Westinghouse Electric Corporation
Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: T. R. QUAY

SUBJECT: DRAFT OF AP600 PRA CHAPTER 57

Dear Mr. Quay:

Enclosed with this letter is a draft copy of Chapter 57 of the AP600 Probabilistic Risk Assessment (PRA) covering the at-power internal fire analysis.

This draft of the AP600 PRA is being submitted for the NRC to begin their review of the revised internal fire analysis. Additionally, as agreed to with the Probabilistic Safety Assessment Branch, the enclosure is being provided for the staff to review and provide initial feedback during the upcoming Westinghouse/NRC PRA meeting scheduled for June 24-26, 1996. Please provide a copy of the enclosure to Mr. Nick Saltos of the NRC. As requested by Mr. Saltos, a separate copy is being transmitted directly to Dr. Nathan Siu of INEL.

The completed at-power internal fire analysis will be provided in Revision 7 of the AP600 PRA, which has an expected transmittal date to the NRC of June 28, 1996.

Please contact Cynthia L. Haag on (412) 374-4277 if you have any questions concerning this transmittal.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

Enclosure

/nja

cc: J. Sebrosky, NRC (without enclosure)
D. Jackson, NRC (enclosure)
J. Flack, NRC (without enclosure)
N. Siu, INEL (enclosure)
N. Liparulo, Westinghouse (without enclosure)

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Enclosure 1 to Westinghouse
Letter NSD-NRC-96-4748
June 14, 1996

CHAPTER 57

INTERNAL FIRE ANALYSIS

57.1 INTRODUCTION

This section provides an overview of the Probabilistic Risk Assessment (PRA) methodology used for analyzing the internal fire hazard for the AP600 design. A qualitative screening and a quantitative analysis were performed as follows:

- Fire areas of potential risk significance were identified using initial qualitative screening steps consistent with those defined in the Fire Induced Vulnerability Evaluation (FIVE) methodology document (Reference 57-1). A modified FIVE methodology qualitative screening procedure was applied, as described in Section 57.2. The following modifications were made to the FIVE methodology:

  - Fire propagation between fire areas that share boundary(ies) were considered possible if the boundary contained any type of penetration (e.g., sealed cable penetrations or fire doors).

  - Those fire areas in which a fire was assumed to cause a plant shutdown, but the fire itself did not impact operability of any PRA-credited shutdown system, were screened out on the basis that these areas will have a low contribution to core damage frequency (CDF) (less than 1.0E-9).

  The results of this screening are presented in Section 57.6.

- Those fire areas that survived the qualitative screening were subjected to quantitative analysis, which included the following evaluations:

  - Fire frequency calculations for each fire area based on both generic experience (U.S. plant experience obtained from the Reference 57-2) and fire area specific features

  - Conditional probability of inter-area fire propagation calculations based on the fire protection features of the fire area

  - Conditional probability of equipment failure mode (spurious operation versus non-spurious operation) calculations based on the data and discussion presented in NUREG/CR-2258 (Reference 57-11) and plant-specific features

  - Bounding estimate of the conditional probability of core damage calculation based on postulated fire-induced equipment damage and using the internal events PRA model

Section 57.3 describes the methodology that was applied in the quantitative analysis.

Attachment 57A of this chapter provides the definitions of some of the more important terms used in this analysis.

57.2 QUALITATIVE ANALYSIS METHODOLOGY

The purpose of the qualitative analysis is to identify the boundaries of the plant fire areas and, if necessary, their respective compartments, together with the location of fire-susceptible equipment and cables within the areas which, if damaged by fire, could cause a plant shutdown and degradation of shutdown paths identified in the AP600 PRA. That information is used as a basis for systematically screening out fire areas from further consideration using the non-probabilistic criteria developed in the FIVE methodology document and additional probabilistic arguments. This additional probabilistic criterion states that fire areas that do not contain components or cabling, which if damaged would degrade any PRA-credited equipment, can be screened out based on their low contribution to core damage frequency. Further use was made of the information gathered during this stage in the quantitative analysis.

The qualitative screening analysis performed for AP600 consists of the following steps:

Step 1 Using the FIVE definition of a fire area (see Attachment 57A) and referencing information provided in Table 9A-6 of the AP600 Standard Safety Analysis Report (SSAR) (Reference 57-7) and the fire area drawings in SSAR Appendix 9A, the plant fire areas were identified.

Fire areas presented in this analysis file correspond to the fire areas defined in the AP600 SSAR, Appendix 9A, with one exception. The Radwaste Building was analyzed as a single location, and fire areas in this building were not broken out.

Step 2 Using fire area drawings and discussions with design engineers, the plant's fire areas were divided into the following types:

1. Totally Safety-Related Fire Areas (TSFA)
2. Mixed Safety-Related Fire Areas (MSFA)
3. Non-Safety-Related Fire Areas (NSFA)

Definitions for these plant fire areas are provided in Attachment 57A.

Step 3 Using the information provided in Sections 6.3, 7.4, and 15 of the AP600 SSAR, and Chapters 4 and 6 of the AP600 PRA, a list of safety-related and nonsafety-related systems that can bring the plant to a safe and stable shutdown condition was developed.

Table 57-1 presents a summary of the various systems that the internal-events PRA credits for providing the mitigating functions necessary to prevent core damage.

Note that in this bounding fire analysis, when calculating the conditional core damage probability (CCDP), only the safety-related systems which can bring the plant to a safe and stable shutdown condition were credited. That is, this analysis uses the same bases as the focused PRA sensitivity study.

Step 4 The data provided in Appendix 9A of the AP600 SSAR were used to identify safety-related Safe Shutdown Divisions (SSD) that could be affected by a fire in each TSFA.

Step 5 The data provided in Appendix 9A of the AP600 SSAR, discussion with design engineers, and plant arrangement drawings were used to identify safety-related safe shutdown components that could be affected by a fire in each MSFA.

Step 6 Plant arrangement drawings, design basis philosophies for separation of the components and cabling associated with the safety and nonsafety-related systems, and interviews with plant designers were used to identify the nonsafety-related shutdown equipment that could be affected by a fire in each MSFA and NSFA. This represents the set of nonsafety-related PRA-credited shutdown systems with components and/or power, control, or instrumentation cables routed through the fire area under consideration.

Step 7 If an MSFA or NSFA was further subdivided into several fire compartments, the impact of a fire on safety and nonsafety-related systems in each fire compartment was determined using the same approach as stated in Steps 4, 5, and 6.

Step 8 Using the information obtained in Steps 4, 5, 6, and 7, a summary of the shutdown systems disabled or degraded in each fire area or fire compartment was developed.

Step 9 The potential for fire propagation across fire area boundaries was considered for all fire areas. The AP600 fire areas are bounded by barriers that will withstand the fire hazards within the fire area and, as necessary, protect important equipment within a fire area from a fire outside the area. In this analysis it was assumed that fire propagation across a fire area boundary could occur:

- If the integrity of a fire area boundary had been compromised by a previously undetected barrier element failure (e.g., penetration seal failure), and
- If the fire suppression activities in the exposing fire area failed to contain the fire within the area.

In assessing the probability and impact of fire propagation, the following ground rules were followed:

- Fires originating in a fire area (exposing fire area) could only propagate to an adjacent fire area (exposed fire area), and no further propagation beyond the exposed fire area was considered to be credible.

- Simultaneous fire propagation from the exposing fire area to more than one adjacent fire area was not considered credible.

- Fire propagation from fire areas with less than 20,000 Btu/sq. ft. combustible loading was not considered credible on the basis that a significant fire cannot develop in the area.

- Fire propagation out of the containment fire area was not considered credible on the basis of very low combustible loading of the containment fire area.

- Fire propagation into the containment fire area from areas outside the containment fire area was not considered credible. The low combustible loading and the large volume of the containment preclude propagation with the potential to cause a damage-producing fire environment inside the containment. Thus, for this analysis, the consequences of propagated fires into the containment were considered to be bounded by the consequences of fire in the exposing fire area.

Step 10 In this step, the existence of a requirement for plant shutdown was determined. For fire areas with no credible propagation pathway, as determined in Step 9, the existence of a requirement for plant shutdown was determined assuming that all equipment and cables in the fire area were damaged. For fire areas where fire propagation was credible, the existence of a requirement for plant shutdown was determined assuming that the fire had propagated to an adjacent fire area and that all equipment and cables in both the exposing and the exposed fire areas were damaged. The fire-induced damage scenarios in which fire propagation to a given adjacent area would have the most severe consequences were selected as appropriate for further development.

A requirement for shutdown was assumed unless it could be shown that the fire would not cause an automatic trip, or that plant operating conditions or violation of technical specifications would not require a shutdown within 8-hours. This evaluation required consideration of several aspects of plant design and operation.

A fire area was screened out from further analysis based on the following criteria:

- If the fire was not expected to create a demand for safe shutdown under normal plant operating conditions, and if none of the PRA-credited equipment was considered damaged. (Note that it is not necessary to assume a loss-of-offsite power (LOOP), unless the postulated fire may induce such an event.)

- If the fire was expected to cause a plant shutdown due to technical specification requirements but was not postulated to impact operability of any PRA-credited shutdown systems. This criterion was judged to be acceptable on the basis that the conditional core damage probability for initiating events that do not cause loss of any PRA-credited shutdown systems is very low (on the order of E-9 or below). Multiplying this low probability with the frequency of such events would give an even lower core damage frequency.

Step 11 For those areas not screened out, a qualitative assessment of the consequences of the fire was performed. As part of this qualitative evaluation, the consequences of different fire-induced cable failure modes (open or short) were considered.

Based on the review of the safe shutdown systems and equipment, in addition to subsections 9A.3.7 (Special Topics) and 9A.2.7.1 (Criteria and Assumptions) of Appendix 9A of the SSAR, spurious operations that could affect the ability to shut down the plant were identified. Active components (motor-operated valves, air-operated valves, etc.) were considered to spuriously operate. The component selection in Appendix 9A and this analysis is based on:

- A review of systems being utilized for shutdown to identify high-low pressure interfaces of any primary coolant boundary, and

- A review of systems to identify which spurious operations may interrupt system operations.

For areas where spurious operation was considered, two scenarios were developed for quantitative evaluation:

1. A scenario that assesses fire damage without the relevant spurious actuation(s).

2. A second scenario that includes such spurious actuations.

The quantitative analysis treats the second scenario probabilistically in these cases.

57.3 QUANTITATIVE METHODOLOGY OF FIRE AREA FREQUENCY

The purpose of this task is to evaluate the postulated fire-induced damage states' contribution to core damage frequency. The following sub-tasks were performed to achieve this objective:

- Fire frequency calculations
- Fire damage category quantification

57.3.1 Fire Frequency Calculations

The purpose of this sub-task was to evaluate the fire frequency for areas and compartments that were not screened out in the qualitative screening process described in Section 57.2.

The fire frequency calculations were performed using the methods provided in the FIVE methodology (Phase 2, Step 1, of Reference 57-1) and generic fire data information provided in the Fire Events Database (Reference 57-2). The approach requires the analyst to weigh generic fire data according to the specific types and quantity of ignition sources present in the area being evaluated. FIVE provides detailed guidance for determining both "Location Weighing Factors" and "Ignition Source Weighing Factors" and a formalized documentation process for recording input data and calculating fire frequencies.

The area/compartment ignition sources and the fire frequency calculations were documented according to the FIVE Attachment 10.2, Table 3, Ignition Source Data Sheet (ISDS).

57.3.2 Fire Damage Category Quantification

The objectives of this sub-task were:

- To determine the frequency of fire damage states (FDS) postulated during the qualitative analysis based on:
  - The frequency of fires developed in the ignition source data sheets
  - The probability of inter-area fire propagation
  - The probability of a specific fire-induced cable fault occurring

- To estimate a bounding value of fire-induced core damage frequency based on:
  - The frequency of FDS obtained as the result of accomplishing the first objective.
  - CCDP calculated by quantifying the focused PRA internal events model (which only credits safety-related systems mitigation functions) given the damage postulated for a specific FDS.

The objectives of this sub-task were achieved by performing the following steps:

Step 1 Based on the description of FDSs, defined in the qualitative analysis, each postulated FDS is characterized by defining a particular "initiating event" and "accident mitigating system damage."

Step 2 The postulated FDSs are then binned into Fire-Induced Damage Categories (FIDCs) DC1, DC2, DC3, etc., based on the result of Step 1.

Step 3 Probability of fire propagation is calculated based on the failure probability of the fire protection features (barrier failure, suppression/detection failure). subsection 57.3.1 presents the approach used to estimate these probabilities.

Step 4 Probability of a specific fire-induced fault occurring is calculated based on the nature of the fault (i.e., open circuit or hot short) that is postulated to occur. In fire PRAs, two types of fire-induced cable-failure modes are considered; namely open circuits and hot shorts. Open circuit failures are the dominant failure mode. Hot shorts are less likely to occur but can happen and may have a significant consequence. Based on NUREG/CR-2258 (Reference 57-11), the best-estimate conditional probability of a hot short event, given occurrence of fire-induced cable damage, is approximated to be 0.06.

Step 5 The total fire frequency of a fire area, as presented in the fire Ignition Source Data Sheets (ISDS), is distributed among the postulated FDSs for that area using the results of Steps 3 and 4, in addition to the description of the FDSs.

Step 6 The conditional core damage probability for each FIDC is obtained by quantifying the focused PRA internal events model for a given FIDC.

Step 7 The contribution of each fire area to core damage frequency is calculated by multiplying the frequency of the area's postulated FDSs, obtained from Step 5, by the CCDP of the damage category assigned to the FDSs. That is:

$$C^{FDSj}_{CDF} = CCDP^{FDSj}_{FDCi} * F_{FDSj}$$

where:

C^{FDSj}_{CDF} = Contribution of fire damage state "j" to CDF

$CCDP^{FDSj}_{FDCi}$ = CCDP of FIDC "i" which is assigned to represent FDS "j"

F_{FDSj} = Frequency of fire damage state "j"

Step 8 The contribution of a fire area, CDF_{FAx}, to core damage frequency is obtained by adding the contribution of its postulated FDSs to core damage frequency. That is:

$$CDF_{FAx} = \sum_{1}^{j} C^{FDSj}_{CDF}$$

Step 9 Similar to that described on page 10.50 of NUREG/CR-2815 (Reference 57-13) a fire area is screened from further evaluation if its total contribution to core damage frequency is smaller than one percent of the overall internal events core damage frequency. The overall internal events core damage frequency is approximately 3E-7 per year. Thus, the screening value can be set as 0.01 * 3E-7 = 3E-9 per year. Conservatively, 1.00E-9 is selected as the screening criterion.

Note that the overall internal events core damage frequency used to establish the screening value is the baseline core damage frequency, where both safety-related and nonsafety-related systems are credited for shutdown, whereas the conditional core damage probability used in this analysis was calculated using the focused PRA model. Thus, the screening criterion set in this analysis is very conservative.

Step 10 The contributions from unscreened fire areas are summed to estimate the fire-induced core damage frequency.

57.3.2.1 Probability of Inter-Area Fire Propagation

It is conservatively assumed that all fires initiating from the ignition sources identified in the ISDS will fully develop with capability to propagate if their propagation is not impeded by fire suppression activities or fire barrier elements. The dominant fire propagation pathways between fire areas are wall penetrations, fire doors, and ventilation ducts. To assess the probability of fire propagation, the following factors have to be considered:

- Fire Severity - For a fire to propagate beyond a fire area, and have a noticeable impact on the cables and components in the exposed fire area, it has to be a fully developed (severe) fire. The major factors influencing the fire severity include the fuel availability, relative location of ignition source and the fuel, and reliability of the fire suppression measures.

- Fire Barrier Integrity - The barrier elements (e.g., fire doors, penetration seals, etc.) must fail or be inadvertently breached.

The following paragraphs discuss the above factors in more detail.

Fire Severity - Probability of Fully Developed Fires

The historical evidence, reported in the fire events data base (Reference 57-2), indicates that fires originating from many of the ignition sources listed in the ISDSs tend to be localized fires with limited severity. For example:

- All "welding/ordinary combustibles"-induced fires reported in the fire event database were manually extinguished with little or no impact.

- The authors of NSAC/178L, Fire Events Database (Reference 57-2), state on page 4-6 that:

  "A review of the electrical cabinet fires in the data-base indicated that it is unlikely that an electrical cabinet fire would damage other equipment. Of the more than one hundred such fires, only one appeared to cause damage based on the event description and the source information. In that event, the additional buses lost appear more likely to be as a consequence of the electrical failure rather than the fire itself."

That is, the majority of fires either self-extinguished or were suppressed with no propagation between fire areas. Thus, it was judged that there would be sufficient time available for confining a fire within an area. Fire confinement can be achieved either manually or automatically. In the AP600 analysis, manual suppression was, conservatively, not credited for preventing fire propagation to an adjacent area. Additionally, for the AP600 fire analysis, fire suppression in the exposed fire area was not credited to prevent fire propagation into that area.

Table 57-2a presents the automatic fire suppression system failure probabilities used in this study. These probabilities are based on the failure to suppress values presented in NSAC/179L (Reference 57-4) and the FIVE methodology.

A list of fire areas where the automatic fire suppression system is credited to reduce the probability of fire propagation is provided in Table 57-2b.

Fire Barrier Integrity - Probability of Fire Barrier Element Failure

Fire doors, piping or cable penetrations, and ventilation ducts, are the major fire propagation pathways. To assign a failure probability for any given fire barrier, generic failure data pertaining to the fire barrier elements and relevant plant-specific data (e.g., number of doors) have to be known. The generic failure data can be obtained from many sources including NUREG/CR-4840 (Reference 57-14), which is presented in Table 57-3.

