant means of isolating or maintaining the affected penetration isolated is lost by securing one of the CIVs in the open position, the overall probability of failing to isolate the blowdown line is still dominated by operator error. Consequently, the change in CDF due to an INOPERABLE CIV secured in the open position for the configuration shown in Figure 9 is negligible.

6.3.2.4.2.2 Impact on LERF/ICLERP

Securing the inoperable CIV associated with the penetration in the open position reduces the number of barriers available for isolating the penetration. Because the steam generator tubes are considered as a closed loop system, a steam generator tube rupture event would breach the closed loop system. A pathway for the release of radioactive material to the environment may be established if the "OPERABLE" CIV in the blowdown line fails to remain closed concurrent with a breach of the Blowdown System. The following expression is therefore used to estimate the impact on the probability of large early release.

$$ICLERP = (CCDP)_{SGTR}\ P_{FRC}\ F_B \left[\frac{AOT}{8760}\right] \qquad (6\text{-}11)$$

where,

ICLERP	=	the incremental conditional large early release probability
$CDDP_{SGTR}$	=	the conditional core damage probability due to SGTR [9.16E-4 per year - Section 6.3.2.1(e)]
P_{FRC}	=	the probability of the operable CIV failing to remain closed during the proposed AOT [2.3E-3 – Section 6.3.2.1(k)]
F_B	=	Random pipe failure of blowdown piping outside the containment [5.0E-3 per year – Section 6.3.2.1(l)]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values into Equation 6-11 yields:

ICLERP = [9.16E-4 - 0.0] * [2.3E-3] * [5.0E-3] * [168 / 8760]

= 2.02E-10

Although the rupture of the blowdown piping is conservatively assume to occur following a seismic event, the impact on steam generator tube failure is insignificant. With no impact on the conditional probability of a steam generator tube rupture, the change in probability for large early release due to a seismic event is negligible.

The calculated change in probability for large early release demonstrates that the level of risk due to the proposed CIV AOT is below the acceptance criterion 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 pressure detector outside the containment. This type of penetration is used for detecting containment pressure 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 pressure 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 configuration is shown in Figure 10. This figure shows a penetration that is equipped with an isolation valve outside the containment. The CIV 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 CIVs for Class D penetrations do not receive a safeguard signal following a design basis event.

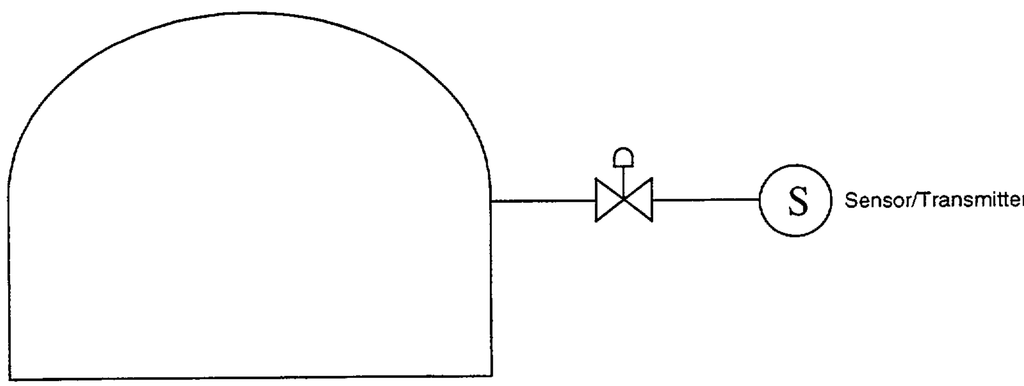

Figure 10
Schematic of Penetration Connected to Containment Instrument Sensor

An inoperable CIV for Class D penetration that is secured in the open position has no impact on CDF because the affected CIV is credited in the PSA model(s) as being in the open position. A rupture in the containment pressure detector line outside the containment may establish a pathway to the environment. However, the risk of a significant release of radioactive material 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 CIV 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 CIVs associated with Class E penetrations are required to open automatically or receive confirmatory signal to open by the safeguard actuation system (i.e. ESFAS or ESCS). Based on their functions, the following generic configurations of Class E penetrations were identified for the CE PWRs.

- Penetrations Used to support RCS Inventory Control Safety Function, or
- Penetrations Used to support Containment Heat Removal Safety Function.

The above generic configurations for Class E penetrations with an associated CIV secured in the open position are described in subsections 6.3.2.6.2.1 and 6.3.2.6.2.2.

Since the CIVs associated with Class E penetrations provide containment isolation and are also required to be open for accident mitigation, an inoperable CIV in either the open or closed position will have an impact on both CDF and LERF. An inoperable Class E CIV 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 or completion time for restoring an INOPERABLE CIV to operability for satisfying the containment isolation function. Additionally, qualitative assessment on risk impact is provided for securing an INOPERABLE Class E CIV in the closed position.

6.3.2.6.1 Risk Impact Associated with Retaining a Class E containment "boundary valve" 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 valves to be in the closed position. This discussion does however support the ISTS general philosophy of associating the inoperability of these valves to open within the system AOT. Retaining an INOPERABLE Class E CIV 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 CIV may be sufficient to cause the complete loss of a system train (i.e. closure of CIV in containment spray line) or may be minimal and have no significant effect on system operation (i.e. closure of CIV in HPSI or LPSI system). For example, San Onofre's analyses (Reference 18) of a single SI line valve in the closed position for the current LPSI AOT (3 days) indicate that the associated incremental CDPs is approximately 4.0E-9, with the incremental impact on LERP about two orders of magnitude lower.

