UNITED STATES
NUCLEAR REGULATORY COMMISSION
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
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Office of Nuclear Reactor Regulation

Project No. 692

Enclosure: Safety Evaluation

cc w/encl: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
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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.

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 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.

CSS Isolation Valves

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.

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. 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 Tier 2 and Tier 3 Capabilities

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

Prepared for

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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.

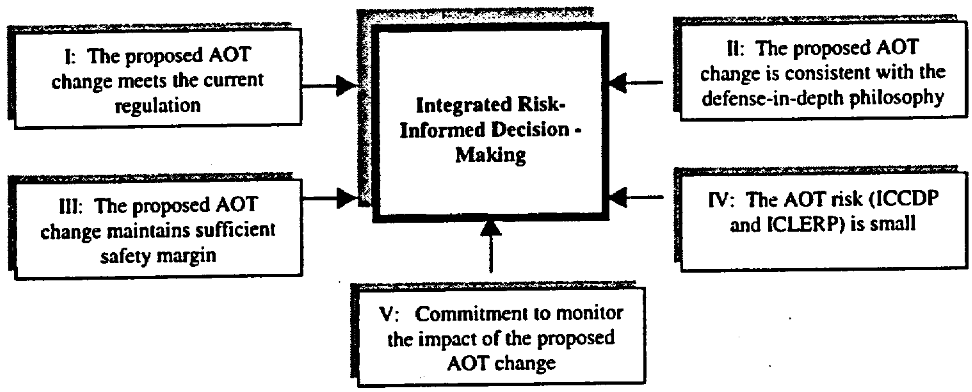

Figure 1: Principles of Risk-Informed Integrated Decision-Making

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.

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[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.

Penetration Path A1:
CIVs in penetrations connected directly to containment atmosphere and outside environment

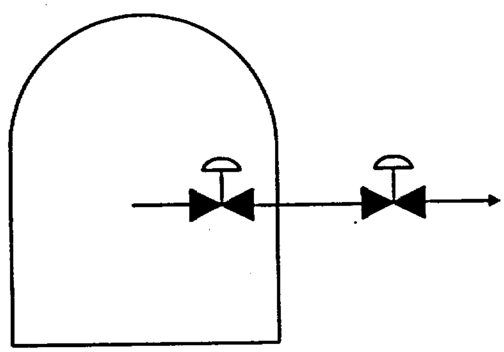

Figure 2: Schematic of Penetration Connected Directly to Containment Atmosphere and Outside Environment -- Penetration Path A1

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

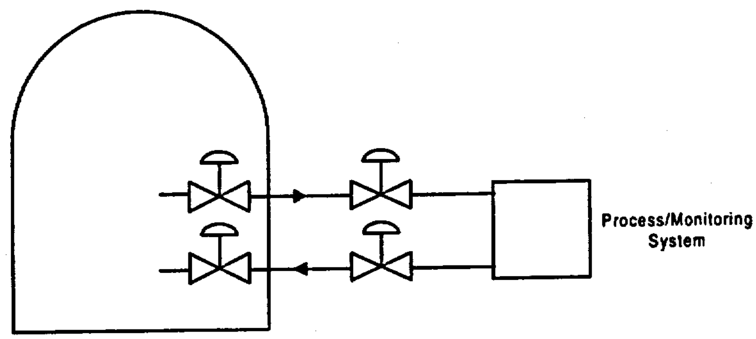

Figure 3: Schematic of Penetration Connected Directly to Containment Atmosphere and a Closed Loop System -- Penetration Path A2

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

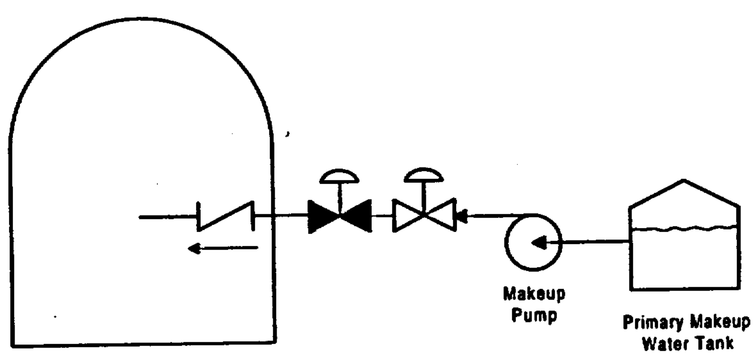

Figure 4: Schematic of Penetration Connected to Containment Atmosphere and an Open Loop System -- Penetration Path A3

