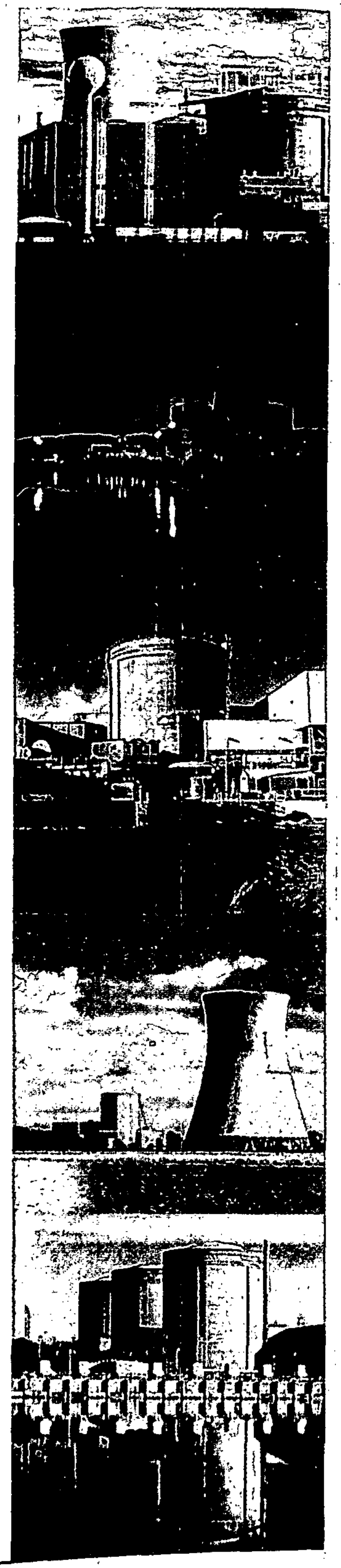
BAW-2461A
October 2007



Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time Change

PWROG
PWR Owners Group

Prepared for
B&W Plants in the PWR Owners Group
By
AREVA NP

AREVA

August 29, 2007

Mr. Gordon Bischoff, Manager
Owners Group Program Management Office
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

SUBJECT: FINAL SAFETY EVALUATION FOR PRESSURIZED WATER REACTOR OWNERS GROUP (PWROG) TOPICAL REPORT BAW-2461, REVISION 0, RISK-INFORMED JUSTIFICATION FOR CONTAINMENT ISOLATION VALVE ALLOWED OUTAGE TIME CHANGE (TAC NO. MC5722)

Dear Mr. Bischoff:

By letter dated January 14, 2005, the PWROG submitted Topical Report (TR) BAW-2461, Revision 0, "Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time [(AOT)] Change," to the U.S. Nuclear Regulatory Commission (NRC) staff. By letter dated May 16, 2007, an NRC draft safety evaluation (SE) regarding our approval of TR BAW-2461 was provided for your review and comments. By letter dated June 19, 2007, the PWROG commented on the draft SE. The NRC staff's disposition of PWROG's comments on the draft SE are discussed in the attachment to the final SE enclosed with this letter.

The NRC staff has found that TR BAW-2461 is acceptable for referencing in licensing applications for the Babcock and Wilcox designed pressurized water reactors listed on page 21 of the enclosed final SE to the extent specified and under the limitations delineated in the TR and in the enclosed final SE. The final SE defines the basis for our acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that PWROG publish accepted proprietary and non-proprietary versions of this TR within three months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed final SE after the title page. Also, they must contain historical review information, including NRC requests for additional information and your responses. The accepted versions shall include an "-A" (designating accepted) following the TR identification symbol.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, the PWROG and/or licensees referencing it will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

Sincerely,

/RA/

Ho K. Nieh, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 694

Enclosure: Final SE

cc w/encl:
Mr. James A. Gresham, Manager
Regulatory Compliance and Plant Licensing
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355
greshaja@westinghouse.com

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Pittsburgh, PA 15230-0355
greshaja@westinghouse.com

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NAME	HCruz	SPeters	DBaxley	HWalker for RDennig	MRubin	SRosenberg	HNieh
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FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT BAW-2461, REVISION 0

"RISK-INFORMED JUSTIFICATION FOR CONTAINMENT ISOLATION VALVE

ALLOWED OUTAGE TIME CHANGE"

PRESSURIZED WATER REACTOR OWNERS GROUP

PROJECT NO. 694

1.0 INTRODUCTION AND BACKGROUND

By letter dated January 14, 2005 (Reference 1), as supplemented by letter dated July 5, 2006 (Reference 2), the former Babcock and Wilcox (B&W) Owners Group, now members of the Pressurized Water Reactor Owners Group (PWROG) submitted risk-informed Topical Report (TR) BAW-2461, Revision 0, "Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time [(AOT)] Change" (Reference 3), for U.S. Nuclear Regulatory Commission (NRC) staff review. The intent of TR BAW-2461 is to support changes to the technical specification (TS) AOT for designated primary containment isolation valves (CIV) by extending the AOT to 168 hours from the current 4 and 72 hours consistent with the acceptance guidelines in Regulatory Guide (RG) 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," dated November 2002 (Reference 4), and RG 1.177, "An Approach for Plant-Specific Risk-Informed Decisionmaking: Technical Specifications," dated August 1998 (Reference 5). The term AOT, as used by TR BAW-2461, is intended to be functionally equivalent to the term "completion time" (CT) as referenced by NUREG-1430, Revision 3, "Standard Technical Specification for Babcock and Wilcox Plants" (Reference 6).

TR BAW-2461 stated that the proposed CT extensions will improve operational safety and reduce unnecessary burden in complying with TS requirements. The extended CTs are also intended to provide additional flexibility in the performance of preventive and corrective maintenance of CIVs in modes 1, 2, 3, and 4, and reduce the potential for plant shutdown and possible plant transients introduced by a mode change evolution. The PWROG CIV CT evaluation concluded that the proposed CT risk impact, using the proposed methodology, is within the acceptance guidelines stated in RG 1.174 and RG 1.177.

1.1 Description of the Proposed Change

The risk-informed evaluation is applicable to penetration flow paths that have at least two CIVs, or one CIV within a closed system. TR BAW-2461 specifically excludes the CIVs in the main steam lines or other CIVs identified on a plant-specific basis to be risk significant for interfacing-system loss-of-coolant accidents (LOCAs). Thus, a plant-specific application of the proposed BAW-2461 methodology may not be found acceptable in all cases.

The proposed change revises the TS for B&W Plants, NUREG-1430, Revision 3, Limiting Condition for Operation (LCO), Section 3.6.3, "Containment Isolation Valves," Conditions A and C to extend the CT for an inoperable CIV. The CT for Condition A is revised from 4 hours to 168 hours. The CT for Condition C is revised from 72 hours to 168 hours. No change is proposed by the PWROG for Condition B (i.e., a penetration flow path with two inoperable CIVs). In support of BAW-2461, the TS Task Force (TSTF) submitted TSTF-498, Revision 0, "Risk-Informed Containment Isolation valve Completion Times (BAW-2461)," by letter dated December 20, 2006, to the NRC. TSTF-498 and the proposed TS revisions are not addressed in this SE. The acceptability of the proposed TSs in TSTF-498 will be addressed in a separate evaluation.

1.2 Related NRC Actions

TR BAW-2461 is not related to or in response to any ongoing NRC activities (e.g., generic letters).

2.0 REGULATORY EVALUATION

The CIVs help ensure that adequate primary containment boundaries are maintained during and after accidents by minimizing potential pathways to the environment and help ensure that the primary containment function assumed in the safety analysis is maintained.

NUREG-1430 states that CIVs form part of the containment pressure boundary and provide a means for fluid penetrations not serving as accident consequence limiting systems (ACLS) to be provided with two isolation barriers that are closed on a containment isolation signal. These isolation devices are either passive or active (i.e., automatic). Manual valves, deactivated automatic valves secured in their closed position (including check valves with flow through the valve secured), blind flanges, and closed systems are considered passive devices. Two barriers in series are provided for each penetration so that no single credible failure or malfunction of an active component can result in a loss of isolation or leakage that exceeds limits assumed in the safety analysis. One of these barriers may be a closed system. These barriers (typically CIVs) make up the containment isolation system.

The containment isolation signal closes automatic CIVs in fluid penetrations not required for operation of engineered safety systems upon receipt of a high containment pressure or diverse containment isolation signal to prevent leakage of radioactive material. Upon actuation of high pressure injection, automatic CIVs also isolate systems not required for containment or reactor coolant system (RCS) heat removal. Other penetrations are isolated by the use of valves in the closed position or blind flanges. As a result, the CIVs (and blind flanges) help ensure that the containment atmosphere will be isolated in the event of a release of radioactive material to containment atmosphere from the RCS following a design-basis accident (DBA). The LCO in the TS ensures that the CIVs will perform their design safety functions to minimize the loss of reactor coolant inventory and establish a containment boundary during an accident. The operability requirements for CIVs help ensure that the containment is isolated within the time limits assumed in the safety analysis.

The DBAs that result in a release of radioactive material within containment are a LOCA, a main steam line break, and a rod ejection accident. In the accident analysis, it is assumed that CIVs are either closed or function to close within the required isolation time following event initiation. This ensures that potential paths to the environment through CIVs (including containment purge valves) are minimized. The safety analysis assumes that the purge valves are closed at event initiation.

2.1 Applicable Regulations

The regulations applicable to the evaluation of TR BAW-2461 include:

Pursuant to Section 50.36 of Title 10 of the *Code of Federal Regulations* (10 CFR) (Reference 7), a licensee's TSs must have surveillance requirements (SRs) relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operations are within safety limits, and that the LCOs will be met. The LCOs are the lowest functional capability, or performance levels, of equipment required for safe operation of the facility. When an LCO of a nuclear reactor is not met, the licensee shall shut down the reactor, or follow any remedial action permitted by the TS until the condition can be met.

Furthermore, the CTs specified in the TSs must be based on reasonable protection of the public health and safety. Therefore, the NRC staff must be able to conclude that there is reasonable assurance that the safety functions affected by the proposed TS CT changes will be performed in accordance with the DBAs identified in Chapter 15 of the licensee's final safety analysis report (FSAR). As set forth in 10 CFR 50.36, a licensee's TS must establish the LCOs that contain certain information. This requirement includes CTs for structures, systems, and components (SSCs) that are required for safe operation of the facility, such as CIVs.

The Maintenance Rule, 10 CFR 50.65, "Requirements for monitoring the effectiveness of maintenance at nuclear power plants," requires licensees to monitor the performance, or condition, of SSCs against licensee-established goals in a manner sufficient to provide reasonable assurance that SSCs are capable of fulfilling their intended functions. The implementation and monitoring program guidance of RG 1.174, Section 2.3, and RG 1.177, Section 3, states that monitoring performed in conformance with the Maintenance Rule can be used when such monitoring is sufficient for the SSCs affected by the risk-informed application. In addition, 10 CFR 50.65(a)(4), as it relates to the proposed CIV CT extension, requires the assessment and management of the increase in risk that may result from the proposed maintenance activity.

Appendix A of 10 CFR Part 50, General Design Criterion (GDC)-35, "Emergency core cooling," requires suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities to assure that the system safety function can be accomplished assuming a single failure.

Appendix A of 10 CFR Part 50, GDC-54, "Piping systems penetrating containment," requires those piping systems that penetrate primary containment be provided with leak detection, isolation, and containment capabilities having redundancy, reliability, and performance capabilities that reflect the importance to safety of isolating these piping systems.

Appendix A of 10 CFR Part 50, GDC-55, "Reactor coolant pressure boundary penetrating containment," requires that each line that is part of the reactor coolant pressure boundary and that penetrates the primary containment shall be provided with CIVs.

Appendix A of 10 CFR Part 50, GDC-56, "Primary containment isolation," requires that each line that connects directly to the containment atmosphere and penetrates the primary reactor containment shall be provided with CIVs.

Appendix A of 10 CFR Part 50, GDC-57, "Closed system isolation valves," requires that each line that penetrates the primary reactor containment and is neither part of the reactor coolant pressure boundary nor connected directly to the containment atmosphere to have at least one CIV that shall be either automatic, or locked closed, or capable of remote manual operation.

Finally, 10 CFR 50.90, "Application for amendment of license or construction permit," addresses the requirements for a licensee desiring to amend its license, which include the TSs.

2.2 Applicable Regulatory Criteria/Guidelines

General guidance for evaluating the technical basis for proposed risk-informed changes is provided in Chapter 19.0, "Use of Probabilistic Risk Assessment (PRA) in Plant-Specific, Risk-Informed Decisionmaking: General Guidance," of the NRC Standard Review Plan (SRP), NUREG-0800 (Reference 8). More specific guidance related to risk-informed TS changes is provided in SRP Section 16.1, "Risk-Informed Decisionmaking: Technical Specifications."

RG 1.174, Revision 1, describes a risk-informed approach, acceptable to the NRC staff, for licensees to assess the nature and impact of proposed permanent licensing basis changes by considering engineering issues and applying risk insights.

RG 1.177 identifies an acceptable risk-informed approach, including additional guidance geared toward the assessment of proposed TS CT changes. Specifically, RG 1.177 identifies a three-tiered approach for the licensee's evaluation of the risk associated with a proposed TS CT change, as described below:

- Tier 1 assesses the risk impact of the proposed change in accordance with acceptance guidelines, as documented in RG 1.174 and RG 1.177. The first tier assesses the impact on operational plant risk based on the change in core damage frequency (ΔCDF) and change in large early release frequency (ΔLERF). It also evaluates plant risk while equipment covered by the proposed CT is out-of-service, as represented by incremental conditional core damage probability (ICCDP) and incremental conditional large early release probability (ICLERP). Tier 1 also addresses PRA quality, including the technical adequacy of the licensee's plant-specific PRA for the subject application. Cumulative risks of the present TS change in light of past (related) applications, or additional applications under review, are also considered.

- Tier 2 identifies and evaluates any potential risk-significant plant equipment outage configurations that could result if equipment, in addition to that associated with the proposed license amendment, is taken out-of-service simultaneously, or if other risk-significant operational factors, such as concurrent system or equipment testing, are also involved. The purpose of this evaluation is to ensure that there are appropriate restrictions in place such that risk-significant plant equipment outage configurations will not occur when equipment associated with the proposed CT is implemented.

- Tier 3 addresses the licensee's overall configuration risk management program (CRMP) to ensure that adequate programs and procedures are in place for identifying risk-significant plant configurations, resulting from maintenance or other operational activities, that may not have been considered when the Tier 2 evaluation was performed and appropriate compensatory measures to avoid such configurations were taken. The CRMP ensures that equipment removed from service prior to, or during, the proposed extended CT will be appropriately assessed from a risk perspective. Compared with Tier 2, Tier 3 provides additional coverage to ensure that risk-significant plant equipment outage configurations are identified in a timely manner, and that the risk impact of out-of-service equipment is appropriately evaluated, prior to performing any maintenance activity over extended periods of plant operation. Tier 3 guidance can be satisfied by the Maintenance Rule (10 CFR 50.65(a)(4)), which requires a licensee to assess and manage the increase in risk that may result from activities such as surveillance testing, and corrective and preventive maintenance. The acceptability of the Maintenance Rule for Tier 3 is subject to the guidance provided in RG 1.177, Section 2.3.7.1, including the technical adequacy of the licensee's Maintenance Rule program and PRA model for the specific application.

RG 1.174 and RG 1.177 also describe risk acceptance guidelines, acceptable implementation strategies, and performance monitoring plans to help ensure that the assumptions and analysis used to support the proposed TS changes will remain valid. The monitoring program should include means to adequately track the performance of equipment that, when degraded, can affect the conclusions of the licensee's evaluation for the proposed licensing basis change.

NUREG-0800, Section 6.2.4, "Containment isolation system," provides deterministic evaluation guidance and acceptance criteria for the review of the containment isolation system.

SRP Section 6.2.4, states that a closed system inside containment can be a containment isolation barrier if it does not communicate with the RCS or containment atmosphere; is protected against missiles and pipe whip; can withstand containment design temperature, structural integrity test pressure, and LOCA transient conditions; and is seismic Category I and Safety Class 2. Similar provisions apply to closed systems outside containment.

3.0 TECHNICAL EVALUATION

The NRC staff has reviewed the analyses in support of the PWROG's original submittal of TR BAW-2461. The evaluation described in this section provides a description of the proposed change, the review methodology used by the NRC staff, the key information used in the review, the applicability of the proposed changes to the regulatory acceptance guidelines, and the NRC staff's findings and conditions.

3.1 Description of the Proposed Change

The following NUREG-1430, Revision 3, LCO 3.6.3 Conditions, Required Actions, and CTs are affected:

- Condition A:

  A new Required Action A.1 is proposed to address common cause failure (CCF), which results in Required Actions A.1 and A.2 being renamed A.2 and A.3.

  The associated CT for Required Action A.1 (now Required Action A.2) is revised from 4 hours to 168 hours.

- Condition C:

  The associated CT for Required Action C.1 is revised from 72 hours to 168 hours.

In addition, new LCO 3.6.3 Conditions, Required Actions, and CTs are proposed for the main steam line CIVs, and additional high-risk CIVs and penetration flow paths with closed systems, as shown in TR BAW-2461.

TR BAW-2461 evaluated valves that have containment isolation functions. The proposed TS changes are applicable to CIV penetrations containing two or more CIVs in series or one CIV within a closed loop system inside containment. The analysis also included CIV maintenance activities that cause the CIV to be inoperable as a pressure boundary and maintenance activities that allow a CIV to remain functional as a pressure boundary. CIVs in the main steam lines are explicitly excluded from the proposed CT extension based on a broader risk impact than containment isolation and were not conducive to the methodology proposed by TR BAW-2461. For CIVs located in a penetration flow path connected to the RCS, there is possibility of an interfacing-system LOCA through exposure of low pressure piping to RCS pressure. The CIVs identified as risk significant for interfacing-system LOCA based on a plant-specific TR BAW-2461 and PRA evaluation (i.e., results are outside the acceptance guidelines for ICCDP and ICLERP) will be specifically identified in the TS with the current CT retained.

Of the conditions identified in LCO 3.6.3, Conditions A and C were evaluated by TR BAW-2461. The risk impact of two CIVs inoperable in a penetration (i.e., Condition B) was not evaluated by TR BAW-2461. The CT for this configuration is generally limited by the LCO to a CT of 1 hour and remains unchanged by the TR. For CIVs in ACLS flow paths, the proposed CT is only applicable to the containment isolation function. An ACLS used for accident mitigation that contain CIVs that also function as containment pressure boundaries were evaluated only with regard to the valve impact on loss of containment isolation. The CT limitations with respect to ACLS function remain unchanged.

3.2 Key Information Used in the Review

Key information used in the NRC staff's review is contained in TR BAW-2461, Chapter 3.0, "Engineering Evaluation," associated Sections 3.2, "Traditional Engineering Evaluation," Section 3.3, "Tier 1: Evaluation of Risk Impact," and Section 3.4, "Tiers 2 and 3: Avoidance of Risk-Significant Plant Configurations and Configuration Risk Management," and Section 3.5, "Maintenance Rule Monitoring Program," of BAW-2461, dated January 2005, as supplemented by PWROG letter dated July 5, 2006, in response to the NRC staff's request for additional information (RAI).

3.3 Comparison Against Regulatory Criteria/Guidelines

In accordance with SRP Chapter 19 and Section 16.1, the NRC staff's evaluation of TR BAW 2461 to extend CIV CTs to 168 hours used the three-tier approach and the five key principles outlined in RGs 1.174 and RG 1.177 and are presented in the following sections.

3.3.1 Traditional Engineering Evaluation

The traditional engineering evaluation addresses Key Principles 1, 2, 3, and 5 of the NRC staff's philosophy of risk-informed decisionmaking, which concerns compliance with current regulations and evaluation of defense in depth, safety margins, and performance measurement strategies.

Key Principle 1: Compliance With Current Regulations

The extended CT proposed by TR BAW-2461 maintains compliance with the TSs. The emergency core cooling system (ECCS) is designed to meet the requirements of 10 CFR 50.46 and GDC-35 of Appendix A to 10 CFR Part 50. Suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities are provided to assure that the system safety function can be accomplished assuming a single active failure. The unavailability of one ECCS train, in addition to one of the injection lines affected by the assumed break, will not compromise the ability of the ECCS to mitigate a design-basis LOCA. Thus, with the inoperability of a single ECCS isolation valve to open, the remaining ECCS train is sufficient to perform the design function of ECCS for mitigating a design-basis LOCA.

The PWROG has evaluated the penetrations associated with the ECCS, which includes portions of the decay heat removal system (DHRS) that serve as a part of ECCS, and their supporting systems, and confirmed that their systems do not contain any containment isolation valves which would close on a containment isolation signal and compromise the safety function of the mitigation system.

The proposed CIV CTs do not affect the design or function of these valves; therefore, compliance with the GDCs is not changed by the proposed CTs. Also, if the basis for extending the CTs is acceptable, then 10 CFR 50.36 will be met by establishing a TS LCO and appropriate SR for the CIVs. The basis in TR BAW-2461 for extending the CIV CTs is risk-informed. The acceptance guidance for accepting CT changes for plants utilizing risk information is discussed in Sections 2.2 and 3.4.2 of this safety evaluation (SE).

Based on the above, the NRC staff finds that the safety function of the ECCS will not be affected by the proposed changes of CIV CT in TSs and thus compliance with current regulations is maintained.

Key Principle 2: Evaluations of Defense in Depth

The extended CT time proposed by TR BAW-2461 results in a small risk impact on containment failure and bypass. Redundancy, independence, and diversity are maintained for the containment isolation system. The balance between prevention, mitigation, and containment integrity are maintained. Defense against CCF was evaluated and no new potential CCF mechanisms were identified. The proposed extended CIV CT does not rely on additional operator actions or an over reliance on programmatic activities. The likelihood of an accident or transient is not impacted. A licensee's CRMP provides a means to identify and limit potentially high risk configurations while a licensee's implementation and monitoring program helps ensure that the TR analysis remains valid for the proposed CIV CT. Based on the above, the NRC staff finds that defense in depth is maintained.

Key Principle 3: Evaluation of Safety Margins

The safety analysis assumptions or inputs to the safety analysis are not impacted by the proposed extended CIV CT. The safety-analysis acceptance criteria, as stated in the updated final safety analysis, are maintained. The plant will be operated and maintained as before. Therefore, the NRC staff finds that adequate safety margins are maintained.

Key Principle 5: Performance Measurement Strategies-Implementation and Monitoring Program

Depending on the penetration's risk significance and the frequency and length of time of the CIV CT, the unavailability of the CIV and the containment isolation function may be impacted. Therefore, a licensee adopting TR BAW-2461 will need to establish an implementation and monitoring program including performance criteria, on a plant-specific basis, consistent with the analysis assumptions and conclusions of the TR. The evaluation of the licensee's implementation and monitoring program is provided in Section 3.4.4 of this SE.

3.3.2 Staff Technical Evaluation (PRA) - Key Principle 4

The proposed change to extend CIV CTs employs a risk-informed approach using risk insights to justify changes to the CIV CTs. The risk metrics ΔCDF, ΔLERF, ICCDP, and ICLERP were used by TR BAW-2461 to estimate the risk impact of the proposed changes and are consistent with the acceptance guidelines of RGs 1.174 and 1.177.

The risk evaluation presented below addresses the NRC staff's philosophy of risk-informed decision making, that if the proposed changes result in a change in risk, then the increase should be small and consistent with the intent of the Commission's Safety Goal Policy Statement.

3.3.3 Description of the Proposed Methodology

The scope of the risk analysis as stated by TR BAW-2461 addresses the following situations:

- Penetrations that must close or stay closed to prevent a large early release following core damage.
- Penetrations that must close or stay closed to prevent loss of RCS inventory and subsequent core damage, and large early release, from an interfacing-system LOCA.
- Penetrations that need to stay open, post-accident, to support an ACLS function, but may need to isolate later in the accident (or upon failure of the ACLS train).

TR BAW-2461 used plant-specific PRA data provided by the participating PWROG utilities. Participating PWROG plants were surveyed to develop a methodology and assumptions that would be applicable to participating licensees. Plant estimates for CDF, initiating events, risk achievement worth (RAW) values, and additional information were collected from each participating licensee. The most limiting PRA parameter estimates from the participating plants were used to evaluate the proposed CIV CT.

In addition, plant-specific CIV failure rate estimates for various valve types and failure modes were also obtained from each participating plant. For each valve type, the median failure rate was selected from the participating plant data for each failure mode. To limit the analysis scope, TR BAW-2461 then selected the highest median failure rate for each failure mode and applied that rate to all valve types. A review of generic data sources indicated that the values selected by TR BAW-2461 are also consistent with these sources.

Since plant-specific PRAs do not necessarily model the CIVs and systems in detail, the PWROG provided specific qualitative and quantitative analyses using simplified models applicable to each penetration flow path proposed for a CT extension. As a result, plant-specific PRA models were not used for the TR BAW-2461 evaluation, except to provide limiting baseline CDF, RAW, common cause beta factor, and component failure rate estimates.

TR BAW-2461 did not credit or screen on penetration flow path line size. In the PWROG RAI response, the PWROG clarified that the methodology assumes that any size penetration flow path will have the potential to contribute to LERF.

The penetration configurations used in TR BAW-2461 are intended to be conservative. The methodology assumed the limiting valve type for each penetration flow path analyzed. No credit was given for ventilation or filtration, to limit the impact of a large early release. The intent by the PWROG was to provide a methodology that would have generic applicability to the participating plants. The NRC staff finds that the applicability and conservatism of the assumptions used in the TR will need to be confirmed on a plant-specific basis. These assumptions should include the acceptance guidelines for RG 1.174 and 1.177

The PWROG included the risk impact of both random pipe failure and CIVs installed in systems with non-seismically qualified piping. The TR BAW-2461 risk assessment for the proposed extended CIV CT during Modes 1, 2, 3, and 4 also included valves in maintenance where the pressure boundary is or is not maintained during the proposed CT.

In addition, TR BAW-2461 evaluated partially opened CIVs, which have the potential to impact ACLS penetrations due to the CIV not meeting its containment isolation function, and possibly not satisfying the ACLS function as well. The PWROG determined that a partially opened CIV may further increase CDF and will impact LERF for the proposed CT extension, due to the delay in isolating the penetration and due to the impact of the degraded mitigation system CDF during the ACLS degraded condition (extended CIV CT). Therefore, the PWROG estimated the increase in LERF by adjusting the CDF based on the loss of the ACLS flow path, in addition to the LERF impact of the inoperable CIV.

For penetration flow paths connected to the RCS, there is potential for CDF to be affected in addition to LERF due to an interfacing-system LOCA. The TR analysis addresses the probability of a failed open CIV penetration flow path from the RCS to the environment.

TR BAW-2461 stated that an interfacing-system LOCA is assumed to lead to core damage and large early release, the effectiveness of mitigation systems besides containment isolation is not considered significant. All failed open penetration flow paths with an RCS connection were assumed to have CDF and LERF contributions. Licensee's incorporating TR BAW-2461 will need to confirm the above assumption for their plant specific implementation of BAW-2461 (i.e., interfacing-system LOCA mitigation is not credited).

3.3.4 Analysis Approach

The CIVs were grouped into general categories as shown below.

- Penetration flow paths connected directly to the RCS.
- Penetration flow paths connected directly with the containment atmosphere.
- Penetration flow paths connected to a closed loop system inside containment.

Additional subgroups in each category identify penetration flow paths that have an ACLS function and ones that do not. Normally closed (NC), and normally open (NO), CIVs and seismic, and non-seismic, configurations were also included in the above categories. TR BAW-2461 also considered non-seismically induced pipe failure and assumed that non-seismic piping fails for a seismic event. The TR failure mode and effects analysis (FMEA) and risk methodology assessed the ICCDP and ICLERP impact using the proposed CIV CT of 168 hours and the 72 hour ACLS CT for CIV configurations that impact an ACLS function.

The TR methodology evaluates single line penetration flow paths that are evaluated separately, or in combination, depending on the penetration flow path configuration. To address additional penetration flow path configurations (parallel valves), or multiple pathways, TR BAW-2461 provides additional guidance to evaluate this risk.

Each penetration CIV flow path category is subdivided into flow path configurations (A thru G) to assess the potential risk of release paths to the outside environment given the inoperable CIV. The CIV penetration flow path category risk result is combined with additional flow path configurations to obtain the overall risk for each penetration flow path ICCDP and ICLERP estimate.

The TR BAW-2461 FMEA, and risk evaluation penetration flow categories, are based on piping type (seismic, non-seismic), the failure mode of the CIVs, normal CIV position, ACLS function, penetration flow path connection (i.e., RCS, containment atmosphere, closed loop) and other criteria. The methodology qualitatively estimates ICCDP and ICLERP for each penetration flow path class description (category) and configuration. The risk impact results are presented in TR BAW-2461, Table 3-3, "FMEA and Risk Calculation for CIV Penetrations" as summarized below.

Class Description 1 - Penetrations Connected to the RCS with no ACLS Function

This category is for penetration flow paths connected to the RCS but with no ACLS function except containment isolation. CIVs, both NC and NO, are considered along with the seismic capability, random failure, and exposure to RCS pressure on the associated piping. The general failure mode addressed by Category 1 is one CIV inoperable and the second CIV failing to close, or remain closed, in an extended CT.

The TR analysis shows that for penetration flow paths with an inoperable CIV and less than two closed valves connected to the RCS, and a low pressure, or environmental, penetration flow path, the estimated risk did not meet the acceptance guidelines for ICCDP and ICLERP as stated by RG 1.177.

The following condition is identified by TR BAW-2461 for this configuration.

- The extended CT will not be applied to CIVs in penetrations connected to the RCS that have two NC CIVs if there are no other valves between the RCS and the environment (i.e., low pressure piping or opening) that may be used for backup isolation and cannot be confirmed closed. In that case, the operable CIV will be verified closed within the original 4-hour CT, thus satisfying the TS Required Action.

  The specific penetrations where this is applicable, or where there is a risk significance for ISLOCA (as determined by the plant-specific risk-informed process including plant-specific LOCA analysis), will be identified on a plant-specific basis prior to implementation of the proposed TS change. They will be listed explicitly in the proposed TS revision, and the current CT will be retained.

Class Description 2 - Penetration Connected to the RCS with an ACLS Function

This category includes penetration flow paths connected to the RCS that have at least two CIVs, an ACLS function, and a containment isolation function. The CIVs are either NC, or NO initially. The general failure mode for this condition is the failure of the second CIV to close with one of the CIVs inoperable and in the proposed extended CT. Since the penetration flow path has an ACLS function, consideration is given to the position of the inoperable CIV. The interfacing-system LOCA risk for this category is considered identical to the above Class 1 non-ACLS configuration with an inoperable CIV. Therefore, the above conditions for Class Description 1 apply for Class 2 as well.

Class Description 3 - Penetrations Connected to Containment Atmosphere with no ACLS Function

This category is for penetration flow paths connected directly to the containment atmosphere with the CIVs providing containment isolation with no ACLS function. The penetration has at least two CIVs. The failure mode addressed by this class is the failure of the second CIV to close, or remain closed, when one of the CIVs is inoperable and in the proposed extended CT.

Class Description 4 - Penetrations Connected to Containment Atmosphere with an ACLS Function

This category is for penetration flow paths connected directly to the containment atmosphere that include an ACLS function and containment isolation. The penetration has at least two CIVs. The CIVs are NO, or NC, or partially open initially. The failure mode considered for this category is the failure of the second CIV to close with a CIV inoperable, and in the proposed extended CT. With an ACLS function, the evaluation considered whether the inoperable CIV is confirmed to be open.

Class Description 5 - Penetrations Connected to a Closed Loop System Inside Containment

This category is for penetration flow paths connected to a closed loop system inside containment with no ACLS function. The closed loop system may interface with the containment atmosphere or the RCS via the steam generators. No ACLS function is assumed for these penetration flow paths, with generally only one CIV and the closed loop acting as the second barrier. Two failure modes are addressed: (1) the failure of the closed loop inside containment with the CIV inoperable and in the proposed extended CT, and (2) the failure of the CIV with the closed loop inside containment inoperable for a pressure boundary not shared with the RCS. The closed loop is considered a second barrier for the analysis and the proposed LCO 3.6.3, TS condition.

Class Description 6 - Penetrations Connected to Closed Loop Systems Inside Containment with an ACLS Function

This category is for CIV penetration flow paths connected to a closed loop system inside containment that also include an ACLS function. The closed loop system can interface with containment atmosphere or the RCS via the steam generators. Two general failure modes were considered: (1) the failure of the closed loop inside containment, given that the CIV is inoperable and in the proposed extended CT; and (2) the CIV is inoperable, given that the pressure boundary of the closed loop inside containment is inoperable for a pressure boundary not shared with the RCS. The closed loop is considered a second CIV for the analysis and the proposed LCO 3.6.3, TS condition.

Overall, the PWROG evaluation concluded that penetration flow paths with direct connection to the containment atmosphere, or closed loop systems inside containment, supported an extended CIV CT and met the RG 1.177 acceptance guidelines for ICCDP and ICLERP. In general, penetration flow paths that connect to the RCS also showed acceptable risk for an extended CIV CT. However, the PWROG analysis for RCS penetration flow paths that connect with low pressure piping outside containment did not result in an acceptable risk impact in all cases due to ISLOCA potential.

3.4 Risk Evaluation

Key Principle 4: Risk Evaluation

The changes proposed by the licensee employ a risk-informed approach using risk insights to justify changes to CIV CTs. The risk metrics ΔCDF, ΔLERF, ICCDP, and ICLERP used by the PWROG to evaluate the impact of the proposed changes are consistent with those presented in RGs 1.174 and 1.177. The evaluation of the TR risk evaluation is provided in the following sections of this SE.

3.4.1 Tier 1: PRA Applicability and Insights

To simplify the analysis, the most limiting plant-specific valve type median failure rate (i.e., fails open, fail closed, fails to remain closed) was selected for use in the analysis. The most limiting plant-specific PRA parameters, including base CDF, from the participating plants were used. The methodology also employed limiting plant-specific RAW values to account for the incremental risk of an ACLS function being out of service.

For the quantitative evaluation of the risk impact of extending the current CIV CT from 4 hours or 72 hours to a proposed duration of 168 hours, the PWROG developed a methodology that organized the various CIV penetrations into categories. These categories were then associated with possible flow path configurations to complete the remainder of the flow path from the RCS or containment atmosphere to the environment. For each defined category and configuration, the PWROG developed generic penetration flow paths to assess at-power risk for the associated penetration flow path CIVs.