The barrier-specific failure probability can be obtained by determining the number of each element in the barrier, multiplying by the corresponding failure probability, and summing the contributions from different elements. However, during the Design Certification stage of the plant layout design process, plant-specific data (i.e., data pertaining to the number of

penetrations or vent ducts) are impractical to designate. Thus, the total failure probability of a barrier (independent of the type of element and number of elements in each barrier) is assumed to be 0.01. This is considered to be a realistic value since, as presented in Table 57-3, failure probability of a barrier is dominated by the fire door failure probability. Unlike early fire door designs, which contribute to the NUREG/CR-4840 data, the AP600 fire doors are designed to have alarms that annunciate in the control room if they were to be left open. Thus, for the AP600 design, the probability of a fire door being left open, facilitating fire propagation, is expected to be less than 7.4E-3.

57.4 CORE DAMAGE QUANTIFICATION METHODOLOGY

The starting point for this effort is the list of fire scenarios identified, and the initiating event frequencies calculated as described in Sections 57.2 and 57.3. The steps in the process for the core damage scenario quantification are as follows:

1. For each identified fire scenario, select a PRA initiating event representative of the impacts from that scenario, based on the fire scenario description.

2. For each fire scenario, identify assumed fire damage to accident-mitigating equipment, based on the fire scenario description.

3. For each fire scenario, assign a damage category, for use in grouping sequences with similar impacts (i.e., similar initiating events and damaged equipment) to minimize the number of sequences to be quantified.

4. Group the fire scenarios by damage category, and identify sequences for which quantification is required to obtain the CCDP, given the occurrence of the fire initiator.

5. Quantify CCDPs for each damage category (as described below).

The selection of the initiating events was based, to the extent possible, on evaluation of how the plant would behave if the identified impacts occurred. This is a somewhat subjective process. However, an attempt has been made to select the most limiting event (i.e., events with the highest conditional core damage probabilities) appropriate to the scenario. For example, events for which the fire had the potential to affect secondary-side cooling were modeled as either loss-of-main feedwater (LMFW) or loss-of-offsite power (LOOP) events (which have similar impacts and CCDPs in the focused PRA). If the fire impacts were limited to reactor trip, or reactor trip with unavailability of equipment not required for safe shutdown (e.g., diesel generator failure), the event was modeled using the Focused PRA transient event tree.

Spurious ADS actuation scenarios were modeled both as medium LOCAs (due to opening of a single ADS stage 4 valve) and as large LOCAs (due to opening of two stage 4 valves). This is further discussed in the assumptions in the next subsection.

The scenarios were grouped according to damage category. Where there was a group of similar damage categories, one category was selected as bounding for the group, and the event and degraded equipment representative of this category were quantified. For example, there are scenarios involving spurious ADS actuations with failure of division A of power and control, other scenarios involving spurious ADS actuations with failure of division B of power and control, scenarios with ADS actuation and failure of division C of power and control, and scenarios with ADS actuation and failure of division D of power and control. The relative impacts of loss of one division versus another were judged to be minor. In this case, all of the corresponding large LOCA scenarios were quantified together as spurious actuation of the two stage 4 ADS valves associated with division D, plus failure of components served by division D; all of the corresponding medium LOCA scenarios were quantified together as spurious actuation of one ADS stage 4 valve served by division D plus failure of components served by division D.

A total of 15 fire damage categories were selected for quantification using the above approach. As noted in the assumptions in the next section, the quantification has been performed using the focused PRA models and assumptions (in particular, the unavailability of nonsafety systems) in order to bound the potential fire core damage frequency.

For scenarios not involving the fire-induced failure of safety systems, the process is as follows. All cutsets pertinent to the fire scenario of interest are captured from the Focused PRA total core damage at power cutset output file. For these cutsets, the existing internal initiating event frequency is replaced with the value of 1.0. The cutsets are then requantified.

For scenarios in which the fire results in failure of safety systems, the process is similar. In addition, the failure probabilities of components that would be disabled by the fire are set to 1.0. Then the cutsets are requantified.

57.5 FIRE ANALYSIS ASSUMPTIONS

57.5.1 Qualitative Analysis Assumptions and Other Modeling Considerations

The following assumptions were made for the qualitative screening analysis and the quantification of fire area frequencies:

a. The same success criteria as those assumed in the internal events PRA were used; that is, reaching and maintaining a safe, stable state as characterized by achievement of stable RCS temperature, pressure, and inventory for 24 hours.

b. Passive mechanical components (e.g., check valves, tanks, pipes) exposed to fire are assumed to remain structurally intact as pressure barriers or structural members of a system.

c. Based on discussion with plant designers and review of SSAR Appendix 9A, it was assumed for stairwell and elevator shaft fire areas:

1. Either that no safety or nonsafety-related component or cabling required for plant shutdown is present in the area, or that only safety-related cabling that is protected by 3-hour rated barriers is present.

2. Fires originating in these fire areas would not cause an automatic reactor trip.

3. Fires originating in these areas would not cause plant operating conditions or violation of the technical specifications that would require a shutdown within eight hours.

d. The combustible loading within the stairwell fire areas is negligible (i.e., significantly less than 5,000 Btu/sq. ft.), and transient combustibles will not be stored within these areas. Thus, fire propagation to the other plant fire areas from the stairwell fire areas was discounted.

e. Based on review of the components and cabling located in the Radwaste Building, fires in any one of the Radwaste Building fire areas would not initiate a plant trip or cause requirement for shutdown within eight hours of the fire.

f. It was assumed that a fire impacting a safety-related division of power would cause spurious opening of the containment isolation valve(s) supported by that division. All fire areas with potential for causing such events were identified and qualitatively evaluated. The impact of such an event on the integrity of interfaces between the high-pressure reactor coolant system and low-pressure systems was not considered to be significant, since design features will be in place to mitigate the impact of such events. As a result, fire-induced spurious opening of valves in the high-low pressure interfaces were not considered to be likely mechanisms for causing loss-of-coolant-accidents (LOCAs). For example, fires in the 1200 AF 01 fire area may cause spurious opening of the normal residual heat removal (RNS) isolation valves supported by Division A. However, the impact of such an event would be mitigated by redundant inboard isolation valves (within containment), which are not affected by a fire in the 1200 AF 01 fire area.

g. Fires in a diesel generator room fire area were assumed incapable of propagating to any other building, since these fire areas do not share boundaries with other plant buildings and fire areas.

h. It was assumed that fault protection has been designed to provide protection for plant electric circuits via protective relaying, circuit breakers, and fuses. The AP600 electrical distribution system is designed such that acceptable coordination and selective tripping is provided for shutdown circuits (safety and non-safety) on the ac and dc power systems. The design of the protective equipment will ensure adequate protection

of electrical distribution equipment from electric fault and overload conditions in the circuits.

i. It was assumed that fire-induced faults in power or control cables will occur with such high impedance that tripping of the affected circuit breakers will occur.

j. Damage to any system credited in the baseline internal-events PRA is assumed to cause a shutdown, unless it can be shown that the postulated damage would not cause a plant trip or result in plant operating conditions or violation of Technical Specifications that would result in plant shutdown.

k. As per Item 5 in Section 5.3.6 of the FIVE methodology documentation (Reference 57-1), fire propagation from fire areas with combustible loading of less than 20,000 Btu/sq. ft. was assumed not to be credible due to the limited severity of fires with this limited fuel source.

l. Processors for the diverse actuation system (DAS) were assumed to be located in the nonsafety-related 4kV switchgear rooms.

m. It was assumed that fire-induced hot shorts in safety- and DAS-related cables and equipment could result in a LOCA due to spurious opening of ADS valves.

n. Based on the AP600 internal-events PRA (Initiating Events Chapter), loss of switchgear room cooling was assumed not to impact the operability of the switchgears located in the switchgear rooms during the mission time required of them for PRA analytical purposes.

o. The spare battery and spare battery charger rooms were designated NSFAs for this analysis, although they are credited as safety-related in AP600 SSAR. The reason for this assignment is that the spare batteries are only connected to the system when the main batteries are disconnected, thus the impact of a fire in the spare battery rooms is effectively modeled by designating the main battery rooms as TSFAs that operate 100 percent of the time. The effect of a fire in the spare battery rooms while operating on spare battery power (with main battery power shut off) is identical to the effect of a main battery room fire for the same train; thus, to simplify the model, the two cases were effectively grouped.

57.5.2 Quantification Assumptions And Modeling Considerations

The following assumptions were made during the at-power fire core damage frequency quantification process:

a. This quantification task does not include the quantification of effects of fires in the main control room, for which a detailed evaluation is provided in Section 57.8.

b. Each fire scenario is assumed to result in either an automatic reactor trip or a reactor trip by the operators soon after the fire occurs.

c. In order to simplify the analysis, the at-power PRA models from the focused PRA were used as the starting point for all damage categories. Thus, the quantified scenarios take no mitigation credit for nonsafety systems (e.g., DAS, RNS, CVS, SFW, CCS, SWS, nonsafety power). The results are therefore believed to be bounding, since most of the scenarios would not result in total failure of nonsafety systems.

d. The system success criteria are as used in the focused PRA.

e. The scenario quantifications reflect a mission time of 24 hours.

f. Fire has no effect on test and maintenance unavailabilities during the mission time.

g. Safety-related Class 1E electrical equipment will be qualified for environmental conditions in which it is required to function, including thermal loads due to fire in adjacent fire areas.

h. Fire-induced failure of containment isolation valves is not modeled. The PRA core damage success criteria are specified assuming failure of containment isolation, so there is no effect on core damage frequency as a result of such fire-related failures.

i. Where spurious opening of ADS valve(s) was identified in the fire scenario description, it was conservatively assumed that there could be a single hot-short actuation of a single ADS stage 4 valve (resulting in a medium LOCA), or a dual independent hot-short actuation of two ADS stage 4 valves (resulting in a large LOCA). Both events were modeled for each spurious ADS actuation scenario, with appropriate conditional probabilities assigned for single and dual hot shorts. That is, for a medium LOCA, the area initiating event frequency was multiplied by the single hot-short probability. For a large LOCA, the area frequency was multiplied by the dual hot-short probability. Spurious actuation of ADS stages 1, 2, and 3 was not separately modeled. Such actuation would require more than one hot short, and the impact would be no worse than the large LOCA already modeled for the case of dual stage 4 valve actuation.

j. Spurious actuations of safety-related equipment other than ADS, and of nonsafety-related equipment, may be possible reactor trip initiators but are not modeled, since the fire initiator is already assumed to result in a reactor trip. Such actuations with a reactor trip would not adversely affect plant response (Reference 57-15).

k. No credit is taken in the quantification for recovery actions, equipment repair, or fire detection and suppression.

l. Only operator actions able to be carried out from the main control room are included in the quantification; ex-control room actions are not modeled. Main control room

personnel will not be responsible for mitigating fires outside the control room. Therefore, the human error probabilities for control room operator actions (e.g., actuating ADS) during a fire will be comparable to human error probabilities for other PRA initiating events. The set of operator actions included in the analysis is the same as those modeled in the focused PRA. When a scenario results in failure of equipment required for main control room actions, all operator actions, as well as I&C indications necessary for such actions (i.e., basic event ALL-IND-FAIL) are assigned to failure for that scenario.

m. Several scenarios include fire-induced failure of reactor trip switchgear or associated divisions of input signals to the reactor trip switchgear. Such failures would increase, rather than decrease, the likelihood of a reactor trip. Since reactor trip is assumed for each scenario, the switchgear impact is not explicitly modeled. Similarly, fire-induced failures of protection and safety monitoring system equipment would increase, rather than decrease the likelihood of a reactor trip.

n. Consistent with assumption c., following a fire-induced loss-of-offsite power, no credit is taken for onsite power (i.e., diesel generators) or offsite power recovery.

57.6 AT-POWER QUALITATIVE ANALYSIS RESULTS

The qualitative analysis process is discussed in Section 57.2. Table 57-4 provides the basis upon which each area was screened. In essence, fire areas were qualitatively screened out on the following bases:

- Bases 1 (B1) - if the fire was not expected to create a demand for safe shutdown under normal plant operating conditions, and if none of the PRA-credited equipment was considered damaged.

- Bases 2 (B2) - if the fire was expected to cause a plant shutdown due to technical specification requirements but was not postulated to impact operability of any PRA-credited shutdown systems. This criterion was judged to be acceptable on the basis that the conditional core damage probability for initiating events that do not cause loss of any PRA-credited shutdown systems is very low (on the order of E-9 or below). Multiplying this low probability by the frequency of such events would give an even lower core damage frequency. Note that care was taken to ensure that fires in the areas that were screened out using this basis did not impact any manual action, if any, credited as part of the internal-events PRA.

Another product of the qualitative analysis was generation of fire-induced damage states (FDSs) for each unscreened fire area. Table 57-4 also presents a summary description of these FDSs.

57.7 AT-POWER QUANTITATIVE RESULTS

57.7.1 Fire Ignition Frequencies for Quantitative Analysis

For each area that was not screened out, estimates of fire ignition frequency were prepared for use in the quantitative analysis. These estimates were based on data from the Fire Events Database for US Nuclear Power Plants (Reference 57-2) and adjusted for the AP600 design using information from plant arrangement drawings or other documentation and equipment databases. A summary of the database appears in the FIVE methodology document. Table 57-6 contains a summary of the fire area ignition frequencies obtained from the individual ISDS for each AP600 fire area. Table 57-7 contains a summary of the fire area ignition frequencies for the AP600 containment fire area.

Note that all events in the EPRI database are included in this analysis. This is very conservative. In a typical detailed fire PRA, several events are usually considered risk-insignificant and are removed or their contribution to the fire frequency (initiating event frequency) is reduced. The types of events that could be removed are those that do not cause significant damage, those occurring during plant commissioning, and those that are self-extinguished.

57.7.2 Fire Damage Category Quantification

A conservative estimate of the contribution of the fire damage category to core damage frequency is made. All fire-susceptible equipment in the exposing and potentially exposed fire areas was assumed to fail due to fire. Using an event tree from the focused PRA representative of the most significant failure, the contribution to the core damage frequency was calculated. If this contribution was less than 1.0E-9 per year, the area was screened out. For this analysis, the appropriately modified focused PRA internal-events models were used.

57.7.3 Individual Area PRA Analysis

The process by which the contribution of each fire area to core damage frequency was quantified is described in Section 57.3. An example of how the methodology was applied is provided in detail in the following subsections. The example is an analysis of the radiologically controlled area (RCA) of the auxiliary building (1200 AF 01). A summary of the quantification results, except the control room, is presented in Table 57-10.

57.7.3.1 Fire Area 1200 AF 01 (RCA of Auxiliary Building)

This area includes most of the RCA of the auxiliary building outside the fuel building area. This fire area contains the RNS pump, RNS heat exchanger, liquid radwaste system, spent fuel pool cooling system, chemical and volume control system (CVS) makeup pump, and lower annulus areas. This fire area contains division A outboard containment isolation valves for CVS, primary sampling system, containment air filtration, normal residual heat removal and spent fuel pit cooling systems. There is the potential for spurious operation of one of these

valves. For this event, isolation is provided by the redundant inboard isolation valves, which are not affected by a fire in this area.

This area also contains a division A and division C safety-related isolation valve in the CVS makeup pump suction line from the demineralized water storage tank. These valves are not required for safe shutdown.

The technique used to determine the effects of fire-induced equipment failures for this area were as follows:

Determine which Fire Scenarios could be Potentially Risk-Significant

In the qualitative evaluation, based on the equipment located in this fire area and its adjacent fire areas, the following fire scenarios were postulated:

- Fire Scenario 1 - For fires confined in the area, loss of RNS and CVS systems. Fire damage state 1AB1 was assigned to represent the postulated damage in this scenario.
- Fire Scenario 2 - For fires propagating from this area, loss of B and D signals to the reactor switchgear, and loss of the DAS, in addition to the loss of equipment discussed in scenario 1. Fire damage state 1AB2 was assigned to represent the postulated damage in this scenario.
- Fire Scenario 3 - For fires propagating from this area, spurious opening of one or two ADS valves, in addition to the loss of equipment discussed in scenario 2. Fire damage state 1AB3 was assigned to represent the postulated damage in this scenario.

Determine the Total Fire Frequency for this Area

Using the methods provided in the FIVE methodology (phase 2, step 1) and generic fire data information provided in the Fire Events Database, the fire frequency for this area was estimated as 2.31E-2 per year.

Determine the Likelihood of Occurrence of the Designated Fire Damage States

As stated above, three fire damage states were designated to represent the damage caused in this area. The total fire frequency for this area is distributed among these fire damage states using the fire progression event tree shown in Figure 57-1. Note that in the third fire scenario, fire-induced spurious opening of one or two valves is postulated. The consequence and probability of these spurious actuations are different. Thus, the fire progression event tree is developed such that these differences are clearly delineated.

The probability of each event on the fire progression event tree was estimated as follows:

- Probability of fire confinement in the area - This area is not provided with an automatic fire suppression system. Thus, conservatively, only the passive fire protection features of the area (i.e., fire barriers) are credited to confine the fire within the area. Based on the discussion presented in subsection 57.3.2.1, this probability was estimated as 0.01.

- Probability of one spurious actuation - This probability was estimated as 0.06 (NUREG/CR-2258, Reference 57-11).

- Probability of two spurious actuations - This probability (0.0036) was estimated by squaring the probability of one spurious actuation.

Determine the Consequences of the Designated Fire Damage States

Based on the description of the fire scenarios, the contribution of fires originating in this area to core damage frequency was evaluated to be bounded by the following initiating events and damage to accident mitigating systems:

Fire Scenario	Fire Damage State	Initiating Event	Accident Mitigating System Damage	Damage Category
1	1AB1	LOOP[(1)]	All Nonsafety-Related Systems[(2)]	NP1
2	1AB2	LOOP[(1)]	All Nonsafety-Related Systems[(2)]	NP1
3	1AB3	Medium LOCA	All Nonsafety-Related Systems[(2)]	NM1
3	1AB3	Large LOCA	All Nonsafety-Related Systems[(2)]	NL1

Note:

1. Although offsite power is not expected to be lost, the LOOP initiating event has the largest CCDP for transients in the focused PRA, and was used to bound the results.
2. Use of the focused PRA models discredits nonsafety systems.