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

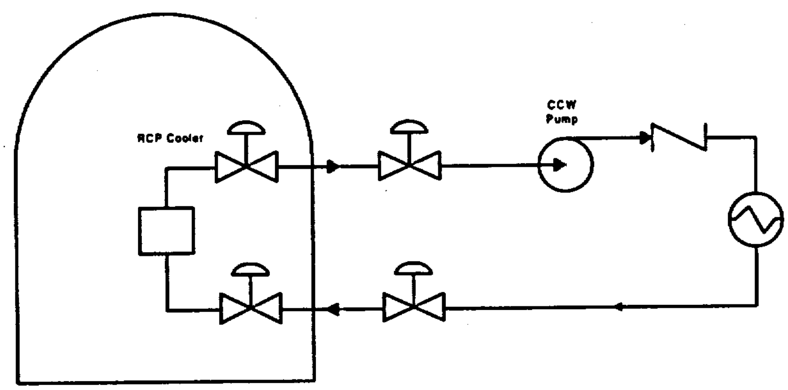

Figure 5: Schematic of Penetration Connected to Closed Loop Inside and Outside Containment -- Penetration Path A4

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

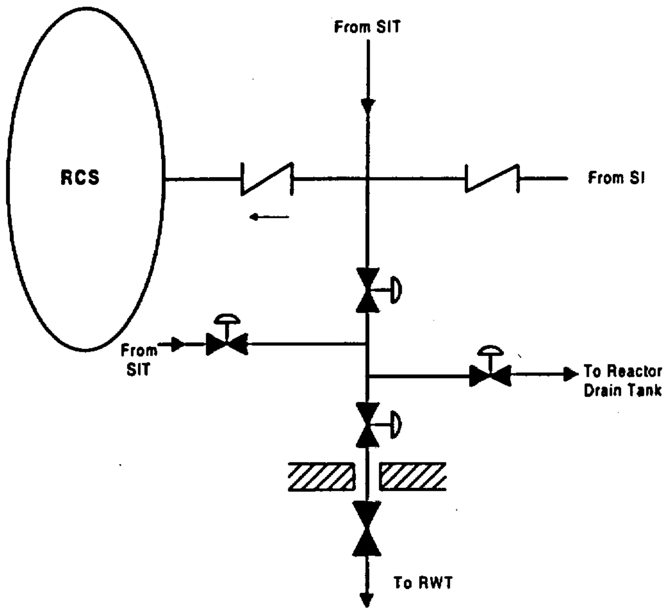

Figure 6: Schematic of Penetration Connected to SI Line Leakage Path -- Penetration Path B1

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

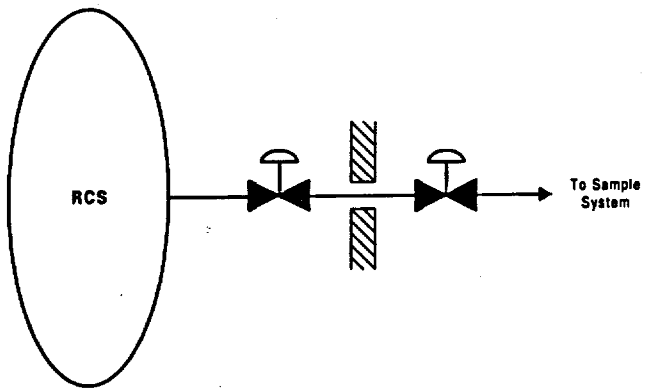

Figure 7: Schematic of Penetration Connected to RCS Sample Line -- Penetration Path B2

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

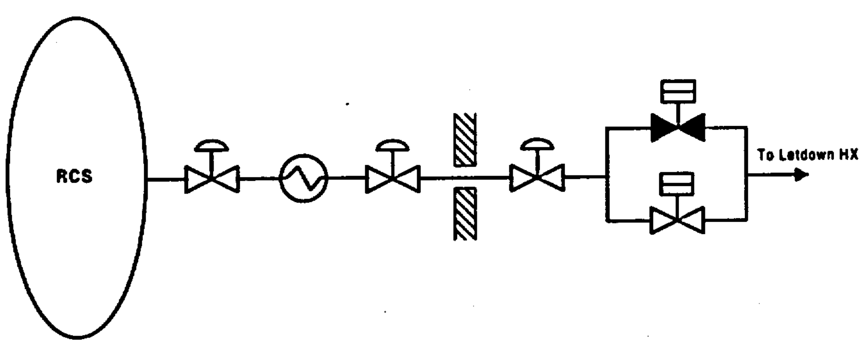

Figure 8: Schematic of Penetration Connected to Letdown Line – Penetration Path B3

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.

