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RELATING TO THE CERTIFICATION OF THE
AP600 STANDARD PLANT DESIGN
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Attachment 2

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1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC or the Commission) has issued a design certification for the Advanced Passive 600 (AP600) design in response to an application submitted on June 16, 1992, by the Westinghouse Electric Corporation (hereinafter referred to as Westinghouse). A design certification is a rulemaking that amends Title 10, Part 52 of the *Code of Federal Regulations* (10 CFR Part 52).

This report presents the environmental assessment (EA) for this rulemaking, which the NRC has prepared in accordance with 10 CFR Part 51 and the requirements of the National Environmental Policy Act of 1969 (NEPA), as amended. This EA addresses the environmental impacts of issuing a design certification. In addition, this report addresses severe accident mitigation design alternatives (SAMDAs), which the NRC has decided to consider as part of this final EA for the AP600 design. This report does not address the environmental impacts of constructing and operating a facility which references the AP600 design certification at a particular site; such impacts will be evaluated as part of the application(s) for siting, constructing, and operating such a facility.

As detailed in Section 4.0 of this report, the NRC determined that issuing this design certification does not constitute a major Federal action significantly affecting the quality of the human environment. This finding of no significant impact is based on the fact that the design certification would not independently authorize the siting, construction, or operation of an AP600 reactor design. Rather, the certification would merely codify the AP600 design in a rule that could be referenced in a construction permit (CP), early site permit (ESP), combined operating license (COL), or operating license (OL) application. Further, because the certification is a rule, it does not involve any resources that would have alternative uses. Therefore, the NRC has decided not to prepare an environmental impact statement (EIS) in connection with this action.

In addition, pursuant to NEPA, the NRC also reviewed Westinghouse's evaluation of SAMDAs that generically apply to the AP600 design. On that basis, the NRC found that the evaluation provides a reasonable assurance that certifying the AP600 design will not exclude SAMDAs for a future facility that would prove cost beneficial had they been considered as part of the original design certification application. These issues are considered resolved for the AP600 design certification.

2.0 THE NEED FOR THE PROPOSED ACTION

The NRC has long sought the safety benefits of commercial nuclear power plant standardization, as well as the early resolution of design issues and the finality of these resolutions. The NRC plans to achieve these benefits by certifying standard plant designs. Subpart B to 10 CFR Part 52 allows for certification in the form of rulemaking of an essentially complete nuclear plant design.

The proposed action would amend 10 CFR Part 52 to certify the AP600 design. The amendment would allow prospective licensee's to reference the certified AP600 design as part of an ESP or a COL application under 10 CFR Part 52 or for a CP application under 10 CFR Part 50. Those portions of the AP600 design included in the scope of the certification rulemaking would not be subject to further regulatory review or approval. In addition, the amendment would eliminate the need to consider SAMDAs for any future facilities that reference the certified AP600 design.

3.0 ALTERNATIVES TO THE PROPOSED ACTION

The NRC had two alternatives to certifying the AP600 design in an amendment to 10 CFR Part 52. Specifically, the NRC could (1) take no action to approve the design, or (2) issue a final design approval (FDA) without certifying the design. In and of themselves, these alternatives would not have a significant impact on the quality of the human environment because they would not authorize the siting, construction, or operation of a facility.

In the first case, the NRC would not approve the design. Therefore, a facility to be built using the AP600 design would require licensing under 10 CFR Part 50 or 10 CFR Part 52, Subpart C, as a custom plant application. Moreover, all design issues would have to be considered as part of each application to construct and operate an AP600 facility at a particular site. As a result, this alternative would not achieve the benefits of standardization, provide early resolution of design issues, or permit finality of design issue resolution.

In the second case, the NRC would issue an FDA under Appendix O to 10 CFR Part 52, but would not certify the design in a rulemaking. Therefore, although the NRC would have approved the design, the design could be modified and thus would require reevaluation as part of each application to construct and operate an AP600 facility at a particular site. This alternative would permit early resolution of issues, but would not achieve the benefits of standardization or establish of design issue resolution.

The NRC sees no advantage in either alternative compared to the design certification rulemaking proposed for the AP600 design. Although neither the alternatives nor the proposed design certification rulemaking would significantly affect the quality of the human environment in and of themselves, the rulemaking achieves standardization, permits early resolution of design issues, and finality of resolutions for design issues (including SAMDAs) that are within the scope of the design certification. Therefore, the NRC concludes that the alternatives to rulemaking would not achieve the objectives the Commission intended by certifying the AP600 design pursuant to 10 CFR Part 52, Subpart B.

3.1 Severe Accident Mitigation Design Alternatives (SAMDAs)

Consistent with its objectives of standardization and early resolution of design issues, the Commission decided to evaluate SAMDAs as part of the design certification for the AP600 design. In a 1985 policy statement, the Commission defined the term "severe accident" as an event that is "beyond the substantial coverage of design-basis events," including events in which there is substantial damage to the reactor core (whether or not there are serious offsite consequences). Design-basis events are considered to be those analyzed in accordance with the NRC's Standard Review Plan (NUREG-0800) and documented in Chapter 15 of the AP600 Design Control Document (DCD).

As part of its design certification application, Westinghouse performed a probabilistic risk assessment (PRA) for the AP600 design to achieve the following objectives:

- Identify the dominant severe accident sequences and associated source terms for the design.
- Modify the design, on the bases of PRA insights, to prevent or mitigate severe accidents and reduce the risk of severe accidents.
- Provide a basis for concluding that all reasonable steps have been taken to reduce the chances of occurrence, and to mitigate the consequences, of severe accidents.

Westinghouse's PRA analysis is presented in Chapter 19 of the AP600 Standard Safety Analysis Report (SSAR).

In addition to considering alternatives to the rulemaking process as discussed in Section 3.0, applicants for reactor design certification or CPs must also consider alternative design features for severe accidents consistent with the requirements of 10 CFR Part 50, as well as a court ruling related to NEPA. These requirements can be summarized as follows:

- 10 CFR 50.34(f)(1)(i) requires the applicant to perform a plant/site-specific probabilistic risk assessment, the aim of which is to seek such improvements in the reliability of core and containment heat removal systems as are significant and practical and do not impact excessively on the plant.
- The U.S. Court of Appeals decision, in *Limerick Ecology Action v. NRC*, 869 F.2d 719 (3rd Cir. 1989), effectively requires the NRC to include consideration of certain SAMDAs in the environmental impact review performed under Section 102(2)(c) of NEPA as part of the OL application.

Although these two requirements are not directly related, they share a common purpose to consider alternatives to the proposed design, to evaluate potential alternatives improvements in the plant design which increase safety performance during severe accidents, and to prevent viable alternatives from being foreclosed. It should be noted that the Commission is not required to consider alternatives to the design in this EA on the rulemaking; however, as a matter of discretion, the Commission has determined that considering SAMDAs is consistent with the intent of 10 CFR Part 52 for early resolution of issues, finality of design issue resolution, and enhancing the benefits of standardization.