6.3.2.6.2 Risk impact associated with retaining a Class E value in the open position:

6.3.2.6.2.1 Penetrations Used to support RCS Inventory Control Safety Functions

This type of Class E penetrations is used to provide makeup of lost reactor coolant and to maintain and control RCS inventory. The HPSI and LPSI portions of the Emergency Core Cooling System (ECCS) and the charging portion of the CVCS are used to accomplish this function when required. The HPSI and LPSI lines upstream of the header valves are equipped with low-pressure piping. Such piping is susceptible to catastrophic failure (i.e. rupture) if exposed to the normal operating temperature and pressure of the RCS. The charging line is equipped with high-pressure piping and is not susceptible to catastrophic failure. Since the piping may or may not be susceptible to catastrophic failure, this type of Class E penetration is further divided into two sub-classes, (a) HPSI/LPSI Line and (b) Charging Line.

a. HPSI/LPSI Line

The HPSI and LPSI lines enter the containment via separate penetrations and then combined into a single line before discharging to the associated RCS cold leg. The configurations for the HPSI and LPSI penetrations are similar, and because of the similarity only the description and assessment of a typical HPSI line penetration is provided. A typical schematic of a HPSI line penetration is shown in Figure 11. The figure shows that a typical HPSI line includes a motor-operated valve and multiple check valves for protecting the low pressure piping from being exposed to the normal operating temperature and pressure of the RCS. The motor-operated valve, which is located outside the containment for most of the CE PWRs, is normally closed and opens automatically upon receipt of SIAS. There are at least two check valves inside the containment that are used for pressure isolation. A pressure transmitter is installed between the two check valves to detect back leakage through the first (closest) check valve to the RCS.

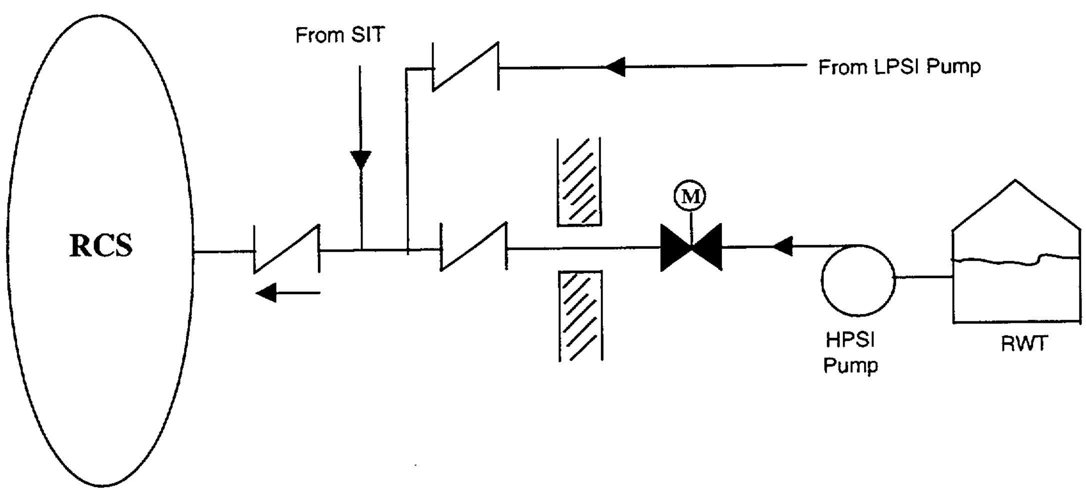

Figure 11
Schematic of Penetration Connected to SI Line

Each of the HPSI line motor-operated CIV is credited in the PSA model(s). The inoperability of a CIV 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 CIV in the closed position is qualitatively assessed in Section 6.3.2.6-1. 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 motor-operated valve in the HPSI line 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. There are four motor-operated CIVs in each train of the HPSI System. It should be noted that having one of these valves in the closed position does not cause the entire train of HPSI to become unavailable to perform its function.)

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the impact on LERF due to the proposed CIV AOT extension.

1. For this configuration, it is assumed that the piping associated with the penetration is equipped with two check valves that are inside the containment and one motor-operated valve that is located outside the containment.

2. The piping upstream of the motor-operated valve is not designed to accommodate full RCS pressure. Exposure of the low pressure piping to normal operating RCS pressure may cause a catastrophic failure of the low-pressure piping and lead to an ISLOCA. The conditional probability of pipe failure due to exposure to normal operating RCS pressure is conservatively assumed to be 0.1. This is the upper limit used in the sensitivity analysis performed [Appendix G of Reference 13] to assess the impact of pipe break probability on ISLOCA frequency.

3. A pressure transmitter is installed between the check valves in each of the safety injection lines. The effect of the transmitter is to identify when the first (closest) check is in the stuck open position or is experiencing excessive back leakage.

4. The random probability that a SI check valve will leak is 8.76E-4 per year, and the probability that a SI check valve fails to reseat is 2.81E-4 (Reference 13).

5. It is assumed that there is an average of three cold shutdowns per year for the CE PWRs. The SI check valves are operated once during each cold shutdown. Therefore, each check valve is assumed to operate a total of three (3) times during the fault exposure time (see item 6 below).

6. The fault exposure time for the check valves in this configuration is equivalent to the time that the plant operates in its non-cold shutdown modes. For this configuration, the fault exposure time is assumed to be one year.