<u>Penetration Path C1</u>:
CIVs in penetrations connected to non-essential containment cooling

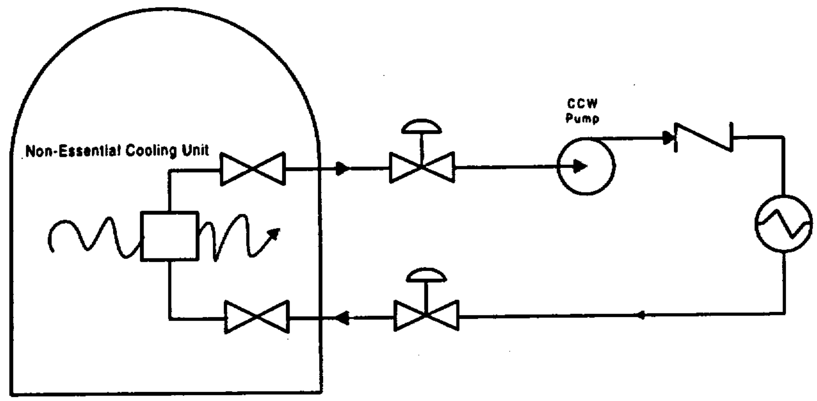

Figure 9: Schematic of Penetration Connected to Non-Essential Cooling Units -- Penetration Path C1

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

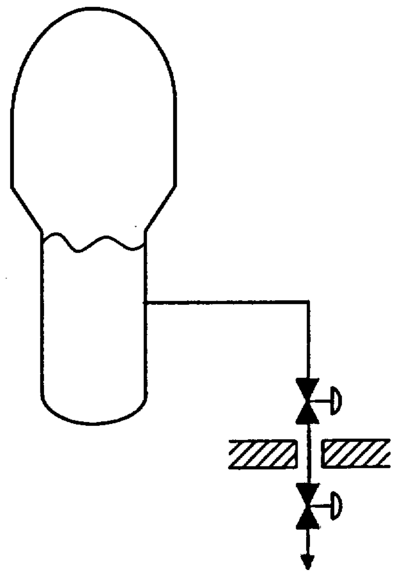

Figure 10: Schematic of Penetration Connected to Steam Generator -- Penetration Path C2

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

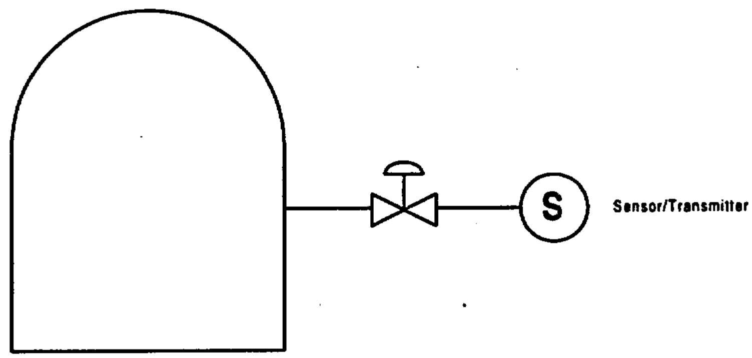

Figure 11: Schematic of Penetration Connected to Containment Instrument Sensor -- Penetration Path D

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

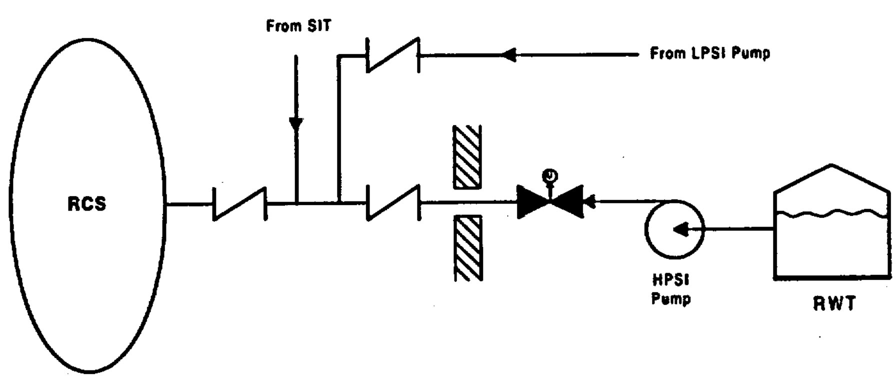

Figure 12: Schematic of Penetration Connected to Safety Injection Line -- Penetration Path E1

