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THE B&W OWNERS GROUP

Technical Specification Committee

Justification for Increasing The Reactor Trip System On-Line Test Intervals

Supplement Number 2
Additional Information on Allowed Outage Time

Babcock & Wilcox
a McDermott company

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JUSTIFICATION FOR INCREASING
THE REACTOR TRIP SYSTEM
ON-LINE TEST INTERVALS

by

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Prepared for the B&W Owners Group
Technical Specification Committee

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EXECUTIVE SUMMARY

This report responds to the SER for B&WOG Topical Report BAW-10167 "Justification for Increasing the Reactor Trip System (RTS) On-Line Test Intervals." The SER approves extension of the RTS instrument strings test interval from 1 month to 6 months. However, the approval of semi-annual testing was made with the stipulation that the Allowed Outage Time (AOT) be limited to 48 hours, after which the inoperable channel must be tripped.

Technical specifications for several operating plants already permit one of four RTS channels to be bypassed indefinitely, if inoperable. The B&WOG continues to believe this to be appropriate and justifiable and in the interest of plant safety.

This report provides additional information for the Staff's consideration, to support the original B&WOG request to retain the indefinite AOT for the fourth RTS instrument string channel.

Nominally the RTS instrument string channels operate in a two-out-of-four configuration. With an inoperable channel that is bypassed, the RTS instrument string channels will operate in a two-out-of-three configuration until the AOT expires. After expiration of the NRC-proposed 48-hour AOT, the inoperable channel must be tripped; this results in a half-trip of the RTS and consequently a one-out-of-three configuration of the remaining RTS instrument string channels.

The analysis presented shows that with an inoperable channel, a two-out-of-three configuration (channel bypassed) provides more safety than a one-out-of-three configuration (channel tripped). This is because the two-out-of-three configuration provides reliability to trip on demand as well as protection against spurious trips. The one-out-of-three configuration is intolerant of single spurious channel trips.

The B&WOG believes that for the B&W four-channel RTS design, a long AOT provides better safety because, on the infrequent occasion when a failure cannot be repaired quickly, it allows the RTS to continue to operate in a two-out-of-three configuration.

Plant safety depends both on the reliability of the RTS to trip and its sensitivity to spurious trips. The best configuration balances the reliability of tripping on demand with a low spurious trip rate. This report uses PRA to analyze the reliability (to trip on demand) aspect and the spurious trip aspect of the two configurations, two-out-of-three and one-out-of-three, resulting from the indefinite and 48 hour AOT, respectively. Core melt risk is used to demonstrate that the two-out-of-three configuration provides a better balance of reliability and spurious trip frequency. The method of analysis, RTS model, assumptions, and data used for this analysis are from BAW-10167 which has been reviewed by the NRC and its subcontractor INEL, and approved in the SER for BAW-10167.

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1. INTRODUCTION

The purpose of this report is to respond to the SER for B&WOG Topical Report BAW-10167 "Justification for Increasing the Reactor Trip System On-Line Test Intervals"[1] and provide additional information for the Staff's consideration.

The SER[2] for the Topical Report approves extension of the Reactor Trip System (RTS)[3] instrument strings test interval from 1 month to 6 months. Relaxation of reactor trip module (RTM) and reactor trip breaker testing was not requested and will remain monthly. However, the approval of semi-annual instrument string testing was made with the stipulation that the Allowed Outage Time (AOT) be limited to 48 hours, after which the inoperable channel must be tripped.

The B&WOG is asking that they be allowed to keep the indefinite AOT that they currently have, in order to preserve the safety and operational benefits gained by the extended test interval.

The SER for Topical Report BAW-10167 states that the B&W RTS has "never been reviewed as a three channel system" and thus an unlimited AOT for the fourth channel cannot be approved. The B&WOG is not asking that it be reviewed as a three-channel system. The B&WOG believes that this is not pertinent because the RTS is a four-channel system with bypass, not a three-channel system.

