NUREG-1332

Regulatory Analysis for the Resolution of Generic Issue 125.II.7, "Reevaluate Provision to Automatically Isolate Feedwater From Steam Generator During a Line Break"

U.S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

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ABSTRACT

Generic Issue 125.II.7 addresses the concern related to the automatic isolation of auxiliary feedwater (AFW) to a steam generator with a broken steam or feedwater line.

This regulatory analysis provides a quantitative assessment of the costs and benefits associated with the removal of the AFW automatic isolation and concludes that no new regulatory requirements are warranted.

TABLE OF CONTENTS

Page

LIST OF TABLES

PREFACE

This report presents the regulatory analysis, including the decision rationale, for the resolution of Generic Issue 125.II.7. The objective of this regulatory analysis is to determine whether the removal of the auxiliary feedwater (AFW) automatic isolation feature, as proposed as a result of the review of the Davis-Besse event of June 1985, is warranted. As part of this effort, four plant designs were evaluated. The risk change estimates, cost-benefit analyses, and other insights gained during this effort have shown that no new regulatory requirements are warranted in relation to this generic issue.

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EXECUTIVE SUMMARY

The report provides supporting information, including a cost-benefit analysis for the Nuclear Regulatory Commission's (NRC) resolution of Generic Issue 125.II.7, "Reevaluate Provision to Automatically Isolate Feedwater from Steam Generator During a Line Break." This issue addresses the concern related to the automatic isolation of AFW to a steam generator with a broken steam or feedwater line. Following the Davis-Besse event in June 1985, the benefits of this automatic isolation design feature system versus its disadvantages were questioned. The purpose of this generic issue is to reevaluate this design feature and to determine whether its disadvantages may outweigh its benefits. The benefits of automatic AFW isolation in the event of a steam or feedwater line break include:

1. The steam generator inventory blowdown is minimized. While isolating AFW does not prevent the initial secondary side inventory blowdown, it does prevent continued blowdown after the initial inventory is expended, and thus minimizes the use of condensate supplies.

2. Excessive primary system cooldown is minimized, thus reducing the likelihood of recriticality and pressurized thermal shock.

3. Excessive containment pressure for a steam line break inside containment is minimized by discontinuing feedwater addition.

The disadvantages of automatic AFW isolation are related to a concern that the automatic isolation system may reduce the reliability of the AFW function. Failures that cause inadvertent AFW isolation could cause loss of all AFW system flow during accidents or transients. Additionally, during a controlled cooldown after an accident, the thresholds for automatic AFW isolation (such as low steam generator pressure, or high steam generator to steam generator pressure differential) may be crossed, which would require that the operator lock out the isolation logic as the steam generator parameters approach the isolation setpoint. Failure to do so would defeat the AFW function until the operator intervenes.

There were four plant designs evaluated under this effort. The results of the quantitative estimates of risk changes in these four plant designs show that removal of the AFW automatic isolation feature would result in a small risk increase in two plant designs, while it would result in a small risk reduction in the other two. For the two latter cases the core damage frequency (CDF) reduction would be in the order of 10^{-7}/Rx-year and the risk reduction would be about 40 person-rem per plant. The cost-benefit ratios for making necessary modifications range from \$8,000/person-rem to \$17,000/person-rem depending on whether the 27 plants affected by this issue already have flow restrictors in the AFW pump discharge lines.

Based on the results of the cost-benefit analyses, and the insights gained during assessment of the pros and cons of removing the automatic isolation design feature of the AFW system, we conclude that no backfit requirement to remove this design feature from PWRs is warranted in accordance with the Backfit Rule, 10 CFR Part 50.109(a)(3).