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

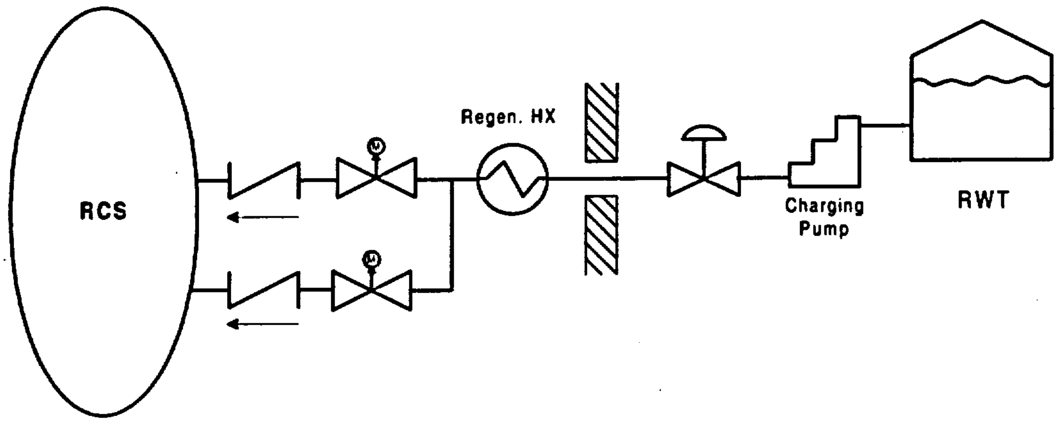

Figure 13: Schematic of Penetration Connected to Charging Line -- Penetration Path E2

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

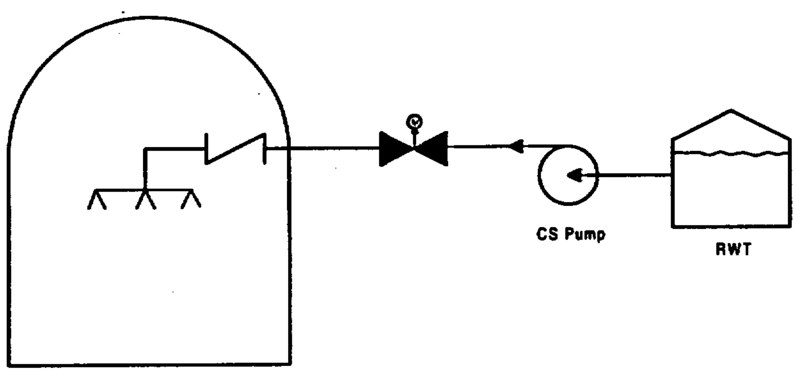

Figure 14: Schematic of Penetration Connected to Containment Spray Line – Penetration Path E3

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

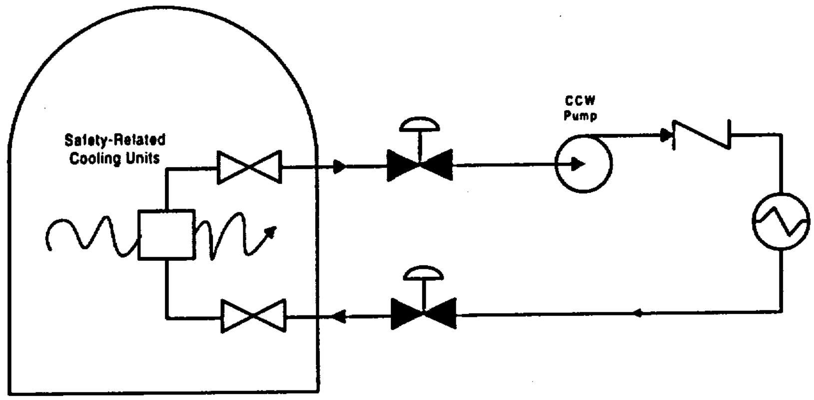

Figure 15: Schematic of Penetration Connected to Safety-Related Cooling Water Line -- Penetration Path E4