Note that fire damage scenarios were also binned into fire-induced damage categories. Each fire-induced damage category defines a unique set of conditions regarding the state of the plant systems. This conservative binning process was performed to minimize the quantification effort while maintaining a traceable track of the postulated events.

The results of the damage state binning process for all the scenarios is provided in Table 57-8.

Determine the Conditional Core Damage Probability for each Designated Fire-induced Damage Category

Using the internal events model from the focused PRA and the methodology outlined in Section 57.4, the following conditional core damage probability for the designated fire-induced damaged categories was estimated:

FIDC	CCDP
NP1	8.75E-8
NM1	2.37E-4
NL1	5.51E-4

Determine the Contribution of this Area to the Fire-induced Core Damage Frequency

Finally, the contribution of area 1200 AF 01 to the fire-induced core damage frequency was found as follows.

Fire Damag State	Frequency	FIDC	CCDP	Core Damage Frequency	Total CDF for 1200 AF 01
1AB1	2.29E-2	NP1	8.75E-8	2.00E-09	5.76E-9
1AB2	2.17E-4	NP1	8.75E-8	1.90E-11	
1AB3	1.39E-5	NM1	2.37E-4	3.29E-09	
1AB3	8.32E-7	NL1	5.51E-4	4.50E-10	

Similar evaluations were performed for each fire area that was not screened during the qualitative analysis.

57.8 CONTROL ROOM FIRE ANALYSIS

57.8.1 Description of the Control Room and Associated Fire Protection

The AP600 main control room (MCR) is designated as fire area 1242 AF 01 and is located at elevation 118' of the auxiliary building. The area is subdivided into three fire zones: zone 242 AF 12401A is the kitchen/operator area; zone 1242 AF 12401B is the shift supervisor/clerk area; and zone 1242 AF 12401C is the main control area. The principal safety-related components are located in the main control area and these include the MCR workstations, controls and indications for plant operations, and Class 1E cable for the four electric power divisions.

In each of the fire zones, the boundaries have a fire rating of at least 1 hour, which is greater than the postulated fire duration in the area. The fire area itself is surrounded by 3-hour rated fire boundaries.

Since the main control room is continuously occupied, a fire is likely to be initially detected by an operator. Otherwise, a fire in this area will be detected by a fire detector, which provides visual and audible alarms in the main control room and the central plant security station.

A hose station located outside the fire area and portable extinguishers are provided for fire suppression. No automatic fire suppression systems exist in the area.

57.8.2 Alternate Shutdown Capability

A remote shutdown workstation is provided as an alternate to the MCR. The workstation room is located at the 100' elevation of the auxiliary building in fire area 1232 AF 01. Transfer of operations from the main control room to the remote shutdown workstation is controlled by transfer switches located in fire area 1231 AF 01 (Division B I&C penetration room), which is located on the path between both areas. The AP600 design calls for the availability of control for all safe shutdown functions at the remote shutdown panel; therefore, given the loss of all control room functions, safe shutdown can be achieved at the remote shutdown workstation.

For small (incipient) fires, control is maintained in the main control room since the potential for damage or spurious signals is limited. In the event of fires that require evacuation, control may be transferred to the remote shutdown workstation. In this event, the main control room functions are assumed to be lost, and safe shutdown is controlled from the remote shutdown workstation.

Once control is transferred, spurious control signals potentially caused by the control room fire can be isolated from the actuated devices by the transfer switches. The extent of the spurious signals is thus limited by the time to transfer control to the remote shutdown workstation.

Cabling to the main control room and to the remote shutdown workstation is separated according to each of the four safe shutdown electrical divisions. The cables for each power division are either routed in separate fire areas or are protected by the equivalent of a 3-hour fire barrier. Therefore, pinch points do not exist in rooms carrying cables between the control room and the remote shutdown workstation, and fires confined to a single area will not disable more than one division of safe shutdown components. The exception to this case is in the control room and the remote shutdown workstation room where cables for all four electric power divisions can be found.

A fire in the remote shutdown workstation room will not affect plant operations since controls from this workstation is not normally activated. In addition, no spurious actuation signals will be generated in the event of a fire in this area.

57.8.3 Fire Hazard Review

57.8.3.1 Combustibles

Table 9A-6 of the AP600 SSAR estimates the combustible loading for the fire area is 1.13×10^8 Btu, with paper (56 percent) and cable insulation (35 percent) being the main contributors. With a floor area of 2600 ft^2, the combustible loading is equivalent to approximately 43,600 Btu/ft^2. For the main control area, the loading is 7.5×10^7 Btu or approximately 55,700 Btu/ft^2.

57.8.3.2 Nature of Control Room Fires

As mentioned above, the fire hazard combustibles in the control room consist mainly of cable insulation within control cabinets, panels and below the raised floor, as well as ordinary combustibles like operator manuals and other paper necessary for control room computer and instrumentation operation. Transient materials such as paper and rags may be brought into the area during normal operations, for normal facilities maintenance and repair, or during plant shutdown. Consistent with existing control room fire analyses, the quantity of transient combustible materials that may be involved in area fires (and consequently, the magnitude of these fires and the resultant damage to plant facilities) is assumed to be controlled by limiting the introduction of transient combustibles through administrative procedures.

The extent of damage within and beyond the fire area is further limited by controlled removal of heat, smoke, and other combustion products. Fire dampers will close automatically on high temperature to control the spread of fire and combustion products. Smoke and hot gases are removed from the fire area by reopening the fire dampers after a fire. The nuclear island non-radioactive ventilation system can be manually aligned to the smoke purge mode to exhaust smoke and hot gases to the atmosphere. Three-hour fire barriers enclose the fire area.

A worst-case fire postulated for this area assumes ignition and subsequent development in a control cabinet. The probability for propagation of the fire to the next cabinet will be small because the cabinets are physically separated. In addition, the control area is continually occupied, facilitating early detection. This probability of fire propagation is further reduced by early detection provided by smoke detectors installed in the area. As such, manual fire response will be initiated promptly. In addition, ready access is provided to the area from adjacent plant areas, facilitating initial use of area fire extinguishers on incipient fires and supplemental use of hose lines on developing fires by employees responding to the fire.

If the fire does grow beyond the incipient stage and propagate, and the control room must be evacuated, the plant can be safely shut down from the remote shutdown workstation. The capability for safe shutdown is therefore not impaired by the postulated fire for this area.

57.8.3.3 Derivation of Control Room Fire Frequencies

Using the methods provided in the FIVE methodology (phase 2, step 1) and generic fire data provided in the Fire Events Data Base, the fire frequency for this area is estimated as 9.9 x 10^{-3} events per year (sum of all potential contributors). With reference to the Ignition Source Data Sheet in the Quantitative Screening Analysis, contributors to this fire frequency are:

Control Room Ignition Sources	Frequency (events/yr)
Electrical cabinets	9.50E-03
Plant-Wide Ignition Sources	
Fire protection panels	4.00E-04
Junction Boxes	1.28E-05

The electrical cabinet fire frequency is based on twelve fires which occurred in control rooms and were reported in the NSAC/178L Fire Events Data Base. Eleven were cabinet fires and one was a kitchen fire. None of the fires appears to have been of significant severity and all were extinguished (or self extinguished) within a few minutes. No control room fires to date have required evacuation of the control room.

The above frequency for cabinet fires is slightly conservative because of the inclusion of the "kitchen fire" event. The AP600 kitchen area fire zone has boundaries with fire resistance that exceeds the equivalent fire duration for this zone; thus, fire propagation to the main control area can be ruled out. However, to be conservative, a frequency of 9.5E-03 per year will be used as the generic electrical cabinet-induced fires in control rooms.

The remaining contribution to the ignition frequency evaluated for the control room comes from plant-wide ignition sources. NSAC/178L (Reference 57-2, p. 3-17), states that plant wide components are not generally applicable to the control room because the room is continuously occupied and the likelihood that a transient fire would not be detected and suppressed in its incipient stage is very small. Therefore, the contribution of plant-wide ignition sources to the control room fire scenario frequencies is assumed to be insignificant. Thus, the control room ignition frequency is 9.5E-03 per year.

57.8.4 AP600 Control Room Fire Evaluation

The general philosophy for fire evaluation of control room fires follows the approach suggested in NSAC/181L. It is similar to that adopted in other areas but differs in two respects:

- Regardless of the level of damage which is actually sustained as a result of a fire, the production of smoke may necessitate the evacuation of the control room. Under such circumstances, the operators will isolate the main control room and shut down the plant using the alternate shutdown capability.

- Detailed fire propagation will not be performed since there are no acceptable models for modeling propagation within and from cabinets. Instead, it is assumed that cabinet fires in the control room will not spread from the confines of the cabinet in which they originate, assuming that the cabinet has solid metal or fire-resistant boundaries. This supposition is supported by the results of the Sandia cabinet fire tests (Reference 57-16), in which all test fires were self-extinguished, and by the reports of control room fires in the data base.

The evaluation of control room fires requires the analyst to identify those cabinets or combination of connected cabinets in which enclosed fires might cause significant degradation of accident mitigating systems. Fire scenarios in such cabinets are evaluated individually.

The methods used for frequency analysis, propagation analysis, and suppression analysis are discussed below.

57.8.4.1 Fire-Induced Equipment Failures for Enclosed Cabinet Fires

The technique used to determine the effects of fire-induced equipment failures for enclosed cabinet fires includes the following steps:

Step 1 Determine which of the cabinets are to be considered critical.

Typically, this will be those that degrade any safety-related system required for shutdown. For AP600, it is assumed that the only significant cabinets are the two Reactor Operator panels, the dedicated control panel, and the Senior Reactor Operator (SRO) panel. In addition, there is an overview mimic panel along the wall facing the control panels.

The two Reactor Operator panels are totally redundant, and they each contain all the software and multiplexer control switches. The SRO panel provides a third level of redundancy to the Reactor Operator panels. However, this panel would normally be used for indication-type functions only, with the control functions being locked out.

The dedicated control panel contains the hard-wired controls like those for reactor trip, startup blocks and permissives, manual PRHR actuation, manual steam line and feedwater isolation, manual safeguards signal, containment cooling actuation, containment isolation, and ADS actuation.

The overview mimic panel is basically a display board and is used for indication purposes only. Because of the redundancy provided by the Reactor Operator panels and the SRO panel, the unavailability of the overview mimic panel will not be risk-significant, and therefore, the unavailability of the panel will not be considered further in this analysis, although it is considered as a contributor to initiators in the control room evaluation.

Step 2 Determine the likelihood a fire will occur in a critical cabinet.

The frequency of fire in any individual cabinet can be derived from generic data on cabinet-induced control room fires. As mentioned in subsection 57.8.3.3, data from the industry show that the ignition frequency from cabinets in the control room is 9.5E-03 per year. This is based on "conventional" control rooms, which typically contain between 30 to 40 electrical cabinets. Assuming an average of 35 cabinets per typical control room, the ignition frequency per cabinet is approximately 3E-04 per year.

Another difference between control rooms at conventional nuclear power plants and the AP600 main control room is the predominance of low-voltage cabling at AP600. The majority of cables in the AP600 control room are 48V 10 mA DC cables. The only higher-energy sources (125 VDC or 110 VAC) are the power sources, and an estimate calls for only between 4 and 10 of such cables. In comparison, an estimate of between 500 to over 1000 125V DC and AC cables are present in control rooms of conventional plants. Based on Westinghouse calculations for a control room similar to the AP600 main control room, it can be shown that these low-voltage cables do not produce enough energy to heat up the cables, thus, ignition is very improbable.

Even with the use of low-voltage cables, it will conservatively be assumed that cable ignition is possible. However, a factor of 10 reduction will be taken from the generic cabinet fire frequency (3E-04 x 0.1 = 3E-05 per year). This will reflect the small (but non-zero) probability of contribution from the power sources and from other ignition sources.

Step 3 Determine how severe a fire would have to be to fail the critical functions supported by a cabinet.

It is assumed that once a fire progresses beyond the incipient stage, all the equipment in the cabinet where the fire originates will fail.

Based on historical experience, all 12 control room fires in the Fire Events Data Base have been extinguished before the fire reached a level capable of causing significant damage. For the purposes of this evaluation, it will be arbitrarily assumed that the next fire to occur will be more severe. Using this assumption, the frequency of control room fires progressing beyond the incipient stage can be estimated as 1/13 = 0.077. This value is assigned as the conditional probability of a fire "progressing beyond the incipient stage."

57.8.4.2 Adverse Effects of Smoke

To account for the effects of smoke, the following considerations were made:

1. Level of smoke that will impair the effectiveness of the operators, and the likelihood that this amount of smoke will be generated by a cabinet fire.

   The Sandia cabinet fire tests (Reference 57-16) indicated fires were self-sustaining and produced sufficient quantities of smoke to cause visual impairment. All of the fires in the data base were small, but this may have been because they were extinguished early. Since there are no tools available for assessing smoke production and the evidence from the historical fires is not conclusive, it is assumed that any fire is capable of producing sufficient smoke if allowed to continue burning for a sufficient period of time.

2. Time available to suppress the fire before the smoke concentration reaches the level of visual impairment (at which time the operators are assumed to evacuate the control room).

   At a ventilation rate of one room change of air per hour (800 cfm), Sandia tests (Reference 57-16) performed in a simulated control room of 48,000 ft^3 indicated that about 15 minutes are available before the control board is obscured. A high ventilation rate test (8 room changes per hour, or 6400 cfm) indicated that about 30 minutes are available before the control board is obscured. The typical AP600 ventilation rate is expected to be between one and eight room changes per hour, therefore, the time to control board obscuration can be assumed to lie within the 15-30 minute range. For conservatism, the lower value was used, and the control room operators will be assumed to be forced to leave the control room due to smoke buildup no later than 15 minutes into the fire scenario for fires that are not suppressed by that time.

3. Probability of detection and suppression prior to smoke level reaching level of visual impairment.

   The control room will be protected by smoke detectors strategically located throughout the fire area, and the control room will be continuously occupied. It is therefore reasonable to expect that a fire would be detected very quickly, most likely well before developing beyond the incipient stage.

   To estimate the probability of control room evacuation due to smoke visual impairment, a methodology described by NSAC/181L (pages 3-22 and 3-23) was combined with existing control room fire data (Reference 57-2). The model used to interpret operator response was EPRI's Human Cognitive Reliability correlation for interpreting measured operator action times in the control room (Reference 57-6). The model fits the fire durations to a lognormal curve to estimate the probability for failure to successfully act (here, failure to suppress the fire) for times greater than those observed. The overall probability of non-suppression within the 15-minute time window using this methodology is 0.0034.

57.8.4.3 Assumptions Regarding Control Room Evacuation

1. Control room evacuation will be procedurized for fires that disable sufficient indication or control functions or for fires where smoke generation will impair operator effectiveness. It is assumed, for this analysis, that evacuation will occur for any fire that grows beyond the incipient stage.

2. It is assumed that smoke generation due to fires in any other area of the plant or from fires external to the plant will not require evacuation of the control room personnel. This is based on the design of the control room habitability systems as described in Section 6.4 of the SSAR.

57.8.5 Fire Scenario Identification and Frequency Determination

The effect of fires affecting control room cabinets is summarized by the eight scenarios described in the following subsections.

It should be noted that fire propagation between cabinets was not explicitly modeled in these scenarios. This propagation will only occur if the fire progresses beyond the incipient stage. However, as noted in the subsections below, all scenarios that involve fire growth conservatively assume control room evacuation and safe shutdown control from the remote shutdown workstation. Since all safe shutdown control functions present in the control room are also present in the remote workstation, the failure of any number of control room functions will be modeled in the same fashion.

57.8.5.1 Scenario CR1 - Fire in a Cabinet with no Growth Beyond the Incipient Stage

In this scenario, fire growth does not progress beyond the incipient stage. These fires will initiate at a cable and will be extinguished (either self extinguished or by operator actions) before enlarging and spreading to other cables. Therefore, the impact of these types of fires is considered to be limited to the loss of function provided by one component. If the damage can be confined locally to the site of the overload, which is in fact the most likely situation given historical experience with control room fires, the resulting impact will be bounded by the random failure of the component itself, which has already been accounted for in the internal-events PRA. Thus, the contribution of this scenario to the fire-induced core damage frequency is insignificant.

57.8.5.2 Scenario CR2 - Fire Beyond the Incipient Stage in a Reactor Operator or SRO Panel

In this scenario, a fire in a Reactor Operator panel or a Senior Reactor Operator panel grows beyond the incipient stage. All functions in the affected cabinet are assumed to be unavailable. Although sufficient redundancy is available from the two other unaffected panels, control room evacuation is assumed due to effects of smoke or the operator interpretation of the evacuation procedures. Prior to evacuation, the operator is assumed to trip the reactor from the control room. Shutdown is controlled from the remote shutdown workstation.

The frequency for this scenario is calculated as follows:

Number of cabinets of concern = 3 (2 Reactor Operator panels and an SRO panel)

Ignition frequency per cabinet = 3E-05 per year

Probability of fire growth beyond incipient stage = 0.077

Scenario frequency = 3 x 3E-05 x 0.077 = 6.9E-06 per year

This scenario is modeled as a transient with main feedwater available. However, since the focused PRA models are used for quantification, the LMFW model is used. Further, because of the fire situation and also because control will be from the remote shutdown workstation, all human error probabilities are increased by a factor of 10 (from the base case, internal-events PRA model); that is, given random failures of auto-actuation, the human error probabilities for manual actuation of the CMT, PRHR, and ADS are increased by a factor of 10. The human error probabilities for RECIR were left as-is because of the length of time available for this action.