REGULATORY ANALYSIS FOR THE RESOLUTION
OF GENERIC ISSUE 125.II.7,
REEVALUATE PROVISION TO AUTOMATICALLY ISOLATE
FEEDWATER FROM STEAM GENERATOR DURING A LINE BREAK

1. STATEMENT OF PROBLEM

The NRC requirements for the auxiliary feedwater (AFW) system related to this issue, as stated in the Standard Review Plan (SRP) (Ref. 1) provide that "the system design possesses the capability to automatically terminate auxiliary feedwater flow to a depressurized steam generator, and to automatically provide feedwater to the intact steam generator. Or, as an alternative, if it is shown that the intact steam generator will receive the minimum required flow without isolation of the depressurized steam generator and containment design pressure is not exceeded, then operator action may be relied upon to isolate the depressurized steam generator." Based on these requirements, 27 PWRs have an AFW automatic isolation design feature to assist in mitigating a steam or feedwater line break.

Generic Issue 125.II.7 addresses the concern related to the automatic isolation of AFW to a steam generator with a broken steam or feedwater line. Following the Davis-Besse event in June 1985 (Ref. 2), the benefits of this automatic isolation system versus its disadvantages were questioned (Ref. 3). The purpose of this generic issue is to reevaluate this design feature and to determine whether its disadvantages may outweigh its benefits. The benefits of automatic AFW isolation in the event of a steam or feedwater line break are:

1. The steam generator inventory blowdown is minimized. While isolating AFW does not prevent the initial secondary side inventory blowdown, it does prevent continued blowdown after the initial inventory is expended and thus minimizes the use of condensate supplies.

2. Excessive primary system cooldown is minimized. Continued AFW flow to the steam generator with the break would result in a sustained cooldown and subsequent repressurization of the primary system, thus contributing to pressurized thermal shock conditions. As the primary system cools down because of the heat transfer to the depressurizing steam generator, a reactor recriticality could occur, especially if the reactor core is approaching end-of-life. This would introduce thermal energy to the primary system. Shutting off AFW to the faulted steam generator will reduce the likelihood of recriticality.

3. Excessive containment pressure is minimized. The containment is designed to accommodate the pressure increase caused by a primary system loss-of-coolant accident (LOCA). A steam or feedwater line break within containment might cause the containment design pressure to be exceeded if the automatic AFW isolation were not available.

4. In some plants, the AFW automatic isolation feature is required to divert AFW from the affected steam generator for orderly and safe plant shutdown and to meet the single failure criterion in supplying feedwater to the intact steam generator(s).

The disadvantages of automatic AFW isolation are related to a concern that the automatic isolation system may reduce the reliability of the AFW function. Failures that cause inadvertent AFW isolation could cause loss of all AFW system flow during accidents or transients. Additionally, during a controlled cooldown after an accident, the thresholds for automatic AFW isolation (such as low steam generator pressure or high steam generator to steam generator pressure differential) may be crossed, which would require that the operator lock out the isolation logic as the steam generator parameters approach the isolation setpoint. During such a scenario (not requiring isolation), the accompanying distractions could result in a failure to lock out the automatic isolation. Thus AFW would not be available until the operator intervenes.

The focus of this generic issue is to reevaluate the automatic isolation of AFW by addressing the question as to whether the positive aspects of this design feature are outweighed by the negative aspects.

2. OBJECTIVE

The objective of this Regulatory Analysis is to determine whether the proposed change in the AFW automatic isolation design, as proposed in the aftermath of the Davis-Besse event of June 1985 (Refs. 2 and 3) is warranted.

3. ALTERNATIVE RESOLUTIONS

There were two basic alternatives (Ref. 3) considered as a basis for resolution of Generic Issue 125.II.7.

1. Take no action. Consistent with the SRP, this alternative does not preclude a licensee from proposing to the NRC staff the removal of the AFW automatic isolation feature based on plant-specific considerations, or

2. Remove the automatic isolation feature of the AFW system. Alternative No. 2 would entail the removal of the automatic isolation feature with the attendant reliance on operator action to cope with a steam or feedwater line break, and, for plants that do not have them already, the installation of flow restrictors in the discharge lines of the AFW pumps for pump runout protection.

