NUREG-1341

Regulatory Analysis for the Resolution of Generic Issue 115, Enhancement of the Reliability of the Westinghouse Solid State Protection System

U.S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

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Manuscript Completed: January 1989
Date Published: May 1989

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Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

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ABSTRACT

Generic Issue 115 addresses a concern related to the reliability of the Westinghouse reactor protection system for plants using the Westinghouse Solid State Protection System (SSPS). Several options for improving the reliability of the Westinghouse reactor trip function for these plants and their effect on core damage frequency (CDF) and overall risk were evaluated.

This regulatory analysis includes a quantitative assessment of the costs and benefits associated with the various options for enhancing the reliability of the Westinghouse SSPS and provides insights for consideration as industry initiatives. No new regulatory requirements are proposed.

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PREFACE

This report presents the regulatory analysis, including the decision rationale, for the resolution of Generic Issue 115. The objective of this regulatory analysis is to determine whether the options evaluated as part of this effort warrant implementation under the backfit and ATWS rules. The risk change estimates, cost-benefit analyses, and other insights gained during this effort have shown that no new regulatory requirements are warranted in accordance with the backfit rule, 10 CFR Part 50.109(a)(3). Certain insights may be considered by the NRC and licensees/applicants of the affected plants for possible industry initiatives.

Demetrios L. Basdekas

EXECUTIVE SUMMARY

This report provides supporting information, including a value-impact analysis, for the Nuclear Regulatory Commission's (NRC's) resolution of Generic Issue 115, Enhancement of the Reliability of the Westinghouse Solid State Protection System. Generic Issue 115 addresses the concern that certain parts of the reactor trip system, including the reactor trip breakers (RTBs), may be contributing to an unreliability level of the reactor trip function resulting in significant levels of risk. It was proposed that this risk might be mitigated by one or more design changes identified by the NRC staff as potential options in enhancing the reactor trip function reliability in Westinghouse (W) plants using the Solid State Protection System (SSPS).

Generic Issue 115 was identified during the anticipated transients without scram (ATWS) rulemaking decision process. The final ATWS rule (10 CFR 50.62) required a diverse scram system for Combustion Engineering (CE) and Babcock & Wilcox (B&W) plants, but not for the W plants. The ATWS rulemaking analysis did not show a favorable cost-benefit ratio for inclusion of both a diverse scram system and diverse auxiliary feedwater initiation and turbine trip actuation for W plants. Therefore, the W plants were required only to have the diverse auxiliary feedwater initiation and turbine trip actuation, known as the ATWS Mitigating Systems Actuation Circuitry (AMSAC).

As a consequence of the Salem ATWS events in 1983, Generic Letter 83-28 established the requirement for the automatic actuation of the shunt trip attachment of the RTBs for W and B&W plants (this feature was included in the original design for CE plants). Although this feature provides additional diversity and increased reliability of the reactor trip system, the reliability of the automatic actuation signal to the RTBs and the RTBs themselves still had to be considered.

The W SSPS design uses a solid state board assembly, called the undervoltage (UV) driver card, to actuate the UV trip and the shunt trip. The potential common cause failure (CCF) of the UV driver card was evaluated in the Generic Issue 115 prioritization analysis, and it was determined to be the dominant contributor to failure of the reactor trip signal to the RTBs. More recent individual failures of the W UV driver card raised the question whether there might be a higher probability of SSPS failure than that calculated during the ATWS rulemaking proceeding. A higher failure rate of the UV driver card would lead to a higher probability of CCF of both reactor trip signal trains. A higher CCF contribution, in turn, would increase the risk due to offsite consequences of an ATWS event.

This regulatory analysis is partially based on a reliability analysis performed at the Idaho National Engineering Laboratory (INEL) of the reactor trip actuation, which includes all the system and plant modifications required in accordance with existing regulations and the ATWS rulemaking requirements. These modifications consist of the automatic actuation of the shunt trip device on the RTBs and the AMSAC modifications. This configuration was taken to be the base case configuration for this analysis.

Because the reliability of the RTBs is an important element of the overall reactor trip reliability, it was also assessed as part of this effort. Relevant data from operational experience, including the Nuclear Plant Reliability Data System (NPRDS) data, were evaluated and incorporated as appropriate in the calculation of the failure rates of such major system components as the RTBs.

The analysis results show a current level of reliability comparable with previous regulatory analyses such as those in the Amendments to 10 CFR Part 50 Related to ATWS Events (SECY-83-293) and the Generic Implications of ATWS Events at the Salem Nuclear Power Plant (Generic Letter 83-28). The results also take into account the currently required regulatory modifications. Since there is little experience to date of operation of the reactor trip system with the automatic shunt trip, an estimate of the improved reliability of the system was performed by modeling the system and performing reliability calculations using the Integrated Reliability and Risk Analysis System (IRRAS) fault tree computer program. The results of this modeling show an improved reliability in line with that estimated by the ATWS Task Force, which recommended the modification.

Results of the reactor trip reliability analysis were applied to a generic W ATWS event tree model. The base case core damage frequency due to an ATWS event sequence was calculated to be 5.0E-06/Rx-year. Six options for improving the reliability of the reactor trip system were identified. The changes in core damage frequency (CDF) between each of these options and the base case system were calculated. The reductions range from 1.0E-07 to 2.1E-06 events/Rx-year. One option resulted in an increase in risk.

The changes in CDF between the base case and the options were applied uniformly to a consequence analysis and cost-benefit analysis using both point estimates and probability distribution mean estimates of risk and costs. The results of the cost-benefit analysis for the options were calculated with and without the potential for manual operator scram, which must take place within one minute from the time of receipt of a reactor trip signal to avoid core damage in worst case scenarios. The results, without taking into account averted onsite costs, are shown below:

			Cost-Benefit ($/Person-Rem Reduction)	
Option	CDF	Cost $K per Plant	Without Operator Action	With Operator Action
1	1.0E-7	50	470	7,750
2	2.0E-7	81	616	10,048
3	2.1E-6	132	843	981
4	4.0E-7	1,084	3,250	48,299
5	-9.0E-7	201	No benefit	No benefit
6	2.1E-6	243	1,120	1,772

When averted onsite costs are taken into consideration, the following results are obtained:

		Cost-Benefit ($/Person-Rem Reduction)	
Option	Net Cost $K per Plant	Without Operator Action	With Operator Action
1	49	320	7,620
2	80	464	9,890
3	112	689	833
4	1,080	3,100	48,100
5	190	No benefit	No benefit
6	223	1,063	1,626

An uncertainty analysis was performed using probability distributions for risk and costs. The results for the mean cost-benefit estimates based on these distributions are all higher when compared with the point estimates (i.e., less cost-effective) and substantially higher than the nominal screening value of $1,000/person-rem.

Based on the results of the cost-benefit analyses and the insights gained during the evaluation of the six options to enhance the reliability of the Westinghouse SSPS, as well as the relatively small risk reduction provided by the analyzed options, we conclude that no backfit requirements are warranted in accordance with the backfit rule, 10 CFR Part 50.109(a)(3).

Based on insights gained during the technical evaluation of this issue, we believe that sufficient incentives exist for subsequent initiatives by the affected licensees and applicants. Such incentives, although not regulatory requirements, would contribute toward reducing the regulatory burden on licensees, while encouraging enhanced reliability of the reactor trip function. The details of these insights are further developed in the regulatory analysis (Section 6).