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[1] R.S. Enzinna, S.H. Levinson, E.W. Swanson. Topical Report BAW-10167, "Justification for Increasing the Reactor Trip System On-Line Test Intervals." B&W Owners Group, B&W, P.O. Box 10935, Lynchburg, Virginia 24506-0935. Volumes 1 & 2, May 1986. Supplement No. 1, February 1988.

[2] Letter from A.C. Thadani, NRC to C.W. Smyth, B&WOG. "NRC Evaluation of BWOG Topical Report BAW 10167 and Supplement 1, 'Justification for Increasing the Reactor Trip System On-Line Test Interval.'" December 5, 1988.

[3] The RTS is comprised of the Reactor Protection System (RPS), Anticipatory Reactor Trip System (ARTS), and Control Rod Drive Control System (CRDCS) subsystems. The instrument strings terminate with the bistables and are contained within the RPS and ARTS subsystems.

At all B&WOG plants, the RTS has been reviewed as a four-channel system with bypass feature. At some plants, the concept that the remaining three-channel system meets IEEE-279 has also been addressed. For example, for ANO-1, in response to the specific NRC request to:

> "...include a listing of the operating bypasses and show that they have been designed to meet the requirements of Paragraph 4.12 of IEEE-279."

The utility responded[4]:

> "The RPS channel bypass is used to perform reactor protection system testing and maintenance. It enables the operator to bypass the trip action of any one channel. An interlock prevents bypassing more than one channel. **The remaining two-out-of-three coincidence fully meets the requirements of IEEE std, 279-1971...**" (emphasis added)

To which the NRC responded in their SER[5] with:

> "The Commission's General Design criteria (GDC), IEEE Criteria for Nuclear Power Plant Protection Systems (IEEE-279), IEEE Criteria for Power Plant Class IE Electrical Systems (IEEE-308), and applicable Regulatory guides for water cooled nuclear power plants have been utilized as the bases for evaluating the adequacy of the protection and control systems...We have reviewed all aspects of the RPS, including logic schematics, test capabilities and control of bypasses, and concluded that this system is acceptable."

Several B&WOG utilities currently have the right to bypass an RTS channel for an unlimited time; their experience shows that the privilege has not been abused. The bypass feature is used mostly for short durations for testing and maintenance. The need for a lengthy bypass is infrequent.

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[4]ANO-1 FSAR, Amendment 25, March 31, 1972. (Item 7.11)

[5]SER for ANO-1 FSAR, June 6, 1973. (Section 7.0)

The SER for BAW-10167 states:

> "Therefore, allowing sufficient time for virtually all repairs to be accomplished without having to place the channels in trip is appropriate."

The B&WOG agrees with this statement. However, the NRC concludes that 48 hours is sufficient to make repairs based on information from Combustion Engineering. Most repairs at B&WOG plants can be made in 48 hours or less. However, on rare occasions a component, such as a sensor attached to the primary pressure boundary, fails that cannot be repaired until an outage because of inaccessibility. Attachment 1 gives a brief history of this type of event at B&WOG plants, and demonstrates the need to maintain the longer AOT.

Over the last several years, the Staff has encouraged the use of probabilistic analyses to provide technical justification for AOTs, implying that the results would be used in setting AOTs. The B&WOG has performed these analyses and the results support a longer AOT than the Staff allowed. The 48-hour time period apparently was not based on either the analysis presented in BAW-10167 or on the results of the INEL review. Both of these indicated that longer AOTs are justified. To ignore these findings would undermine Industry and Staff efforts to provide firm technical bases for surveillance test intervals and AOTs.

The B&WOG believes that safety is better served by retaining the longer AOT. Nominally the RTS instrument string channels operate in a two-out-of-four (2/4) configuration. With an inoperable channel that is bypassed, the RTS instrument string channels[6] will operate in a two-out-of-three (2/3) configuration until the AOT expires. After expiration of the 48-hour AOT, the inoperable channel must be tripped; this results in a half-trip of the

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[6] "Instrument string" is defined as that portion of the RTS from the sensors to the bistables. All of the strings that terminate in a particular RPS cabinet are defined as a "channel." The configuration of the Reactor Trip Modules and Reactor Trip Breakers (one-out-of-two-twice) is unaffected by bypass or trip of an instrument string channel.