4. TECHNICAL FINDINGS SUMMARY

4.1 Summary of Risk Estimates

Probabilistic methods were used for a generic study of the changes in risk that would occur if the AFW automatic isolation feature was removed. The results of this study by the Idaho National Engineering Laboratory (INEL) are reported in NUREG/CR-5178 (Ref. 4).

Four PWRs, one from each reactor vendor (two B&W AFW designs), were evaluated to determine the AFW automatic isolation system's contribution to the core damage frequency (CDF). Since the decay heat removal safety function via cooling through the steam generator is of importance in these CDF sequences, it is expected that the greatest risk associated with this issue would be for plants with marginal or no feed-and-bleed capabilities. An analysis has been performed to determine the sensitivity of CDF changes, for the sequences analyzed for this issue, to the unavailability of the feed-and-bleed capability. The results of this sensitivity analysis confirm this conclusion (Ref. 5). This study included two such plants. Another significant consideration was that some plants utilize the automatic AFW isolation system to prevent AFW pump runout conditions with resultant possible pump damage and AFW system failure when supplying water to a depressurized (steam or feedwater line break condition) steam generator. The evaluation performed for this study also included three of these plants.

The evaluation indicates that the quantitative effects on CDF of the AFW automatic isolation system are largely dependent on the particular plant design. The auxiliary feedwater system is a part of the balance of plant design usually contributed by the architect-engineer, and not normally part of the more standardized reactor and primary system provided by the reactor vendor. The estimated changes in CDF due to AFW isolation system's contribution are low, but the range between the highest and lowest value is about an order of magnitude.

At Plant A (CE), removing the isolation system will not cause a failure of the AFW system because the plant has flow restrictors in the AFW headers that limit flow to a ruptured steam generator and maintain flow to the intact steam generator. Removing the isolation system at this plant would decrease the CDF by 5.5E-07. At Plant B (B&W), removing the automatic AFW isolation system would cause AFW system failure without operator action because the plant does not have flow restrictors in the AFW headers and the pump trains are cross connected. Thus, AFW flow would be diverted to the ruptured steam generator and the pumps would be damaged because of low net positive suction head caused by the high flow rate. Removing the automatic isolation system would cause a CDF increase of 9.6E-08. At Plant BB (B&W), removing the automatic isolation system would also cause AFW failure without operator action because the plant does not have flow restrictors in the AFW headers and the pumps are cross-connected. Removing the automatic AFW isolation system would cause a CDF decrease of 9.0E-07. At Plant C (W), only part of the AFW system would fail if the automatic isolation features were removed and the operator took no action to isolate a ruptured steam generator. A ruptured steam generator would cause the flow from one of the motor-driven pumps and the turbine-driven pump to be diverted to the break, but the other motor-driven pump would still supply two intact steam generators, which is the AFW success criterion for most accidents. Removing the automatic isolation system would cause a CDF increase of 4.0E-07.

Table 1. Change to CDF Caused by Removing the AFW Automatic Isolation System

Plant	Decrease in CDF Caused by Deactivating AFW Isolation System	Increase in CDF Caused by Deactivating AFW Isolation System	Net Change In CDF
A (CE)	5.50E-07	0	-5.5E-07
B (B&W)	4.40E-08	1.4E-07	+9.6E-08
BB (B&W)	1.04E-06	1.4E-07	-9.0E-07
C (W)	4.00E-08	4.4E-07	+4.0E-07

Even though only four plant designs were evaluated in this study, it is expected that the results of this study can be extrapolated to address this issue on a generic basis. This judgment is based on the following factors:

1. The four plants evaluated in this study include plants with somewhat different automatic AFW isolation system designs. Based on a survey of all PWRs, one of these designs is representative of system designs used at all the 27 plants that have the AFW automatic isolation feature.

