PROFESSIONAL LOSS CONTROL, INC.

ENCLOSURE 1

FIRE VULNERABILITY EVALUATION METHODOLOGY

FIVE

PLANT SCREENING GUIDE

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PLANT SCREENING GUIDE

1.0 INTRODUCTION

U.S. nuclear utilities are performing individual plant examinations (IPEs) as part of their responsibilities outlined in the U.S. Nuclear Regulatory Commission's (NRC) Severe Accident Policy Statement. These IPEs are expected to yield improved understanding of the types of severe accidents relevant for each plant and provide utility management the information necessary to make prudent, cost-effective changes to either reduce the likelihood or consequences of such severe accidents. Most utility IPEs are currently limited to an evaluation of what is referred to as internally initiated events. In the near future, the NRC Staff is expected to request nuclear utilities to conduct individual plant examinations for externally initiated events (IPEEE). External events to be addressed in this latter request are: seismic, fires, high winds, external floods, and man-made hazards.

The Nuclear Management and Resources Council (NUMARC), through its Severe Accident Working Group (SAWG), is coordinating industry activities for the IPE and other programs related to severe accidents. As part of this effort, in the past two years NUMARC has had numerous discussions with NRC Staff, their contractors, representatives of industry, vendors, consultants and organizations, as well as utility fire protection and risk assessment engineers. The objective of these discussions was to better define the nature and scope of the severe accident risk from fires, the extent of existing plant fire protection, safe shutdown design considerations and related surveillance activities, and the current state-of-the-art of fire assessment techniques.

The findings reached were that: (1) Certain aspects of current fire PRA methods are not as robust as those for internal event PRAs, and (2) Each plant has already expended tremendous analytical and plant change efforts enhancing their fire protection capabilities in response to the 10CFR50 Appendix R rule. Therefore, the NUMARC SAWG concluded that development of a more cost-effective and efficient examination methodology based on available information and knowledge obtained from Appendix R implementation as an alternative to the normal PRA process would be of benefit to the industry. At the request of NUMARC, the Electric Power Research Institute (EPRI) sponsored the preparation of this alternative Fire Vulnerability Evaluation (FIVE) methodology.

This report outlines the background and basis for the FIVE methodology and provides guidance to utilities in performing an examination of potential plant severe accidents caused by fire initiated events. FIVE is oriented toward uncovering limiting plant design or operating characteristics (vulnerabilities) that make certain fire-initiated events more likely than others. It provides a combination of deterministic and probabilistic techniques for examining a power plant's fire probability and protection characteristics. It includes a two phase progressive screening method and a third phase consisting of a plant walkdown/verification process and documentation of the results and conclusions.

FIVE has been developed for implementation by plant personnel who are most experienced with their plant's operations, fire hazards and fire protection features. The methodology provides these plant personnel with guidelines to quickly screen the plant down to the most significant locations where vulnerabilities may exist and then identify options to reduce the vulnerabilities. FIVE provides the following features:

a. Screening Guidelines
b. Determination of Fire-Induced Failures
c. Determination of Non-Fire Related Failures
d. Determination of Areas of Vulnerabilities
e. Determination of Potential Vulnerabilities
f. Guidance on corrective measures to reduce identified fire-related vulnerabilities
g. Guidance on documentation for the IPEEE
h. Databases to quantify the frequency of fire scenario events
i. Fire Hazard Assessment techniques for evaluating various fire exposures
j. An evaluation method that uses plant personnel, taking full advantage of the extensive evaluations and plant fire protection programs and modifications implemented to satisfy the NRC's criteria in 10CFR50 Appendix R.

Although the foundation of the FIVE methodology centers on providing assurance of the availability of at least one train of the safe shutdown systems defined in a plant's 10CFR50 Appendix R safe shutdown analysis, it IS NOT intended to be a re-verification of that analysis. It is important, however, to analyze the plant "as is". For IPEEE purposes, an exemption to the NRC regulations does not necessarily constitute an exemption to the IPEEE and the "as built" conditions must be modeled in the analysis. Planned plant modifications (i.e., hardware or procedures) could be incorporated in the analysis as appropriate.

FIVE has been developed for application at either PWR or BWR nuclear power plants.

Additionally, several potential risk significant items identified in NUREG/CR-5088, "Fire Risk Scoping Study: Investigation of Nuclear Power Plant Fire Risk, Including Previously Unaddressed issues," are addressed in the FIVE methodology (Section 7.0).

Finally, although FIVE is not a complete fire PRA, it does provide very valuable and necessary input information for a potential follow-up fire PRA. Thus, the effort expended on FIVE would not be wasted even if, subsequently, a utility decides to proceed with a full fire PRA.

2.0 DEFINITIONS

2.1 Fire Barrier

Those structural components (walls, floors and ceilings) that have been evaluated to be rated as defined by nationally recognized standards in hours of resistance to fire to pre[illegible] the spread of fire.

2.2 Fire Area

An area, as defined in the Appendix R Analysis, sufficiently bounded by fire barriers that will withstand the fire hazards within the fire area and, as necessary, to 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 2 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 at least equivalent to the barrier in which it is installed.

Fire area boundaries mu[illegible] be completely sealed with floor-to-ceiling and/or wall-to-wall fire barriers or 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 protect important equipment in the area from a fire outside the area.

A fire area boundary may also include fire wrap assemblies (for example, cable trays or conduits) with a 3 hour fire rating. For purposes of the Phase I analysis, only structural barriers and 3 hour fire wraps will be considered fire area boundaries.

2.3 Safe Shutdown System

Structures, systems, cables (power, instrumentation and control), equipment and components within the Appendix R framework identified to achieve and maintain sub-critical reactivity conditions in the reactor, maintain reactor coolant inventory, and maintain safe and stable shutdown conditions following a fire initiated event. Passive components, such as pipes, tanks, heat exchangers and manual valves will be assumed to be unaffected by fire.

2.4 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. The barriers may have open equipment hatches, ladderways, doorways or unsealed penetrations.

2.5 Fire Initiated Event

An event from a fire in any area that results in a demand for safe shutdown functions e. reactor trip, loss of feedwater, inadvertent opening of PORV's, etc.) while at the same time damaging safe shutdown components of at least one train or shutdown path.

2.6 Mitigating Systems

Plant systems including equipment, cables, structures, and components available to replace the function of safe shutdown equipment assumed damaged by a fire in a given fire area.

2.7 Target

A safe shutdown component or intervening combustible material such as a cable tray being exposed from a floor based fire source. This term is applied in conjunction with the fire modelling methodology in Phase II.

2.8 System Unavailability

The probability of the system being unavailable to perform its intended function due to the system being out-of-service, a standby failure or failure to function on demand.

2.9 Alternate Safe Shutdown System

Structures, systems, cables (power, instrumentation and control) equipment and components identified within the Appendix R framework to replace the function of safe shutdown systems.

3.0 RESOURCES

3.1 Project Team Qualifications

The FIVE methodology has been developed for use by plant personnel or individuals familiar with the plant's Appendix R analysis, safe shutdown systems and shutdown paths, fire protection program, fire hazards and fire protection systems. This analysis should be performed by a project team consisting of qualified fire protection engineers, plant systems engineers and utility personnel familiar with the plant's Individual Plant Examination (IPE).

3.2 Plant Specific Reference Materials

Example reference materials recommended to perform FIVE include:

a. IPE Front-end Analysis

b. Plant Fire Hazards Analysis

c. Appendix R Safe Shutdown Analysis

d. Plant Fire Barrier Drawings

e. Cable Tray/Conduit Routing Maps and Cable Schedules

d. Fire Protection Inspection and Maintenance Procedures

f. Fire Brigade Training Procedures

g. Emergency Operating Procedures and Appendix R Safe Shutdown Procedures

h. Plant Final Safety Analysis Report (FSAR)

4.0 FIVE METHODOLOGY

4.1 Introduction

The FIVE Methodology is a screening technique based on conservative assumptions using industrial and plant specific data bases for evaluating fire event sequences. The overall objective is to determine the availability of plant equipment, cabling and components necessary to achieve and maintain safe and stable shutdown of the reactor, (i.e. maintain reactor reactivity, coolant inventory and decay heat removal control) and thereby prevent core damage. The methodology considers all plant areas and focuses on (but is not limited to) the availability of Appendix R Safe Shutdown equipment remaining free of fire damage. Appendix R equipment has been chosen since this equipment has been previously reviewed to ensure a minimum set of equipment would be available (free from fire damage) to shutdown the plant under the conditions and criteria established in 10CFR50 Appendix R. Additional equipment can also be credited in the analysis. Appendix R conditions such as loss of off-site power do not have to be artificially imposed but only considered to the extent that they are likely to occur as a result of the postulated fire. Note, however, that the intent of the methodology is to study the plant "as built". Thus, exemptions to Appendix R that may lead to potential vulnerabilities must be included "as is" in the analysis.

FIVE provides a method to determine the availability of plant equipment by evaluating the combination of events that lead to fire damage and loss of a safe shutdown function. Figure 4.1 shows the general combination of events that were considered in the methodology. FIVE uses a progressive screening approach based on quantifying the:

1. Frequency of fire ignition in specific plant areas.

2. Availability of automatic suppression systems

3. Availability of redundant/alternate safe shutdown systems

4. Probability of having sufficient combustibles and heat release to cause damage to safe shutdown systems.

5. Probability of Manual Suppression Effectiveness

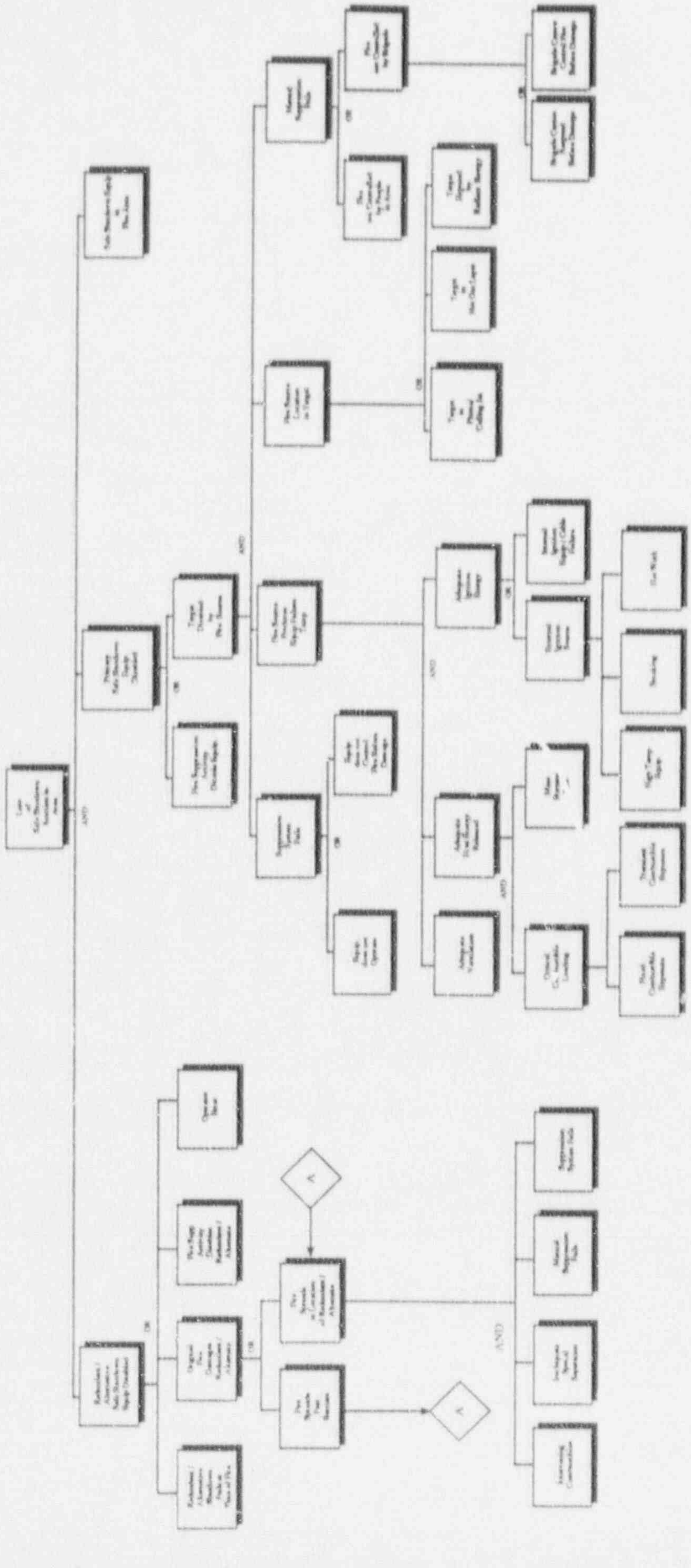
FIVE is designed for application by a project team consisting of plant personnel familiar with the plant's IPE, a Plant Systems Engineer familiar with Appendix R and the plant's safe shutdown analysis, and a Fire Protection Engineer familiar with the plant's fire protection program, fire protection systems, fire hazards analysis, and how they relate to the Appendix R safe shutdown analysis.

In performing FIVE, the project team will be required to apply their engineering judgment in order to assess how well the plant satisfies the intent of a specific step in the methodology. The project team must be prepared to support their position and rationale in selecting the numbers that are input into the screening steps. The steps are arranged progressively, but may be implemented in any order depending on the difficulty of application for the particular area or compartment of concern. If at any point in the process, the frequency of losing a safe shutdown function is less than 1E-6/reactor year, the vulnerability to the plant from a fire at that location will not be considered significant and can be screened out from further evaluation. Figure 4.2 shows the flow diagram for the overall Fire Vulnerability Evaluation.

FIVE consists of three Phases:

- Phase I. Fire Area Screen (Qualitative Analysis)
- Phase II. Critical Fire Compartment Screen (Quantitative Analysis)
- Phase III. Plant Walkdown/Verification and Documentation

The following provides a description and scope of each screen along with the resulting output that can be expected. Each phase utilizes guides and data worksheets that will direct the project team through the evaluation process. These guides, data worksheets and other necessary data base resources can be found in Attachments 10.1 through 10.6. Attachment 10.7 provides the technical basis for FIVE's Fire Hazard Evaluation methods.



FIRE EVENT SEQUENCE TREE

FIGURE 4.1

4.2 General Basis

4.2.1 Fire Initiated Events

FIVE's objective is to identify potential plant vulnerabilities from fires that could result in the loss of safe shutdown functions necessary to maintain reactivity, coolant inventory and decay heat removal to control and prevent damage to the core. Therefore, the methodology concentrates on searching for fires in any area of the plant that could require the need for safe shutdown functions (e.g. plant transient leading to automatic or manual plant trip), or administrative controls requiring a controlled shutdown and at the same time damage safe shutdown components (structures, equipment, cables or controls) associated with at least one of the identified shutdown paths. Plant areas where a fire cannot create a fire initiated event, shutdown, or cannot cause the loss of safe shutdown functions will be screened from further evaluation.

Note: Before screening out an area on the basis that no plant trip or controlled shutdown would result from a fire the FIVE team should confirm this assumption with qualified operations and electrical/systems engineers in order to confirm that no further analysis is warranted in Phase II.

4.2.2 Equipment Survival From Non-Thermal Environmental Effects of Smoke

For the purposes of this evaluation, the potential detrimental short or long term effects of combustion products on the ability of safe shutdown equipment to continue to function in smoke filled environments or the evaluation of smoke transport throughout buildings is not being considered. The present state of knowledge regarding the actual effects of combustion products is inadequate to allow any specific treatment of the issue at this time. However, the detrimental short-term effects of smoke on equipment are not believed to be significant.

It is prudent, however, that the FIVE team be aware of and sensitive to potential negative impact of smoke and products of combustion on human performance. Products of combustion may reduce visibility or otherwise hinder access and thereby affect timing of local operator actions and firefighting performance.

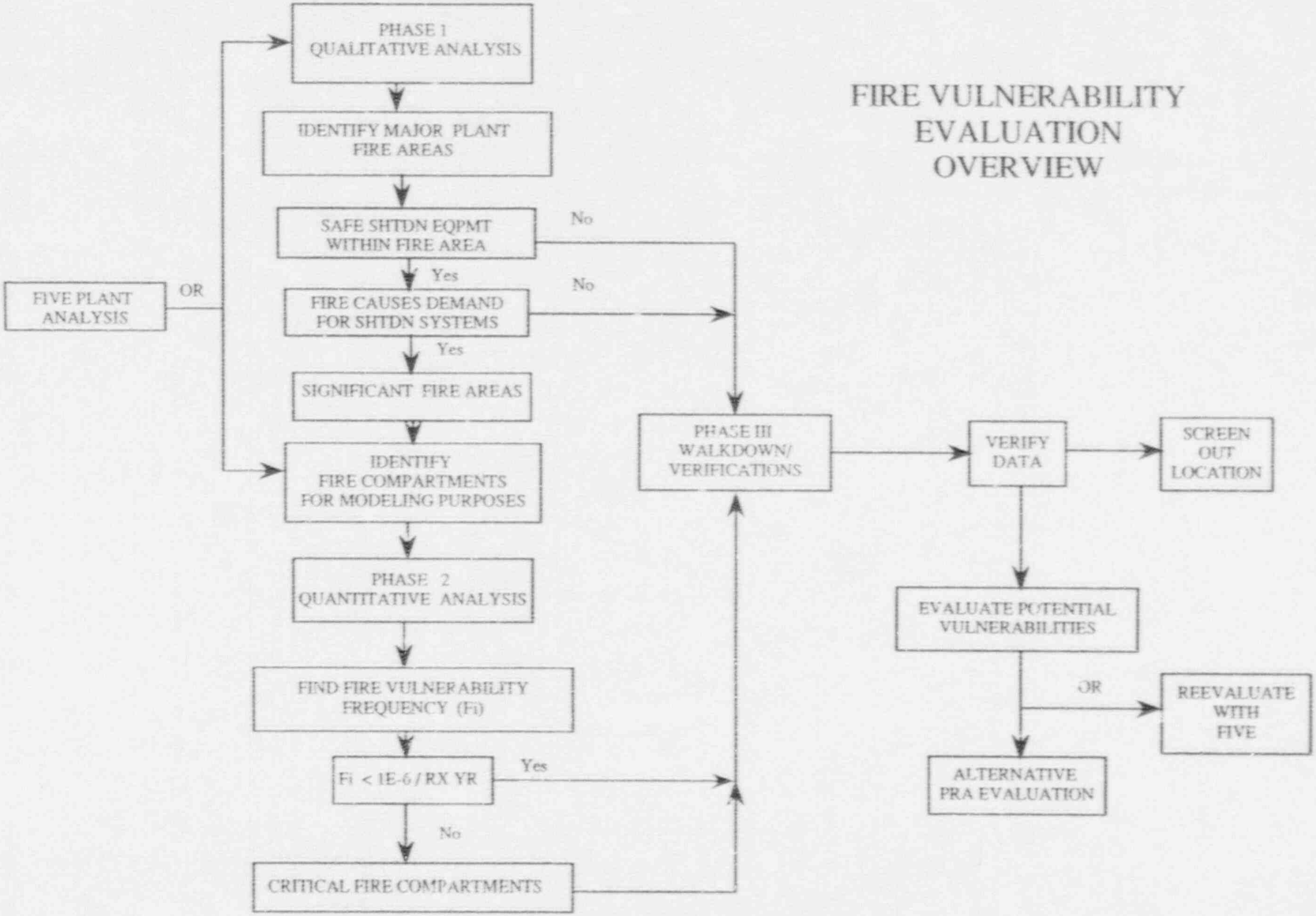

FIRE VULNERABILITY
EVALUATION
OVERVIEW
FIVE PLANT ANALYSIS
OR
PHASE 1 QUALITATIVE ANALYSIS
IDENTIFY MAJOR PLANT FIRE AREAS
SAFE SHTDN EQPMT WITHIN FIRE AREA
No
Yes
FIRE CAUSES DEMAND FOR SHTDN SYSTEMS
No
Yes
SIGNIFICANT FIRE AREAS
IDENTIFY FIRE COMPARTMENTS FOR MODELING PURPOSES
PHASE 2 QUANTITATIVE ANALYSIS
FIND FIRE VULNERABILITY FREQUENCY (Fi)
Fi < 1E-6 / RX YR
Yes
No
CRITICAL FIRE COMPARTMENTS
PHASE III WALKDOWN/ VERIFICATIONS
VERIFY DATA
SCREEN OUT LOCATION
EVALUATE POTENTIAL VULNERABILITIES
OR
REEVALUATE WITH FIVE
ALTERNATIVE PRA EVALUATION

Figure 4.2

5.0 PHASE I - FIRE AREA SCREEN (QUALITATIVE ANALYSIS)

5.1 Introduction

This Phase provides a method for quickly screening plant areas whose loss due to fire will have no impact on the ability to achieve and maintain safe shutdown. Figure 5.1 shows the flow diagram for the Phase I methodology.

The evaluation is performed on a fire area by fire area basis. An exposure fire is assumed to occur within each fire area and all safe shutdown components within the fire area are considered damaged by the fire. At the same time, the normal redundant or alternate shutdown path outside the fire area is assumed to be unavailable. The fire is confined to the boundaries of the fire area.