RTS and consequently a one-out-of-three (1/3) configuration of the remaining RTS instrument string channels. The B&WOG believes that a long AOT provides better safety because, if a failure cannot be repaired quickly[7], it allows the RTS to continue to operate in a 2/3 configuration, and avoids the less safe 1/3 configuration.

A better level of safety can be achieved by placing an inoperable channel in bypass (2/3 configuration) rather than placing that channel in trip (1/3 configuration) because spurious trips are more likely when one channel is already tripped. Spurious trips can occur with one channel in trip when either a random hardware failure occurs in an adjacent channel or human errors occur during testing. This report demonstrates that the spurious trip concern outweighs the reliability improvement obtained by tripping the inoperable channel. The safety tradeoff between spurious trip potential and reliability is expressed in terms of core melt risk.

The following evaluation assumes a failed RTS channel for a long period of time (as would be the case upon failure of an inaccessible sensor), and compares the 2/3 configuration resulting from bypass of the failed channel with the 1/3 configuration resulting from a required trip of the failed channel. Section 2 discusses the RTS and the configurations resulting from single channel inoperability, in qualitative terms. The following sections break the quantitative analysis down into its reliability (to trip on demand) aspect (Section 3) and its spurious trip aspect (Section 4). In Section 5, the RTS unavailability and spurious trip rate are combined on the basis of core melt risk to see which configuration provides a better balance of reliability and spurious trip frequency.

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[7]Failures of inaccessible components, such as RTD sensors , cannot be repaired until an outage. (Failed sensors attached to the primary pressure boundary cannot be repaired with the system pressurized.) Sometimes other repairs take longer than 48 hours due to scarcity of parts. Attachment 1 gives information on the B&WOG's experiences in this realm.

2. DESIGN CONSIDERATIONS

The B&W-designed Reactor Trip System is different than those used by others. Besides having a fourth channel, which many others do not, it has a designed-in bypass. This means that when one of the four channels is bypassed, it is done at the control room RTS cabinets and interlocks are provided to prevent simultaneous bypass of redundant channels. There is also a very high degree of diversity in the B&WOG RTS. There are undervoltage and shunt trip devices on the mechanical breakers and Silicon Controlled Rectifiers (SCRs) for the electronic trip. The many diverse parameters monitored by the RPS and ARTS portions of the RTS are combined in a global rather than local trip logic. This means that a single surviving input from one parameter and a single surviving input from a diverse parameter can combine to satisfy the coincidence logic and trip the reactor; it is not necessary that two like parameters trip in order to satisfy the coincidence logic. These features yields an RTS that is highly reliable and insensitive to inoperability of a single channel. Hence, the RTS reliability is insensitive to whether the inoperable channel in bypassed or tripped.

Plant safety, however, depends both on the reliability of the RTS to trip and its sensitivity to spurious trip. A good system balances the reliability of tripping on demand with a low spurious trip rate. A failure in the four-channel system that cannot be repaired right away, forces the remaining three channels to be configured either in a 2/3 or a 1/3 configuration. Both three-channel configurations require multiple channel failures to defeat the trip function. However, the 2/3 configuration is also single failure proof for spurious trips. The 1/3 configuration is intolerant of a single spurious channel trip. Plant safety is therefore better with the inoperable channel bypassed (i.e. 2/3 configuration) rather than tripped (i.e. 1/3 configuration).

This can be shown quantitatively by computing the core melt risk contributions from both spurious trip and unavailability for each configuration. The better configuration is the one that produces the smallest combined risk.

3. RELIABILITY ANALYSIS

The method of analysis, RTS model, assumptions, and data used for this analysis are from BAW-10167 which has been reviewed by the NRC and its subcontractor INEL, and approved in the SER[8]. As described in BAW-10167, the analysis placed heavy emphasis on the use of actual operating experience[9]. The model included contributions from both random and common-mode-failure, from both human and hardware causes. The model, data, and assumptions are described in detail in BAW-10167.