REGULATORY ANALYSIS FOR THE RESOLUTION OF GENERIC ISSUE 115, ENHANCEMENT OF THE RELIABILITY OF THE WESTINGHOUSE SOLID STATE PROTECTION SYSTEM

1. STATEMENT OF PROBLEM

The ATWS rule (Ref. 1) for Westinghouse (W) plants required the implementation of a diverse ATWS Mitigating Systems Actuation Circuitry (AMSAC). The functions prescribed for AMSAC are automatic turbine trip and the initiation of auxiliary feedwater, independent of the reactor trip system.

As a consequence of the Salem ATWS events of February 1983, Generic Letter 83-28 (Ref. 2) established the requirement that the shunt trip attachment of the reactor trip breakers (RTBs) for W and Babcock and Wilcox (B&W) plants should be provided with automatic actuation in addition to the existing manual actuation (this feature was included in the original design for Combustion Engineering (CE) plants). Although this modification provides a significant increase in the reliability of the RTBs and, hence, the reactor trip system, it had not been previously pursued as an action to reduce the potential of an ATWS event during the extensive dialogue and study of the ATWS issue. Indeed, certain other options for increasing the reliability of the reactor trip system for W plants had also not received detailed consideration.

Westinghouse plants with the Solid State Protection System (SSPS) design have had recent failures of the undervoltage (UV) driver card that have raised concerns about the susceptibility of the design to common mode and random failures of redundant components. Enhancement of the reliability of the W SSPS was discussed by NRR in a 1985 request for consideration (Ref. 3).

The observed failures of the UV driver card suggest a higher probability of SSPS failure than that calculated during the ATWS rulemaking proceeding. A higher probability of SSPS failure in turn would lead to a higher probability of ATWS and, consequently, to a higher risk to the offsite population surrounding W plants equipped with the SSPS. These systems are used in 30 operating W plants and seven under construction.

Incorporation of additional diversity for the UV driver card function would reduce the probability of an ATWS event. For example, one way that the UV driver reliability could be improved is by installing a relay driver and associated relays to duplicate the function of the UV driver, thereby providing diversity for this function. A number of additional options to improve the reliability of the W SSPS trip function were considered as part of this work as discussed in Section 3 and in NUREG/CR-5197 (Ref. 4).

In an analysis performed by PNL (Ref. 5), it is assumed that the AMSAC required by the ATWS rule for W plants is in place and operational. Based on this analysis, a prioritization was performed (Ref. 6) resulting in the assignment of **high** priority to this issue. It was designated Generic Issue 115, "Enhancement of the Reliability of Westinghouse Solid State Protection System."

Having investigated five UV driver card failures, W determined that these failures were caused by poor maintenance and test-related practices. These practices involved the inadvertent shorting of the scram breaker's UV trip coil, causing a shorted failure of the output transistor in the UV driver card. To eliminate this safety problem, W modified the design of the UV card to provide a fusible link in the output circuit that will open the circuit when the UV coil is shorted. The modification will produce a UV trip signal to the respective RTB that will persist until the card is removed, repaired (by W), and replaced. Westinghouse Technical Bulletin NSID-T8-85-16 (Ref. 7), dated July 31, 1985, was issued to the W utilities, as required by the Salem ATWS Generic Letter 83-28 (Ref. 2), recommending installation of modified UV driver cards. The Westinghouse Technical Bulletin also recommends specific maintenance and test procedures to be followed to prevent failures of this type pending installation of the modified UV driver card. An informal survey of the affected plants by the NRC staff indicates that at least seven of the 37 plants have installed the new UV driver cards and modified their test procedures, or they are in the process of doing so. Most of the remaining 30 plants have adopted only the new test procedures.

2. OBJECTIVE

The objective of this regulatory analysis is to determine whether any of the six options intended to enhance the reliability of the W SSPS are warranted under existing requirements, including the backfit rule.

3. ALTERNATIVE RESOLUTIONS

There were two basic alternatives (Refs. 6 and 8) considered as a basis for resolution of Generic Issue 115.

Alternative 1

Take no action. Under this alternative there will be no new regulatory requirements. Consistent with existing regulations, this alternative does not preclude a licensee, or an applicant for an operating license, from proposing to the NRC staff design changes intended to enhance the reliability/operability of the reactor trip system and its components on a plant-specific basis, nor does it preclude W, which is the NSSS and RTB vendor, from doing so on a generic basis.

Alternative 2

Require design changes corresponding to one or more of the six options to enhance the reliability of the W SSPS that were evaluated under this effort (Ref. 4). The six options, proposed by W or the NRC staff, are described briefly below.

3.1 Option 1 – New UV Driver Card

This option entails the replacement of the UV driver card with one that was modified and recommended by W (Ref. 7). W modified the design of the UV card to provide a fusible link in the output circuit that will open the circuit when the UV coil is shorted. The modification will produce a UV trip signal to the respective RTB that will persist until the card is removed, repaired (by W), and replaced. The new UV driver card with a fuse on the 48-volt output would have prevented four of the five short-circuit failures experienced by the original UV driver card design.

3.2 Option 2 – Diverse and Redundant New Relay UV Driver

This option provides a diverse and redundant UV trip path consisting of relays arranged in parallel with the UV driver card. These relays would receive the same reactor trip inputs from the SSPS logic cards and provide driver relays for the RTB's UV trip and shunt trip devices (Refs. 6 and 8), basically duplicating the function of the UV driver card by diverse means.

3.3 Option 3 – Overcurrent/Fusible Link

This option entails the incorporation of design changes/additions to provide a diverse tripping mechanism redundant and diverse to the RTBs that would create an overcurrent condition on receipt of a reactor trip signal, causing the opening of a fusible link placed in series with the RTBs.

3.4 Option 4 – Relay Logic System

This option provides a diverse trip logic composed of a relay logic system in parallel with the SSPS reactor trip logic and respective UV driver cards. This diverse logic system would receive the same input from the analog instrumentation input relays as the SSPS logic and provide a redundant UV trip output to the RTBs.

3.5 Option 5 – Redundant Shunt Trip Coil

This option, in replacing the UV trip mechanisms on each RTB with a shunt trip mechanism, provides a redundant shunt trip configuration for each RTB (Ref. 9). The shunt trip dc power supply would be supplemented with a fail-safe capacitor circuit that would supply a dc charge to operate the shunt trip on loss of the dc power supply.

3.6 Option 6 – Contactors

Under this option, one RTB and its corresponding bypass breaker would be replaced each by a contactor (Ref. 10).

4. TECHNICAL FINDINGS SUMMARY

Probabilistic methods were used for a generic assessment of the changes in risk that would occur for each of the six options to augment the reliability of the basic design of the reactor trip system in W plants using the SSPS. The method and results of this assessment by the Idaho National Engineering Laboratory (INEL) are reported in NUREG/CR-5197 (Ref. 4). Basically, the assessment was performed by constructing a reliability model of the reactor trip system and quantifying the attendant fault trees for the reactor trip base case and its modified design reflecting each of the six options described in Section 3, using the IRRAS (Ref. 11) computer program.