Impact on ISLOCA for Securing a CIV in Locked Open Position

Securing the motor-operated CIV in a HPSI line in the open position will not degrade the operability of the HPSI 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 RCS 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. For this case, only the two check valves are available for pressure protection during the AOT. The methodology described in Reference 13 was used to estimate the conditional ISLOCA frequency. The expression for the average frequency of coincident failure of the two check valves in series over time period T is as follows:

$$ISLOCA = \frac{\lambda^2 T}{2} + \lambda \lambda_d \left[\frac{d\,T+1}{2} \right] \qquad (6\text{-}12)$$

where,

ISLOCA	=	Frequency of ISLOCA (per year)
λ	=	Random leakage rate of a SI check valve [8.76E-4 per year - Assumption (4) above]
λ_d	=	The probability of the second check valve failing to reseat [2.81E-4 per demand - Assumption (4) above]
d	=	The number of times the check valve is operated [3 - Assumption (5) above]
T	=	Fault exposure time [1 year - Assumption (6) above]

Equation 6-12 credits the effect of the installed pressure transmitter between the check valves. This is a repeat of Equation 9a of Reference 13. The first term on the right of Equation 6-14 represents random leakage of the check valves during the exposure time. The second term in the equation represents random leakage of the first check valve and failure of the second check valve to reseat after opening. [Note that the first check valve is defined as the check valve closest to the RCS.]

Substituting the above values in Equation 6-12 yields:

$$ISLOCA = \frac{(8.76E-4)^2\,(1)}{2} + (8.76E-4)(2.81E-4)\left[\frac{(3)\,(1)+1}{2} \right]$$

= [3.84E-7] + [4.92E-7]
= 8.76E-7 per year

The above frequency can be conservatively assumed to be the change in the average ISLOCA frequency. In crediting an operable motor-operated CIV in the HPSI line, the above frequency would decrease by at least two orders of magnitude to become 8.76E-9 per year. The difference in ISLOCA frequency with an operable and inoperable CIV is therefore estimated as 8.67E-7 per year (i.e. 8.76E-7– 8.76E-9). The incremental conditional ISLOCA probability during the AOT of 7 days (or 168 hours) is estimated as:

$$ISLP = ISLOCA\ P_C \left[\frac{AOT}{8760} \right] \tag{6-13}$$

where,

ISLP	=	The incremental conditional ISLOCA probability
ISLOCA	=	The ISLOCA frequency [8.76E-7 per year]
P_C	=	Conditional probability of pipe failure following exposure to RCS pressure [0.1 - Assumption (2) above]
AOT	=	The proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values in Equation 6-13 yields an incremental conditional ISLOCA probability of:

$$ISLP = 8.76E\text{-}7 * (0.1) * [168 / 8760]$$

$$= 1.68E\text{-}9$$

b. Charging Line

The charging line is connected directly to the RCS and is used to provide makeup to the RCS during normal power operation. Charging to the RCS is also normally provided during post-accident conditions, except when containment isolation is required. A typical schematic of the charging line penetration is shown in Figure 12. This schematic shows that the portion of the charging line associated with the containment piping penetration, which includes a CIV that is located outside the containment.

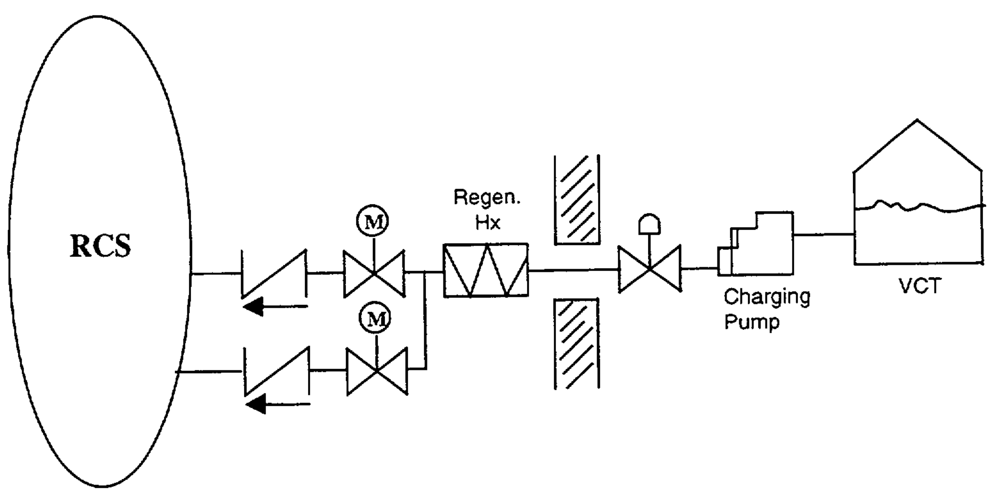

Figure 12

Schematic of Penetration Connected to Charging Line

Multiple diverse valves (i.e. motor-operated valve and check valve) are located inside the containment. Although not shown in the schematic, the charging line is equipped with additional valves between the charging pumps and the containment penetration. The charging line is designed to handle high pressure and is therefore not susceptible to a catastrophic failure if exposed to normal operating temperature and pressure of the RCS. The PSA credits charging flow with the associated CIV in the charging line in the open position. Securing the CIV in the charging line in the open position will have no impact on either CDF or LERF.

For the two cases considered for this configuration of Class E penetrations, the calculated incremental conditional probabilities for core damage and large early release indicate that the level of risk due to the proposed CIV AOT extension is well below the acceptance criteria of 5.0E-7 and 5.0E-8, respectively.