The B&WOG and NRC proposed AOT schemes were modeled. The B&WOG proposed AOT permits a single inoperable channel to be put into bypass immediately and left in bypass indefinitely until repair can be made (2/3 configuration). The NRC proposed AOT permits the inoperable channel to be bypassed for the first 48 hours, then if repairs are not finished, placed into trip (1/3 configuration). "Minor" repairs that can be made within 48 hours are not at issue since both proposed schemes are the same with respect to the first 48 hours. Therefore, the model assumes a failure that cannot be repaired at power, and hence results in a long period with the RTS in a three-channel configuration. The analysis models the reliability after the initial 48 hours, in other words, during the period of "vulnerability."

The Davis Besse and Oconee cases from BAW-10167 with six-month instrument string test interval were used in this analysis. They were re-executed with one of the four instrument string channels in an assumed pre-failed condition. Two cases were run for each plant-type, one with the failed channel tripped and the other with the failed channel bypassed. All other

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[8]Letter from A.C. Thadani, NRC to C.W. Smyth, B&WOG. "NRC Evaluation of BWOG Topical Report BAW 10167 and Supplement 1, 'Justification for Increasing the Reactor Trip System On-Line Test Interval.'" December 5, 1988.

[9]Sensor and instrument string data, for example, came from NUREG/CR-3289, "Common Cause Fault Rates for Instrumentation and Control Assemblies," by C. L. Atwood and T. R. Meachum, INEL, May 1983.

aspects of the analysis are as they were in BAW-10167, as reviewed by INEL and the NRC.

The model for the reactor trip breaker and RTM portion of the RTS is unchanged from BAW-10167 because the configuration of the reactor trip breakers (one-out-of-two-twice) is not affected by bypass or trip of the instrument string channels. This is because the instrument string bypass and trip circuits are upstream of the RTMs. The binary signal, coming from the bistables of the affected instrument string channel, is preempted by the trip and bypass circuits to a continuous tripped or untripped state. Each RTM processes the binary signals from the four instrument string channels through a 2/4 coincidence logic (which is effectively reduced to 2/3 or 1/3 because of the preempted signal) and provides the result to its assigned breaker(s). Thus while the internal coincidence logic in each RTM effectively changes from 2/4 to 2/3 or 1/3, the RTM outputs remain in the one-out-of-two-twice logic dictated by the reactor trip breaker arrangement.

The analysis shows the RTS reliability to be very high and not significantly better for 1/3 versus 2/3 coincidence logic. The RTS unavailability (failure to trip on demand) for the two configurations is shown in Table 1. For comparison, the unavailability of the four-channels-operable RTS, taken from BAW-10167, is shown for the six-month test interval case. For both the Davis Besse and Oconee RTS types, the difference between the 1/3 and 2/3 cases is small. For the Oconee case, the results are dominated by breaker failures and are insensitive to instrument string configuration. For the Davis Besse configuration, the reliability is relatively insensitive to whether the inoperable channel is tripped or bypassed.

The reason that RTS reliability is insensitive to the bypass/trip status of a single inoperable channel is that the system has a very high degree of redundancy and diversity. Consequently, common-mode-failure, which is insensitive to extra redundancy, dominates the failure potential. Due to this high degree of redundancy and diversity, single channel inoperability is not a factor.

Table 1
RTS Unavailability Comparison

	2/3 configuration (channel bypassed)	1/3 configuration (channel tripped)	2/4 configuration (from BAW-10167)
Davis Besse	$3x10^{-8}$/demand	$9x10^{-9}$/demand	$9x10^{-9}$/demand
Oconee	$1x10^{-6}$/demand	$1x10^{-6}$/demand	$1x10^{-6}$/demand

4. SPURIOUS TRIP ANALYSIS

The opportunity for spurious reactor trip with the inoperable channel tripped is greater than with the inoperable channel bypassed. Besides the obvious reason that a half-trip of the RTS would exist, having the channel tripped for a lengthy period requires more human interactions with the channel bypass and trip controls for subsequent testing of other channels.