The project team determines if this fire initiated event has the potential to result in a demand for safe shutdown functions (eg. reactor trip, loss of feedwater, stuck open PORV) while simultaneously damaging safe shutdown components in the fire area. If not, the fire area can be screened out.

5.2 Phase I Basis and Assumptions

5.2.1 Fire Barrier Availability

The Phase I Screen takes credit for fire area boundaries (see Definitions 2.1 and 2.2) being effective in controlling a fire from spreading to the other side of a fire barrier. This is based on an assumption that the plant can demonstrate that the fire barriers and their components (i.e. fire doors, fire dampers and fire penetration seal assemblies) are being inspected and maintained on a regular basis in accordance with established plant surveillance procedures. This plant fire barrier surveillance program should be able to satisfy the intent of the guidelines in Item II of the Sandia Fire Risk Scoping Study Evaluation (Attachment 10.5).

Fire barriers reviewed as part of the plant's Appendix R Safe Shutdown Analysis are also assumed to be designed and installed correctly in accordance with good fire protection engineering practice and nationally recognized fire protection standards.

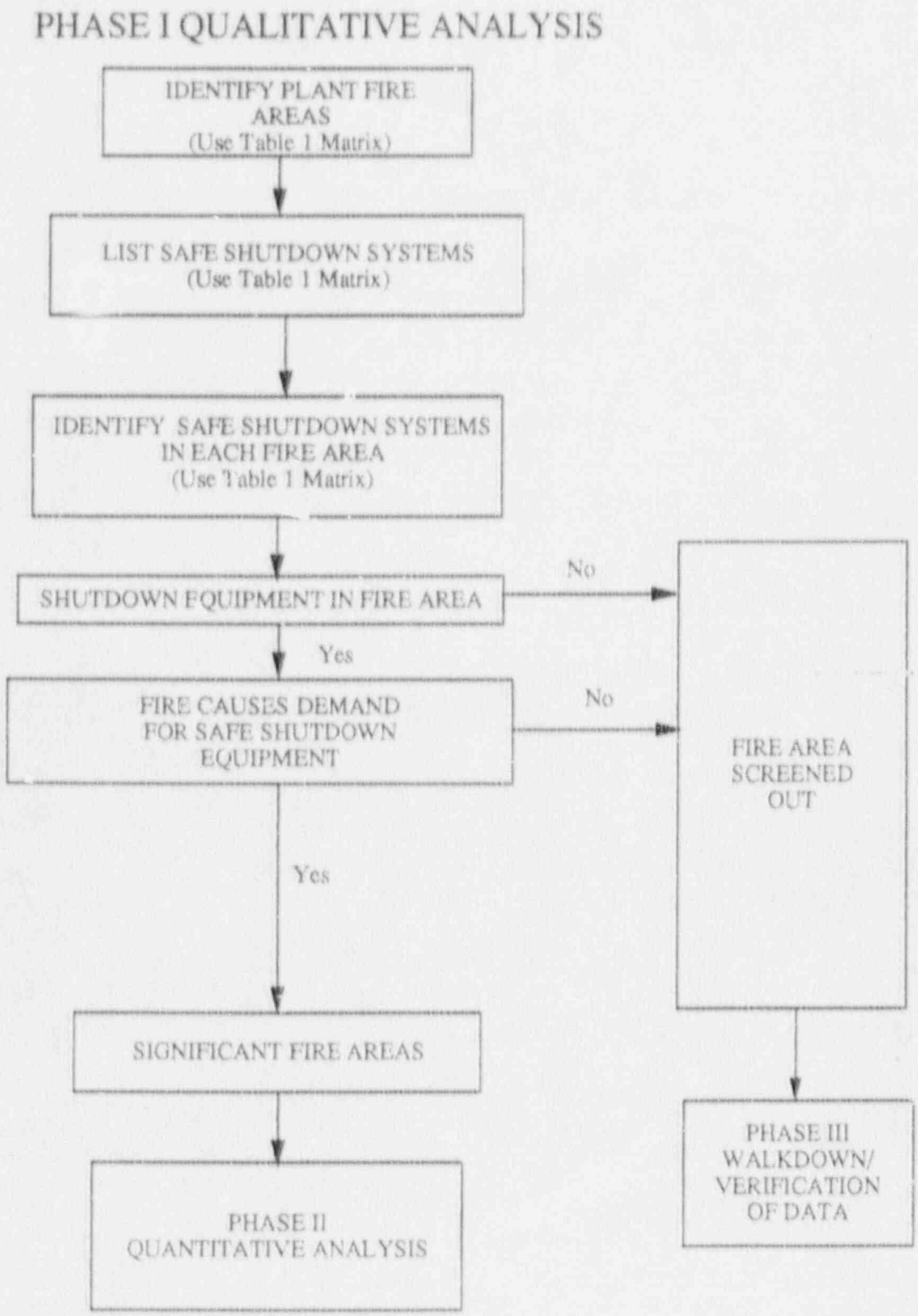

PHASE I QUALITATIVE ANALYSIS
IDENTIFY PLANT FIRE AREAS (Use Table 1 Matrix)
LIST SAFE SHUTDOWN SYSTEMS (Use Table 1 Matrix)
IDENTIFY SAFE SHUTDOWN SYSTEMS IN EACH FIRE AREA (Use Table 1 Matrix)
SHUTDOWN EQUIPMENT IN FIRE AREA
No
Yes
FIRE CAUSES DEMAND FOR SAFE SHUTDOWN EQUIPMENT
No
Yes
FIRE AREA SCREENED OUT
SIGNIFICANT FIRE AREAS
PHASE II QUANTITATIVE ANALYSIS
PHASE III WALKDOWN/ VERIFICATION OF DATA

FIGURE 5.1

5.3 Phase I Procedure

Phase I is performed using the Phase I Screening Guide and Table 1 in Attachment 10.1. Table 1 provides a matrix for displaying Safe Shutdown Systems located in each plant fire area.

A fire area can be screened out from further evaluation if:

1. There are no Appendix R safe-shutdown components in the fire area

OR

2. Following a fire initiated event in a fire area, there is no demand for safe-shutdown functions because the plant can maintain normal plant operations (eg. fire causing loss of one fire pump). If however, there is any doubt whether the plant would require the shutdown equipment, then assume they will and do not screen the area out. The project team should consult with the plant operations staff to make this determination.

Alternatively, if the project team feels there is little benefit or few areas that would be screened out in Phase I, it can be bypassed altogether and the project team can move on to the Phase II Screening Method.

5.3.1 Step 1: Identify Plant Fire Areas

The plant should be divided into plant fire areas that conform to Definition 2.2. This will apply to any enclosure bounded by fire barriers. This step could be accomplished using plant general arrangement and elevation drawings and highlighting the fire areas including location of system fire wrap enclosures. Identify each fire area using a numbering system or method that relates to the plant's Appendix R Safe Shutdown Analysis. Credit can only be taken for fire area barriers that are included in the plant's inspection, testing, and maintenance program.

List the fire areas down Column B in Table 1. (Attachment 10.1)

5.3.2 Step 2: Identify Plant Safe Shutdown Systems

List the systems necessary to maintain the plant in a safe and stable shutdown condition that were credited in the Appendix R Analysis along the top row in Table 1. For example, the major safe shutdown systems might be the safety injection pump (SIP), residual heat removal system (RHR), reactor core isolation cooling system (RCIC), or other safe shutdown paths used in the plant's Appendix R safe shutdown analysis.

5.3.3 Step 3: Perform Fire Area vs. Safe Shutdown System Screen

1. Evaluate each fire area listed in Column B of Table 1 and place a corresponding "X" in each column below the safe shutdown systems having components or equipment associated with that shutdown system within the fire area that are susceptible to fire damage. (See Definition 2.3) Passive components, such as pipes, tanks and manual valves will be assumed unaffected by fire within the Appendix R framework.

2. After reviewing Table 1, any fire areas that do not have safe shutdown system equipment, cables or components (no "X"'s) can be screened out. An "X" should be placed in Column C of Table 1 for each fire area screened out. The letter "A" should be placed in Column D of Table 1 for each fire area that satisfies this condition.

3. For those areas not yet screened, the next step is to perform an evaluation of the safe shutdown functions that would be lost due to a fire within the fire area.

5.3.4 Step 4: Perform Fire Area vs. Safe Shutdown Function Evaluation

1. Evaluate each fire area having safe shutdown equipment.

2. Assume all safe shutdown system components (within the Appendix R framework) in the fire area are damaged and that the normal alternate shutdown path is unavailable.

3. Determine if this condition would demand the need for safe shutdown equipment at the time of the fire. Plant operators and/or electrical/systems engineers may need to be consulted to determine the appropriate response for a given fire area scenario. If the scenario would not create the need to shutdown using this equipment under normal operating conditions (not an Appendix R scenario involving loss of off-site power) then the fire area could be screened out (eg. fire in the fire pump house). If however, there is any doubt whether the plant would shutdown for a fire in a given fire area, assume the plant would shutdown and do not screen the area out in Phase I.

4. If a fire initiated event occurs in a fire area but does not cause a demand for safe shutdown functions in that fire area, then the fire area can be screened out. An "X" should be placed in Column C and "B" (representing this basis for screening) listed in Column D of Table 1.

The plant must be prepared to support the logic for screening out a fire area. Appendix R documentation can be used to support project team decisions.

Fire areas not screened in Table 1 after completing the Phase I Fire Area Screen are considered significant fire areas that will require further evaluation in Phase II of this methodology.

6.0 PHASE II: FIRE COMPARTMENT SCREEN (QUANTITATIVE ANALYSIS)

6.1 Introduction

The purpose of Phase II is to identify potential fire vulnerabilities to equipment, components and cables necessary to assure the capability for safe and stable plant shutdown conditions. Figure 6.0 shows the general overall flow diagram for the Phase II methodology.

Plant areas will be reviewed on a fire compartment basis (See Definition 2.4) in this Phase of the methodology. The fire compartment concept is introduced at this point to allow for a more realistic evaluation of the fire's plume dynamics and resulting hot gas layer at the ceiling. The objective is to estimate the temperature rise and potential for damage to safe shutdown components in the compartment or for spreading fire to adjacent compartments. Potential fire scenarios will be defined by the location of expected combustibles (both fixed and transient) within the fire compartment. Each fixed combustible and the worst case credible transient combustible fire scenario will be examined to determine the likelihood of producing temperatures sufficient to cause loss of safe shutdown functions.

Plant areas will be evaluated to determine the likelihood of a fire starting in any given plant location and growing to damage safe shutdown components while considering the simultaneous availability of the identified redundant/alternate safe shutdown components to achieve their safe shutdown function.