The core damage frequency (CDF) calculations were performed using the generic ATWS event trees developed for W plants as part of the ATWS rulemaking regulatory analysis (Ref. 12). The event trees for W plants were developed for turbine trip initiating events and nonturbine trip initiating events. These event trees were quantified with the AMSAC modifications included (Refs. 1 and 12).

The early ATWS sequence is a very short-term sequence with potentially high consequences. The sequence starts with a transient-initiating event on the secondary side of a PWR plant. ATWS events taking place at low power levels (< 25%) have been judged to be inconsequential to the plant. Failures of additional safety systems would be required to cause core damage. The reactor system design parameters that most affect the ATWS sequence are the pressurizer to reactor coolant volume ratio and primary system pressure relief capacity. In W plants these two parameters are more favorable toward ATWS mitigation than in plants supplied by the other PWR vendors. Also, these two parameters are nearly the same in three- and four-loop W plant designs, which makes all W SSPS plants similar for ATWS analysis purposes.

Another variable affecting the ATWS pressure transient is the moderator temperature coefficient (MTC). The MTC is the measure of how reactor power (reactivity) varies with moderator (reactor coolant) temperature. If the MTC is more negative, then the fission reaction is shut down faster as the moderator temperature rises. If the MTC is less negative, then the reaction shutdown is slower as the temperature rises. The slower the reaction shutdown, the higher the pressure transient in the reactor coolant system, which gives a higher potential for core damage.

The mean ATWS core damage frequencies (CDFs) are shown in Table 1 for two cases, with and without operator action to manually scram the reactor. An uncertainty analysis using Monte Carlo simulation was performed by INEL (Ref. 4) and is discussed in Section 5.4.

Table 1. Core damage frequency results

	Core Damage Frequencies[a] (Events/Reactor Year)						
	Base Case	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**	**Option 6**
Without operator action to manually scram	9.9E-6	8.3E-6	7.9E-6	7.5E-6	4.8E-6	1.1E-5	8.1E-6
Change in core damage frequency	---	1.6E-6	2.0E-6	2.4E-6	5.1E-6	-1.1E-6	1.8E-6
With operator action to manually scram	5.0E-6	4.9E-6	4.8E-6	2.9E-6	4.6E-6	5.9E-6	2.9E-6
Change in core damage frequency	---	1.0E-7	2.0E-7	2.1E-6	4.0E-7	-9.0E-7	2.1E-6

[a] For comparison, the ATWS goal established by the NRC is 1.0E-5 events/reactor year (Ref. 12).

Without the operator action, the results show the contribution to a change in CDF due only to the automatic reactor trip function. With the operator action, the results show the contribution to change in CDF varies with both the manual operator reactor trip and automatic reactor trip functions.

Without operator action taken into account, the CDF results in Table 1 show only slight improvements. For Options 1, 2, 3, and 6, the decrease in CDF is less than 3.0E-06 events/Rx-year. For Option 4, the CDF decrease is 5.1E-06 events/Rx-year, and for Option 5, the CDF increases.

With the operator action taken into account, the improvement options are even less effective because the operator can mitigate many automatic reactor trip failures with a manual trip action. For Options 1, 2, and 4, the decrease in CDF is less than 4.0E-07. For Options 3 and 6, the CDF decrease is 2.1E-06, and for Option 5, the CDF increases.

As expected, without the operator action included, the options show a greater improvement in CDF and greater improvement in automatic reactor trip reliability.

5. CONSEQUENCES

This section assesses the cost-benefit aspects of the alternative resolutions of this issue.

In such an assessment, "costs" provide a measure of primarily economic consequences resulting from the implementation of alternative resolutions. Based on their definition, these costs may be considered positive (e.g., the incurred costs in 1988 U.S. dollars for installing, operating, and maintaining the plant modifications needed to implement a resolution, including the cost of any replacement power during a necessary downtime for the plant), or they may be considered negative (e.g., savings to the operating utility in terms of averted accident costs associated with plant repairs, cleanup, power replacement, etc.). Thus, the net cost represents the positive costs minus the present worth of the negative costs (averted onsite costs) over the remaining lifetime of the plant(s).

Conversely, the term "benefits" denotes the improvements made to public health and safety as measured in the reduction of person-rems of population exposure as well as in the reduction of offsite property damage costs associated with land interdiction and decontamination that may be necessary. In the analysis used for this study, offsite property damage was not estimated separately. Instead, a reasonably conservative allowance in the public dose estimate was used as an adequate surrogate in this case.

The number and importance of parameters contributing to the costs and benefits vary with the type of accident and the plant location (Ref. 13). In the analyses performed in this study, the site characteristics for a "typical" midwestern plant and site (Refs. 4 and 14) are used as representative of the population of U.S. PWRs affected by this issue.

5.1 Consequence Analysis

The consequence analysis obtained the person-rem dose from three sources of previous analyses shown in Table 2. This person-rem dose is based upon an average derived from the consequence analyses of the source studies. These source studies derived the person-rem doses per event based upon various consequence methodologies that include an evaluation of core damage, source term, and potential release to the environment. A mean (point estimate) value of 2.7E+06 person-rem per event was obtained from NUREG-0933 (Ref. 8). NUREG-0933 used the Oconee 3 RSSMAP (Reactor Safety Study Methodology Application Program) study to derive a person-rem dose with a generic plant site calculation. The only ATWS dominant risk sequence (T_2KMU) in this study is assumed to result in a Category 3 release with a conditional probability of 0.5, a Category 5 release with a conditional probability of 0.007, and a Category 7 release with a conditional probability of 0.5. Thus, based upon the generic site and the above release categories, which are defined in the PRA Procedures Guide (Ref. 15), a weighted average of 2.7E+06 person-rem/event was used for the consequences of ATWS events using CRAC code results of the NUREG-0933 analysis.

Two other sources of consequence data were used in the evaluation of uncertainties. The first source is WASH-1400 (Ref. 14), from which a consequence of 1.0E+07 person-rem per event was used for all core damage events. The second source is Reference 16. Two W plants, Sequoyah and Surry, were evaluated for consequence results. The results are shown in Table 2.

The 30 operating W plants using the SSPS (see Table 1) have a total of 737 reactor years of operation remaining. The calculated reduction of core damage frequency is applied in the following manner:

CDF Reduction (Events/Reactor Year)		Offsite Radiation Dose (Person-Rem/Event)		Reactor Years Remaining (30 Plants)		Total Risk Reduction (Person-Rem)
	x		x		=	

Table 2. Consequence analysis data

Source	Sequence(s)			Person-Rem per Event
Reference 14 (WASH-1400)	——			1.0E+7
Reference 8 (NUREG-0933)	——			2.7E+6
Reference 16				
Sequoyah	Transient, fail to SCRAM, HPI fails, or MTC unfavorable			8.7E+4
Surry	Transient, fail to SCRAM, HPI fails, or MTC unfavorable			8.0E+4
	Mean	5th	95th	
Consequence Distribution (Log-normal)	2.7E+6	1.0E+6	1.0E+7	

The CDF value is in terms of events per reactor year, which reflects the units in the results of the event tree analysis. The event tree initiating-event data are collected in terms of events per reactor year of operation, which reflects the utilization factor of the entire population of PWRs in the initiating-event data base.