There are two sources of spurious trip relevant to this analysis.

1) Spurious trips during testing. These errors occur during human interaction with bypass/trip controls during testing.

2) Spurious half-trips. These are random failures that are usually benign because they do not propagate through the coincidence logic to cause a spurious reactor trip. However, when the coincidence logic is reduced to 1-out-of-3, such as the case with deliberate tripping of an inoperable channel, a random half-trip will cause a spurious reactor trip.

4.1. Spurious Trips During Testing

The test-caused spurious trip frequency is proportional to the frequency of human interaction with the channel bypass/trip circuits and is primarily a function of the test interval. There are two kinds of on-line surveillance tests performed on the RTS. One involves testing the trip function of each instrument string. The other involves functional testing of the RTMs and reactor trip breakers. As approved by the SER for BAW-10167, the instrument string tests will be semi-annually on a staggered basis (one channel every month-and-a-half) while the breaker/RTM tests will be monthly on a staggered basis (one channel per week).

When an instrument string channel is inoperable, these functional tests are affected as follows:

The functional surveillance testing of the remaining three operable instrument string channels continues. After an initial check of the operable instrument channels, each will be functionally tested every six months (staggered about one per six weeks). Each test affects two channels: the inoperable channel and the channel being tested. Since simultaneous bypass of two channels is (by design and procedure) not possible, and simultaneous trip of two channels produces reactor trip, the test temporarily requires that one channel be tripped and the other be bypassed. This is true regardless of whether the inoperable channel is initially bypassed or tripped. With one channel already inoperable, discovery of a second instrument string failure invokes the action statement for two inoperable channels requiring plant shutdown.

Functional testing of the four channels of reactor trip breakers and RTMs continues as before at a 1-month interval (staggered one per week). The logistics of testing during this period depend on whether the inoperable instrument string channel is bypassed or tripped. If the inoperable instrument string is bypassed, then testing of the four RTM/breaker channels is unaffected. However, if the inoperable instrument string channel is tripped, the trip must be cleared before the RTM/breaker testing begins. This is because the instrument string trip is processed through the coincidence logic in all four RTMs, resulting in a half-trip in all four RTMs. Each RTM/breaker test creates another half-trip in all four RTMs. Therefore, to avoid two half-trips and a consequential reactor trip, the RTM/breaker test requires first that the instrument string trip be cleared (i.e. bypassed).

Usually, the RTM/breaker functional test does not affect operation of the RTS instrument strings. However, as described above, when a channel is inoperable for an extended period, the logistics of subsequent surveillance tests will change. In the specific situation where the inoperable instrument string channel is tripped for technical specification requirements, the RTM/breaker test cannot proceed as usual without tripping the reactor. The tripped channel must be bypassed and the trip reset before the breaker/RTM test can start. After the test, the inoperable channel must be unbypassed and retripped to return it to the required tripped state. These additional operations must be performed each time the functional test is performed (weekly); these human interactions would not be necessary if the inoperable channel were in bypass.

Table 2 shows the approximate frequency of human interactions that affect the RTS instrument strings and breakers, and the resulting spurious trip rate prediction. The table shows the spurious trip rates obtained from BAW-10167 for the case of a four-channel system with one-month and six-month test intervals. Also shown are the spurious trip rates for the three-channel configurations, resulting from bypass and from trip of the fourth channel. These predictions were made using spurious trip data, collected by INPO[10], from B&WOG operating history. This data was used in BAW-10167 and correlated to test frequency to make a prediction for the test interval extension to six months. The same linear relationship between human interaction and spurious trip rate was used to infer trip rates for the hypothesized cases involving 2/3 and 1/3 RTS configuration.

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[10]"SCRAM Reduction Practices." INPO 85-011. INPO, Atlanta, Georgia. May 1985.