It should be noted that this fire scenario was not modeled to result in spurious actuations of any kind. It is very unlikely that encoded information can be reproduced in a "hot short" of the fiber-optic cables in these panels. In addition, because of the control logic, a spurious signal will require two hot shorts in the correct order.

57.8.5.3 Scenario CR2A - Fire Beyond the Incipient Stage in a Reactor Operator or SRO Panel - Sensitivity Case A

This scenario is similar to Scenario CR2 with the exception that all operator actions are assumed to be failed. Prevention of core damage is dependent solely on the success of the automatic passive systems. The effects of operator failure to transfer control to the remote shutdown workstation or the failure of the remote controls themselves, or the failure of the operators to evacuate the control room in a timely fashion are all covered by this sensitivity case.

57.8.5.4 Scenario CR3 - Fire Beyond the Incipient Stage in the Dedicated Control Panel - Without Spurious Actuation of the ADS Valves

In this scenario, a fire in the Dedicated Control panel grows beyond the incipient stage. All functions in this panel are assumed to be unavailable. Control room evacuation is assumed due to effects of smoke or the operator interpretation of the evacuation procedures. Manual trip is assumed from the DAS. Shutdown is controlled from the remote shutdown workstation.

The frequency for this scenario is calculated as follows:

Number of cabinets of concern = 1

Ignition frequency per cabinet = 3E-05 per year

Probability of fire growth beyond incipient stage = 0.077

Scenario frequency = 1 x 3E-05 x 0.077 = 2.3E-06 per year

The modeling of this scenario is the same as that for Scenario CR2A, i.e., a transient with main feedwater available modeled, using the focused PRA, as loss of main feedwater. As a bounding case, all human error probabilities are assumed to be unity.

57.8.5.5 Scenario CR4 - Fire Beyond the Incipient Stage in the Dedicated Control Panel - With Spurious Actuation of the ADS Valves

This scenario is similar to Scenario CR3 with the exception that spurious actuations of the ADS valves is considered. For Scenario CR4, the CR3 frequency can be reduced as follows:

- Conservatively assume that the fraction of fires that will result in hot shorts leading to the opening of both divisions of the Stage 1 ADS valves is 0.1
- According to the functional diagrams for the automatic RCS depressurization valve sequencing (see Figure 7.2-1, sheet 15, of the SSAR), the opening of an ADS valve requires 2-out-of-4 logic in the correct sequence. A conservative probability of 0.1 was assigned to this improbable sequence of events.

Therefore, the frequency for Scenario CR4 is

2.3E-06 x 0.1 x 0.1 = 2.3E-08 per year

The control logic sequence that caused the spurious opening of the ADS valves will also trip the reactor, actuate PRHR, and trip the reactor coolant pump. Control room evacuation is assumed, and shutdown is controlled from the remote shutdown workstation. Because of the opening of both stage 1 ADS valves, the transient modeled for this scenario is an intermediate LOCA. All human error probabilities were assumed to have a value of 0.1, except for those associated with recirculation, since the time available for the event RECIR is large.

(In theory, when controls are transferred from the control room to the remote shutdown workstation, all spurious actuations will be stopped. However, to be conservative, the LOCA was not assumed to be isolated in the scenario. Note that, in using the focused PRA models, an intermediate LOCA is treated as a medium LOCA, so that this case also covers the possibility that one or more ADS stage 2 or 3 valves also opens.)

57.8.5.6 Scenario CR4A - Sensitivity Case A for Scenario CR4

This scenario is the same as Scenario CR4 except that the human error probabilities are all set to a value of 1.0

57.8.5.7 Scenario CR4B - Sensitivity Case B for Scenario CR4

This scenario is the same as Scenario CR4 except that the spurious opening of stage 4 ADS valves is assumed. In this case, a large LOCA is the initiator.

57.8.5.8 Scenario CR5 - An Unsuppressed Fire in the Overview Mimic Panel

As mentioned in subsection 57.8.4.1, a fire in the overview mimic panel is not risk-significant because the loss of functions at this panel is not risk-significant. However, if this fire is not suppressed within 15 minutes, the smoke generated is assumed to require the evacuation of the control room. The transient modeled is similar to that modeled for Scenario CR2.

The frequency for this scenario is calculated as follows:

Number of cabinets of concern = 1

Ignition frequency per cabinet = 3E-05 per year

Probability of fire unsuppressed in 15 minutes = 0.0034

Scenario frequency = 1 x 3E-05 x 0.0034 = 1.0E-07 per year

57.8.6 Control Room Fire Scenario Quantification and Results

To obtain a value for the core damage frequency contribution of each control room fire scenario, the frequency of occurrence for each scenario is multiplied by the conditional core damage probability given the damage caused by the postulated fire for that scenario.

The conditional core damage probability for each fire scenario is quantified using the parameters specified in Section 57.4. The AP600 focused PRA model was modified to account for the fire damage to systems and on the effect on human interaction. The evaluated CCDPs are listed in Table 57-12. The calculation of core damage frequency for each fire scenario is also presented in Table 57-12.

From Table 57-12, it can be seen that the expected core damage frequency from control room fire scenarios is 5.70E-11 per year. Note that sensitivity case CR2A was used to represent scenario CR2 and case CR4A was used to represent the CR4 scenario since these were the most conservative cases.

57.9 SUMMARY AND CONCLUSIONS

The total at-power fire-induced core damage frequency, determined on a bounding basis using the focused PRA model, is estimated as 6.5E-07 per reactor year. This corresponds to about 11 percent of the at-power focused PRA core damage frequency. The dominant at-power fire core damage cutsets are provided in Table 57-[TBD].

Fires postulated in the containment with the frequency of 3.0E-7 per year, are, as a group, the major contributor to this frequency (almost 50 percent). This relatively high contribution is because the containment is one of the few areas in the plant that is designed to contain cabling and components from more than one safety-related division (the other areas being the control room and the remote shutdown panel room). This estimated containment contribution is based on highly conservative modeling and assumptions. Indeed, fire PRAs, including FIVE, generally exclude the containment building from the analysis (i.e., screens it out at the qualitative level). The basis for this typical exclusion includes the following justifications which are presented in the FIVE methodology (Reference 57-1):

- The unlikelihood of a hot gas layer forming in areas that would damage cabling
- Industry-wide improvements in RCP oil collection systems, which have essentially eliminated this primary cause of past containment fires
- A low frequency of containment fires in operating plant experience

However, the AP600 containment building was conservatively not excluded from the AP600 analysis at the qualitative screening level. Since fire PRAs generally screen the containment area out at the qualitative level, the results of the AP600 study cannot be compared with others to draw conclusions with respect to the relative importance of this area to the AP600 design in contrast with the same area in currently operating plants.

A conservatism exercised in the evaluation of the AP600 containment area includes the estimation of containment fire frequency, which was done by making a conservative interpretation of the limited available data.

Another major conservatism used in the fire analysis is the use of the AP600 focused PRA model for the quantification of the conditional core damage probabilities. The focused PRA model does not take credit for any nonsafety-related equipment for achieving shutdown following an initiating event. Since fires in the containment building would not have a significant impact on the availability of important nonsafety-related systems (such as normal residual heat removal, startup feedwater, and DAS), this modeling approach has a significant impact on the estimated contribution of this area to the fire-induced core damage frequency.

Another AP600 fire area that merits discussion is the control room. Unlike most fire PRAs, the AP600 fire PRA estimates a very low contribution from this area. This relatively low contribution is a result of the following:

- The ignition frequency is low because of the use of low-voltage 48V 10 mA dc cables in the AP600 control room. These low-voltages cables do not produce enough energy to heat the cables, thus ignition is not probable.

- Redundancy in control room operations is available within the control room itself, that is, if control room evacuation is not required, there is at least one other means available within the control room to shut down and control the plant.

- If control room evacuation is necessary, the remote shutdown workstation provides complete redundancy in terms of control for all safe shutdown functions.

- Finally, the AP600 design calls for availability of diverse and redundant systems for plant shutdown. Therefore, loss of control of one division of power or for a whole system is not risk-significant. In addition, the passive systems are designed to operate without the need for operator interaction. Therefore, operator actions that might be disrupted by the fire scenario are backup actions, and are not significant for AP600.

The conservatisms employed in the AP600 fire PRA include the following:

- A fire originating from any ignition source in an area is assumed to disable all equipment located in the fire area. A review of the historical evidence indicates that most fires are localized fires with limited severity (Reference 57-2).

- An assumed total at-power fire initiating event frequency corresponding to about one fire with significant consequences every 4 reactor years, well in excess of current plant experience and of that anticipated for AP600.

- Manual fire suppression is not credited to limit the extent of damage in an area nor to prevent fire propagation to an adjoining area. Historical evidence indicates that the majority of suppressed fires were manually suppressed with little or no additional damage.

- In order to minimize potential uncertainty in the results arising from the lack of as-built equipment location and cable routing information, a bounding approach to quantification, using the focused PRA models, was taken. Thus, in the quantification process, the nonsafety-related systems (e.g., main feedwater, startup feedwater, normal residual heat removal, or DAS) are not credited. In reality, fires in only a few AP600 fire areas would be capable of disabling all the nonsafety-related systems.

Because the approach taken in performing the AP600 internal fire analysis makes various conservative assumptions and is bounding, the results of uncertainty, sensitivity, or importance

analyses would be biased. Therefore, these analyses were not performed based on the judgement that they would be of little value in providing additional insights to determine whether fire vulnerabilities exist for beyond-design-basis fires.

The major reasons for the AP600's relatively low overall fire-induced core damage frequency, even on a bounding basis, include the following:

- The AP600 fire protection design provides, to the extent possible, separation of the alternate safety-related shutdown components and cabling using 3-hour rated fire barriers. For example, areas containing safety-related cabling or components are physically separated from one another and from the areas that do not contain any safety-related equipment by completely sealed 3-hour rated fire barriers, with no openings (e.g., doors, fire dampers, or fire penetration seals) in the barriers. This defense-in-depth feature diminishes the probability of a fire to impact more than one safety-related shutdown system.

- Since the passive safety-related systems do not require cooling water or ac power, they are less susceptible to being unavailable due to a fire than currently operating plant's active safe shutdown equipment. As a result, the impact of fires on the shutdown capability is significantly reduced compared to current plants.

The results of the AP600 fire PRA study show that the plant's system and layout designs promote a low at-power fire-induced core damage frequency compared with existing plants. Also, the results indicate that, when nonsafety-related systems are not credited and containment is treated as a special case, the fire-induced core damage frequency profile is a flat one (i.e., no fire area is significantly more important than others)

Because of the bounding nature of the at-power fire analysis performed for AP600, it is inappropriate to compare the numerical results of this analysis directly to the results of the internal-events analysis. However, the results of this analysis show that the AP600 design is sufficiently robust that internal fires during power operation do not represent a significant contribution to core damage frequency.

57.10 REFERENCES

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57-3 NSAC/181L, *Fire PRA Requantification Studies*, Electric Power Research Institute, March 1993.

57-4 NSAC/179L, *Automatic/Manual Suppression Reliability Data for Nuclear Power Plant Fire Analysis*, Electric Power Research Institute, February 1994.

57-5 NUREG/CR-2300, *PRA Procedures Guide*, January 1983.

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57-7 AP600 Standard Safety Analysis Report, Revision 1, January 1994.

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57-14 NUREG/CR-4840, Procedures for the External Event Core Damage Frequency Analysis for NUREG-1150, November 1990.

57-15 WCAP-14477, "The AP600 Adverse System Interactions Evaluation Report," February 1996.

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Table 57-1

AP600 SYSTEMS CREDITED FOR SHUTDOWN

Function	System
Reactivity Control	Integrated protection and control system Reactor trip system Diverse actuation system* Chemical and volume control system* Core makeup tanks and in-containment refueling water storage tank
Reactor Coolant System Pressure Control	Pressurizer safety valves
Reactor Coolant System Inventory Control	Chemical and volume control system* Core makeup tanks Automatic depressurization system Normal residual heat removal system* Accumulators In-containment refueling water storage tank gravity injection and recirculation
Decay Heat Removal	Main feedwater* Startup feedwater* Secondary-side pressure relief (condenser* or power-operated relief valve and main steam line safety valves) Accumulators Core makeup tanks Passive residual heat removal Automatic depressurization system In-containment refueling water storage tank injection Normal residual heat removal* Passive containment cooling
Containment Integrity (Heat Removal Only)	Passive containment cooling Normal residual heat removal system*

* Not credited in the CCDP calculations.

Table 57-2a

AUTOMATIC SUPPRESSION SYSTEM RELIABILITY

System Type	Unavailability of System
Wet Pipe Sprinkler	2.0E-2
Preaction Sprinkler	5.0E-2
Deluge Sprinkler	5.0E-2
CO_2	4.0E-2
Halon	5.0E-2

Table 57-2b

FIRE AREAS WITH AUTOMATIC FIRE SUPPRESSION

Fire Area	Description	Suppression System
1240 AF 01	Non-1E Electrical Pen. Room	Preaction Sprinklers
2033 AF 01	Aux. Boiler Room	Wet Pipe Sprinkler
2033 AF 02	Diesel Driven Fire Pump Room	Wet Pipe Sprinkler
2043 AF 01	Chemical Laboratory	Wet Pipe Sprinkler
2050 AF 01	Lube Oil Room	Water Spray
4031 AF 02	Containment Access Corridor	Wet Pipe Sprinkler
4032 AF 01	Non-1E Battery Charger #2	Preaction Sprinkler
4032 AF 02	Non-1E Battery Charger #1	Preaction Sprinkler
4041 AF 01	Electrical Switchgear Room #2	Preaction Sprinkler
4041 AF 01	Electrical Switchgear Room #1	Preaction Sprinkler

Table 57-3

FIRE BARRIER FAILURE PROBABILITIES

Barrier Type	Barrier Failure Probability/Demand
Type 1- Fire doors	7.4E-3
Type 2- Fire and Ventilation Dampers	2.7E-3
Type 3- Penetration Seals	1.2E-3

Table 57-4 (Sheet 1 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
0000AF00	Yard	NSFA	No	1. For fires confined in the area, LOOP with all other PRA credited safe shutdown systems operable is postulated.	FDS 1TY1
1000AF01	Containment	NSFA	No	See Table 57-5	
1200AF01	RCA of the Auxiliary Building	MSFA	No	1. For fires confined within this fire area, loss of RNS and CVS is postulated. Fire-induced spurious opening of valves or spurious running of a makeup pump is possible.	FDS 1AB1
				2. This fire scenario is bounded by the loss of equipment discussed in (1), loss of B and D signals to the reactor switchgear, and loss of DAS.	FDS 1AB2
				3. This fire scenario is bounded by the loss of equipment discussed for FDS 1AB1, loss of B and D signals to the reactor switchgear, and spurious opening of ADS valves due to fire-induced damage to ADS-related cabling.	FDS 1AB3
1200AF02	Fuel Handling Area	NSFA	Yes (B2)	N/A	N/A
1200AF02	Spent Fuel Pit/Fuel Unloading	NSFA	Yes (B2)	N/A	N/A
1201AF02	Division B Batteries	TSFA	No	1. The B division of power and control is assumed lost with no other systems or equipment impacted.	FDS 1AB4
				2. This fire scenario is bounded by the loss of the equipment discussed in (1) plus spurious opening of ADS valves due to fire-induced damage to division B-related cabling that supports ADS valves.	FDS 1AB5
1201AF03	Division D dc Equipment/I&C Room	TSFA	No	1. For fires confined in the area, the fire scenario is bounded by loss of division D of power and control.	FDS 1AB6

Table 57-4 (Sheet 2 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
1201AF03	Division D dc Equipment/I&C Room	TSFA	No	2. For fires confined in the area, an additional fire scenario is bounded by loss of division of power and control plus spurious opening of ADS valves due to fire-induced damage to division D-related cabling that supports ADS valves.	FDS 1AB7
				3. For fires propagating from this area, the fire scenario is bounded by loss of division D of power and control, plus loss of service water, main feedwater, startup feedwater, component cooling, and instrument air/service air systems.	FDS 1AB10
				4. For fires propagating from this area, an additional fire scenario is bounded by loss of division D of power and control plus spurious opening of ADS valves due to fire-induced damage to division D-related cabling that supports ADS valves in addition to loss of service water, main feedwater, startup feedwater, component cooling, and instrument air/service air systems.	FDS 1AB11
1201AF04	Division B/D VBS Equipment	MSFA	No	1. For fires confined in the area, the fire scenario is bounded by loss of division D of power and control.	FDS 1AB7
				2. For fires confined in the area, an additional fire scenario is bounded by loss of division of power and control plus spurious opening of ADS valves due to fire-induced damage to division D-related cabling that supports ADS valves.	FDS 1AB7
				3. For fires propagating from this area, the fire scenario is bounded by loss of division D of power and control, plus loss of the service water, main feedwater, startup feedwater, component cooling, and instrument air/service air systems.	FDS 1AB10

Table 57-4 (Sheet 3 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
1201AF04	Division B/D VBS Equipment	MSFA	No	4. For fires propagating from this area, an additional fire scenario is bounded by loss of division D of power and control plus spurious opening of ADS valves due to fire-induced damage to division D-related cabling that supports ADS valves in addition to the loss of the service water, main feedwater, startup feedwater, component cooling, and instrument air/service air systems.	FDS 1AB11
1201AF05	MSIV Compartment A	MSFA	No	1. Systems with components and cabling located in this fire area will be disabled. That is, a fire in this fire area is postulated to result in loss of secondary-side cooling.	FDS 1AB12
				2. For fires propagating from this area, the fire scenario is bounded by that postulated for FDS 1AB12 and loss of division D of power and control.	FDS 1AB13
				3. For fires propagating from this area, an additional fire scenario is bounded by loss of division D of power and control plus spurious opening of ADS valves due to fire-induced damage to division D-related cabling that supports ADS valves in addition to damage postulated for 1AB12 FDS.	FDS 1AB14
1201AF06	MSIV Compartment B	MSFA	No	1. Fire in this fire area is postulated to result in loss of secondary-side cooling.	FDS 1AB12
				2. For fires propagating from this area, the fire scenario is bounded by that postulated for 1AB12 FDS and loss of division D of power and control.	FDS 1AB13
				3. For fires propagating from this area, an additional fire scenario is bounded by loss of division D of power and control plus spurious opening of ADS valves due to fire-induced damage to division D-related cabling that supports ADS valves in addition to damage postulated for 1AB12 FDS.	FDS 1AB14
1202AF01	East Stairwell	NSFA	Yes (B1)	N/A	N/A