2. If automatic AFW isolation designs are used at some plants that may be significantly different from those evaluated in this study, the findings of this study related to differences in CDF compared to system design can be extrapolated. This study indicated that the differences in isolation system design had little bearing on the change in CDF. The major factor affecting the CDF calculations was the presence, or absence, of flow restrictors in the AFW system. All PWRs either have AFW flow restrictors or do not. This study showed the worst case was for plants that do not have flow restrictors. Even these plants showed no significant benefit in removing the AFW automatic isolation feature.

3. As noted in Item 2 above, removal of the AFW automatic isolation system would result in the largest risk increase for plants that do not have AFW flow restrictors. If the existing isolation system were removed, these plants would incur the highest cost because AFW flow restrictors would need to be added. However, the most favorable cost-benefit ratio (approximately $8K/person-rem) calculated during this study used the highest risk reduction value calculated for a plant without AFW flow restrictors and used the least expensive cost (for plants not requiring the addition of AFW flow restrictors). This conservative method was used for initial scoping calculations to account for analytical uncertainty and also to provide some assurance that differences not addressed in Items 1 and 2 above would not change the conclusions of this study.

4.2 Summary of Implementation of Alternative Resolutions

Based on the results summarized in Subsection 4.1, the implementation of the two alternatives discussed in Section 3 may be summarized as follows:

1. The "no-action" alternative would simply rely on normal distribution of this regulatory analysis and the contractor's report (NUREG/CR-5178) to allow these insights to be available to all utilities. No further action would be taken. Consistent with the SRP, a licensee may propose to the NRC staff the removal of the AFW automatic isolation feature based on plant-specific considerations.

2. The No. 2 alternative would entail the removal of the automatic isolation feature with the attendant reliance on operator action to cope with a steam or feed line break, and, for plants that do not have them already, the installation of flow restrictors in the discharge lines of the AFW pumps to protect them from runout.

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(s)), 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 offsite property damage costs associated with land interdiction and decontamination that may be necessary.

The number and importance of parameters contributing to the costs and benefits vary with the type of accident and the plant location (Ref. 6). In the analyses performed in this study, the site characteristics for a "typical" midwestern plant and site (Refs. 4 and 7) are used because they are representative of the population of U.S. PWRs affected by this issue. This consequence analysis contains some bounding assumptions on the consequences associated with individual plants and the corresponding analyses on a plant-specific basis. However, the need to go back and perform a more realistic cost-benefit estimate became moot when, even with the preceding bias, the results did not warrant a backfit.

The averted onsite dose due to avoided accidents associated with the removal of the AFW automatic isolation feature (for plants that show a risk reduction) is neglected in this analysis. This is because the change in CDF (10^{-7} events/Rx-year) and corresponding total consequences are small, thus the small onsite population and attendant meteorological characteristics would make the onsite averted dose negligible.

Also, based on the small calculated changes of CDF, the averted onsite costs involved would be very small (ee Section 5.1) compared with the costs associated with the removal of the automatic isolation capability. Hence, these small costs were also neglected in the calculation of the respective cost-benefit ratios. The expected uncertainties associated with offsite consequences regarding person-rem doses with offsite protective actions are large (Ref. 8). Therefore, for initial scoping of cost-benefit estimates, the analysis was based on a 50-mile radius of a "typical" midwestern location (Refs. 4 and 7). As it is shown in Section 5.2.3, the need to obtain a more realistic cost-benefit estimate became moot when, even with the preceding bounding bias, the results did not warrant a backfit.