The methodology used in TR BAW-2461 is generic, and therefore, each participating licensee requesting a CIV CT extension will need to confirm the applicability of the TR BAW-2461 penetration flow path configuration results to its particular plant. A plant-specific analysis must be performed to ensure the applicability of the TR with respect to penetration configurations and CT risk impact for inoperable CIVs to ensure that the acceptance guidelines of RG 1.174 and 1.177 are met.

The licensee's analysis must be applied to penetrations analyzed in TR BAW-2461. Any additional CIV configurations, CT extensions, or non-bounding risk parameter values not evaluated by TR BAW-2461 should be addressed by plant-specific analyses.

3.4.1.1 PRA Technical Adequacy

The objective of the PRA review is to determine whether the generic-risk assessments used in evaluating the proposed CIV extended CTs were of sufficient scope and detail. The NRC staff reviewed the information provided in TR BAW-2461 and, based on the above discussion, the NRC staff concludes that the PWROG adequately addressed the issue of capability and that the risk analysis was of sufficient scope and detail to estimate the risk measures associated with the proposed CIV extended CTs on a generic basis.

To ensure the applicability of TR BAW-2461 to a licensee's plant, additional information on PRA quality with respect to Tier 3 will be required by licensees addressing the following areas:

1. The plant-specific PRA reasonably reflects the as-built, as-operated, plant.

2. Applicable PRA updates, including individual plant examination (IPE)/individual plant examination of external events (IPEEE), peer reviews, and self assessment findings and modifications.

3. Conclusions of the industry/Nuclear Energy Institute (NEI) peer review and self assessment, including the disposition of significant facts and observations applicable to the proposed CIV extended CTs.

4. PRA quality assurance programs/procedures.

5. PRA adequacy and completeness with respect to evaluating the proposed CIV CT extension risk and applicability to the plant.

3.4.1.2 PRA Insights

The intent of TR BAW-2461 is to provide a generic methodology applicable to participating PWROG plants. The risk impact of extending CIV CTs for various penetration configurations is summarized in Table 3-3 of the TR. The results show that the risk impacts of the proposed CIV CTs are generally within the ICCDP and ICLERP acceptance guidelines of RG 1.177. The PWROG did not specifically address ΔCDF and ΔLERF in TR BAW-2461 regarding the acceptance guidelines of RG 1.174. The PWROG stated that it is not expecting that on-line CIV preventive maintenance will increase with the proposed 168-hour CIV. TR BAW-2461 further stated that the CIV maintenance unavailability will be monitored through the licensee's Maintenance Rule program. To address this, licensee's adopting TR BAW-2461 will need to assess, on a plant-specific basis, the ΔCDF and ΔLERF acceptance guidance of RG 1.174, including the expected frequency of entering the proposed CT and the expected mean CT for CIV maintenance.

To implement TR BAW-2461, it is expected that a licensee would reference Table 3-3 to develop plant-specific CIV penetration flow path configurations consistent with the TR. Once the plant-specific configurations are established, any risk significant penetration flow paths are to be identified and documented by the licensee as not eligible for an extended CIV CT based on flow path or maintenance configuration. A licensee that implements TR BAW-2461, must demonstrate, by plant-specific analyses, the applicability of the TR input parameter assumptions and analysis with respect to its particular plant.

TR BAW-2461, through the PWROG RAI response dated July 5, 2006, adds a TS action to address CCF for like valves within the original 4-hour inoperable CIV CT. The new action is applicable to redundant valves in the same penetration with similar design. This new TS action is to verify that the redundant CIVs are not susceptible to the same CCF mode prior to extending the CT for the inoperable CIV. This is required because the methodology presented in TR BAW-2461 does not specifically consider CCF in the evaluation to extend the CIV CT to 168 hours.

The TR BAW-2461 analysis assumes only one CIV is in maintenance at any one time. While it is not expected that multiple CIVs will be out of service simultaneously during extended CTs, the TR does not preclude the practice. TS LCO 3.6.3, Note 2, allows separate condition entry for each penetration flow path which could result in multiple simultaneous CIV CTs, which is not consistent with the TR analysis. Based on this, a licensee's proposed TS LCO 3.6.3 must limit the cumulative risk impact of multiple failed CIVs. The NRC staff concludes that a CIV in an extended 168-hour CT should be specifically limited by LCO 3.6.3 such that only a single CIV is in an extended CT at any one time. This will ensure that the conclusions of the TR continue to be met (i.e., a single CIV in the proposed extended CT) and will maintain the current LCO 3.6.3 separate condition entry provision.

In addition, the licensee must confirm that its Tier 3 CRMP addresses simultaneous inoperable CIV LCOs (i.e., separate condition entry) such that the cumulative CIV risk, including LERF, are maintained consistent with the assumptions and conclusions of TR BAW-2461.

3.4.1.3 PRA Uncertainty

The parameters used (e.g.,valve failure rates and PRA parameters) were based on limiting participating plant-specific estimates. The valve failure rates were stated as being median values obtained from the participating licensee plant PRA models with the limiting valve type being used in the analysis. The PRA parameters were obtained through a survey of the participating plants, with the limiting values selected. The PWROG, in its RAI response, performed sensitivity studies for the CIV failure rate and the individual system and pipe size group failure rate. For the TR analysis, the PWROG selected the highest generic system and pipe size group failure rate based on EPRI TR-102266.

Based on the TR methodology, penetration flow paths can be shown to be sensitive to pipe failure rates. The PWROG, in its RAI response, demonstrated conservatism in the selection of 100 pipe sections per penetration flow path. The response also showed that using the highest system and pipe size group failure rate shown in the EPRI report would result in an ICLERP value within 5E-8 for these penetration flow paths. It is also noted that there are expected to be a limited number of penetration flow paths in this category and that the pipe failure rate used in the analysis was based on the worst-case, generic pressurized water reactor (PWR) system and pipe size group.

To evaluate the impact of valve failure rates on the analysis, the PWROG increased the valve failure rates by a factor of 2. The increased valve failure rates did not change the conclusions of TR BAW-2461, except for configurations associated with Category 1.4, and Configurations E, F, and G. For Configuration E, the ICLERP increased from 3.6E-8 to 8.0E-8 and for Configurations F and G, ICLERP increased from 3.3E-8 to 6.6E-8. The ICLERP estimates are greater than the RG 1.177 acceptance guidance of 5E-8 for Category 1.4, Configurations E, F, and G. For the listed penetration flow path configurations, ICLERP is impacted by pipe failures caused by a seismic event and the operable CIV failing to close. The PWROG RAI response stated that there are few, if any, penetration flow paths that will meet this category. In addition, the PRA parameters for these configurations were limiting, based on plant-data, and the pipe failure rates are expected to be conservative, based on the system and pipe size group number and associated number of pipe sections selected.

As a further check, the NRC staff reviewed NUREG-1715, Volume 3, "Component performance study-Air-Operated Valves, 1987-1998," and Volume 4, "Component Performance Study-Motor-Operated Valves, 1987-1998 Commercial Power Reactors" (Reference 9), data for motor-operated and air operated valve failures. Although limited to motor-operated and air operated valves, the data presented in NUREG-1715 shows that the CIV failure probability estimates used by TR BAW-2461 are consistent with the failure rates given in NUREG-1715. NUREG-1715 also indicated a statistically significant decreasing trend for both motor-operated and air-operated valve failures on demand on a per fiscal year basis for risk important systems.

Based on the above, a licensee implementing TR BAW-2461 will need to confirm the above penetration results on a plant-specific basis, such that the proposed CIV CT risk remains within the acceptance guidance of RG 1.177 and 1.174 and the analysis conclusions of TR BAW-2461 for the plant-specific case.

3.4.1.4 External Events

Seismic Events

The impact of a seismic event is included in the TR CIV risk estimates with respect to non-seismic pipe failures in penetration flow paths. No credit is given for non-seismic pipe in a seismic event. Non-seismically qualified piping is assumed to always fail during a seismic event. The seismic initiating event frequency and seismic CDF used in the TR BAW-2461 must be verified as bounding for the plant-specific case, or plant-specific information, used. For plants that used a seismic-margin analysis, a quantitative assessment of seismic CDF is not considered in the TR limiting seismic CDF estimate. Therefore, each licensee will need to confirm that the seismic CDF referenced for TR BAW-2461 is bounding for its plant, or incorporate a plant-specific seismic CDF estimate. In addition, the seismic initiating event frequency will need to be defined and justified for each licensee implementing TR BAW-2461.

Additional seismic risk may contribute to the CIV risk estimates. For example, licensee's should confirm that seismic induced relay chatter (spurious CIV actuation - USI A46) or seismic commitments/analysis/assumptions from the IPEEE have been resolved. Conclusions with regard to containment performance (i.e, containment isolation including relay chatter) should be confirmed with respect to the proposed 168-hour CIV CT.

Fire and High Winds, Floods, and Other External Events

TR BAW-2461 considered the contribution of fire/high winds and other (HFO) external events with respect to the proposed CIV CT to be a small risk contributor compared to the failure probability of the operable CIV. TR BAW-2461 based this conclusion on the probability of an internal fire or external events occurring during the proposed CIV CT being sufficiently small. However, the NRC staff is concerned that fire and external event risk may not be sufficiently small with respect to the proposed 168-hour CIV CT.

A review of the Crystal River, Davis Besse, and Oconee IPEEE shows that CDF contribution from fire risk for each plant is as follows:

- Crystal River, Unit 3- Fire CDF contribution estimated at 4E-5/year.
- Davis Besse- Fire CDF contribution estimated at 2.5E-5/year.
- Oconee, Units 1, 2, and 3- Fire CDF contribution estimated at 5.0E-6/year.

A review of HFO events shows that the above licensees generally used a screening approach and, therefore, did not quantitatively estimate a CDF contribution from HFO events. However, HFO events, in some cases, (Oconee, Units 1, 2, and 3 for example) can contribute significantly to overall CDF.

Although TR BAW-2461 assumes the risk from external events to be insignificant with respect to the proposed CIV extended CT, the TR assumes only the internal plant CDF in the analysis. For some participating plants, internal fires and other external event risk may contribute significantly to overall plant baseline risk, which may impact the TR methodology results such that a plant-specific application of the TR BAW-2461 methodology may not be found acceptable in all cases.

In addition, RG 1.174, Section 2.2.5.5, "Comparisons With Acceptance Guidelines," states that for very small increases of CDF and LERF, as shown in Region III, Figures 3 and 4 of RG 1.174, a detailed quantitative assessment of baseline risk (internal and external events) is not necessary and the change in risk would be considered regardless of whether there is a calculation of the total baseline risk. There is no requirement to calculate the total baseline risk. However, if there is an indication that the risk may be considerably higher than 1E-4/reactor-year for CDF (or 1E-5/reactor-year for LERF), then the focus should be on finding ways to decrease rather than increase the risk.

Therefore, the potential for external events should be assumed credible during the extended CIV, and licensees implementing TR BAW-2461 must demonstrate that external event risk, including fire, by either quantitative or qualitative means, will not have an adverse impact on the conclusions of the plant-specific application of TR BAW-2461. Specifically: (1) the risk from external events cannot make the total baseline risk exceed 1E-4/yr CDF, or 1E-5/yr LERF, without justification, (2) the risk from external events (i.e., high winds, floods and other) should be specifically evaluated with respect to the extended CIV CT, and (3) fire risk should be specifically addressed.

3.4.1.5 Cumulative Risk

With respect to past plant-specific license amendments or additional plant-specific applications for a TS change under NRC review that have not been incorporated into the baseline PRA used to evaluate the proposed change, the cumulative risk must be evaluated on a plant-specific basis consistent with the guidance given in RG 1.174, Sections 2.2.6 and 3.3.2, and addressed in a licensee's plant-specific application.

3.4.1.6 Transition and Shutdown Risk (CIV extended CT)

TR BAW-2461 did not provide a specific assessment of transition risk, although TR BAW-2461 qualitatively discusses transition risk as a potential reason to extend a CIV CT. The NRC staff notes that the additional benefit to transition risk would only occur when unscheduled corrective maintenance could not be completed within the proposed TS CT. For failures occurring during surveillance, transition risk should be considered, but this should have a limited impact on the analysis. The proposed extended CIV CTs may provide additional flexibility in the performance of preventive and corrective maintenance during power operation, including a reduced potential for plant shutdown and possible plant transients introduced by this reactor mode change. With respect to the proposed extended CIV CT, the transition risk averted may provide a qualitative risk benefit, but is not credited or quantified in the risk evaluation performed by TR BAW-2461.

3.4.2 Tier 2: Avoidance of Risk-Significant Plant Configurations

For the Tier 2 analysis, a licensee must provide reasonable assurance that risk significant plant equipment outage configurations will not occur when specific plant equipment is out of service, in accordance with the proposed TS change. A Tier 2 program is intended to limit the degradation of plant mitigation capabilities with a CIV out of service (LCO condition), such that defense in depth is maintained. The TR BAW-2461 evaluation identified generic Tier 2 conditions as a result of the proposed CT extension for CIVs beyond those already identified by the TSs, such as the redundant CIV on the same penetration, support systems, additional equipment taken out of service, or equipment credited in the CIV CT evaluation.

TR BAW-2461 also stated that CIVs subject to CCF evaluations are to be documented on a plant-specific basis by licensees since the analysis performed by the TR assumed that no CIV CCF would be present upon entering the extended CIV CT. Additionally, TR BAW-2461 is not applicable to the main steam lines. Furthermore, certain other lines, identified as risk-significant configurations with respect to interfacing-system LOCA, are excluded from TR BAW-2461. These lines will be identified by licensees on a plant-specific basis when implementing TR BAW-2461. For licensees adopting TR BAW-2461, a plant-specific evaluation should be performed specific to Tier 2 with confirmation that the TR is applicable to their plant.

3.4.3 Tier 3: Risk-Informed Configuration Risk Management

A Tier 3 program ensures that while a CIV is inoperable, additional activities will not be performed that could further degrade the capability of the plant to respond to a condition the inoperable CIV or system was designed to mitigate and, therefore, increase plant risk beyond that assumed by TR BAW-2461. Tier 3 programs: (1) ensure that additional maintenance does not increase the likelihood of an initiating event intended to be mitigated by the out-of-service equipment, (2) evaluate the effects of additional equipment out of service during CIV maintenance activities that would adversely impact CIV CT risk, such as from redundant systems or components, and (3) evaluate the impact of maintenance on equipment or systems assumed to remain operable by the CIV CT TR BAW-2461 analysis.

Accordingly, a licensee should develop a program to ensure that it appropriately evaluates the risk impact of out-of-service equipment before performing a maintenance activity. Licensees can utilize the overall CRMP (as referenced in RG 1.177) through the Maintenance Rule (10 CFR 50.65(a)(4)) if the PRA risk assessment quality aspects of this program meet the quality needs of a risk-informed licensing action. Specifically, the rule requires that, before performing any maintenance activity, the licensee must assess and manage the potential risk increase that may result from a proposed maintenance activity. Therefore, a licensee's submittal must include a discussion on: (1) the licensee's CRMP for assessing the risk associated with removal of CIVs from service and (2) their conformance to the requirements of 10 CFR 50.65(a)(4), and the additions and clarifications outlined in Section 2.3.7.2 of RG 1.177, as they relate to the proposed CIV CTs.

TR BAW-2461 stated that a licensee's CRMP will ensure that:

- No action or maintenance activity is performed that will remove equipment that is functionally redundant to the inoperable CIV, including the redundant CIVs on the same penetration and support systems for the redundant CIV.

- No action or maintenance activity is performed that will significantly increase the likelihood of challenge to the CIVs. Challenges to the CIVs include DBAs that result in a release of radioactive material within containment (LOCA, main steam line break, and rod ejection accident). Another challenge to the CIVs is the removal of equipment from service that may cause a significant increase in the likelihood of core damage while in the proposed CT, which may in turn increase the large early release via the inoperable CIV.

- No action or maintenance activity is performed that will remove equipment that supports success paths credited in the CT risk evaluation. This includes the other series valves, if any, credited in the risk assessment for RCS penetrations that otherwise would be at risk significant for interfacing-system LOCA.

NUREG-1430 allows multiple simultaneous condition entries (TS 3.6.3, NOTE 2, "Separate condition entry is allowed for each penetration flow path") for LCO 3.6.3, but not for multiple CIVs associated with the same flow path (i.e., multiple inoperable CIVs in the same flow path are limited by TS 3.6.3). However, multiple LCO 3.6.3 entries for single inoperable CIVs in multiple penetrations would result in CDF, LERF, ICCDP, and ICLERP estimates which are greater than those assumed in TR BAW-2461. Simultaneous multiple TS entries and the subsequent impact on risk were not specifically evaluated by the TR.

CTs, as implemented per the NRC staff findings and conditions of this SE, including limiting an extended CIV CT to a single LCO entry at any one time, and the maintenance rule (10 CFR 50.65(a)(4)) are intended to limit the overall risk associated with extended CIV CT interval maintenance. Because a CRMP does not typically include the containment isolation function, and plant PRAs do not model all the CIVs, participating licensees adopting TR BAW-2461 must include CIV plant-specific Tier 3 information in their plant-specific submittals regarding the estimation of ΔCDF, ΔLERF, ICCDP, and ICLERP within their respective CRMP.

Therefore, CIV maintenance including multiple simultaneous LCO entries for single inoperative CIVs in multiple penetrations must be evaluated on a plant-specific basis to ensure that the TR BAW-2461 conclusions, including risk estimates of ΔCDF, ΔLERF, ICCDP, and ICLERP are reasonable when implementing the proposed CIV CTs.

3.4.4 Implementation and Monitoring Program

RG 1.174 and RG 1.177 also establish the need for an implementation and monitoring program to ensure that extensions to TS CTs do not degrade operational safety over time and that no adverse degradation occurs due to unanticipated degradation or CCF mechanisms. An implementation and monitoring program is intended to ensure that the impact of the proposed TS change continues to reflect the reliability and availability of SSCs impacted by the change. With respect to the proposed CIV CT, the application of the three-tiered approach in evaluating the proposed CIV CTs provides additional assurance that the changes will not significantly impact the key principle of defense in depth.

An implementation and monitoring plan should ensure CIV reliability and availability remains consistent with (or bounded by) the CIVs performance assumed for the proposed CIV CT extension and that the containment isolation function has not been adversely impacted. RG 1.174 states that monitoring performed in conformance with the maintenance rule of 10 CFR 50.65 can be used when such monitoring is sufficient for the SSCs affected by the risk-informed application. TR BAW-2461 is based on generic-plant characteristics, therefore, each licensee adopting TR BAW-2461 must confirm plant-specific implementation and monitoring of CIVs in accordance with the guidance of RG 1.174 and RG 1.177 in its individual submittals.

TR BAW-2461 and the PWROG, in their RAI response, stated that to ensure that plant risk is not adversely impacted by the proposed change, licensee's will establish performance criteria and track maintenance unavailability for the containment isolation system under the maintenance rule program, 10 CFR 50.65.

3.5 Comparison With Regulatory Guidance

The proposed change to provide an extended CIV CT meets the acceptance guidance of RGs 1.174 and 1.177 and the guidance outlined in Chapter 19.0 and Section 16.1 of NUREG-0800. The proposed CIV CTs do not affect the design or function of these valves; therefore, compliance with the referenced GDCs is not changed by the proposed CTs. Also, with the basis for extending the CTs shown to be acceptable, then 10 CFR 50.36 is also met.

3.6 TR BAW-2461 Revisions

1. TR BAW-2461, Table 2-1 will be revised to add an LCO Required Action to address CCF in the redundant CIV.

2. To clarify the PWROG intent of TR BAW-2461, the option to screen penetration line sizes and thresholds in estimating LERF impact is removed from TR BAW-2461. The last two sentences in Assumption 3, Section 3.3.2 are deleted and replaced with the following:

   > Therefore, a conservative estimate of cumulative LERF risk for multiple penetrations in the LCO simultaneously can be determined by combining the ICLERP probabilities alone, without regard for cumulative line size.

3. Change bullet on page 3-30 to read:

   "The extended AOT will not be applied to CIVs in penetrations connected to the RCS that have two NC CIVs if there are no other valves between the RCS and the environment (i.e., low pressure piping, or opening) that may be used for backup isolation. In that case, the operable CIV will be verified closed within the original 4-hour AOT, thus satisfying the TS Required Action."

   Similar changes are also proposed for bullets on pages 3-41 and 4-2 of TR BAW-2461.

4. Add the following bullet in Section 4.3 of TR BAW-2461:

   "If the extended AOT is applied to an RCS penetration that has two NC CIVs, then when entering the AOT, confirm that there is at least one other closed valve between the RCS and any low pressure piping or opening."

5. Revise the first bullet on page 3-43, from "Supports for" to "support system."

4.0 <u>LIMITATIONS AND CONDITIONS</u>

4.1 Staff Findings and Conditions and Limitations

The results presented in TR BAW-2461 are consistent with the acceptance guidelines given in RGs 1.177 and 1.174 and show a small increase in plant risk due to the extension of a CIV CT to 168 hours. This conclusion is predicated on adopting TR BAW-2461 in a manner consistent with the NRC staff's SE and the guidelines and assumptions identified in TR BAW-2461. In addition, the NRC staff's approval of this TR is subject to the following limitations and conditions:

1. Based on TR BAW-2461, the CIV methodology, PRA parameters, configurations, and data used to evaluate an extended CIV CT to 168 hours is limited to the following plants.

   - Davis-Besse
   - Oconee Units 1, 2, and 3
   - Crystal River 3

   Other licensees of B&W designed PWRs requesting to use the TR methodology must provide the same level of information provided by these demonstration plants to ensure that TR BAW-2461 is applicable to their plant.

2. Because not all penetrations have the same impact on ΔCDF, ΔLERF, ICCDP, or ICLERP, verify the applicability of TR BAW-2461 to the specific plant, including verification that: (a) the CIV configurations for the specific plant match the configurations in TR BAW-2461, and (b) the risk-parameter values used in TR BAW-2461, including the sensitivity studies contained in the RAIs, are representative or bounding for the specific plant. Any additional CIV configurations, CT extensions, or non-bounding risk parameter values not evaluated by TR BAW-2461 should be addressed in the plant-specific analyses. [Note that CIV configurations and extended CTs not specifically evaluated by TR BAW-2461, or non-bounding risk parameter values outside the scope of the TR, will require NRC staff review and licensee development of the specific penetrations and related justifications for the proposed CTs].

3. Each licensee adopting TR BAW-2461 will need to confirm that the plant-specific risk assessment including both internal and external events is within the assumptions of TR BAW-2461 and the acceptance guidelines of RG 1.174 and 1.177. The licensee's application verifies that external event risk, including seismic, fires, floods, and high winds, either through quantitative or qualitative evaluation, is shown to not have an adverse impact on the conclusions of the plant-specific analysis for extending the CIV CTs. Specifically: (1) the risk from external events cannot make the total baseline risk exceed 1E-4/yr CDF, or 1E-5/yr LERF, without justification, (2) the risk from external events (i.e., high winds, floods and other) should be specifically evaluated with respect to the extended CIV CT, and (3) fire risk should be specifically addressed. The evaluation should include fire-induced spurious actuation (including containment performance) with respect to the proposed 168-hour CIV CT.

   Additionally, each licensee will need to confirm that the seismic CDF referenced for TR BAW-2461 is bounding for its plant, or incorporate a plant-specific seismic CDF estimate. Furthermore, the seismic initiating event frequency will need to be defined and justified for each licensee implementing TR BAW-2461. See Section 3.4.1.4 of this SE.

4. For licensees adopting TR BAW-2461, confirmation should be provided that the Tier 2 and Tier 3 conclusions of the TR are applicable to the licensee's plant and that plant-specific Tier 2 evaluations including CCF and risk-significant configurations including interfacing-system LOCA have been evaluated and included under Tier 2 and Tier 3 including the CRMP as applicable.

- The proposed 168-hour CIV CT will not be applied to CIVs in penetrations connected to the RCS that have two NC CIVs if there are no other valves between the RCS and the environment (i.e., low pressure piping, or opening) that may be used for backup isolation and cannot be confirmed closed. In that case, the operable CIV will be verified closed within the original 4-hour CT, thus satisfying the TS Required Action. See Section 3.3.4 of this SE.

  The specific penetrations where this is applicable or where interfacing-system LOCA is shown to be risk-significant (as determined by the plant-specific risk-informed process including plant-specific LOCA analysis) will be identified on a plant-specific basis prior to implementation of the proposed TS change. They will be listed explicitly in the proposed TS revision and the current CT will be retained.

  TR BAW-2461 stated that an interfacing-system LOCA is assumed to lead to core damage and large early release, the effectiveness of mitigation systems besides containment isolation is not considered significant. All failed open penetration flow paths with an RCS connection were assumed to have CDF and LERF contributions in TR BAW-2461. Licensees incorporating TR BAW-2461 will need to confirm the above assumption for their plant specific implementation of BAW-2461.

- The specific penetrations with CCF potential will be identified by the licensee on a plant-specific basis. Upon entry into TS LCO 3.6.3, Condition A, the utility will confirm that the redundant similarly-designed CIV has not been affected by the same failure mode as the inoperable CIV. This verification will be performed before entering into the extended portion of the CT (i.e., within 4 hours). The specific penetrations with CCF potential will be identified on a plant-specific basis and listed in a plant-specific TS document or other administrative source. See Section 3.4.1.2 of this SE.

- No action or maintenance activity is performed that will remove equipment that is functionally redundant to the inoperable CIV, including the redundant CIV(s) on the same penetration and support systems for the redundant CIV. See Section 3.3 of TR BAW-2461.

- No action or maintenance activity is performed that will significantly increase the likelihood of challenge to the CIVs. Challenges to the CIVs include DBAs that result in a release of radioactive material within containment (LOCA, main steam line break, and rod ejection accident). Also included is the removal of equipment from service that may cause a significant increase in the likelihood of core damage while in the proposed CT, which may increase the large early release via the inoperable CIV. See Section 3.4 of TR BAW-2461.

- No action or maintenance activity is performed that will remove equipment that supports success paths credited in the CT risk evaluation. This includes the other series valves, if any, credited in the risk assessment for RCS penetrations that otherwise would be risk-significant (i.e., interfacing-system LOCA). See Section 3.4 of TR BAW-2461.

5. TR BAW-2461 was based on generic-plant characteristics. Each licensee adopting TR BAW-2461 must confirm plant-specific Tier 3 information in their individual submittals. The licensee must discuss conformance to the requirements of the maintenance rule (10 CFR 50.65(a)(4)), as they relate to the proposed CIV CTs and the guidance contained in NUMARC 93.01, Section 11, as endorsed by RG 1.182, including verification that the licensee's maintenance rule program, with respect to CIVs, includes a LERF/ICLERP assessment (i.e., CRMP). See Section 3.4.3 of this SE.

6. TS LCO 3.6.3 Note 2 allows separate condition entry for each penetration flow path. Therefore, each licensee adopting TR BAW-2461 will address the simultaneous LCO entry of an inoperable CIV in separate penetration flow paths such that the proposed 168-hour CIV CT LCO will be limited to no more than one CIV at any given time. In addition, the licensee must confirm that its Tier 3 CRMP addresses simultaneous inoperable CIV LCOs (i.e., separate condition entry) such that the cumulative CIV risk, including LERF, are maintained consistent with the assumptions and conclusions of TR BAW-2461. See Section 3.4.1.2 of this SE.

7. The licensee shall verify that the plant-specific PRA quality is acceptable with respect to its use for Tier 3 for this application in accordance with the guidelines given in RG 1.174 and as discussed in Section 3.4.1.1 of this SE.

8. With respect to past plant-specific license amendments or additional plant-specific applications for a TS change under NRC review that have not been incorporated into the baseline PRA used to evaluate the proposed change, the cumulative risk must be evaluated on a plant-specific basis consistent with the guidance given in RG 1.174, Section 2.2.6 and 3.3.2, and addressed in a licensee's plant-specific application. See Section 3.4.1.5 of this SE.

9. Closed systems inside and outside containment, which are considered to be containment isolation barriers, must meet the provisions outlined in NUREG-0800, Section 6.2.4, "Containment Isolation System." See Section 2.2 of this SE.

10. With an extended CIV CT, the possibility exists that the CIV unavailability will be impacted. Depending on the penetration risk significance and the frequency and length of time of the CIV CT, the unavailability of the containment isolation function may also be impacted. Therefore, licensee's adopting TR BAW-2461 will need to establish an implementation and monitoring program for CIVs, including performance criteria, on a plant-specific basis. See Sections 3.4.1.2 and 3.4.4 of this SE.

11. The PWROG did not specifically address ΔCDF and ΔLERF in TR BAW-2461 regarding the acceptance guidelines of RG 1.174. The PWROG stated that it is not expecting that on line CIV preventive maintenance will increase with the proposed 168-hour CIV. To

address this, licensee's adopting TR BAW-2461 will need to assess, on a plant-specific basis, the ΔCDF and ΔLERF acceptance guidance of RG 1.174 including the expected frequency of entering the proposed CT and the expected mean CT for CIV maintenance. See Section 3.4.1.2 of this SE.

4.2 Regulatory Commitment

The RG 1.177 Tier 3 program ensures that while a CIV is in an LCO condition, additional activities will not be performed that could further degrade the capabilities of the plant to respond to a condition for which the inoperable CIV or system was designed to mitigate, and as a result, increase plant risk beyond that assumed by the TR BAW-2461 analysis. A licensee's *implementation of RG 1.177 Tier 3 guidelines generally implies the assessment of risk with* respect to CDF. However, the proposed CIV CT impacts containment isolation and consequently LERF and ICLERP, as well as CDF. Because the extended CIV CTs are also based on the LERF and ICLERP metrics, the management of risk in accordance with 10 CFR 50.65(a)(4) for these extended CIV CTs must also assess LERF and ICLERP.

Therefore, a licensee's CRMP, including those implemented under the maintenance rule of 10 CFR 50.65(a)(4), must describe how LERF/ICLERP is assessed as well as demonstrating PRA quality as part of the licensee's Tier 2 and Tier 3 assessment. Since NUMARC 93-01 implements ICLERP as the quantitative risk metric (i.e., based on a zero maintenance model), and RG 1.177 utilizes ICLERP (i.e., based on an average maintenance model), the licensees, in their implementation of TR BAW-2461 will need to demonstrate the equivalence for Tier 3 decisionmaking. The methodology for assessing LERF and ICLERP are to be documented in the plant-specific application as a regulatory commitment (i.e., included in the licensee's commitment tracking system in accordance with NEI 99-04, Revision 0, "Guidelines for Managing NRC Commitment Changes") (Reference 10) in the licensees' plant-specific applications referencing TR BAW-2461.

The NRC staff finds that reasonable controls for the implementation and for subsequent evaluation of proposed changes pertaining to regulatory commitment(s) can be provided by the licensees' administrative processes, including their commitment management program. The NRC staff has agreed that NEI 99-04 provides reasonable guidance for the control of regulatory commitments made to the NRC staff (see Regulatory Issue Summary 2000-17, "Managing Regulatory Commitments Made by Power Reactor Licensees to the NRC Staff," dated September 21, 2000). The NRC staff notes that this establishes a voluntary reporting system for the operating data that is similar to the system established for the reactor oversight process performance indicators program. The commitments would be controlled in accordance with the industry guidance or comparable criteria employed by a specific licensee. The NRC staff may choose to verify the implementation and maintenance of these commitments in a future inspection or audit. Should licensees choose to incorporate a regulatory commitment into the final safety analysis report or other document with established regulatory controls, the associated regulations would define the appropriate change-control and reporting requirements.

5.0 CONCLUSION

The risk impact of the proposed 168-hour CT for a CIV as estimated by ΔCDF, ΔLERF, ICCDP, and ICLERP, is consistent with the acceptance guidelines specified in RG 1.174, RG 1.177, and NRC staff guidance outlined in Chapter 16.1 of NUREG-0800. The NRC staff finds that the risk analysis methodology and approach used by the PWROG to estimate the CIV CT risk impacts were reasonable and of sufficient quality for the intended application. However, to be within these guidelines, some CIVs may not qualify for the proposed CT. Specifically, CIVs located in the main steam lines are excluded on a generic basis. In addition, CIVs found to be risk significant with respect to interfacing-system LOCA will be identified and excluded on a plant-specific basis. Thus, plant-specific application of the proposed methodology may not support an increased CT for all CIV configurations addressed by TR BAW-2461.

Although TR BAW-2461 identified generic guidance in implementing the TR, the Tier 2 evaluation did not identify plant-specific risk-significant plant equipment configurations requiring TSs, procedures, or compensatory measures. Therefore, a plant-specific Tier 2 analysis must be done for plants adopting TR BAW-2461 to confirm or adjust this aspect of the evaluation, as appropriate.

TR BAW-2461 references a CRMP (Tier 3) using 10 CFR 50.65(a)(4) to manage plant risk when CIVs are taken out of service. CIV availability will also be monitored and assessed under the maintenance rule (10 CFR 50.65) to confirm that performance continues to be consistent with the analysis assumptions used to justify the proposed 168-hour CIV CT. Based on the above, and contingent on the licensee adequately addressing the SE conditions and limitations and regulatory commitment as part of the basis of a risk-informed application, the NRC staff finds the proposed 168-hour CT acceptable for the CIVs evaluated in TR BAW-2461 pending that each plant submit a risk-informed assessment showing that the guidelines identified in TR BAW-2461 are satisfied.

6.0 REFERENCES

1. The B&W Owners Group, "Request for Approval of BAW-2461, Revision 0, 'Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time Change,'"January 14, 2005, Accession No. ML051600236.

2. PWR Owners Group, "Responses to NRC Request for Additional Information Regarding the Review of BAW-2461, 'Risk Informed Justification for Containment Isolation Valve Allowed Outage Time Change,'" July 5, 2006, Accession No. ML061880299.

3. B&W Owners Group, Topical Report BAW-2461, "Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time Change," Accession No. ML071090548.

4. U.S. Nuclear Regulatory Commission, RG 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," November 2002.

5. U.S. Nuclear Regulatory Commission, RG 1.177, "An Approach for Plant-Specific, Risk-Informed Decisionmaking: Technical Specifications," August 1998.

6. U.S. Nuclear Regulatory Commission, NUREG-1430, "Standard Technical Specifications - Babcock and Wilcox Plants," June 2004.

7. U.S. *Code of Federal Regulations*, "Domestic Licensing of Production and Utilization Facilities," Part 50, Title 10, "Energy."