Table 57-4 (Sheet 4 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
1202AF02	Northeast Elevator Shaft	NSFA	No	1. The loss of CVS is postulated	FDS 1AB51
1202AF03	Division C Batteries	TSFA	No	1. For fires confined in the area, C division of power and control is assumed lost with no other systems or equipment impacted.	FDS 1AB15
				2. For fires propagating from this area, the fire scenario is bounded by FDS 1AB15 plus loss of CVS.	FDS 1AB16
1202AF04	Division A Electrical Equipment	TSFA	No	1. For fires confined in the area, the fire scenario is bounded by loss of division A of power and control.	FDS 1AB17
				2. For fires confined in the area, an additional fire scenario is bounded by loss of division A of power and control plus spurious opening of ADS valves due to fire-induced damage to division A-related cabling that supports ADS valves.	FDS 1AB18
				3. For fires propagating from this area, the fire scenario is bounded by loss of division A of power and control, plus loss of B division input to RCP trip switchgear and divisions B and D reactor trip signals.	FDS 1AB19
				4. For fires propagating from this area, an additional fire scenario is bounded by loss of division A of power and control plus non-recoverable spurious opening of ADS valves due to fire-induced damage to division A-related cabling that supports ADS valves, in addition to loss of B division input to RCP trip switchgear and divisions B and D reactor trip signals.	FDS 1AB20
1202AF05	Division C Electrical Equipment	TSFA	No	1. For fires confined in the area, this fire scenario is bounded by loss of division C of power and control.	FDS 1AB21

Table 57-4 (Sheet 5 of 13)					
SUMMARY OF QUALITATIVE EVALUATION RESULTS					
Fire Area	**Description**	**Type**	**Screened**	**Fire Scenario**	**Fire Damage State**
1202AF05	Division C Electrical Equipment	TSFA	No	2. For fires confined in the area, an additional fire scenario is bounded by loss of division C of power and control plus spurious opening of ADS valves due to fire-induced damage to division C-related cabling that supports ADS valves.	FDS 1AB22
				3. For fires propagating from this area, the fire scenario is bounded by loss of division C of power and control, plus loss of C division input to RCP trip switchgear and divisions B and D reactor trip signals.	FDS 1AB23
				4. For fires propagating from this area, an additional fire scenario is bounded by loss of division C of power and control plus non-recoverable spurious opening of ADS valves due to fire-induced damage to division C-related cabling that supports ADS valves, in addition to loss of B division input to RCP trip switchgear and divisions B and D reactor trip signals.	FDS 1AB24
1204AF01	Shield Building Stairwell	NFSA	Yes (B1)	N/A	N/A
1204AF02	Shield Building Elevator Shaft	NFSA	Yes (B1)	N/A	N/A
1204AF03	Plant Vent	NFSA	Yes (B1)	N/A	N/A
1205AF01	Southeast Stairwell	NFSA	Yes (B1)	N/A	N/A
1205AF02	Southeast Elevator Shaft	NSFA	No	1. For fires confined within this fire area, loss of RNS and CVS is postulated. Fire-induced spurious opening of valves or spurious running of a makeup pump is possible.	FDS 1AB52
1205AF03	RCA Ventilation System	NFSA	Yes (B2)	N/A	N/A
1206AF01	Southwest Stairwell	NFSA	Yes (B1)	N/A	N/A
1210AF01	Corridor/Access Area 66'-6"	NFSA	Yes (B2)	N/A	N/A

Table 57-4 (Sheet 6 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
1211AF01	Division D Batteries	TSFA	No	1. This fire scenario is bounded by loss of the equipment discussed for FDS 1AB25.	FDS 1AB25
				2. For fires propagating from this area, the fire scenario is bounded by loss of equipment discussed for FDS 1AB25 plus spurious opening of ADS valves due to fire-induced damage to division D-related cabling that supports ADS valves.	FDS 1AB26
1212AF01	Division A Electrical Rooms	TSFA	No	1. The A division of power and control is assumed lost with no other systems or equipment impacted.	FDS 1AB27
				2. For fires propagating from this area, the fire scenario is bounded by loss of equipment discussed for FDS 1AB27 plus spurious opening of ADS valves due to fire-induced damage to division A-related cabling that supports ADS valves.	FDS 1AB28
1212AF02	Spare Batteries	NSFA	Yes (B1)	N/A	N/A
1212AF03	Spare Battery Charger Room	NSFA	Yes (B1)	N/A	N/A
1212AF04	Spare Room (Elevation 66'-6")	NSFA	Yes (B1)	N/A	N/A
1220AF01	Division B/D Corridor 82'-6'	MSFA	No	1. Loss of CVS is postulated.	FDS 1AB29
1222AF01	Division B Electrical Equipment	TSFA	No	1. For fires confined in the area, the fire scenario is bounded by loss of division B of power and control.	FDS 1AB30
				2. For fires confined in the area, an additional fire scenario is bounded by loss of division B of power and control plus spurious opening of ADS valves due to fire-induced damage to division B-related cabling that supports ADS valves.	FDS 1AB31
				3. For fires propagating from this area, the fire scenario is bounded by loss of division B of power and control, plus loss of division D reactor trip signal.	FDS 1AB32

Table 57-4 (Sheet 7 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
1222AF01	Division B Electrical Equipment	TSFA	No	4. For fires propagating from this area, an additional fire scenario is bounded by loss of division B of power and control plus non-recoverable spurious opening of ADS valves due to fire-induced damage to division B-related cabling that supports ADS valves, in addition to loss of division D reactor trip signal.	FDS 1AB33
1222AF02	Division B RCP Trip Switchgear	MSFA	No	1. Loss of division B RCP trip switchgear is postulated.	FDS 1AB34
				2. This fire scenario is bounded by loss of equipment discussed in (1), loss of B and D signals to reactor switchgear, and loss of DAS.	FDS 1AB53
				3. This fire scenario is bounded by loss of equipment discussed for FDS 1AB1, loss of B and D signals to reactor switchgear, and spurious opening of ADS valves due to fire-induced damage to ADS-related cabling.	FDS 1AB54
1230AF01	Division A/C Corridor 100'	MSFA	No	1. Spurious opening of ADS valves caused by the fire-induced damage to ADS cables is postulated.	FDS 1AB35
1230AF02	Rail Car Access Bay	NSFA	Yes (B1)	N/A	N/A
1230AF03	Non-class 1E Electrical Compartment 100'	MSFA	No	1. For fires confined in the area, spurious opening of ADS valves caused by fire-induced damage to ADS cables is postulated. Also, loss of reactor trip signals from B and D electrical divisions is postulated.	FDS 1AB36
				2. For fires propagating from the area, the fire scenario is bounded by spurious opening of ADS valves caused by fire-induced damage to the DAS cables, loss of reactor trip signals from B and D electrical divisions, and loss of division C power and control.	FDS 1AB55
1230AF04	Corridor 100'	NSFA	Yes (B2)	N/A	N/A
1231AF01	Division B I&C Equipment	TSFA	No	1. For fires confined in the area, the fire scenario is bounded by loss of division B of power and control.	FDS 1AB37

Table 57-4 (Sheet 8 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
1231AF01	Division B I&C Equipment	TSFA	No	2. For fires propagating from this area, the fire scenario is bounded by loss of division B of power and control plus spurious opening of ADS valves due to fire-induced damage to division B-related cabling that supports ADS valves.	FDS 1AB38
1232AF01	Remote Shutdown Workstation	MSFA	No	1. For fires confined in the area, the fire scenario is bounded by loss of control for all safe shutdown equipment from the control room due to damage to transfer switch. Control for all safe shutdown equipment can be restored by performing manual action from safety-related I&C switchgear rooms.	FDS 1AB39
				2. For fires propagating from this area, the fire scenario is bounded by loss of control for all safe shutdown equipment from the control room due to damage to transfer switch plus spurious opening of ADS valves. Control for all safe shutdown equipment can be restored by performing manual action from safety-related I&C switchgear rooms.	FDS 1AB40
1240AF01	Non-class 1E Electrical Compartment 117'	MSFA	No	1. For fires confined in the area, only reactor trip is postulated.	FDS 1AB41
				2. For fires propagating from this area, the fire scenario is bounded by loss of division A of power and control.	FDS 1AB42
				3. For fires propagating from this area, an additional fire scenario is bounded by loss of equipment discussed for FDS 1AB41 plus spurious opening of ADS valves due to fire-induced damage to division A-related cabling that supports ADS valves.	FDS 1AB43
1240AF02	Corridor 117'-6"	NSFA	Yes (B2)	N/A	N/A
1242AF01	Main Control Room	MSFA	No	Detailed analysis of this room is presented in the quantitative analysis file.	

Table 57-4 (Sheet 9 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
1242AF02	Division A Penetration Area	TSFA	No	1. This fire scenario is bounded by loss of division A of power and control.	FDS 1AB44
				2. This fire scenario is bounded by loss of division A of power and control plus spurious opening of ADS valves due to fire-induced damage to division A-related cabling that supports ADS valves.	FDS 1AB45
1243AF01	Reactor Trip Switchgear I	MSFA	No	1. For fires confined in the area, turbine trip with all PRA-credited systems other than reactor trip switchgear I available is postulated.	FDS 1AB46
				2. For fires propagating from this area, turbine trip with all PRA-credited systems other than reactor trip switchgears I and II available is postulated.	FDS 1AB47
1243AF02	Reactor Trip Switchgear II	MSFA	No	1. For fires confined in the area, turbine trip with all PRA-credited systems other than reactor trip switchgear I available is postulated.	FDS 1AB48
				2. For fires propagating from this area, turbine trip with all PRA-credited systems other than reactor trip switchgears I and II available is postulated.	FDS 1AB49
1244AF01	UFS Containment Penetrations	MSFA	No	1. For fires propagating out of this fire area, turbine trip with loss of one division of nonsafety-related AC and DC power is postulated.	FDS 1AB50
1252AF01	Non-radioactive Ventilation System	NSFA	No	1. Fire in this fire area is postulated to result in loss of secondary-side cooling.	FDS 1AB56
1254AF01	VAS/VFS Equipment Room	NSFA	Yes (B2)	N/A	N/A
1254AF02	Personnel Hatch	NSFA	Yes (B2)	N/A	N/A
2000AF01	Turbine Building Floor	NSFA	No	1. For fires confined in the area, the impact of fires will be bounded by the loss of all nonsafety-related PRA-credited safe shutdown equipment.	FDS 1TB1

Table 57-4 (Sheet 10 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
2000AF01	Turbine Building Floor	NSFA	No	2. For fires propagating from this area, the fire scenario is bounded by loss of division D of power and control, plus loss of service water, main feedwater, startup feed water, component cooling, and instrument air/service air systems.	FDS 1TB2
				3. For fires propagating from this area, an additional fire scenario is bounded by the loss of division D of power and control plus spurious opening of ADS valves due to fire-induced damage to division D-related cabling that supports ADS valves in addition to loss of service water, main feedwater, startup feedwater, component cooling, and instrument air/service air systems.	FDS 1TB3
2000AF02	Stairwell #1 Southwest	NSFA	Yes (B1)	N/A	N/A
2009AF01	Stairwell #2 and Freight Elevator	NSFA	No	1. For fires propagating from this area, all nonsafety-related, PRA-credited systems are assumed to be unavailable.	FDS 1TB4
2033AF01	Aux. Boiler Equipment Room	NSFA	No	1. For fires propagating from this area, all nonsafety-related, PRA-credited systems are assumed to be unavailable.	FDS 1TB5
2033AF02	Diesel-Driven Fire Pump Room	NFSA	No	1. For fires propagating from this area, all nonsafety-related, PRA-credited systems are assumed to be unavailable.	FDS 1TB6
2033AF03	Motor-Driven Fire Pump Room	NFSA	No	1. For fires propagating from this area, all nonsafety-related, PRA-credited systems are assumed to be unavailable.	FDS 1TB7
2043AF01	Chemical Laboratory	NSFA	No	1. For fires propagating from this area, all nonsafety-related, PRA-credited systems are assumed to be unavailable.	FDS 1TB8
2050AF01	Lube Oil Conditioner Room	NSFA	No	1. For fires propagating from this area, all nonsafety-related, PRA-credited systems are assumed to be unavailable.	FDS 1TB9
2052AF01	Southwest 4KV Switchgear Room	NSFA	No	1. For fires confined in the area, loss of the ECS-ES-3 4kV bus is assumed.	FDS 1TB10
				2. For fires propagating from the area, all nonsafety-related, PRA-credited systems are assumed to be unavailable.	FDS 1TB11

Table 57-4 (Sheet 11 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
2053AF01	Generator Panel Room	NFSA	No	1. LOOP with EDG power and safety-related power available are postulated.	FDS 1TB12
2053AF02	Northwest 4KV Switchgear Room	NSFA	No	1. For fires confined in the area, loss of the ECS-ES-4 4kV bus is assumed.	FDS 1TB13
				2. For fires propagating from the area, all nonsafety-related, PRA-credited systems are assumed to be unavailable.	FDS 1TB14
4001AF01	South Annex Building	NSFA	Yes (B2)	N/A	N/A
4001AF02	Elevator (Annex II)	NSFA	Yes (B1)	N/A	N/A
4003AF01	North Annex Stairwell	NSFA	Yes (B1)	N/A	N/A
4003AF02	Elevator (Annex I)	NSFA	Yes (B1)	N/A	N/A
4031AF01	Hot Machine Shop	NSFA	Yes (B2)	N/A	N/A
4031AF02	Containment Access Corridor	NSFA	No	1. For fires confined in the area, loss of RNS and CVS systems is assumed.	FDS 1AN1
				2. For fires propagating from this area, loss of the RNS and CVS systems plus loss of one division of nonsafety-related AC and DC power are assumed.	FDS 1AN2
4031AF03	HP Offices and Access Portal	NSFA	No	1. For fires confined in the area, loss of RNS and CVS systems is assumed.	FDS 1AN3
				2. For fires propagating from this area, loss of RNS and CVS systems plus loss of all nonsafety-related, PRA-credited safe shutdown systems are assumed.	FDS 1AN4
4031AF04	Demin. Water Degassifier	NSFA	No	1. For fires confined in the area, loss of RNS and CVS systems is assumed.	FDS 1AN5
4031AF05	Electrical Equipment	NSFA	No	1. For fires confined within this fire area, loss of all nonsafety-related systems is postulated.	FDS 1AN6
				2. For fires propagating from this fire area, spurious opening of ADS valves with all nonsafety-related, PRA-credited safe shutdown systems unavailable is postulated.	FDS 1AN7

Table 57-4 (Sheet 12 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
4032AF01	Non-class 1E Battery Charger #2	NSFA	No	1. For fires confined in the area, loss of one division of nonsafety-related DC power is postulated.	FDS 1AN8
				2. For fires propagating from this fire area, loss of all nonsafety-related systems is postulated.	FDS 1AN9
4032AF02	Non-class 1E Battery Charger #1	NSFA	No	1. For fires confined in the area, loss of one division of nonsafety-related DC power is postulated.	FDS 1AN10
				2. For fires propagating from this fire area, loss of all nonsafety-related systems is postulated.	FDS 1AN11
4032AF03	Non-class 1E Batteries #2	NSFA	No	See 4032AF01 fire area.	FDS 1AN12
4032AF04	Non-class 1E Batteries #1	NSFA	No	See 4032AF02 fire area.	FDS 1AN13
4033AF01	General Offices	NSFA	No	1. For fires propagating from this area, loss of all nonsafety-related systems is postulated.	FDS 1AN14
4041AF01	Non-class 1E Switchgear #2	NSFA	No	1. For fires confined within the area, loss of non-class 1E AC power and loss of DAS system are postulated.	FDS 1AN15
				2. For fires propagating from this area, loss of all nonsafety-related systems is postulated.	FDS 1AN16
				3. For fires propagating from this area, spurious opening of the ADS valves and loss of all nonsafety-related, PRA-credited safe shutdown systems are postulated.	FDS 1AN17
4042AF01	Non-class 1E Switchgear #1	NSFA	No	1. For fires confined within the area, loss of one division of non-class 1E AC power and loss of DAS are postulated.	FDS 1AN18
				2. For fires propagating from this area, loss of all nonsafety-related systems is postulated.	FDS 1AN19

Table 57-4 (Sheet 13 of 13)

SUMMARY OF QUALITATIVE EVALUATION RESULTS

Fire Area	Description	Type	Screened	Fire Scenario	Fire Damage State
4042AF01	Non-class 1E Switchgear #1	NSFA	No	3. For fires propagating from this area, spurious opening of ADS valves and loss of all nonsafety-related, PRA-credited safe shutdown systems are postulated.	FDS 1AN20
4042AF03	Conference/Turnover Room	NSFA	No	1. Loss of one division of nonsafety-related power and control and loss of DAS control of ADS valves are postulated.	FDS 1AN21
				2. Spurious opening of ADS valves caused by fire-induced damage to DAS cables routed in this fire area with one division of nonsafety-related systems and DAS unavailable are postulated.	FDS 1AN22
4051AF01	Operating Deck Staging/Storage Areas	NFSA	Yes (B2)	N/A	N/A
4051AF02	Containment Purge/ Exhaust Room	NSFA	No	1. Loss of RNS.	FDS 1AN23
4052AF01	Air Handling Equipment Room	NSFA	Yes (B2)	N/A	N/A
5000AF00	Radwaste Building	NSFA	No	1. For fire propagation out of this area, loss of RNS is postulated.	FDS 1RW1
6030AF01	DG Room A	NSFA	No	1. For fires propagating from the area, loss of power from both DGs is postulated.	FDS 1DG1
6030AF02	DG Room B	NSFA	No	1. For fires propagating from this area, loss of power from both DGs is postulated.	FDS 1DG2
6030AF03	Fuel Oil Day Tank Room A	NSFA	No	1. For fires propagating from this area, loss of power from both DGs is postulated.	FDS 1DG3
6030AF04	Fuel Oil Day Tank Room A	NSFA	No	1. For fires propagating from this area, loss of power from both DGs is postulated.	FDS 1DG4