In its decision in *Limerick Ecology Action v. NRC*, the Court of Appeals for the Third Circuit expressed its opinion that it would likely be difficult to evaluate SAMDAs for NEPA purposes on a generic basis. However, the NRC has determined that generic evaluation of SAMDAs for the AP600 standard design is warranted for two significant reasons. First, the design and construction of all plants referencing the certified AP600 design will be governed by the rule certifying a single design. Second, the site parameters specified in the rule and the AP600 SSAR establish the consequences for a reasonable set of SAMDAs for the AP600 design. The low residual risk of the AP600 and limited potential for further risk reductions provides high confidence that additional cost beneficial SAMDAs would not be found. Should the actual parameters for a particular site exceed those assumed in the rule and the SSAR, SAMDAs would have to be reevaluated in the site-specific environmental report and the EIS.

3.2 Potential SAMDAs Identified by Westinghouse

To identify candidate design alternatives, Westinghouse reviewed the design alternatives for other plants including Limerick, Comanche Peak, and the Combustion Engineering (CE) System 80+ design. Westinghouse also reviewed the results of the AP600 PRA and design alternatives suggested by AP600 design personnel.

Appendix 1B of the SSAR does not explicitly state whether Westinghouse's evaluation included plant improvements considered as part of the NRC's Containment Performance Improvement (CPI) program (NUREG/CR-5562, -5567, -5575, and -5630). However, Westinghouse stated that the types of design changes identified in the CPI program have already been incorporated into the AP600 design or have been considered as design alternatives. The improvements identified in the CPI program were also evaluated in other documents reviewed by Westinghouse, including the CE System 80+ design alternative evaluations.

Westinghouse eliminated certain SAMDAs from further consideration on the basis that they are already incorporated in the AP600 design. Such features include the following:

- hydrogen ignition system
- reactor cavity flooding system
- reactor coolant pump seal cooling (AP600 has canned motor pumps)
- reactor coolant system depressurization
- external reactor vessel cooling
- nonsafety-grade containment sprays

On the basis of the screening, Westinghouse retained 14 potential SAMDAs for further consideration. These SAMDAs, described in Section 1B.7 of the SSAR, are summarized below:

(1) Upgrade the Chemical and Volume Control System (CVCS) for Small Loss-of-Coolant Accidents (LOCAs): The CVCS is currently capable of maintaining the reactor cooling system (RCS) inventory for LOCAs with effective break sizes up to 0.97 cm (⅜ in.) in diameter. This design alternative would extend the capability of the CVCS so that it could maintain the RCS inventory during small and intermediate LOCAs up to an effective break size of 15.2 cm (6 in.) in diameter. Implementation of this design alternative would require installation of in-containment refueling water storage tank (IRWST) / containment recirculation connections to the CVCS, as well as the addition of a second line from the CVCS pumps to the RCS. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 5.5E-04 person-rem/yr.

(2) Filtered Containment Vent: This design alternative would involve the installation of a filtered containment vent, including all associated piping and penetrations. This modification would provide a means to vent the containment to prevent catastrophic overpressure failures, as well as a filtering capability for source term release. The filtered vent would reduce the risk associated with late containment failures that might occur after failure of the passive containment cooling system (PCS). However, even if the PCS fails, air cooling would be expected to limit the containment pressure to less than the ultimate pressure. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 1.0E-03 person-rem/reactor-year.

(3) Self-Actuating Containment Isolation Valves: Self-actuating containment isolation valves could increase the likelihood of successful containment isolation during a severe accident. This design alternative would involve adding a self-actuating valve or enhancing the existing containment isolation valves on containment penetrations that are normally-open. (Specifically, penetrations that provide normally open pathways to the environment during power and normal shutdown conditions.) This would permit automatic self-actuation in the event that containment conditions indicate a severe accident. Closed systems inside and outside containment, such as residual heat removal system and component cooling, would be excluded from this design alternative. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 7.4E-04 person-rem/yr.

(4) Passive Containment Sprays: Installing a passive safety-related containment spray system could result in the following risk benefits:
    (a) Scrub fission products, primarily for containment isolation failure.
    (b) Provide an alternative means to flood the reactor vessel (in-vessel retention).

(c) Control containment pressure for cases in which the PCS has failed.

Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 6.9E-03 person-rem/yr, which would represent eliminating all release categories except containment bypass.

(5) Active High-Pressure Safety Injection System: Adding a safety-related, active high-pressure safety injection system would enable the reactor to prevent a core melt in all events except excessive LOCA and anticipated transient without scram. Note, however, that this design alternative is not consistent with the AP600 design objectives, in that it would change the AP600 from a plant with only passive systems to a plant with both passive and active systems. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 6.1E-03 person-rem/yr.

(6) Steam Generator Shell-Side Heat Removal System: This design alternative would involve installing a passive safety-related heat removal system to the secondary side of the steam generators. This enhancement would provide closed loop secondary system cooling via the use of natural circulation and stored water cooling, thereby preventing loss of the primary heat sink given loss of startup feedwater and the passive residual heat removal heat exchanger. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 5.3E-04 person-rem/yr.

7. Direct Steam Generator Safety and Relief Valve Flow to the IRWST: To prevent or reduce fission product release from bypassing containment during an steam generator tube rupture (SGTR) event, flow from the steam generator safety and relief valves could be directed to the IRWST. An alternative, lower cost approach to this design alternative would be to redirect the flow only from the first stage safety valve to the IRWST. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 4.2E-04 person-rem/yr.

(8) Increased Steam Generator Pressure Capability: In lieu of design alternative (7) above, fission product release bypassing containment could be prevented or reduced by increasing the steam generator secondary side and safety valve set point to a level high enough so that an SGTR will not cause the secondary system safety valve to open. Although detailed analyses have not been performed, it is estimated that the secondary side design pressure would have to be increased by several hundred psi to make this alternative effective. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 4.2E-04 person-rem/yr.

(9) Secondary Containment Filtered Ventilation: This design alternative would involve installing a passive charcoal and high-efficiency particulate air filter system for the middle and lower annulus region of the secondary concrete containment (below Elevation 135'-3"). Drawing a partial vacuum on the middle annulus via an eductor with motive power from compressed gas tanks would operate the filter system. This design alternative would reduce particulate fission product release from any failed containment penetrations. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 7.4E-04 person-rem/yr.

(10) Diverse IRWST Injection Valves: In the current design, a squib valve in series with a check valve isolates each of the four IRWST injection paths. To provide diversity, the design could be modified so that a different vendor provides the valves in two of the lines. This enhancement would reduce the likelihood of common cause failures of the four IRWST injection paths. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 5.3E-03 person-rem/reactor-year, which would represent eliminating all core damage sequences resulting from a failure of IRWST injection (3BE sequences).

(11) Diverse Containment Recirculation Valves: In the current design, a squib valve isolates each of the four containment recirculation paths. In two of the four paths, each of the squib valves is in series with a check valve. In the remaining two paths, each squib valve is in series with a motor-operated valve (MOV). To provide diversity, the design could be modified so that a different vendor provides the squib valves in two lines. This enhancement would reduce the likelihood of common cause failures of the four containment recirculation paths. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 1.5E-04 person-rem/reactor-year, which would represent eliminating all core damage sequences resulting from a failure of containment recirculation (3BL sequences).