The mean (point estimate) value results used in the consequence analysis are shown in Table 3. The uncertainty analysis results are discussed in Section 5.4. The person-rem reductions are the difference between the base case consequences and the options consequences.

5.2 Cost Analysis

The guidance given in Reference 17 was used to estimate and analyze the costs of implementing the six options. The results of the cost analysis are presented in Table 4. The definition of cost categories, cost estimate rationale, and justification for Table 4 are explained in this subsection.

In general, cost estimates are based first on figures derived from referenced sources and from cost estimating methodologies in *Generic Cost Estimates* (Ref. 18). The cost estimates are based on low, best estimate, and high values to represent the uncertainty range of each cost item. The best estimate is used as the mean (point estimate) value. In selected cases where costing information was available on specific components and attendant engineering and regulatory effort, that information was used (Ref. 19).

Table 3. Consequence analysis results

SSPS	Core Damage Frequency (Event/Reactor Year)	Offsite Dose (Person-Rem/Event)	Reactor Years Remaining (for 30 Plants)[a]	Total Risk (Person-Rem)	Total Risk Reduction (Person-Rem)
Without Operator Action					
Base Case	9.9E-06	2.7E+06	737	19,614	—
Option 1	8.3E-06	2.7E+06	737	16,425	-3,189
Option 2	7.9E-06	2.7E+06	737	15,670	-3,944
Option 3	7.5E-06	2.7E+06	737	14,914	-4,700
Option 4	4.8E-06	2.7E+06	737	9,614	-10,000
Option 5	1.1E-05	2.7E+06	737	21,473	1,869
Option 6	8.1E-06	2.7E+06	737	16,118	-3,496
With Operator Action					
Base Case	5.0E-06	2.7E+06	737	9,882	—
Option 1	4.9E-06	2.7E+06	737	9,689	-193
Option 2	4.8E-06	2.7E+06	737	9,640	-242
Option 3	2.9E-06	2.7E+06	737	5,846	-4,036
Option 4	4.6E-06	2.7E+06	737	9,209	-673
Option 5	5.9E-06	2.7E+06	737	11,685	1,803
Option 6	2.9E-06	2.7E+06	737	5,770	-4,112

[a]Based on 30-year plant life multiplied by 30 plants, equals 900 total reactor years minus 163 reactor years of cumulative operating experience of the 30 plants.

Table 4. Options cost analysis data (cost $K)

	Option 1			Option 2			Option 3			Option 4			Option 5			Option 6		
Categories	Low	Best Estimate	High	Low	Best Estimate	High	Low	Best Estimate	High	Low	Best Estimate	High	Low	Best Estimate	High	Low	Best Estimate	High
Replacement power cost	0	0	94	0	0	187	0	0	187	0	0	934	0	0	187	0	0	187
Factory hardware	21	28	35	3	8	13	8	16	32	—	—	—	47	95	145	42	84	126
Utility engineering and QA	3	5	7	3	4.5	6	20	40	60	750	1,000	1,250	20	30	40	30	60	90
Installation	0	0.2	0.5	1.5	2.5	3.5	8	10	12	—	—	—	3	5	7	13	15	17
Training	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance procedures	0.8	0.9	1.1	0.8	0.9	1.1	0.8	0.9	1.1	2.7	3.6	4.5	2.7	3.6	4.5	2.7	3.6	4.5
Operating procedures	0.8	0.9	1.1	0.8	0.9	1.1	0.8	0.9	1.1	3.1	3.6	4.1	3.1	3.6	4.1	3.1	3.6	4.1
Record keeping and reporting	3	5	7	5	7	9	5	7	9	10	20	25	5	7	9	10	20	25
Utility licensing	3	5	10	16	32	42	16	32	42	16	32	42	16	32	42	16	32	42
NRC review	3	5	10	13	25	35	13	25	35	13	25	35	13	25	35	13	25	35
Totals (per plant)	35	50	166	43	81	298	72	132	379	795	1,084	2,296	110	201	475	130	243	531
Industry Total (30 plants)	1,050	1,500	4,980	1,290	2,430	8,940	2,160	3,960	11,370	23,850	32,520	68,880	3,300	6,030	14,250	3,900	7,290	15,930

5.2.1 Replacement Power Cost

The replacement power cost category includes any cost related to plant downtime owing to the required plant modifications. This downtime is a result of installing the modification or is a result of inadvertent plant shutdowns caused by the modification after installation. This analysis assumed all options could be installed during plant refueling shutdowns. The only contributor to replacement power costs is inadvertent shutdowns due to the modification installed. Options 1, 2, 3, 5, and 6 require insignificant equipment additions. Option 4 requires a relatively large amount of key equipment for a diverse logic and actuation system and has a greater potential for inadvertent trips. However, Option 4 can be properly engineered, installed, and maintained, such that it should not cause an appreciable increase in inadvertent trips. Therefore, the best estimate increase in advertent shutdowns is negligible, if any.

Even though the best estimate increase in inadvertent trips is basically zero for all options, there is some change in the probability of inadvertent trips, and it is accounted for in the high-estimate numbers of the distribution used in the uncertainty analysis presented in Section 5.4. Each reactor trip is assumed to cause a half day outage or to cost $250,000 per trip. The statistical data for the number of trips per reactor year of operation were obtained from Reference 20. The high-estimate incremental increases in the number of inadvertent trips over the remaining lifetime of the population of plants are 0.37, 0.75, 0.75, 3.73, 0.75, and 0.75 events for Options 1 through 6, respectively.

The number of events for each option multiplied by $250,000 per event is equal to the cost attributed to these events and is used as the high-cost estimate for inadvertent trip downtime.

5.2.2 Hardware Costs

This category includes the cost of all required hardware for the modifications for each option. The cost of two replacement and two spare (four total) UV driver cards and technical support was determined to be $28,000. This figure was used as the best estimate, with the cost of three cards ($21,000) for a low estimate, and a 20 percent increase in cost as the high estimate.

For Option 2, the factory hardware for relays and other hardware is estimated to be $3,000 (Ref. 8). An estimate for a qualified enclosure in addition to the relays and other hardware adds another $5,000. Therefore, $8,000 is used as the best estimate, $3,000 as a low estimate, and an additional $5,000 for the high estimate of $13,000.

A cost estimate for Option 3 was calculated and provided in Reference 19. The best estimate for factory hardware for Option 3 was $16,000. The low estimate was based on half ($8,000), and the high estimate was based on double ($32,000).

A cost estimate for Option 4 was taken from the ATWS rulemaking analysis (Ref. 12). The cost of a diverse reactor trip system for W plants was estimated at $1 million. This includes hardware, utility engineering, and installation. Therefore, the $1 million cost total is applied to cost Categories 2, 3, and 4 for Option 4.

In assessing the cost of Option 5, the required modifications of four RTBs and two spares (six total) were estimated at $10,000 each. In addition to the RTB modifications, some relays, two capacitor circuits, and miscellaneous equipment would be required at an estimated cost of $35,000. The total for this option's hardware is $95,000 as the best estimate, with half ($47,000) as the low estimate, and one and a half ($145,000) as the high estimate.