Table 57-5 (Sheet 1 of 2)

SUMMARY OF QUALITATIVE EVALUATION RESULTS FOR CONTAINMENT

Fire Zone	Description	Fire Scenario	Fire Damage State
1100AF11206	PXS Valve/ Accumulator Room A	1. Malfunction of power and control to all energized valves located in the zone. That is, MOVs for CMT, and IRWST/containment sump recirc line isolation valves supported by divisions B and D of power and control will remain closed.	FDS 1CT1
1100AF11207	PXS Valve/ Accumulator Room B	1. Malfunction of power and control to all energized valves located in the zone. That is, MOVs for CMT, and IRWST/containment sump recirc line isolation valves supported by divisions A and C of power and control will remain closed.	FDS 1CT2
1100AF11300A	Maintenance Floor	1. Loss of CMT-A.	FDS 1CT3
		2. Spurious opening of ADS valves with CMT-A unavailable.	FDS 1CT4
1100AF11300B	Maintenance Floor	1. Loss of one PRHR isolation valve and loss of one CCW flow path to the containment.	FDS 1CT5
1100AF11300C	Maintenance Floor	1. Loss of CMT-A due to damage to CMT-A-related cabling.	FDS 1CT6
		2. Spurious opening of ADS valves with CMT-A unavailable.	FDS 1CT7
1100AF11301	SG Compartment 1	1. Loss of secondary side cooling and loss of one fourth-stage ADS valves.	FDS 1CT8
		2. Loss of secondary side cooling and spurious opening of ADS valves.	FDS 1CT9
1100AF11302	SG Compartment 2	1. Loss of secondary side cooling and loss of one forth stage ADS valves.	FDS 1CT10
		2. Loss of secondary side cooling and spurious opening of ADS valves.	FDS 1CT11
1100AF11303	Pressurizer Compartment	1. Loss of auto-actuation of the CMTs.	FDS 1CT12
1100AF11303A	ADS Upper Valve Area	1. Failure of ADS valves supported by divisions B and D of safety related power.	FDS 1CT13
		2. Spurious opening of the stage 1, 2, and 3 ADS valves supported by divisions B and D of power and control.	FDS 1CT14

Table 57-5 (Sheet 2 of 2)

SUMMARY OF QUALITATIVE EVALUATION RESULTS FOR CONTAINMENT

Fire Zone	Description	Fire Scenario	Fire Damage State
1100AF11303B	ADS Lower Valve Area	1. Failure of ADS valves supported by divisions A and C of safety-related power.	FDS 1CT15
		2. Spurious opening of stage 1, 2, and 3 ADS valves supported by divisions A and C of power and control.	FDS 1CT16
1100AF11500	Operating Deck	1. Failure of ADS valves supported by divisions A and C of safety-related power.	FDS 1CT17
		2. Spurious opening of stage 1, 2, and 3 ADS valves supported by divisions A and C of power and control.	FDS 1CT18
1200AF12356	Middle Annulus	1. Loss of one division of power and control.	FDS 1CT19
		2. Fire-induced LOCA due to spurious opening of ADS valves with one division of power and control unavailable.	FDS 1CT20

Table 57-6 (Sheet 1 of 3)

FIRE IGNITION FREQUENCIES FOR AP600 FIRE AREAS

Fire Area	Area Description	Ignition Frequency
0000 AF 00	Yard Building (including transformer yard)	2.00E-2
1000 AF 01	Containment/Shield Building	4.28E-3
1200 AF 01	RCA of Aux. Building	2.31E-2
1201 AF 02	Division B Batteries	7.47E-4
1201 AF 03	Division D DC Equipment/I&C	2.42E-3
1201 AF 04	Division B/D VBS Equipment	3.60E-4
1201 AF 05	MSIV Compartment A	6.60E-4
1201 AF 06	MSIV Compartment B	3.31E-4
1202 AF 02	Northeast Elevator Shaft	1.17E-3
1202 AF 03	Division C Batteries	7.47E-4
1202 AF 04	Division A Electrical Equipment	2.42E-3
1202 AF 05	Division C Electrical Equipment	3.70E-3
1205 AF 02	Southeast Elevator Shaft	1.17E-3
1211 AF 01	Division D Batteries	6.20E-4
1212 AF 01	Division A Electrical Rooms	5.84E-4
1220 AF 01	Division B/D Corridor - 82'-6"	1.60E-3
1222 AF 01	Division B Electrical Equipment	1.46E-3
1222 AF 02	Division B RCP Trip Switchgear	2.97E-3
1230 AF 01	Division A/C Corridor - 100'	1.71E-4
1230 AF 03	Non-Class 1E Electrical Compartment - 100'	1.56E-3
1231 AF 01	Division B I&C Equipment	1.52E-3
1232 AF 01	Remote Shutdown Workstation	1.32E-4
1240 AF 01	Non-Class 1E Electrical Compartment - 117'	1.55E-3
1242 AF 01	Main Control Room	1.03E-2
1242 AF 02	Division A Penetration Area	3.33E-4

Table 57-6 (Sheet 2 of 3)

FIRE IGNITION FREQUENCIES FOR AP600 FIRE AREAS

Fire Area	Area Description	Ignition Frequency
1243 AF 01	Reactor Trip Switchgear I	2.84E-3
1243 AF 02	Reactor Trip Switchgear II	2.84E-3
1244 AF 01	VFS Containment Penetrations	1.38E-4
1252 AF 01	Nonradioactive Ventilation System	2.68E-3
2000 AF 01	Turbine Building Floor	6.47E-2
2009 AF 01	Stairwell #2 and Freight Elevator	1.17E-3
2033 AF 01	Aux. Boiler Equipment Room	1.23E-3
2033 AF 02	Diesel-Driven Fire Pump Room	1.02E-3
2033 AF 03	Motor-Driven Fire Pump Room	1.01E-3
2043 AF 01	Chemical Laboratory	3.23E-4
2050 AF 01	Lube Oil Conditioner Room	2.83E-4
2052 AF 01	Southwest 4KV Switchgear Room	2.48E-3
2053 AF 01	Generator Panel Room	6.70E-3
2053 AF 02	Northwest 4KV Switchgear Room	2.48E-3
4031 AF 02	Containment Access Corridor	4.38E-4
4031 AF 03	HP Offices and Access Portal	8.53E-4
4031 AF 04	Demin. Water Degassifier	2.30E-3
4031 AF 05	Electrical Equipment	1.49E-3
4032 AF 01	Non-Class 1E Battery Charger #2	1.26E-3
4032 AF 02	Non-Class 1E Battery Charger #1	2.25E-3
4032 AF 03	Non-Class 1E Batteries #2	6.22E-4
4032 AF 04	Non-Class 1E Batteries #1	6.22E-4
4033 AF 01	General Offices	2.84E-3
4033 AF 02	Central Alarm Station	1.93E-3

Table 57-6 (Sheet 3 of 3)

FIRE IGNITION FREQUENCIES FOR AP600 FIRE AREAS

Fire Area	Area Description	Ignition Frequency
4041 AF 01	Non-Class 1E Switchgear #2	2.66E-3
4042 AF 01	Non-Class 1E Switchgear #1	8.34E-3
4042 AF 02	Technical Support Center	4.66E-4
4042 AF 03	Conference/Turnover Room	4.50E-4
4051 AF 02	Containment Purge Exhaust Filter Room	4.35E-4
5000/Radwaste	Radwaste Building	2.42E-2
6030 AF 01	Diesel Generator Room A	2.99E-2
6030 AF 02	Diesel Generator Room B	3.03E-2
6030 AF 03	Fuel Oil Day Tank Room A	2.10E-4
6030 AF 04	Fuel Oil Day Tank Room B	2.10E-4

Table 57-7

FIRE IGNITION FREQUENCIES FOR AP600 CONTAINMENT FIRE AREA

Fire Area	Description	Frequency
1100 AF 11206	Accumulator Room A	1.81E-05
1100 AF 11207	Accumulator Room B	1.81E-05
1100 AF 11300A	Maintenance Floor (SE quadrant access)	2.45E-05
1100 AF 11300B	Maintenance Floor (NNE quadrant) and RCDT access	1.75E-04
1100 AF 11300C	Maintenance Floor (NNE quadrant above platform)	8.24E-04
1100 AF 11301	SG Compartment 1	1.70E-04
1100 AF 11302	SG Compartment 2	9.51E-05
1100 AF 11303	Pressurizer Compartment	1.81E-05
1100 AF 11303A	ADS Lower Valve Area	1.81E-05
1100 AF 11303B	ADS Upper Valve Area	1.81E-05
1100 AF 11500	Operating Deck	2.86E-03
1200 AF 12356	Middle Annulus	2.29E-05
1200 AF 12556	Upper Annulus	1.97E-05
	TOTAL	4.28E-03

Table 57-8 (Sheet 1 of 7)

SUMMARY OF FIRE DAMAGE STATE BINNING PROCESS

Fire Area	Fire Damage State	Modeled Event	Modeled Accident Mitigating System Damage[4]	Damage Category
0000AF00	FDS 1TY1	LOOP	Loss of all nonsafety-related systems	LP1
1000AF01	See Table 57-9			
1200AF01	FDS 1AB1	Focused LOOP[1]	Loss of all nonsafety-related systems	NP1
	FDS 1AB2	Focused LOOP[1]	Loss of all nonsafety-related systems	NP1
	FDS 1AB3	Focused LLOCA/ MLOCA	Loss of all nonsafety-related systems	NL1 NM1[3]
1201AF02	FDS 1AB4	LMFW (degraded)[1][2]	Loss of all nonsafety-related systems, loss of one division of power and control, including failure of IRWST valves 123A, 117A, 118A, degrading support for ADS, loss of secondary-side PORVs	TB1
	FDS 1AB5	LLOCA/ MLOCA (degraded)[2]	Loss of all nonsafety-related systems, loss of one division of power and control, loss of IRWST valves 125A, 120A	LB1 MB1[3]
1201AF03	FDS 1AB6	LMFW (degraded)[1][2]	Loss of all nonsafety-related systems, loss of one division of power and control, loss of IRWST valves 123A, 117A, 118A	TD1
	FDS 1AB7	LLOCA/ MLOCA (degraded)[2]	Loss of all nonsafety-related systems, loss of one division of power and control, loss of IRWST valves 125A, 120A	LD1 MD1[3]
	FDS 1AB8	LMFW (degraded)[1][2]	Loss of all nonsafety-related systems, loss of one division of power and control, loss of IRWST valves 123A, 117A, 118A	TD1
	FDS 1AB9	LLOCA/ MLOCA (degraded)	(See FDS 1AB7)	LD1 MD1

Table 57-8 (Sheet 2 of 7)

SUMMARY OF FIRE DAMAGE STATE BINNING PROCESS

Fire Area	Fire Damage State	Modeled Event	Modeled Accident Mitigating System Damage[4]	Damage Category
1201AF04	FDS 1AB6	LMFW (degraded)	(See FDS 1AB6)	TD1
	FDS 1AB7	LLOCA/ MLOCA (degraded)	(See FDS 1AB7)	LD1 MD1
	FDS 1AB10	Focused LOOP (degraded)	Loss of all nonsafety-related systems, loss of one division of power and control, failure of IRWST valves 125A, 120A	NP2
	FDS 1AB11	Focused LLOCA/ MLOCA (degraded)	Loss of all nonsafety-related systems, loss of one division of power and control, failure of IRWST valves 125A, 120A	NL2 NM2
1201AF05	FDS 1AB12	Focused LOOP	Loss of all nonsafety-related systems	NP1
	FDS 1AB13	LMFW (degraded)	(See FDS 1AB6)	TD1
	FDS 1AB14	LLOCA/ MLOCA (degraded)	(See FDS 1AB7)	LD1 MD1
1201AF06	FDS 1AB12	Focused LOOP	Loss of all nonsafety-related systems	NP1
	FDS 1AB13	LMFW (degraded)	(See FDS 1AB6)	TD1
	FDS 1AB14	LLOCA/ MLOCA (degraded)	(See FDS 1AB7)	LD1
1202AF02	FDS 1AB51	Focused TRANS	Loss of all nonsafety-related systems	TL1
1202AF03	FDS 1AB15	LMFW (degraded)	Loss of one division of power and control, failure of IRWST valve 125	TB1
	FDS 1AB16	LMFW (degraded)	(See FDS 1AB15)	TB1

Table 57-8 (Sheet 3 of 7)

SUMMARY OF FIRE DAMAGE STATE BINNING PROCESS

Fire Area	Fire Damage State	Modeled Event	Modeled Accident Mitigating System Damage[(4)]	Damage Category
1202AF04	FDS 1AB17	LMFW (degraded)	(See FDS 1AB19)	TD1
	FDS 1AB18	LLOCA/ MLOCA (degraded)	1 or 2 Stage 4 ADS open IRWST V117A, 118B, 123B inop. RNS inop. Loss of Div. A	LA1 MA1
	FDS 1AB19	LMFW (degraded)	MSIV Closes FWV Closes RNS V022, V011 inop. IRWST V117A, 118B, 123B inop. Degraded ADS	TD1
	FDS 1AB20	LLOCA/ MLOCA (degraded)	(See FDS 1AB18)	LA1 MA1
1202AF05	FDS 1AB21	LMFW (degraded)	(See FDS 1AB15)	TB1
	FDS 1AB22	LLOCA/ MLOCA (degraded)	Loss of all nonsafety-related systems, loss of one division of power and control, failure of IRWST valves 125A and 120A	LC1 MC1
	FDS 1AB23	LMFW (degraded)	(See FDS 1AB15)	TB1
	FDS 1AB24	LLOCA/ MLOCA (degraded)	(See FDS 1AB22)	LC1 MC1
1205AF02	FDS 1AB52	Focused LOOP	Loss of all nonsafety-related systems	NP1
1211AF01	FDS 1AB25	LMFW (degraded)	(See FDS 1AB6)	TD1
	FDS 1AB26	LLOCA/ MLOCA (degraded)	(See FDS 1AB7)	LD1 MD1
1212AF01	FDS 1AB27	LMFW (degraded)	(See FDS 1AB19)	TD1
	FDS 1AB28	LLOCA/ MLOCA (degraded)	(See FDS 1AB18)	LA1 MA1

Table 57-8 (Sheet 4 of 7)

SUMMARY OF FIRE DAMAGE STATE BINNING PROCESS

Fire Area	Fire Damage State	Modeled Event	Modeled Accident Mitigating System Damage[(4)]	Damage Category
1220AF01	FDS 1AB29	Focused TRANS	Loss of all nonsafety-related systems	TL1
1222AF01	FDS 1AB30	LMFW (degraded)	(See FDS 1AB4)	TB1
	FDS 1AB31	LLOCA/ MLOCA (degraded)	(See FDS 1AB5)	LB1 MB1
	FDS 1AB32	LMFW degraded)	(See FDS 1AB4)	TB1
	FDS 1AB33	LLOCA/ MLOCA (degraded)	(See FDS 1AB5)	LB1 MB1
1222AF02	FDS 1AB34	TRANS	Loss of all nonsafety-related systems	TR1
	FDS 1AB53	Focused LOOP	Loss of all nonsafety-related systems	NP1
	FDS 1AB54	Focused LLOCA/ MLOCA	Loss of all nonsafety-related systems	NL1 NM1
1230AF01	FDS 1AB35	LLOCA/ MLOCA	Loss of all nonsafety-related systems	LL1 ML1
1230AF03	FDS 1AB36	LLOCA/ MLOCA	(See FDS 1AB35)	LL1 ML1
	FDS 1AB55	LLOCA/ MLOCA (degraded)	(See FDS 1AB22)	LC1 MC1
1231AF01	FDS 1AB37	LMFW (degraded)	(See FDS 1AB4)	TB1
	FDS 1AB38	LLOCA/ MLOCA (degraded)	(See FDS 1AB5)	LB1 MB1
1232AF01	FDS 1AB39	TRANS (degraded)	Loss of manual control from the control room	TD2
	FDS 1AB40	LLOCA/ MLOCA	Loss of manual control from the control room	LL2 ML2

Table 57-8 (Sheet 5 of 7)

SUMMARY OF FIRE DAMAGE STATE BINNING PROCESS

Fire Area	Fire Damage State	Modeled Event	Modeled Accident Mitigating System Damage[4]	Damage Category
1240AF01	FDS 1AB41	TRANS		TR1
	FDS 1AB42	LMFW (degraded)	(See FDS 1AB19)	TD1
	FDS 1AB43	LLOCA/ MLOCA (degraded)	(See FDS 1AB18)	LA1 MA1
1242AF02	FDS 1AB44	LMFW (degraded)	(See FDS 1AB19)	TD1
	FDS 1AB45	LLOCA/ MLOCA (degraded)	(See FDS 1AB18)	LA1 MA1
1243AF01	FDS 1AB46	TRANS	-	TR1
	FDS 1AB47	TRANS	-	TR1
1243AF02	FDS 1AB48	TRANS	-	TR1
	FDS 1AB49	TRANS	-	TR1
1244AF01	FDS 1AB50	Focused LOOP	(See FDS 1AB1)	NP1
1252AF01	FDS 1AB56	Focused LOOP	SFW MFW	NP1
2000AF01	FDS 1TB1	Focused LOOP	(See FDS 1AB1)	NP1
	FDS 1TB2	Focused LOOP (degraded)	(See FDS 1AB10)	NP2
	FDS 1TB3	Focused LLOCA/ MLOCA (degraded)	(See FDS 1AB11)	NL2 NM2
2009AF01	FDS 1TB4	Focused LOOP	(See FDS 1AB1)	NP1
2033AF01	FDS 1TB5	Focused LOOP	(See FDS 1AB1)	NP1
2033AF02	FDS 1TB6	Focused LOOP	(See FDS 1AB1)	NP1