5.1 Alternative Resolution No. 1 - No Action

There are normally no costs attributed to a "no-action" alternative. However, by convention they are treated as benefits of other alternative resolutions. Averted onsite costs can have a significant effect on the overall cost-benefit ratio depending on the expected reduction in CDF. These costs may be estimated by multiplying the change in accident frequency by the discounted onsite damage costs. The following equations (Ref. 10) may be used to estimate these costs on a per plant basis:

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

and

$$U = \frac{C}{m} [(e^{-rt_i})/r^2][1 - e^{-r(t_f-t_i)}](1 - e^{-rm})$$

where
V_{op} = value of onsite averted costs
N = number of affected facilities = 1
ΔF = reduction in accident frequency = 10^{-7}
U = present value of onsite property damage
C = cleanup, repair, and replacement power costs = $2.4 billion
t_f = years remaining until end of plant life = 25
t_i = years before reactor begins operation = 0
r = discount rate = .10 (10%); .05 (5%)
m = period of time over which damage costs are paid out (recovery period in years) = 10

On the basis of the above formulas and assigned parameter values, we find that the averted onsite costs per plant are expected to vary between $1,500 and $3,000. Table 2 summarizes the discounted values for 10% and 5% discount rates.

Table 2. Discounted Present Value of Averted Onsite Damage Cost per Plant

Averted Costs	Discounted Present Value	
	10% Discount Rate	5% Discount Rate
Cleanup, repair, and replacement power	$1,500	$3,000

As shown above, these averted onsite costs for this particular issue are very small ($3,000 or less). In some cases, they are negative. As discussed in Section 6, these results translate to retaining the current design as the best alternative.

5.2 Alternative Resolution No. 2 - Removal of Automatic Isolation of AFW System

This alternative resolution involves the removal of the automatic isolation of AFW during a steam or feed line break. A detailed analysis of representative PWR designs was performed by selecting one Westinghouse plant, one Combustion Engineering plant, and two Babcock & Wilcox design versions of the same plant (with and without the Emergency Feedwater Initiation and Control (EFIC) System).

As proposed originally (Ref. 3), removing the AFW automatic isolation feature consists of disconnecting and securing the automatic enable circuits. This modification will provide the AFW system with manual control once the system has been activated. Once the isolation function becomes a manual action, it will necessitate additional operator training and revised plant operating procedures. A further complication has been identified for plants that use the automatic AFW isolation system to prevent AFW pump runout. If the automatic AFW isolation system were disabled in these plants, additional plant modification would be required to prevent pump runout.

A survey performed of all operating PWRs indicated that 27 plants would be affected by this issue. Nineteen of these 27 plants would be affected by AFW pump runout considerations. These plants, if they have the AFW automatic isolation removed, would require the additional installation of AFW pump discharge flow restrictors or block existing suitable valves to prevent pump runout.

Changes to the AFW flowrate characteristics and initiation times by the introduction of flow restricting devices and operator action, respectively, would also require detailed reanalysis of steam and feed line break accidents in the Final Safety Analysis Reports (FSARs), changes of operating procedures, and operator training. Technical Specification changes would be required to reflect the modified design and to provide for periodic testing of the modified AFW system.

5.2.1 Change in Risk Evaluation

To evaluate the proposed modifications on a risk change (benefit) versus cost basis, the risk change associated with the scenarios of concern was calculated, using the following relationship (Ref. 4):

Change in CDF (events/yr) x Containment Failure Probability x Offsite Radiation Dose (person-rem) = Risk Change (person-rem/year)

To calculate the total change to the potential population exposure or risk per plant life due to this issue, the above relationship was extended over the plant life, taking into account plant downtime. The total change in population exposure over the remaining plant lifetime is calculated as follows:

Change in Risk (person-rem/year) x Remaining Plant Life (years) x Plant Utilization Factor = Total Change in Population Risk (person-rem)

The potential change in risk due to the proposed AFW modification, for the selected plants, was evaluated using the plant-specific containment failure and release category information delineated in the respective PRAs (Ref. 4). To extrapolate the estimated person-rem/year risk to total change in plant risk, the plant life was estimated utilizing the expected remaining lifetime of 23 years. An associated utilization factor of 75% was used. These values were taken from NUREG-0933 (Ref. 7) and Reference 11.