Phase II is basically a five step progressive probabilistic evaluation (shown in Figure 6.0) that considers the sequence of events which must occur to create the loss of safe shutdown functions based on the event tree in Figure 4.1. Step 1, Fire Ignition Frequency and Step 3, Critical Combustible Loading Evaluation involve multiple sub-steps. The sequence of these sub-steps are shown in flow diagrams in Figures 6.3.1.2 and 6.3.3.2, respectively. Consideration for fire suppression methods (automatic and manual) are included in Steps 3.2 and 3.3 on Figures 6.3.1.2 and 6.3 3.2. Figure 6.3.5 shows the flow diagram for evaluating Fire Suppression Availability. As in Phase I, the methodology focuses on Appendix R safe shutdown systems since this is a set of equipment made available to safely shutdown and control plant operations for a fire anywhere in the plant.

PHASE II QUANTITATIVE ANALYSIS
FLOWCHART

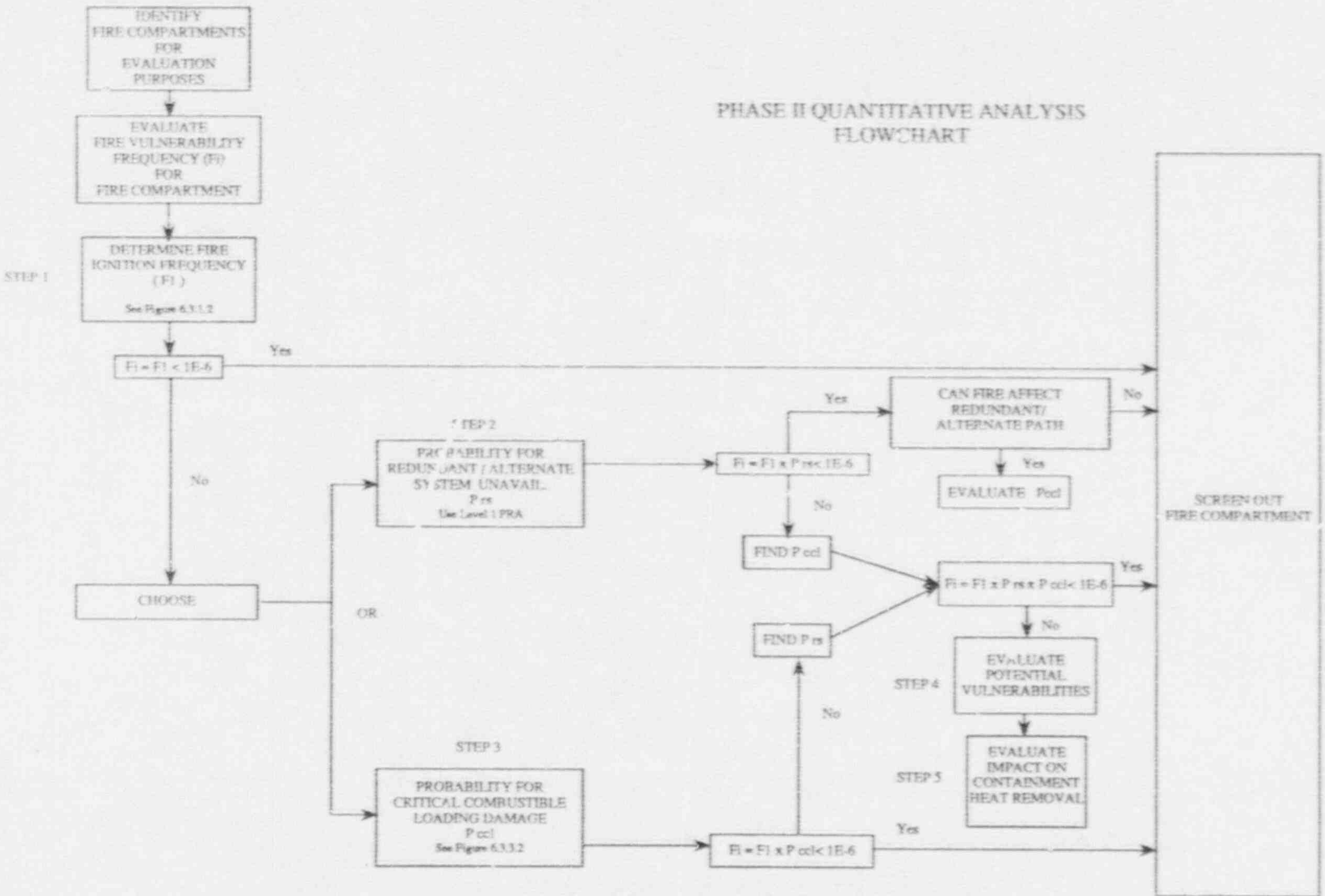


FIGURE 6.0

Phase II involves developing and assigning frequencies to the sequence of events necessary for a fire in conjunction with other unrelated component unavailabilities to result in the complete loss of a safe shutdown function. If this probability is less than 1E-6/reactor year at any point in the process, the fire compartment can be screened out from further evaluation and the plant's vulnerability from a fire in this fire compartment will be considered insignificant.

The steps are considered independent. They should be evaluated in the sequence provided in the flow charts. Note that either Step 2 "or" Step 3 can be performed after Step 1 in Figure 6.0. The project team may recognize that the 1E-6/reactor year screening threshold may be reached with less effort by following the Step 3 flow path first for different fire compartments. If so, the project team may consider this path first if it allows them to reach the 1E-6/reactor year threshold sooner.

6.2 Phase II Basis and General Assumptions

6.2.1 Appendix R Fire Protection Provides Adequate Separation between Shutdown Paths.

In Phase II of the methodology, credit will be taken for adequate fire protection separation between redundant/alternate shutdown paths if the separation satisfies the 10CFR50 Appendix R separation criteria. This assumes that a fire exposing one safe shutdown path will not also expose its redundant/alternate path at the same time if separation of the two systems has been satisfactorily demonstrated in conformance with Appendix R requirements.

6.2.2 Appendix R Equipment Availability.

Phase II focuses on evaluating the availability of Appendix R equipment to demonstrate the plant's ability to safely shutdown from a fire. This study emphasizes Appendix R equipment because:

1. Structures, components, cables and support systems for this equipment have already been extensively evaluated to determine their routing and location throughout the plant; and

2. Significant analysis of associated electrical circuits (spurious operation and isolation, etc) and plant fire protection features have been implemented to protect such equipment from fires identified in the Appendix R analyses.

This permits maximum efficiency in the use of utility time and effort required to perform the analysis.

Although this limitation reduces the effort of the analysis, it is also expected to be conservative since there may actually be other alternative (i.e. non-Appendix R) systems available to plant operators that may compensate for the loss of the Appendix R equipment. FIVE and external event risk assessments are not bound by the initial condition assumptions required when performing the Appendix R Safe Shutdown Analysis (i.e. loss of off-site power at the same time as a fire). Other plant systems can be included in the analysis if the utility can verify the location of equipment and cables and can determine that they also meet the independence criteria. The availability of these systems due to effects other than fire must also be considered.

6.2.3 Fire Compartments

Phase II takes a more realistic look at the frequency of fire damage to the safe shutdown systems exposed to a fire rather than assuming the systems are automatically lost, as in Phase I and the Appendix R Safe Shutdown Analysis. This requires an evaluation of fire growth within the fire compartment (see Definition 2.4) where the released energy will be confined. The use of fire compartments allows an evaluation of a fire's plume and hot gas layer exposure to safe shutdown targets. Using fire compartment boundaries, the temperature rise and thermal effects to safe shutdown components can be more realistically estimated to determine the potential for damage or fire spread to adjacent compartments.

A typical fire compartment is bounded by non-combustible barriers at the ceiling and walls (with minor, if any, openings near the ceiling) extending from the ceiling to the floor where a descending hot gas layer from the postulated fire can be created. For purposes of this analysis, openings in the ceiling boundary such as hatchways, ladderways or doorways will be assumed closed to confine hot gases. This assumption will result in a faster descending hot gas layer in the compartment. However, the project team fire protection engineer must consider the significance of hot gases spreading to the upper floors and the proximity of combustibles to determine if there is a potential for fire spreading to the floor above.

6.3 Phase II Procedure

All plant locations not screened out in Phase I should be considered in Phase II. Each of the remaining plant locations should be divided into appropriate fire compartments (per Definition 2.4) for evaluation. A Fire Compartment Critical Screen Data Sheet (CSDS) and Critical Combustible Data Sheet (CCDS) should be completed for each fire compartment (See Attachment 10.2). The fire compartment should be identified and barrier boundary descriptions provided or a highlighted plant plan drawing showing the fire compartment boundaries should be attached to the data sheets for that compartment. The Phase II Fire Compartment Screening Guide (See Attachment 10.2) and data sheets provide a step-wise approach for evaluating each fire compartment. Generic industry data base inputs for certain steps are provided in Reference Tables 1 through 3 in Attachment 10.3. A description of each of these steps, special considerations and method of calculation follows. References identifying where the necessary data inputs might be found for each step are listed in the Fire Compartment Critical Screen Data Sheet.

6.3.1 Step 1: Ignition Source Frequency

6.3.1.1 Basis and Assumptions

This step provides for an evaluation of the potential ignition source frequency for a fire compartment (F_1). Generic fire frequencies for typical buildings in the nuclear industry have been compiled by EPRI [3,4]. The data for this data base was compiled from the following sources:

1. NRC Daily Plant Status Reports (DPSR)
2. Unpublished EPRI Fire Data Base EPRI RP 2639-1
3. Major Common Cause Initiating Events Study, Shoreham Nuclear Power Station
4. Seabrook Station Probability Safety Assessment Section 9.5
5. Nuclear Power Plant Fire Loss Data (EPRI Report NP-3179), July 1983.
6. W.T. Wheelis "Users Guide for Personal Computer - Based Nuclear Power Plant Fire Data Base", (NUREG/CR-4586), August 1986[9.6]
7. Utility responses to an EPRI questionnaire.

A total of 800 events over a period from 1965-1988 were identified from 140 BWR and PWR units across the United States representing a total sample size of about 1300 reactor years of operation. The data includes fire incidents caused from both fixed and transient ignition sources due to normal plant operations and maintenance activities. It provides actual nuclear power plant fire incident experience to assist in determining the likelihood of a fire in typical power plant buildings. The fire ignition frequencies identified from this generic data base are mean values which represent a typical condition for the industry. This generic data was used to develop Reference Tables 1.1 and 1.2 in Attachment 10.3 for use in establishing Fire Ignition Frequencies for similar fire compartments in nuclear power plants.

The Generic Fire Data Base Reference Tables can be used directly for implementation of this methodology using the following procedure or can be superseded or modified by a plant specific fire incident data base.

6.3.1.2 <u>Step 1: Procedure</u>

The following provides a procedure to evaluate fire-compartment specific fire ignition frequencies. The four-step procedure uses two Reference Tables 1.1 and 1.2 included in Attachment 10.3 and is illustrated in Figure 6.3.1.2. The data selected and calculations performed should be listed on a separate Fire Compartment Ignition Source Data Sheet (ISDS) (Attachment 10.2 - Table 3) for each fire compartment.