8. U.S. Nuclear Regulatory Commission, NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, June 1987.

9. U.S. Nuclear Regulatory Commission, NUREG-1715, Accession Nos. ML011800236 and ML012630199.

10. Nuclear Energy Institute 99-04, Revision 0, "Guidelines for Managing NRC Commitment Changes," July 1999.

Attachment: Resolution of Comments

Principle Contributor: C. Doutt

Date: August 29, 2007

RESOLUTION OF COMMENTS ON DRAFT SAFETY EVALUATION FOR

PRESSURIZED WATER REACTOR OWNERS GROUP (PWROG)

TOPICAL REPORT (TR) BAW-2461, REVISION 0, "RISK-INFORMED JUSTIFICATION

FOR CONTAINMENT ISOLATION VALVE ALLOWED OUTAGE TIME CHANGE"

By letter dated January 14, 2005, as supplemented by letter dated July 5, 2006, the former Babcock and Wilcox (B&W) Owners Group, now members of the Pressurized Water Reactor Owners Group (PWROG) submitted risk-informed TR BAW-2461, Revision 0, "Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time [(AOT)] Change", for U.S. Nuclear Regulatory Commission (NRC) staff review. This Appendix provides the NRC staff's review and disposition of the comments made by the PWROG in its June 19, 2007, letter.

PWROG General Comment

On Page 2-2, Table 2-1, "Summary of Proposed Technical Specifications Change," is modified by Footnote 1 which states, "Markup is for illustration only and is based upon NUREG-1430 (some notes have been removed from the table for simplification). See applicable plant-specific TS, NUREG-1430, and/or Technical Specifications Task Force Traveler (TSTF) for specific wording. TSTF-498, "Risk-Informed Containment Isolation Valve Completion Times (BAW-2461)," was submitted to the NRC on December 22, 2006. The NRC provided an acceptance and review schedule letter on March 1, 2007 (ADAMS [Agencywide Documents Access and Management System] ACCESSION NO: ML070510680).

Despite the disclaimer in the Topical Report and the NRC's acknowledgment of receipt and acceptance of a corresponding TSTF Traveler, the draft Safety Evaluation (SE) references the superseded example specifications in BAW-2461 which, in many instances, are different from the proposed TS changes in TSTF-498. This creates a conflict between the proposed SE and the proposed TS to implement BAW-2461. The SE should be revised, as described below, to reference TSTF-498 and to reflect the wording proposed in TSTF-498 instead of the superseded example TS wording in BAW-2461. The NRC should also consider addressing TSTF-498 in the SE for BAW-2461 instead of the unnecessary duplication of creating a separate SE for TSTF-498 after approving BAW-2461.

NRC Response

The NRC staff has modified the SE to reference TSTF-498. However, the NRC staff's SE will not be revised to reflect the TSs contained within TSTF-498. The NRC staff's TR reviews are based upon the information contained within the TR. TR BAW-2461 does not currently use the TSTF-498 TSs, therefore, the NRC staff's SE for TR BAW-2461 similarly will not reflect the TSTF-498 TSs.

ATTACHMENT

Furthermore, given that the NRC staff's goal is to complete all TR evaluations within 3 years, the submittal of TSTF-498 nearly 2 years into the review of the TR did not provide an adequate review time to combine the SEs of both TSTF-498 and TR BAW-2461. Therefore, the NRC staff will not reflect the TSTF-498 TSs within its SE. The NRC staff will evaluate these TSs within its TSTF-498 review.

PWROG Comment 2 (Page 2, Line Number 6)

Add the following. "The example technical specifications shown in BAW-2461, Table 2-1, "Summary of Proposed Technical Specifications Change," have been superseded by the proposed Technical Specification changes in TSTF-498, Revision 0, "Risk-Informed Containment Isolation Valve Completion Times (BAW-2461)" (Reference X). The cited reference should be ADAMS Accession No. ML063560402.

NRC Response

The NRC staff does not agree with this comment. See the NRC Response to the PWROG General Comment above.

PWROG Comment 3 (Page 5, Line Numbers 46-49)

The quote should be revised to be consistent with the Note in TSTF-498.

NRC Response

The Note has been removed. Otherwise see the NRC Response to the PWROG General Comment above.

PWROG Comment 4 (Page 5, Section 3.1)

The wording of the NOTE for Condition A is not consistent with the wording used in TSTF-498, Rev. 0.

NRC Response

The Note has been removed.

PWROG Comment 5 (Page 6, Line Number 4)

Revise to state, "The associated CT [completion time] for Required Action A.1 (now Required Action A.2) is revised from 4 hours to 168 hours."

NRC Response

The comment was incorporated.

PWROG Comment 6 (Page 6, Line Numbers 10-12)

Revise to state, "In addition, new LCO [limiting condition for operation] 3.6.3 Conditions, Required Actions, and CTs are proposed for the valves excluded from Condition A (containment isolation valves in the main steam lines and specific penetrations (if any) identified by the plant specific risk analysis as having high risk significance for an interfacing systems loss of coolant accident as shown in TSTF-498."

NRC Response

TR BAW-2461 specifically references closed systems in its text. Because the comment, as proposed, would eliminate closed systems from discussion, the NRC staff cannot incorporate these proposed changes.

PWROG Comment 7 (Page 9, Line Number 13)

Text states that most PRAs [probabilistic risk assessments] don't model CIVs [containment isolation valves] and the topical report provided analyses using simplified models. Later in the SE it says that licensees need to confirm the assumptions of the topical and must address ΔCDF [change in core damage frequencies] and ΔLERF [change in large early release frequencies] which was not addressed by the topical. The SE does not indicate how to do this; quantitative or qualitatively. A licensee has limited ability to provide a quantitative analysis.

NRC Response

The NRC staff has issued guidance in Regulatory Guides 1.174 and 1.177 (see References 4 and 5 of SE) for risk-informed license amendment submittals. This guidance specifically establishes guidelines for addressing changes in ΔCDF and ΔLERF.

PWROG Comment 8 (Page 12, Line Number 18)

Delete the ending phrase "and the proposed LCO 3.6.3, TS condition." LCO 3.6.3 only places requirements on containment isolation valves, not closed systems. This is further discussed in TSTF-498.

NRC Response

The NRC staff does not agree with this comment. See the NRC Response to the PWROG General Comment above.

PWROG Comment 9 (Page 12, Line Number 30)

Delete the ending phrase "and the proposed LCO 3.6.3, TS condition." LCO 3.6.3 only places requirements on containment isolation valves, not closed systems. This is further discussed in TSTF-498.

NRC Response

The NRC staff does not agree with this comment. See the NRC Response to the PWROG General Comment above.

PWROG Comment 10 (Page 14, Line Number 35)

> Addresses multiple condition entry (i.e., multiple inoperable CIVs in different penetrations inoperable simultaneously and utilizing the extended CT). See discussion of multiple, simultaneous inoperable CIV below.

NRC Response

See NRC response to PWROG Comment 20 below.

PWROG Comment 11 (Page 17, Line Numbers 15-20)

> Section 3.4.1.5 states, "3.4.1.5 Cumulative Risk. With respect to past plant-specific license amendments or additional plant specific applications for a TS change under review, the cumulative risk must be evaluated on a plant-specific basis consistent with the guidance given in RG 1.174, Section 2.2.6 and 3.3.2, and addressed in a licensee's plant-specific application." This is similar to Condition 8 on Page 23, Lines 28-31, which states, "The cumulative risk impact of previous licensee changes or current license changes under review with respect to the proposed CIV CT extension will be addressed per the acceptance guidelines of RG 1.174, Sections 2.2.6 and 3.3.2. See Section 3.4.1.5 of this SE." Both sections are overly broad with respect to the referenced RG 1.174 guidance. RG 1.174, Section 2.2.6, is titled, "Integrated Decisionmaking," and discusses the importance of considering the cumulative impact on CDF and LERF of previous changes and the trend in CDF. Section 3.3.2, "Cumulative Risks," states, "Optimally, the PRA used for the current application should already model the effects of past applications." It is recommended that Section 3.4.1.5 and Condition 8 be revised to state, "With respect to past plant-specific license amendments or additional plant-specific applications for a TS change under NRC review that have not been incorporated into the baseline PRA used to evaluate the proposed change, the cumulative risk must be evaluated on a plant-specific basis consistent with the guidance given in RG 1.174, Section 2.2.6 and 3.3.2, and addressed in a licensee's plant-specific application."

NRC Response

The SE has been revised to reflect the proposed clarification.

PWROG Comment 12 (Page 18, Line Number 8)

> Revise to "A Tier 3 program ensures that while a CIV is inoperable, additional activities .... "

NRC Response

The comment has been incorporated.

PWROG Comment 13 (Page 20, Line Number 11)

> Revise Item 1 to state that TR BAW-2461, Table 2-1, will be marked as superseded by TSTF-498.

NRC Response

Following the NRC staff's TR procedures in NRR Office Instruction LIC-500, the PWROG would have three months from the date of the NRC staff's Final SE to publish the approved version of TR BAW-2461. Given that all of the issues with implementation of TSTF-498 have yet to be resolved, there is no guarantee that acceptable TSs from TSTF-498 will be available in time for the publication. Therefore, the NRC staff will not incorporate this comment.

PWROG Comment 14 (Page 21, Line Numbers 22-23)

> Suggest changing wording to "(b) the risk-parameter values used in TR BAW-2461, including the sensitivity studies contained in the RAIs, are representative or bounding for the specific plant."

NRC Response

The comment was incorporated.

PWROG Comment 15 (Page 21, Lines 44-48, Page 16, Lines 5-8)

> It is not necessary to calculate the plant-specific seismic initiating event frequency in order to confirm that the TR assumptions are conservative.
>
> In BAW-2461 AREVA used the seismic initiating event frequency information from TMI-1 [Three Mile Island, Unit 1]. The TMI information was chosen for the generic analysis because the literature (see references below) indicates that the TMI site has the most severe seismic hazard of the B&W plants.
>
> The seismic initiating event frequency in the TR (5e-4/yr) is for the full spectrum of seismic events considered in the TMI PRA, and represents the frequency for peak ground acceleration greater than about 0.05g. This is a very conservative initiating event frequency for use in BAW-2461, because the seismic events that cause the most damage are the high amplitude seismic events (> 0.5g) and they have a much smaller frequency (about 4e-6/yr).

Seismic References:

1) NUREG-1488, Revised Livermore Seismic Hazard Estimate for 69 Nuclear Power Plant Sites East of the Rocky Mountains," Lawrence Livermore National Lab, 1994.

2) EPRI NP-6395-D, "Probabilistic Seismic Hazard Evaluation at Nuclear Plant Sites in the Central and Eastern United States: Resolution of the Charleston Issue," EPRI, April 1989.

NRC Response

It is noted by the NRC staff that the seismic evaluation methods and the seismic risk contribution to overall CDF may vary significantly among participating licensee's. Confirmatory information should be provided by a licensee showing that the seismic CDF referenced in the TR is bounding for its plant. Licensees should confirm that vulnerabilities and improvements (i.e., relays - spurious actuation) identified in the Individual Plant Examination of External Events (IPEEE) have been resolved with respect to the proposed primary CIV (PCIV) CT extensions. A licensee should show by quantitative or qualitative means that the seismic risk contribution, including impact on containment performance, is expected to be negligible for the plant-specific application, and that the estimated seismic risk, in conjunction with the total plant risk (internal and external event risk), is within the RG 1.174 acceptance guidelines for a base CDF of 1E-4/year.

PWROG Comment 16 (Page 16, Line Numbers 20-32)

The TR basis being discussed was not merely that the fire CDF contribution is small. It also considers the probability of the fire occurring in the same fire zone as the redundant operable CIV, and at the same time that the inoperable CIV in within the AOT. In addition, there either has to be an independent DBA that leads core damage, or the fire in the same zone that affects the CIV also leads to a core damage event.

NRC Response

It is noted by the NRC staff that the fire evaluation methods and the fire risk contribution to overall CDF may contribute significantly to overall baseline risk. Licensee's should confirm that vulnerabilities and improvements identified in the IPEEE have been resolved with respect to the proposed PCIV CT extensions. A licensee should show by quantitative or qualitative means that the fire risk contribution, including impact on containment performance, is expected to be negligible for the plant-specific application and that the estimated fire risk in conjunction with the total plant risk (internal and external event risk) is within the RG 1.174 acceptance guidelines for a base CDF of 1E-4/year for the proposed 168 hour CIV CT.

PWROG Comment 17 (Page 17, Lines 11-13, Page 21, Lines 40-42)

It is not clear why fire-induced spurious actuation of CIVs is important for this issue. If the concern is spurious opening of a closed CIV due to fire, this would be risk significant for the CIV function only if the same fire also caused a core damage event. As explained in RAI response 13, this may be the case for certain penetrations that are already high ISLOCA [interfacing-systems loss-of-coolant accident] risk contributors, but those are excluded from the extension request anyway.

NRC Response

Spurious actuations resulting from fire-induced circuit failures is an ongoing generic issue and should be considered in the plant specific implementation of TR BAW-2461 including high risk ISLOCA CIV contributors. The specific reference has been revised in the SE.

PWROG Comment 18 (Page 10, Lines 1-9, Page 22, Lines 21-26)

It is not clear why this assumption needs to be confirmed. If the licensee determines that indeed some penetrations do not have CDF and/or LERF consequences; then including them in the TR analysis is conservative and does no harm.

NRC Response

The intention was that, for licensees that may credit mitigation of an ISLOCA, the BAW-2461 assumption that an ISLOCA is assumed to lead to core damage and large early release would be part of the plant specific analysis consistent with BAW-2461. The SE will be revised to clarify the TR assumption.

PWROG Comment 19 (Page 22, Line Number 34)

Delete the word "interpretation." Licensees are not allowed to interpret Technical Specifications.

NRC Response

The comment has been incorporated.

PWROG comment 20 (Page 23, Lines 15-22, Page 14, Lines 35-48, Page 19, Lines 1-21, Page 20, Lines 14-16, Page 9, Lines 19-24)

This condition (#6) is contradictory and overly burdensome. The point of the methodology guidance provided in response to the RAIs (see attachment to the RAI response "Implementation Guidance," section titled "Suggested use of CIV Risk parameters in CRMP [configuration risk management program]") was to allow the CRMP to measure the cumulative risk associated with multiple penetrations within the extended CT simultaneously. If the extended CIV CT is to be limited to one entry at a time, then the cumulative risk calculation for multiple penetrations is unnecessary. The risk of multiple simultaneous condition entries for the existing CTs (4 hours) is already implicitly included in the base plant risk, and is therefore not a part of the incremental risk associated with the proposed extension.

For a single penetration in the extended CT, the CRMP can provide adequate assurance without a complicated quantitative analysis of ΔCDF, ΔLERF, ICCDP, and ICLERP for multiples.

To resolve this issue, the licensees are willing to limit the extended AOT to one penetration at a time. Therefore, it is proposed that the traveler, TSTF-498, be revised by adding a Condition "Two or more penetration flow paths with one containment isolation valve inoperable [for reasons other than Condition[s] E [and F]]," with a Required Action, "Isolate all but one penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange." This action will have 4 hour CT. There may be a Reviewer's Note that states that if the licensee provides plant-specific justification to support multiple inoperable CIVs, Condition D can be modified or deleted.

Concurrent with the proposed TSTF revision, it is requested that the NRC staff delete references in the draft SER to plant-specific evaluation regarding estimates of ΔCDF, ΔLERF, ICCDP and ICLERP for multiple penetration LCO entries.

NRC Response

The limitation to a single CIV in an extended surveillance is a finding of the NRC staff's SE. However, NUREG-1430 will continue to allow multiple condition entry for CIVs not in an extended CT. A licensee's Tier 3 program will need to evaluate the risk of these configurations.

The RG 1.177 Tier 3 program ensures that while a CIV is in a LCO condition, additional activities will not be performed that could further degrade the capabilities of the plant to respond to a condition for which the inoperable CIV or system was designed to mitigate, and as a result, increase plant risk beyond that assumed by the TR analysis. A licensee's implementation of RG 1.177 Tier 3 guidelines generally implies the assessment of risk with respect to CDF. However, the proposed CIV CT impacts containment isolation and consequently LERF and ICLERP, as well as CDF. Because the TR extended CIV CTs uses ICLERP acceptance guidance, the management of risk in accordance with 50.65(a)(4) of Title 10 of the *Code of Federal Regulations* (10 CFR) for these extended CIV CTs must assess LERF and ICLERP.

Therefore, a licensee's CRMP, including those implemented under the Maintenance Rule of 10 CFR 50.65(a)(4), is addressed in the SE, including how CIV LERF/ICLERP will be assessed. These assessments must be documented in the licensees' plant-specific application referencing TR BAW-2461.

The licensee must confirm that its Tier 3 risk management program, in accordance with 10 CFR 50.65(a)(4), will address the possibility of simultaneous LCO entries of inoperable CIVs in separate penetrations such that this combination will not exceed the RG 1.174 and RG 1.177 acceptance guidelines confirmed by the analysis presented in the TR, and that defense-in-depth for safety systems is maintained.

However, the NRC staff SE will be modified to remove specific references to BAW-2461 revisions concerning the added guidance on estimation of LERF and ICLERP on entry into LCO 3.6.3. The specifics for the evaluation of LERF and ICLERP can be addressed on a plant specific basis and/or through the review of TSTF-498.

PWROG Comment 21 (Page 23, Lines 24-26, Page 13, Lines 35-36, Page 9, Lines 13-17)

> Condition 7 should read "The licensee shall verify that the plant-specific PRA quality is acceptable with respect to its use for Tier 3 for this application ... " to be consistent with the other referenced paragraphs.

NRC Response

The comment has been incorporated.

PWROG Comment 22 (Page 23, Lines 44-48, Page 24, Lines 1-2, Page 14, Lines 9-17)

> We believe this was addressed in RAI #2. The ΔCDF and ΔLERF are easily derived from the ICCDP and ICLERP, given the expected frequency of entry into the extended AOT. A survey of the licensees indicates that the expected frequency of entry into the extended AOT will be less than once per year. This yields ΔCDF or ΔLERF from 5E-16 up to about 2E-8 per reactor-year depending upon the penetration involved.
>
> It was also acknowledged that if the proposed AOT change is implemented, that the CIV maintenance unavailability would be monitored as required by RG 1.177.
>
> Therefore, we believe that condition 11 is redundant to condition 10 and unnecessary.

NRC Response

Although discussed in the RAI response, a licensee will need to confirm condition 11 on a plant specific basis to ensure that the acceptance guidance of RG 1.174 and RG 1.177 are met. Therefore, the SE will not be revised.

December 9, 2005
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OG:05:1876

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

Response to Request for Additional Information on BAW-2461, Revision 0, "Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time Change"

Ref. 1: Letter, Jerald S. Holm (Framatome ANP) to Document Control Desk (NRC), "Request for Approval of BAW-2461, Revision 0, 'Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time Change'," NRC:05:003, OG:05:1860, January 14, 2005.

On behalf of the B&W Owners Group, Framatome ANP, Inc. (FANP) requested NRC review and approval for referencing in licensing actions the topical report BAW-2461, Revision 0, "Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time Change" in Reference 1. In an email dated December 1, 2005, the NRC requested additional information to facilitate the completion of its review. A response to this request is provided in Attachment A.

Sincerely,

Ronnie L. Gardner, Manager
FANP Site Operations and Regulatory Affairs

Howard Crawford, Chairman
B&W Owners Group Steering Committee

Attachment

cc: G.S. Shukla
Project 693

Framatome ANP, Inc. B&W Owners Group
3315 Old Forest Road
Lynchburg, VA 24501
Phone: 434-832-3635 Fax: 434-832-4121

Attachment A

REQUEST FOR ADDITIONAL INFORMATION
BAW-2461, Revision 0
Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time Change

Question 1: *Page 2-10 of BAW-2461 indicates that some of the valves that have a containment isolation function are also in an accident consequence limiting system (ACLS) flow path. For these valves, the proposed TS change only applies to the containment isolation function. The requirements for the ACLS function are covered by the applicable TS of the ACLS, for which no changes are proposed by this topical report. Please confirm that the emergency core cooling system (ECCS), decay heat removal system (DHRS) and their supporting systems do not contain any isolation valves which are either classified as containment isolation valves or designed to be closed on containment isolation signals so that the ACLS function of these systems are not affected by the containment isolation actuation following an accident.*

Response 1: Although all containment penetrations are required to have containment isolation valves, only those that do not have post-accident functions are designed for automatic closure. The valves being discussed in the referenced paragraph (page 2-10 of BAW-2461) are those valves in the Engineered Safeguards (ES) systems (e.g., HPI, and LPI -- FANP believes when the staff references DHRS, the staff is referring to the LPI function of DHRS) that are designed to be open post-accident, and hence receive no automatic close signals. The containment isolation signal closes automatic containment isolation valves only in fluid penetrations that are not required for operation of engineered safeguard systems. Therefore, none of ECCS flowpaths can be defeated by a containment isolation signal.

Project Number 694

July 5, 2006

OG-06-213

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

Subject: Pressurized Water Reactor Owners Group
Responses to NRC Request for Additional Information Regarding the Review of BAW-2461, "Risk Informed Justification for Containment Isolation Valve Allowed Outage Time Change" (LSC-0236)

Reference: Letter from J. S. Holm to Document Control Desk, "Request for Approval of BAW-2461, Revision 0, "Risk Informed Justification for Containment Isolation Valve Allowed Outage Time Change."

In January 2005, the former B&WOG, now members of the Pressurized Water Owners Group, submitted BAW-2461, Rev. 0 "Justification for Containment Isolation Valve Allowed Outage Time Change" for review and approval in the referenced letter.

On January 24, 2006, a meeting was held with NRC representatives to discuss draft questions raised during NRC review of BAW-2461. Official RAIs were issued by the NRC in February 2006.

Attached to this letter are the responses to the official RAIs. These RAI responses are being provided to support the issuance of the draft Safety Evaluation for BAW-2461.

We appreciate the opportunity to work with the Staff during the review of this Topical Report. If there are any questions on our responses, please feel free to contact Mr. Tom Laubham at 412-374-6788.

Very truly yours,

Frederick P. "Ted" Schiffley, II
Chairman, PWR Owners Group

FPS:TJL:las

Attachment

cc: PWROG Steering Committee
PWROG Management Committee
PWROG Licensing Subcommittee (B&W Participating Members)
PWROG Project Management Office
G. Shukla, USNRC
R. J. Schomaker, AREVA

NRC Question Number 1:

Page 2-8. Section 2.2.2 "Common Cause Failure Determination" - The topical report (TR) states that an action has been added to perform a common cause failure determination of the second redundant containment isolation valve (CIV), of a like pair, within the original four-hour allowed outage time (AOT) of the inoperable CIV. Confirm that this action is included in the technical specification (TS) markups and associated technical specification task force (TSTF).

Response:

AREVA NP intended to put the condition mentioned in the TS markup, but it was inadvertently omitted. The condition would be to ensure that the redundant CIV of a like pair is operable before taking the inoperable CIV on the same penetration beyond the original four-hour AOT.

This condition is necessary only for penetrations with two CIVs that are similar (i.e., have potential for common cause failure). Therefore, it is not necessary where the redundant CIV is diverse from the inoperable CIV (i.e., different valve body and/or operator type, depending upon which parts of the inoperable CIV are affected). The licensee may list the applicable penetrations in the TS or supporting documentation.

Therefore, the following addition is proposed to BAW-2461 in Table 2-1:

Condition	Required Action	Completion Time
	[new condition] **A.1 [change next action to A.2]** **Verify that the redundant CIV on the same penetration is operable [applicable only if the redundant CIV has an operator and/or body type that is not diverse from the inoperable CIV depending on which part(s) are inoperable].** **<u>AND</u>**	**4 hours**

NRC Question Number 2:

Discuss the increase in CIV unavailability due to test or maintenance as a result of the AOT extension to 168 hours. Also confirm the impact on the average core damage frequency (CDF) and large early release frequency (LERF) remains acceptable, and is consistent with the expected number of preventive and corrective maintenance evolutions to be performed.

Response:

A survey of recent operating history by the participating plants indicates that the frequency of entering the current CIV AOT and exceeding the four-hour time limit is about 0.7 per reactor-year. It is not expected that there will be an increase in routine preventive maintenance performed on-line as a result of the extended AOT. Therefore, the expected frequency of entering the extended AOT is less than once per reactor-year.

The expected increase in average CDF and LERF can be estimated from the frequency of entry into the extended AOT and the single-AOT risk impact[1] calculated in the topical report. The risk impact for a single AOT entry of the full 168-hour duration is reflected in the ICCDP and ICLERP estimates, which range from about $1x10^{-15}$ up to about $4x10^{-8}$ depending upon penetration (penetrations with ICLERP greater than $5x10^{-8}$ are excluded from the AOT extension – see NRC questions 11 and 15). It can also be presumed that the average time in the extended AOT will be about half of the allowed maximum (i.e., 84 hours). Therefore, the expected incremental change in CDF or LERF ranges from about $5x10^{-16}$ up to about $2.x10^{-8}$ per reactor-year. This is well into Region III of the acceptance guidelines from Reg. Guide 1.174 (ΔCDF < $1x10^{-6}$/reactor-year, ΔLERF < $1x10^{-7}$/reactor year). The incremental risk will still fall within Region III even if the realized frequency of entry into the extended AOT is several times greater than the expected frequency.

Nonetheless, to ensure that overall plant risk is not significantly impacted by the proposed change, the maintenance unavailability for the containment isolation system will be tracked by the plant's maintenance rule program, per the requirements of Reg. Guide 1.177.

[1] The risk from simultaneous AOT entries should not be significant because simultaneous extended AOT entries will be rare at the expected frequency (less than one per year), and they will be limited by the configuration risk management program (CRMP) to those with small risk impact (see NRC question 3).

NRC Question Number 3:

Page 3-12 - The TR states that the acceptance criteria for incremental conditional core damage probability and incremental conditional large early release probability (ICLERP) ensure that the overall risk impact of the proposed AOT will be small, even considering separate TS limiting conditions for operation (LCO) entries for multiple penetrations. The TR states that the maintenance rule will be used to evaluate multiple, simultaneous extended, AOT CIV entries in separate penetrations. However, the topical report analysis is applicable to only a single CIV AOT entry at a time.

The topical report BAW-2461 implementation of Regulatory Guide (RG) 1.177, Tier 3 guidelines generally implies the assessment of risk with respect to CDF. However, the proposed CIV AOT impacts containment isolation and, consequently, LERF and CDF. Therefore, a licensee's configuration risk management program (CRMP), including those implemented under the maintenance rule of 10 Title 10 of the Code of Federal Regulations, Part 50.65(a)(4), must be enhanced to include a LERF methodology/assessment and must be documented in a licensee's plant-specific submittal (see RG 1.174 Section 2.3.7.2 and RG 1.182 for key components of a CRMP).

The staff is concerned that configuration risk management as implemented under the maintenance rule is inadequate to evaluate the risk impact of CIVs in maintenance or repair, such that the assumptions of BAW-2461 remain valid. The extension of the AOTs for CIVs generally does not have a significant impact on CDF but does impact LERF/ICLERP (containment isolation). The TS allows multiple condition entry for CIVs but the topical report analyses are based on a single CIV AOT and, therefore, cumulative risk must also be evaluated for multiple CIV LCOs. Plant Tier 3 programs that are based on the maintenance rule generally do not provide a quantitative or qualitative assessment of LERF. BAW-2461 provides limited guidance on performing a Tier 3 LERF analysis either for single, or multiple CIV AOTs. The maintenance rule does not require a quantitative risk assessment and, usually, the Tier 3 assessment is done with only a level 1 CDF analysis. Since the extension of a CIV AOT mainly impacts LERF/ICLERP, it is the staff's concern that the evaluation of CIVs in a Tier 3 configuration risk management program is limited, in that the configuration risk assessment may be incomplete for CIVs in maintenance or repair (only a quantitative or qualitative CDF assessment with a limited qualitative LERF/ICLERP assessment is performed).

Provide an evaluation as to the applicability of topical report BAW-2461 to simultaneous multiple extended CIV AOTs in separate penetrations, including the methodology to be used to evaluate LERF/ ICLERP, such that the conclusions of the topical report continue to be met based when inoperable primary containment isolation valves are evaluated by a licensee's CRMP.

Response:

This question addresses how the plant's maintenance rule program and CRMP will be enhanced to evaluate inoperable CIVs. The CRMP is already a licensee commitment under the maintenance rule. Implementation of the maintenance rule and CRMP is plant-specific; however, the participating B&W plant owners acknowledge that some enhancement to the CRMP will be necessary to meet the requirements of RG 1.174, which requires that components with extended AOTs be evaluated by the CRMP when multiple components are in the AOT at the same time, and that the maintenance rule program will need to track containment isolation system unavailability.

The existing CRMPs do not generally include the containment isolation function, and the plant PRAs do not typically model all of the CIVs. Hence, the topical report was specifically structured to enable the results to be used in addressing the LERF risk for multiple penetrations in the LCO.

Multiple LCO entries increase the probability of a large early release. However, the assumed consequence does not change with multiple entries because the risk analysis assumes the same result for all penetration sizes. This conservatism was done purposely, to avoid the issue of cumulative LERF risk, and put fewer burdens on the CRMP. That is, if one open small penetration is assumed to be a LERF, then it is treated the same as one large penetration, or several small ones. Because there is no assumed size threshold, the cumulative LERF risk (from multiple LCO entries) can be determined by simply summing the individual probability values (ICLERP) contained in the topical report.

Suggested guidance is contained in the response to NRC question 15 on how to assign the probabilities for inoperable CIVs, and how to combine them in the CRMP to estimate cumulative ICLERP when multiple penetrations are in the LCO at the same time.

NRC Question Number 4:

Page 2-2, 3-12 - The analysis by the B&WOG assumed that core damage events with open penetration flow paths to the environment are assumed to be candidates for a large early release. No credit is given in the TR analysis for line size, termination point, or ventilation systems. The TR recognizes that TSs allow separate LCO entry that may increase the effective hole size. The TR, as an option, allows licensees to use plant-specific probabilistic risk assessments to screen penetrations based on hole size and size threshold for an interfacing-systems loss-of-coolant accident (ISLOCA). The TR states that this approach would be further supported by a licensee's CRMP to monitor simultaneous CIV LCO entries.

Several studies, including NUREG/CR-4330, "Review of Light Water Reactor Regulatory Requirements," NUREG-1493, "Performance-Based Containment Leak-Test Program," NUREG/CR-6418, "Risk Importance of Containment and Related [Engineered Safety Feature] System Performance Requirements," and NUREG-1765, "Basis Document for Large Early Release Frequency (LERF) Significance Determination Process (SDP)," have been performed to determine the risk significance of various levels of containment leakage.

Describe the alternative methodology suggested by the TR including acceptance criteria individual licensees will use in performing this evaluation. Also, discuss the use of a plant CRMP including LERF/ICLERP evaluation used to monitor multiple simultaneous CIV LCO entries, applicable TS documentation, and the associated TSTF markup.

Response:

It is not the intent on this submittal to address LERF risk by line size (see response to NRC question 3). On the contrary, the intent was to conservatively assume that any size hole, even small ones, have the potential to contribute to LERF. This assumption means that risk from multiple penetrations (in the LCO simultaneously) can be determined by combining probability only, without regard to the effect of (cumulative) size on the consequence. Hence, this puts fewer burdens on the CRMP.

The intent of assumption 3 (pg 3-12) was to make a statement that if the utility wanted to screen penetrations by size, then they would have to include tracking of the aggregate size of the multiple penetrations in their CRMP, using a plant-specific methodology (i.e., LERF consequence determination as suggested above by the NRC staff).

To clarify the intent, it is proposed that the option to use an alternative methodology involving screening of penetrations by hole size and size threshold, as suggested by assumption 3, be removed. Hence, it is proposed that the last two sentences in Assumption 3 in Section 3.3.2 of the topical report be deleted and replaced with the following:

"Therefore, a conservative estimate of cumulative LERF risk for multiple penetrations in the LCO simultaneously can be determined by combining the ICLERP probabilities alone, without regard for cumulative line size."

NRC Question Number 5:

Page 3-13 - With penetrations with two or more like CIVs, the analysis did not include common cause failure when one CIV is inoperable. The B&WOG analysis assumes that plant operators will verify within 4 hours (the original AOT) that the remaining CIV of the like pair has not been affected by the same failure mode. Are the 4 hours with potential common cause accounted for in the extended AOT risk?

Response:

The existing TS is unclear about verification of the operability of the redundant CIV; it is only implied via the application of either the A or B Condition Statement. Hence, the proposed TS is an improvement because it will explicitly call for verification of operability of a redundant like CIV before going beyond the original four hours (see response to NRC question 1).

With respect to the risk assessment, the proposed condition (verify operability of the redundant CIV) is the justification for not including common cause failure (CCF) of the redundant CIV in the risk assessment of the extended portion of the AOT. Whether or not CCF within the first four hours is included is a moot point because that portion of the risk is the same for both the existing and the proposed AOT. That is, the delta-risk is associated only with the contribution from four hours and beyond.

NRC Question Number 6:

Page 3-17 - Although the TR states that the failure rate for the most limiting valve type for each failure mode was selected based on participating plant data, the TR also states that failure rates were determined for each valve type and failure mode by comparing the failure rates for the participating plants and using the median values. Why were median values selected for the bounding analysis instead of the worst case data based on the intended bounding nature of the TR to the plants surveyed? Is the methodology intended to be applicable on a plant-specific basis using plant-specific data as well as generically?

Response:

AREVA NP's intent is that the topical report be generically applicable to the participating B&W plants. The choice of data was intended to be conservative; however we also strove to avoid excessive conservatism, which is also not appropriate for risk-informed applications. While our approach does not preclude the participating plants from recalculating the results with plant-specific data, it is our assertion that there is sufficient conservatism in the analysis that that is unnecessary.

The CIV failure rates used in the topical report were chosen in a conservative manner. All CIVs are represented by the failure rate of the most limiting valve type, which corresponds to a motor-operated valve (MOV) for fails-to-close and an air-operated valve (AOV) for fails-to-remain-closed (fails open). This approach was chosen both as a conservatism, and to reduce the number of generic penetration configurations to analyze.

To select the failure rate for each valve type, the median value from a survey of the participating plants was used. That choice was made to avoid the use of the oldest data (some from pre-1999) that did not appear to be representative of recent experience. For example, Oconee showed an improvement in MOV failure rate from $3.5x10^{-3}$/demand to $1.7x10^{-3}$/demand in the last PRA update.