6.3.2.6.2.2 Penetrations Used for Containment Heat Removal

This type of Class E penetration is used to provide containment pressure control and containment heat removal. The Containment Spray System (CSS) and the Containment Cooling System (CCS) are used to perform these functions. The CSS is also used to remove radioactive particulate from the containment atmosphere. The penetrations associated with the CSS are connected directly to the containment atmosphere. Unlike the CSS, the penetrations associated with the CCS are connected to piping that form a closed loop system inside the containment. The CIVs installed in the penetrations for each system design is described below.

a. CSS Lines

The CSS is in the standby mode during normal power operation. The system is actuated automatically by the containment safeguard signal (i.e. CSAS) in order to perform its functions. A typical schematic of a CSS line penetration is shown in Figure 13. This schematic shows that two CIVs are installed in the line.

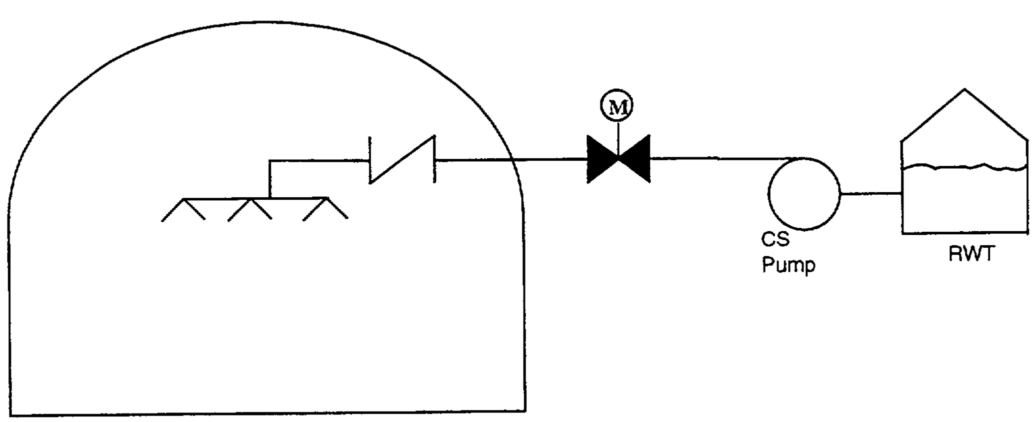

Figure 13
Schematic of Penetration Connected to Containment Spray Line

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

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the potential impact on core damage and large early release due to the proposed CIV AOT extension.

1. For this configuration, it is assumed that the CSS containment penetration is equipped with one MOV that is located outside the containment and a check valve that is located inside the containment. The MOV is secured in open position in order to assess its potential impact on risk due to the proposed CIV AOT extension.

2. Securing the CIV in the open position will satisfy the mitigating function for CSS 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 CIV 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. Based on the information provided in Reference 10, the mean probability of a check valve to close is 1.52E-3. These values are used in the calculations.

Impact on Risk for Retaining an INOPERABLE CIV in its Non-ESF Actuated Position

This information is provided for purposes of completeness. This report is not requesting an extension of the AOT for the Class E valves to be in the closed position. This discussion does however support the ISTS general philosophy of associating the inoperability of these valves to open with the system AOT. Retaining an INOPERABLE motor-operated CIV in a containment spray line in the closed position renders the affected train of containment spray unavailable to perform its core damage mitigating function. The increase in conditional core damage probability for an inoperable train of CSS for a proposed AOT of 7 days was assessed and documented in the CEOG Joint Application Report for the CSS (Reference 15). The results of this assessment indicate that ICCDP is of the order of 2.0E-8 for the CEOG utilities, except the Palo Verde Units. For Palo Verde, the increase in core damage probability is 5.0E-7. The higher value for Palo Verde is attributed to a design that does not have safety-related containment cooling units to provide backup to CSS. The increase in large early release probability conditional on the unavailability of a CSS train was also assessed in response to request for additional information on CEOG Joint Application Report (Reference 15). The incremental LERP for each CEOG utility was estimated using one of two approaches. In the first approach, the large early release model developed as part of the PSA was used for plants that have the model in place. In the second approach, bounding estimates were developed for plants that did not have a large early release model. The results for the incremental probabilities (Reference 16) indicate that ICLERP for the CEOG utilities is of the order of 3.0E-9 or less.

Impact on Risk for Securing an INOPERABLE CIV in Locked Open Position

Securing the motor-operated CIV 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 CIV secured in the open position, a pathway for the release of radioactive material following core damage may be established if the check valves fails to close concurrent with a random pipe failure in the associated spray line. The following expression is therefore used to estimate the change in large early release probability.

$$ICLERP = (CDF_T - CDF_{BY})\, P_{CK}\; P_B \left[\frac{AOT}{8760}\right] \qquad (6\text{-}14)$$

where,

ICLERP	=	the incremental conditional large early release probability
CDF_T	=	the total average core damage frequency [2.00E-4 per year - Section 6.3.2.1(e)]
CDF_{BY}	=	the core damage frequency (per year) due to bypass events [0.0 - Section 6.3.2.1(d)]
P_{CK}	=	the probability of a check valve failing to isolate the associated containment penetration [1.52E-3 - Assumption /Input (4) above]
P_B	=	the probability of a pipe failure in the open loop system outside the containment [1.0E-4 - Section 6.3.2.1 (l)]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values into Equation 6-14 yields:

ICLERP = [2.00E-4 – 0.0] * [1.52E-3] * [1.0E-4] * [168 / 8760]

= 5.83E-13

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

b. CCS Lines

The function of the Containment Cooling System (CCS) is to maintain the ambient temperature in the containment atmosphere below a specified limit. This is achieved by circulating containment air through the safety-related cooling units. Safety-related cooling water (i.e. component cooling water or service water) is supplied to the cooling units to remove heat from the containment atmosphere. A typical schematic of a CCS cooling water line is shown in Figure 14. The figure shows that one CIV is installed in the supply and return portion of the cooling water line. A MOV is used for isolating the containment penetration. The CIV is normally closed during normal power operation and is automatically opened by the safeguard signal following a design basis event. The design and location of the cooling units and associated cooling water lines precludes rupture of the closed loop system inside the containment from the effects of a LOCA or a high energy line break inside the containment. The CCS piping outside the containment also forms a closed loop system that is seismically qualified. Similar to the CSS, the CCS is also credited in the PSA for long-term heat removal. Securing closed a CIV in the associated cooling water line will impact the potential for core damage and large early release.