The plant-specific PRAs (Ref. 4), except for plant C (W), were performed on the basis of the methodology and data developed as part of the WASH-1400 analysis, which has been subsequently found to be conservative in portions of its estimation of the source terms and containment failures. However, ongoing work has also shown areas in which the WASH-1400 treatment was not sufficiently conversative; for example, neglecting to account for the effect of revaporization of plated-out fission products in the initial stages of an accident (Ref. 12). Hence, the conservative elements tended to be balanced out by other elements that were on the nonconservative side. The plant C (W) PRA (Ref. 12) was performed on the basis of the methodology and data developed as part of the work on NUREG-1150 (Ref. 13), i.e., the applicable release fractions were taken from the 19 release bins instead of the nine release categories used in WASH-1400 and the PRAs for Plants A, B, and BB. The final numbers for the change in risk for the four plant designs analyzed are within a factor of about 3 (Ref. 4), which is well within the error band of of ±10 that was used in the cost-benefit sensitivity analysis. Hence, while extensive work is under way to better quantify the source terms of various accidents, the WASH-1400 results in this area for Plants A, B, and BB were deemed appropriate.

Table 3 summarizes the change in risk due to the AFW system modification.

Table 3. Risk Change Due to Proposed AFW System Modification

Plant	Plant PRA Data Data (person-rem)	NUREG-0933[7] Data (person-rem)
A (CE)	36 (Decrease)	1.5 (Decrease)
B (B&W)	4 (Increase)	0.25 (Increase)
BB (B&W)	44 (Decrease)	3.0 (Decrease)
C (W)	13 (Increase)	No Data

5.2.2 Cost Estimation

Using the guidance contained in References 10 and 14, the costs of implementing the modifications involved under Alternative Resolution No. 2 were analyzed in NUREG/CR-5178 (Refs. 4 and 9). A cost analysis for disabling the automatic feedwater isolation system was also conducted by the NRC staff, as documented in a memorandum from A. J. Dipalo to G. R. Mazetis, dated February 5, 1988 (Ref. 9). The results of these two cost analyses were in close agreement. Table 4 presents the results of the cost analysis (Refs. 4 and 9) with the exception that replacement power costs were also calculated for the case of installed flow restrictors.

5.2.3 Cost-Benefit Summary

To determine the cost effectiveness of the proposed modification for each of the plants, a cost-benefit analysis was performed. The cost-benefit ratio was estimated using the following equation:

[Estimated Cost of Modification ($)] ÷ [Change in Risk (person-rem)] = [Cost-Benefit ($/person-rem)]

The risk reduction values employed in this analysis used the largest decrease in risk from Table 3 and the smallest cost from Table 4. This scoping approach was taken to ensure that the likelihood of excluding viable fixes was minimized. Should the result be shown to be cost-beneficial, a new estimate would then be necessary to obtain a more realistic value.

The results of this analysis are shown in Table 5. The cost-benefit analysis was compared against the $1,000 per person-rem screening value to evaluate the cost effectiveness of the proposed modification. As shown, neither set of modifications would be cost-beneficial.

Table 4. Cost Estimate for Proposed Modifications (per Plant)[a]

Cost Category	Cost to Disable Automatic AFW Isolation Systems Without Flow Restrictors Installed ($1000)	Cost to Disable Automatic AFW Isolation Systems with Flow Restrictors Installed ($1000)
Design, Hardware, and Installation	Not Applicable	$75[b]
Utility Licensing[c]	$250[d]	800[d]
Operator Training	43	43
NRC Review	58	158
Total if modifications are performed during a scheduled outage	$351	$1,076
Replacement Power Cost	Not Applicable	$6,000[e]
Total if modifications are performed	$351	$7,076

a. Without averted onsite costs (see Section 5.1).

b. Estimate includes design, installation, calibration, and testing.

c. Estimation includes Technical Specification, FSAR, and procedure changes and amendments.

d. Estimate based on reanalyses required of selected DBAs.

e. E timate based on the power replacement costs of $300K/day associated with a 20-day specially required outage (Ref. 14).