Step 1.1: <u>Select a Location</u> - Select from Reference Table 1.1 in Attachment 10.1, the appropriate location (room or building) which corresponds best to the fire compartment in question. The appropriate location is the most specifically applicable one. For example, if a fire compartment is a 480 volt switchgear room in your Auxiliary Building, the switchgear room location should be selected in preference to the Auxiliary Building. Some locations may be specific Appendix R fire areas (e.g. control room, cable spreading room, etc.); other locations may contain more than one Appendix R fire area (e.g. Auxiliary Building). Some ignition sources, (e.g., cables and transformers), are best apportioned by ignition source on a "plant-wide" basis. One has to account for the contribution from these ignition sources when they appear in the given location. List the selected location on the ISDS in Attachment 10.2 - Table 3.

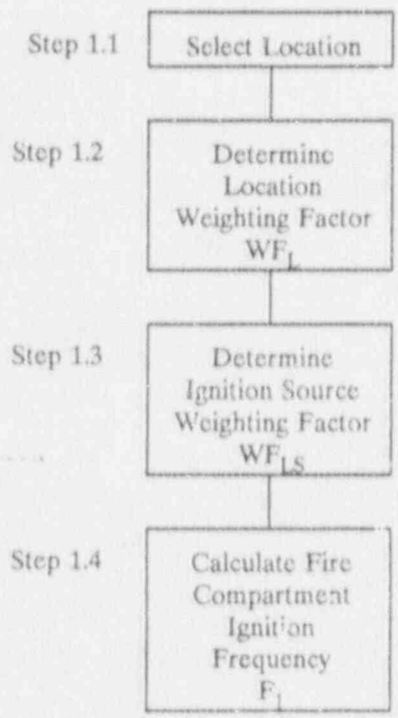
Step 1.2: Determine a Weighting Factor for the Location. (WF_L) Determine a weighting factor for the location selected in Step 1.1. This weighting factor will be used to translate generic fire frequencies for a location to specific, single unit fire frequencies. The weighting factors are designed to account for the relative amount of ignition sources in your plant compared to the "average" plant. Reference Table 1.1 in Attachment 10.3 provides, for each generic location, the method for calculating these weighting factors. Alternatively, for a certain type of ignition source, (e.g., electrical cabinet), the number is roughly the same in each compartment in a location. The weighting factor can be the reciprocal of the number of compartments. List the selected WF_L on the ISDS in Attachment 10.2 - Table 3.

Step 1.3: Determine a Weighting Factor for Each Type of Ignition Source (WF_{LS}) Reference Table 1.2 lists the ignition sources typically found in each fire location. List the number and each type of ignition source in the fire compartment as well as the total number in the (room or building) location selected in Step 1.1 on the ISDS. In general, calculate the weighting factor for each type of ignition source in the fire compartment by dividing the number of that type of ignition source in the fire compartment by the total number in the generic location selected in Step 1.1. For example, the weighting factor for pumps in an Auxiliary Feedwater (AFW) pump room would equal the number of pumps in the AFW pump room divided by the number of pumps in the Auxiliary Building (if the AFW pumps were the only ones in the room). If for certain types of ignition sources, (e.g., electrical cabinets), the number of ignition sources is roughly the same in each compartment in a location, the weighting factor can simply be computed as the reciprocal of the number of compartments in that location. The footnotes in Table 1.2 provide specific guidance for each ignition source.

Step 1.4: Calculate the Fire Compartment Fire Frequency (F_1) Reference Table 1.2 also lists the fire frequency for each ignition source by location. Calculate the fire compartment frequency for each ignition source (F_{if}) by multiplying: 1) the fire frequency (F_f) from Reference Table 1.1 for an ignition source present in the fire compartment, 2) the weighting factor for that ignition source as calculated in Step 1.3, (WF_{LS}) and 3) the weighting factor for the location determined in Step 1.2 (WF_L). Repeat the calculation for each ignition source and sum the results to obtain the total fire frequency F_1 for that fire compartment. List F_1 at the bottom of the Ignition Source Data Sheet (ISDS) and in the right hand column corresponding to Step 1 on the Fire Compartment Critical Screen Data Sheet (CSDS).

FIGURE 6.3.1.2

OVERVIEW OF
PROCEDURE TO DETERMINE
FIRE COMPARTMENT IGNITION FREQUENCY



Following the flowpath shown in Figure 6.0, if F_1 is less than or equal to 1E-6/reactor year, then the fire compartment can be screened out from any further evaluation. This result indicates that there are no significant fire vulnerabilities in this fire compartment.

If F_1 is greater than 1E-6/reactor year, there still may be a potential for fire vulnerabilities in this fire compartment. Further evaluation is required or apparent corrective actions could be taken that would allow this compartment to be screened out. The project team should decide if Step 2 or Step 3 should be performed next. The choice is based on the path that will allow reaching the 1E-6/reactor year threshold sooner. (See Figure 6.0)

6.3.2 Step 2: Redundant/Alternate Shutdown Path Unavailability

6.3.2.1 Basis and Assumptions

This step uses the assumption that Appendix R fire protection is adequate to prevent a fire from damaging both the primary and redundant/alternate shutdown paths from a single fire event if they are separated in accordance with Appendix R separation criteria.

6.3.2.2 Step 2: Procedure

The purpose of this step is to evaluate the likelihood of redundant/alternate Appendix R safe shutdown paths being unavailable at the same time a fire occurs within a fire compartment.

The safe shutdown system unavailability data (see Definition 2.8) necessary for this step, are generally developed and available from the front end analysis of an IPE (or Level 1 PRA).

First, the safe shutdown systems within the fire compartment and their corresponding alternate shutdown systems must be identified. These may include systems identified in the Appendix R analysis or other mitigating plant systems that could replace the safe shutdown functions that might be lost due to the fire. Multiple alternate paths can be included in the analysis if all components and equipment including power, control and instrumentation cables and any local operator actions are separated from the fire location in conformance with Appendix R fire protection separation criteria.

Given that a fire initiates and damages the safe shutdown systems in the fire compartment, calculate the probability of having the redundant/alternate shutdown path systems unavailable. The safe shutdown system unavailability could be obtained from the associated fault trees for the shutdown system equipment and components generated in the IPE. If redundant/alternate shutdown path systems are located in the same fire compartment, review each path separately assuming the loss of only one path from a single fire at a time as long as the separation between paths is in conformance with Appendix R fire protection separation criteria. The overall redundant/alternate safe shutdown system unavailability (P_2) will be the product of each alternate safe shutdown path unavailability.

$$P_2 = P_{2,1} \times P_{2,2} \times P_{3,3} \ldots \times P_{2,i}$$

List the redundant/alternate safe shutdown system unavailability (P_2) in Step 2 of the Fire Compartment Critical Screen Data Sheet for each safe shutdown system within the fire compartment. The likelihood of initiating a fire, and failing to restore the lost function(s) with alternate/redundant systems is thus determined by:

$$F_2 = F_1 \times P_2$$

If F_2 is less than or equal to 1E-6/reactor year then the fire compartment can be screened out from further evaluation. If the combustible loading and fire modeling Step 3 (P_{ccl}) has not yet been evaluated, the project team should qualitatively review the potential for fire spread beyond the fire compartment. This review should determine if there is any likelihood of the fire spreading to the adjacent compartment to adversely impact other safe shutdown systems or the redundant path.

If F_2 is greater than 1E-6/reactor year the evaluation of this fire compartment must continue to relax other conservative assumptions in the analysis and further examine the events in the fire damage sequence. Following the flow chart in Figure 6.0, the next step would be to evaluate the probability for critical combustible loading damage - Step 3 (P_{ccl}). If P_{ccl} has already been considered and F_i is still greater than 1E-6/reactor year than the project team should evaluate fire compartment conditions for potential vulnerabilities.

PROBABILITY OF CRITICAL COMBUSTIBLE LOADING DAMAGE

Page 1 of 2

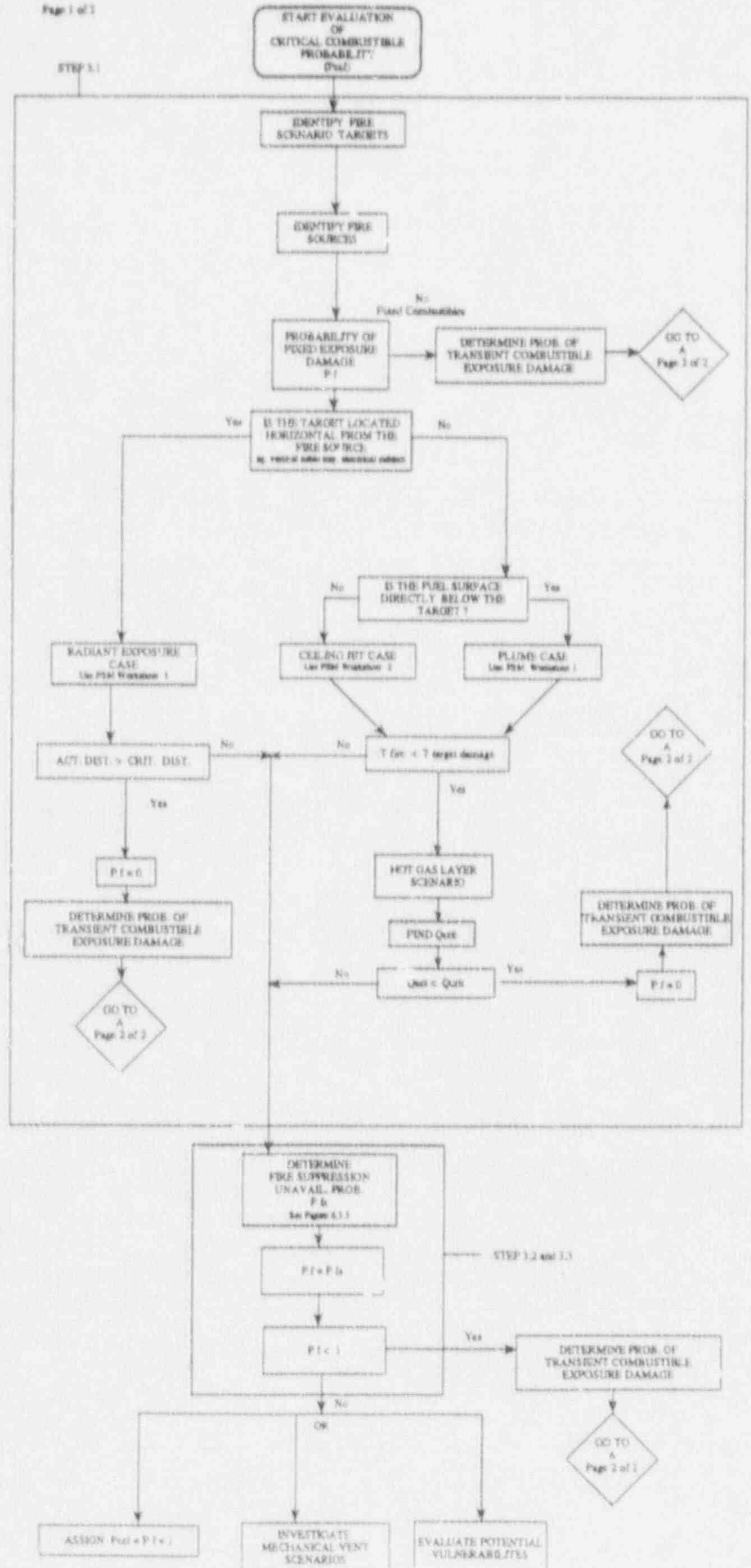


FIGURE 6.3.3.2 (a)