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 $SAOT_{LERF} = \Delta CDF * P_{CIV} * \frac{AOT}{8760} = 8.8E-9$ 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 (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 $SAOT_{LERF} = \Delta CDF * P_{CIV} * P_{cl} \frac{AOT}{8760} = 1.5E-12$ 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 $SAOT_{LERF} = \Delta CDF * P_{CIV} * \frac{AOT}{8760} = 1.3E-9$ 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 $SAOT_{LERF} = \Delta CDF * P_{CK} * P_B \frac{AOT}{8760} = 5.83E-13$ where $SAOT_{LERF}$ = single AOT risk for large early release ΔCDF = change in CDF, baseline CDF assumed to be: 2E-4/yr P_{CK} = 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 $SAOT_{LERF} = \Delta CDF * P_{CK} * \frac{AOT}{8760} = 5.1E-10$ 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 $SAOT_{LERF} = \Delta CDF * P_{CIV} * P_{cli} * P_{clo} \frac{AOT}{8760} << 2E-13$ 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_{cli} = probability of a pipe failure in close loop system inside containment: 1E-4 P_{clo} =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 $SAOT_{LERF} = \Delta CDF * P_{CIV} * \frac{AOT}{8760} = 1.3E-9$ 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: • 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)	$ISLOCA = \frac{\lambda_1 \lambda_2 \lambda_3 T^2}{3} + \lambda_1 \lambda_2 \lambda_{d3}\left[\frac{d_3 T + 1}{2}\right] + \lambda_1 \lambda_{d2} \lambda_3 T\left[\frac{d_2 T + 1}{2}\right]$ $+ 2\lambda_1 \lambda_{d2} \lambda_{d3}\left[\frac{d_2 T + 1}{2}\right]\left[\frac{d_3 T + 1}{2}\right] = 2.19E-8 \ per\ year$ $SAOT_{LERF} = ISLOCA * \frac{AOT}{8760} = 4.19E-10$ 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)	$SAOT_{LERF} = CCDP_{SL} * F_P * P_{FRC} * \frac{AOT}{8760} = 8.23E-10$ 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_{FRC} = 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_{FRC} 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
CI	CIVs in penetrations connected to non-essential containment cooling (See Figure 9)	CASE INVOLVING A RANDOM PIPE FAILURE AND CAUSING REACTOR SCRAM: $SAOT_{CDF} = ICCDP = CCDP_T * F_P * \frac{AOT}{8760}$ $= 3.07E-9$ $SAOT_{LERF} = ICCDP * P_R$ $= 1.84E-12$ (*without* P_F) CASE INVOLVING A PIPE FAILURE CONCURRENT WITH CORE DAMAGE: $SAOT_{LERF} = \Delta CDF * P_F * P_R * \frac{AOT}{8760}$ $= 2.30E-13$ 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 ΔCDF = 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_R = 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_F). • 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)	$SAOT_{LERF} = CCDP_{SGTR} * P_{FRC} * F_B * \frac{AOT}{8760}$ $=2.02E-10$ where $SAOT_{LERF}$ = single AOT risk for large early release $CCDP_{SGTR}$ = conditional core damage probability due to SGTR: 9.16E-4 P_{FRC} = 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: $ISLOCA = \frac{\lambda^2 T}{2} + \lambda\lambda_d\left[\frac{dT+1}{2}\right]$ $SOAT_{LERF} = ISLP = ISLOCA * P_C * \frac{AOT}{8760}$ $= 1.68E-9$ where $SAOT_{LERF}$ = 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)	$SAOT_{LERF} = \Delta CDF * P_{CK} * P_{R} * \frac{AOT}{8760}$ $= 5.83E-13$ 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_{R} = 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_R. • 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)	$SAOT_{LERF} = \Delta CDF * P_F * P_B * \frac{AOT}{8760}$ $= 2.30E-13$ *for closed loop* $= 3.84E-10$ *for open loop* where $SAOT_{LERF}$ = 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 $SAOT_{LERF}$ 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 N	Seismic Effect on Piping Y	CDF-based Single AOT Risk (ICCDP)	LERF-based Single AOT Risk (ICLERP)
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

1 Joint Applications Report for Containment Isolation Valve AOT Extension, C-E Owners Group, CE NPSD-1168, March 1999.

2 US NRC, "Standard Technical Specifications: Combustion Engineering Plants," NUREG-1432, Volume 1, Revision 1, April 1995.

3 NRC Task Order No. 202, "Review of CE Owner's Group Joint Applications Report," Contract No. NRC-03-95-026.

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.

5 US NRC, Chapter 16.1 of the Standard Review Plan, "Risk-Informed Decision Making: Technical Specifications," NUREG-0800.

6 US NRC, Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," July 1998.

7 US NRC, Regulatory Guide 1.177, "An Approach for Plant-Specific, Risk-Informed Decision Making: Technical Specifications," August 1998.

8 US NRC, "Safety Goals for the Operation of Nuclear Power Plants; Policy Statement," Federal Register, Vol. 51, p. 30028 (51 FR 30028), August 4, 1986.

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

10 Samanta, P.K., et.al, "Handbook of Methods for Risk-Based Analyses of Technical Specifications," NUREG/CR-6141, Brookhaven National Laboratory, December 1994.

11 Science and Engineering Associates, Inc., "Calvert Cliffs 1 and 2 Technical Evaluation Report on the Individual Plant Examination Front End Analysis," SEA 92-553-003-A:3, January, 16, 1996.