5.2.3 Utility Engineering and Quality Assurance Costs

The cost of utility engineering and quality assurance is based on an engineering hourly cost of $100/hour (Ref. 18). The hours for each option are 50, 45, 400, 300, and 600 for Options 1, 2, 3, 5, and 6, respectively (these costs for Option 4 are included in Section 5.2.2). The estimate for Option 3 was provided in Reference 19, and the other estimates were made taking into account the complexity of Option 3. The low and high estimates were based on a difference from the best estimate of $2,000, $1,500, $20,000, $10,000, and 30,000, respectively, for each of the other options.

5.2.4 Installation Costs

Installation costs are assessed at a labor rate of $25/hour (Ref. 18). Hours estimated for installation of each of the options are 8, 100, 400, and 200, respectively, for Options 1, 2, 3, and 5 (these costs for Option 4 are included in Section 5.2.2). The best estimate costs are $200, $2,500, $10,000, and $5,000. The low cost for Option 1 is zero with a high cost of $500. For Option 2, the low and high estimates were a $1,000 difference from the best estimate. For Options 3 and 5, the low and high estimates were a $2,000 difference from the best estimate.

5.2.5 Training Costs

After careful consideration of the nature of modifications involved in all six options, it was concluded that, because of the similarity and/or simplicity of the equipment, maintenance, and testing practices, no training would be required.

5.2.6 Maintenance Procedures and Operating Procedures Development Costs

Procedures will have to be written for all option modifications. Estimates for procedure changes for two categories, routine and complex, are provided in Reference 18. The estimates are given as best, low, and high estimates for each of the categories. Options 1, 2, and 3 would require routine procedure changes, while Options 4, 5, and 6 would require complex procedure changes.

5.2.7 Recordkeeping and Reporting Costs

The initial cost for evaluating changes in recordkeeping and reporting requirements is approximately $40,000 for a complex change and ranges downward from $40,000 for changes of less complexity (Ref. 18). After the initial cost, it is assumed that the continuing cost is negligible, and the additional reporting and recordkeeping can be accomplished by the current staffing. The best estimates for these costs are based on the complexity of the option. Option 1 is considered to be the least complex, with Options 2, 3, and 5 more complex, and Options 4 and 6 the most complex. The low and high estimates were taken as a $2,000 difference from the best estimates for Options 1, 2, 3, and 5, and a $10,000 and $5,000 difference for the low and high of Options 4 and 6.

5.2.8 Utility Licensing Costs

The utility licensing costs are based on Reference 21, a cost analysis for Generic Issue 125.II.7, which showed a utility licensing cost of $32,000 per plant for a complex modification. Options 2, 3, 4, 5, and 6 are assumed to be complex changes with $32,000 as the best estimate. The low and high estimates are based on a difference of $16,000 and $10,000. Option 1 is of lesser complexity, so a lower estimate ($5,000) and high and low differentials are applied.

5.2.9 NRC Review Costs

The NRC review cost estimate is taken from Reference 8. The best estimate given in this analysis is approximately $25,000. The low was estimated at $13,000 and the high at $35,000. Option 1 used a lower estimate, based on lesser complexity, which is the same as the utility licensing costs for Option 1.

5.2.10 Averted Onsite Costs

In addition to the cost associated with the modifications, averted onsite costs can have a significant effect on the overall cost-benefit ratio depending on the expected reduction in CDF. They include cleanup, repair, and replacement power costs. These costs may be estimated by multiplying the change in accident frequency by the discounted onsite damage costs. Based on the guidance of Reference 22, an estimate of these costs on a per plant basis was made for each option using the following equation:

$$V_{op} = N\,\Delta F U$$

where

V_{op} = value of onsite averted costs

N = number of affected facilities

ΔF = reduction in accident frequency

U = present value of onsite property damage

Estimated values for U, present value of onsite property damage, are as follows:

Best estimate	\$1.0E+10/severe accident event
High estimate	\$3.0E+10/severe accident event
Low estimate	\$7.0E+9/severe accident event

These values are multiplied with the expected change in CDF for each option shown in Table 1. The results of the analysis for a 10 percent discount rate are shown in Table 5. If a 5 percent discount rate is assumed, the averted onsite costs would be twice as high.

Table 5. Averted onsite costs ($)

	Without Operator Action			With Operator Action		
	Low	Best	High	Low	Best	High
Option 1	11,200	16,000	48,000	679	970	2,900
Option 2	14,000	20,000	60,000	840	1,200	3,600
Option 3	16,800	24,000	72,000	14,000	20,000	60,000
Option 4	35,000	50,000	150,000	2,380	3,400	10,200
Option 5	6,510	9,300	27,900	6,370	9,100	27,300
Option 6	12,600	18,000	54,000	14,000	29,000	60,000

5.3 Cost-Benefit Summary

The cost-benefit analysis was performed in accordance with the following equation:

Option Cost (30 Plants)	÷	Person-Rem Reduction (30 Plants)	=	Cost/Benefit ($/Person-Rem)

The mean (point estimate) value results of the cost-benefit analysis are shown in Table 6. The results in Table 6 summarize only the costs listed in Table 4. The costs associated with averted onsite costs (Subsection 5.2.10) are not included in the cost-benefit results of Table 6. The impacts of the averted onsite costs were evaluated separately.

The averted onsite costs of Subsection 5.2.10 are subtracted from the costs listed in Tables 4 and 6 resulting in the net cost of performing the modifications. The cost-benefit impacts of subtracting the onsite averted costs from each option are shown in Table 7.

5.4 Cost-Benefit Uncertainties

The uncertainty of the data has two effects on the cost-benefit results. The first effect is on the value of the risk reduction; the second effect is on the value of the cost. Hence, the uncertainties associated with the cost data and risk reduction data determine the uncertainties of the cost-benefit values.

Uncertainty data were gathered, evaluated, and reported in the form of distributions for all data used in this analysis. This data-gathering and reduction is used to gauge the effects of the individual data uncertainty on the final cost-benefit modeling results of the analysis. There is also uncertainty associated with the modeling in the analysis. It is assumed that the model and modeling assumptions adequately represent the W reactor trip system and generic W ATWS sequence for the quantifications and comparisons used in this analysis. This uncertainty evaluation addresses the uncertainty associated with the data used in the analysis.

The basic approach to the evaluation of the cost-benefit uncertainties uses a Monte Carlo sampling program called @RISK (Ref. 23). The simulation program was used to evaluate the uncertainty of the cost-benefit, represented by cost distributions and risk reduction distributions. The cost distributions are represented by a triangular distribution with the low and high cost estimates forming the base of the triangle and the best cost estimate forming the peak of the triangle. The triangular distribution is used in cost applications where only three points, low-, best-, and high-cost estimates, are known (Ref. 23).

The equations used in the uncertainty quantification are as follows:

$$\text{Cost/Benefit} = \text{Cost/delta R}$$

$$\text{delta R} = R_{bc} - R_i$$

Where

delta R = Change in Risk or Risk Reduction

R_{bc} = Base Case Risk

R_i = Option i Risk

The risk (R), base case or option, is defined as follows:

R = Core Damage Frequency x Consequences

Risk reduction is defined as the change in risk from a base case model and the option models. The risk reduction uncertainty has two contributions that have two different effects on the risk reduction uncertainty. These two effects

Table 6. Cost-benefit summary without averted onsite costs ($/person-rem reduction)

	Cost $K[a] (30 Plants)	Person-Rem Reduction Without Operator Scram (30 Plants)	Cost-Benefit ($/Person-Rem)	Person-Rem Reduction With Operator Scram (30 Plants)	Cost-Benefit ($/Person-Rem)
Option 1	1,500	3,189	470	193	7,750
Option 2	2,430	3,944	616	242	10,048
Option 3	3,960	4,700	843	4,036	981
Option 4	32,500	10,000	3,250	673	48,299
Option 5	6,030	-1,869	—[b]	-1,803	—[b]
Option 6	7,290	6,504	1,120	4,112	1,77

[a]Using costs from Table 4.
[b]No benefit; see text.