Table 57-8 (Sheet 6 of 7)

SUMMARY OF FIRE DAMAGE STATE BINNING PROCESS

Fire Area	Fire Damage State	Modeled Event	Modeled Accident Mitigating System Damage(4)	Damage Category
2033AF03	FDS 1TB7	Focused LOOP	(See FDS 1AB1)	NP1
2043AF01	FDS 1TB8	Focused LOOP	(See FDS 1AB1)	NP1
2050AF01	FDS 1TB9	Focused LOOP	(See FDS 1AB1)	NP1
2052AF01	FDS 1TB10	LMFW	MFW	TR2
	FDS 1TB11	Focused LOOP		NP1
2053AF01	FDS 1TB12	LOOP	-	LP1
2053AF02	FDS 1TB13	LMFW		TR2
	FDS 1TB14	Focused LOOP		NP1
4031AF02	FDS 1AN1	Focused LOOP	(All nonsafety-related systems)	NP1
	FDS 1AN2	Focused LOOP	Loss of all nonsafety-related systems + NS Power/Control	NP1
4031AF03	FDS 1AN3	Focused LOOP	(All nonsafety-related systems)	NP1
	FDS 1AN4	Focused LOOP	(All nonsafety-related systems) + NS Power/Control	NP1
4031AF04	FDS 1AN5	Focused LOOP	(All nonsafety-related systems)	NP1
4031AF05	FDS 1AN6	Focused LOOP		NP1
	FDS 1AN7	Focused LLOCA/ MLOCA	1 or 2 Stage 4 ADS Open	NL1 NM1
4032AF01	FDS 1AN8	Focused LOOP		NP1
	FDS 1AN9	Focused LOOP		NP1

Table 57-8 (Sheet 7 of 7)

SUMMARY OF FIRE DAMAGE STATE BINNING PROCESS

Fire Area	Fire Damage State	Modeled Event	Modeled Accident Mitigating System Damage[4]	Damage Category
4032AF02	FDS 1AN10	Focused LOOP		NP1
	FDS 1AN11	Focused LOOP		NP1
4032AF03	FDS 1AN12	Focused LOOP		NP1
4032AF04	FDS 1AN13	Focused LOOP		NP1
4033AF01	FDS 1AN14	Focused LOOP		NP1
4041AF01	FDS 1AN15	Focused LOOP		NP1
	FDS 1AN16	Focused LOOP		NP1
	FDS 1AN17	Focused LLOCA/ MLOCA	2 Stage 4 ADS Open	NL1 NM1
4042AF01	FDS 1AN18	Focused LOOP		NP1
	FDS 1AN19	Focused LOOP		NP1
	FDS 1AN20	Focused LLOCA/ MLOCA	2 Stage 4 ADS Open	NL1 NM1
4042AF03	FDS 1AN21	Focused LOOP		NP1
	FDS 1AN22	Focused LLOCA/ MLOCA	2 Stage 4 ADS Open	NL1 NM1
4051AF02	FDS 1AN23	(TRANS) (degraded)	(All nonsafety-related system)	XT2
5000AF00	FDS 1RW1	(TRANS) (degraded)	(All nonsafety-related system)	XT2
6030AF01	FDS 1DG1	(TRANS)	DG	XT1
6030AF02	FDS 1DG2	(TRANS)	DG	XT1
6030AF03	FDS 1DG3	(TRANS)	DG	XT1
6030AF04	FDS 1DG4	(TRANS)	DG	XT1

Note:

1. Results of the focused PRA showed that the highest CCDPs for transient events were those corresponding to loss-of-main feedwater (LMFW) and loss-of-offsite power (LOOP), and that the two CCDPs were about the same. Thus, the modeled event was assigned as LOOP in some scenarios. LMFW was generally selected when it was clear from the damage scenario that main feedwater isolation would occur.
2. The notation "degraded" implies that some equipment credited in the modeled focused PRA scenario would be affected by the fire, and that the model was revised to eliminate credit for such components.
3. For scenarios in which spurious ADS valve actuation was identified, two scenarios were quantified: one as a medium LOCA resulting from a single-hot-short actuation of a stage 4 ADS valve; and the other as a large LOCA resulting from multiple-hot-short actuation of two-stage 4 ADS valves.
4. Although some entries specifically note a loss of nonsafety-related systems as a modeled input and other entries do not, all scenarios were modeled with no credit for nonsafety-related systems.

Table 57-9 (Sheet 1 of 2)

SUMMARY OF FIRE DAMAGE STATE BINNING PROCESS FOR CONTAINMENT

Fire Zone	Fire Damage State	Modeled Event	Modeled Accident Mitigating System	Damage Category
1100AF11206	FDS 1CT1	(TRANS) (degraded)	IRWST V117A, 118A, 120A, 123A, 125A inop. Loss of Div. B & D	XCT
1100AF11207	FDS 1CT2	(TRANS) (degraded)	IRWST V117B, 118B, 120B, 123B, 125B inop. Loss of Div. A & C	XCT
1100AF11300A	FDS 1CT3	(TRANS) (degraded)	1 CMT inop. Loss of Div. A	TD1
	FDS 1CT4	(LLOCA) (degraded)	2 Stage 4 ADS Open 1 CMT inop. Loss of Div. A	LA1 MA1
1100AF11300B	FDS 1CT5	(TRANS) (degraded)	Degraded PRHR	TD1
1100AF11300C	FDS 1CT6	(TRANS) (degraded)	1 CMT inop. Loss of Div. A	TD1
	FDS 1CT7	LLOCA (degraded)	2 Stage 4 ADS Open 1 CMT inop. Loss of Div. A	LA1 MA1
1100AF11301	FDS 1CT8	Focused LOOP (degraded)	MFW, SFW 1 ADS Stage 4 inop. Loss of 1 Div.	TB1
	FDS 1CT9	MLOCA	1 Stage 4 ADS Open MFW + Loss of 1 Div. SFW	NM2 NL2
1100AF11302	FDS 1CT10	Focused LOOP (degraded)	MFW + Loss of 1 Div. SFW 1 Stage 4 ADS inop.	TB1
	FDS 1CT11	MLOCA	1 Stage 4 ADS Open MFW + Loss of 1 Div. SFW	NM2 NL2
1100AF11303	FDS 1CT12	(TRANS) (degraded)	Degraded CMT	XCT
1100AF11303A	FDS 1CT13	(TRANS) (degraded)	2 Stage 4 ADS inop. 2 Stage 2/3 ADS inop. 1 Stage 1 ADS inop. Loss of Div. B & D	XCT
	FDS 1CT14	LLOCA	2 Stage 4 ADS Open Loss of Div. B & D	CL3

Table 57-9 (Sheet 2 of 2)

SUMMARY OF FIRE DAMAGE STATE BINNING PROCESS FOR CONTAINMENT

Fire Zone	Fire Damage State	Modeled Event	Modeled Accident Mitigating System	Damage Category
1100AF11303B	FDS 1CT15	(TRANS) (degraded)	(See FDS 1CT13) + Loss of Div. A & C instead of B & D	XCT
	FDS 1CT16	LLOCA	2 Stage 4 ADS Open Loss of Div. A & C	CL3
1100AF11500	FDS 1CT17	(TRANS) (degraded)	Degraded ADS Loss of Div. A & C	XCT
	FDS 1CT18	LLOCA	ADS Loss of Div A & C	CL3
1200AF12356	FDS 1CT19	LMFW (degraded)	(See FDS 1AB6) (Loss of Div. D)	TD1
	FDS 1CT20	LLOCA (degraded)	(See FDS 1AB7) (Loss of Div. D + LOCA)	LD1

Table 57-10 (Sheet 1 of 9)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS

Fire Area	Total Fire Ignition Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Probability (CCDP)	Core Damage Frequency (CDF)	Total Contribution of Fire Area to CDF
0000AF00	2.00E-02	FDS 1TY1	2.00E-02	LP1	8.75E-08	1.75E-09	1.75E-09
1000AF01	4.37E-03	See Table 57-11					3.04E-07
1200AF01	2.31E-02	FDS 1AB1	2.29E-02	NP1	8.75E-08	2.00E-09	5.76E-09
		FDS 1AB2	2.17E-04	NP1	8.75E-08	1.90E-11	
		FDS 1AB3	8.34E-07	NL1	5.51E-04	4.50E-10	
			1.39E-05	NM1	2.37E-04	3.29E-09	
1201AF02	7.47E-04	FDS 1AB4	7.47E-04	TB1	1.19E-07	8.89E-11	2.73E-10
		FDS 1AB5	2.69E-08	LB1	7.86E-04	2.11E-11	
			4.48E-07	MB1	3.64E-04	1.63E-10	
1201AF03	2.42E-03	FDS 1AB6	2.25E-03	TD1	1.19E-07	2.68E-10	6.00E-08
		FDS 1AB7	8.62E-06	LD1	7.86E-04	6.78E-09	
			1.44E-04	MD1	3.64E-04	5.24E-08	
		FDS 1AB8	2.26E-05	TD1	1.19E-07	2.69E-12	
		FDS 1AB9	8.71E-08	LD1	7.86E-04	6.85E-11	
			1.45E-06	MD1	3.64E-04	5.28E-10	

Table 57-10 (Sheet 2 of 9)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS

Fire Area	Total Fire Ignition Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Probability (CCDP)	Core Damage Frequency (CDF)	Total Contribution of Fire Area to CDF
1201AF04	3.60E-04	FDS 1AB6	3.34E-04	TD1	1.19E-07	3.97E-11	8.89E-09
		FDS 1AB7	1.28E-06	LD1	7.86E-04	1.01E-09	
			2.13E-05	MD1	3.64E-04	7.75E-09	
		FDS 1AB10	3.38E-06	NP2	1.09E-07	3.68E-13	
		FDS 1AB11	1.30E-08	NL2	7.86E-04	1.02E-11	
			2.17E-07	NM2	3.64E-04	7.90E-11	
1201AF05	6.60E-04	FDS 1AB12	6.53E-04	NP1	8.75E-08	5.71E-11	2.21E-10
		FDS 1AB13	6.18E-06	TD1	1.19E-07	7.35E-13	
		FDS 1AB14	2.38E-08	LD1	7.86E-04	1.87E-11	
			3.97E-07	MD1	3.64E-04	1.45E-10	
1201AF06	3.31E-04	FDS 1AB12	3.28E-04	NP1	8.75E-08	2.87E-11	1.10E-10
		FDS 1AB13	3.30E-06	TD1	1.19E-07	3.93E-13	
		FDS 1AB14	1.19E-08	LD1	7.86E-04	9.35E-12	
			1.98E-07	MD1	3.64E-04	7.21E-11	
1202AF02	1.17E-03	FDS 1AB51	1.17E-03	TL1	5.78E-08	6.76E-11	6.76E-11

Table 57-10 (Sheet 3 of 9)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS

Fire Area	Total Fire Ignition Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Probability (CCDP)	Core Damage Frequency (CDF)	Total Contribution of Fire Area to CDF
1202AF03	7.47E-04	FDS 1AB15	7.47E-04	TB1	1.19E-07	8.89E-11	8.89E-11
		FDS 1AB16	4.48E-07	TB1	1.19E-07	5.33E-14	
1202AF04	2.42E-03	FDS 1AB17	2.25E-03	TD1	1.19E-07	2.68E-10	6.00E-08
		FDS 1AB18	8.62E-06	LA1	7.86E-04	6.78E-09	
			1.44E-04	MA1	3.64E-04	5.24E-08	
		FDS 1AB19	2.26E-05	TD1	1.19E-07	2.69E-12	
		FDS 1AB20	8.71E-08	LA1	7.86E-04	6.85E-11	
			1.45E-06	MA1	3.64E-04	5.28E-10	
1202AF05	3.70E-03	FDS 1AB21	3.43E-03	TB1	1.19E-07	4.08E-10	9.18E-8
		FDS 1AB22	1.32E-05	LC1	7.86E-04	1.04E-08	
			2.20E-04	MC1	3.64E-04	8.01E-08	
		FDS 1AB23	3.47E-05	TB1	1.19E-07	4.13E-12	
		FDS 1AB24	1.33E-07	LC1	7.86E-04	1.05E-10	
			2.22E-06	MC1	3.64E-04	8.08E-10	
1205AF02	1.17E-03	FDS 1AB52	1.17E-03	NP1	8.75E-08	1.02E-10	1.02E-10

Table 57-10 (Sheet 4 of 9)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS

Fire Area	Total Fire Ignition Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Probability (CCDP)	Core Damage Frequency (CDF)	Total Contribution of Fire Area to CDF
1211AF01	6.20E-04	FDS 1AB25	6.20E-04	TD1	1.19E-07	7.38E-11	2.26E-10
		FDS 1AB26	2.23E-08	LD1	7.86E-04	1.75E-11	
			3.72E-07	MD1	3.64E-04	1.35E-10	
1212AF01	5.84E-04	FDS 1AB27	5.84E-04	TD1	1.19E-07	6.95E-11	2.13E-10
		FDS 1AB28	2.10E-08	LA1	7.86E-04	1.65E-11	
			3.50E-07	MA1	3.64E-04	1.27E-10	
1220AF01	1.60E-03	FDS 1AB29	1.60E-03	TL1	5.78E-08	9.25E-11	9.25E-11
1222AF01	1.46E-03	FDS 1AB30	1.35E-03	TB1	1.19E-07	1.61E-10	3.62E-08
		FDS 1AB31	5.20E-06	LB1	7.86E-04	4.09E-09	
			8.67E-05	MB1	3.64E-04	3.16E-08	
		FDS 1AB32	1.36E-05	TB1	1.19E-07	1.62E-12	
		FDS 1AB33	5.26E-08	LB1	7.86E-04	4.13E-11	
			8.77E-07	MB1	3.64E-04	3.19E-10	
1222AF02	2.97E-03	FDS 1AB34	2.76E-03	TR1	5.78E-08	1.59E-10	1.75E-10
		FDS 1AB53	1.78E-04	NP1	8.75E-08	1.56E-11	

Table 57-10 (Sheet 5 of 9)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS

Fire Area	Total Fire Ignition Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Probability (CCDP)	Core Damage Frequency (CDF)	Total Contribution of Fire Area to CDF
1230AF01	1.71E-04	FDS 1AB35	6.16E-07	LL1	5.51E-04	3.39E-11	2.47E-09
			1.03E-05	ML1	2.37E-04	2.44E-09	
1230AF03	1.56E-03	FDS 1AB36	5.56E-06	LL1	5.51E-04	3.06E-09	2.54E-08
			9.27E-05	ML1	2.37E-04	2.20E-08	
		FDS 1AB54	5.62E-08	LC1	7.86E-04	4.42E-11	
			9.37E-07	MC1	3.64E-04	3.41E-10	
1231AF01	1.52E-03	FDS 1AB37	1.56E-03	TB1	1.19E-07	1.86E-10	5.61E-10
		FDS 1AB38	5.47E-08	LB1	7.86E-04	4.30E-11	
			9.12E-07	MB1	3.64E-04	3.32E-10	
1232AF01	1.32E-04	FDS 1AB39	1.31E-04	TD2	1.55E-06	2.03E-10	2.86E-10
		FDS 1AB40	4.75E-09	LL2	1.02E-03	4.85E-12	
			7.92E-08	ML2	9.87E-04	7.82E-11	
1240AF01	1.55E-03	FDS 1AB41	1.55E-03	TR1	5.78E-08	8.96E-11	4.08E-10
		FDS 1AB42	7.28E-07	TD1	1.19E-07	8.66E-14	
		FDS 1AB43	4.65E-08	LA1	7.86E-04	3.65E-11	
			7.75E-07	MA1	3.64E-04	2.82E-10	

Table 57-10 (Sheet 6 of 9)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS

Fire Area	Total Fire Ignition Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Probability (CCDP)	Core Damage Frequency (CDF)	Total Contribution of Fire Area to CDF
1242AF01	1.03E-02	See Control Room Analysis	1.03E-02				5.70E-11
1242AF02	3.33E-04	FDS 1AB44	3.11E-04	TD1	1.19E-07	3.70E-11	8.26E-09
		FDS 1AB45	1.20E-06	LA1	7.86E-04	9.43E-10	
			2.00E-05	MA1	3.64E-04	7.28E-09	
1243AF01	2.84E-03	FDS 1AB46	2.81E-03	TR1	5.78E-08	1.62E-10	1.62E-10
		FDS 1AB47	2.84E-05	TR1	5.78E-08	1.64E-12	
1243AF02	2.84E-03	FDS 1AB48	2.81E-03	TR1	5.78E-08	1.62E-10	1.62E-10
		FDS 1AB49	2.84E-05	TR1	5.78E-08	1.64E-12	
1244AF01	1.38E-04	FDS 1AB50	1.38E-06	NP1	8.75E-08	1.21E-13	1.21E-13
1252AF01	2.65E-03	FDS 1AB55	2.65E-03	NP1	8.75E-08	2.32E-10	2.32E-10
2000AF01	6.47E-02	FDS 1TB1	6.41E-02	NP1	8.75E-08	5.61E-09	2.16E-8
		FDS 1TB2	6.44E-04	NP2	1.09E-07	7.02E-11	
		FDS 1TB3	2.33E-06	NL2	7.86E-04	1.83E-09	
			3.88E-05	NM2	3.64E-04	1.41E-08	
2009AF01	1.17E-03	FDS 1TB4	1.17E-05	NP1	8.75E-08	1.02E-12	1.02E-12