(12) Ex-Vessel Core Catcher: This design alternative would inhibit core-concrete interaction (CCI), even in cases where the debris bed dries out. The enhancement would involve designing of a structure in the

containment cavity or using a special concrete or coating. The current AP600 design incorporates a wet cavity design in which ex-vessel cooling is used to maintain core debris within the vessel. In cases where reactor vessel flooding has failed, the PRA assumes that containment failure occurs from an ex-vessel steam explosion or CCI. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 6.1E-03 person-rem/reactor-year.

(13) High Pressure Containment Design: The proposed high-pressure containment design would have a design pressure of approximately 300 psi, and would include a passive cooling feature similar to the existing containment design. This design would reduce the likelihood containment failures from severe accident phenomena such as steam explosions and hydrogen detonation. However, this alternative would not reduce the frequency or magnitude of releases from an unisolated containment. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 6.1E-03 person-rem/reactor-year.

(14) Increased Reliability of the Diverse Actuation System (DAS): This design alternative would involve improving the reliability of the DAS. The DAS is a nonsafety system that can automatically trip the reactor and turbine and actuate certain engineered safety features (ESF) equipment if the protection and safety monitoring system is unable to perform these functions. In addition, the DAS provides diverse monitoring of selected plant parameters to guide manual operation and confirm reactor trip and ESF actuations. Westinghouse estimated that implementing this design alternative would reduce plant risk by at most 2.2E-04 person-rem/reactor-year.

3.3 Staff Evaluation

The staff reviewed the set of potential SAMDAs identified by Westinghouse and found it to be reasonably complete. The activity was accomplished by reviewing design alternatives associated with the following plants: Limerick (NUREG-0974), Comanche Peak (NUREG-0775), CE System 80+ (NUREG-1462), Watts Bar (NUREG-0498), and the ABWR (NUREG-1503). Also surveyed were accident management strategies (NUREG/CR-5474), and alternatives identified through the Containment Performance Improvement (CPI) Program (NUREG/CR-5567, -5575, -5630, and -5562).

The results of the staff's assessment are summarized in Appendix A to the "Review of Severe Accident Mitigation Design Alternatives (SAMDAs) for the Westinghouse AP600 Design" (SEA 97-2708-010-A;1) prepared by Science and Engineering Associates Inc., and dated August 29, 1997. That appendix briefly summarizes each of the design alternatives identified in the foregoing references. Also included are the Westinghouse AP600 design alternatives, which are discussed in Appendix 1B of the SSAR. In all, the staff reviewed more than 120 possible design alternatives including most improvements identified as part of the NRC's CPI program. Specific improvements considered applicable to the AP600 included a filtered containment vent and a flooded rubble bed core-retention device, two improvements specifically mentioned in NUREG-0660 for evaluation as part of Three Mile Island (TMI) Item II.B.8. The list of 120 also included potential SAMDAs oriented toward reducing the risk from major contributors to risk for AP600, including SGTR events.

Although the Westinghouse analysis did not consider several design alternatives, in most instances the excluded alternatives are either (1) already included in the AP600 design, or (2) bounded in terms of risk reduction by one or more of the design alternatives that were included in the Westinghouse analysis. In other cases, the design alternatives were pertinent only to boiling water reactors. The staff's preliminary review did not reveal any additional design alternatives that obviously should have been considered by Westinghouse. Also, Westinghouse considered some potential design alternatives to be considerations for accident management strategies rather than design alternatives.

The staff noted that the set of SAMDAs reviewed by Westinghouse is not all inclusive, in that additional (perhaps less-expensive) SAMDAs could be postulated. However, the benefits offered by any additional modifications would not likely exceed those for the modifications evaluated, and the costs of alternative improvements are not expected to be less than those of the least expensive improvements evaluated, when the subsidiary costs associated with maintenance, procedures, and training are considered.

The discussions in Appendix 1B of the SSAR do not specify the basis or the process that Westinghouse used to screen the many possible design alternatives to arrive at the final list of 14 selected for further evaluation. Similarly, Westinghouse's responses to the staff's request for additional information (RAIs) provided few additional insights into the process. Nonetheless, as noted above, the staff's review of the more than 120 candidate designs did not identify any new alternatives likely to be more cost-beneficial than those included in Westinghouse's evaluation of

AP600 design alternatives. On this basis, the staff concludes that the set of potential SAMDAs identified by Westinghouse is acceptable.

3.4 Risk Reduction Potential of SAMDAs

3.4.1 Westinghouse Evaluation

In its evaluation, Westinghouse assumed that each design alternative would work perfectly to completely eliminate the respective accident sequences. This assumption is conservative, as it maximizes the benefit of each design alternative, which is measured on the basis of risk reduction. (For example, the risk reduction assigned to passive containment sprays assumes that all release categories except containment bypass are eliminated.) In each case, Westinghouse used analytical models and results contained in the AP600 PRA to estimate the risk reduction for each design alternative. Westinghouse then expressed the risk reduction in terms of whole body person-rem per year received by the total population within a radius of 80.5 km (50 mi.) of the AP600 plant site. Each of the 14 design alternatives was evaluated separately.

Table 1 of this EA summarizes Westinghouse's risk reduction estimates by comparing the benefits of averting offsite exposure using each potential design alternative. The bases for these estimates are provided in section 1.B.7 of the SSAR.

Table 1 Comparison of Estimated Benefits from Averted Offsite Exposure

Severe Accident Mitigation Design Alternative	Estimated Capital Cost, $	Averted Risk, person-rem per year	Westinghouse Benefits*, $	Staff Benefits** @ $2000/ person-rem, 1996$	Staff Benefits** @ $5000/ person-rem, 1996$
Upgrade Chemical and Volume Control System for Small LOCA	1,500,000.00	0.00055	4	17	39
Filtered Containment Vent	5,000,000.00	0.00100	6	30	70
Self-Actuating Containment Isolation Valves	33,000.00	0.00074	5	22	52
Passive Safety Grade In-Containment Sprays	3,900,000.00	0.00690	44	207	484
Active High-Pressure Safety Injection System	20,000,000.00	0.00610	39	183	428
Steam Generator Shell-Side Passive Heat Removal System	1,300,000.00	0.00053	3	16	37
Direct Steam Generator Safety and Relief Valve Flow to IRWST	620,000.00	0.00042	3	13	29
Increased Steam Generator Pressure Capability	8,200,000.00	0.00042	3	13	29
Secondary Containment Filtered Ventilation	2,200,000.00	0.00074	5	22	52
Diverse IRWST Injection Valves	570,000.00	0.00530	34	159	372
Diverse Containment Recirculation Valves	150,000.00	0.00015	1	5	11
Ex-Vessel Core Catcher	1,660,000.00	0.00610	39	183	428
High Pressure Containment Design	50,000,000.00	0.00610	39	183	428
Increase Reliability of Diverse Actuation System (DAS)	470,000.00	0.00022	2	7	15
100% Effective Design Alternative***		0.00734	47	221	551

* Benefits account only for offsite effects, 15.7% effective discount rate, 30-yr plant life, $1000/person-rem

** Benefits account only for offsite effects, 7% effective discount rate, 60-yr plant life

*** See discussion in Section 3.6.2

3.4.2 Staff Evaluation

The staff reviewed Westinghouse's bases for estimating the risk reduction associated with the various SAMDAs, and concluded that Westinghouse used a reasonable, and generally conservative, rationale and assumptions as the bases for the risk reduction estimates regarding each design alternative.

