Project Number 694

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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.

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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 1×10^{-15} up to about 4×10^{-8} depending upon penetration (penetrations with ICLERP greater than 5×10^{-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 5×10^{-16} up to about $2. \times 10^{-8}$ per reactor-year. This is well into Region III of the acceptance guidelines from Reg. Guide 1.174 (ΔCDF < 1×10^{-6}/reactor-year, ΔLERF < 1×10^{-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 $6.0x10^{-10}$ per pipe section per hour. This yields a failure rate per penetration of $6.0x10^{-8}$/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 ($6.01x10^{-10}$/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 $6.01x10^{-10}$ 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 2.0×10^{-8} before the sensitivity analysis to 2.0×10^{-7} after (configuration E) or from 1.7×10^{-8} to 2.0×10^{-7} (configuration F, G); which is moderately above the ICLERP small impact criterion of 5×10^{-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 5×10^{-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 (1.42×10^{-9}/section-hour) instead of the generic value (6.01×10^{-10}/section-hour) is not enough to increase the ICLERP above 5×10^{-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.

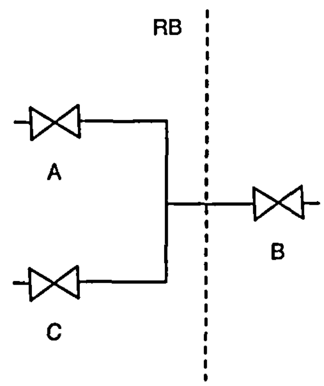
Quantification of Risk Parameters for Inoperable CIVs

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:

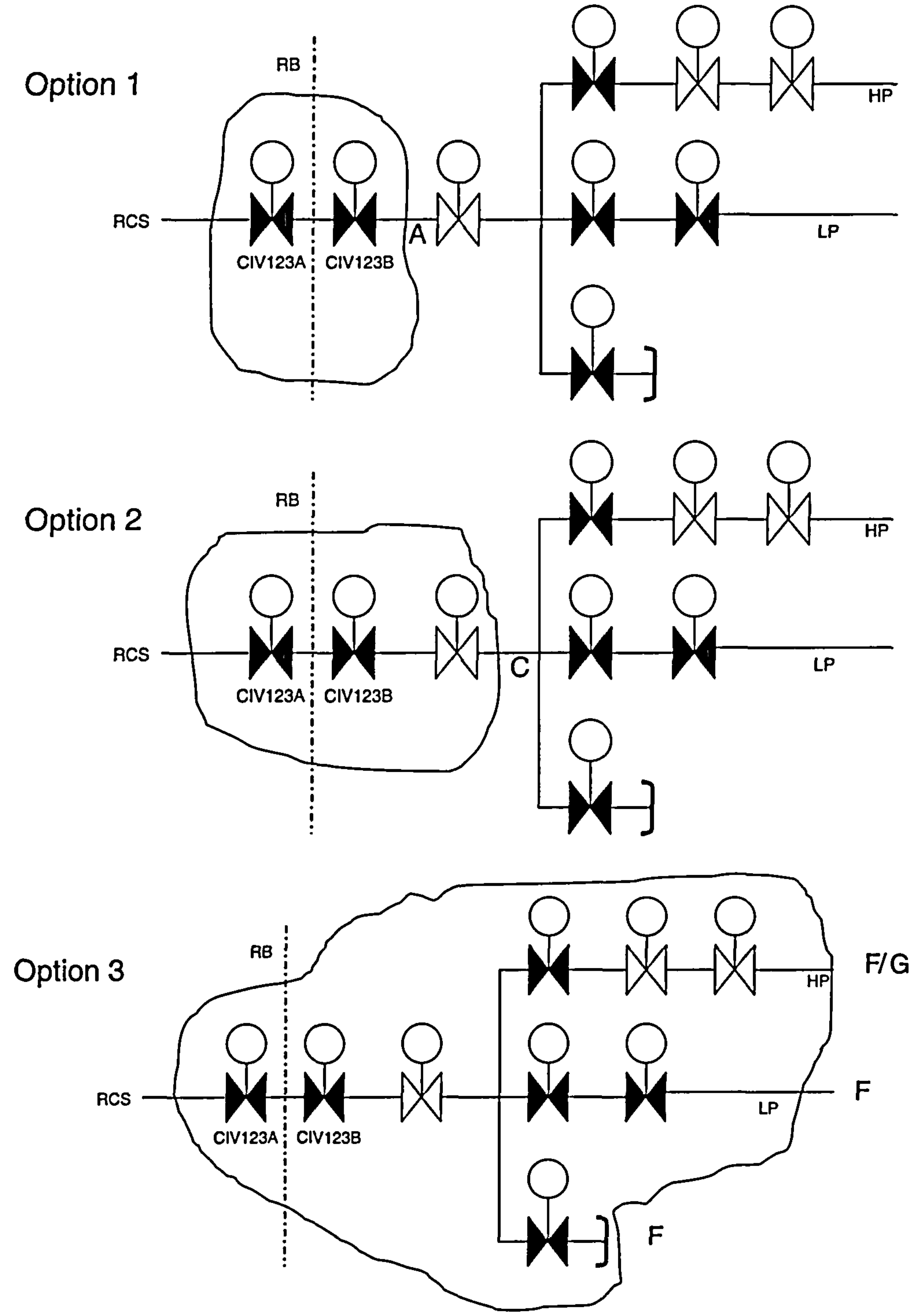
4) Identify any low-pressure piping interface or system opening that would be vulnerable if valves failed in the open position.

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



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≤$5x10^{-7}$ & ICLERP≤$5x10^{-8}$)	ICCDP/ ICLERP if CIV pressure boundary open (configuration A) (n/a for RCS connection, n/a for inboard CIV)	Acceptable? (ICCDP≤$5x10^{-7}$ & ICLERP≤$5x10^{-8}$)
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 ≤ $5x10^{-7}$ and ICLERP ≤ $5x10^{-8}$. 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).