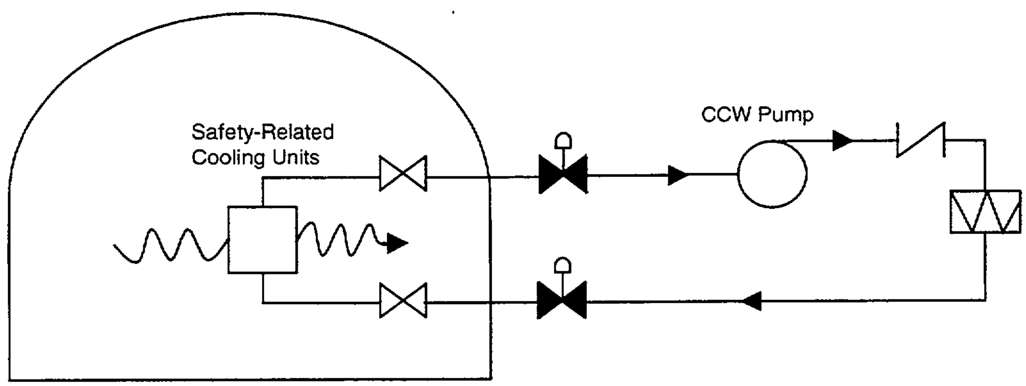

Figure 14
Schematic of Penetration Connected to Safety Related Cooling Water Line

In addition to the general assumptions/input provided in Section 6.3.2.1, the following configuration specific assumptions were made in estimating the potential impact on core damage and large early release due to the proposed CIV AOT extension.

1. For this configuration, it is assumed that the containment penetration associated with the cooling water line of the CCS is equipped with a normally closed MOV that is located outside the containment. The line is also equipped with a normally open manually operated valve that is located inside the containment. The MOV is secured in either the open or closed position in order to assess its potential impact on risk due to the proposed CIV AOT extension.

2. A LOCA or high energy line break inside the containment is assumed to have no impact on the cooling water line of the CCS. Therefore, the probable means of establishing a pathway from the containment to the environment is through a random failure of the cooling water line. The probability of a random pipe failure occurring

within the proposed AOT of 168 hours is 1.0E-4. This value is based on a random pipe failure rate of 1.17E-9 per section-hour (Reference 11) and assuming that there are 100 section under consideration. For conservatism, the failure frequency was increased by a factor of 5 and then multiplied by the AOT duration of 168 hours.

3. Pressure relief protection is provided for the enclosed loop system outside the containment. In addition to a pipe failure, inadvertent opening of a relief valve will also breach the closed loop system outside the containment. An estimated probability of 5.0E-4 is assumed and used for inadvertent opening of a relief valve within the proposed AOT of 168 hours. The probability value is based on a mean failure rate of 2.43E-6 per hour (Reference 10) for inadvertent opening of a relief valve. The product of the failure rate and AOT (i.e. 4.08E-4 = 2.34E-6/hr * 168 hr) was rounded up to 5.0E-4. The overall probability of 6.0E-4 for breaching the closed system outside the containment includes a random pipe failure or inadvertent opening of a relief valve during the AOT.

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

5. Securing the motor-operated CIV in the cooling water line in the closed position will result in action per Technical Specification [3.6.2.3]. The proposed AOT for an inoperable CCS cooling water line CIV is 7 days (or 168 hours).

Impact on Risk for Retaining an INOPERABLE CIV in the Non-ESF Actuated Position

This information is provided for purposes of completeness. This report is not requesting an extension of the AOT for the Class E valves to be in the closed position. This discussion does however support the ISTS general philosophy of associating the inoperability of these valves to open with the system AOT. When the motor-operated CIV for the CCS cooling water line is in the closed position the affected train of CCS is unavailable to perform its mitigation function. The CCS provides backup to the CSS. The impact of an inoperable CCS train on the change in core damage and large early release is considered to be no more adverse than an inoperable train of CSS. The increase in conditional core damage and large early release probabilities for an inoperable train of CCS during a proposed AOT of 7 days was assessed in support of an amendment to the Technical Specifications for the San Onofre Units [Reference 18]. The San Onofre results indicate that the change in probability for both core damage and large early release is less than 1.0E-9. The incremental change in core damage probability is therefore bounded by the incremental probability for CSS (i.e. 2.0E-8). This is applicable to the CEOG utilities, except the Palo Verde Units. The Palo Verde design is not equipped with CCS. The incremental conditional large early release probability for an inoperable train of CCS is considered to be bounded by the incremental probability for CSS (i.e. 3.0E-9).