The level of risk reduction estimated for the various SAMDAs is driven by two underlying assumptions in the methodology. Specifically, Westinghouse's risk reduction estimates reflect only the contribution from internal events initiated at power, and they are point estimate (mean) values without consideration of uncertainties in core damage frequency (CDF) or offsite consequences. Although this is consistent with the approach taken in previous design alternative evaluations, further consideration of these factors could lead to significantly higher risk reduction values, given the extremely small CDF and risk estimates in the baseline PRA for internal events.

In assessing the risk reduction potential of SAMDAs for the AP600 design, the staff considered Westinghouse's risk reduction estimates for the various alternatives, in conjunction with supplementary parametric analyses to evaluate the potential impact of external events and uncertainties. These analyses are further discussed in Section 3.7 of this EA.

3.5 Cost Impacts of Candidate SAMDAs

3.5.1 Westinghouse Evaluation

Sections 1B.4.2, 1B.4.3, and 1B.8 of the SSAR discuss the capital cost estimates for the AP600 design alternatives evaluated by Westinghouse, and Table 1B.8-1 of the SSAR presents the results of the cost evaluations. Specifically, for each design alternative, Table 1B.8-1 lists the potential risk reduction, the capital benefit (assuming the design alternative was highly effective in reducing accident risks), the capital cost, and the net capital benefit. Notably, Westinghouse's cost evaluations did not account for factors such as design engineering, testing, and maintenance associated with each design alternative. If included, these factors would increase the overall costs and decrease the capital benefits of each alternative. Thus, this approach is conservative.

3.5.2 Staff Evaluation

To gauge the reasonableness of the cost estimates that Westinghouse presented in the SSAR, the staff compared the capital costs for the AP600 design alternatives with those evaluated for the ABWR and CE System 80+ designs. However, there is not an exact match in the design alternatives among the reactor designs, so only broad comparisons are possible.

For example, the AP600 active high-pressure safety injection system, which is estimated to cost $20 million, adds an active high-pressure safety injection pump and associated piping, valves, and supports, thus adding an entire new safety-related system to the AP600 design. This alternative can be compared to the alternative high-pressure safety injection for the CE System 80+ design, which is estimated to cost $2.2 million. However, the design alternative for the CE System 80+ design simply adds parallel piping and valves to an existing system, which would be expected to cost only a fraction of the total system price.

Similarly, the filtered containment vent for the AP600 design can be compared to systems with similar functions for the ABWR and the CE System 80+ designs. The AP600 design included a filtered containment vent and all associated piping and penetrations. The ABWR design added an ex-containment filter system to an existing venting system. The System 80+ design included a filtered containment vent similar to the multi-venturi scrubbing systems implemented in some European plants. The estimated costs for the three venting systems – $5 million, $3 million, and $10 million, respectively – reasonably agree with each other given the differences in the designs.

The costs for the non safety-grade containment spray for AP600 design, which was evaluated in an earlier version of SSAR Section 1B before it was incorporated into the AP600 design, can be compared to the reactor building sprays for the ABWR design and the alternative containment spray for CE System 80+ design. This AP600 design alternative involves adding piping and spray headers inside containment, and connects to an existing fire water system. Similarly, for the ABWR, the existing in-containment fire spray system would be modified to provide sprays in areas vulnerable to fission product release. The ABWR modification would thus be limited to providing sprays only to selected areas of containment. For the CE System 80+ design, this alternative involves adding piping to connect to the existing in-containment spray system, together with new pumps to supply the water. Estimated costs for these three spray systems were $415,000 for the AP600 design, $100,000 for the ABWR design, and $1.5 million for the CE System 80+ design. In light of the scope differences among these design alternatives, the estimates for the AP600 spray system appear to be reasonable.

These comparisons indicate that the cost estimates for several of the AP600 design alternatives reasonably agree with the costs for roughly similar design alternatives evaluated for the ABWR and the CE System 80+ designs.

To further assess the reasonableness of the AP600 design alternative cost estimates, the staff developed independent cost estimates for one particular design alternative, the active, non safety-related containment spray system. (This analysis was performed before the nonsafety-grade spray system was incorporated into the AP600 design and deleted from SSAR Section 1B.) The assessment assumed the addition of fire protection system grade spray headers and supply piping inside containment (carbon steel), and the addition of control valves and piping outside containment and connected to the existing fire water supply system. The resulting costs for the containment spray system ranged from about $300,000 to $350,000 (1996 dollars), depending on the assumptions made regarding the required pipe size. These independent estimates did not include design engineering; first-of-a-kind costs; or allowances for associated personnel training, procedure development, or recurring operations and maintenance costs. This approach is similar to that used in Westinghouse's cost estimation. Thus, the Westinghouse estimate of $415,000 for this design alternative reasonably agrees with the independent estimate. In addition, the staff developed an independent cost estimate for a containment spray system similar to that described above, but with increased pumping capacity. (The increased pumping capacity is needed because Westinghouse's letter of March 13, 1997, indicated that the currently designed fire water supply system is capable of delivering less than 1.89 kL/min (500 gpm) to the proposed containment spray system.) The system evaluated for this alternative would increase the fire water pump capacity so that each pump would be capable of delivering 11.36 kL/min (3000 gpm) to the containment sprays against a containment pressure of 310.3 kPa (30 psig). The piping used to supply fire water to the containment in the current design would be increased in size to reduce the flow resistance. This modification to the AP600 design was estimated to cost about $370,000 (1996 dollars). As with the foregoing estimate, no allowance was made for personnel training, procedure development, or recurring operations and maintenance costs.

On the basis of this audit, the staff viewed Westinghouse's approximate cost estimates as adequate, given the uncertainties surrounding the underlying cost estimates, and the level of precision necessary given the greater uncertainty inherent on the benefit side, with which these costs were compared.

3.6 Cost-Benefit Comparison

3.6.1 Westinghouse Evaluation

After considering the risk reduction potential and cost impact of the various SAMDAs, Westinghouse performed cost-benefit comparison to determine whether any of the potential severe-accident mitigation design features would be justified. To do so Westinghouse assessed the benefits of each design alternative in terms of potential risk reduction, which was defined as the reduction in whole-body person-rem per year received by the total population within a radius 80.5 km (50 mi.) of the AP600 plant site. Westinghouse then assigned a value of $1,000 to each person-rem of averted offsite exposure, which was assumed to account for both health effects and offsite property damage. This value was treated as the annual levelized benefit for averted risk.

To determine the maximum expenditure justified by a given reduction in risk ("maximum capital benefit"), Westinghouse divided the annual levelized benefit by the annual levelized fixed charge rate. The annual levelized fixed charge rate was determined to be 15.7 percent in current U.S. dollars on the basis of factors and methods provided in documents developed by the Electric Power Research Institute (EPRI P-6587-L) and the U.S. Department of Energy (DOE/NE-0095). Westinghouse calculated the fixed charge rate using a component "book life" of 30 years. The use of a high charge rate tends to minimize the capital benefit associated with each design alternative. Nevertheless, the 30-year life used in the calculations makes little difference in the economic benefit compared to the more typical 60-year life, particularly when the high levelized annual fixed charge rate of 15.7 percent is used.