PROBABILITY OF CRITICAL COMBUSTIBLE LOADING DAMAGE

Page 2 of 2

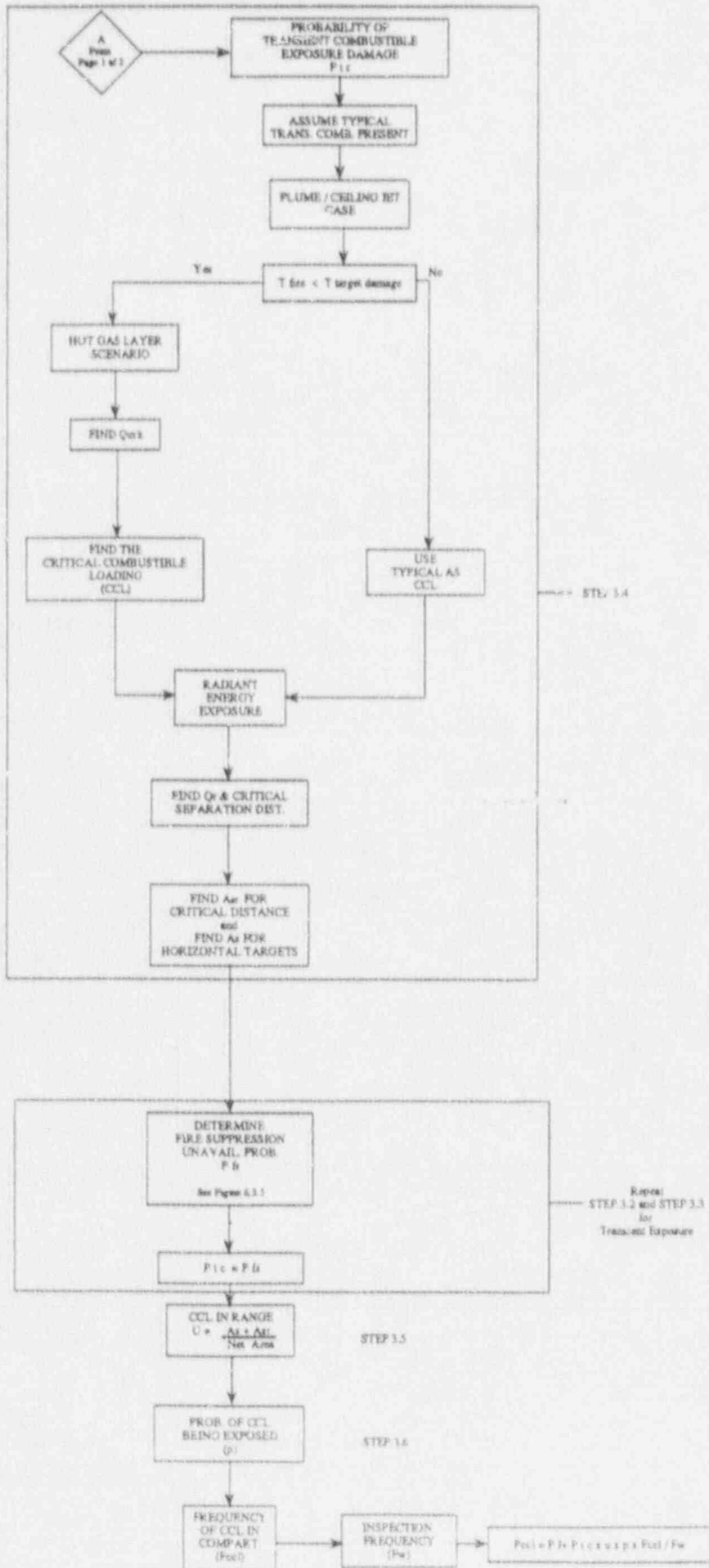


FIGURE 6.3.3.2 (b)

6.3.3 Step 3: Fire Hazards Analysis and Combustible Material Evaluation

6.3.3.1 Fire Hazard Evaluation Basis and Assumptions

Figure 6.3.3.2 (a) and (b) show a nine sub-step methodology for evaluating the critical combustible loading in a fire compartment (P_{cel}). First the fixed combustibles are reviewed to determine if there is enough material always available in a location that could cause target damage (Step 3.1). If not, then the amount of transient combustibles needed to cause damage will be determined (Step 3.4). Once this amount is determined, the project team will evaluate the probability of having it located in an area where it can cause damage (u) (Step 3.5), probability of finding the material in an exposed condition (Step 3.6) and the frequency of having that amount in the compartment F_{cel}/F_w (Step 3.7 and 3.8).

Fire suppression unavailability (automatic and manual) to function prior to target damage will be evaluated in Steps 3.2 and 3.3 for fixed and transient combustible exposures. The flow diagram showing the methodology for evaluating fire suppression unavailability is shown in Figure 6.3.5. This method uses fire modeling techniques to determine if the suppression method (automatic and manual) can function before critical damage to the target. If the automatic system operates in time, the system is assumed to cool the area and prevent damage to the target. The unavailability of the automatic suppression systems (P_{as}) will be factored in by applying data from the fire suppression system unavailability data base, Reference Table 2 in Attachment 10.3.

The following provides the general basis and assumptions used in the Step 3 methodology. Details regarding the fire modeling techniques and calculation procedures are provided in Attachment 10.4 and 10.7.

1. Point Source Fires

   Point source exposure fires from either fixed or transient combustibles expected within a fire compartment will be considered in this step of the methodology as initiators. These fire sources can be considered by placing the point source of the fire at the highest elevation of the postulated fire source. This fire source might be an electrical cabinet, pump, liquid spill or intervening combustible at some elevation above the floor.

   For example, the top of a switchgear or MCC cabinet will be chosen as the location for the point source of the postulated fire in this type of equipment. The point source of a transient combustible liquid spill or pump fire will be at the floor.

Self-ignited cable fires will not be considered fire source initiators in this methodology to be consistent with past PRA methods and because the ignition frequency of such events is low based on past nuclear power plant experience. However, if a cable tray (or other intervening combustible) is located between the potential fire source and target, and it can be shown that the fire source is large enough to involve the cable tray, the fire can be assumed to spread to that cable tray and the point source of the resulting cable fire should be taken at the elevation of the tray. The exposure from the cable tray and the exposure fire to the target can then be evaluated by assuming the point source is at the elevation of the cable tray. This method, however, cannot be used to model fire propagation to multiple elements because it does not address the combination of fuel elements in the fire exposure. (See Attachment 10.7)

2. Critical Failure Temperature

In general, the temperature of 700°F will be used as the failure temperature criteria for safe shutdown systems and components when applying the fire modeling evaluation. This temperature is the ignition temperature of polyethylene/polyvinyl chloride (PE/PVC) jacketed cable. It was selected because PE/PVC is considered a worst case cable material and the ignition temperature of the cable will be reached before the cable function is lost.[3,4] The value is also consistent with values used in previous PRA's. This is a practical failure temperature criteria for this methodology, since the most likely component to be exposed by a fire will be cables. Other equipment such as switchgear cabinets, MCC's, pumps, motors, and heat exchangers typically have a higher tolerance to increased temperature environments. The failure temperature is considered to be reached when the air temperature surrounding the target reaches the critical temperature. This is conservative since the target must be exposed for some time before the temperature of the target increases to its ignition temperature. Other critical failure temperatures can be applied if more specific data is available. Additional target thermal response data is provided in Table A-7E in Attachment 10.4.

3. Theoretical Basis For The Fire Hazard Evaluation Model (Steps 3.1 and 3.4)

The fire hazard evaluation model is designed to conservatively estimate the quantity of typical combustibles found in a compartment needed to increase the temperature at the location of the most susceptible safe-shutdown component (target) to the critical failure temperature. It is conservatively assumed that once the failure temperature is reached at the target, the function of that component will be lost.

The theoretical basis and derivation of the fire hazard evaluation model is described in Attachment 10.7. The Fire Model User Guide and calculation worksheets are provided in Attachment 10.4. The User Guide provides a stepwise description for completing the worksheets. These techniques are based on current fire modeling methods and fire dynamic correlations available in the fire protection engineering industry. These are the same basic correlations used as the foundation for COMPBRN IIIe developed at UCLA. [9.7,9.8,9.9] However, this method utilizes more conservative assumptions to reduce the complexity and number of variables required for calculation. This allows the use of look-up tables for ease in quantifying the potential fire exposure to targets in a compartment.

4. Exposure of Combustibles (Step 3.6)

This step requires a review and determination of fixed and estimated transient combustibles in a fire compartment. Combustibles will be evaluated based on whether or not they are normally exposed in such a way as to allow ignition. A few fixed combustible examples that would not be considered exposed include cables that are in conduit, wrapped cables and cables in cable trays with solid bottoms and covers.

Other fixed combustible sources such as combustible liquids associated with pumps are not normally considered exposed combustibles, however for this methodology it will be assumed they may become exposed as the result of a leak or small line break. The FIVE project team should determine a conservative spill size appropriate for the amount of combustible liquid in the equipment.

If combustible liquid filled equipment is diked and the quantity of liquid in the equipment is sufficient to fill the entire dike area, the pool size should be considered to be the dike surface area.

Transient combustibles need only be considered exposed if they are not stored in proper containers while in the fire compartment. Examples of transients that do not have to be considered exposed include:

a. Flammable and combustible liquids stored in approved containers.
b. Flammable or combustible liquids stored in approved flammable liquid storage cabinets.
c. Combustible liquids stored in sealed 55 gallon drums.
d. Radiation Work Permit (RWP) clothing and other incidental combustibles kept in closed metal cabinets.
e. Dirty RWP clothing or trash kept in closed non-combustible containers, equipped with fusible link actuated covers or Factory Mutual approved self extinguishing type lids.