Table 7. Cost-benefit including averted onsite costs ($/person-rem reduction)[a]

	Cost $K[b] (30 Plants)	Person-Rem Reduction Without Operator Scram (30 Plants)	Cost-Benefit ($/Person-Rem)	Cost $K[b] (30 Plants)	Person-Rem Reduction With Operator Scram (30 Plants)	Cost-Benefit ($/Person-Rem)
Option 1	1,020	3,189	320	1,470	193	7,616
Option 2	1,830	3,944	464	2,394	242	9,893
Option 3	3,240	4,700	689	3,360	4,036	833
Option 4	31,000	10,000	3,100	32,398	673	48,140
Option 5	5,751	-1,869	—[c]	5,757	-1,803	—[c]
Option 6	6,750	6,504	1,038	6,690	4,112	1,626

a. The result of subtracting the averted onsite costs changes the cost-benefit results, but it does not change their position relative to the $1,000/person-rem nominal cost-benefit screening value.

b. Using cost from Tables 4 and 5.

c. No benefit; see text.

come from (1) those risk contributors that remain the same from the base case to the options and (2) those risk contributors that change from the base case to the options. Those risk contributors that do not change from base case to the options only affect the uncertainty in the absolute value of the total risk due to an ATWS event. The risk contributors that change from base case to the options affect the uncertainty of the risk reduction (fraction of total risk reduced) from the base case. Therefore, the two uncertainties in the risk analysis are those that affect the absolute value (total) risk associated with the ATWS sequence and those that affect the relative risk (risk reduction) from base case to options.

In all cases (base and options), the same model is used with the only difference being the elimination or addition of some cutsets of the reactor trip reliability failure frequency.

The uncertainty in the base case risk analysis is analyzed to assess the uncertainty bounds on the total risk due to the ATWS sequences. The event sequences and consequence analysis distributions for the base case are run using Monte Carlo sampling to arrive at the results in Table 8. The distribution graphs (density and cumulative distributions) are shown in Appendix C of Reference 4.

The risk reduction from the base case to the options is calculated by subtracting the option risk from the base case risk. Therefore, the uncertainty in risk reduction is determined by contributors to reactor trip reliability in risk changes from the base case to the options, with all other contributors remaining constant. The cost-benefit uncertainty is evaluated with Monte Carlo sampling using the cost distributions and the risk reduction distribution (represented by those cutsets that changed in each option with all other risk model contributors represented by constants). The results of the cost-benefit uncertainty analysis are shown in Table 9.

The results of the cost-benefit uncertainty analysis show that none of the means of the cost-benefit distributions are below the $1,000 per person-rem guideline. However, without operator action, Option 1, for example, has a 26 percent probability of being at $1,000/person-rem or less. A comparison of the uncertainty ranges associated with each option's cost-benefit result is shown in Figure 1. The uncertainty distribution results reflect the uncertainty in the data used to quantify the cost-benefit ratios. The uncertainty in the cost distributions and the consequence distributions tends to drive the mean values of the cost-benefit uncertainty distributions to values higher than the point estimate results. To understand why this occurs, the underlying cost and consequence distributions must be examined.

The cost distribution is asymmetric with a high probability density on the low cost side and a tail stretched out to the high cost estimate. The consequences distribution is also asymmetric with a high probability density on the low consequences side with some probability toward high consequences. Both of these uncertainty distributions (cost and consequences) cause the Monte Carlo random simulation to yield cost-benefit uncertainty mean values higher than the point estimate values.

The uncertainties associated with the risks and costs of this cost-benefit analysis are large. Therefore, the point estimate results have a wide uncertainty associated with them; hence, they have a potentially large error factor. A comparison between the point estimate cost-benefit results and the uncertainty cost-benefit results is shown in

Table 8. Base case risk uncertainty results (person-rem)

	Mean	5th	50th	95th
Without Operator Action	28,567	1,100	10,900	108,600
With Operator Action	16,831	600	5,700	59,100

Table 9. Cost-benefit uncertainty results

	Cost/Benefit ($/Person-Rem Reduction)					
	Distribution Parameters					
Option	Mean	5th	50th	95th	% Probability from $0 to $1,000	% Probability More than $1,000
Without Operator Action						
1	6,750	201	2,280	26,200	26	74
2	10,020	278	3,320	38,300	20	80
3	22,100	600	6,010	85,600	8	92
4	42,200	1,300	14,300	167,000	4	96
5	No positive benefit					
6	131,000	7,100	70,900	505,000	0	100
With Operator Action						
1	146,000	4,430	44,000	579,000	0	100
2	159,000	4,600	50,600	649,000	0	100
3	78,000	3,400	33,900	301,000	1	99
4	526,000	17,300	171,000	2,030,000	0	100
5	No positive benefit					
6	127,000	4,100	41,400	467,000	0	100

Table 10. The uncertainty distribution mean values are higher than the point estimate mean values.

For comparison purposes, the cost-benefit uncertainty results of Options 6 and 3 were evaluated to assess which option would be more favorable. The cost-benefit uncertainty of Option 3 was subtracted from the cost-benefit uncertainty of Option 6. The resulting uncertainty distribution would be on both sides of zero, both negative and positive. If the result was more positive than negative, then the cost benefit of Option 3 would be less than that of Option 6 making Option 3 more favorable or vice versa for Option 6. As shown in Table 11, with credit for operator action, neither option is more favorable than the other.