The Westinghouse approach for calculating the benefits or reduced risk from each individual design alternative also does not give credit for averted onsite property damage and replacement energy costs which are realized through a reduction in accident frequency. The onsite property damage and replacement energy costs may have been neglected because the estimated CDF is very low. However, as indicated below, these onsite considerations can substantially add to the benefits that may be achieved using design alternatives.

Table 1 of this EA reports Westinghouse's cost-benefit estimates for each potential SAMDA using a screening criterion of $1,000/person-rem-averted to identify whether any of the SAMDAs could be cost effective. As shown in Table 1, the highest capital benefit calculated by Westinghouse for any design alternative is about $50, while the capital cost for the least expensive design alternative is $33,000. On this basis, Westinghouse concluded that no additional modifications to the AP600 design are warranted.

3.6.2 Staff Evaluation

The NRC recently updated its recommended approach for the monetary conversion of radiation exposures. Previous guidance specified that 1 person-rem of exposure should be valued at $1,000. This conversion factor for offsite doses was intended to account for both health effects and offsite property damage, and exposures incurred in future years were not to be discounted. The recent guidance given in the NRC's regulatory analysis guidelines (NUREG/BR-0058, Revision 2), recommends using $2,000 per person-rem of exposure as the monetary conversion factor. In addition for assessing values and impacts, future exposures are to be discounted to arrive at their present worth. Offsite property damage from nuclear accidents is to be separately valued, and is not part of the $2,000 per person-rem value.

Evaluations recently performed by Brookhaven National Laboratory for the NRC assessed total costs associated with offsite releases, including both health effects and property damage/loss effects (NUREG/CR-6349). Costs were assessed for each of the five NUREG-1150 plants (Grand Gulf, Peach Bottom, Sequoyah, Surry and Zion). The results indicated that overall costs associated with offsite releases of radioactive materials, presented on a cost per person-rem of exposure to the public, ranged from about $2,000 to more than $5,000 per person-rem, depending on factors such as the assumed interdiction criteria. A criterion of $3,000 per person-rem averted was added to account for offsite property damage and other related costs for severe accidents. Thus, the Westinghouse cost-benefit evaluation approach used for AP600 design alternatives is not consistent with the approach recommended in NUREG/BR-0058 Revision 2. The key differences are summarized in Table 2 of this EA, and the staff's independent evaluation is found below.

Table 2 Key Differences Between the Westinghouse Approach and NUREG/BR-0058

Westinghouse's SAMDA Approach	**NUREG/BR-0058 Recommended Approach**

$1,000 per person-rem averted (for valuing risk reduction)	$2,000 per person-rem averted to account for health effects, plus $3,000 per person-rem averted to account for other offsite effects and related costs
15.7% discount rate	7% discount rate
No accounting for benefits of averted onsite cleanup and decontamination costs	Consideration given for benefits of averted onsite cleanup and decontamination costs
No accounting for benefits of averted replacement energy costs	Consideration given for benefits of averted replacement energy costs

To arrive at a baseline potential benefit from the reduction in offsite risk, the staff applied the recommended approach in NUREG/BR-0058, Revision 2 to the design alternatives identified for the AP600 design. This EA used a discount rate of 7-percent and assumed a reactor life of 60 years. The averted risk for each design alternative was taken from Table 1B.8-1 of the SSAR. In addition, the staff used two monetary conversion factors for radiation exposures. The first is the $2,000/person-rem recommended in NUREG/BR-0058, Revision 2. The second, $5,000/person-rem, is intended to account for offsite property damage and health effects. The results for each design alternative are shown in columns 5 and 6 of Table 1. For comparison purposes, Westinghouse's estimates of the capital cost, averted risk, and capital benefit for each design alternative are also presented (columns 2, 3, and 4 of Table 1). A 100% effective design alternative would reduce the CDF and/or offsite releases to zero. Estimated benefits from a 100% effective design alternative are also shown for each of the alternative cost bases (last row of Table 1).

The results shown in Table 1 indicate that the benefits calculated using a 7-percent discount rate, a 60-year plant life, and a $2,000/person-rem conversion factor is about a factor of four higher than those calculated by Westinghouse. The benefits calculated using $5,000/person-rem are about a factor of 10 higher than those estimated by Westinghouse. The highest capital benefit shown in Table 1 amounts to less than $500, while the capital cost for the least expensive design alternative is $33,000. Thus, even with the highest benefit basis ($5,000/person-rem, 7-percent discount rate, 60-year life), the calculated benefits are almost two orders of magnitude too small to justify the addition of any of the design alternatives listed. It should be noted, however, that this assessment neglected the benefits from averted onsite costs, which are relevant for design alternatives that reduce core damage frequency. Dollar savings derived from averted onsite costs are treated as an offset or reduction in the capital cost of the design alternative in the staff's analysis. Averted onsite costs are significant for certain design alternatives and are further considered below.

3.7 Further Considerations

The estimates of potential design alternative benefits listed in Table 1 of this EA reflect Westinghouse's estimates of averted risk and neglect the benefits from averted onsite costs. As mentioned in Section 3.2 of this EA, Westinghouse's risk estimates do not account for uncertainties either in the CDF or in the offsite radiation exposures resulting from a core damage event. The uncertainties in both of these key elements are fairly large because key safety features of the AP600 design are unique, and their reliability has been evaluated through analysis and testing programs rather than operating experience. In addition, the estimates of CDF and offsite exposures do not account for the added risk from external events such as earthquakes.

To further explore these areas, the staff screened the candidate SAMDAs to determine whether any of the design alternatives could be cost-beneficial when the costs-benefit analysis incorporates uncertainties, added risk from external events, and averted onsite costs. The staff then performed a more detailed assessment for those design alternatives having potentially favorable cost-benefit factors under these more limiting considerations. These analyses are discussed in Sections 3.7.1 – 3.7.3 below.

3.7.1 Uncertainties in Core Damage Frequency and Accident-Related Exposures

Revision 8 to the PRA discussed the uncertainty in the estimated CDF for the AP600 design. Specifically, the CDF uncertainty distribution was characterized by an error factor (EF) of about 5.7. Assuming a log normal distribution, the EF is the ratio of the 95th percentile to the median, and also the ratio of the median to the 5th percentile. Thus, the CDF for internal events could be a factor of six higher or lower than assumed in the analysis discussed above.

Additional factors that could substantially increase the estimated CDF for the AP600 plant include the contributions from events and accident sequences that have not yet been identified, as well as those identified sequences that have not yet been analyzed in the PRA. Examples of the latter include external events such as fires and earthquakes. Notably, the CDF base estimate of 1.7E-07/reactor-year does not include the contribution of external events. In the PRA, Westinghouse indicated that external events, in particular internal fires, are estimated to increase the CDF by about a factor of four. However, the PRA available for this study did not define the potential contributions from seismic events, which could readily increase the CDF by an order of magnitude or more. These external events can also degrade the containment performance, so that the releases from containment may also be higher than for accidents associated with internal events.