Table 57-10 (Sheet 7 of 9)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS

Fire Area	Total Fire Ignition Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Probability (CCDP)	Core Damage Frequency (CDF)	Total Contribution of Fire Area to CDF
2033AF01	1.23E-03	FDS 1TB5	1.23E-05	NP1	8.75E-08	1.08E-12	1.08E-12
2033AF02	1.02E-03	FDS 1TB6	1.02E-05	NP1	8.75E-08	8.93E-13	8.93E-13
2033AF03	1.01E-03	FDS 1TB7	1.01E-05	NP1	8.75E-08	8.84E-13	8.84E-13
2043AF01	3.23E-04	FDS 1TB8	3.23E-06	NP1	8.75E-08	2.83E-13	2.83E-13
2050AF01	2.83E-04	FDS 1TB9	2.83E-06	NP1	8.75E-08	2.48E-13	2.48E-13
2052AF01	2.48E-03	FDS 1TB10	2.46E-03	TR2	8.78E-08	2.16E-10	2.16E-10
		FDS 1TB11	2.48E-05	NP1	8.75E-08	2.17E-12	
2053AF01	6.70E-03	FDS 1TB12	6.70E-03	LP1	8.75E-08	5.86E-10	5.86E-10
2053AF02	2.48E-03	FDS 1TB13	2.46E-03	TR2	8.78E-08	2.16E-10	2.16E-10
		FDS 1TB14	2.48E-05	NP1	8.75E-08	2.17E-12	
4031AF02	4.38E-04	FDS 1AN1	4.34E-04	NP1	8.75E-08	3.80E-11	3.80E-11
		FDS 1AN2	4.38E-06	NP1	8.75E-08	3.83E-13	
4031AF03	8.53E-04	FDS 1AN3	8.44E-04	NP1	8.75E-08	7.39E-11	7.46E-11
		FDS 1AN4	8.53E-06	NP1	8.75E-08	7.46E-13	
4031AF04	2.30E-03	FDS 1AN5	2.30E-03	NP1	8.75E-08	2.01E-10	2.01E-10

Table 57-10 (Sheet 8 of 9)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS

Fire Area	Total Fire Ignition Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Probability (CCDP)	Core Damage Frequency (CDF)	Total Contribution of Fire Area to CDF
4031AF05	1.49E-03	FDS 1AN6	1.48E-03	NP1	8.75E-08	1.30E-10	3.71E-10
		FDS 1AN7	5.36E-08	NL1	5.51E-04	2.95E-11	
			8.93E-07	NM1	2.37E-04	2.12E-10	
4032AF01	1.26E-03	FDS 1AN8	1.26E-03	NP1	8.75E-08	1.10E-10	1.10E-10
		FDS 1AN9	6.30E-07	NP1	8.75E-08	5.51E-14	
4032AF02	2.25E-03	FDS 1AN10	2.25E-03	NP1	8.75E-08	1.97E-10	1.97E-10
		FDS 1AN11	1.12E-06	NP1	8.75E-08	9.80E-14	
4032AF03	6.22E-04	FDS 1AN8	2.83E-04	NP1	8.75E-08	2.48E-11	2.48E-11
		FDS 1AN9	3.11E-07	NP1	8.75E-08	2.72E-14	
4032AF04	6.22E-04	FDS 1AN10	2.83E-04	NP1	8.75E-08	2.48E-11	2.48E-11
		FDS 1AN11	3.11E-07	NP1	8.75E-08	2.72E-14	
4033AF01	2.84E-03	FDS 1AN14	2.84E-05	NP1	8.75E-08	2.49E-12	2.49E-12
4041AF01	2.66E-03	FDS 1AN15	1.32E-04	NP1	8.75E-08	1.16E-11	3.70E-10
		FDS 1AN16	1.25E-06	NP1	8.75E-08	1.09E-13	
		FDS 1AN17	7.98E-08	NL1	5.51E-04	4.40E-11	
			1.33E-06	NM1	2.37E-04	3.15E-10	

Table 57-10 (Sheet 9 of 9)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS

Fire Area	Total Fire Ignition Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Probability (CCDP)	Core Damage Frequency (CDF)	Total Contribution of Fire Area to CDF
4042AF01	8.34E-03	FDS 1AN18	4.13E-04	NP1	8.75E-08	3.61E-11	1.16E-09
		FDS 1AN19	3.92E-06	NP1	8.75E-08	3.43E-13	
		FDS 1AN20	2.50E-07	NL1	5.51E-04	1.38E-10	
			4.17E-06	NM1	2.37E-04	9.88E-10	
4042AF03	4.50E-04	FDS 1AN21	4.21E-04	NP1	8.75E-08	3.68E-11	7.33E-09
		FDS 1AN22	1.62E-06	NL1	5.51E-04	8.93E-10	
			2.70E-05	NM1	2.37E-04	6.40E-09	
4051AF02	4.35E-04	FDS 1AN23	4.35E-04	XT2	5.78E-08	2.51E-11	2.51E-11
5000AF00	2.42E-02	FDS 1RW1	2.42E-02	XT2	5.78E-08	1.40E-09	1.40E-09
6030AF01	2.99E-02	FDS 1DG1	2.99E-04	XT1	5.78E-08	1.73E-11	1.73E-11
6030AF02	3.03E-02	FDS 1DG2	3.03E-04	XT1	5.78E-08	1.75E-11	1.75E-11
6030AF03	2.10E-04	FDS 1DG3	2.10E-06	XT1	5.78E-08	1.21E-13	1.21E-13
6030AF04	2.10E-04	FDS 1DG4	"	XT1	5.78E-08	1.21E-13	1.21E-13
						TOTAL	6.36E-07

Table 57-11 (Sheet 1 of 2)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS FOR CONTAINMENT

Fire Zone	Total Fire Zone Fire Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Prob. (CCDP)	Core Damage Frequency (CDF)
1100AF11206	1.81E-05	FDS 1CT1	1.81E-05	XCT	2.55E-06	4.62E-11
1100AF11207	1.81E-05	FDS 1CT2	"	XCT	2.55E-06	4.62E-11
1100AF11300A	2.45E-05	FDS 1CT3	2.29E-05	TD1	1.19E-07	2.73E-12
		FDS 1CT4	8.82E-08	LA1	7.86E-04	6.93E-11
			1.47E-06	MA1	3.64E-04	5.35E-10
1100AF11300B	1.75E-04	FDS 1CT5	6.30E-07	TD1	1.19E-07	7.50E-14
			1.74E-04	TR1	5.78E-08	1.01E-11
1100AF11300C	8.24E-04	FDS 1CT6	7.72E-04	TD1	1.19E-07	9.19E-11
		FDS 1CT7	2.97E-06	LA1	7.86E-04	2.33E-09
			4.95E-05	MA1	3.64E-04	1.80E-08
1100AF11301	1.70E-04	FDS 1CT8	1.60E-04	TB1	1.19E-07	1.90E-11
		FDS 1CT9	6.12E-07	NL2	7.86E-04	4.81E-10
			1.02E-05	NM2	3.64E-04	3.71E-09
1100AF11302	9.51E-05	FDS 1CT10	8.93E-05	TB1	1.19E-07	1.06E-11
		FDS 1CT11	3.42E-07	NL2	7.86E-04	2.69E-10
			5.71E-06	NM2	3.64E-04	2.08E-09

Table 57-11 (Sheet 2 of 2)

SUMMARY OF QUANTITATIVE ANALYSIS RESULTS FOR CONTAINMENT

Fire Zone	Total Fire Zone Fire Frequency	Fire Damage State	Scenario Frequency	Damage Category	Conditional Core Damage Prob. (CCDP)	Core Damage Frequency (CDF)
1100AF11303	1.81E-05	FDS 1CT12	1.81E-05	XCT	2.55E-06	4.62E-11
1100AF11303A	1.81E-05	FDS 1CT13	1.79E-05	XCT	2.55E-06	4.56E-11
		FDS 1CT14	6.51E-08	CL3	2.65E-02	1.73E-09
			1.09E-06	CM3	1.22E-02	1.33E-08
1100AF11303B	1.81E-05	FDS 1CT15	1.79E-05	XCT	2.55E-06	4.56E-11
		FDS 1CT16	6.51E-08	CL3	2.65E-02	1.73E-09
			1.09E-06	CM3	1.22E-02	1.33E-08
1100AF11500	2.86E-03	FDS 1CT17	2.83E-03	XCT	2.55E-06	7.22E-09
		FDS 1CT18	1.03E-06	CL3	2.65E-02	2.73E-08
			1.72E-05	CM3	1.22E-02	2.10E-07
1200AF12356	2.29E-05	FDS 1CT19	2.14E-05	TD1	1.19E-07	2.55E-12
		FDS 1CT20	8.24E-08	LD1	7.86E-04	6.48E-11
			1.37E-06	MD1	3.64E-04	4.99E-10
					TOTAL	3.03E-07

Table 57-12

QUANTIFICATION OF CORE DAMAGE FREQUENCY FOR CONTROL ROOM FIRE SCENARIOS

Scenario	Ignition Frequency	CCDP	CDF (per year)
CR1	--	insignificant	insignificant
CR2	6.9E-6	1.13E-7	7.80E-13
CR2A	6.9E-6	1.55E-6	1.07E-11
CR3	2.3E-6	1.55E-6	3.56E-12
CR4	2.3E-8	2.90E-4	6.67E-12
CR4A	2.3E-8	9.83E-4	2.26E-11
CR4B	2.3E-8	5.50E-4	1.26E-11
CR5	1.0E-7	1.03E-7	1.03E-13
		TOTAL	5.70E-11

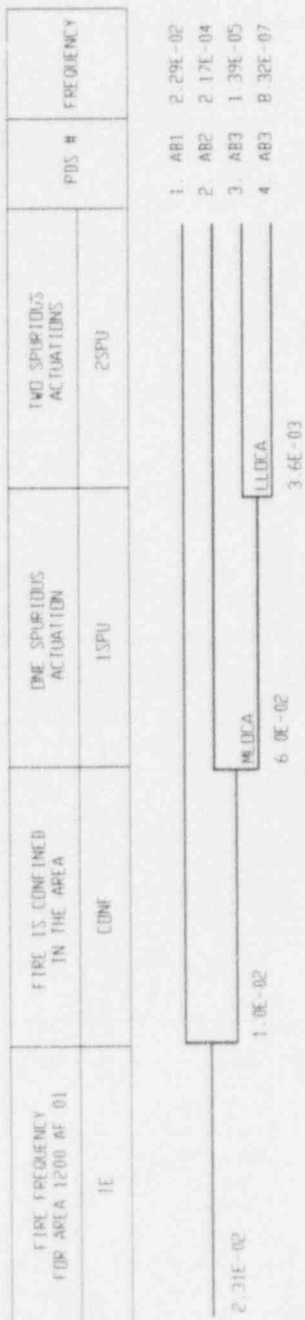

Figure 57-1

Fire Progression Event Tree for 1200 AF 01 Fire Area

ATTACHMENT 57A

DEFINITIONS

A.1 Fire Barrier

Those structural components (i.e., walls, floors, and ceilings) that have been evaluated and rated in hours of resistance to fire as defined by nationally recognized standards. Note that, consistent with the design of existing plants, the boundaries of the containment fire area (1000AF01) are not rated barriers.

A.2 Fire Area

An area sufficiently bounded by fire barriers that will withstand the fire hazards within the fire area and, as necessary, protect important equipment within a fire area from a fire outside the area. A fire area must be made up of fire barriers having at least a two-hour fire rating or equivalent, with openings in the barriers provided with fire doors, fire dampers, and fire penetration seal assemblies having a fire resistance rating appropriate for the barrier in which they are installed.

Fire area boundaries normally must be completely sealed with floor-to-ceiling and/or wall-to-wall fire barriers. Where such boundaries are not wall-to-wall or floor-to-ceiling with all penetrations sealed to the fire rating required of the boundaries, an evaluation must have been performed by a fire protection engineer and, if required, a systems engineer to assess the adequacy of the fire area boundaries to determine whether they can withstand the fire hazards within the area and important equipment in the area from a fire outside the area.

A.3 Safe Shutdown System

Structures, systems, cables (power, instrumentation, and control), equipment and components identified as being required to achieve and maintain subcritical reactivity conditions in the reactor, maintain reactor coolant inventory, and maintain safe and stable shutdown conditions following a fire-initiated event. Passive mechanical components (e.g., check valves, heat exchangers, piping) exposed to a fire are assumed to remain structurally intact as pressure barriers or structural members of a system. Electrical components such as power and instrument cables cannot be considered "passive." Therefore, the effect of fire on such components should be addressed explicitly.

A.4 Fire Compartment

A space bounded by non-combustible barriers where heat and products of combustion from a fire within the enclosure will be substantially confined.

A.5 Fire-Initiated Event

An event resulting from a fire in any area that results in a demand for safe shutdown functions or damages safe shutdown components in at least one train or shutdown path, unless it can be shown that the postulated fire event will not cause a demand for plant trip or shutdown within eight hours of the event.

A.6 Safe and Stable Shutdown Condition

For the purpose of this analysis, a safe and stable shutdown condition is the point in the reactor shutdown where subcritical reactivity and reactor coolant inventory temperature and pressure can be maintained at target values for a period of at least 24 hours without sustaining damage to the core. This is consistent with the AP600 internal-events PRA.

A.7 Ignition Source

A material or piece of equipment capable of being a fire initiator.

A.8 Qualified Cable

Electrical cable that meets the standards defined in IEEE Standard 383, "IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations."

A.9 Totally Safety-Related Fire Areas (TSFA)

Those fire areas that have the following characteristics:

i) Contain components and cabling for only one of the safety-related shutdown divisions (i.e., either A, B, C, or D).

ii) Do not contain any nonsafety-related components and cabling associated with (or capable of adversely impacting the operation of) nonsafety-related systems that can be utilized for plant shutdown.

iii) Are physically separated from one another and from the nonsafety-related fire areas (NSFA) by three-hour rated fire barriers. Fire area boundaries are completely sealed with floor-to-ceiling and/or wall-to-wall fire barriers, with no openings (e.g., doors, fire dampers, or fire penetration seals) in the barriers between any two TSFAs of a different train or a TSFA and an NSFA. Additionally, these areas are separated from the mixed safety-related fire areas (MSFA) by three-hour rated fire barriers, and their boundaries are completely sealed with floor-to-ceiling and/or wall-to-wall fire barriers, with openings in the barriers equipped with fire doors, fire dampers, and fire penetration seal assemblies meeting applicable fire codes (e.g., NFPA-803, Reference 57-12) for the barrier.

A.10 Mixed Safety-Related Fire Areas (MSFA)

Those fire areas that have the following characteristics:

i) Contain components and cabling for both safety-related and nonsafety-related safe shutdown systems.

ii) May contain components and cabling associated with more than one division of safety-related power systems.

iii) Are configured such that fire-induced loss of safety-related components (due to damage to the components themselves or damage to the cabling associated with the components) located within these fire areas would not impact any one of the safety-related safe shutdown passive systems. For example, fire area 1200 AF 01 includes the radwaste pipe chase (1212 AF 12154) and the pipe chase (92' 6" elevation) (1220 AF 12253) fire zones. These compartments contain the normal residual heat removal system's isolation valves (RNS V022 and RNS V011) and spent fuel system suction line isolation valve (SFS V035), respectively. These valves are designated as safety-related components supported by division A of safety-related power. Thus, fire area 1200 AF 01 is classified as an MSFA. However, the impact of fires in this fire area (i.e., 1200 AF 01) would be limited to the loss (or spurious opening/closing) of these valves only; neither division A of safety-related power nor any other passive (safety-related) safe shutdown equipment supported by the A division of safety-related power will be adversely impacted.

iv) Are physically separated from the TSFAs by three-hour rated fire barriers and their boundaries are completely sealed with floor-to-ceiling and/or wall-to-wall fire barriers, with openings in the barriers equipped with fire doors, fire dampers and fire penetration seal assemblies having a three-hour rated fire resistance rating. Furthermore, these fire areas are physically separated from one another and the NSFAs by fire barriers that will withstand the fire hazards within the fire area. Fire area boundaries will be completely sealed with floor-to-ceiling and/or wall-to-wall fire barriers, with openings in the barriers equipped with fire doors, fire dampers, and fire penetration seal assemblies having a fire resistance rating at least equivalent to the barrier in which they are installed.

A.11 Non-Safety-Related Fire Areas (NSFA)

Those fire areas that have the following characteristics:

i) Do not contain components and cabling for safety-related systems that can be utilized for plant shutdown.

ii) Fire-induced loss of nonsafety-related components (due to damage to the components themselves or damage to the cabling associated with the components) located within

these fire areas would not impact any one of the safety-related safe components (e.g., would not open a containment isolation valve). For example, the 1200 AF 02 (fuel handling building) or 6030 AF 01 (diesel generator room A) fire areas do not contain any components or cabling for which fire-induced damage could lead to failure or malfunction (spurious actuation) of any safety-related components.

iii) These fire areas are physically separated from the TSFAs by three-hour rated fire barriers and boundaries are completely sealed with floor-to-ceiling and/or wall-to-wall fire barriers, with no openings (e.g., doors, fire dampers and fire penetration seal) in the barriers. Furthermore, these fire areas are physically separated from one another and the MSFAs by fire barriers that will withstand the fire hazards within the fire area. Fire area boundaries will be completely sealed with floor-to-ceiling and/or wall-to-wall fire barriers, with openings in the barriers provided with fire doors, fire dampers and fire penetration seal assemblies having a fire resistance rating at least equivalent to the barrier in which they are installed.