It is illustrative to compare the failure rates used in the topical report with generic data. The value used for CIV fails open ($3.9x10^{-7}$/hr) is comparable with generic data sources for AOVs (e.g., $5x10^{-7}$/hr for AOV spuriously opens from NUREG/CR-4550). The value used for CIV fails-to-close ($1.7x10^{-3}$/demand) is a little more optimistic than the generic data sources for MOVs (e.g., $3x10^{-3}$/demand for MOV fails-to-close from NUREG/CR-4550). However, the generic data sources are old; so it is not surprising that recent experience is better. In this case, this is probably due to NRC and industry MOV reliability initiatives. NUREG/CR-6819, Volume 2 (MOV common cause failure study) also shows an improving trend in MOV failure rate in the years since Generic Letter 89-10.

At the request of the NRC staff (see NRC question 10), a sensitivity analysis has been performed on the CIV failure rate data. For this sensitivity case, all of the CIV failure rates for both fails-open and fails-to-close were increased by a factor of two, which was chosen since the old generic data for MOVs (e.g., $3x10^{-3}$/demand from NUREG/CR-4550) is about a factor of two worse than the corresponding value that was used in the topical report. It is also consistent with the recent improvements seen in plant-specific data (such as in the example for Oconee mentioned above), if that improvement were to be somehow reversed.

The results of the sensitivity analysis did not change the conclusions of the study. Most of the penetrations that had a small impact on risk (ICCDP < $5x10^{-7}$, ICLERP < $5x10^{-8}$) continued to have a small impact on risk with the higher failure rates. The only exception was category 1.4 (from Table 3-3), which is an RCS connection that is normally open (NO), but has non-seismic pipe outside of the containment (i.e., additional valves between the RCS and the portion of the outside system that is low pressure or open are in the non-seismic pipe). The failure modes for this penetration category change from a probability of $3.6x10^{-8}$ before the sensitivity analysis to $8.0x10^{-8}$ after (configuration E) or from $3.3x10^{-8}$ to $6.6x10^{-8}$ (configuration F, G); which is slightly above the ICLERP small impact criterion of $5x10^{-8}$. This small increment is from a seismic event occurring during the extended AOT, followed by failure of the operable CIV to close and isolate the (seismically) broken pipe (the additional valves are of no value because they are downstream of the pipe break). This is not a serious sensitivity consideration because there are conservatisms in the analysis, the sensitivity is limited to seismic events, and there are few if any penetrations in the plant that will fit this category (i.e., NO RCS connection with no valves other than the two CIVs in the seismic portion of the pipe).

Any sensitivity to valve failure rate will be appropriately addressed by the plant's maintenance rule program, which will track reliability degradation of CIVs in these and other penetrations.

NRC Question Number 7:

Page 3-14 - The failure rate for random pipe failure is 6.0E-10/hour per penetration flow path. The TR assumes 100 pipe sections per flow path, giving a value of 6.0E-8/hour or 5.24E-4/year. Provide a discussion on the basis for this estimate.

Response:

The failure rate used for random pipe failure is 6.0×10^{-10} per pipe section per hour. This yields a failure rate per penetration of 6.0×10^{-8}/hour based on 100 pipe sections per penetration. The basis for this estimate is directly from the referenced EPRI report TR-102266 (K. Jamali, "Pipe Failure Study Update"). The failure rate estimate extracted from the reference consists of two parts, the failure rate per pipe section, and the estimated number of pipe sections per penetration.

For the pipe failure rate (6.01×10^{-10}/section-hour), the topical report uses the failure rate for a generic PWR system. This generic PWR failure rate is a combination of the data from all PWR safety-related systems. The pipe size group with the worst failure rate was used (ID from 0.5 to 2 inches), which provides the failure rate per pipe section-hour of 6.01×10^{-10} with an upper error factor of 3. An excerpt from Table 4-9 of EPRI TR-102266 is shown below. (The other data in this table is used in a sensitivity analysis – see below.)

Rupture Failure Rates and Error Factors for Each Generic System or System Group and Pipe Size Group Combination (Excerpt)

	Failure Rate in per-Section-Hour and Error Factors (Eu,El)		
System Group	**0.5" to < 2" ID**	**2" to < 6" ID**	**≥ 6" ID**
Generic PWR	6.01E-10 (3,3)	3.98E-10 (3,3)	5.64E-10 (3,3)
PWR System 1	1.42E-9 (5,5)	1.13E-10 (10,30)	1.92E-10 (10,30)
PWR System 2	7.09E-10 (5,5)	7.03E-11 (7,20)	1.39E-10 (7,20)
PWR System 3	7.39E-10 (5,5)	1.17E-9 (5,5)	6.40E-10 (5,5)
PWR System 4	3.50E-10 (5,5)	9.77E-10 (5,5)	8.90E-10 (5,5)
PWR System 5	2.13E-10 (10,30)	1.70E-11 (10,30)	2.87E-11 (10,30)

Jamali also provides a table of pipe section counts (see excerpt below from Table 3-3 of TR-102266), which provided the basis for the per-section failure rates. To estimate the number of pipe sections per penetration, the topical report uses the B&W safety injection and recirculation system, because it is a typical B&W system, and it is a system that the EPRI report breaks out separately (for other systems, the counts are combined). The EPRI table provides a count of about 400 segments (417 specifically) in a B&W safety injection and recirculation system in three different size groups ranging from 0.5 to 6 inches. Since a typical system has multiple trains (at least two) as well as main and secondary (branch line) flow paths, we conservatively estimated 100 pipe segments per penetration flow path. For example, the pipe sections count for the safety injection and recirculation system would include at least four high pressure injection penetrations, two low pressure injection penetrations, and two recirculation penetrations, as well as others. Using the conservative estimate of 100 pipe sections per penetration yielded a failure rate of 6.0×10^{-8}/hour for a typical penetration flow path.

The topical report uses this failure rate for the portion of (high pressure) pipe between the CIVs and any additional valves in the interfacing system. We view this calculation as conservative because the topical report assumes that the break occurs near the containment where there is no benefit from any additional valves in the flow path beyond the CIVs. As the distance from the containment increases, the likelihood that additional valves will be available for isolation of the leak increases. After 100 pipe segments from the containment wall, the likelihood of additional valves is very high.

This failure rate is not used for over-pressurization of low-pressure piping or for failure of non-seismic piping during a seismic event. For these cases, a failure probability of 1.0 is used.

Pipe Section Counts for Various BWR and PWR System Combinations (Excerpt)

Vendor	Pipe Size Group	Safety Injection System
B&W	2" to < 6" ID	48
	≥ 6" ID	120
	0.5" to < 2" ID	249

At the request of the NRC staff (see NRC question 10), a sensitivity analysis has been performed on the pipe failure rate. For the sensitivity analysis, the individual system data that make up the generic PWR failure rate were examined. The system and pipe size with the highest failure rate is 1.42×10^{-9}/section-hour with an upper error factor of 5 (the error factor times the best estimate corresponds to the 95% value in a lognormal distribution). The error factor for the individual system is larger than for the generic failure rate because there are less data available for an individual system. If this failure rate and error factor is used in a sensitivity analysis, the per-section failure rate is 7.1×10^{-9}/section-hour; slightly more than an order of magnitude greater than the best estimate value (6.01×10^{-10}) used in the topical report. One order of magnitude of sensitivity is conservative in light of the data in the EPRI table because it can only be obtained by using the worst case system and error factor.

Therefore, a sensitivity analysis was performed using a failure rate per penetration of 7.1×10^{-7}/hr (assuming 100 pipe sections per penetration) instead of 6.0×10^{-8}/hour.

The results of the sensitivity analysis did not change the conclusions of the study. Most of the penetrations that had a small impact on risk (ICCDP < 5×10^{-7}, ICLERP < 5×10^{-8}) continued to have a small impact on risk with the higher failure rates. The only exception was category 1.3 (from Table 3-3), which is an RCS connection that is normally open

(NO), and the related categories that are derived from category 1.3 (i.e., category 1.4 – NO RCS with non-seismic pipe outside containment, and category 2.2 – NO RCS with ACLS function). The failure modes for this penetration category (1.3) change from a probability of $2.0x10^{-8}$ before the sensitivity analysis to $2.0x10^{-7}$ after (configuration E) or from $1.7x10^{-8}$ to $2.0x10^{-7}$ (configuration F, G); which is moderately above the ICLERP small impact criterion of $5x10^{-8}$ (by a factor of four). The failure mode of interest is a random pipe failure occurring during the extended AOT (in the high pressure pipe outboard of the CIVs, but before other valves), followed by failure of the operable CIV to close and isolate the broken pipe. (The calculation is conservative for the cases where the additional valves are inboard of the CIVs inside containment.) Note that the incremental probability above the ICLERP small impact criterion of $5x10^{-8}$ is caused by application of the error factor 5 (95% value) to the failure rate; simply using the higher best estimate failure rate of the worst system ($1.42x10^{-9}$/section-hour) instead of the generic value ($6.01x10^{-10}$/section-hour) is not enough to increase the ICLERP above $5x10^{-8}$.

Although this penetration category (NO RCS connection) is sensitive to the random failure rate of the high-pressure piping, this sensitivity is offset by conservatism in the pipe section count, which is assumed to be 100 sections per penetration. In other words, if the run of pipe between the outboard CIV and the next available valve is not very long (e.g., 25 sections or less), or there is an additional valve inside the containment, then the ICLERP will be under the criterion for small risk impact even with the conservative upper bound pipe failure rate. This is not a serious sensitivity consideration due to the conservatisms in the analysis, and that there are few, if any, penetrations in the plant where there is a NO RCS connection and a long section of high-pressure piping outside of the containment that cannot be isolated except by the two CIVs.

NRC Question Number 8:

Page 3-18 - Provide a basis for the common cause beta factor selected.

Response:

The beta factor was selected by a survey of the participating B&W plants and picking a value (0.03) that is typical for the B&W plant PRAs. This is a conservative value for beta factor. By comparison, the NRC common cause failure database (on the NRC website) associated with NUREC/CR-6819 provides a beta factor for generic MOV fail-to-close of 0.021.

NRC Question Number 9:

Page 3-29, first paragraph - The TR discusses the applicability of the proposed AOT in delaying the repair of an inoperable CIV with regard to configuration "A." It is assumed that an extended AOT cannot be used to delay repair of an inoperable CIV on a reactor coolant system (RCS) flow path if the reason for the inoperability is a failure of the valves RCS pressure boundary. Is this intended to be a condition of the TR and/or controlled by TS condition?

Response:

It was not AREVA NP's intention to make a new licensing commitment, because the commitment already exists. The point being made by this paragraph is that inoperability of the RCS pressure boundary is already covered by another TS (STS 3.4.13 &14).

Therefore, if the CIV inoperability is due to failure of its RCS pressure boundary, then the proposed CIV AOT extension is not relevant (i.e., to allow continued leakage) because the existing commitment to the RCS pressure boundary TS is controlling.

Consequently, the proposed AOT extension for CIVs has no effect for failures involving the RCS pressure boundary. Once the penetration is isolated (either because of the RCS pressure boundary TS or to initiate valve repair), then the required action of the CIV TS is satisfied and the AOT extension is moot. Hence, the requested AOT change for CIVs does not represent a change for CIV inoperability that involves the RCS pressure boundary.

NRC Question Number 10:

TR BAW-2461 does not discuss uncertainty in the proposed CIV extended AOT risk results. Provide this discussion for BAW-2461. As discussed in RG 1.174 and NUREG/CR-6141, "Handbook of Methods for Risk-Based Analyses of Technical Specifications," a licensee can perform sensitivity studies to provide additional insights into the uncertainties related to the proposed AOT extension and demonstrate compliance with the guidelines and evaluate uncertainties related to modeling and completeness.

Response:

Uncertainty was addressed in the topical report by choosing conservative analysis inputs and modeling assumptions. In addition, sensitivity analysis has been performed in response to this request for valve failure rates and for piping failure rates. These sensitivity studies are described in the responses to NRC questions 6 and 7, respectively.

NRC Question Number 11:

Page 3-30 states that ISLOCA risk is exacerbated when one CIV is inoperable. An example is given for a penetration flow path with two normally closed (NC) CIVs and low pressure piping downstream. If one CIV is inoperable the remaining CIV is insufficient to keep the risk impact small during the proposed AOT extension unless de-energized. The topical report states that this suggests against extending the AOT for any penetration flow paths that may have this configuration. However, it is also stated that the extended AOT will not be used for an inoperable NC CIV if it leaves the penetration flow path with only one closed valve between the RCS and the environment (i.e., low pressure piping or opening) and the valve is not verified closed.

Additionally, Page 3-41 of the topical report states that for situations where there are only two NC CIVs between the RCS and the low-pressure interfacing system it is necessary when implementing the proposed TS changes to identify where this is the case to ensure that the proposed AOT extension is not applied to those penetrations. However, the proposed resolution states that these configuration are acceptable if the remaining CIV is verified closed.

Reconcile the apparent discrepancy. How is valve position confirmation considered in the risk assessment?

Response:

This confusion is a result of poorly-chosen wording in the topical report.

If there are penetrations with only two NC valves (both CIVs) separating the RCS from low pressure piping, then the risk that is estimated by the topical report does not justify an extension of the AOT. These penetrations, if they exist, are also risk significant for ISLOCA in the plant-specific PRA. If one of the CIVs is inoperable, then only one NC valve remains to prevent exposure of the low-pressure pipe. This inoperable CIV will retain the existing (four-hour) AOT and the TS markup will explicitly identify the four-hour AOT as applying to this penetration. (See Table 2-1 of the topical report, proposed new condition following Condition A; note that the number of penetrations that will be in this category is few). Therefore, the Required Action will be applicable and the penetration will be isolated by one of the methods indicated in the TS. The topical report used the terminology "verified closed" to mean that the operable CIV will be in a secured closed state such that it satisfies the Required Action (see footnote number 6 on the bottom of page 3-31). Hence, the topical report requests no relief from the existing TS for these particular penetrations.

To clarify the language in the topical report, the following changes to the topical report are proposed:

Change bullet on page 3-30 to read:

"The extended AOT will not be applied to CIVs in penetrations connected to the RCS that have two NC CIVs if there are no other valves between the RCS and the environment (i.e., low pressure piping or opening) that may be used for backup isolation. In that case, the operable CIV will be verified closed within the original four-hour AOT, thus satisfying the Required Action."

Similar changes are proposed for the bullets on pages 3-41 and 4-2 of the topical report.

Also, with respect to how confirmation of valve position is considered in the risk assessment, this was an important factor in the risk assessment in only one case. As noted by footnotes j and l in Table 3-3 of the topical report, this is the case where there is an NC RCS penetration and there is one additional valve, besides the two CIVs, between the RCS and the low-pressure piping (i.e., similar to the penetrations excluded from the relief request in the discussion above, except with one additional valve). For these penetrations, there is a sensitivity to whether or not that additional valve is open or closed. As the footnote j indicates, if the additional valve is NO, the risk can be reduced to an acceptable level if the valve is closed when entering the AOT (closed, but not necessarily secured, as that would satisfy the existing Required Action, thus making the extended AOT immaterial). Similarly, as indicated in footnote l, the risk is increased if the additional valve is NC, but is inadvertently left open. In either of these cases, closing and/or confirming that the additional valve is closed helps to reduce the ISLOCA and LERF risk. Therefore, this is a suggested compensatory action that is appropriate for the plant's CRMP when CIVs in this particular category of penetrations are inoperable (i.e., NC RCS penetration with two CIVs and only one additional NC valve or only NO valves separating the RCS from the low-pressure piping).

Therefore it is also proposed that the following bullet be added to the topical report in Section 3.4, which discusses the CRMP:

"If the extended AOT is applied to an RCS penetration that has two NC CIVs, then when entering the AOT, confirm that there is at least one other closed valve between the RCS and any low pressure piping or opening."

NRC Question Number 12:

Page 3-42 - The topical report discusses Tier 2 and the identification of potentially risk-significant configurations that could exist with additional equipment out of service besides inoperable CIVs. The discussion is mainly concerned with redundant CIVs in the affected penetration but does not discuss CIVs in penetrations associated with an accident consequence limiting system (ACLS). What Tier 2 restrictions, if any, have been identified for penetration flow paths that include an ACLS.

Response:

The ACLS functions are already in the plant-specific CRMP. If an LCO of an ACLS TS is invoked, then the CRMP should already have restrictions in place, if appropriate, for when a train of the ACLS is out of service. Extending the AOT for the CIV helps the ACLS function by ensuring that the flow path for the ACLS stays open longer, if possible. If any restrictions are placed on redundant CIVs, they should be done only if they are not detrimental to an ACLS function. The second bullet on page 3-43 is intended to address activities that may increase CDF while in the extended AOT for the CIV, which includes activities that may impact ACLS functions. Other than those discussed, we did not find any generic Tier 2 restrictions applicable to an ACLS.

NRC Question Number 13:

Discuss the additional impact of external events on the proposed extended CIV AOTs. and how external events are to be evaluated using the TR bounding approach.

Response:

Seismic events are explicitly accounted for in the analysis.

Fires are addressed by the plant's Appendix R evaluation. Appendix R limits fire damage for systems and components that are required for safe shutdown. Containment isolation is not a function required for safe shutdown, but it does function to ensure that the containment atmosphere is isolated in the event of a release to the containment atmosphere following a design basis accident (DBA). By limiting the likelihood of fuel damage and a fission product release due to a fire, Appendix R also reduces the likelihood of ex-containment release.

Environmental qualification (EQ) protects components from external hazards, such as floods, that may be associated with a DBA. EQ requirements provide assurance that damage from flooding will be limited for components and systems that are needed for mitigation of the DBAs that may involve flooding.

With respect to a fire or flood affecting the redundant CIV, the probability of CIV failure due to fire or flood is much less than the random valve failure probability already included in the analysis. In addition, the fire or flood would have to occur in the specific location of the operable CIV during the specific time that the other CIV is inoperable. The probability of containment isolation failure due to this failure mode, along with an independent DBA that leads to a release of activity in the containment, is remote.

Therefore, the question of whether there is a risk-significant CIV failure mode involving fire or flood focuses on whether the same fire or flood might also be a factor in causing a DBA or other initiating event, and subsequent fuel damage. The postulated event that might meet this description is an ISLOCA caused by failure of the operable CIV while the redundant CIV is inoperable. This would be an issue only for penetrations that are high-to-low-pressure interfaces, and where the CIVs are also relied upon to provide the high-to-low-pressure isolation. (The risk diminishes if there are additional valves upstream or downstream of the CIVs that may provide backup isolation.) For these cases, whatever small increase there may be in the CIV failure rate due to external events does not change the result. Penetrations in this category (see response to NRC question 11) are already risk significant for ISLOCA and have been excluded from the TS relief request.

Hence, consideration of external events does not affect the results and conclusions of the topical report.

NRC Question Number 14:

Page 3-43 - No action or maintenance activity is performed that will remove equipment that is functionally redundant to the inoperable CIV, including the redundant CIV(s) on the same penetration and support for the redundant CIV. Clarify that "supports for" is meant to reference "support systems?"

Response:

The intended text is “support systems.” Therefore, it is proposed that the text in question be changed to read “support systems” instead of “supports.”

NRC Question Number 15:

Page 3-19, 22 - The TR analysis presents only single line penetration flow paths. To address additional pathways (parallel valves), or multiple pathways, the TR suggests using the most limiting penetration pathway or combining the multiple flow path risk. Provide the methodology, including basis and applicable acceptance guidance, for either approach in the application of the TR.

Response:

The response to this NRC question addresses plant-specific implementation of the topical report. It is our intention that the licensee would compare a plant-specific list of CIVs with the generic configurations covered by Table 3-3 of the topical report. This would serve three purposes: the first purpose is that it would demonstrate that the topical report is applicable to all of the penetrations, including penetrations that are ganged together, i.e., have multiple pathways. The methodology for addressing multiple pathways is addressed in the implementation guidelines that are attached below. The second purpose is that it would identify any penetrations that are risk significant and would need to be excluded from the relief request. This might include identifying some penetrations that are risk significant only if the corrective maintenance involves breach of the CIV's pressure boundary, a topic which is also addressed in the guidance (see NRC question 9). The third purpose is that it will provide a risk impact value (i.e., ICLERP primarily, but also ICCDP) for each CIV that is inoperable, which may be used in the plant-specific CRMP by summing with the risk impact for CIVs in other penetrations that may be inoperable at the same time. This approach is valid because the ICLERP values do not screen penetrations by line size, which allows the cumulative risk impact to be estimated by combining the probabilities only (see NRC question 4).

To clarify the intent, it is proposed that the following implementation guidance be added to BAW-2461 as an appendix (see attachment).

Attachment

Proposed Appendix to Topical Report BAW-2461

Implementation Guidance

Purpose

The purpose of this implementation guidance is to suggest a methodology that may be used on a plant-specific basis to:

- Demonstrate that the topical report is applicable to all of the plant-specific penetrations, including penetrations that have multiple pathways.
- Identify any penetrations that are risk significant and would need to be excluded from the AOT extension.
- Provide a risk impact value (ICLERP and ICCDP) for each potentially inoperable CIV, which may be used in the plant-specific CRMP to assess the risk impact of multiple penetrations with inoperable CIVs at the same time.

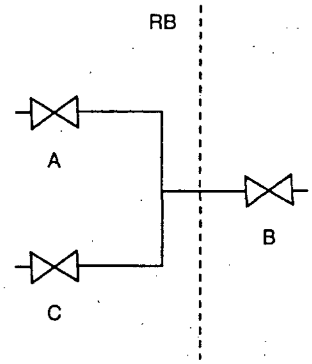
Quantification of Risk Parameters for Inoperable CIVs

The following quantification (steps 1 through 14 below) should be done for each CIV in the scope of the relief request (i.e., exclude CIVs in the main steam lines, and CIVs identified by the plant-specific risk-informed process to be high risk for ISLOCA). For penetrations that have only one CIV and a closed system, treat the inoperable pressure boundary of the closed system (closed loop inside containment) as if it were an inoperable CIV, per the proposed TS markup in Section 2.1. Use Table 3-3 to determine the ICCDP/ICLERP estimate for the inoperable CIV, as follows:

1) Determine if the CIV is on a penetration that has ganged CIVs; for example, some penetrations may have an outboard CIV that is in series with two or more parallel inboard CIVs (see example illustration below). If the penetration has ganged CIVs, then determine if the inoperable CIV affects one CIV pathway or multiple CIV pathways (consider only the CIVs). In the example, if CIV A is inoperable, then one flow path is affected (A:B). Similarly, only one flow path is affected for CIV C inoperable. However, if CIV B is inoperable, then two CIV flow paths are affected (A:B) and (C:B). Hence in the case of CIV B inoperable, the risk impact (from Table 3-3) is the sum of the two risk impacts, e.g., $ICLERP_{(A:B)} + ICLERP_{(C:B)}$.

   Therefore, in cases where the postulated inoperable CIV is paired with multiple CIVs on the opposite side of the RB wall, perform steps 1 through 13 for each pair and sum the risk impacts.

Example of Ganged CIVs



2) For each inoperable CIV (and CIV pathway if multiple), find the applicable category from Table 3-3.

Category from Table 3-3	Description
1	Penetrations connected to RCS that have no accident consequence limiting system (ACLS) function
2	Penetrations connected to RCS that have ACLS function
3	Penetrations connected to containment atmosphere that have no ACLS function
4	Penetrations connected to containment atmosphere that have ACLS function
5	Penetrations connected to closed loop systems inside containment that have no ACLS function
6	Penetrations connected to closed loop systems inside containment that have ACLS function

Find also the applicable subcategory: normally closed (NC), normally open (NO), seismic, non-seismic, etc.

For categories with an ACLS function, there may be two failure modes listed on Table 3-3 for the inoperable CIV, one for the inoperable CIV is assured open (i.e., CIV TS is affected, but the ACLS TS is not affected) and one for the inoperable CIV is not assured open (i.e., both CIV TS and ACLS TS are affected).[2] If the plant-specific TS interpretation allows entry into the CIV TS without entering the ACLS

[2] In this context, "assured open" means that the inoperable CIV is in a state or is put into a state such that entering the Conditions and Required Actions of the applicable ACLS Technical Specification is not required.

TS (e.g., by securing the valve open), then quantify and record results for both cases, otherwise quantify for the case that assumes the inoperable CIV is not assured open (i.e., assume ACLS function is affected).

3) The risk impact estimates in Table 3-3 are also a function of the configuration of the other piping and valves in the path between the RCS or containment atmosphere, and the environment or low-pressure piping. These are represented by configurations A through G in the table (see full descriptions in Section 3.3.5). The probabilities in Table 3-3 associated with configurations A through G represent the conditional probability of a path to the environment, given CIV failure.

   Configurations of flow path to the environment (given CIV failure), as shown in Table 3-3, are:

Configuration of Escape Path	**Description**
A	Open Pipe (no other intervening valves).
B	Low Pressure Pipe (no other valves between the RCS or containment atmosphere and the low pressure vulnerability).
C	Open System or Path with One or Two Additional Open Valves
D	Open System or Path with One Additional Closed Valve
E	Open System or Path with Two Additional Closed Valves
F	Open System or Path with Three or More Additional Valves
G	Closed System

   Therefore, for each penetration, the configuration of the interfacing system piping and valves (potential escape path to environment) must be matched to the configurations A through G in the table. Usually there are multiple pathways outboard of the CIVs to various places (main process line, branch lines, vent lines, drain lines, etc.). The applicable risk (i.e., the CIV failure probability times the conditional probability of an escape path) is determined by evaluating the combination of these multiple pathways as potential escape paths. Usually the risk can approximated by the "most limiting pathway," but this can be done only after considering all of the pathways and making that determination. Therefore, continue with steps 4 through 13 for each potentially inoperable CIV:

4) Identify any low-pressure piping interface or system opening that would be vulnerable if valves failed in the open position.

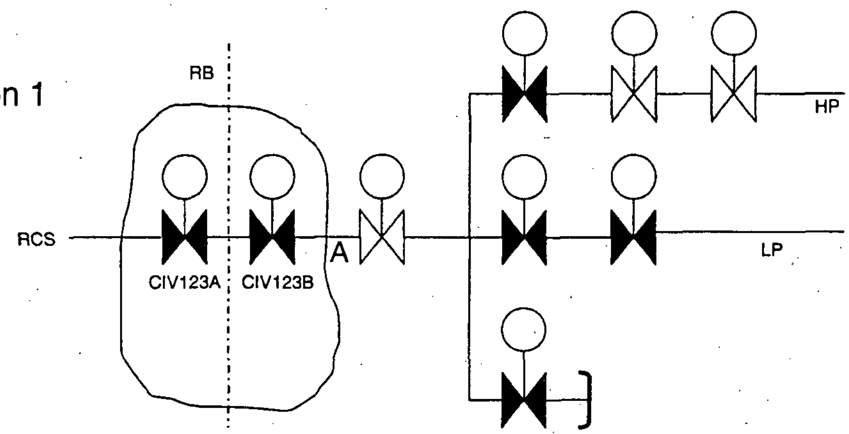
5) Draw a boundary around the specific penetration and CIVs, as well as any additional valves (between the RCS or containment atmosphere and the portion of the outside system that is low pressure or open) that may be credited to reduce risk. (The

additional valves may be inboard or outboard of the CIVs, but do not credit manual valves that are NO, or outwardly oriented check valves.) Draw the boundary to limit the multiple pathways and branch lines. The risk for multiple flow paths can be simplified by crediting the minimum amount of the interfacing system necessary to show a small risk, and assuming that any piping outside of the boundary is open to the environment.

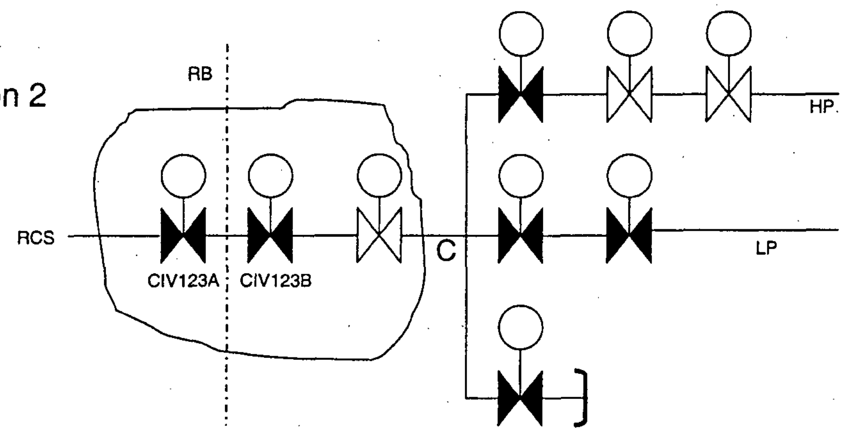
For example, see the simple example in the figure below. If the boundary is drawn around just the CIVs (option 1), then Configuation A is assumed for the outboard piping. In many cases, the open pipe assumption (A) produces acceptable risk, making it unnecessary to be concerned about the state of the system downstream of the CIVs. However, if the boundary is drawn to include the additional NO MOV (option 2), then Configuration C is assumed, improving the risk. The boundary can also be drawn larger to credit additional valves (option 3); in this case, all of the pathways have at least three additional valves (cap on pipe end is counted as a valve) before the low-pressure piping, and configuration F is used for each.

Example of Boundary Options for Crediting Additional Valves in Risk Calculation

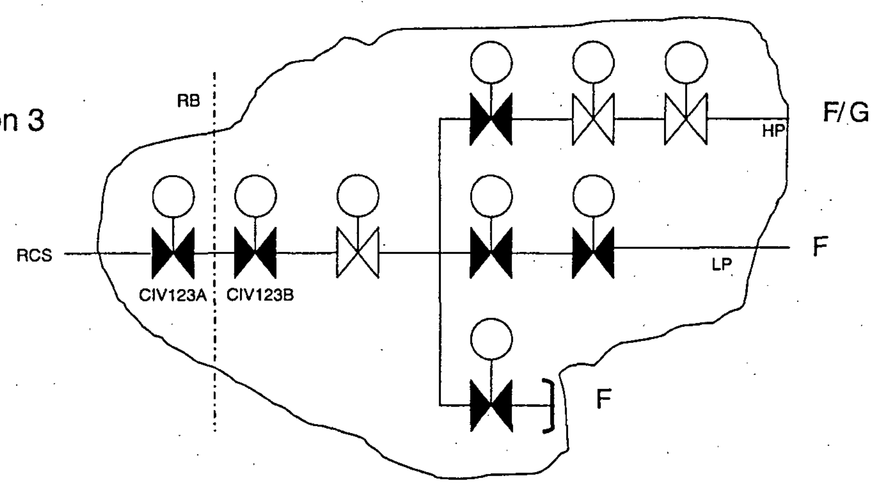
Option 1



Option 2



Option 3



6) Identify the seismic/non-seismic interface. Are the valves credited on seismic piping? If the valves to be credited are not within the seismic portion of the piping, then the risk values should taken from the non-seismic subcategories in Table 3-3, or the boundary should be drawn to exclude the non-seismic valves.

7) Examine the individual pathways from the CIV to the (drawn) boundary and label each with the appropriate configuration A to G.

8) If any pathways within the boundary are category A or B, that is, they are open or have low pressure piping, and have no other intervening valves, then this is the most limiting configuration. The conditional probability (i.e., of escape path to environment given CIV failure) is assumed to be 1.0 and it is not necessary to evaluate the other pathways on this penetration since category A and B are limiting (equal to 1.0).

9) The next most limiting pathway configuration is C (open path with open valves). If one or more of the pathways has only open valves within the boundary (other than the CIVs), then this pathway is also limiting. The conditional probability for this configuration is dominated by the human error probability assumed for the operator action (0.05 assumed). Other pathways (configurations D through G) connected to this penetration will not be significant relative to this one.

10) Configurations E to G (closed system or multiple valves separating the low-pressure interface or opening) are dominated by failure of the high pressure pipe. These pathways include multiple valves separating the high pressure pipe from low pressure or open interfaces, and the random pipe failure is assumed to occur in the portion of the pipe upstream of the additional valves so that they are of no value for isolation (risk calculation is conservative if the additional valves are inside containment). Since the pipe rupture failure rate is based on an assumption of 100 pipe segments between the outboard CIV and the next available valve, and because failure of the piping in any of the interfacing pathways between the CIV and the first valve on any pathway has the same consequence, then the probability displayed for E, F or G (whichever is most limiting for the penetration) is representative of the multiple pathways as long as the total number of pipe sections prior to the first valves does not exceed 100. (If the total number of sections does exceed 100, then sum the contributions.)

11) This leaves any penetration pathways that are configuration D (one additional closed valve separating the low-pressure or open interface); these pathways are dominated by failure of the valve, hence the failure probability for each interfacing pathway with configuration D must be summed with any others that are configuration D or configuration E, F or G from the previous step.

12) Record the results (ICCDP, ICLERP) for the inoperable CIV. It is convenient to enter results in a table such as the one shown below. For example (using the above figure with option 3):

Example Table for Recording Results

Inoperable CIV	Category	ICCDP/ ICLERP	Acceptable? ($ICCDP \leq 5x10^{-7}$ & $ICLERP \leq 5x10^{-8}$)	ICCDP/ ICLERP if CIV pressure boundary open (configuration A) (n/a for RCS connection, n/a for inboard CIV)	Acceptable? ($ICCDP \leq 5x10^{-7}$ & $ICLERP \leq 5x10^{-8}$)
CIV123A	1.1F	$6.6x10^{-10}$/ $6.6x10^{-10}$	Y	n/a	n/a
CIV123B	1.1F	$6.6x10^{-10}$/ $6.6x10^{-10}$	Y	n/a	n/a

13) If the inoperable CIV is an outboard CIV and it is not an RCS connection, then another case is needed for the situation where failure or repair of the inoperable valve involves breach of the inoperable valve's pressure boundary. If the configuration is not already modeled as configuration A (or B), then quantify another case for the CIV where configuration A (conditional probability = 1.0) is used. This configuration is applicable when the outboard CIV on a non-RCS connection is inoperable because of a pressure boundary that is not intact (or the repair activity involves breach of the pressure boundary). The point is moot if the affected penetration is isolated by securing the inboard CIV or other secured closed valve (i.e., satisfying the Required Action). This case is not applicable to RCS connections because the RCS pressure boundary is covered by a different TS.

14) Repeat the process above (starting at step 1) and calculate ICCDP/ICLERP for inoperability of each CIV. The risk is acceptably small (for single CIV inoperable) if $ICCDP \leq 5x10^{-7}$ and $ICLERP \leq 5x10^{-8}$. CIVs not meeting this acceptance guideline should be treated as exceptions (i.e., current AOT retained). Note that it is possible that an inoperable CIV may have acceptable risk if the pressure boundary is intact, but be unacceptable if the pressure boundary is not intact, and that it may be necessary to take exception in the case of inoperability involving a breached pressure boundary.