The potential increases in CDF attributed to accident sequences that have not yet been identified is very difficult to estimate. Presumably, the contributions from such sequences should be small if Westinghouse performs the PRA in a thorough and systematic manner. For the purposes of the present analysis, the effects of these sequences are assumed to be captured by the potential increase in CDF attributed external events.

Section 1B.6 of the SSAR presented Westinghouse's estimates of offsite exposures for the major release categories (RCs) defined for the AP600 design. On the basis of the CDF reference value of 1.7E-07/reactor-year and the total risk of 7.3E-03 person-rem/reactor-year, Westinghouse estimated that the "average" offsite exposure is of the order of 50,000 person-rem per core damage event.   However, Westinghouse's documentation did not indicate the uncertainty in the estimated releases.

The average offsite exposure of 50,000 person-rem per AP600 core damage event estimated by Westinghouse is a factor of 2.7 lower than the average public exposures calculated for the five current-generation nuclear plants addressed in NUREG-1150 (after adjusting the NUREG-1150 plant releases to that of a 600-MWe plant). The better performance of the AP600 design may be attributed, in part, to methods and assumptions for defining source terms, as well as the high likelihood of successful RCS depressurization and in-vessel retention of damaged fuel in the AP600 design.

Uncertainties in the offsite exposure estimates for the AP600 design are significant. As described in Section 19.1.3.3.3 of NUREG-1512, the AP600 Final Safety Evaluation Report (FSER), the AP600 risk profile is shaped by the following major assumptions regarding containment failure modes and release characteristics:

- conservative assumptions regarding early containment failure from ex-vessel phenomena
- optimistic assumptions that external reactor vessel cooling will always prevent reactor pressure vessel (RPV) breach
- substantial credit for additional aerosol removal in SGTR events

If early containment failure is avoided (as suggested by deterministic calculations performed subsequent to the PRA), and reactor pressure vessel breach instead results in a more benign release (e.g., a containment failure in the intermediate time frame), overall risk for internal events would be reduced by about a factor of two. By contrast, if credit for external reactor vessel cooling (ERVC) is reduced or eliminated, containment failure frequency would increase proportionally, since all RPV breaches are assumed to lead to early containment failure in the baseline PRA. Under the most limiting assumption that ERVC always fails and leads to early containment failure, the containment failure frequency would approach the core melt frequency and risk would increase by a factor of 20 (to about 0.16 person-rem/yr). Similarly, offsite risk can be significantly impacted if the design fails to realize the decontamination factor (DF) of 100 applied to aerosol release fractions for SGTR events predicted by the materials access authorization program (MAAP) to account for fission product removal by impaction on steam generator tubes. With this credit for aerosol removal, the risk contribution from a containment bypass is minimal (6-percent of the total). Without this credit, overall risk for internal events would increase by a factor of seven and would be dominated by containment bypass releases. Finally, the PRA did not credit the impact of the non safety-related containment spray system on fission product releases. Containment sprays could significantly reduce the estimated risk in the baseline PRA (by perhaps a factor of 2), since the sprays would be effective in reducing the source terms in the risk-dominant RCs such as early containment failure (CFE) and containment isolation failure (CI). However, sprays would not impact releases attributed to SGTR events.

In summary, the actual offsite exposure could range from a factor of two lower to an order of magnitude higher than the Westinghouse estimate, given the uncertainties in the underlying analyses of containment performance. This uncertainty range was factored into the staff's reassessment discussed below.

3.7.2 Reassessment of Design Alternative Cost-Benefit Relationships in Light of Uncertainties

The staff-performed analyses reassess the benefits of potential AP600 design alternatives taking into account the uncertainties in estimated CDF, offsite releases of radioactive materials given a severe accident, and effects of external events. For these analyses, the staff estimated the *maximum* benefits that can be achieved with AP600 design alternatives, assuming that a alternative can either completely eliminate all core damage events or completely eliminate offsite releases of radioactive materials if a severe accident does occur. To calculate these estimated benefits, the staff used the FORECAST code (NUREG/CR-5595, Revision 1, "FORECAST: Regulatory Effects Cost Analysis Software Manual, Version 4.1," Science and Engineering Associates, Inc., July 1996). FORECAST allows the use of uncertainty ranges for all key parameters and provides a means to combine uncertainties in these parameters. It also provides a distribution for the bottom line costs or benefits, and thus presents a picture of the uncertainty in the "bottom line" figures. Table 3 of this EA presents the key parameters used in evaluating the maximum potential benefit.

Table 3 Key Parameters Used by FORECAST in Evaluating Maximum SAMDA Benefits

Parameter	**Value**
Reference AP600 core damage frequency	1.7E-7/reactor-year (EF=5.7)
Average public radiation exposure per accident:	43,200 person-rem (rounded to 50,000) (assumed error factor: 5)
Plant lifetime	60 years
Discount rate	7%
Conversion factor[1]	$5000/person-rem
Replacement energy costs	$277,000/day of downtime
Averted cleanup and decontamination costs[2]	$1,690,000,000 /major accident
Averted replacement energy costs[3]	$20,200,000,000/major accident

[1] Based on NUREG/CR-6349; accounts for both offsite health effects and offsite property damage effects
[2] Based on guidance provided in NUREG/BR-0184 (not adjusted for AP600-specific features)
[3] Based on average replacement energy costs for pressurized water reactors in the 500 – 1000 MWe range

For the purposes of estimating the maximum potential benefit from AP600 design alternatives, the staff assumed that external events and accident sequences not yet accounted for in the PRA would increase the reference CDF by two orders of magnitude, (i.e., a factor of 100), with an EF of six used for this higher CDF. The staff then evaluated cases assuming the reference value of 50,000 person-rem per accident. Table 4 of this EA presents the results of this analysis.

Table 4 SAMDA Benefits Accounting for Uncertainties and External Events Effects (Benefits, 1996$)

Case No.	Description	5% Confidence Level	Mean	95% Confidence Level
1	Base CDF (1.7E-07/yr) and reference offsite release (50,000 person-rem); design alternatives which reduce the accident frequency to zero	$1,100	$8,000	$26,600
2	Base CDF increased by factor of 100 to account for external events and other accident sequences not yet accounted for; other factors same as Case 1; design alternatives which reduce the accident frequency to zero	$90,500	$647,000	$2,257,000
3	Base CDF increased by factor of 100 to account for external events; other factors same as Case 1; design alternatives which reduce the offsite releases to zero, but do not change the accident frequency	$1,700	$49,000	$223,000

The entries in Table 4 indicate that design alternatives which prevent accidents (reduce the accident frequency to zero) are much more cost-effective than design alternatives which reduce or eliminate offsite releases but have no effect on accident frequency. This is because of the fairly large benefits associated with averted onsite cleanup and decontamination costs, and avoided replacement energy costs, neither of which are assumed to be impacted by design alternatives which do not reduce accident frequency.

Case 1 is the reference case utilizing the base CDF and Westinghouse-estimated offsite exposures. In this case, the estimated benefits are considerably higher than those cited in Table 1 of this EA, primarily because they include averted onsite cleanup and decontamination costs, as well as averted replacement energy costs.