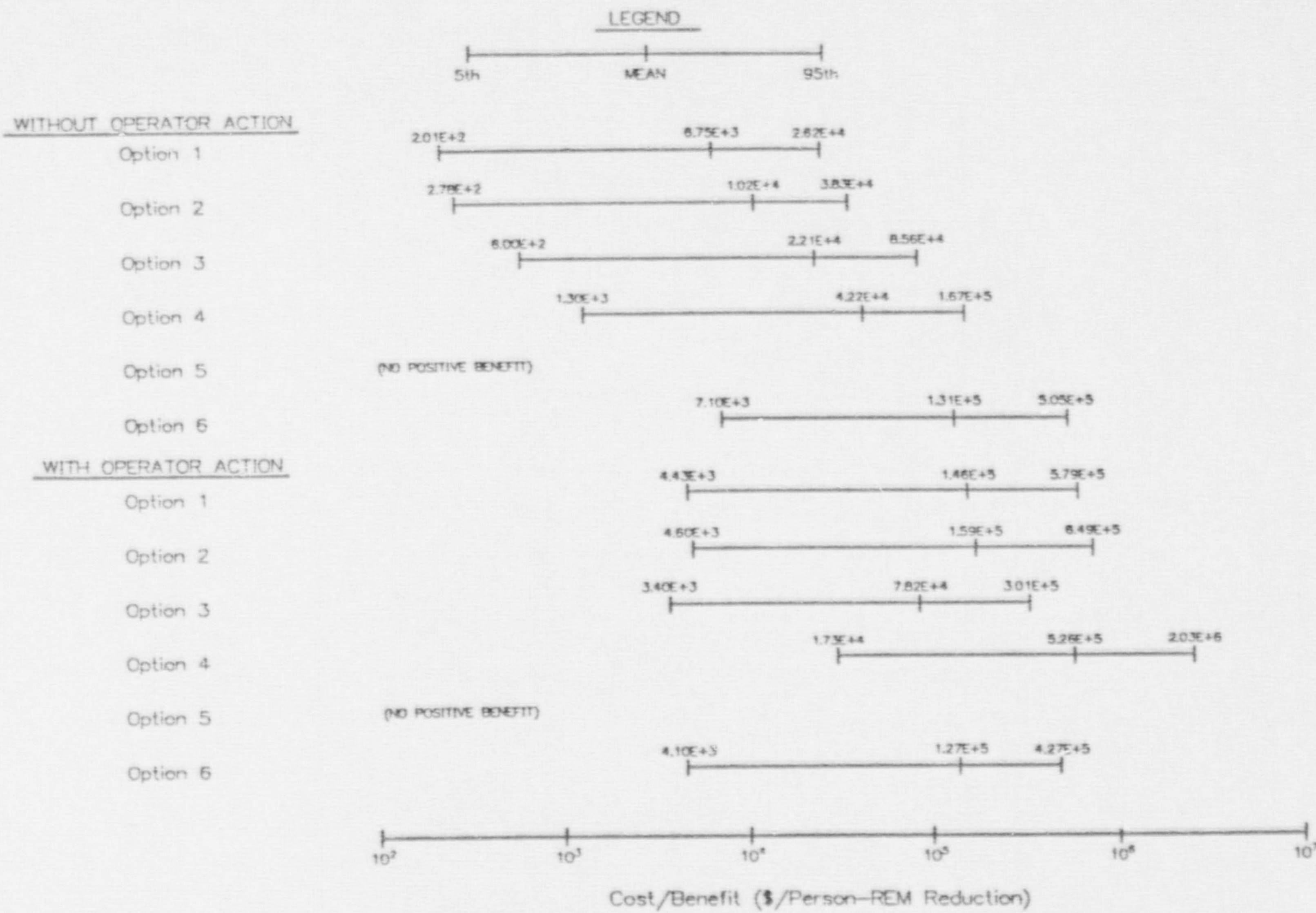

Figure 1. Cost-benefit uncertainty distributions.

Table 10. Point estimate/uncertainty results comparison

Option	Cost/Benefit ($/person-rem reduction) Point Estimate Mean	Distribution Mean
Without Operator Action		
1	320	6,750
2	464	10,200
3	689	22,100
4	3,100	42,200
5	No benefit	No benefit
6	1,038	131,000
With Operator Action		
1	7,616	146,000
2	9,893	159,000
3	883	78,200
4	48,140	526,000
5	No benefit	No benefit
6	1,626	127,000

Table 11. Option 6 versus Option 3 cost-benefit uncertainty comparison

	Cost-Benefit ($/person-rem)					
	Mean	5th	50th	95th	Percent <0	Percent >0
Without Operator Action	99,300	-37,900	10,200	367,000	42	58
With Operator Action	46,200	-36,000	-718	184,000	50	50

6. DECISION RATIONALE

This generic issue was identified as a consequence of the 1983 Salem ATWS events and Generic Letter 83-28 (Ref. 2) to evaluate certain options for increasing the reliability of the reactor trip function in W plants. As part of this evaluation, the operational experience with two key components of the W SSPS received particular attention: the UV driver cards and the RTBs. Six options to enhance the reliability of the reactor trip function were evaluated and are described in Section 3 of this report and in Reference 4. In the interest of completeness, a brief description is also given in the discussion below where the bases and rationale for their respective dispositions are presented. With the exception of one option, which would result in an increase in risk if implemented, all other options would provide a reduction in risk corresponding to a range of reduction in CDF by 1.0E-7 to 2.1E-6 events/Rx-year and a cost-benefit ratio generally higher than the $1,000/person-rem nominal screening value for backfit considerations. A particular area of concern that was examined as part of this issue was the reliability of the RTBs. The RTBs used in W plants are W-supplied breakers of the DS-416 and DB-50 series, appropriately modified for use in the reactor protection system. There has been no appreciable change in the failure rates of these breakers since the ATWS rulemaking analysis (Ref. 1). This matter is under active consideration by NRC as part of the requirements of Items 4.2.3 and 4.2.4 of Generic Letter 83-28 (Ref. 2) and is the subject of an ongoing evaluation of a proposed action regarding RTB life testing and refurbishment or replacement. It is also under evaluation as part of a larger research program on the aging assessment of W DS-Series circuit breakers used in all plant systems and not only the reactor protection system.

Based on the relatively small predicted risk reduction from the evaluated options and the results of the cost-benefit analysis (see Table 10), no backfit requirements are justified in accordance with the backfit rule, 10 CFR Part 50.109(a)(3).

In the course of evaluating this generic issue, and the six options in particular, we have gained certain insights that could be useful in improving the reliability and performance of the reactor protection system. These insights may be the subject of consideration by industry for possible voluntary changes in design and procedures, including technical specifications. If properly implemented, they could improve, or at least maintain an acceptable level of, the reliability of the reactor protection system, reduce the regulatory burden on the licensees, and extend the life of the RTBs. These insights are presented at the end of this section following the discussion of each of the six options. These discussions include certain deterministic considerations germane to the disposition of each option.

6.1 Option 1 – New UV Driver Card

This option entails the replacement of the UV driver card with one that was modified and recommended by W (Ref. 7). The new UV driver card has a fuse on the 48-volt output and would have prevented four of the five short-circuit failures experienced by the original UV driver card design.

Even though the criteria for backfit requirements are not met on the basis of the PRA results, we believe that the relatively low cost, the simplicity, and the effectiveness of this design change in eliminating the most troublesome failure modes of the UV driver cards make this W-recommended option worthy of serious consideration by W plant owners. A survey of the 30 W plants with the SSPS design indicates that several plants have already replaced or are in the process of replacing the old UV driver cards with the new design cards along with the W-recommended changes in test procedures (Ref. 7). We endorse the W recommendations contained in Reference 7. However, based on the results of our analyses, we conclude that this option cannot be made a regulatory requirement because of the associated small safety improvement (a CDF reduction of 1.0E–07/Rx-year) and an unfavorable minimum cost-benefit ratio of $7,600/person-rem.

6.2 Option 2 – Diverse and Redundant New Relay UV Driver

This option provides a diverse and redundant UV trip path consisting of relays arranged in parallel with the UV driver card. These relays would receive the same reactor trip inputs from the SSPS logic cards and provide driver relays for the RTBs' UV trip and shunt trip devices (Refs. 6 and 8), basically duplicating the function of the UV driver card by diverse means.