Table 2
Spurious Trip Rate Caused by Testing

Instrument String Status[a]:			Approximate Frequency of Human Interaction:		Spurious Trip Frequency[b]
test interval	coincidence logic	inoperable channel	w/strings	w/breakers	
1 month	2/4	none	1/week	1/week	.50/Rxyr[c]
6 month	2/4	none	1 per 6 weeks	1/week	.29/Rxyr[d]
6 month	2/3	bypassed	1 per 6 weeks	1/week	.29/Rxyr[e]
6 month	1/3	tripped	1/week[f]	1/week	.50/Rxyr[e]

[a]Status of instrument strings is shown for four cases. For each case, the reactor trip modules and breakers have test interval of 1 month (staggered one channel per week) and coincidence logic of one-out-of-two-twice.

[b]Rxyr is an abbreviation for Reactor-year.

[c]From BAW-10167, derived from INPO data, and B&WOG experience.

[d]From BAW-10167, linear extrapolation of 1-month rate based on number of human interactions.

[e]Frequency inferred from above based on number of human interactions.

[f]Even though the instrument string test interval is 6 months (staggered one channel about every 6 weeks), the instrument string trip has to be reset to perform the weekly breaker/RTM test and then retripped after the test (see text).

4.2. Spurious Half-Trips

Spurious half-trips become significant during long periods of time in a 1/3 configuration, as would be the case when the AOT expires and the action statement forces a trip of the inoperable channel. Half-trips are usually benign because the usual 2/4 configuration of the instrument string channels stops the half-trip from propagating through the coincidence logic. Similarly, half-trips have a benign effect on the 2/3 configuration that results from bypass of an inoperable channel. Half-trips in the breaker portion of the RTS are usually insignificant because the breakers are arranged in a one-out-of-two-twice logic for reactor trip. Therefore, during periods of time when the inoperable RTS instrumentation channel is tripped, an increase in the spurious reactor trip rate can be expected.

The likely increase in spurious trip rate to be expected while operating in the 1/3 configuration was quantified. Operating history was used to determine the rate of spurious half-trips experienced at B&WOG plants. A survey was taken of the B&WOG utilities to identify half-trips that have occurred. The identified events were reviewed to determine if they would have caused a reactor trip if the RTS was in the 1/3 configuration.

Some utilities did not keep records of half-trips. The plants for which half-trip records are available include Crystal River-3 and Oconee-1,2,3. Attachment 2 shows the applicable events identified.

Five half-trips were recorded from 1984 through May 1989 at the four plants where half-trips were recorded. These five half-trips in about 22 reactor-years of data recording yield a half-trip frequency of 0.23 per reactor-year. All of these would have been whole-trips if another channel had already been tripped due to inoperability. Thus, a reactor trip rate increase of 0.23 per reactor-year can be expected while in the 1/3 configuration required after expiration of the 48-hour AOT.

Summing the additional spurious trip rate expected from half-trips with that expected from test-related trips yields the total spurious trip rates presented in Table 3. These rates are for the six-month instrument string test interval approved by the NRC, but with a single channel inoperable. These are the expected spurious trip frequencies while the RTS is operating in the 2/3 and 1/3 configurations. Also shown for comparison is the spurious trip rate for the four-channels-operable case, with six-month test interval, taken from BAW-10167.

Table 3
Combined Test and Half-Trip Caused Spurious Trip Rate

	2/3 configuration (channel bypassed)	1/3 configuration (channel tripped)	2/4 configuration (from BAW-10167)
spurious trips caused by test	.29/Rxyr	.50/Rxyr	.29/Rxyr
spurious trips caused by half-trips	N/A	.23/Rxyr	N/A
Total spurious trip rate:	.29/Rxyr	.73/Rxyr	.29/Rxyr

5. RISK COMPARISON

Tables 4 through 6 calculate the core melt risk contributed by unavailability and spurious trip of the RTS when one of the four instrument string channels is out of service. They compare the risk for the 1/3 configuration resulting from tripping the inoperable channel with the 2/3 configuration resulting from bypassing the inoperable channel. Also shown is the four-channels-operable case, with six-month test interval, taken from BAW-10167.