Suggested use of CIV Risk parameters in CRMP

The ICCDP and ICLERP values determined as described above may be used in the plant-specific CRMP. For situations where CIVs in multiple penetrations are inoperable simultaneously, the appropriate ICCDP and ICLERP values calculated above may be summed. This approach is appropriate because calculation of the ICLERP values does not include screening penetrations by line size; this allows the cumulative risk impact to be estimated by combining the probabilities only. Since even small penetration line sizes were conservatively considered a LERF risk, there is no cumulative size threshold to consider for multiple penetrations with inoperable CIVs. Therefore the cumulative probability is a conservative measure of the risk for multiple penetrations in the LCO simultaneously.

For situations where a CIV that is inoperable is one of those that is excluded from the relief request (i.e., retains the four-hour AOT), there is no need to combine the risk for this penetration with others that are inoperable at the same time to determine if the cumulative risk is significant. That is because these inoperable CIVs are always potentially risk significant (and should be treated as such in the CRMP).

AREVA

BAW-2461

Risk-Informed Justification for Containment Isolation Valve Allowed Outage Time Change

B&W Owners Group
Licensing Working Group

January 2005

Framatome ANP, Inc.

U.S. Nuclear Regulatory Commission
Report Disclaimer

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Abstract

This report contains a risk-informed evaluation performed by Framatome ANP for the B&W Owners Group (B&WOG) Licensing Working Group and is applicable to the participating B&WOG plants, which are Davis-Besse, Oconee Nuclear Station Units 1, 2, and 3, and Crystal River Unit 3. The purpose of this evaluation is to provide justification for a longer allowed outage time (AOT) for containment isolation valves (CIVs). It is proposed that the AOT for CIVs be extended to seven days from the current AOT of four or 72 hours. This risk-informed evaluation is applicable to penetration flow paths that have at least two CIVs, or one CIV and a closed loop system, but does not include the CIVs in the main steam lines, and certain other lines (which will be identified on a plant-specific basis) that may represent high risk significance for interfacing systems loss of coolant accident (ISLOCA).

The proposed Technical Specifications change will improve operational safety and reduce unnecessary burdens in complying with Technical Specifications requirements. Unnecessary plant shutdowns may be avoided by allowing more time for repairs. Operational flexibility will be enhanced by allowing some repairs to be performed online. For penetration flow paths with accident consequence limiting system (ACLS) functions, an extended AOT for CIVs will avoid unnecessary flow path isolation that may result in degraded function of the ACLS.

The justification provided in this report is consistent with the guidance set forth in Regulatory Guides 1.177 and 1.174. The proposed Technical Specifications change is in compliance with existing regulations, is consistent with the philosophy of defense-in-depth, and will not erode safety margins. The risk-informed evaluation uses the three-tiered approach expected by the NRC for implementing proposed Technical Specifications changes. The risk-informed evaluation demonstrates that the risk impact of the proposed change is small (Tier 1). The evaluation also relies upon the plant-specific configuration risk management program (CRMP). The CRMP ensures that potential high risk configurations that may result from equipment being taken out of service at the same time as the CIVs are identified (Tier 2), and that this risk is evaluated (Tier 3) prior to taking the equipment out of service.

The B&WOG has demonstrated that the proposed extension of the AOT for containment isolation valves does not adversely impact risk or public safety, and is therefore an appropriate change to the Technical Specifications.

Contents

Tables

Nomenclature

Acronym	Definition
ACLS	accident consequence limiting system
AOT	allowed outage time
AOV	air-operated valve
B&WOG	B&W Owners Group
CDF	core damage frequency
CIS	containment isolation system
CIVs	containment isolation valves
CRMP	configuration risk management program
DBA	design basis accident
EFW	emergency feedwater (sometimes called auxiliary feedwater)
FMEA	failure modes and effects analysis
FV	Fussell-Vesely importance
ICCDP	incremental conditional core damage probability
ICLERP	incremental conditional large early release probability
ISLOCA	interfacing systems loss of coolant accident
LCO	limiting condition for operation
LERF	large early release frequency
MOV	motor-operated valve
NC	normally closed
NO	normally open
NRC	Nuclear Regulatory Commission
PRA	probabilistic risk analysis
RAW	risk achievement worth
RCS	reactor coolant system
SG	steam generator
SGTR	steam generator tube rupture
SOV	solenoid-operated valve
TS	Technical Specifications
TSTF	Technical Specifications Task Force Traveler
UFSAR	Updated Final Safety Analysis Report

1.0 INTRODUCTION

This report contains a risk-informed evaluation performed by Framatome ANP for the B&W Owners Group (B&WOG) Licensing Working Group. The purpose of this evaluation is to provide justification for a longer allowed outage time (AOT) for containment isolation valves (CIVs). The evaluation contained herein is applicable to the participating B&WOG plants, which are Davis-Besse, Oconee Nuclear Station Units 1, 2, and 3, and Crystal River Unit 3.

The Nuclear Regulatory Commission's (NRC's) policy statement on probabilistic risk analysis (PRA) (Reference 1) encourages greater use of risk-informed evaluations to improve safety decision-making and regulatory efficiency. The B&WOG has successfully used risk-informed evaluations for changes to the Technical Specifications (TS). The justification provided in this report uses the guidance set forth in Regulatory Guides 1.177 and 1.174 (References 2 and 3) for risk-informed decision-making.

The risk-informed evaluation described in this report uses the three-tiered approach expected by the NRC for implementing proposed TS changes. Application of the three-tiered approach underscores the fundamental principle that the proposed change is consistent with the defense-in-depth philosophy, and that safety margins will not be eroded by the proposed change. Tier 1 is a demonstration that the risk impact of the proposed change is small. A risk assessment was performed to demonstrate that the incremental risk impact associated with the proposed AOT extension is small. The risk assessment was performed with a failure modes and effects analysis (FMEA) and a set of simplified and conservative risk models that encompass every applicable penetration. The risk model was developed using limiting parameters and conservative data extracted from the plant-specific PRAs. The risk assessment includes the effect that the proposed AOT extension has upon the probability of large early release following core damage, the probability of an interfacing system loss of coolant accident (ISLOCA), and the probability of affecting a post-accident ACLS function. The risk impact is expressed as the incremental change in the probability of core damage or large early release while in the proposed AOT.

Tiers 2 and 3 ensure that potential high risk configurations that may result from equipment being taken out of service at the same time as the CIVs are appropriately evaluated prior to taking the equipment out of service. The risk-informed evaluation relies upon the plant-specific configuration risk management program (CRMP). The CRMP ensures that potential high risk configurations that may result from equipment being taken out of service at the same time as the CIVs are identified (Tier 2), and that this risk is evaluated (Tier 3) prior to taking the equipment out of service. The CRMP enhances defense-in-depth because it provides a means of ensuring that the independence of the physical barriers will not be degraded by the proposed change. The B&WOG plant-specific CRMPs satisfy the Tier 2 and Tier 3 requirements of Regulatory Guide 1.177.

2.0 DEFINITION OF THE PROPOSED CHANGES

2.1 Summary of Technical Specifications Change

The relevant portion of the TS for the proposed AOT change is the "Containment Isolation Valves" Limiting Condition for Operation (LCO), which is Section 3.6.3 of the Standard Technical Specifications, NUREG 1430 (Reference 4). The proposed change pertains to the AOT (also known as Completion Time) for penetration flow paths with one inoperable CIV, which are Conditions A and C in the aforementioned LCO. The proposed change is to increase the Completion Time from four hours to seven days for Condition A (one CIV inoperable in containment penetration flow paths with two or more CIVs), and increase the Completion Time from 72 hours to seven days for Condition C (one CIV inoperable in containment penetration flow paths with only one CIV and a closed system). No change is proposed for the Condition related to a penetration flow path with two inoperable CIVs (Condition B). The proposed changes are summarized in Table 2-1.

Table 2-1 Summary of Proposed Technical Specifications Change[1]

Condition	Required Action	Completion Time[2]
A. ------------NOTE------------ Only applicable to penetration flow paths with two [or more] containment isolation valves with the exception of containment isolation valves in the main steam lines [and list of specific penetrations (if any) identified by the plant-specific risk-informed process to have high risk significance for ISLOCA]. -------------------------------- One or more penetration flow paths with one containment isolation valve inoperable [for reasons other than purge valve leakage not within limit].	A.1 Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured. AND	~~4 hours~~ 7 days

[1] Markup is for illustration only and is based upon NUREG-1430 (some notes have been removed from the table for simplification). See applicable plant-specific TS, NUREG-1430, and/or Technical Specifications Task Force Traveler (TSTF) for specific wording. Proposed new items are in **Bold**.
[2] Current completion times may vary for plants not using the Standard Technical Specifications.

Table 2-1 Summary of Proposed Technical Specifications Change[1]

Condition	Required Action	Completion Time[2]
	A.2 Verify the affected penetration flow path is isolated.	Once per 31 days for isolation devices outside containment AND Prior to entering MODE 4 from MODE 5 if not performed within the previous 92 days for isolation devices inside containment

Table 2-1 Summary of Proposed Technical Specifications Change[1]

Condition	Required Action	Completion Time[2]
[New Condition] **------------NOTE------------** **Only applicable to penetration flow paths with two [or more] containment isolation valves in the main steam lines [and list of specific penetrations (if any) identified by the plant-specific risk-informed process to have high risk significance for ISLOCA].** **--------------------------------** **One or more penetration flow paths with one containment isolation valve inoperable.**	**Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.** **<u>AND</u>**	**4 hours**
	Verify the affected penetration flow path is isolated.	**Once per 31 days for isolation devices outside containment** **<u>AND</u>** **Prior to entering MODE 4 from MODE 5 if not performed within the previous 92 days for isolation devices inside containment**

Table 2-1 Summary of Proposed Technical Specifications Change[1]

Condition	Required Action	Completion Time[2]
B. ------------NOTE------------ Only applicable to penetration flow paths with two [or more] containment isolation valves. -------------------------------- One or more penetration flow paths with two [or more] containment isolation valves inoperable [for reasons other than purge valve leakage not within limit].	B.1 Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange.	 1 hour
C. ------------NOTE------------ Only applicable to penetration flow paths with only one containment isolation valve and a closed system. -------------------------------- One or more penetration flow paths with one containment isolation valve inoperable.	C.1 Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange. AND	 ~~72 hours~~ 7 days
	C.2 Verify the affected penetration flow path is isolated.	 Once per 31 days

Table 2-1 Summary of Proposed Technical Specifications Change[1]		
Condition	Required Action	Completion Time[2]
[New Condition] ------------NOTE------------ **Only applicable to penetration flow paths with only one containment isolation valve and a closed system.** -------------------------------- **One or more penetration flow paths with the closed system pressure boundary inoperable (and the *inoperable portion of* the closed system pressure boundary is not an RCS pressure boundary[3]).**	**Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange.** **AND**	**7 days**
	Verify the affected penetration flow path is isolated.	**Once per 31 days**
[New Condition] ------------NOTE------------ **Only applicable to penetration flow paths with only one containment isolation valve and a closed system.** -------------------------------- **One or more penetration flow paths with one containment isolation valve and the closed system pressure boundary inoperable**	**Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange.**	**1 hour**

[3] In that case see STS 3.4.13 "RCS operational Leakage"

Table 2-1 Summary of Proposed Technical Specifications Change[1]		
Condition	Required Action	Completion Time[2]
D. [One or more penetration flow paths with one or more containment purge valves not within purge valve leakage limits.	D.1 Isolate the affected penetration flow path by use of at least one [closed and de-activated automatic valve, closed manual valve, or blind flange]. AND	24 hours
	D.2 Verify the affected penetration flow path is isolated. AND	Once per 31 days for isolation devices outside containment AND Prior to entering MODE 4 from MODE 5 if not performed within the previous 92 days for isolation devices inside containment
	D.3 Perform SR 3.6.3.6 for the resilient seal purge valves closed to comply with Required Action D.1.	Once per [ ] days]
E. Required Action and associated Completion Time not met.	E.1 Be in MODE 3. AND E.2 Be in MODE 5.	6 hours 36 hours

2.2 Discussion of Technical Specifications Change

2.2.1 AOT Change

It is proposed that the Completion Time for the action of isolating the affected penetration be changed to seven days for Condition A (one CIV inoperable in a penetration with two or more CIVs) and for Condition C (one CIV inoperable in a penetration with one CIV and a closed system). The risk-informed evaluation contained in this Topical Report provides the basis for the proposed change.

The main steam line penetrations are excluded from the AOT extension. These are excluded because the risk associated with an AOT extension for these lines was not evaluated (see Section 2.3).

Specific other penetrations may also be excluded (on a plant-specific basis) from the AOT extension if they have high risk significance for ISLOCA (see Section 3.3.6). This may occur in a few cases where there are just two normally closed CIVs and no other closed valves between the RCS and the low-pressure interfacing system. These penetrations may not meet the Regulatory Guide 1.177 guideline for small risk impact, when one of the CIVs is inoperable and the AOT is extended. These specific penetrations will be identified on a plant-specific basis prior to implementation of the proposed TS change.

2.2.2 Common Cause Failure Determination

An action is added to perform a common cause failure (CCF) determination for a second (redundant) CIV of a like pair within the original four-hour AOT of the first inoperable CIV. This action applies only to redundant CIVs in the same penetration that have a valve operator of similar design for both the inboard and outboard CIVs. The purpose of this requirement is to verify that the redundant CIV has not experienced a common cause failure (CCF) that would put the penetration into Condition B, two CIVs inoperable.

Upon entry into Condition A, the B&WOG utility will confirm that the redundant similarly-designed CIV has not been affected by the same failure mode as the inoperable CIV.

This verification will consist of a situation-specific evaluation (e.g., inspection, partial stroke, functionality test, or engineering evaluation) as appropriate to verify that the redundant CIV has not been affected by the same failure mode. This verification will be performed before entering into the extended portion of the AOT (i.e., within four hours).

This verification is necessary because the treatment of CCF is important to the PRA calculations used to support the proposed AOT extension. This verification allows the risk calculation for the redundant CIV to use the random failure rate rather than the CCF rate. This ensures that the risk exposure will be minimal during the proposed AOT extension for penetrations that have a pair of similar CIVs.

The plant-specific risk-informed process (e.g., PRA methodology/guidance document, PRA engineer, or expert panel) will be used to determine which penetrations this action is applicable to, i.e., which penetrations contain redundant CIVs that are in the same "common cause failure group." The specific penetrations with CCF potential will subsequently be listed in a plant-specific TS interpretation document or other administrative resource.

2.2.3 New Condition for Penetrations with a Closed System

A new set of conditions is proposed to clarify the TS interpretation for the situation involving a penetration flow path with one CIV and a closed loop system, and the pressure boundary of the closed loop system has an operability issue. This situation is analogous to Condition A for a penetration connected to the containment atmosphere, because the open pipe loop with an unaffected CIV is functionally the same as a penetration connected to the containment atmosphere with one of two CIVs inoperable. However, if both the CIV and the closed loop pressure boundary are inoperable, then it is analogous to Condition B of TS 3.6.3.

A parenthetical note is included that the condition applies only if the inoperable portion of the pressure boundary in the closed system is not an RCS pressure boundary. For the penetrations involving a closed system, the closed loop usually provides a barrier for isolation of the containment atmosphere. If the affected portion of the closed system provides a barrier for the RCS pressure boundary (e.g., SG tubes), then a different LCO is applicable (3.4.13 "RCS Operational Leakage"), which is more limiting.

2.3 Applicable Containment Isolation Valves

The evaluation contained herein is applicable to the participating B&WOG plants, which are Davis-Besse, Oconee Nuclear Station Units 1, 2, and 3, and Crystal River Unit 3. The applicable CIVs are listed in each plant's Updated Final Safety Analysis Report (UFSAR).

All of the applicable valves have a containment isolation function. Some of the valves that have a containment isolation function are also in an accident consequence limiting system (ACLS) flow path. The TS bases document, NUREG-1430 Volume 2 (Reference 4), states that CIVs provide an automatic isolation barrier function for containment penetrations not serving an ACLS. This risk analysis assumes that for the CIVs in ACLS flow paths, an isolation function may be needed late in an accident, after the ACLS function is finished. For these valves, the proposed TS change only applies to the containment isolation function. The requirements for the ACLS function are covered by the applicable TS of the ACLS, for which no changes are proposed by this report.

The proposed TS change applies only to penetration flow paths containing two (or more) CIVs in series, or one CIV and a closed loop system inside containment. Some of the penetrations with two (or more) CIVs connect directly with the reactor coolant system (RCS), and some connect directly with the containment atmosphere. For the penetrations with a single CIV and a closed loop system inside containment, the closed loop provides the second containment isolation barrier. The closed loop pressure boundary may provide a barrier with only the containment atmosphere, but in some cases portions of it may also be part of the RCS pressure boundary (e.g., the secondary side of steam the generator tubes).

The CIVs in the main steam lines are explicitly excluded from the proposed AOT extension. These are excluded because the isolation of these penetrations has a risk/safety impact that goes beyond the containment isolation function. Because of the complexity of determining the incremental risk that would be associated with extending the AOT for these valves, the B&WOG has not included them in this AOT relaxation proposal.

2.4 Generic Applicability

Plant-specific input used for this submittal ensures applicability. PRA parameters used in the risk analysis (valve failure rates, core damage frequency, etc.) were surveyed from the participating B&WOG utilities, and limiting values for each parameter were used in the risk analysis.

The configurations analyzed for penetrations and release paths are conservative with respect to isolation. In the categorization of penetration configurations, several different valve types are used (MOV, AOV, etc.). Rather than analyze each different combination of valves that could occur on a penetration, the generic risk analysis assumes the valve type with the worst failure rate for all cases. This was done in the interest of conservatism, and to reduce the number of variations in the risk analysis. In addition, no credit was given in the risk assessment for systems such as emergency ventilation and filtration at the pipe terminations, which may reduce the probability or severity of large early release. Hence, the risk analysis is conservative for most of the penetration population. This ensures generic applicability of the results.

2.5 Need for Proposed Change

The proposed TS change will improve operational safety and reduce unnecessary burdens in complying with current TS requirements. Unnecessary plant maneuvers (forced shutdowns) may be avoided by allowing more time for repairs. The current four-hour AOT is not sufficient to perform meaningful repairs. An extension of the AOT will provide operational flexibility by allowing some repairs to be performed online. For penetration flow paths with ACLS functions, an extended AOT for CIVs will delay and possibly avoid unnecessary flow path isolation that may result in degraded function of the ACLS.

3.0 ENGINEERING EVALUATION

The proposed TS change has been evaluated with regard to the principles that adequate defense- in-depth is maintained, that sufficient safety margins are maintained, and that proposed increases in core damage frequency (CDF) and risk are small, and are consistent with the intent of the Commission's Safety Goal Policy Statement (Reference 5).

3.1 Compliance with Current Regulations

The proposed changes do not impact compliance with the regulations governing TS. The NRC regulations specific to TS are stated in 10 CFR 50.36, "Technical Specifications" (Reference 6). Additional information is contained in the "Final Policy Statement on Technical Specification Improvements for Nuclear Power Reactors" (Reference 7), and the statement of considerations for 10 CFR 50.36. These documents define the main elements of TS, provide criteria for items to be included in TS, and discuss the use of probabilistic approaches to improve TS. The proposed TS changes are consistent with these regulations.

The proposed TS changes are also consistent with precedence established by Standard Technical Specifications (Reference 4), and by previous B&WOG and industry submittals. Upon discovery of a failure to meet an LCO, TS specify time for completing Required Actions of the associated TS conditions. Required Actions establish remedial measures that must be taken within specified completion times (AOTs). These times define limits during which operation in a degraded condition is permitted. Incorporating completion time extensions is acceptable because completion times take into account the operability status of the redundant equipment, the capability of the equipment, a reasonable time for repairs of required equipment, and the low probability of a design basis accident (DBA) occurring during the repair period (Reference 8).

3.2 Traditional Engineering Evaluation

3.2.1 Bases of TS for CIVs

The TS Bases Document (Reference 4) describes the bases for the CIV TS. The CIVs satisfy Criterion 3 of 10 CFR 50.36[c] (2)(ii).

The CIVs form part of the containment pressure boundary and provide a means for fluid penetrations not serving ACLSs to be provided with two isolation barriers that are closed on an automatic isolation signal. These isolation devices consist of either passive devices or active (automatic) devices. Manual valves, de-activated automatic valves secured in their closed position (including check valves with flow through the valve secured), blind flanges, and closed systems are considered passive devices. Check valves, or other automatic valves designed to close following an accident without operator action, are considered active devices. Two barriers in series are provided for each penetration so that no single credible failure or malfunction of an active component can result in a loss of isolation or leakage that exceeds limits assumed in the safety analyses. One of these barriers may be a closed system. These barriers (typically CIVs) make up the Containment Isolation System.

Containment isolation occurs upon receipt of a high containment pressure or diverse containment isolation signal. The containment isolation signal closes automatic CIVs in fluid penetrations not required for operation of engineered safeguard systems to prevent leakage of radioactive material. Upon actuation of high pressure injection, automatic CIVs also isolate systems not required for containment or RCS heat removal. Other penetrations are isolated by the use of valves in the closed position or blind flanges. As a result, the CIVs (and blind flanges) help ensure that the containment atmosphere will be isolated in the event of a release of radioactive material to containment atmosphere from the RCS following a DBA.

The DBAs that result in a release of radioactive material within containment are a loss of coolant accident (LOCA), a main steam line break, and a rod ejection accident (Reference 4). In the analysis for each of these accidents, it is assumed that CIVs are either closed or function to close within the required isolation time following event initiation. The DBA analysis assumes that, within 60 seconds after the accident, isolation of the containment is complete and leakage terminated, except for the design leakage rate. The containment isolation total response time of 60 seconds includes signal delay, diesel generator startup (for loss of offsite power), and containment isolation valve stroke times. The operability requirements for CIVs help ensure that containment is isolated within the time limits assumed in the safety analysis.

The automatic power-operated isolation valves are required to have isolation times within limits (in design basis documents) and to actuate on an automatic isolation signal. The valves covered by this LCO are listed along with their associated stroke times in the UFSAR. The passive (normally closed) isolation valves are considered OPERABLE when manual valves are closed, check valves have flow through the valve secured, blind flanges are in place, and closed systems are intact. These passive isolation valves/devices are listed in the UFSAR.

The CIV leakage rates are addressed by LCO 3.6.1, "Containment." CIV leakage is tested in accordance with the Containment Leak Rate Test Program. In the event CIV leakage results in exceeding the established containment leakage rate limits, the TS requires entry into the applicable Conditions and Required Actions of LCO 3.6.1. The proposed changes do not affect this portion of the TS and no changes are proposed herein for this portion of the TS.

The proposed TS changes do not affect the ability of the Containment Isolation System (CIS) to perform its intended safety function. Each CIV of a redundant CIV pair (or CIV and closed piping loop) is individually capable of performing the containment isolation safety function. (The proposed TS change applies only to penetration flow paths containing two or more CIVs, or one or more CIV, and a closed loop system.) The design criteria of the CIS ensures that no single failure or malfunction can result in a loss of isolation, or result in exceeding the leakage limits or time limits assumed in the safety analyses. The LCO takes into account the operational status and capability of the redundant equipment. Therefore, the remaining CIV is capable of protecting the leakage and time limits assumed in the safety analysis, should a DBA occur while the (first) CIV is in a degraded condition (i.e., temporary reduction of redundancy) associated with the extended AOT.

3.2.2 Dual Function CIVs

Some CIVs are in penetration flow paths that also have an ACLS function. These penetrations, which are identified in the UFSAR, have a post-accident position of open, and are not closed on an automatic isolation signal. For these CIVs, the valve position that satisfies the accident mitigation function (open) is opposite of the valve position that satisfies the containment isolation function (closed). The close function, if needed, is used later in the event (when the ACLS has completed its function).

If a DBA does occur during the extended AOT of the CIV function, the redundant CIV (or closed loop) is still available to isolate the penetration when needed. The longer AOT may have the effect of postponing the Required Action for isolation to a later time such that the reduced redundancy will not be limiting for the ACLS. With the proposed extended AOT for the CIVs, the AOT of the ACLS (72 hours) will be the most limiting AOT for the ACLS function.

The TS requirements of the ACLS ensure that appropriate remedial actions are taken, if the affected ACLS flow path(s) are rendered inoperable by an inoperable CIV (or the subsequent Required Action to isolate the affected penetration flow path). The system TS associated with the ACLS function of these dual function valves is not affected by the proposed change and no changes are proposed herein for that portion of the TS.

Therefore the safety consequences of degraded ACLS function are not affected by extension of the AOT for the CIV TS. Although degradation of the ACLS function may occur due to inoperability of the dual function CIV, and safety may be affected by the ACLS degradation, the ACLS function is not impaired by delayed isolation of the CIV. The proposed AOT extension for the CIV function may be beneficial to the ACLS function, because delay of isolation may allow the ACLS train to be capable of full or partial capacity for a longer period of time (until reaching the ACLS AOT limit). Compensatory Actions (Required Actions and Completion Times) taken with respect to the ACLS TS, which are related to degradation of ACLS functionality, are not changed by the proposal.

3.2.3 Repairs that involve the Valve Pressure Boundary

Consideration has been given to the impact of repairs that may be initiated during the extended AOT that involve opening of the valve pressure boundary. Failures of the valve body are uncommon (but are included in this category), as are leaky valve stems, which are more common (but do not impact the containment isolation capability because the valve can still close). Some repairs to valves can involve removal of sealing material (packing) or other valve components that would affect penetration integrity. For an outboard CIV, this possibility may be equivalent to an open escape path to the outside environment. (In the subsequent risk analysis, the open escape path case is modeled as configuration "A.") For penetration flow paths that are open to the RCS or the steam generator (SG), a repair involving breach of the valve pressure boundary could not be performed on-line without first isolating the valve. For penetration flow paths open to the containment atmosphere, isolation of the line (via the redundant CIV or other valve) reduces the risk of offsite release. Similarly, for closed loop systems, the risk of offsite release is acceptable because the closed loop provides isolation from the containment atmosphere.

The purpose of the proposed AOT extension is to allow more time with the penetration flow path open (i.e., before the Required Action to isolate). If maintenance is required that involves pressure boundary teardown, then the plant will most assuredly require closure of the flow path (i.e., isolation of the component), if it is a flow path that is open to the RCS, the secondary side of the SG, or to the containment atmosphere. Therefore, the extended AOT is not particularly relevant or useful in those situations because the Required Action (i.e., isolation) is satisfied.

For CIV pressure boundary repairs where the extended AOT may be useful (such as on a closed system), the risk has been evaluated. (In the risk analysis, the open escape path case is modeled as configuration "A.")

3.2.4 Defense-in-Depth

The impact of the proposed TS change is consistent with the defense-in-depth philosophy. The risk evaluation has considered the impact of the proposed TS change on barriers to core damage, and the impact is small. The risk analysis has also considered the impact of the proposed change on containment failure and bypass, and the impact is small. The proposed changes do not degrade the independence of physical barriers to fission product release. System redundancy, independence, and diversity are maintained commensurate with the expected risk of challenges to the CIS.

Furthermore, the proposed TS change will not significantly change the balance among defense-in-depth attributes (prevention, mitigation, and containment). The anticipated operational changes associated with the proposed change in the AOT will not introduce any new accidents or transients or increase the likelihood of an accident or transient that may challenge the containment barrier. (The DBAs that result in a release of radioactive material within containment are a LOCA, a main steam line break, and a rod ejection accident, Reference 4.) Nor will the proposed changes introduce any new common cause failure modes or operator response not previously considered. (The proposed TS change includes a CCF determination for penetration flow paths with two or more like CIVs to be performed within the original four-hour AOT).

There is not an over-reliance on programmatic activities to compensate for weaknesses in plant design or to justify the use of optimistic reliability estimates. The programmatic activities that are used include the CRMP and the Maintenance Rule. The CRMP provides a means of ensuring that the independence of the physical barriers will not be degraded by the proposed change. The plants' CRMP ensures that no action or maintenance is done to increase the frequency of a DBA that may challenge the containment, or remove redundant functionality while in the LCO. The CRMP helps to avoid inadvertent high risk configurations from emerging while in the LCO that may erode the principles of redundancy and diversity. The Maintenance Rule will provide an oversight against inadvertent reliability and availability degradation of the CIS function from the proposed change in the AOT. Furthermore, the Maintenance Rule will ensure appropriate risk management actions (e.g., compensatory actions) as warranted by the change in risk introduced by the maintenance activity. These programmatic activities enhance defense-in-depth because they provide backup protection (beyond the Compensatory Actions dictated by the LCO) against inadvertent or unforeseen consequences of the proposed TS change. In addition, "application of the three-tiered approach provides assurance that defense-in-depth will not be significantly impacted by the proposed change" (Reference 2).

3.2.5 Safety Margins

The proposed TS change does not erode safety margins. The proposed AOT change does not adversely affect any assumptions or inputs to the safety analysis, or conflict with approved codes and standards. The UFSAR acceptance criteria are not affected, assuming the plant is in the AOT (i.e., one CIV is inoperable in one or more penetration flow paths) and there are no additional failures. The proposed TS change applies only to penetration flow paths containing two or more CIVs, (or one CIV and a closed loop system). Since each CIV by design is individually capable of performing the containment isolation safety function, the remaining CIV will protect the leakage and time limits assumed in the safety analysis, should a DBA occur while in the AOT. There are no situations, apart from additional failures, in which entry into the proposed AOT would result in failure to meet an intended safety function.

3.3 Tier 1: Evaluation of Risk Impact

The NRC staff has identified a three-tiered approach to evaluate the risk associated with proposed TS AOT changes. Tier 1 is an evaluation of the impact on plant risk of the proposed TS change as expressed by the incremental conditional core damage probability (ICCDP), and the incremental conditional large early release probability (ICLERP). The risk being addressed in this case is the incremental risk, during the extended AOT, that is related to the inoperable CIV being left open or partially open (i.e., the Required Action to isolate delayed) until the expiration of the proposed AOT extension.

The ICCDP and ICLERP are the incremental change in CDF and large early release frequency (LERF) due to the CIV being out of service, times the length of the proposed AOT extension (assuming that the full duration of the AOT is used). Since plant practices typically do not plan for using the full duration of the AOT, using the full duration in this analysis will yield conservative results.

ICCDP = CDF impact x (duration of proposed AOT)

ICLERP = LERF impact x (duration of proposed AOT)

According to Regulatory Guide 1.177, an ICCDP equal to 5e-7 and an ICLERP equal to 5e-8 represent a small impact on risk.

Tier 1, the impact of the proposed TS change on risk, is assessed below. Tiers 2 and 3, identification of potentially high-risk configurations that could exist if other equipment were to be taken out of service simultaneously and configuration risk management, are discussed in Section 3.4. Application of the three-tiered approach to the proposed risk-informed TS AOT change provides additional assurance that defense-in-depth will not be significantly impacted by the proposed changes to the licensing basis.

3.3.1 Scope and General Approach of the Risk Evaluation for the Proposed Technical Specification Change

To evaluate a TS change, the specific systems or components involved need to modeled in the risk analysis. The plant-specific PRAs do not necessarily model the CIS in detail and every penetration for which the TS change is being proposed. Therefore, a specialized analysis was necessary involving a set of simplified models that can be applied to each penetration.

The plant-specific PRA models were not used directly in this evaluation. Instead, equations were developed for each penetration type, and were quantified using parameters extracted from the plant-specific PRAs, such as base CDF and CIV failure rates.

The scope of risk analysis developed for evaluation of the proposed TS change is driven by how the CIVs might impact severe accident risk. This impact may be different than the impact associated with loss of the design basis safety function. With respect to severe accident risk, there are:

1. Penetrations that must close or stay closed to prevent a large early release following core damage.
2. Penetrations that must close or stay closed to prevent loss of RCS inventory and subsequent core damage and large early release from an interfacing systems loss of coolant accident (ISLOCA).
3. Penetrations that need to stay open post-accident to support an ACLS function, but may need to isolate later in the accident (or upon failure of the ACLS train).

For a CIV in a flow path that is not connected to the RCS and has no design basis safety function other than containment isolation, the CIV's risk limiting function is to prevent a large early release following core damage. This applies to penetration flow paths connected directly to the containment atmosphere, and to closed loop systems if there is a coincident failure of the pipe loop inside containment. A bounding LERF is generally estimated from the plants' CDF coincident with the probability of a failed open CIV/penetration flow path to the outside environment. The base CDF can be extracted from the plant-specific PRA because the CIS models are generally separate from and not integral to the level 1 PRA model and can be treated independently from the CDF. This approach is similar to the simplified event tree in NUREG/CR-6595, "An Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events" (see Figure 2.1 of Reference 9). This approach does however result in a gross simplification in the conservative direction because it ignores the magnitude and timing of the radionuclide release (i.e., the potential for early fatalities). Offsite doses could be below the threshold for large early release, and the timing of the release may allow for evacuation of the close in population. This conservative approach overestimates the LERF (and hence ICLERP) due to the proposed AOT extension.

For CIVs in a flow path connected to the RCS, there is potential to affect CDF and LERF via an ISLOCA. A bounding risk for this case is generally determined from the probability of a failed open CIV/penetration flow path between the RCS and the environment outside of the containment. Since the ISLOCA is assumed to result in core damage and large early release, the impact of mitigation systems other than the CIS is not particularly relevant. In plant-specific PRAs, the ISLOCA type failures are typically treated separate from the base PRA. However, the ISLOCA studies generally screen out most of the less-significant penetrations (e.g., based on line size or number of valves). That approach is not taken here, and all failed open penetrations connected to the RCS are conservatively assumed to have CDF and LERF potential.

For a CIV in penetration flow paths that need to stay open post-accident to support an ACLS function, the risk assessment considers the potential change in the CDF due to degradation of the ACLS function. In most cases, the isolation function of the CIV is not shared with the ACLS function of the CIV because the ACLS function is to remain open. The position of the CIV associated with the proposed AOT extension (i.e., temporarily unisolated/open), is generally the safe position with respect to the ACLS function. Lengthening the AOT for an inoperable CIV may increase the incremental probability of CIS failure (if an accident occurs during the proposed AOT extension); however the proposed extension may improve the conditional core damage probability during the period of inoperability by being less obtrusive to the ACLS function. The beneficial part of this risk tradeoff is not quantified; in this risk analysis, only the potential increases in risk are estimated.