Impact on Risk for Securing a CIV in the Locked Open Position

When the CIV is in the open position one of the barriers to guard against the release of radioactive materials is eliminated. With the CIV open, the release of radioactive materials from the containment to the environment can occur in the presence of a damaged core concurrent with breach of the closed loop system, both inside and outside of the containment. Since the CIV in the open position has no impact on core damage frequency, the following expression is used to estimate the conditional change in large early release probability.

$$ICLERP = (CDF_T - CDF_{BY})\, P_F \, P_B \left[\frac{AOT}{8760}\right] \qquad (6\text{-}15)$$

where,

ICLERP	=	the incremental large early release probability
CDF_T	=	the total average core damage frequency [2.00E-4 per year - Section 6.3.2.1(e)]
CDF_{BY}	=	the core damage frequency (per year) due to bypass events [0.0 - Section 6.3.2.1(d)]
P_F	=	the probability of a pipe failure in the closed loop system inside the containment [1.0E-4 - Assumption/Input (2) above]
P_B	=	the probability of breaching the closed loop system outside the containment [6.0E-4 - Assumption/Input (3) above]
AOT	=	the proposed allowed outage time [168 hours - Section 6.3.2.1(a)]

Substituting the above values into Equation 6-15 yields:

ICLERP = [2.00E-4 - 0.0] * [1.0E-4] * [6.0E-4] * [168 / 8760]
= 2.30E-13

The above estimate for ICLERP is based on a closed loop system inside and outside the containment. The type of cooling water design utilized at the CE PWRs varies among the CEOG utilities. For example, a cooling water design that forms a closed loop inside and outside the containment is installed at the San Onofre units while ANO-2 utilizes a design with a closed loop inside the containment and an open loop outside the containment. For an open loop design, the change in large early release probability can be estimated by substituting a value of 1.0 for P_B in Equation 6-17. After making the substitution, the change in probability for an open loop system (outside containment) becomes:

ICLERP = [2.00E-4 – 0.0] * [1.0E-4] * [168 / 8760]

= 3.84E-10

A comparison of ICLERP for an open loop vs closed loop system outside the containment indicates that the open loop design is bounding for the CEOG utilities.

For the two cases considered for this configuration of Class E penetrations, the calculated incremental conditional probabilities for core damage and large early release indicate that the level of risk due to the proposed CIV 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 6.3-4 summarizes the "risk" impact of extending the CIV AOTs for the various types containment penetrations for the full AOT duration. The risk ratios included in the last two columns of Table 6.3-4 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 CIV for any particular containment penetration configuration is no greater than 18% of the regulatory guidelines and in many instances are orders of magnitude lower.

Table 6.3-3

Summary of Plant Risk for Proposed CIV AOT Extension

CTMT Pen. Class	Description	Seismic Effect on Piping		Position of INOPERABLE CIV	Proposed AOT (Days)	ICCDP	ICLERP	ICCDP Risk Ratio (Note 7)	ICLERP Risk Ratio (Note 8)
		N	Y						
A	CIVs in penetrations connected directly to containment atmosphere and outside environment	(Note 1)		OPEN	7	0	8.82E-9	0	**1.8E-1**
	CIVs in penetration connected directly to containment atmosphere and closed loop system outside containment	✓		OPEN	7	0	1.48E-12	0	2.96E-5
			✓	OPEN	7	0	1.29E-09	0	2.6E-2
	CIVs in penetrations connected to containment atmosphere and open loop system outside containment	✓		OPEN	7	0	5.83E-13	0	1.2E-5
			✓	OPEN	7	0	5.10E-10	0	1.0E-2
	CIVs in penetrations connected to closed loop system inside and outside containment	✓		OPEN	7	0	<1.00E-12	0	<2.0E-5
			✓	OPEN	7	0	1.29E-09	0	2.6E-2
B	CIVs in penetrations connected to SI Line check valve leakage path	(Note 2)		OPEN	7	4.16E-10	4.16E-10	8.3E-4	8.3E-3
	CIVs in penetrations connected to the RCS sample line	✓		OPEN	7	8.27E-10	8.27E-10	1.65E-3	1.65E-2
			✓	OPEN	7	6.57E-10	6.57E-10	1.31E-3	1.31E-2
	CIVs in penetrations connected to Letdown or RCP bleedoff line	(Note 2 & 3)		OPEN	7	7.82-09	7.82E-09	1.56E-2	1.56E-1
C	CIVs in penetrations connected to non-essential containment cooling units	(Note 4 & 5)		OPEN	7	3.07E-9	1.84E-12	6.1E-3	3.7E-5
	CIVs in penetrations connected to secondary side of steam generator	✓		OPEN	7	0	2.02E-10	0	4.0E-3
			✓	OPEN	7	0	Neg	0	Neg
D	CIVs in penetrations connected to containment atmosphere pressure detector	(Note 2)		OPEN		Neg	Neg	Neg	Neg
E	CIVs in penetrations used to support RCS Inventory Control Safety Function - safety injection	(Note 2)		OPEN	7	1.68E-9	1.68E-9	3.4E-3	3.4E-2
	CIVs in penetrations used to provide Charging	(Note 2)		OPEN (Note 9)		0	Neg	0	Neg
	CIVs in penetrations used to support Containment Heat Removal safety function using containment sprays	(Note 2)		OPEN	7	2.0E-8	5.83E-13	4.0E-2	1.2E-5
	CIVs in penetrations used to support Containment Heat Removal safety function using safety-related containment cooling units	(Note 2 & 6)		OPEN	7	2.0E-8	3.84E-10	4.0E-2	7.7E-3

Notes for Table 6.2.3.6:

1. The associated piping located downstream of the CIV outside CTMT 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. ICCDP is bounded by letdown pipe break outside the containment, ICLERP is bounded by letdown pipe break outside containment.
4. Associated piping inside the containment is seismically qualified.
5. ICCDP and ICLERP are bounded by pipe failure causing reactor trip.
6. ICLERP is bounded by penetration connected to an open loop cooling water system.
7. ICCDP risk ratio is defined as the ratio of the estimated ICCDP to RG 1.177 acceptance criteria of 5.0E-7.
8. ICLERP risk ratio is defined as the ratio of the estimated ICLERP to RG 1.177 acceptance criteria of 5.0E-8.
9. CIVs associated with the charging line penetration are open during Modes 1 through 4 and are required to remain open for post-accident operation.