Conditional probabilities were used to calculate the core melt risk associated with RTS failure to trip and spurious trip. These conditional values came from BAW-10167, and were originally derived from the Oconee PRA as described in BAW-10167. The conditional core melt frequency given an ATWS (.2/reactor year) and the conditional core melt probability given a spurious trip (3.7×10^{-7}) were combined with the reliability and spurious trip results presented in Tables 1 and 3 to yield net risk applicable to the AOT issue.

It can be seen from Table 6 that for both the Oconee and Davis Besse type RTS designs, the net core melt risk is better for the 2/3 configuration than the 1/3 configuration. The 2/3 configuration provides a better optimum balance between RTS reliability and spurious trip avoidance than the 1/3 configuration.

Although the overall risk for all of these cases is small, forcing the inoperable channel to be tripped after 48 hours, rather than leaving it bypassed, increases the likelihood of a spurious plant trip (and thus the possibility of a "complex" transient), without a corresponding increase in reliability. Hence, for the four-channel B&W RTS design, public safety is best served when an inoperable channel may be bypassed as long as necessary rather than requiring that it be tripped after 48 hours.

Table 4
Risk due to Spurious RTS Trip

	2/3 configuration (channel bypassed)	1/3 configuration (channel tripped)	2/4 configuration (from BAW-10167)
RTS spurious trip rate (from Table 3)	.29/Rxyr	.73/Rxyr	.29/Rxyr
x Conditional core melt probability (from BAW-10167)	x 3.7×10^{-7}	x 3.7×10^{-7}	x 3.7×10^{-7}
Core melt risk from RTS spurious trip	1.07×10^{-7}/Rxyr	2.70×10^{-7}/Rxyr	1.07×10^{-7}/Rxyr

Table 5
Risk due to RTS Unavailability

Davis Besse:

	2/3 configuration (channel bypassed)	1/3 configuration (channel tripped)	2/4 configuration (from BAW-10167)
Davis Besse RTS unavailability (from Table 1)	$3x10^{-8}$/demand	$9x10^{-9}$/demand	$9x10^{-9}$/demand
x Conditional core melt frequency (from BAW-10167)	x .2/Rxyr	x .2/Rxyr	x .2/Rxyr
Core melt risk from RTS unavailability	$6x10^{-9}$/Rxyr	$1.8x10^{-9}$/Rxyr	$1.8x10^{-9}$/Rxyr

Oconee:

	2/3 configuration (channel bypassed)	1/3 configuration (channel tripped)	2/4 configuration (from BAW-10167)
Oconee RTS unavailability (from Table 1)	$1x10^{-6}$/demand	$1x10^{-6}$/demand	$1x10^{-6}$/demand
x Conditional core melt frequency (from BAW-10167)	x .2/Rxyr	x .2/Rxyr	x .2/Rxyr
Core melt risk from RTS unavailability	$2x10^{-7}$/Rxyr	$2x10^{-7}$/Rxyr	$2x10^{-7}$/Rxyr

Table 6

Net Core Melt Risk from RTS with an Inoperable Channel

Davis Besse:

	2/3 configuration (channel bypassed)	1/3 configuration (channel tripped)	2/4 configuration (from BAW-10167)
Risk from RTS unavailability (from Table 5)	$6x10^{-9}$/Rxyr	$1.8x10^{-9}$/Rxyr	$1.8x10^{-9}$/Rxyr
Risk from RTS spurious trip (from Table 4)	$1.07x10^{-7}$/Rxyr	$2.70x10^{-7}$/Rxyr	$1.07x10^{-7}$/Rxyr
Total core melt risk from RTS	$1.1x10^{-7}$/Rxyr	$2.7x10^{-7}$/Rxyr	$1.1x10^{-7}$/Rxyr

Oconee:

	2/3 configuration (channel bypassed)	1/3 configuration (channel tripped)	2/4 configuration (from BAW-10167)
Risk from RTS unavailability (from Table 5)	$2x10^{-7}$/Rxyr	$2x10^{-7}$/Rxyr	$2x10^{-7}$/Rxyr
Risk from RTS spurious trip (from Table 4)	$1.07x10^{-7}$/Rxyr	$2.70x10^{-7}$/Rxyr	$1.07x10^{-7}$/Rxyr
Total core melt risk from RTS	$3.1x10^{-7}$/Rxyr	$4.7x10^{-7}$/Rxyr	$3.1x10^{-7}$/Rxyr

6. SUMMARY AND CONCLUSIONS

6.1. Summary

The analysis shows that for the B&W four-channel RTS with an inoperable channel, a 2/3 configuration (corresponding to a bypassed inoperable channel) provides more safety than a 1/3 configuration (corresponding to a tripped inoperable channel). This is because the 2/3 configuration provides for reliability to trip on demand as well as protection against spurious trips.