In order to take credit for combustibles not being exposed, the plant must have and be able to demonstrate:

a. Effective transient combustible controls.

b. A combustible administrative control that requires combustibles be stored in non-combustible enclosures such as metal cabinets, approved flammable liquid con[illegible] and non-combustible RWP clothing containers with fusible link actuated covers.

c. An inspection program that monitors these administrative controls and takes corrective action when violations are discovered.

Transient combustibles used by plant personnel while working in an area, but immediately removed when vacating the area, need not be considered ex[illegible] if plant controls restrict st[illegible]ring transient materials in the area.

6.3.4 Step 3.1 Procedure for Evaluating Fixed Combustible Exposure [illegible]d Step 3.4 Procedure for Evaluating Transient Combustible Exposu[illegible]

These steps provide a methodology including fire modeling technique[illegible] determine whether the potential exists for the compartment to contain a sufficient quantity of combustibles to produce enough heat to damage safe shutdown components. Figure 6.3.3.2 (a) and (b) show the flow charts for evaluating the probability of equipment damage in a fire compartment from fixed and transient combustibles respectively. Fire hazards evaluation worksheets and a User's Guide with examples are provided in Attachment 10.4 to perform the fire modeling portions of these steps (Step 3.1 and 3.4). Fire compartment specific data are used to estimate fire growth and exposure to targets. The fire modeling has been simplified by making conservative fire protection assumptions. Such conservatism may be removed in later analyses should a higher degree of precision be warranted. The technical basis and conservative limitations behind the fire modeling techniques are outlined in Attachment 10.7.

1. Identifying Targets

The approach involves analyzing fires that could expose targets in the compartment. For the purpose of this analysis, the target is either a safe shutdown component or an intervening combustible such as non-safe shutdown cable tray that could become ignited and expose a safe-shutdown cable tray directly above it.

To ensure conservative results, the worst case targets are evaluated. The worst case fire plume scenario and radiant flux scenario involve evaluating expected combustibles (i.e. which could realistically be found in the compartment) with the highest heat release rate exposing the targets located closest to the fire source. The worst case ceiling jet and hot gas layer scenario involves evaluating expected combustibles with the highest potential heat release rates and targets located closest to the ceiling of the compartment.

Prior to using the Fire Hazard Evaluation Worksheets in Attachment 10.4, for plume/ceiling jet cases the target can be quickly evaluated to determine if it might be damaged by the fire plume exposure of a fixed combustible by using Table 4E, "Damage Threshold Elevations" in Attachment 10.4. Target damage can be quickly estimated by:

a. Identifying the heat release rate (HRR) of the combustible fire source from Table 2E.

b. Using Table 4E for that HRR and Critical Failure Temperature of 700°F to determine the minimum damage threshold elevation above the fire source.

c. If any targets in the compartment are located less than the minimum threshold distance away from that fixed combustible source, then damage from a plume fire exposure can be assumed without completing the Fire Hazard Evaluation Worksheet. The next step would be to continue and evaluate whether the fire suppression methods would be available before target damage following Step 3.2 and 3.3 in Figure 6.3.5.

The effect of fixed combustible plume fires is only evaluated for those situations in which they are located directly below targets. For this case, the Fire Screening Methodology (FSM) Worksheet 1 in Attachment 10.4 should be used. Otherwise, the ceiling jet scenario needs to be considered by applying the FSM Worksheet 2 in Attachment 10.4. In either case, if it is identified that the temperature of the plume/ceiling jet is less than the critical temperature of the target then the temperature rise due to the hot gas layer is evaluated.

2. Identifying Expected Fire Sources

The fire hazards evaluation worksheets are structured to allow one to quantify the fixed or transient combustibles necessary in a fire compartment to create damage to safe shutdown equipment. Further discussion on how to apply the fire hazards evaluation worksheet's are provided in the Users Guide in Attachment 10.4.

The first step in applying the fire hazard evaluation worksheet is to determine the expected type of fixed and transient combustibles in the fire compartment and whether or not these combustibles are normally exposed. A Fire Compartment Critical Combustible Data Sheet (CCDS) (Attachment 10.2, Table 5) must be completed for each fire compartment. The following describes the types of combustibles to be listed on the CCDS:

a. Permanent or Fixed Combustibles

The types of fixed combustibles located in the fire compartment should be listed on the top half of the CCDS along with the total quantity of each and the elevation between the combustible and the closet target located directly above (if any). An "X" should be placed in the "exposed" column if the combustibles are not normally enclosed in a metal enclosure (e.g. oil in pumps) or other similar enclosures.

b. Transient Combustibles

Typical transient combustibles expected within the fire compartment during full power plant operation should be listed on the CCDS. The project team should determine the types of expected transient combustibles that could be located in this fire compartment based on the types of equipment and maintenance activities that normally occur in the fire compartment.

The plant transient combustible control procedures should be reviewed to determine the types and quantities of expected transient combustibles in the fire compartment while the plant is at power. An "X" should be marked in the "Exposed" column for those transient combustibles that are not normally kept in metal cabinets or approved containers when in the area. In order to take credit for non-exposure of transients the plant must be able to demonstrate adequate controls for these combustibles.

Alternatively, the project team may have to interview maintenance personnel, plant operators and fire protection personnel who perform transient combustible and housekeeping inspections to identify the types and quantities of transient combustibles that could be expected.

A written transient combustible control program must exist to take credit for restrictions on the quantities of combustibles located in a fire compartment during plant full power operation. The transient combustible program must include: (1) specific restrictions on combustibles allowed in areas without review by plant personnel, (2) a surveillance program that monitors program implementation, and (3) a process to correct violations in a timely manner.

c. Flammable Liquids or Gas Storage Vessels

The CCDS also includes questions to identify whether there are any flammable liquid or gas storage vessels or piping located in the fire compartment. This information is gathered to address an issue to be considered later in the Sandia Fire Risk Scoping Study Evaluation discussed in Section 7.0.

3. Fire Exposure Scenarios

Two main scenarios must be considered for each of the expected fixed (Step 3.1) and worst case transient combustible (Step 3.4) fires:

a. The target is located in the fire plume or exposed to the ceiling jet.

Targets located vertically above the fire source should be evaluated from the plume/ceiling jet/hot gas layer exposure. If the target is not in the plume or ceiling jet so that the fire temperature (T_f) exceeds the target's critical failure temperature (T_{crit}), then the target temperature rise due to the hot gas layer is evaluated.

b. The target is located near to the fire source exposed to the radiant flux of the fire.

If the target is located horizontally from the fire source, the radiant exposure case should be considered. This would be appropriate for targets such as vertical cable trays or electrical cabinets. The Fire Screening Methodology (FSM) Worksheet 3 in Attachment 10.4 would be applied for these cases. The target damage threshold from radiant heat is assigned the conservative value of 10 Kw/m^2.

The heat flux seen at the target is a function of distance between the fire source and target. If the exposure fire is located beyond the critical distance such that the target will see less than 10 Kw/m^2 then no damage is considered to occur. The evaluation would continue by examining the transient combustible exposures. If the fire source is located within the critical distance the fire suppression unavailability should be evaluated (Step 3.2 and 3.3 in Figure 6.3.5)

4. Determine the Critical Combustible Loading (Qcrit)

The typical heat release rates for the types of combustibles expected in this fire compartment should be reviewed against the examples in Reference Table 3 in Attachment 10.3. The fixed combustible with the worst case heat release rate should be used with the Fire Hazards Evaluation Worksheets.

Using the Fire Hazards Evaluation Worksheets 1 or 2 and look-up tables, the maximum energy (Qcrit) that must be released to increase the temperature at the target(s) above 700°F from the hot gas layer can be calculated for the type and location of the worst case combustible in the fire compartment. This critical energy increase (Qcrit) is compared to the actual expected energy release (Qact) from the worst case fixed combustible listed in the CCDS. If the amount of energy (Qact) that could theoretically be released from the fixed combustible is less than Qcrit then assume there is not enough fixed combustible to cause target damage and continue to evaluate the potential transient combustible exposure. (See Figure 6.3.3.2(b))

If there is enough combustible energy available (Qact) from existing fixed combustibles then the unavailability of fire suppression methods to control the fixed fire exposure (Step 3.2 and 3.3 in Figure 6.3.5) should be evaluated.

6.3.5 Step 3.2 Automatic Suppression Unavailability

6.3.5.1 Basis and Assumptions

1. System Design and Installation

FIVE assumes that automatic fire suppression systems have been correctly designed and installed for the expected fire exposure in that location based on good fire protection engineering principles. The FIVE team should confirm this assumption.

2. Suppression System Unavailability

The probability of suppression systems being unavailable are taken from a generic fire suppression system unavailability data base (see Reference Table 2 Attachment 10.3). This data base is compiled from suppression system unavailability values for general industry in the U. S. The unavailability values include consideration for failure of systems to operate on demand and systems being out of service at the time of a fire (due to shut control valves, etc.).

These unavailability values are expected to be conservative with respect to nuclear industry experience, because general industry does not have the level of control over fire suppression systems that is found at nuclear power plants. For instance, nuclear plants have specific procedural controls for taking fire protection systems out of service, strict valve operational control programs, in addition to detailed requirements for the inspection, testing and maintenance of fire suppression systems on a regular basis.

These programs are implemented, maintained and given a much higher priority than would be found throughout general industry. Therefore, the unavailability of the fire suppression systems at nuclear power plants is expected to be much lower than that found in general industry and reflected in the generic data base.

Nevertheless, it is important that the FIVE team confirm that fire suppression systems have been designed and installed according to good fire protection engineering principles.

3. Redundant Fire Suppression Systems

If there are two single active failure proof fire suppression systems, the probability of automatic suppression being unavailable will be equal to the product of the unavailability (Reference Table 2 - Attachment 10.3) for each system.

4. Manually Operated Suppression Systems

Credit for manual only actuated suppression systems will only be taken if the project team can demonstrate that the systems can be operated prior to target damage. The plant must use the fire modeling worksheets to determine the time to critical damage (t_{crit}) and compare this to the expected time for fire detection (t_d) and actual response times for personnel to reach the equipment and control the fire (t_r) (See Figure 6.3.5). Once the suppression system is operated it will be assumed that the fire will be controlled. In this case t_r is equal to the time it would take to operate the ɂpression system once the fire has been detected. Note that the time for fire detection (t_d) will be assumed equal to 0 minutes if there is smoke detection installed in the area.

6.3.5.2 Step 3.2 Procedure

This step takes into consideration the effects of automatic suppression operations in controlling a fire within the fire compartment before it damages safe shutdown components. The flow chart in Figure 6.3.5 shows the methodology for determining the probability for fire suppression unavailability (P_{fs}). The first step in this process is to determine if automatic suppression systems are provided in the fire compartment. The type of automatic suppression system(s) installed within a fire compartment can be identified from the fire hazards analysis, pre-fire plans or plant fire protection personnel familiar with automatic suppression system location and arrangements within the plant.