A partially open CIV (or one that cannot be assured to be open) has the potential to impact risk for ACLS penetrations, because the CIV does not satisfy its containment isolation function, and the partially open flow path **may not** completely satisfy the ACLS function either. The partially open flow path is probably better for the ACLS function than having the CIV closed (which is the Required Action of the CIV TS that the proposed AOT extension seeks to delay). If the flow path is left as is, and an accident occurs, its ACLS function **may** be lost; if the flow path is isolated, its ACLS function is definitely lost (the AOT clock of the associated ACLS TS starts in either case). Hence, not isolating the CIV generally does not further increase the core damage probability during the proposed AOT extension. However, the probability of large early release during the proposed AOT extension is affected because the proposed **delay** in taking the Required Action for an inoperable CIV (isolation of the penetration) increases the exposure to the higher CDF caused by the ACLS degradation. The general approach for estimating the large early release impact for this situation is to adjust the plants' CDF with the risk achievement worth (RAW)[4] for loss of the safety function associated with the affected ACLS flow path (or a bounding value), conservatively assuming that the safety function of the ACLS flow path is lost. The calculations also include the coincident probability of failure of the redundant CIV and/or flow path to the outside environment.

3.3.2 Assumptions used in the AOT Risk Evaluation

The following assumptions were used for the risk evaluation of the proposed AOT:

1. The AOT risk evaluation was performed for power operation. The CIV Technical Specifications and the proposed AOT change apply to operating modes 1, 2, 3, and 4. The risk at power is bounding for the risk at the other operating modes. That is because the energy that can be released to the reactor building when in the hot standby, hot shutdown, and startup modes is only a fraction of that associated with a DBA at power. The post-accident RB pressure will be lower, RCS pressure may be lower, and significant radionuclide decay has occurred. Hence, the risk for power operation is conservative for Modes 2, 3, and 4.

2. The base CDFs used in this evaluation include the mean outage times (i.e., maintenance unavailability) for all systems. There are no experience data for the extended AOT to suggest that increased opportunity for online maintenance will

[4] The risk achievement worth importance measure is the factor that CDF will increase if the subject component is guaranteed failed.

improve CIV failure rates. Therefore, the assumption is made that the frequency of outage for maintenance and the component failure rates will remain the same. The ICCDP and ICLERP (single AOT risk) calculations assume that the full length of the proposed AOT is used for the maintenance activity. The acceptance criteria for ICCDP and ICLERP (5e-7 and 5e-8, respectively) (Reference 2), ensure that the overall risk impact of the proposed AOT change will be small, even considering separate LCO entries for multiple penetrations. Nonetheless, the maintenance unavailability for the CIS will be tracked by the Maintenance Rule to ensure that overall risk is not significantly impacted by the change (see discussion of Maintenance Rule in Section 3.5).

3. In this evaluation, core damage events with open penetration flow paths to the outside environment are assumed to be candidates for large early release. No credit is given for small line size, or for emergency ventilation systems at the termination point. Since separate LCO entry is allowed for each penetration flow path, simultaneous AOT entries in different penetrations may increase the possible effective containment hole size, albeit with diminishing probability. This risk evaluation does not limit the LERF risk by making a distinction by size of the penetration. However, plant-specific PRAs may consider penetrations smaller than a certain size to be below the size threshold of a large early release, or below the size threshold of an ISLOCA. Individual B&WOG members may chose to categorize certain penetrations into the small risk category (i.e., allow extended AOT) based on the size of the pipe being too small to meet the definition of LERF and/or ISLOCA (as defined by their plant-specific PRA), especially if the plant operators use their CRMP to monitor multiple simultaneous CIV LCO entries.

4. The CDF used in the equations for LERF does not make a distinction with respect to magnitude and timing of the radionuclide release. This is a conservatism in the risk analysis because it ignores that a fraction of the events included in the LERF may involve doses that are below the threshold for large early release or may involve timing that allows for evacuation of the close-in

population. This conservative approach overestimates the LERF (and hence ICLERP) associated with the proposed AOT extension.

5. External events such as fires and floods are assumed to be insignificant risk contributors with respect to the incremental conditional probability of core damage or large early release during the proposed AOT. The basis for this assumption is that the probability of a fire or flood occurring during the limited time of the AOT (even seven days) is small. In addition, the probability that the fire or flood also occurs in a specific zone that would affect the operable CIV on a specific penetration, is even smaller. This fire or flood would also have to affect other components to cause core damage. Hence, the contribution of fire or flood is a small increment relative to the base failure probability of the operable CIV.

6. In the case of a penetration flow path with two like CIVs, and one CIV is inoperable, the risk analysis does not include common cause failure of the second CIV. The CCF contribution is not included because it is assumed that the plant operators will verify (within the original four-hour AOT) that the other CIV of the like pair has not been affected by the same failure mode. The AOT and Required Actions for Condition B (penetration flow path with two CIVs inoperable) are not changed by the proposed AOT extension.

7. Many of the CIVs that are required to close post-accident are air-operated valves (AOVs), which are designed to fail in the safe state upon loss of air or control power. A few small penetrations also use solenoid-operated valves (SOVs), which also fail in the safe state upon loss of power. Some of the penetrations use motor-operated valves (MOVs), which fail as-is upon loss of motive power. A review of the failure probabilities of the associated buses reveals that failure to close due to unavailability of the power bus is not significant relative to random hardware failure of the MOV (and a power outage affecting the MOV coincident with inoperability of the redundant CIV would trigger the Required Action for Condition B, i.e., two inoperable CIVs). Dependent failure between CIVs is not an issue because redundant CIVs on the same penetration are powered by

different buses. The other dependency that was considered is between the CIV failure and CDF. A review of Fussell-Vesely (FV)[5] importance measures for these buses indicates that their contribution to CDF is a small, but not insignificant fraction. Therefore, for those risk calculations where the CDF is combined with failure to close of an open motor-operated CIV, a contribution is added to represent the portion of the CDF involving the bus failure (i.e., the CDF times FV for a typical electrical bus) along with a dependent MOV failure probability that is 1.0.

8. Transition risk (risk of changing operating modes if the end of the AOT is reached before maintenance is completed) is conservatively ignored, even though the longer AOT may result in fewer mode changes than the current AOT.

9. No credit is given for non-seismic pipe in seismic events. The risk calculations include consideration of the probability of a seismic event occurring during the AOT combined with failure a probability of 1.0 for the non-seismic pipe.

10. The failure rate for random pipe failure (i.e., non-seismically-induced failure of pipe exposed to pressure less than or equal to design pressure) is assumed to be 6.0e-8 /hour per penetration flow path. This failure rate was derived from K. Jamali, "Pipe Failure Study Update" (Reference 10). The pipe failure rate for a generic PWR assuming the most-limiting pipe size group (ID from 0.5 to 2 inches) is 6.01e-10/segment-hour. A typical system (safety injection and recirculation) is reported (also in Reference 10) to have about 400 pipe segments spread over three pipe size groups (from 0.5 to 2 inches, from 2 to 6 inches, and greater than 6 inches) and multiple system trains. Assuming two trains and an even split between main flow paths and branch lines results in an assumption of about 100 pipe segments per flow path, yielding 6.0 e-8/hour for a typical penetration flow path. This is a conservative estimate for the penetration flow paths under consideration because the pipe segments closest to the containment wall are the most risk significant for rupture; as the distance from the containment

[5] The FV importance measure represents the fraction of the CDF contributed by the failure of interest.

increases, the likelihood that additional valves will be available for isolation of the leak increases.

11. Selected penetrations have additional CIVs over what has been evaluated in the risk analysis (e.g., three CIVs in series instead of two). For these cases, the risk analysis is conservative.

12. Exposure times used in the risk analysis are based upon the proposed AOT (168 hours) for the CIVs. In the case of penetration flow paths that are part of an ACLS, and failure modes that impact the ACLS, the exposure time used is that associated with the ACLS (72 hours), because it is more limiting.

13. In determining the exposure time for normally closed (NC) non-ACLS CIVs (normally open CIVs, and CIVs in ACLS flow paths have per-demand failure rates), it is assumed that a failure of both CIVs is either self-revealing or else the position of the unaffected CIV is verified (i.e., not in Condition B) prior to entering into the extended portion of the AOT for the inoperable CIV.

14. For normally open (NO) CIVs, the failure probability of the automatic isolation signal is assumed to be small relative to the CIV failure-to-close probability.

3.3.3 Risk Analysis Input

Plant-specific input is used throughout the risk evaluation. PRA-derived parameters used in the risk analysis (CDF, etc.) were surveyed from the participating B&WOG plants, and the most limiting values for each parameter were used in the risk analysis. This ensures generic applicability, as well as conservatism of the results. Table 3-1 shows the risk-related inputs that were used in this analysis.

The RAW values used in the risk analysis account for the incremental increase in risk associated with a train of an ACLS being out of service. The PRAs from the participating B&WOG plants were reviewed to determine representative values for the most limiting ACLS systems. When these RAW values were used, the risk calculations also note the approximate upper limit that the RAW value could take on for an ALCS train and still achieve acceptable risk for an AOT extension of the CIVs in that penetration flow path. This is intended as a sensitivity analysis so that penetration flow paths would not be excluded from applicability in future plant-specific submittals if PRA updates proved to have slightly higher RAW scores for some ACLS trains.

Table 3-1 PRA Parameters used in CIV Risk Evaluation

PRA Parameter	Limiting Plant-Specific Value
Base CDF (not including ISLOCA)	5.0e-5/year
CDF for Seismic	3.9e-5/year
Seismic initiating event frequency	5.0e-4/year
CDF that includes steam generator tube rupture (SGTR)	8.8e-7/year
CCDP for reactor trip transient	1.1e-6
RAW value relative to CDF for an ACLS train connected directly to the RCS (e.g., LPI and HPI)	29.8
RAW value relative to CDF for an ACLS train connected directly to containment atmosphere (e.g., RB sprays)	1.0
RAW value relative to CDF for an ACLS train in closed-loop system (e.g., cooling water loop)	12.0
RAW value relative to CDF for failed secondary side isolation following SGTR	1.04

In addition, the risk evaluation uses failure rates for the CIVs, other valves contained in the penetration flow paths, and related parameters. The values for these component basic events also came from a survey of the PRAs of the participating B&WOG plants. The configurations analyzed for the penetration flow paths and the potential release paths to the outside environment involve several different valve types (MOV, AOV, etc.). Rather than analyze each different combination of valves that could occur on a penetration, this generic risk analysis assumes the valve type with the most limiting failure rate for all of the cases. This was done in the interest of conservatism, and to reduce the number of variations to analyze in the risk analysis.

As shown in Table 3-2, failure rates were determined for each valve type and failure mode (fails to close, fails open). These were obtained by comparing the failure rates from the three plant-specific PRAs and using the median value. Then the failure rate of the most limiting valve type for each failure mode was chosen and propagated through the risk analysis. This method provides a conservative assessment based on the bounding valve type, without introducing excess conservatism.

Table 3-2 Component Failure Rates used in CIV Risk Evaluation

Basic Event	Representative Plant-Specific Value	Limiting Failure Rate
MOV fails to close	1.7e-3/demand	Most limiting fails to close: 1.7e-3/demand
AOV fails to close	1.7e-3/demand	
SOV fails to close	9.1e-4/demand	
Check valve fails to close (reseat)	4.7e-4/demand	
MOV fails open (fails to remain closed)	1.0e-7/hour	Most limiting fails open: 3.9e-7/hour
AOV fails open (fails to remain closed)	3.9e-7/hour	
SOV fails open (fails to remain closed)	3.8e-7/hour	
Check valve fails open (fails to remain closed)	7.6e-8/hour	
Manual valve fails open (fails to remain closed)	4.5e-8/hour	
Blind flange fails open	Insignificant relative to valves	
480V bus - FV importance (dependent probability that MOV power bus will have failed during core damage sequence)	2.2e-3	
HEP for failure to close other (non-CIV) valves to terminate potential ISLOCA and/or offsite release	0.05	
CCF beta-factor between non-CIV valves (MOV assumed)	0.03	
Relief valve fails open (fails to remain closed)	1.7e-6/hour	

3.3.4 Approach for Assessing Risk using Generic Configurations

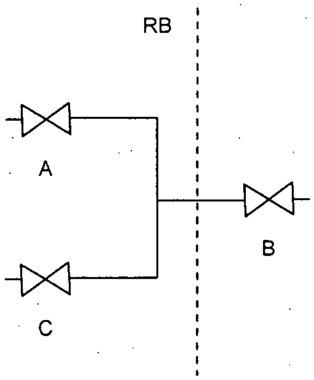
The principal tool for assessing the risk associated with the proposed AOT extension is a failure modes and effects analysis (FMEA), amended with risk calculations, as show in Table 3-3. The FMEA table has sections for each of the general categories of penetration flow paths, namely:

- Penetrations connected directly to the RCS,
- Penetrations connected directly with the containment atmosphere, and
- Penetrations connected to a closed loop system inside containment.

Each of these categories is further divided into those without an ACLS function (i.e., other than containment isolation), and those that have an ACLS function. Within each of these categories are cases with NO and NC CIVs, and cases for seismic and non-seismic piping, where applicable. The FMEA assesses the incremental impact upon CDF and LERF of the proposed AOT extension for an inoperable CIV, which is expressed in terms of ICCDP and ICLERP.

With a few exceptions (noted in Section 2.3), all of the penetrations listed in the plant UFSARs that have CIVs meeting Conditions A and C of Technical Specification 3.6.3, can be matched to one of the categories in Table 3-3. These calculations are general enough to encompass a wide range of valve arrangements.

While the FMEA addresses single line penetration pathways, they can be taken either individually or in combination to address penetrations with ganged CIVs. For example, some smaller penetrations may have an outboard CIV that is in series with two parallel inboard CIVs (see figure below).



In this example, if CIV A is inoperable, one flow path is affected. However, if CIV B is inoperable, then two flow paths are affected and the calculated risk is therefore twice what is indicated in the table. However, these are small lines (such as sample lines), which have limited potential for core damage or large early release. Therefore, doubling the probability did not make a difference with respect to changing a small risk impact to a significant risk impact.

Each category of penetration flow path in the FMEA is also matched with a matrix of possible configurations for the remainder of the flow path (i.e., excluding the CIVs) from the RCS or containment atmosphere to the outside environment. These broadly define a range of escape path possibilities for a potential release (and/or loss of coolant), given failure of the CIVs. The escape path matrix ranges from an open pipe outside of containment to a completely closed loop system outside of containment, with categories in between to credit open loop systems with additional open or closed valves in the pathway. The next section (Section 3.3.5) contains a generic risk calculation for each of the simplified escape path configurations, with the bounding risk being associated with the escape path that is completely open (i.e., conditional probability of release equals 1.0, given a release past the CIVs), and the best risk being with the outside interfacing system that is completely closed (i.e., release is dependent upon failure of high-pressure pipe). The sections that follow (starting with Section 3.3.6) provide a discussion of the risk calculations for an inoperable CIV in each general category of penetration flow path shown on the FMEA.

3.3.5 Failure Probability for Flow Path Configurations to Outside Environment

Failure probabilities were calculated for possible configurations of the remainder of the penetration flow path(s) (i.e., excluding the CIVs) from the RCS or containment atmosphere to the outside environment. This is a simplified and bounding approach. The bounding case is the assumption of an open path to the outside environment (Configuration A), where the conditional probability of release is assumed to be 1.0. In most cases the risk associated with the inoperable CIV was acceptable for this bounding case. The exceptions are noted in the results with a discussion of the circumstances wherein the risk would be acceptable.

The least limiting case is the case where the CIV exit path is connected to a closed loop system outside of the containment (Configuration G) that is designed to withstand the pressure of the RCS or the post-accident containment atmosphere, as the case may be. The remaining cases (Configurations B through F) all assume that there is a vulnerable low-pressure pipe or system opening somewhere in the interfacing system. Various numbers of open or closed valves are assumed to intervene. As with the CIVs, the failure probability of these additional (non-CIV) valves was bounded by assuming the most limiting valve type (Table 3-2). The additional valves credited in these pathways may be inside or outside of the containment, although the fault trees presume that the extra valves are outside of the containment because that is most limiting with respect to the inability to isolate random piping failures outside of containment.

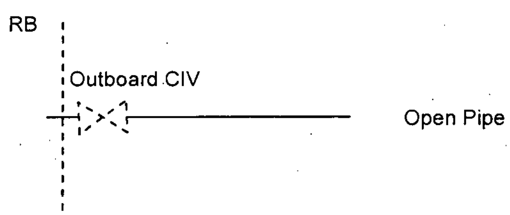
The paragraphs and figures below show the failure probability calculation for the assumed interfacing system flow path configurations ranging from open pipe to closed system. These calculations apply only to the portion of the system exclusive of the CIVs in the pathway to the outside environment, given that the CIVs have failed to isolate the flow path. These probabilities must be combined with the ICCDP and ICLERP calculations for the CIV portion of the flow path, as indicated on the FMEA. The probabilities are calculated for two different AOT assumptions, once for the proposed 168-hour AOT, and once for the 72-hour AOT associated with the ACLS Technical Specifications.

Since the interfacing systems often have multiple pathways and branch lines, the risk associated with a specific penetration can be approximated by using the most limiting applicable pathway. Alternately, the risk for multiple flow paths can be combined, crediting the minimum amount of interfacing system necessary to show a small risk. For example, in most cases, the open pipe assumption produces acceptable risk, making it unnecessary to be concerned about the state of the system downstream of the CIVs.

The calculations below include the probability of non-seismically-induced piping failure. For a seismic event and non-seismic pipe in the interfacing system, the pipe failure probabilities below are assumed to be 1.0, and the conditional failure probabilities for Configurations A through G all reduce to 1.0.

3.3.5.1 Configuration A: Open Pipe

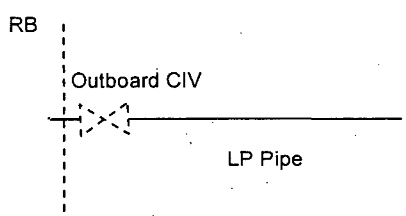
This configuration applies to penetration flow paths that are open to the outside environment beyond the outboard CIV with no other intervening valves. This case is also applicable to the situation where the pressure boundary of the outboard CIV is breached due to the repair activity. Conditional probability of an escape path to outside environment is assumed to be 1.0.



With respect to CIV repairs involving pressure boundary teardown (or a failure that involves a breach of the CIV pressure boundary), the repair procedure generally requires closure of the line (i.e., isolation of the component). Since isolation of the line will satisfy the Required Action, it is apparent that for corrective maintenance requiring pressure boundary teardown, the extended AOT is not particularly relevant once the repair activity is initiated. Therefore, this configuration can be used to assess the risk for the situation where there may be a breach of the CIV pressure boundary, and repair is not initiated within the original four-hour AOT. Also, if the CIV flow path has an ACLS function, and the CIV flow path is isolated, cannot be assured open, or the pressure boundary is breached, then the separate LCO for the ACLS TS will be invoked.

3.3.5.2 Configuration B: Low Pressure Pipe

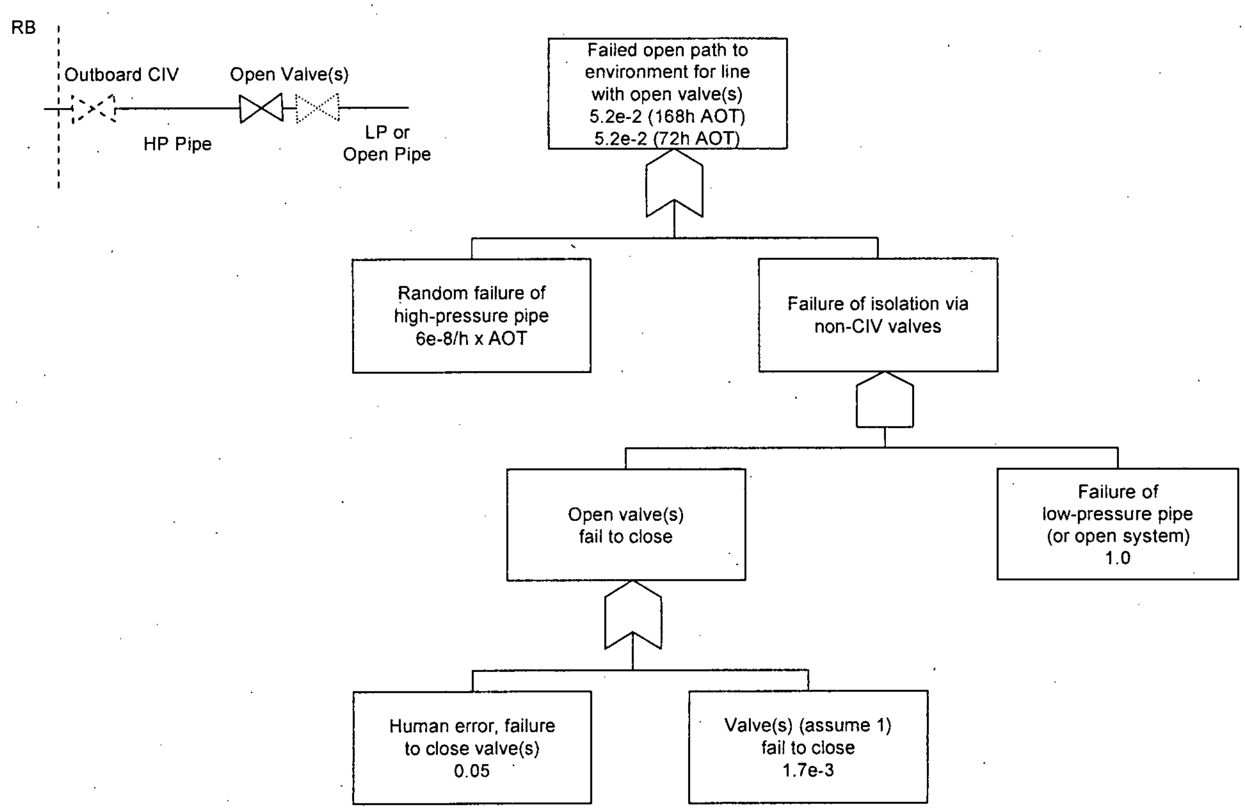
This configuration applies to penetration flow paths that interface with low pressure piping directly beyond the outboard CIV (with no other valves between the RCS or containment atmosphere and the low pressure vulnerability). For penetration flow paths connected to the RCS, this would be piping that is not designed for exposure to RCS pressures. For penetrations connected to containment atmosphere, low-pressure pipe is defined as pipe with design pressure less than peak post-accident or severe accident containment pressure. For this evaluation, the probability of rupture of the low-pressure pipe is conservatively assumed to be 1.0. In some cases, the low-pressure pipe may be protected by a relief valve; then, there is a probability that the relief valve may prevent failure of the pipe, which for conservatism and simplification of the analysis has been ignored in this evaluation.



3.3.5.3 Configuration C: Open System or Path with One or Two Additional Open Valves

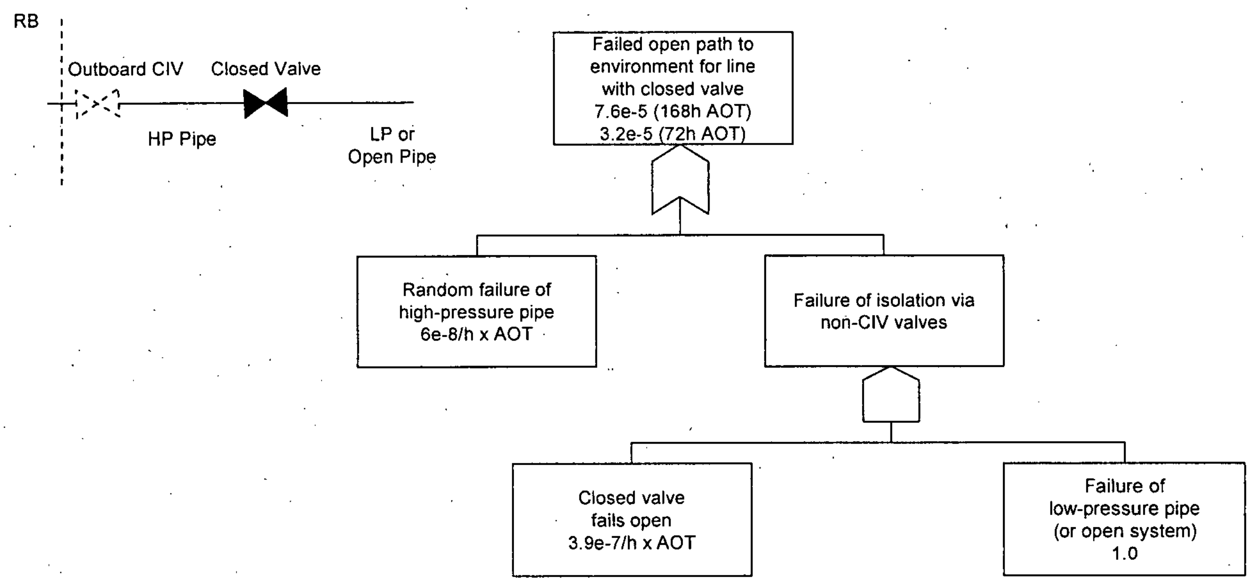
This configuration applies to penetration flow paths that interface with low pressure or open piping, but with intervening valve(s) in series with the CIVs that could be called into service if needed for backup isolation. There is at least one additional open, remote-operated valve or check valve (not including the CIVs, which can be NO or NC) between the RCS or containment atmosphere, and the portion of the outside system that is low pressure or open. The check valves must be oriented so that they block flow exiting containment and they are considered open if they open to pass flow before or during the accident. (The fault tree below is conservative with respect to check valves because it assumes a valve type that requires an operator action to close, and because open-loop systems are likely to have a check valve.) The fault tree includes the probability that the high-pressure pipe upstream of the valve fails, as well as failure of the valve to close and isolate the failed low-pressure pipe or other system opening downstream of the valve.

This case may apply to the situation where the flow path contains a NO valve or a NC valve that opens to perform a post-accident function. It may also be used to represent the risk for the case where there are NC valves in the pathway (e.g., configurations D and E) that are not in their correct position at the beginning of the AOT.



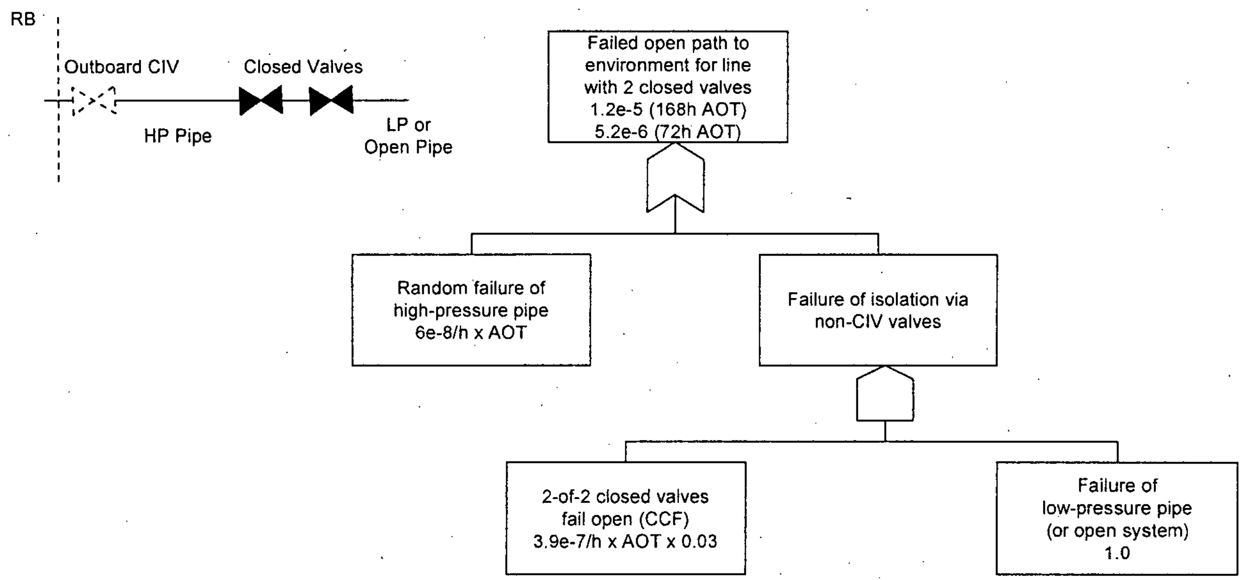
3.3.5.4 Configuration D: Open System or Path with One Additional Closed Valve

This configuration applies to penetration flow paths that interface with low pressure or open piping, but with an intervening valve that provides backup isolation. There is one closed valve (not including the CIVs) between the RCS or containment atmosphere and the portion of the outside system that is low pressure or open. The valve may be power-operated, manual, a check valve, or a flange. It is interpreted as a closed valve if it is NC, is closed at the beginning of the CIV's extended AOT, and also stays closed post-accident; an example may be a manual valve in a branch line off of the main flow path that is used for a drain or vent.



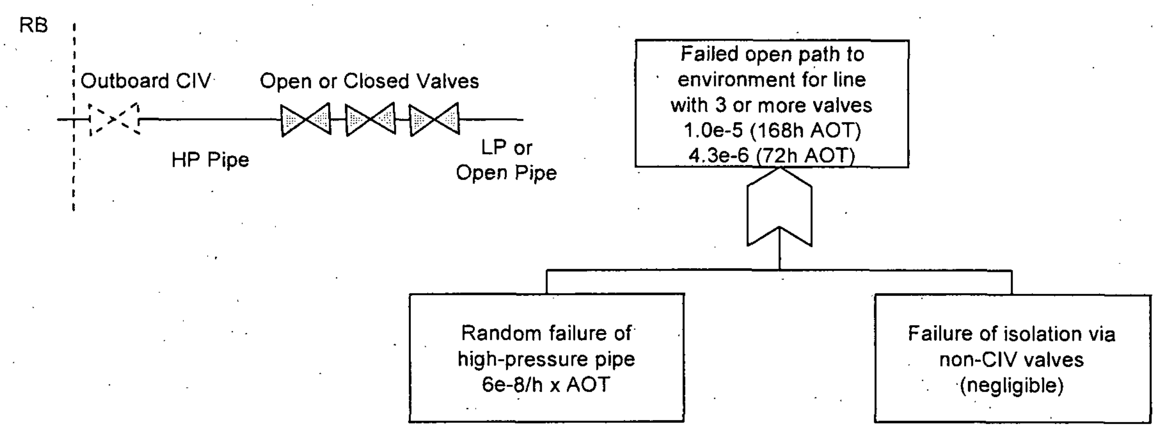
3.3.5.5 Configuration E: Open System or Path with Two Additional Closed Valves

This configuration applies to penetration flow paths that interface with low pressure or open piping, but with intervening valves that provide backup isolation. There are two closed valves (not including the CIVs) between the RCS or containment atmosphere, and the portion of the outside system that is low pressure or open. A common cause failure (CCF) is assumed between the two valves; this is conservative because the two valves may not be alike (e.g., a manual valve and a blind flange).



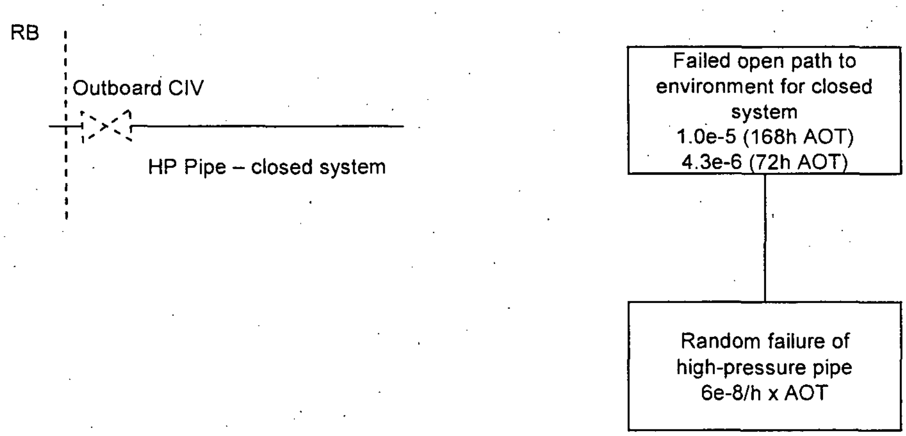
3.3.5.6 Configuration F: Open System or Path with Three or More Additional Valves

This configuration applies to penetration flow paths that interface with an open system so that there is low pressure or open piping, but with intervening valves that provide backup isolation. There are three or more valves that are closed or can be closed (not including the CIVs) between the RCS or containment atmosphere, and the portion of the outside system that is low pressure or open. Typically, in open systems, the flow path contains a diverse series of valves including one or more check valves, as well as remote-operated valves. From a risk perspective, this configuration is essentially a closed system and equivalent to Configuration G, because there is a very low probability that the low pressure or open portion of the system will be exposed to high RCS or containment pressure.



3.3.5.7 Configuration G: Closed System

This configuration applies to penetration flow paths that interface with closed loop systems outside of containment that have no low design pressure vulnerabilities. An environmental exposure requires failure of the high-pressure pipe.



3.3.6 Assessment of Risk for Penetrations Connected to the RCS

The first category of CIVs in the FMEA (Table 3-3, item 1.) is for those flow paths connected to the RCS that have no ACLS function other than containment isolation. These penetrations have at least two CIVs. Within the subcategories on the FMEA, there are CIVs that are NO and CIVs that are NC. The failure mode being addressed is the failure of the second CIV to close or to remain closed, given that one of the CIVs is inoperable and within the extended AOT. The CDF and LERF impact that is addressed (qualitatively and quantitatively) is limited to that which can be attributed to extension of the AOT. The incremental risk for this is expressed in terms of the ICCDP and ICLERP.

For CIVs in a flow path connected to the RCS, there is potential to affect CDF and LERF via an ISLOCA. A bounding risk for this case is determined from the probability of a failed open penetration flow path between the RCS and the environment outside of the containment. This involves the inoperable CIV, failure of the redundant CIV, and as applicable, failures in the interfacing system. Like the traditional ISLOCA analysis (in plant-specific PRAs), the interfacing system failure can occur due to exposure of low-pressure lines to RCS pressure. This can occur directly as a result of the CIV failures or due to failure of additional valves. In addition, (unlike most traditional ISLOCA analysis), the risk assessment includes a contribution for random failure of the high-pressure pipe in the interfacing system. For systems that are closed loop systems outside of containment, the ISLOCA requires random failure of the pipe or induced pipe break from overpressure or a seismic event (if non-seismic piping). For systems that are open loops, additional valve failures may also contribute to the ISLOCA. The ISLOCA is assumed to lead to eventual core damage, and large early release.