Limiting the AOT to 48 hours, and forcing the RTS to a 1/3 configuration, does not meet the NRC intent for safety improvement.

Extended periods with a fourth channel in bypass do not significantly affect risk because of the high reliability of the RTS. Because of the high degree of redundancy and diversity associated with ultra-high reliability systems, common-mode-failures and not single channel failures dominate the risk. As shown in BAW-10167, and again in this re-assessment, the RTS unavailability is insensitive to single channel failures.

However, operating with a fourth channel tripped increases the potential for spurious reactor trip because the 1/3 configuration is susceptible to half-trips, and because the number of human/RTS interactions involving placing a channel in and out of trip and bypass for subsequent tests increases. Human error potential can be decreased by reducing the frequency of human interaction with the RTS equipment. This was one goal sought by the B&WOG in BAW-10167, and the Staff, in examining the RTS test intervals. Maintaining the indefinite AOT is also compatible with this goal.

6.2. Conclusions

Based on the Topical report, the INEL review, and the new information presented above, the B&WOG concludes that retaining an indefinite AOT is in the interest of plant safety. Technical specifications for several operating plants already permit one of four RTS instrument string channels to be bypassed indefinitely, if inoperable. The B&WOG continues to believe this to be appropriate and justifiable.

ATTACHMENT 1

ILLUSTRATION OF NEED: B&WOG SURVEY

On several occasions B&WOG utilities have had the need for long AOTs because of failed parts in inaccessible areas of the plant or because of difficulty in obtaining parts. As the age of the equipment increases, time needed to restore inoperable channels may continue to increase due to parts availability and QA requirements.

Below are the results of a survey taken of B&WOG utilities to determine their need for an AOT longer than 48 hours. In some cases, specific details were not readily available.

Survey Question: Has your plant experienced any failures at power (since 1980) of an RPS/ARTS channel* where repairs took longer than 48 hours either because repairs could not be made at power or another reason?

Plant	Response To Question
Crystal River-3	Data unavailable.
Three Mile Island-1	Event in 8/86 took 4-5 days.
Oconee-1,2,3	Several RTD failures that could not be repaired until refueling. There were also other failures that were not repaired within 48 hours.
Davis Besse	Data unavailable.
Arkansas Nuclear One-1	Failures in 6/80, 7/80, 11/81, and 8/85 required reactor building entry.

*In the above question, "channel" refers to only the instrument string portion, including sensors, signal conditioning, and bistables, and not the reactor trip breakers.

ATTACHMENT 2

HALF TRIPS EXPERIENCED (and recorded): B&WOG SURVEY

Survey Question: Does your plant have records that keep track of inadvertent half-trips of RPS/ARTS, i.e. single channel* trips that did not necessarily result in reactor trip? If yes, when did tracking of this information at your plant begin, and how many half-trips have occurred since then?

Plant	Response To Question
Crystal River-3	Found one half-trip since 1984. In 10/85, a single channel tripped due to signal spike.
Three Mile Island-1	Not recorded.
Oconee-1,2,3	Four half-trips since recording started in 1984. At Oconee-3 in 8/84 and 2/85. At Oconee-1 in 9/85 and 1/89. These were single channel trips caused by loose connections or power supply failures.
Davis Besse	Data unavailable.
Arkansas Nuclear One-1	Data unavailable.

*In the above questions, "channel" refers to only the instrument string portion, including sensors, signal conditioning, and bistables, and not the reactor trip breakers.