Table 5. Summary of Cost-Benefits in Dollars per Person-rem Reduction

For Plants Not Requiring Hardware Modifications	For Plants Requiring Hardware Modifications
$351K/44.4 person-rem= $7,905/person-rem	$768K/44.4 person-rem= $17,290/person-rem

5.2.4 Cost-Benefit Uncertainties

The cost estimates used to calculate the cost-benefit ratios are subject to some uncertainty.[4] These costs were estimated using NUREG/CR-4568 (Ref. 14) as guidance and the specific information provided in Reference 9.

One major area of uncertainty is whether the proposed modifications can be completed during a scheduled outage. Table 4 shows the costs associated with the bounding cases (i.e., estimated cost when the modification requires an outage--the upper bound on estimated cost, and the estimated cost when the modification is performed during a scheduled plant outage--the lower bound on estimated cost).

Other uncertainties, of lesser importance, including those related to the exclusion of any averted onsite costs (see Section 5.1) are not large enough to cause any change in the conclusion regarding the cost effectiveness of removing the AFW automatic isolation feature.

The individual tasks performed during the technical evaluation of GI 125.II.7 are also subject to some level of uncertainty. This evaluation consisted of the following tasks: evaluation of the contribution to various CDF sequences due to the automatic AFW isolation system, assignment of containment failure probabilities, and evaluation of the offsite dose factor, which are presented below.

In this evaluation, the major uncertainties associated with the evaluation of the core damage contribution due to the AFW automatic isolation system are in the assessment of the values for the pertinent individual failures involved in the CDF sequences identified as the most important contributors to risk. These failures are:

1. Inadvertent actuation of the AFW automatic isolation system,
2. Failure to recover AFW,
3. Failure to achieve feed and bleed, and
4. Failure to bypass AFW isolation logic during long-term shutdown.

The uncertainties associated with the expected frequencies for these events were evaluated by reviewing the uncertainties associated with comparable events involving the AFW and their treatment in References 15, 16, and 17. It was determined from this review that the error bands for such comparable events were in the range of 5-8. It was decided that an error factor of 10 would be appropriate for the four events cited above.

One method that could be employed to determine the uncertainty in the estimated offsite consequences would be to employ a Monte-Carlo analysis and propagate the distributions through the models. However, based on statistical methodology for the log-normal distributions, the combined error factor for the end state of an event tree was approximated to be equal or less than the largest individual error factor of the events used in the estimation of the contribution to CDF. Hence, an upper bound on the combined error factor is assumed equal to the largest individual error factor.

Uncertainties associated with the probability of containment failure were estimated in a similar manner drawing from the plant-specific PRAs (Ref. 4) NUREG-0933 (Ref. 7), and NUREG-1150 (Ref. 13).

The offsite dose release fractions used in the GI 125.II.7 evaluation were those presented in NUREG-0933 and WASH-1400 with the exception of Plant C. The NUREG-0933 fractions represent the uncertainties of offsite dose calculated for a typical plant. Certain plant-specific characteristics such as assumed source terms and population density surrounding a specific plant introduces some uncertainty in the calculated offsite consequences. However, the NUREG-0933 values are considered representative in lieu of a detailed plant-specific evaluation of the offsite consequences. The evaluation of the offsite consequences for Plant C are based on more recent offsite consequence information as part of the NUREG-1150 work.

Based on the previous discussion of the estimated uncertainties, the use of an error factor of ten was estimated to be representative of the total uncertainties of the factors used to calculate the cost-benefit ratio. This estimate is reasonable because of the scoping nature of this analysis in order to (1) provide an approximate evaluation of the sensitivity of the recommendation to the uncertainty of the factors used in the analysis, and (2) provide an additional input to the deterministic considerations for this generic issue.