For RCS connections, one flow path configuration (from those outlined in the previous section) that was not explicitly analyzed for the proposed AOT is one that is open to the outside environment just past the CIVs (configuration A). The risk for this configuration was not analyzed because there are no penetration flow paths that meet this description for an RCS connection except for the situation where the CIV inoperability or subsequent repair activity involves a breach of the pressure boundary of the outboard CIV (e.g., repairs involving removal of seal packing or other valve components that would affect penetration integrity). However, once the repair is initiated, this analysis configuration is no longer applicable because the plant operator could not work on the pressure boundary of the outboard CIV without first isolating the line from the RCS via securing of the inboard CIV or other valve (and hence satisfying the Required Action of the Technical Specifications). The incremental risk (for configuration A) would only be incurred if the AOT extension was to be used to delay initiation of repair for an inoperable CIV and the reason for the inoperability was a failed pressure boundary. However that risk is controlled by the Technical Specifications for RCS pressure boundary leakage (Standard TS 3.4.13), which have a more limiting AOT than the proposed CIV AOT. Therefore, the assumption is made that the extended AOT cannot be used to delay repair for an inoperable CIV on an RCS flow path if the reason for the inoperability is a failure of the valve's RCS pressure boundary. Hence there is no incremental risk associated with the proposed AOT extension for valve inoperability or repair activity involving the valve's RCS pressure boundary.

There are usually other valves in series with the two CIVs. For NC CIVs (item 1.1), the analyzed configurations for the interfacing system pipe include a direct connection to low pressure pipe (configuration B), connection to high-pressure pipe with low-pressure vulnerabilities (or openings) past additional interfacing system valves (configurations C through F), and a completely closed high-pressure system (configuration G). For NO CIVs (item 1.3), the configurations with open or low-pressure vulnerabilities (configurations A through D) are not applicable because the interfacing system must be high-pressure piping; all pathways between the RCS and the environment (or low-pressure vulnerability) have at least three additional valves or at least two NC valves/flanges (e.g., drain lines). The other entries in the FMEA (1.2 and 1.4) are the contributions from a seismic event if the piping outside the containment is non-seismic. In the non-seismic pipe cases, the failure modes outside of containment are replaced with the probability of a seismic event coupled with an assumed probability of 1.0 for pipe failure.

Like in the traditional ISLOCA studies, the penetrations that have low risk significance are those that have multiple closed valves in series protecting low pressure or open systems. Configurations that include multiple valves, not counting the inoperable CIV, or a high pressure closed loop outside containment, have a small impact on risk during the proposed AOT (ICCDP is 5e-7 or better, and ICLERP is 5e-8 or better per Regulatory Guide 1.177). This is consistent with plant-specific PRA results, which typically show low ISLOCA risk for penetrations that have a sufficient number of valves.

The AOT risk is not small (per the Regulatory Guide criteria) for the cases where a NC CIV is inoperable and there are less than two closed valves not counting the inoperable CIV (but including the unaffected CIV) between the RCS and an environmental opening or low-pressure vulnerability. This includes RCS penetrations with NC CIVs that connect to low-pressure pipe or an open path with no additional intervening closed valves (FMEA item 1.1, configurations B and C). However, there should be very few if any penetration flow paths in this category. The few penetration flow paths that may fit this description are also likely to be dominant contributors to the ISLOCA risk in the plant-specific PRA. (Since this is a simplified and conservative analysis, the plant-specific ISLOCA analysis should be yielded to for determining the risk from these penetrations.) That ISLOCA risk is exacerbated when one of the CIVs is inoperable. An example of a penetration flow path in this category may be the decay heat removal (DHR) suction line at Oconee. This line has two NC CIVs with low-pressure piping downstream. One of the CIVs has the power removed from it during power operation (which satisfies the Required Action for isolation); however, if that CIV was inoperable, the remaining CIV is insufficient to keep the risk impact small during the proposed AOT extension, unless it is also de-energized. This result suggests against extending the AOT for any penetration flow paths that may have this configuration. Hence, the conclusion:

- The extended AOT will not be used for an inoperable NC CIV if it leaves the penetration flow path with only one closed valve between the RCS and the environment (i.e., low pressure pipe or opening) and that valve is not verified closed.[6]

The specific penetrations (if any) where this is applicable or where the there is a high risk significance for ISLOCA (as determined by the plant-specific risk-informed process) will be identified on a plant-specific basis prior to implementation of the proposed TS change. They will be listed explicitly in the proposed TS revision, and the current AOT will be retained.

3.3.7 Assessment of Risk for Penetrations Connected to the RCS that have an ACLS Function

The next category of CIVs in the FMEA (item 2.) is for those flow paths connected to the RCS that have an ACLS function in addition to containment isolation. These penetrations have at least two CIVs. The CIVs may be either NO or NC initially, but since they have an ALCS function they are assumed to be open post-accident. The failure mode being addressed is the failure of the second CIV to close given that one of the CIVs is inoperable and within the extended AOT. Since the flow path has an ACLS function, a distinction is made as to whether or not the inoperable CIV is known to be open (i.e., assured open[7]). The CDF and LERF impact that is addressed is that which can be attributed to the proposed extension of the AOT.

For inoperable CIVs, the ISLOCA risk is essentially identical to the non-ACLS case (item 1.) since the ACLS function is not important to the outcome of ISLOCA type events. Since the ISLOCA is assumed to result in core damage and large early release, the impact of mitigation systems other than the CIS is not particularly relevant and is not credited in the risk analysis. Hence, the conclusions for RCS penetrations with ACLS functions are the same as for RCS penetrations without ACLS functions.

There is also a contribution to large early release risk, unrelated to ISLOCA, if there is a core damage event and the operable CIV that was opened for a post-accident function later fails to close. This risk is very small relative to the ISLOCA risk and is included in the FMEA for completeness.

The risk is from an offsite release following a non-ISLOCA core damage event that occurs during the proposed AOT. An operable CIV that opened for the post-accident ACLS function may need to reclose later if the various ACLS functions are unsuccessful in preventing core damage. With respect to the risk impact of extending the AOT of the

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[6] In this context, "verified closed" means the definition provided in the LCO 3.6.3 action statements, e.g., closed and de-activated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

[7] In this context, "assured open" means that the inoperable CIV is in a state or is put into a state such that entering the Conditions and Required Actions of the applicable ACLS Technical Specification is not required.

inoperable CIV, there is an increment to LERF if a core damage event occurs coincident with the extended AOT (because the isolated penetration may have prevented offsite release). With respect to the ACLS function, the proposed AOT extension has no impact if the inoperable CIV is assured open. If the inoperable CIV is only partially open (or cannot be assured to be open), then the CIV **may not** satisfy the ACLS function. The approach for estimating the risk impact for this situation is to conservatively assume that the safety function of the ACLS flow path is lost and adjust the core damage probability with the RAW importance for loss of the safety function associated with the affected ACLS flow path. The calculation then proceeds as in the other cases with the coincident probability of a failed open flow path to the outside environment.

The results are not sensitive to the RAW importance of the ACLS flow path. The RAW would have to be extremely high (above 10,000) before the non-ISLOCA contribution to risk became significant during the proposed AOT.

3.3.8 Assessment of Risk for Penetrations Connected to Containment Atmosphere

The third category of CIVs in the FMEA (item 3.) is for those flow paths connected directly to the containment atmosphere that have no ACLS function other than containment isolation. These penetrations have at least two CIVs. Within the subcategories on the FMEA there are CIVs that are NC and CIVs that are NO, as well as cases for seismic and non-seismic piping. The failure mode being addressed is the failure of the second CIV to close or to remain closed, given that one of the CIVs is inoperable and within the extended AOT. The CDF and LERF impact that is addressed is the risk that can be attributed to extension of the AOT. The incremental risk for this is expressed in terms of the ICCDP and ICLERP.

For CIVs in a flow path connected to the containment atmosphere, there is no impact on CDF because there is no interface with the RCS or an ACLS. However, there is potential to affect LERF. LERF may be affected during the proposed AOT if the penetration fails open and there is also a core damage event. The LERF impact is determined from the probability of a failed open penetration flow path between the containment atmosphere and the environment outside of containment, and the probability of a coincident core damage event occurring during the proposed AOT. The open flow path involves the inoperable CIV, failure of the redundant CIV, and applicable failures of the interfacing system (from Section 3.3.5). The interfacing system failure can occur due to over pressurization of piping that is not designed for exposure to post-accident containment pressure, from random failure of piping, or due to a seismic event. Failure of additional valves can also expose the environment, or the pipe may be open to the environment (possibly due to repair activity).

All of the CIV flow path configurations in this category have a small risk impact for the proposed AOT. This is because the probability of a core damage event occurring coincident with failure of the operable CIV during the extended AOT is small. In this case, no credit is needed for any additional valves other than the CIVs, and the conclusion is not sensitive to whether or not the interfacing system design is strong enough to withstand post-accident or severe accident pressures.

3.3.9 Assessment of Risk for Penetrations Connected to Containment Atmosphere that have an ACLS Function

The fourth category of CIVs in the FMEA (item 4.) is for those flow paths connected directly to the containment atmosphere that have an ACLS function in addition to containment isolation. These penetrations have at least two CIVs. The CIVs may be either NO or NC initially, but since they have an ALCS function they are assumed to be open post-accident. The failure mode being addressed is the failure of the second CIV to close given that one of the CIVs is inoperable and within the extended AOT. Since the flow path has an ACLS function, a distinction is made as to whether or not the inoperable CIV is known to be open (i.e., assured open). The CDF and LERF impact that is addressed (qualitatively and quantitatively) is that which can be attributed to the proposed extension of the AOT.

If there is assurance that the inoperable CIV is open, the risk increment is identical to the non-ACLS case (item 3.). The CIV position associated with the proposed AOT extension (i.e., open), is generally the safe position with respect to the ACLS function. CDF is not affected by the AOT extension because the ACLS function is not impaired if the CIV is open. However there is an impact upon LERF if there is a core damage event during the AOT and the operable CIV fails to close. The operable CIV may be NO or opened for a post-accident function, but may need to close later if there is core damage.

If the inoperable CIV is only partially open (or cannot be assured to be open), then the CIV may **not** satisfy the ACLS function. The CDF and LERF may be affected by the impaired ACLS train. However, the risk impact from the degraded ACLS function is not a result of the proposed AOT extension. (Delaying the Required Action to isolate the flow path improves the likelihood that the ACLS train will be available if an accident occurs during the AOT, and does not change the LCO or Required Action associated with the ACLS Technical Specifications.) However, there is a potential impact on LERF from the AOT extension if the impaired ACLS train affects CDF at the same time that CIV operability is degraded. (The LCO of the ACLS Technical Specifications will also be invoked if applicable, and the AOT for the CIV and ACLS functions will run concurrently.) The magnitude of the release may also be worsened by the degraded containment ACLS function; however this does not impact the calculated risk further because core damage coincident with containment isolation failure is conservatively assumed to be a large early release (Section 3.3.2, Assumption 4).

Therefore, the incremental large early release risk is estimated from the probability of a core damage event occurring during the extended AOT coincident with failure of the operable CIV. To determine the risk impact it is conservatively assumed that the safety function of the ACLS flow path is lost. The probability of core damage occurring during the concurrently running AOTs is adjusted with the RAW importance to CDF for loss of the safety function associated with the affected ACLS flow path.

The calculation then proceeds as in the other cases with the probability that the rest of the flow path to the outside environment is failed open. The most limiting of these configurations is the case of an open pipe outside of containment, which may apply to the circumstance where the reason for inoperability of the outboard CIV is a leaking CIV pressure boundary (however it is assumed that repair of the pressure boundary would require isolation). All of the CIV flow path configurations in this category have a small risk impact for the proposed AOT. This is because the probability of a core damage event occurring coincident with failure of the operable CIV during the extended AOT is small. The valves in the flow path other than the CIVs are not pertinent to the conclusion that there is a small risk impact for the proposed AOT.

Containment systems rarely have a significant impact on CDF and the RAW importance is typically close to 1.0 for containment systems. The RAW would have to be very high for a containment system (about 30) before the contribution to risk became significant during the proposed AOT.

3.3.10 Assessment of Risk for Penetrations Connected to a Closed Loop System Inside of Containment

The fifth category of CIVs in the FMEA (item 5.) is for those flow paths connected to a closed loop system inside containment that have no ACLS function except containment isolation. The closed loop system may interface with the containment atmosphere or with the RCS (via the SGs). These penetrations generally have one CIV, because the closed loop provides the second barrier. There are also cases for seismic and non-seismic interfacing system piping. One failure mode being addressed is the failure of the second barrier (i.e., the closed loop inside containment), given that the CIV is inoperable and within the extended AOT. Another failure mode that is addressed is failure of the CIV, given that the pressure boundary of the closed loop inside containment is inoperable (for pressure boundaries not shared with the RCS). This failure mode assumes that the closed loop pressure boundary is a treated like a second CIV (see proposed new Condition described in Section 2.1) because it represents the redundant containment isolation barrier. The CDF and LERF impact that is addressed is the risk that can be attributed to extension of the AOT. The incremental risk for this is expressed in terms of the ICCDP and ICLERP.

The first two subsections in this category (FMEA items 5.1 and 5.2) are for penetration flow paths that connect with closed loop systems interfacing with the containment atmosphere. The first failure mode in each of these subcategories involves an inoperable CIV. For an inoperable CIV, there is not likely to be any CDF impact from the extended AOT because the system is not connected with either the RCS or an

ACLS function. However there is a possibility that failure of the pressure boundary of the closed loop system train may cause a reactor trip. Extending the AOT for the CIV increases the exposure time to the pressure boundary failure mode. Therefore, the calculation for CDF impact makes the conservative assumption that a reactor trip will occur, and determines the incremental change in core damage probability if the failure occurs during the proposed AOT. The LERF impact for this case also requires failure of the pressure boundary of the closed loop inside containment, coincident with a core damage event either from the reactor trip mentioned above or an independently occurring accident. As with the other cases a path to the outside environment is needed for an offsite release. However, the valves in the flow path other than the CIV are not pertinent to the conclusion that there is a small risk impact for the proposed AOT. The risk impact during the proposed AOT is small for these CIVs because they are paired with closed loop systems inside containment that do not have an RCS pressure boundary or ACLS function. The probability of core damage and coincident failure of the closed loop piping during the proposed AOT is not significant.

The second failure mode addressed for each of these subcategories (FMEA items 5.1 and 5.2) involves inoperability of the closed loop inside containment (which is the second containment isolation barrier). This assumes that the proposed longer AOT applies to the closed loop pressure boundary with the containment atmosphere. Here the AOT extension has no impact on CDF because the system is not connected with either the RCS or an ACLS function. (No reactor trip contribution is included because the AOT would not be relevant if a reactor trip occurred due to the pressure boundary issue.) There is a LERF impact because the long AOT for the closed loop increases the exposure time to a coincident core damage event and failure of the operable CIV.

The impact on risk is small for this case, and is the same as the analogous case of a penetration flow path that is open to the containment atmosphere with one operable CIV (FMEA items 3.3 and 3.4).

For CIVs in penetration flow paths that connect with closed loop systems interfacing with the RCS (i.e., the steam generator, FMEA item 5.3), there is an impact on CDF and

LERF because part of the closed loop system inside containment also has an RCS pressure boundary function. The CDF is impacted if a SGTR event occurs during the extended AOT. The increase in CDF results from the increased probability that the affected SG is not isolated, which occurs due to the inoperable CIV and failure of other valves or pipes in the interfacing system. The magnitude of the CDF impact is estimated from the base CDF and the RAW importance for SGTR with failure to isolate.

Similarly, there is an impact upon LERF from the proposed AOT extension if a coincident SGTR occurs. If a core damage event that includes SGTR occurs during the proposed AOT, then an offsite release may result if there is also a failure of secondary side isolation and a pathway to the environment. In this case the probability of SGTR-related core damage includes the base contribution from SGTR events as well as the incremental increase in CDF (described above) related to the increased failure probability of SG isolation.

The incremental increase in core damage probability and large early release probability during the proposed AOT is small. The results are not sensitive to the RAW importance of secondary side isolation failure for SGTR events. The RAW would have to be very high (on the order of 400) before the incremental risk during the proposed AOT is significant.

3.3.11 Assessment of Risk for Penetrations Connected to Closed Loop Systems Inside Containment that have an ACLS Function

The last category of CIVs in the FMEA (item 6.) is for those flow paths connected to a closed loop system inside containment that have an ACLS function in addition to containment isolation. The closed loop systems in this case interface with the containment atmosphere or with the RCS (via the SGs). These penetrations generally have one CIV, because the closed loop provides the second barrier. One failure mode being addressed is the failure of the second barrier (i.e., the closed loop inside containment), given that the CIV is inoperable and within the extended AOT. Another failure mode that is addressed is failure of the CIV, given that the pressure boundary of the closed loop inside containment is inoperable (for pressure boundaries not shared with the RCS). This failure mode assumes that the closed loop pressure boundary is a treated like a second CIV (see proposed new Condition described in Section 2.1) because it represents the redundant containment isolation barrier.

The first subsection in this category (FMEA item 6.1) is for CIVs in penetration flow paths that connect with closed loop systems interfacing with the containment atmosphere. The first failure mode addressed involves an inoperable CIV. The inoperable CIV is assumed to be open, and its position is not important to the ACLS function since the ACLS train is assumed to be failed due to the pipe break. The risk impact for these penetrations is similar to the case above without an ACLS function (item 5.1 in FMEA) except for an additional increment associated with degradation of the ACLS function of the affected train.

The FMEA addresses the CDF and LERF impact that can be attributed to extension of the AOT. Failure of the pressure boundary of the closed loop system train during the extended AOT may cause a reactor trip. Extending the AOT for the CIV increases the exposure time to the pressure boundary failure mode. The calculation for core damage assumes that a reactor trip will occur, and determines the incremental change in core damage probability if the failure occurs during the proposed AOT. Failure of the closed loop pipe inside containment may also provide a pathway for large early release if core damage also occurs either due to the trip or an independent event. Both the CDF and LERF impact account for the incremental increase associated with failure of the ACLS train. The impact of the degraded ACLS function is included by adjusting the probability of core damage during the proposed AOT with the RAW value for loss of the ACLS train function.

As with the other cases, a path to the outside environment is needed for an offsite release. The most limiting configuration for the rest of the flow path is the case of an open pipe outside of containment, which for a closed loop system would occur only in the circumstance where the reason for the CIV inoperability was a failure of the CIV pressure boundary. Once a repair of the CIV is initiated that requires a pressure boundary teardown, the ACLS loop would be isolated and it would not be likely to cause a reactor trip. For this as well as the other flow path configurations in this category, the impact upon risk (as measured by ICCDP and ICLERP) is small and the additional valves in the flow path are not pertinent to the conclusion that there is a small risk impact for the proposed AOT.

The RAW value used in this calculation for the degraded ACLS function is the most limiting RAW value (i.e., 12.0) for this type of system that could be found in the PRAs of the participating plants. However, the risk impact of the proposed AOT extension is small even with a RAW value that is considerably higher (e.g., 80) than the most limiting plant-specific value.

The second failure mode addressed for this category (FMEA item 6.1) involves inoperability of the closed loop inside containment (which is the second containment isolation barrier). This assumes that the proposed longer AOT applies to the closed loop pressure boundary with the containment atmosphere. Here the AOT extension has no impact on CDF because the ACLS train is degraded whether or not the penetration flow path is isolated. (No reactor trip contribution is included because the AOT would not be relevant if a reactor trip occurred due to the pressure boundary issue.) There is a LERF impact because the long AOT for the closed loop increases the exposure time to a coincident core damage event and failure of the operable CIV.

With respect to the probability of a flow path to the outside environment, the most limiting configuration for this case is that of low-pressure pipe (i.e., the interfacing pipe outside of containment cannot withstand post accident pressure). The open pipe case does not apply because a repair activity on the outboard CIV would violate the implied TS (i.e., both containment isolation barriers inoperable). The impact on risk is small for this case, even considering the most limiting interfacing system configuration combined with the most limiting known ACLS train RAW value (12.0), which probably would not exist on the same system penetration. The risk impact is small for ACLS train RAW values up to about 30.

The second subsection in this category (FMEA item 6.2) is for the closed loop systems where part of the ACLS closed loop includes an interface with the RCS pressure boundary. That is, portions of the closed loop are also part of the RCS pressure boundary. In this case, the RCS pressure boundary is the secondary side of the SG tubes. The CDF and LERF are impacted if a SGTR event occurs during the extended AOT. The increase in CDF results from the increased probability that the affected SG is not isolated, which may occur due to the inoperable CIV and failure of other valves or pipes in the interfacing system. The impact upon LERF results from any SGTR core damage scenario that occurs during the proposed AOT, coincident with an offsite release pathway that may result from the inoperable CIV.

The incremental risk for this case is essentially the same as the similar case involving non-ACLS systems (FMEA item 5.3). This is because loss of the affected ACLS function (e.g., loss of emergency feed water to the affected SG) is of little consequence in these SGTR scenarios because under most circumstances the ACLS flow path to the affected SG is isolated. Terminating the ACLS (i.e., emergency feedwater) flow to the affected SG is performed by valves other than the CIV, and so is unaffected by its inoperability. While the operators may feed the affected SG under some circumstances, and it is important that they be able to do so, in the scenario where the SGTR is large enough to represent a LERF path, there will be sufficient inventory from the tube rupture that emergency feedwater (EFW) will not be necessary for adequate SG heat transfer. The incremental increase in core damage probability and large early release probability during the proposed AOT is small.

The main steam lines are excluded from the analysis because an AOT extension is not proposed for CIVs in the main steam lines.

3.3.12 Summary of Risk Results

All penetration flow path configurations involving direct connection to the containment atmosphere or closed-loop systems inside containment have a small impact on risk during the proposed AOT of an inoperable CIV. The ICCDP is less than 5e-7 and the ICLERP is less than 5e-8 in all cases. The low risk impact can generally be attributed to the low probability that a core damage event will occur during the proposed AOT coincident with failure of the redundant containment isolation barrier (other CIV or closed loop system). The risk impact is small even if the most-limiting applicable configuration is assumed with respect to the interfacing system piping outside of containment that provides the postulated release pathway, such as the assumption of an open pipe. These results are robust because they were determined using conservative values for CDF and other plant-PRA derived parameters, as well as conservative assumptions for the valve types and failure rates. Limiting values were used for RAW importance of affected ACLS trains, and the results are robust even with significantly higher RAW values than those found in a search of the PRAs of the participating plants.

For penetration flow path configurations involving direct connection to the RCS, most of the penetrations that exist in actual plant systems have a small impact on risk during the proposed AOT of an inoperable CIV. However, in this case assuming the most-limiting configuration for the interfacing system did not produce acceptable risk. The RCS penetration flow paths that interface with low pressure piping outside of containment present a risk of ISLOCA. For NC CIVs, the incremental risk impact from ISLOCA during the proposed AOT is higher than the guideline presented by Regulatory Guide 1.177 (greater than an ICCDP of 5e-7 or greater than an ICLERP of 5e-8) for some cases. These are the cases where there are not at least two closed valves (not counting the inoperable NC CIV) in the pathway between the RCS and the environment (pipe opening or low-pressure vulnerability).

The situation where this vulnerability may occur is in the rare instance where there are only the two NC CIVs between the RCS and the low-pressure interfacing system. Therefore it will be necessary when implementing the proposed TS change to identify where this is the case, to ensure that the proposed AOT extension is not applied to those penetrations.

- The extended AOT will not be used for an inoperable NC CIV if it leaves the penetration flow path with only one closed valve between the RCS and the environment (i.e., low pressure pipe or opening) and that valve is not verified closed.

The specific penetrations, if any, where this is applicable or where there is high risk significance for ISLOCA will be identified on a plant-specific basis prior to implementation of the proposed TS change. They will be listed explicitly in the proposed TS revision, and the current AOT will be retained.

3.4 Tiers 2 & 3: Avoidance of Risk-Significant Plant Configurations and Configuration Risk Management

Application of the three-tiered approach to the proposed AOT change for CIVs provides additional assurance that defense-in-depth will not be impacted by the proposed changes to the licensing basis. Tier 2 is an identification of potentially high-risk configurations that could exist if equipment in addition to the inoperable CIVs were to be taken out of service simultaneously. In this case, that equipment includes the redundant CIV on the affected penetration and required support systems. It also includes any equipment out of service that could increase the likelihood of challenge of the CIVs. The CIV Standard Technical Specifications (Reference 4) already recognize the higher risk associated with two CIVs out of service on the same penetration. Condition B (for which no change is proposed) includes Conditions and Required Actions for when two CIVs on the same penetration are out of service. This is further strengthened by the proposed action to verify within four hours (the original AOT), that the redundant CIV has not been affected by a CCF if the two CIVs are of like kind. In addition, Tier 3 is the establishment of a CRMP to provide continuing assurance of minimal risk of interactions with other out-of-service equipment.

The participating B&WOG licensees have established CRMPs that ensure that the risk impact of out-of-service equipment is appropriately evaluated prior to performing any maintenance activity and are committed to applying the CRMP to out-of-service CIVs. The B&WOG recognizes that the potential for an impact from multiple equipment outages may increase when using the longer AOT, because the increased duration and the quantity of penetrations increases the probability of overlapping of routinely scheduled activities and random failures. The plant-specific B&WOG CRMPs provide reasonable assurance that risk-significant plant equipment outage configurations will not occur when CIV equipment is out of service consistent with the proposed TS change. These CRMPs will ensure that:

- No action or maintenance activity is performed that will remove equipment that is functionally redundant to the inoperable CIV, including the redundant CIV(s) on the same penetration and supports for the redundant CIV.
- No action or maintenance activity is performed that will significantly increase the likelihood of challenge of the CIVs. Challenges to the CIVs include DBAs that result in a release of radioactive material within containment (LOCA, main steam line break, and rod ejection accident). Also included is removing equipment from service that may cause a significant increase in the likelihood of core damage while in the proposed AOT,[8] which may increase the risk of large early release via the inoperable CIV.
- No action or maintenance activity is performed that will remove equipment that supports success paths credited in the AOT risk evaluation. This includes the other series valves, if any, credited in the risk assessment for RCS penetrations that otherwise would be at high risk for ISLOCA.

The Tier 2 and 3 programs ensure that the utilities will evaluate defense-in-depth prior to entering into the proposed extended AOT. The plant-specific CRMP combined with the LCO Conditions and Action Statements ensure that the Tier 2 and 3 requirements are met.

3.5 Maintenance Rule Monitoring Program

To ensure that extension of the AOT for CIVs does not degrade operational safety over time, the participating B&WOG utilities will ensure, as part of their Maintenance Rule program (Reference 11), that the performance of the CIS is tracked. By extending the AOT, it is possible for there to be an increase in the cumulative time that CIV

[8] Examination of the calculations in Table 3-3 (which use conservative values for CDF and other parameters) indicates that a cumulative RAW (for all equipment out of service) of about 30 or higher (depending upon penetration affected) could be applied to the CDF before the AOT risk is high enough to

redundancy is degraded in one or more penetrations. The B&WOG programs that implement the Maintenance Rule will track CIVs to ensure that the changed AOT does not adversely impact the reliability and availability of the containment isolation function. Performance criteria established by the utility may consider the number of penetrations affected, the size of the penetration(s) affected (versus LERF definition), and the risk significance of the penetrations. Significant degradation of CIV availability (a function of repair frequency as well as out of service time) is not expected as a consequence of the proposed AOT extension because LCO entries should still be infrequent, and reliability may improve due to more timely maintenance. However, if the performance or condition of the CIVs affected by the proposed TS change does not meet the performance criteria established by the utility, appropriate corrective action will be taken, in accordance with the Maintenance Rule.

threaten the Regulatory Guide 1.177 criterion for small risk impact. Actual performance criteria will be established by the utility.

Table 3-3
FMEA and Risk Calculation for CIV Penetrations

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
1. Penetrations connected to RCS that have no accident consequence limiting system (ACLS) function						
1.1 RCS, NC, Seismic • Direct connection to RCS • Inside piping is seismic • Outside piping seismic • CIVs normally	One CIV inoperable and second CIV fails in open position.	May contribute to CDF via ISLOCA, if NC CIV fails open and exposes outside (possibly low-pressure) piping to RCS pressure.	LERF = CDF for ISLOCA type events.	All, however Configuration A (open pipe) is not applicable.[f]	ICCDP = ICLERP = ISLOCA = (operable NC CIV fails to stay closed) x (path to outside environment) = (3.9e-7/h x 168h) x … continue below	
				B: Low-pressure pipe[g]	x 1.0	6.6e-5[h]
				C: Open system or path with one or two additional open valves[i]	x 5.2e-2	3.4e-6

[a] Inside CIVs may be MOV, AOV, check valve, manual (NC), or blind flange (closed).
[b] Outside CIVs may be MOV, AOV, check valve, SOV, manual (NC), or blind flange (closed).
[c] For derivation of conditional probabilities, see text. "Other valves" are valves or blind flanges in series with the CIVs in the pathway between the RCS or containment atmosphere, and the outside environment that are either already closed or can be closed (remotely or automatically) to prevent release to the outside.
[d] Incremental conditional core damage probability (ICCDP) = CDF impact x (AOT duration); incremental conditional large early release probability (ICLERP) = LERF impact x (AOT duration)
[e] For small impact on risk, acceptable ICCDP is 5e-7 and ICLERP is 5e-8, per Reg. Guide 1.177.
[f] There are no penetration flow paths with this configuration (open pipe) for an RCS connection except for the situation where repair of the outboard CIV involves a breach of the valve pressure boundary. However, this configuration is not applicable once the repair is initiated because the plant operator could not work on the pressure boundary of the outboard CIV without first isolating the line from the RCS (and hence satisfying the Required Action of the Technical Specifications). An incremental risk (associated with an open pipe) would only be incurred if the AOT extension was used to delay initiation of repair for an inoperable CIV and the reason for the inoperability was a failed pressure boundary. However, that risk is controlled by another Technical Specification (3.4.13, RCS pressure boundary leakage) that is more limiting than the proposed AOT extension for CIVs. Hence there is no risk increment associated with Configuration A for the CIV AOT extension.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
closed (NC)				D: Open system or path with one additional closed valve[k]	x 7.6e-5	5.0e-9[l]
				E: Open system or path with two additional closed valves	x 1.2e-5	7.9e-10
				F,G: Closed system (or open system with three or more additional valves)	x 1.0e-5	6.6e-10
1.2 RCS, NC, Non-seismic • Direct connection to RCS • Inside piping is seismic • Outside piping non-seismic • CIVs normally closed	One CIV inoperable and second CIV fails in open position.	Same as above (item 1.1), plus additional contribution to CDF via ISLOCA, if NC CIV fails open and coincident seismic event ruptures outside pipe.	LERF = CDF for ISLOCA type events.	All, however Configuration A (open pipe) is not applicable.	In addition to above (item 1.1), ICCDP = ICLERP = ISLOCA = (operable NC CIV fails to stay closed) x (seismic event) x (failure of outside pipe) = (3.9e-7/h x 168h) x (5.0e-4/yr x 168h x yr/8760h) x (1.0)	
				B: Low-pressure pipe	= 6.3e-10 (+ Result from item 1.1)	6.6e-5[m]
				C: Open system or path with one or two additional open valves	= 6.3e-10 (+ Result from item 1.1)	3.4e-6[n]
				D: Open system or path with one additional closed valve	= 6.3e-10 (+ Result from item 1.1)	5.6e-9[o]

[g] If the low-pressure pipe is protected by a relief valve, then the probability of the relief valve failing to open could be included instead of assuming pipe failure. However for conservatism, the low-pressure pipe is assumed to fail in this evaluation.
[h] If any penetration flow paths are in this subcategory, then they may also be dominant contributors to the ISLOCA risk in the plant-specific PRA. This result suggests against extending the AOT for those (very few) penetration flow paths that may be in this subcategory.
[i] Includes NO valves that are remotely-operated.
[j] If any penetration flow paths are in this subcategory, the risk can be reduced (to configuration D) by closing the NO valve prior to entering the extended AOT. Otherwise, this result suggests against extending the AOT for those (very few) penetration flow paths that may be in this subcategory.
[k] A closed valve may be power-operated, manual, a check valve, or a flange. It is interpreted as a closed valve if it is NC and also stays closed post-accident.
[l] This result is sensitive to the assumption that the additional NC valve is in the closed position at the beginning of the extended AOT. If this valve's position is not self-revealing, or is not checked on a regular basis, then it may be prudent to verify its position prior to entering the extended portion of the CIV AOT.
[m] See footnote from item 1.1.
[n] See footnote from item 1.1.
[o] See footnote from item 1.1.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
				E: Open system or path with two additional closed valves	= 6.3e-10 (+ Result from item 1.1)	1.4e-9
				F,G: Closed system (or open system with three or more additional valves)	= 6.3e-10 (+ Result from item 1.1)	1.3e-9
1.3 RCS, NO, Seismic • Direct connection to RCS • Inside piping is seismic • Outside piping is seismic • CIVs normally opened (NO) • NO applies to cycling CIV as well	One CIV inoperable and second CIV fails in open position.	May contribute to CDF via containment bypass, if high-pressure pipe ruptures outside (or a branch line opens to expose low-pressure or open pipe) and NO CIV fails to close.	LERF = CDF for ISLOCA type events.	All, however Configurations A to D are not applicable. (Since the CIVs are NO, the interfacing system is high-pressure piping. All pathways between the RCS and the environment (or low-pressure vulnerability) have at least three additional valves or at least two NC valves/flanges.)	ICCDP = ICLERP = ISLOCA = (operable NO CIV fails to close) x (path to outside environment) = (1.7e-3) x … continue below	
				E: Open system or path with two additional closed valves	x 1.2e-5	2.0e-8
				F,G: Closed system (or open system with three or more additional valves)	x 1.0e-5	1.7e-8
				However, if line is very small (like sample or drain line) so break is too small to be an ISLOCA (but assume break will cause reactor trip) …	ICCDP and ICLERP as above … x (CCDP for reactor trip transient) x (path to outside environment) = As above … x 1.1e-6 x continue below …	
				E: Open system or path with two additional closed valves	x (1.2e-5)	2.2e-14
				F,G: Closed system (or open system with three or more additional valves)	x (1.0e-5)	1.9e-14