6.4 Considerations of Multiple AOT entries and Accumulated Risk

As identified in Section 3.6.3 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 3.6.3 of the ISTS. Therefore all entries into the LCO which result in opening a 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 6.2.3.6, 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

For any given AOT extension, there is an "at power" increase in risk associated with it. This increase may be negligible or significant. To fully understand the impact of this increased risk, the activity would be viewed in the context of the averted risks associated with the activity. Therefore, a complete approach to assessing the change in risk accounts for the effects of avoided plant shutdown, or "transition risk". Transition Risk represents the risk associated with changing the operating mode of a plant from its nominal full power operating state to a low power or shutdown mode following equipment failure, in this case, an inoperable CIV in the open position. Transition Risk is of interest in establishing the tradeoff between shutting down the plant and restoring the affected CIV to operability. The risk of transitioning from "at power" to a shutdown mode must be balanced against the risk of continued operation and performing corrective maintenance while the plant is at power.

The CE transition risk methodology is discussed in Reference 15. This methodology was used to assess the transition risk associated with the unavailability of a single train of containment spray. For plants with diverse and redundant containment heat removal systems, continued operation with one containment spray train unavailable has minimal impact on CDF and LERF, and therefore transition risk would be similar to that assocaited with a plant with inoperable CIVs. The range of transition risk obtained for plant shutdown is between 1E-7 and 3E-6[1]. These risks are comparable to, or greater than, the risks of continued operation with on-line CIV repairs. Thus, the risk of transitioning the plant from power operation to Mode 4 offsets the risk associated with "at power" on-line CIV repair.

6.6 Tier 2 Considerations

Regarding multiple unavailabilities of CIVs for performing their containment isolation function, no Tier 2 conditions were noted that were not already prohibited by TS 3.6.3 (that is, 2 CIVs OOS in the same line, loss of function, etc.). The plant Configuration Risk Management Program (CRMP) will limit the overall risk of CIV maintenance for valves in this class by

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[1] The evaluation is based on the transition risk associated with a plant shutdown from Mode 1 to 4 with the unavailability of one train of containment spray (Reference 15).

controlling the cumulative and simultaneous unavailabilities of CIVs and associated system pressure boundary valves.

6.7 Commitment to Configuration Risk Management Program

In conformance with Regulatory Guide 1.177, the CEOG member utilities commit to the use of a risk-informed configuration risk management program. This program will assess the risk associated with plant maintenance activities and may be included within the plant program(s) to meet paragraph A.4 of the proposed revision to the Maintenance Rule. Risk informed cumulative unavailability targets for CIVs are already being established within the scope of the current Maintenance Rule.

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7.0 SUMMARY AND CONCLUSIONS

This report provides the results of an evaluation for extending the Allowed Outage Time (AOT)/ Completion Time (CT) for a specific set of CIVs from 4 hours to 7 days during Modes 1, 2, 3, and 4. The specific set of CIVs is addressed by Conditions A and C of Section 3.6.3 of NUREG-1432, Revision 1 (Attachment 1). This AOT/CT extension is sought to provide flexibility in the performance of surveillance testing, preventative 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 CIV. Justification of this AOT/CT modification was based on an integrated review and assessment of plant operations, deterministic/design basis factors, and plant risk.

The proposed increase in AOT/CT for a particular CIV was evaluated from the perspective of various risks associated with plant operation. Incorporation of the proposed extension of AOT/CT 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/CT is utilized. It is expected that the primary usage of the proposed extended AOT/CT will involve low risk or risk insignificant maintenance activities associated with preventive maintenance of the subject CIV.

The inoperability of a CIV 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 CIV 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 CE PWRs.

In conclusion, the results of this evaluation demonstrate that the proposed AOT/CT 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/CT is below the regulatory guidelines set forth in Regulatory Guide 1.174.

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8.0 REFERENCES

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

2. NRC, "Standard Technical Specifications for Combustion Engineering Pressurized Water Reactors," NUREG-0212, July 9, 1982.

3. NRC, "Standard Technical specifications: Combustion Engineering Plants," NUREG-1432, Revision 1, April 1995.

4. NRC Inspection Manual Part 9900 Technical Guidance, "Maintenance-Voluntary Entry into Limiting Conditions for Operation Action Statements to Perform Maintenance," 1991.

5. LER # 94-005-02, Palo Verde Unit 2.

6. Samata, P., et al, "Technical Evaluation of South Texas Project (STP) Analysis for Technical Specification Modifications," Technical Report # L-2591, January 11, 1994.

7. Samata, P., et al, "Handbook of Methods for Risk Based Analyses of Technical Specifications," NUREG/CR-6141, July 1994.

8. 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.

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

10. Gilbert, B.G., et al, "Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) Data Manual - Part 3: Hardware Component Failure Data (HCFD)," NUREG/CR-4639, Vol. 5, Revision. 3, December 1990.

11. Jamali, K., "Pipe Failure Study Update", EPRI TR-102266, April 1993.

12. Not used.

13. Bozoki, G., et al, "Interfacing System LOCA: Pressurized Water Reactors," NUREG/ CR-5102, February 1989.

14. Mosleh, A., "Procedure for Analysis of Common-Cause Failures in Probabilistic Safety Analysis," NUREG/CR-5801, April 1993.