Cases 2 and 3 show the effects of the higher CDF associated with external events, but do not include the effects of possible higher releases from containment attributed to such events. (In other words, these cases retain the base offsite exposure of 50,000 person-rem/event.) These cases may be used as the basic benefits including external events and assuming that external events would not impact containment performance. Case 2 shows the potential benefit range for a design alternative which could reduce the accident frequency to zero. Case 3 applies to a design alternative which would eliminate all offsite releases, but which would not impact the CDF.

Table 5 of this EA combines the information in Tables 1 and 4 to estimate the total benefit possible from specific design alternatives. The design alternatives are divided between those that impact the CDF and those that impact containment performance but not the CDF. Benefits have been estimated by taking the fractional reduction in risk for each design alternative (compared to the AP600 baseline risk as defined by Westinghouse) and applying that fraction to the mean benefits displayed in Table 4. Design alternatives that reduce the CDF were applied to the Case 2 mean benefit, while those that only effect containment performance were applied to the Case 3 mean benefit.

The values shown in Columns 4 through 7 of Table 5 reflect benefits calculated using the mean values. By contrast values shown in Columns 8 through 11 were calculated using the 95^{th}-percentile values. In other words, there is only a 5-percent chance that the actual benefits will be greater than the values shown in Columns 8-11.

The use of the maximum benefits typically improves the cost-benefit ratio by a factor of approximately five, but does not alter any of the overall conclusions about design alternatives that have acceptable cost-benefit ratios.

3.7.3 Further Evaluation of Design Alternatives With Potentially Favorable Cost-Benefit Factors

Design alternatives that are within a decade of meeting the cost-benefit criteria of $5,000/person-rem were subjected to further probabilistic and deterministic considerations, including a qualitative assessment of the following:

- the impact of additional benefits that could accrue for the design alternative if it would be effective in reducing risk from certain external events, as well as internal events

- the effects of improvements already made at the plant

- any operational disadvantage associated with the potential design alternative

None of the design alternatives have a cost-benefit ratio of less than $5,000/person-rem. However, the only design alternatives that come within a decade of the $5,000/person-rem standard are the diverse IRWST valves at $19,800/person-rem and the self-actuating containment isolation valves at $33,700/person-rem, as described in the following sections.

Table 5 Estimated Maximum Benefit from Individual SAMDAs

Design Alternative	Fractional Risk	Capital Cost	Mean Benefit from Reduced Risk[1]	Mean Benefit from Averted Onsite Costs[2]	Adjusted Capital Costs Reduced by Mean Averted Onsite Costs[3]	$/person-rem based on Mean Benefits[4]
Alternatives that Reduce Core Damage Frequency						
Upgrade Chemical and Volume Control System for Small LOCA <4"	0.075	$1,500,000	$3,675	$44,850	$1,455,150	$1,979,796
Active High-Pressure Safety Injection System	0.830	$20,000,000	$40,670	$496,340	$19,503,660	$2,397,794
Steam Generator Shell-Side Heat Removal	0.070	$1,300,000	$3,430	$41,860	$1,258,140	$1,834,023
Diverse IRWST Injection Valves	0.720	$570,000	$35,280	$430,560	$139,440	$19,762
Diverse Containment Recirculation Valves	0.020	$150,000	$980	$11,960	$138,040	$704,286
Increased Reliability of Diverse Actuation System	0.030	$470,000	$1,470	$17,940	$452,060	$1,537,619
Alternatives that Reduce Offsite Releases but do not Impact Core Damage Frequency						
Filtered Containment Vent	0.136	$5,000,000	$6,664		$5,000,000	$3,751,501
Self-Actuating Containment Isolation Valves	0.100	$33,000	$4,900		$33,000	$33,673
Passive Containment Sprays	0.940	$3,900,000	$46,060		$3,900,000	$ 423,361
Direct Steam Generator Safety and Relief Valve Flow to the IRWST	0.057	$620,000	$2,793		$620,000	$1,109,918
Increased Steam Generator Pressure Capability	0.057	$8,200,000	$2,793		$8,200,000	$14,679,500
Secondary Containment filtered Ventilation	0.100	$2,200,000	$4,900		$2,200,000	$2,244,898
Ex-Vessel Core Catcher	0.830	$1,660,000	$40,670		$1,660,000	$204,082
High-Pressure Containment Design	0.830	$50,000,000	$40,670		$50,000,000	$6,147,037

1- Benefit because of reduced offsite exposures. For design alternatives that reduce CDF, this value also includes any benefits from reduced occupational exposures from averted onsite cleanup and decontamination efforts.
2- Benefits from averted onsite costs (i.e., averted cleanup and decontamination costs and averted replacement energy costs.)
3- The benefits from averted onsite costs are used to effectively reduce the capital cost of each design alternative.
4- The cost-benefit ratio for each AP600 design alternative evaluated as “mean” estimates of benefits. Each person-rem of averted public exposure was assigned a value of $5,000.

3.7.3.1 Diverse IRWST Injection Valves

In the current AP600 design, a squib valve in series with a check valve isolates each of four IRWST injection paths. This design alternative would reduce the likelihood of common cause failures of IRWST injection to the reactor by utilizing diverse valves in two of the four paths. If it functioned perfectly, this design alternative could potentially reduce the CDF by about 72-percent. When taking into account external events, other accident sequences not yet included in the AP600 PRA, and other uncertainties, this design alternative is estimated to be highly cost-effective. In the absence of a comprehensive external events PRA for the AP600 plant, it is difficult to estimate the effectiveness of this design alternative in reducing the risk from such events. However, it appears likely that failure to inject coolant to the reactor would remain a prominent contributor to the CDF from external events, in which case, diversity in the IRWST injection valves should help to reduce the risk from both external and internal events.

Alternative vendors are available for the check valves, however, it is questionable whether check valves from different vendors would be sufficiently different to be considered diverse unless the type of check valve was changed from the current swing disk check valve to another type. The swing disk type is preferred for this application, and other types are considered less reliable.

Adding diversity to the injection line squib valves would require additional spares at the plant, and some additional training for plant operations and maintenance staff, but would not appear to add significantly to the operational aspects of the AP600. However, a greater issue concerns the availability and costs of acquiring diverse valves from a second vendor. Squib valves are specialized valve designs for which there are few vendors. Westinghouse claims that a vendor may not be willing to design, qualify, and build a reasonable squib valve for this AP600 application considering that they would only supply two valves per plant. The cost estimate for this design alternative assumes that a second squib valve vendor exists and that the vendor would provide only the two diverse IRWST squib valves. The cost impact does not include the additional first-time engineering and qualification testing that would be incurred by the second vendor. (Westinghouse estimated that those costs could be more than a million dollars.) As a result, Westinghouse concluded that this design alternative would not be practicable because of the uncertainty in availability of a second squib valve design/vendor and because of the uncertainty in reliability of another type of check valve. The staff considers the rationale set forth by Westinghouse regarding the potential reductions in reliability and high costs associated with obtaining diverse valves to be reasonable. On the bases of these arguments, the staff concludes that this design alternative need not be further pursued.