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
1.4 RCS, NO, Non-seismic • Direct connection to RCS • Inside piping is seismic • Outside piping non-seismic • CIVs normally opened	One CIV inoperable and second CIV fails in open position.	Same as above (item 1.3), plus additional contribution to CDF via ISLOCA, if seismic event ruptures outside pipe and NO CIV fails to close.	LERF = CDF for ISLOCA type events.	All, however Configurations A to D are not applicable.	In addition to above (item 1.3), ICCDP = ICLERP = ISLOCA = (seismic event) x (failure of outside pipe) x (operable CIV fails to close) = (5.0e-4/yr x 168h x yr/8760h) x (1.0) x (1.7e-3)	
				E: Open system or path with two additional closed valves	= 1.6e-8 (+ Result from item 1.3)	3.6e-8
				F,G: Closed system (or open system with three or more additional valves)	= 1.6e-8 (+ Result from item 1.3)	3.3e-8
				However, if line is very small (like sample) so break is too small to be an ISLOCA (but assume break contributes to seismic core damage) …	In addition to above (item 1.3), ICCDP = ICLERP = (core damage due to seismic) x (failure of outside pipe) x (operable CIV fails to close) = (3.9e-5/yr x 168h x yr/8760h) x (1.0) x (1.7e-3)	
				E: Open system or path with two additional closed valves	= 1.3e-9 (+ Result from item 1.3)	1.3e-9
				F,G: Closed system (or open system with three or more additional valves)	= 1.3e-9 (+ Result from item 1.3)	1.3e-9

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
2. Penetrations connected to RCS that have accident consequence limiting system function						
2.1 RCS, NC, ACLS • Direct connection to RCS • Inside piping is seismic • Outside piping is seismic • CIVs open post-accident for ACLS function (normally closed initially)	One CIV inoperable (failed fully open/assured open)[p] and second CIV fails in open position.	ISLOCA contribution same as those above for no ACLS function.	ISLOCA contribution same as those above for no ACLS function.	All, however Configuration A not applicable.	ICCDP = ISLOCA, same as above (item 1.1) for NC CIV case: accident consequence limiting systems are not important for the outcome of ISLOCA type events, and are not credited in the risk assessment.	See item 1.1 above
		No additional CDF impact (other than ISLOCA above) because the function of the ACLS is not impaired by delaying isolation of the CIV.	In addition to ISLOCA, may contribute to LERF if CIV that is opened post-accident subsequently fails to close after a non-ISLOCA core damage event.	All, however Configuration A not applicable. Since the CIV is designed to be open post-accident, immediate piping interfaces must be designed for the applicable post-accident pressure (but not necessarily RCS design pressure); therefore escape path probabilities for B, C, and D may be conservative for post-accident pressure.	In addition to ISLOCA contribution from above (item 1.1), ICLERP = (any core damage except ISLOCA) x (operable CIV fails to close) x (escape path to outside environment) = (5e-5/yr x 168h x yr/8760h) x (1.7e-3) x … continue below	
				B: Low-pressure pipe	x 1.0 = 1.6e-9 (+ ICLERP result from item 1.1)	6.6e-5[q]
				C: Open system or path with one or two additional open valves	x 5.2e-2 = 8.5e-11 (+ ICLERP result from item 1.1)	3.4e-6[r]

[p] In this context, "assured open" means that the inoperable CIV is in a state or is put into a state such that entering the Conditions and Required Actions of the applicable ACLS Technical Specification is not required.
[q] See footnote from item 1.1.
[r] See footnote from item 1.1.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
				D: Open system or path with one additional closed valve	x 7.6e-5 = 1.2e-13 (+ ICLERP result from item 1.1)	5.0e-9[s]
				E: Open system or path with two additional closed valves	x 1.2e-5 = 2.0e-14 (+ ICLERP result from item 1.1)	7.9e-10
				F,G: Closed system (or open system with three or more additional valves)	x 1.0e-5 = 1.6e-14 (+ ICLERP result from item 1.1)	6.6e-10
	One CIV inoperable but not assured open (e.g., fails half-way), and second CIV fails in open position.	ISLOCA contribution same as those above for no ACLS function.	ISLOCA contribution same as those above for no ACLS function.	All, however Configuration A not applicable.	ICCDP = ISLOCA, same as above (item 1.1): accident consequence limiting systems are not important for the outcome of ISLOCA type events, and are not credited in the risk assessment.	See item 1.1 above
		No additional CDF impact (other than ISLOCA above) due to CIV AOT extension. Although the CDF may be affected by ACLS degradation, the ACLS function does not benefit from the Required Action to isolate the CIV. Compensatory	If the inoperable CIV is stuck partially open, then the ACLS degradation may have an impact on non-ISLOCA CDF, which must be considered in the delta-LERF since the ACLS AOT may run concurrent[t] with the CIV AOT. If	All, however Configuration A not applicable. Since the CIV is designed to be open post-accident, immediate piping interfaces must be designed for the applicable post-accident pressure (but not necessarily RCS design pressure); therefore escape path probabilities for B, C, and D may be conservative for post-accident pressure.	In addition to ISLOCA contribution above (item 1.1), ICLERP = (any core damage except ISLOCA) x (RAW[u] for impacted ACLS) x (operable CIV fails to close) x (escape path to outside environment) = (5e-5/yr x 72h x yr/8760h) x (29.8) x (1.7e-3) x … continue below	

[s] See footnote from item 1.1.
[t] Note that exposure time is per shorter ACLS Technical Specification.
[u] RAW = risk achievement worth importance measure; it is the factor that CDF will increase if the subject component is guaranteed failed. Note that this contribution has a negligible impact on ICLERP for ACLS trains even with very high RAW values (e.g. 10000).

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
		Actions taken with respect to the ACLS tech. spec. are not changed by the proposal.	*the operable CIV* fails to close (post-core damage), then LERF may be affected.	*B: Low-pressure pipe*	x 1.0 = 2.1e-8 (+ ICLERP result from item 1.1)	6.6e-5[v]
				C: Open system or path with one or two additional open valves	x 5.2e-2 = 1.1e-9 (+ ICLERP result from item 1.1)	3.4e-6[w]
				D: Open system or path with one additional closed valve	x 3.2e-5 = 6.7e-13 (+ ICLERP result from item 1.1)	5.0e-9[x]
				E: Open system or path with two additional closed valves	x 5.2e-6 = 1.1e-13 (+ ICLERP result from item 1.1)	7.9e-10
				F,G: Closed system (or open system with three or more additional valves)	x 4.3e-6 = 9.0e-14 (+ ICLERP result from item 1.1)	6.6e-10

[v] See footnote from item 1.1.
[w] See footnote from item 1.1.
[x] See footnote from item 1.1.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
2.2 RCS, NO, ACLS • Direct connection to RCS • Inside piping is seismic • Outside piping is seismic • CIVs open post-accident for ACLS function (normally open initially)	One CIV inoperable and second CIV fails in open position.	Same as those above for no ACLS function.	Same as those above for no ACLS function.	All, however Configurations A to D are not applicable.	ICCDP, ICLERP same as above (item 1.3) for NO CIV case with no ACLS function. Accident consequence limiting systems are not important for the outcome of ISLOCA type events, and are not credited in the risk assessment. (Cut sets for containment isolation failure modes following non-ISLOCA core damage sequences are non-minimal because the open pathway cut sets already contribute to ICCDP and ICLERP via ISLOCA)	See item 1.3 above
3. Penetrations connected to containment atmosphere that have no accident consequence limiting system function						
3.1 Atmosphere, NC, Seismic • Direct connection to containment atmosphere • Outside piping is seismic • CIVs normally closed	One CIV inoperable and second CIV fails in open position.	No CDF impact, since penetration is not connected to the RCS, and has no accident consequence limiting system function.	May contribute to LERF if NC CIV fails open coincident with a core damage event.	All	ICLERP= (any core damage except ISLOCA) x (operable NC CIV fails to stay closed) x (path to outside environment) = (5.0e-5/yr x 168h x yr/8760h) x (3.9e-7/h x 168h) x … continue below	
				A: Open pipe	x 1.0	6.3e-11
				B: Low-pressure pipe[y]	x 1.0	6.3e-11
				C: Open system or path with one or two additional open valves	x 5.2e-2	3.3e-12

[y] For penetrations connected to containment atmosphere, low-pressure pipe is defined as pipe (or attachments) that cannot withstand peak post-accident or severe accident containment pressure.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
				D: Open system or path with one additional closed valve	x 7.6e-5	4.8e-15
				E: Open system or path with two additional closed valves	x 1.2e-5	7.5e-16
				F,G: Closed system (or open system with three or more additional valves)	x 1.0e-5	6.3e-16
3.2 Atmosphere, NC, Non-seismic • Direct connection to containment atmosphere • Outside piping non-seismic • CIVs normally closed	One CIV inoperable and second CIV fails in open position.	Same as above (item 3.1).	Same as above (item 3.1), plus additional contribution to LERF if NC CIV fails open and coincident seismic event ruptures outside pipe and causes core damage.	All	In addition to above (item 3.1), ICLERP= (operable NC CIV fails to stay closed) x (core damage from seismic event) x (failure of outside pipe) = (3.9e-7/h x 168h) x (3.9e-5/yr x 168h x yr/8760h) x (1.0)	
				A: Open pipe	= 4.9e-11 (+ Result from item 3.1)	1.1e-10
				B: Low-pressure pipe	= 4.9e-11 (+ Result from item 3.1)	1.1e-10
				C: Open system or path with one or two additional open valves	= 4.9e-11 (+ Result from item 3.1)	5.2e-11
				D: Open system or path with one additional closed valve	= 4.9e-11 (+ Result from item 3.1)	4.9e-11
				E: Open system or path with two additional closed valves	= 4.9e-11 (+ Result from item 3.1)	4.9e-11
				F,G: Closed system (or open system with three or more additional valves)	= 4.9e-11 (+ Result from item 3.1)	4.9e-11

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
3.3 Atmosphere, NO, Seismic • Direct connection to containment atmosphere • Outside piping is seismic • CIVs normally open (applies to cycling CIV as well)	One CIV inoperable and second CIV fails in open position.	No CDF impact, since penetration is not connected to the RCS, and has no accident consequence limiting system function.	May contribute to LERF if NO CIV fails to close coincident with a core damage event.	All	ICLERP= (any core damage except ISLOCA) x {(operable CIV fails to close) + (FV[z] for MOV power bus)} x (path to outside environment) = (5.0e-5/yr x 168h x yr/8760h) x {(1.7e-3) + (2.2e-3)} x ... continue below	
				A: Open pipe	x 1.0	3.7e-9
				B: Low-pressure pipe[aa]	x 1.0	3.7e-9
				C: Open system or path with one or two additional open valves	x 5.2e-2 (or x 1.0 if on same bus as CIV[bb])	1.9e-10 (3.7e-9)
				D: Open system or path with one additional closed valve	x 7.6e-5	2.8e-13
				E: Open system or path with two additional closed valves	x 1.2e-5	4.5e-14
				F,G: Closed system (or open system with three or more additional valves)	x 1.0e-5	3.7e-14

[z] FV = Fussell-Vesely importance measure, represents the fraction of CDF contributed by failure of the power bus that also powers the CIV; this dependency applies only to MOVs and is conservative for the other CIV types.

[aa] For penetrations connected to containment atmosphere, low-pressure pipe is defined as pipe (or attachments) that cannot withstand peak post-accident or severe accident containment pressure.

[bb] Failure probability = 1.0 is a conservative assumption. If the open valve is one that fails as is upon loss of power (i.e., an MOV), then the conditional probability of failure may be assumed to be 1.0 if the valve in question is on the same power bus as the CIV, and the CIV failed to close due to power failure.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
3.4 Atmosphere, NO, Non-*seismic* • Direct connection to containment atmosphere • Outside piping non- seismic • CIVs normally opened	One CIV inoperable and *second CIV fails in* open position.	Same as above (item 3.3).	Same as above (item 3.3), plus *additional* contribution to LERF if seismic event causes core damage and ruptures outside pipe, and NO CIV fails to close.	All	In addition to above (item 3.3), ICLERP= *(core damage from seismic event)* x (failure of outside pipe) x {(operable CIV fails to close) + (FV[cc] for MOV power bus)} = (3.9e-5/yr x 168h x yr/8760h) x (1.0) x {(1.7e-3) + (2.2e-3)}	
				A: Open pipe	= 2.9e-9 (+ Result from item 3.3)	6.6e-9
				B: Low-pressure pipe	= 2.9e-9 (+ Result from item 3.3)	6.6e-9
				C: Open system or path with one or two additional open valves	= 2.9e-9 (+ Result from item 3.3)	3.1e-9 (6.6e-9[dd])
				D: Open system or path with one additional closed valve	= 2.9e-9 (+ Result from item 3.3)	2.9e-9
				E: Open system or path with two additional closed valves	= 2.9e-9 (+ Result from item 3.3)	2.9e-9
				F,G: Closed system (or open system with three or more additional valves)	= 2.9e-9 (+ Result from item 3.3)	2.9e-9

[cc] Estimated FV of essential power bus for seismic CDF case is assumed to be the same as in base CDF case.
[dd] If power by same bus as operable CIV.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
4. Penetrations connected to containment atmosphere that have accident consequence limiting system function						
4.1 Atmosphere, ACLS • Direct connection to containment atmosphere • CIVs open post-accident for ACLS function (normally closed or normally open initially) • Outside piping is seismic	One CIV inoperable (failed fully open/assured open) and second CIV fails in open position.	No CDF impact, since penetration is not connected to the RCS, and the function of the ACLS is not impaired by delaying isolation of the CIV.	LERF impact same as above for no ACLS function, since the function of the ACLS is not impaired by delaying isolation of the CIV.	Same as above (item 3.3) for no ACLS function and NO CIVs.	Same as above for no ACLS function and NO CIVs (item 3.3).	See item 3.3 above.
	One CIV inoperable but not assured open (e.g., fails half-way), and second CIV fails in open position.	No change to CDF due to CIV AOT extension. Although the ACLS degradation may have a small effect on CDF, the ACLS function does not benefit from the Required Action to isolate the CIV. Compensatory Actions taken with respect to the ACLS tech. spec.	If the inoperable CIV is stuck partially open, then the ACLS degradation may have an impact on CDF and LERF that is unrelated to the proposed AOT extension. However, the CDF impact must be considered in the delta-LERF since the ACLS AOT may run	All	ICLERP= (any core damage except ISLOCA) x (RAW[ff] for impacted ACLS) x {(operable CIV fails to close) + (FV[gg] for MOV power bus)} x (path to outside environment) = (5.0e-5/yr x 72h x yr/8760h) x (1.0) x {(1.7e-3) + (2.2e-3)} x … continue below	
				A: Open pipe	x 1.0	1.6e-9
				B: Low-pressure pipe[hh]	x 1.0	1.6e-9
				C: Open system or path with one or two additional open valves[ii]	x 5.2e-2 (or x 1.0 if on same bus as CIV)	8.3e-11 (1.6e-9)

[ee] Note that exposure time is per shorter AOT of ACLS Technical Specification.

[ff] RAW (relative to CDF) is typically small (close to 1.0) for containment systems. Note that the ICLERP would be acceptable in this case for ACLS trains with RAW value as high as 30.

[gg] The fraction of CDF contributed by failure of the power bus that also powers the CIV. This dependency applies only to MOVs and is conservative for the other CIV types. Using RAW and FV in the same equation would slightly overestimate the importance (for RAW values greater than 1.0) because the FV importance is based on the fraction of the base CDF, which yields a larger FV fraction than if based on the potentially larger CDF x RAW.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
		are not changed by the proposal.	concurrent[ee] with the CIV AOT. If the operable CIV also fails to close, then LERF may be affected.	D: Open system or path with one additional closed valve	x 3.2e-5	5.1e-14
				E: Open system or path with two additional closed valves	x 5.2e-6	8.3e-15
				F,G: Closed system (or open system with three or more additional valves)	x 4.3e-6	6.9e-15
5. Penetrations connected to closed loop systems inside containment that have no accident consequence limiting system function						
5.1 Closed loop, Atmosphere, Seismic • Inside is closed loop • Closed loop interface with containment atmosphere • Inside piping is seismic • Outside piping is seismic	CIV inoperable (assumed fully or partially opened) and closed loop pressure boundary fails.	None likely, since closed loop is not connected to RCS and it has no ACLS function. However, there is a possibility that a failure of the pipe in the loop may cause a reactor trip during the extended AOT.	May contribute to LERF if closed loop pipe breaks and coincident core damage occurs either independently or as a consequence of the break.	All	ICCDP= (random failure of inside pipe[jj]) x (failed pipe causes reactor trip[kk]) x (CCDP for reactor trip) = (1.76e-6/h x 168h) x (1.0) x (1.1e-6)	3.3e-10
				All	ICLERP= {(ICCDP from above) + (any core damage except ISLOCA) x (random failure of inside pipe)} x (path to outside environment) = {(3.3e-10) + (5.0e-5/yr x 168h x yr/8760h) x (1.76e-6/h x 168h)} x … continue below	

[hh] For penetrations connected to containment atmosphere, low-pressure pipe is defined as pipe (or attachments) that cannot withstand peak post-accident or severe accident containment pressure.

[ii] An open valve in this case includes remote-operated NO valves and valves that are NC initially but must open post accident (including check valves). Calculation is conservative for check valve failure to reseat because calculation assumes a remote-operated valve that requires operator action to close.

[jj] The closed loop pipe inside containment is conservatively assumed to be protected by an overpressure relief valve that is included here in addition to random pipe failure as a potential open pathway from the containment atmosphere. The failure rate for a relief valve failing open (1.7e-6/hour) is added to the pipe break failure rate (6.0e-8/hour).

[kk] Probability of reactor trip due to rupture of the closed loop system and/or loss of its function is conservatively assumed to be 1.0.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
				A: Open pipe	x 1.0	6.1e-10
				B: Low-pressure pipe[ll]	x 1.0	6.1e-10
				C: Open system or path with one or two additional open valves	x 5.2e-2	3.2e-11
				D: Open system or path with one additional closed valve	x 7.6e-5	4.6e-14
				E: Open system or path with two additional closed valves	x 1.2e-5	7.3e-15
				F,G: Closed system (or open system with three or more additional valves)	x 1.0e-5	6.1e-15
	Closed loop pressure boundary inside containment is inoperable[mm] and the CIV fails.	No CDF impact since penetration is not connected to the RCS, and has no ACLS function.	May contribute to LERF if CIV fails to close coincident with a core damage event	All, however Configuration A is not applicable because on open pipe would not exist on this type of penetration unless the CIV pressure boundary was also being repaired, which would violate the TS.	This is similar to a penetration flow path that is open to the containment atmosphere with one of two CIVs operable. Therefore, the risk impact is the same as item 3.3 above.	See item 3.3 above
5.2 Closed loop, Atmosphere, non-seismic • Inside piping is closed loop • Closed loop	CIV inoperable and closed loop pressure boundary fails.	Same as above (item 5.1, first failure mode).	Same as above (item 5.1, first failure mode), plus additional contribution to LERF if closed	All	ICCDP is same as above item 5.1, first failure mode.	See item 5.1 above

[ll] For penetrations interfacing with containment atmosphere, low-pressure pipe is defined as pipe (or attachments) that cannot withstand peak post-accident or severe accident containment pressure (assuming failure of the closed loop pressure boundary inside containment).
[mm] Proposed new condition that is not currently addressed by Technical Specification 3.6.3.; assumes closed loop pressure boundary (acting like second CIV) has an operability issue and is within the proposed AOT.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
interface with containment atmosphere • Inside piping is seismic • Outside piping non-seismic			loop pipe fails and coincident seismic core damage event occurs, which also ruptures outside pipes.	All	In addition to above (item 5.1, first failure mode), ICLERP= (random failure of inside pipe) x (core damage from seismic event) x (failure of outside pipe) = (1.76e-6/h x 168h) x (3.9e-5/yr x 168h x yr/8760h) x (1.0)	
				A: Open pipe	= 2.2e-10 (+ ICLERP result from item 5.1, first failure mode)	8.3e-10
				B: Low-pressure pipe[nn]	= 2.2e-10 (+ ICLERP result from item 5.1, first failure mode)	8.3e-10
				C: Open system or path with one or two additional open valves	= 2.2e-10 (+ ICLERP result from item 5.1, first failure mode)	2.5e-10
				D: Open system or path with one additional closed valve	= 2.2e-10 (+ ICLERP result from item 5.1, first failure mode)	2.2e-10
				E: Open system or path with two additional closed valves	= 2.2e-10 (+ ICLERP result from item 5.1, first failure mode)	2.2e-10
				F,G: Closed system (or open system with three or more additional valves)	= 2.2e-10 (+ ICLERP result from item 5.1, first failure mode)	2.2e-10

[nn] For penetrations interfacing with containment atmosphere, low-pressure pipe is defined as pipe (or attachments) that cannot withstand peak post-accident or severe accident containment pressure (assuming failure of the closed loop pressure boundary inside containment).

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
	Closed loop pressure boundary inside containment is inoperable and the CIV fails.	Same as above (item 5.1, second failure mode).	Same as above (item 5.1, second failure mode), plus additional contribution to LERF if seismic event causes core damage and ruptures outside pipe, and CIV fails to close.	All, however Configuration A is not applicable because on open pipe would not exist on this type of penetration unless the CIV pressure boundary was also being repaired, which would violate the TS.	This is similar to a penetration flow path that is open to the containment atmosphere with one of two CIVs operable. Therefore the risk impact is the same as item 3.4 above.	See item 3.4 above
5.3 Closed loop, RCS • Inside piping is closed loop • Closed loop interfaces partially with RCS (i.e., SG secondary side, e.g. blowdown, drains, vents, sample lines) • Inside piping is seismic	CIV inoperable (assumed open) and SGTR occurs.	CDF may be impacted if SGTR occurs during the extended AOT, and isolation of secondary side penetration fails due to inoperable CIV and other failures in the interfacing system.	If an escape path to the atmosphere opens up, then there is a new contribution to LERF from the base CDF for SGTR plus the delta CDF for this new unisolated SGTR.	All, however Configurations A to C are not applicable. (For practical purposes there must be at least one other NC valve in the path or a closed system outboard of the CIV in order to operate with the open CIV.)	ICCDP= (any core damage except ISLOCA) x ((RAW for failed secondary side isolation after SGTR) – 1.0)[pp] x (path to outside environment) = (5.0e-5/yr x 168h x yr/8760h) x ((1.04) – 1.0) x … continue below	
				D: Open system or path with one additional closed valve	x 7.6e-5	2.9e-12
				E: Open system or path with two additional closed valves	x 1.2e-5	4.6e-13
				F,G: Closed system (or open system with three or more additional valves)	x 1.0e-5	3.8e-13

[oo] Seismic event is not relevant for this case because the impact of a seismic event on SGTR probability is insignificant.

[pp] This RAW is for CDF because, when the secondary side isolation is assumed to fail (to calculate the CDF RAW) the resulting CDF includes the increase in CDF that occurs due to failure to isolate the SG. These are all from SGTR sequences. 1.0 is subtracted from the RAW to get just the conditional incremental CDF increase from failure of isolation. This is then multiplied by the failure probability of the specific penetration path of interest (assuming it is equivalent to secondary isolation failure). For the ICLERP calculation (next row), the base CDF contribution for all SGTR must be added back in. Note that the ICCDP and ICLERP are acceptable with RAW value as high as 400.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
• Outside piping is seismic or non-seismic[oo] • Most penetrations have one CIV; but some have two CIVs (calculation is conservative for two CIVs).				All (Configurations A to C are not applicable.)	ICLERP= {(any core damage that includes SGTR) + (ICCDP from above)} x (path to outside environment) = {(any core damage that includes SGTR) + (any core damage except ISLOCA) x ((RAW for failed secondary side isolation on SGTR) – 1.0)} x (path to outside environment) = {(8.8e-7/yr x 168h x yr/8760h) + (5.0e-5/yr x 168h x yr/8760h) x ((1.04) – 1.0)} x … continue below	
				D: Open system or path with one additional closed valve	x 7.6e-5	4.2e-12
				E: Open system or path with two additional closed valves	x 1.2e-5	6.6e-13
				F,G: Closed system (or open system with three or more additional valves)	x 1.0e-5	5.5e-13

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
6. Penetrations connected to closed loop systems inside containment that have accident consequence limiting system function						
6.1 Closed loop, Atmosphere, ACLS • Inside piping is closed loop • ACLS closed loop interfaces with containment atmosphere • Inside piping is seismic • Outside piping is seismic	One CIV inoperable and closed loop pressure boundary fails.	Failure of the ACLS pressure boundary may cause a reactor trip during the extended AOT. The ACLS function will be degraded due to failure of the pipe.	LERF is affected if the closed loop pipe break causes a path to the environment and coincident core damage occurs (independently or as a consequence of the break).	All	ICCDP= (random failure of inside pipe[qq]) x (failed pipe causes reactor trip[rr]) x (CCDP for reactor trip) x (RAW[ss] for impacted ACLS) = (1.76e-6/h x 168h) x (1.0) x (1.1e-6) x (12.0)	3.9e-9
				All	ICLERP= {(ICCDP from above) + (any core damage except ISLOCA) x (random failure of inside pipe) x (RAW for impacted ACLS)} x (path to outside environment) = {(3.9e-9) + (5.0e-5/yr x 168h x yr/8760h) x (1.76e-6/h x 168h) x (12.0)} x … continue below	
				A: Open pipe	x 1.0	7.3e-9
				B: Low-pressure pipe[tt]	x 1.0	7.3e-9

[qq] The closed loop pipe inside containment is conservatively assumed to be protected by an overpressure relief valve that is included here in addition to random pipe failure as a potential open pathway from the containment atmosphere. The failure rate for a relief valve failing open (1.7e-6/hour) is added to the pipe break failure rate (6.0e-8/hour).

[rr] Probability of reactor trip due to rupture of the closed loop system and/or loss of its function, is conservatively assumed to be 1.0.

[ss] Although a fairly high RAW value (12.0) is used here (representing an example cooling water system), note that ACLS trains with RAW values of about 80 or less provide acceptable ICCDP and ICLERP for this case.

[tt] For penetrations interfacing with containment atmosphere, low-pressure pipe is defined as pipe (or attachments) that cannot withstand peak post-accident or severe accident containment pressure (assuming failure of the closed loop pressure boundary inside containment).

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
				C: Open system or path with one or two additional open valves[uu]	x 5.2e-2	3.8e-10
				D: Open system or path with one additional closed valve	x 7.6e-5	5.5e-13
				E: Open system or path with two additional closed valves	x 1.2e-5	8.8e-14
				F,G: Closed system (or open system with three or more additional valves)	x 1.0e-5	7.3e-14

[uu] An open valve in this case includes remote-operated NO valves and valves that are NC initially but must open post accident (including check valves). Calculation is conservative for check valve failure to reseat because calculation assumes a remote-operated valve that requires operator action to close.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
	Closed loop pressure boundary inside containment is inoperable[vv] and the CIV fails.	There is no change to the CDF due to the proposed AOT extension. The ACLS degradation may have an effect on CDF; however if the ACLS train function is lost, that is not changed by isolating the penetration. Compensatory Actions taken with respect to the ACLS tech. spec. are not changed by the proposal.	The ACLS degradation may have an impact on CDF and LERF that is unrelated to the proposed AOT extension. However, the CDF impact must be considered in the delta-LERF since the ACLS AOT may run concurrent[ww] with the "CIV" AOT. If the operable CIV also fails to close, then LERF may be affected.	All, however Configuration A is not applicable because on open pipe would not exist on this type of penetration unless the CIV pressure boundary was also being repaired, which would violate the TS.	This is similar to a penetration flow path that is open to the containment atmosphere with one of two CIVs operable. Therefore the risk impact is similar to item 4.1 above, except that the RAW importance for a closed loop ACLS is used. Therefore: ICLERP= (any core damage except ISLOCA) x (RAW[xx] for impacted ACLS) x {(operable CIV fails to close) + (FV[yy] for MOV power bus)} x (path to outside environment) = (5.0e-5/yr x 72h x yr/8760h) x (12.0) x {(1.7e-3) + (2.2e-3)} x … continue below	
				B: Low-pressure pipe	x 1.0	1.9e-8
				C: Open system or path with one or two additional open valves	x 5.2e-2 (or x 1.0 if on same bus as CIV)	1.0e-9 (1.9e-8)
				D: Open system or path with one additional closed valve	x 3.2e-5	6.2e-13
				E: Open system or path with two additional closed valves	x 5.2e-6	1.0e-13

[vv] Proposed new condition that is not currently addressed by Technical Specification 3.6.3.; assumes closed loop pressure boundary (acting like second CIV) has an operability issue and is within the proposed AOT.
[ww] Note that exposure time is per shorter AOT of ACLS Technical Specification.
[xx] Note that the ICLERP would be acceptable in this case for ACLS trains with RAW value as high as 30.
[yy] The fraction of CDF contributed by failure of the power bus that also powers the CIV. This dependency applies only to MOVs and is conservative for the other CIV types. Using RAW and FV in the same equation would slightly overestimate the importance (for RAW values greater than 1.0) because the FV importance is based on the fraction of the base CDF, which yields a larger FV fraction than if based on the potentially larger CDF x RAW.

Class Description of CIV[a,b] and Penetration	Failure Mode of CIVs	CDF Impact of AOT Extension	LERF Impact of AOT Extension	Configuration of Escape Path to Outside Environment (other valves)[c]	"Equation" for ICCDP and ICLERP[d]	Result[e]
				F,G: Closed system (or open system with three or more additional valves)	x 4.3e-6	8.3e-14
6.2 Closed loop, RCS, ACLS • Inside piping is closed loop • ACLS closed loop interfaces partially with RCS (i.e., secondary side of SG tubes, e.g. EFW) • Inside piping is seismic • Outside piping is seismic **Note**: Does not apply to the main steam line. For those penetrations the risk impact is more complex; relaxation of AOT is not proposed for those at this time.	CIV inoperable and SGTR occurs.			All, however Configurations A to C are not applicable.	The risk impact is approximately the same as above for the non-ACLS case (item 5.3). Loss of the affected ACLS function (i.e., EFW to the affected SG) should have a minimal impact on CDF for these SGTR scenarios. The feed water to the affected SG is usually isolated (by valves other than the CIV) in these scenarios. While the operators may feed the affected SG under some circumstances, in the scenario where the SGTR is large enough to represent a LERF path, there will be sufficient inventory from the tube rupture that EFW will not be necessary for adequate SG heat transfer.	See item 5.3 above

4.0 CONCLUSIONS

This report contains a risk-informed evaluation performed by the B&WOG to provide justification for a longer AOT for CIVs. It is applicable to penetration flow paths that have at least two CIVs, or one CIV and a closed loop system. These penetrations are listed in each plant's UFSAR. The CIVs in the main steam lines (and others on a plant-specific basis that may represent high risk significance for ISLOCA) are explicitly excluded from this evaluation.

The justification provided in this report is consistent with the guidance set forth in Regulatory Guides 1.177 and 1.174. The proposed TS change is in compliance with existing regulations, is consistent with the philosophy of defense-in-depth, and will not erode safety margins. The risk-informed evaluation described in this report uses the three-tiered approach put forth by the NRC for implementing proposed TS changes. The evaluation described herein demonstrates that the risk impact of the proposed change is small.

To evaluate the risk impact associated with the proposed TS change (Tier 1), a specialized analysis was developed because the plant-specific PRAs do not model every penetration in detail. A FMEA with a set of simplified and conservative risk models was developed that encompass every applicable penetration. The risk model was developed using limiting parameters and conservative data extracted from the plant-specific PRAs. The scope of the risk assessment includes the effect that the proposed AOT extension has upon the probability of large early release following core damage, the probability of an ISLOCA, and the probability of affecting a post-accident ACLS function. The risk assessment calculates the incremental risk impact associated with the proposed AOT extension. This is the increased vulnerability to core damage and large early release during the AOT, which is expressed in terms of ICCDP and ICLERP. Regulatory Guide 1.177 considers an ICCDP of 5e-7 and an ICLERP of 5e-8 to be a small impact for a single AOT entry.

In almost every case, the risk impact meets the Regulatory Guide 1.177 guideline for small risk impact. The exceptions are described in the report and have resulted in the following conclusion:

- The extended AOT will not be used for an inoperable NC CIV if it leaves the penetration flow path with only one closed valve between the RCS and the environment (i.e., low pressure pipe or opening) and that valve is not verified closed. Penetrations meeting this criterion have a higher risk for ISLOCA; they will be identified during implementation and the current AOT will be retained.

Subject to this exception, all of the applicable CIVs represent a small risk impact when in the proposed AOT.

The B&WOG plant-specific CRMP satisfy the Tier 2 and Tier 3 requirements of Regulatory Guide 1.177. The B&WOG plant programs for configuration risk management provide reasonable assurance that risk-significant plant equipment outage configurations will not occur when CIV equipment is out of service consistent with the proposed TS change. The CRMP ensures that the risk impact of out-of-service equipment is appropriately evaluated prior to performing any maintenance activity. The CRMP enhances defense-in-depth because it provides a means of ensuring that the independence of the physical barriers will not be degraded by the proposed change.

The proposed TS change will improve operational safety and reduce unnecessary burdens in complying with TS requirements. Unnecessary plant shutdowns may be avoided by allowing more time for repairs. Operational flexibility will be enhanced by allowing some repairs to be performed online. For penetration flow paths with ACLS functions, an extended AOT for CIVs will avoid unnecessary flow path isolation that may result in degraded function of the ACLS.

The B&WOG has demonstrated that the proposed extension of the AOT for containment isolation valves does not adversely impact risk or public safety, and is therefore an appropriate change to the Technical Specifications.

5.0 REFERENCES

1. USNRC, “Use of Probabilistic Risk Assessment Methods in Nuclear Activities: Final Policy Statement,” Federal Register, Vol. 60, p. 42622, August 16, 1995.

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3. RG 1.174, Revision 1, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,” USNRC, November 2002.

4. NUREG-1430, “Standard Technical Specifications, Babcock and Wilcox Plants,” Revision 3, June 2004.

5. USNRC, “Safety Goals for Operations of Nuclear Power Plants; Policy Statement,” Federal Register 51 FR 30028, August 4, 1986.

6. USNRC, 10 CFR 50.36, “Technical Specifications,” July 1996.

7. USNRC, “Final Policy Statement on Technical Specifications Improvements for Nuclear Power Reactors,” Federal Register 58 FR 39132, July 22, 1993.

8. Prairie Island Draft Safety Evaluation Report, ADAMS accession number ML021540301, June, 3, 2002.

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