As pointed out earlier, the safety improvement that may result from implementing this option is very small (a CDF reduction of 2.0E–07/Rx-year) with an unfavorable minimum cost-benefit ratio of $9,900/person-rem. Furthermore, if the recommendations under Option 1 are implemented, as some W licensees are now doing, the need for a diverse and redundant UV trip path would further diminish. Hence, we conclude that this option should not be made a regulatory requirement.

6.3 Option 3 – Overcurrent/Fusible Link

This option entails the incorporation of design changes/additions to provide a diverse tripping mechanism redundant and diverse to the RTBs that would create an overcurrent condition on receipt of a reactor trip signal, causing the opening of a fusible link placed in series with the RTBs (Ref. 24)..

The risk reduction and cost-benefit quantification for this option show that this option rated relatively better than most of the other options evaluated, but it would still result in a relatively small improvement in safety (a CDF reduction of 2.1E–06/Rx-year) with an unfavorable cost-benefit ratio estimated to be closer to the distribution mean value of $78,000/person-rem than the point estimate of $833/person-rem.

The addition of a fusible link in series with the RTBs and the introduction of more components with poorly known reliabilities and associated costs would likely result in a smaller safety benefit, and costs larger than those estimated in Reference 19. An alternative approach based on using the existing component may be far more cost- and safety-effective as discussed later under recommendations. We conclude that this option should not be made a regulatory requirement.

6.4 Option 4 – Relay Logic System

This option provides a diverse trip logic composed of a relay logic system in parallel with the SSPS reactor trip logic and respective UV driver cards. This diverse logic system would receive the same input from the analog instrumentation input relays as the SSPS logic and provide a redundant UV trip output to the RTBs.

The evaluation of this option confirms the ATWS rule provision exempting W plants from the requirement to provide a separate and independent reactor trip system such as that of this option. The results of the risk and cost-benefit analyses (a CDF reduction of 4.9E-07 with a cost-benefit ratio of at $48,140/person-rem) show that no backfit based on this option is warranted. Hence, we conclude that this option should not be made a regulatory requirement.

6.5 Option 5 - Redundant Shunt Trip Coil

This option provides a redundant shunt trip configuration for each RTB by replacing the UV trip mechanisms on each RTB with a shunt trip mechanism (Ref. 9). The shunt trip dc power supply would be supplemented with a fail-safe capacitor circuit that would supply a dc charge to operate the shunt trip on loss of the dc power supply.

The evaluation of this option indicated that its implementation would result in an increase in risk. This is due, in part, to the fact that the replacement of the UV trip coil mechanism with a shunt trip type of mechanism would remove the element of diversity between the UV and shunt trip coil mechanisms used in the present design of the RTBs. Hence, we conclude that this option should not be made a regulatory requirement.

6.6 Option 6 - Contactors

Under this option, one RTB and its corresponding bypass breaker would be replaced each by a contactor (Ref. 10).

The risk reduction and cost-benefit quantification for this option show that this option rated relatively better than most of the other options evaluated, but it would still result in a relatively small improvement in safety (a CDF reduction of 2.1E-06/Rx-year with a cost-benefit ratio estimated to be closer to the distribution mean value of $127,000/person-rem than the point estimate of $1,626/person-rem). The replacement of one RTB and one bypass trip breaker in the present design would introduce components of a different physical configuration with the distinct possibility of introducing an unquantified reduction in safety improvement associated with the physical and functional integrity of their interface with the existing system components and configuration. We conclude that this option should not be made a regulatory requirement.

As discussed under Option 3, an alternative approach based on using existing components may be far more cost- and safety-effective. This alternative approach is discussed below under conclusions and recommendations.

Conclusions and Insights for Further Work

On the basis of the technical findings of the risk and cost-benefit analyses performed, and the discussion of each option presented in the preceding paragraphs, we conclude that no backfit requirements are warranted in accordance with the backfit rule, 10 CFR Part 50.109(a)(3). However, based on insights gained during the technical evaluation of this issue in general, and the six options in particular, the following insights should be considered:

- Decreasing the RTB test frequency in conjunction with the addition of an automatic trip function of the contactors supplying the field current to the motor-generator (M/G) sets, and/or the M/G sets output breakers. These changes if implemented, would contribute toward (1) reducing the regulatory burden on the affected licensees and applicants, and (2) extending the life of the RTBs, as well as providing a diverse and redundant interruption of power to the control rods, thus improving, or at least maintaining, the reliability of the reactor trip function.

  A recommendation to study whether the RTB testing frequency can be decreased has been made by NRR in its assessment of the feasibility of reducing technical specifications surveillance requirements (Ref. 25).

- The licensees proposing to adopt an approach such as the above should be allowed to do so assuming that the recommendations contained in W Technical Bulletin NSID-TB-85-16 (Ref. 7) have been implemented. These recommendations, developed in accordance with the requirements of 10 CFR Part 21, have already been implemented in several W plants.

- Incorporation of the above insights in the design of the advanced LWR (ALWR) plant proposed by EPRI. Incorporation of these design features at this early stage of the ALWR design would be more efficiently implemented than in a backfit setting.

7. IMPLEMENTATION

No action imposing new regulatory requirements is necessary for resolution of this issue. A distribution of Reference 4 and the regulatory analysis NUREG report is made to include all W licensees. The insights contained in Section 6 could form the basis of industry initiatives and subsequent discussions between NRC and the affected licensees and applicants.

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NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)

NUREG-1341

2. TITLE AND SUBTITLE

Regulatory Analysis for the Resolution of Generic Issue 115, Enhancement of the Reliability of the Westinghouse Solid State Protection System

3. DATE REPORT PUBLISHED

MONTH	YEAR
May	1989

4. FIN OR GRANT NUMBER

5. AUTHOR(S)

Demetrios L. Basdekas

6. TYPE OF REPORT

Technical

7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION — NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Division of Safety Issue Resolution
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

9. SPONSORING ORGANIZATION — NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Division of Safety Issue Resolution
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

Generic Issue 115 addresses a concern related to the reliability of the Westinghouse reactor protection system for plants using the Westinghouse Solid State Protection System (SSPS). Several options for improving the reliability of the Westinghouse reactor trip function for these plants and their effect on core damage frequency (CDF) and overall risk were evaluated.

This regulatory analysis includes a quantitative assessment of the costs and benefits associated with the various options for enhancing the reliability of the Westinghouse SSPS and provides recommendations for consideration as industry initiatives. No new regulatory requirements are proposed.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

Reactor Protection System, Reactor Trip Breakers, Undervoltage Driver Card, Anticipated Transients Without Scram

13. AVAILABILITY STATEMENT

Unlimited

14. SECURITY CLASSIFICATION

(This Page)

Unclassified

(This Report)

Unclassified

15. NUMBER OF PAGES

16. PRICE

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

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

SPECIAL FOURTH-CLASS RATE
POSTAGE & FEES PAID
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PERMIT No. G-67

120555139531 1 1AN1AI1RG1RS1
US NRC-OADM
DIV FOIA & PUBLICATIONS SVCS
TPS PDR-NUREG
P-209
WASHINGTON DC 20555

NUREG-1341

REGULATORY ANALYSIS FOR THE RESOLUTION OF GENERIC ISSUE 115, ENHANCEMENT OF THE RELIABILITY OF THE WESTINGHOUSE SOLID STATE PROTECTION SYSTEM

MAY 1989