15. CEOG, "Joint Applications Report for Modifications to the Containment Spray System, and Low Pressure Safety Injection Technical Specifications," CE NPSD-1045, February 1998.

16. CEOG Letter, (CEOG-99-082), "Response to Request for Additional Information Regarding CE NPSD-1045", from Ralph Phelps (CEOG) to Stewart L. Magruder (NRR), dated March 15, 1999.

17. Not used.

18. Letter, "Docket Nos. 50-361 and 50-362, Supplement 1 to Amendment Application Nos. 158 and 142, Containment Isolation Values Completion Time, San Onofre Nuclear Generating Station Units 2 and 3," from D.E. Nunn to U.S. Nuclear Regulatory Commission, dated April 6, 1998.

19. Letter, "Docket Nos. 50-361 and 50-362, Response to Generic Letter 88-20, Supplement 4, Individual Plant Examination of External Events (IPEEE)," from W.C. Marsh, Southern California Edison Company, dated December 15, 1995.

Attachment 1
NUREG-1432 Revision 1, Section 3.6.3

(Pages 3.6-8 through 3.6-14)

3.6 CONTAINMENT SYSTEMS

3.6.3 Containment Isolation Valves (Atmospheric and Dual)

LCO 3.6.3 Each containment isolation valve shall be OPERABLE.

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTIONS

-----------------------------------NOTES-----------------------------------

1. Penetration flow paths [except for [42] 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 system(s) made inoperable by containment isolation valves.
4. Enter applicable Conditions and Required Actions of LCO 3.6.1, "Containment," when leakage results in exceeding the overall containment leakage rate acceptance criteria.

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. ------ --NOTE--------- Only applicable to penetration flow paths with two containment isolation valves. --------------------- One or more penetration flow paths with one containment isolation valve inoperable [except for purge valve leakage and shield building bypass leakage not within limit].	A.1	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
	<u>AND</u>		

(continued)

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. (continued)	A.2	---------NOTE--------- Isolation devices in high radiation areas may be verified by use of administrative means. --------------------- Verify the affected penetration flow path is isolated.	Once per 31 days for isolation devices outside containment AND Prior to entering MODE 4 from MODE 5 if not performed within the previous 92 days for isolation devices inside containment
B. ----------NOTE---------- Only applicable to penetration flow paths with two containment isolation valves. ---------------------- One or more penetration flow paths with two containment isolation valves inoperable [except for purge valve leakage and shield building bypass leakage not within limit].	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

(continued)

ACTIONS (continued)

CONDITION	REQUIRED ACTION		COMPLETION TIME
C. ---------NOTE--------- Only applicable to penetration flow paths with only one containment isolation valve and a closed system. ---------------------- One or more penetration flow paths with one containment isolation valve inoperable.	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
	<u>AND</u>		
	C.2	--------NOTE--------- Isolation devices in high radiation areas may be verified by use of administrative means. --------------------- Verify the affected penetration flow path is isolated.	Once per 31 days
[D. Secondary containment bypass leakage not within limit.	D.1	Restore leakage within limit.	4 hours]
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 with resilient seals, closed manual valve with resilient seals, or blind flange].	24 hours
	<u>AND</u>		

(continued)

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
E. (continued)	E.2	--------NOTE--------- Isolation devices in high radiation areas may be verified by use of administrative means. --------------------- Verify the affected penetration flow path is isolated.	Once per 31 days for isolation devices outside containment AND Prior to entering MODE 4 from MODE 5 if not performed within the previous 92 days for isolation devices inside containment
	AND		
	E.3	Perform SR 3.6.3.6 for the resilient seal purge valves closed to comply with Required Action E.1.	Once per [ ] days
F. Required Action and associated Completion Time not met.	F.1	Be in MODE 3.	6 hours
	AND		
	F.2	Be in MODE 5.	36 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
[SR 3.6.3.1	Verify each [42] inch 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 3.6.3.2	Verify each [8] inch purge valve is closed except when the [8] inch purge valves are open for pressure control, ALARA or air quality considerations for personnel entry, or for Surveillances that require the valves to be open.	31 days
SR 3.6.3.3	-------------------NOTE------------------- Valves and blind flanges in high radiation areas may be verified by use of administrative means. -- Verify each containment isolation manual valve and blind flange that is located outside containment and is required to be closed during accident conditions is closed, except for containment isolation valves that are open under administrative controls.	31 days

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.6.3.4	-------------------NOTE------------------- Valves and blind flanges in high radiation areas may be verified by use of administrative means. --- Verify each containment isolation manual valve and blind flange that is located inside containment and required to be closed during accident conditions is closed, except for containment isolation valves that are open under administrative controls.	Prior to entering MODE 4 from MODE 5 if not performed within the previous 92 days
SR 3.6.3.5	Verify the isolation time of each power operated and each automatic containment isolation valve is within limits.	[In accordance with the Inservice Testing Program or 92 days]
SR 3.6.3.6	Perform leakage rate testing for containment purge valves with resilient seals.	184 days AND Within 92 days after opening the valve
SR 3.6.3.7	Verify each automatic containment isolation valve that is not locked, sealed, or otherwise secured in position, actuates to the isolation position on an actual or simulated actuation signal.	[18] months

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
[SR 3.6.3.8	Verify each [ ] inch containment purge valve is blocked to restrict the valve from opening > [50]%.	[18] months]
[SR 3.6.3.9	Verify the combined leakage rate for all secondary containment bypass leakage paths is ≤ [L_a] when pressurized to ≥ [psig].	-----NOTE----- SR 3.0.2 is not applicable -------------- In accordance with 10 CFR 50, Appendix J, as modified by approved exemptions]