Table 6 presents the basic information utilized in performing the sensitivity analysis. This table is a compilation of data previously presented. Table 7 presents the results of the sensitivity analysis. The sensitivity of the results presented in this table as to the uncertainties in the cost-benefit ratios were calculated using an error factor of 10 as described above. Cost-benefit ratios were not calculated for those plants (Plants B and C) for which a net increase in the CDF due to implementing the proposed modifications was estimated. The best estimate cost-benefit ratios for all cases are above the $1,000/person-rem criterion. The same is true even for the lower bound estimates with the exception of one for plant A which is $970/person-rem.

Table 6. Basic Data Used in the Uncertainty Sensitivity Analysis

Plant	Total Change in CDF Offsite (per Rx-year)	Consequences (Total person-rem)	Cost ($1000)	Cost-Benefit Ratio ($/person-rem)
A (CE)	5.5E-07 (decrease)	36	351	9,700
B (B&W)	9.6E-08 (increase)	4	768	*
BB (B&W)	9.0E.7 (decrease)	44	768	17,200
C (W)	4.0E-07 (increase)	13	351	*

* Cost benefit ratios were not calculated for plants where the implementation of this issue would result in an increase in the estimated risk.

Table 7. Sensitivity Analysis Results

		Cost-Benefit Ratio ($/person-rem)
		Based on PRAs (Ref. 4) Containment Failure Information
A (CE)		
	Upper Bound	97,000
	Best Estimate	9,700
	Lower Bound	970
BB (B&W)		
	Upper Bound	172,000
	Best Estimate	17,200
	Lower Bound	1,700

6. DECISION RATIONALE

This generic issue was identified as part of the evaluation of the Davis-Besse event of June 1985 (Ref. 2). Although this issue has a bearing on all PWRs, it was particularly identified with the B&W plants. B&W plants have been under continuing NRC and industry assessment (Refs. 18 and 19) and one of the focal points of this assessment is directly related to the reliability and operational aspects of the AFW system (known also as Emergency Feedwater System (EFS) in B&W terminology). The recognition of the need to improve the operation of this system has been manifested by the installation of the Emergency Feedwater Initiation and Control (EFIC) System in a number of B&W plants, or an acceptable equivalent in other B&W plants.

Based on the results of the cost-benefit analyses, and the insights gained during assessment of the pros and cons of removing the automatic isolation design feature of the AFW system, we conclude that no backfit requirement to remove this design feature from PWRs is warranted. This conclusion is based on the following considerations:

1. The risk reductions realized in some plants by removing the automatic isolation of AFW are very small (on the order of a few person-rem per plant) and the corresponding cost is in the range of \$350,000 to \$800,000 (assuming no replacement power costs and depending on the need to install flow restrictors in the AFW pump discharge lines). Hence, both basic backfit criteria (Ref. 20) that (1) substantial increase in the overall protection of the public health and safety is achieved, and (2) that the direct and indirect costs of implementation are justified, are not met.

2. Our assessment of this issue has shown that, for some plants, removal of the automatic isolation of AFW would result in a very small increase of the risk to public health and safety.

3. The installation of the EFIC system in a number of B&W plants has been shown to improve safety and has already been accepted by the staff.

Hence, we recommend that Alternative Resolution No. 1 - "No Action" be approved.

7. IMPLEMENTATION

No regulatory action is necessary for resolution of this issue. A distribution of Reference 4 has been made to include all PWR licensees and vendors. This regulatory analysis will also be made publicly available as part of its normal distribution.

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13. ABSTRACT (200 words or less)

Generic Issue 125.II.7 addresses the concern related to the automatic isolation of Auxiliary Feedwater (AFW) to a steam generator with a broken steam or feedwater line.

This regulatory analysis provides quantitative assessment of the costs and benefits associated with the removal of the AFW automatic isolation, and concludes that no new regulatory requirements are warranted.

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