3.7.3.2 Self-Actuating Containment Isolation Valves

This design alternative would reduce the likelihood of containment isolation failure by adding self-actuating valves or enhancing the existing containment isolation valves for automatic closure when containment conditions indicate that a severe accident has occurred. Conceptually, the design would be either an independent valve or an appendage to an existing fail-closed valve that would respond to post-accident containment conditions within containment. For example, a fusible link would melt in response to elevated ambient temperatures, thereby providing the self-actuating function to vent the air operator of a fail-closed valve. This design alternative is estimated to impact releases from containment by only 10-percent. It has a cost-benefit ratio of $33,000/person-rem, and achieves this ratio primarily because of its low capital costs.

This improvement to the containment isolation capability would appear to be effective in reducing offsite releases for accidents involving either external or internal events. Also, the effectiveness of this design alternative would not be affected by the design changes made as a result of the AP600 PRA.

The addition of this design alternative would impose minor operational disadvantages to the plant in that the operations and maintenance staff would require some additional training. In addition, these automatic features would require periodic testing to ensure that they are functioning properly.

Perhaps the biggest question regarding this design alternative is whether it can be implemented for a cost of only $33,000. The cost estimate does not appear to include the first-time engineering and qualification testing that would be required to demonstrate that the valve would perform its intended function in a timely and reliable manner. The costs associated with periodic testing and maintenance also do not appear to have been included. The staff believes that the actual costs of this design alternative would be substantially higher than Westinghouse’s estimate (perhaps by a factor of 10) when all related costs are realistically considered. On the basis of the unfavorable cost-benefit ratio, and the expectation that actual costs would be even higher than estimated by Westinghouse, the staff concludes that this design alternative is not cost-beneficial and need not be further evaluated.

3.8 <u>Conclusions</u>

As discussed in Section 19.1 of AP600 FSER, Westinghouse extensively used the PRA results to arrive at a final AP600 design. As a result, the estimated CDF and risk calculated for the AP600 plant are very low both relative to operating plants and in absolute terms. Moreover, the low CDF and risk for the AP600 design reflect Westinghouse's efforts to systematically minimize the effect of initiators/sequences that have been important contributors to CDF in previous PWR PRAs. Westinghouse has achieved this objective largely by incorporating a number of hardware improvements in the AP600 design. These and other AP600 design features which contribute to low CDF and risk for the AP600 design are discussed in Section 19.1 of the AP600 FSER.

Because the AP600 design already contains numerous plant features oriented toward reducing CDF and risk, the benefits and risk reduction potential of additional plant improvements are significantly reduced. This is true for both internally and externally initiated events. Moreover, with the features already incorporated in the AP600 design, the ability to estimate CDF and risk approaches the limitations of probabilistic techniques. Specifically, when CDFs of 1 in 100,000 or 1,000,000 years are estimated in a PRA, it is the area of the PRA where modeling is least complete, or supporting data is sparse or even nonexistent, that could actually be the more important contributors to risk. Areas not modeled or incompletely modeled include human reliability, sabotage, rare initiating events, construction or design errors, and system interactions. Although improvements in the modeling of these areas may introduce additional contributors to CDF and risk, the staff does not expect that additional contributions would change anything in absolute terms.

The staff concurs with Westinghouse’s conclusion that none of the potential design modifications evaluated are justified on the basis of cost-benefit considerations. The staff further concludes that it is unlikely that any other design changes would be justified on the basis of person-rem exposure considerations, because the estimated CDFs would remain very low on an absolute scale.

4.0 THE ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

Issuing an amendment to 10 CFR Part 52 certifying the AP600 design would not constitute a significant environmental impact. The amendment would merely codify the results of the NRC's review and approval of the AP600 design as defined in the FSER, dated September 1998 (NUREG-1512). Further, because the amendment is a rule, there are no resources involved that would have alternative uses.

As described in Section 3 of this EA, the NRC reviewed alternatives to the design certification rulemaking and alternative design features related to preventing and mitigating severe accidents. Consideration of alternatives under NEPA was necessary (1) to show that the design certification rule is the appropriate course of action, and (2) to ensure that the design codified in the certification rule would not exclude any cost-beneficial design changes related to the prevention and mitigation of severe accidents. The NRC concludes that the alternatives to design certification did not provide for resolution of issues as did the proposed design certification rulemaking.

This design certification rulemaking is in keeping with the Commission's intent in the "Standardization and Severe Accident Policy Statements," and 10 CFR Part 52, to make future plants safer than the current generation plants, to achieve early resolution of licensing issues, and to enhance the safety benefits of standardization. Through its own independent analysis, the NRC also concludes that Westinghouse adequately considered an appropriate set of SAMDAs, and none were found to be cost-beneficial. Although no design changes resulted from reviewing the SAMDAs, Westinghouse had already incorporated certain features in the AP600 design on the basis of the PRA results. Section 3.2 of this EA presents examples of these features. These design features relate to severe accident prevention and mitigation, but were not considered in the SAMDA evaluation because they were already part of the design. See FSER Section 19.1.6, "Use of PRA in the Design Process."

Finally, the certification rule by itself would not authorize the siting, construction, or operation of an AP600 design nuclear power plant. The issuance of a CP, ESP, COL, or OL for the AP600 design will require a prospective applicant to address the environmental impacts of construction and operation at a specific site. At that time, the NRC will evaluate the environmental impacts and issue an EIS in accordance with NEPA. The SAMDA analysis for the AP600, however, has been completed as part of this EA and will not need to be reevaluated as part of an EIS related to siting, construction, or operation.

5.0 AGENCIES AND PERSONS CONSULTED, AND SOURCES USED

The sources for this EA include Westinghouse's "AP600 Standard Safety Analysis Report," as amended, August 19, 1998; and the NRC's "Final Safety Evaluation Report Related to the Certification of the AP600 Standard Design" (NUREG-1512, Volumes 1, 2 and 3), September 1998.

The Director, Office of Nuclear Reactor Regulation (NRR), has determined under the National Environmental Policy Act of 1969, as amended, and the NRC's regulations in 10 CFR Part 51, Subpart A, that this rule is not a major Federal action significantly affecting the quality of the human environment, and therefore, an EIS not required. The basis for the determination, as documented in this final EA, is that the amendment to 10 CFR Part 52 would not authorize the siting, construction, or operation of a facility using the AP600 design; it would only codify the AP600 design in a rule. Therefore, the NRC staff did not issue this EA for comment by Federal, State, and local agencies. However, the NRC's finding of no significant environmental impact was published in the Federal Register on XXX XX, 1999, together with the proposed AP600 design certification rule and there were no comments received related to this EA. The NRC will evaluate the environmental impacts and issue an EIS as appropriate in accordance with NEPA as part of the application(s) for the siting, construction, or operation of a facility.

The Director of NRR finds that Westinghouse's evaluation provides a sufficient basis to conclude that there is reasonable assurance that an amendment to 10 CFR Part 52 certifying the AP600 design will not exclude a severe accident design alternative for a facility referencing the certified design that would have been cost-beneficial had it been considered as part of the original design certification application. The evaluation of these issues under NEPA is considered resolved for the AP600 design.