If automatic systems are available, the project team must determine if these systems can operate prior to the target reaching its damage temperature when exposed to a fixed or transient combustible fire source. This can be found by applying the FSM Worksheet A-1 in Attachment 10.4. The time for the target to reach the damage temperature (t_{crit}) is determined and compared to the time for the suppression system to actuate (t_{supp}). The latter is found by applying the same fire modeling methodology in Step 3.1 except the target will now be the detector (sprinkler or heat detection actuation device). If the system activates before damage occurs to the target then the probability (P_{as}) of the system being unavailable on demand is selected from Reference Table 2 in Attachment 10.3. If the damage to the target occurs before actuation of the suppression system, then $P_{as} = 1$.

List the unavailability probability of automatic suppression systems (P_{as}) in the fire compartment on the Fire Compartment Critical Screen Data Sheet (Table 4). If there is more than one automatic suppression system installed in a fire compartment, credit can be taken for both suppression systems if the systems operate independently including electrical equipment and detection systems. For example; if two water based suppression systems are supplied by a common water main controlled by a single control valve, both suppression systems are dependent on a single point of failure. In this case, the automatic suppression system with the lowest (i.e. least penalizing) unavailability should be listed on the data sheet.

STEP 3.2 and 3.3 FIRE SUPPRESSION AVAILABILITY FLOW CHART

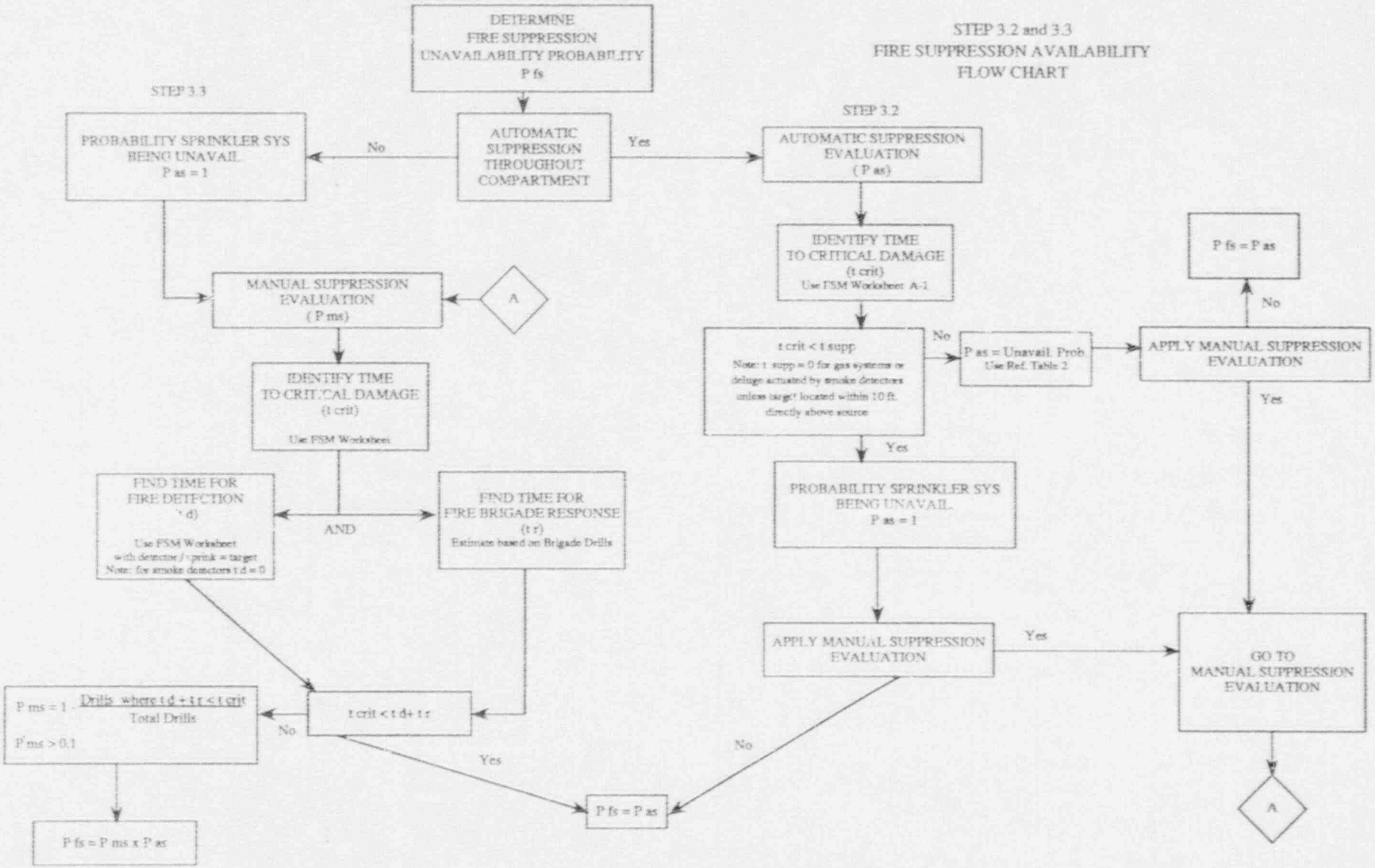


FIGURE 6.3.5

6.3.6 Step 3.3: Manual Suppression Unavailability

6.3.6.1 Basis and Assumptions

To take credit for brigade or manually actuated suppression system response (P_{ms}), the plant must demonstrate that the fire brigade can assemble, fight and control a fire in the compartment in less than $t_d + t_r$ minutes before it causes damage to safe shutdown systems (t_{crit}). The response time t_r is specific to the compartment under consideration and will be evaluated by the project team based on plant specific drills and other considerations. There is currently no simple or approved method to determine t_r or firefighting effectiveness in general. One method consists of establishing t_r on the basis of unannounced drills if a sufficient sample exists. In any case, the analyst must include a conservative judgment factor to account for heat and smoke effects and the time needed to locate the fire in a smoke-filled environment.

A fire detection system must also be installed in the fire compartment that provides an early warning signal of the fire to a central monitoring location. For smoke detection or other early warning systems, the time to detection (t_d) will be considered 0 minutes. This is considered a conservative assumption since the fire is assumed fully involved at time O whereas smoke detection devices actuate during the incipient stage of the fire. For heat detection devices, t_d could be determined using the fire modeling worksheets using the detector as the target.

Manual suppression unavailability will only be quantified if through the use of the fire hazard evaluation model (Worksheet A-1 in Attachment 10.4), COMPBRN IIIe model or similar method, the time to critical damage (t_{crit}) from the fire can be determined to be longer than $t_d + t_r$ minutes for manual response to the scene.

6.3.6.2 Step 3.3: Procedure

The flow chart in Figure 6.3.5 shows the method for considering the probability for manual fire suppression unavailability (P_{ms}).

Nuclear power plants have plant personnel trained to use portable extinguishers and fire brigades at the site. Fire incident records show that most fires are extinguished by plant personnel or the fire brigade in the very early stages of fire development. Manual suppression can play a major role in preventing fire damage to safe shutdown components. However, effectiveness in controlling a fire before the actual loss of safe shutdown functions depends on the time to detect the fire (t_d) and manual suppression response time (t_r) relative to fire growth time to critical damage (t_{crit}).

In order to take credit for fire brigade fire fighting activities or manual suppression actuation, the plant must be able to demonstrate that the fire can be detected, and the fire brigade can respond to the scene with equipment and control the fire before damage occurs to the safe shutdown components. Similarly, manually actuated suppression systems must be able to control the fire before damage occurs.

The project team should also be prepared to demonstrate that the fire brigade is adequately equipped and trained to be effective in fighting fires in the plant. The Sandia Fire Risk Scoping Study Evaluation Item III in Attachment 10.5, "Manual Fire Fighting Effectiveness" suggests attributes that can demonstrate plant brigade effectiveness.

The probability of manual suppression activities not controlling the fire (P_{ms}) will be assigned a value based on an evaluation of fire brigade response times if:

1. The plant can demonstrate manual response within $t_d + t_r$ minutes before fire damage to safe shutdown components (t_{crit}) and
2. Fire Brigade effectiveness can be demonstrated. (See Sandia Fire Risk Scoping Study Item II - Attachment 10.5).

If these two points can be demonstrated P_{ms} can be assigned a value based on the following:

$$P_{ms} = 1 - \frac{\text{Brigade drills performed in } t_d + t_r < t_{crit}}{\text{Total Number of Drills}}$$

$$P_{ms} \text{ cannot be } < 0.1$$

If these two points cannot be demonstrated, the team should set $P_{ms} = 1$, and no credit should be taken for the quantitative analysis. Clearly however, the presence of a well-trained and equipped fire brigade could be used as a qualitative consideration by a utility as part of its evaluation of potential vulnerabilities. (See Section 6.3.8).

6.3.7 Steps 3.5 - 3.8: Critical Combustible Loading Frequency

6.3.7.1 Basis and Assumptions

1. Frequency of Critical Combustible Loading (F_{ccl})

The frequency of having a critical combustible loading present (F_{ccl}) will be chosen based on the effectiveness of the plant transient combustible control program. Available plant records from the following sources can be reviewed to determine the number of times the critical loading of combustibles was found present in violation of controls:

a. Past audits and inspections by the NRC, QA Department, independent auditors, plant fire protection personnel/operations personnel.

b. Inspections performed in accordance with the transient combustible procedures or housekeeping inspection procedures.

The number of incidents found from these sources will be divided over the number of years from which the data was taken. This calculates an average number of transient combustible control breakdowns per year and should be used as (F_{ccl}).

As an alternative, if no records are available, interviews with maintenance, fire protection and operations personnel can be conducted to determine the likely quantities and frequencies for combustibles in a particular fire compartment. A representative F_{ccl} for that compartment can then be determined. However, in either case a conservative assumption will be made that F_{ccl} cannot be set lower than 1 event/year/compartment.

The fire compartment may be considered susceptible to fire damage if:

a. There is no transient combustible procedure that covers the fire compartment, or
b. The transient combustible procedure allows the critical quantity of combustible without additional fire protection precautions, or
c. The quantity of fixed combustibles exceeds the critical combustible loading.

If any of these conditions exist the fire compartment must be considered a significant fire compartment and will require further review. (See Section 6.3.8).

2. Frequency of Transient Combustible Inspections (F_w)

The probability of having combustibles located in an area where they do not belong is related to the number of times the area is inspected for unwanted combustible storage. More inspections reduce the likelihood of having exposed or unauthorized combustibles in the compartment.

The frequency of inspections for combustibles (F_w) for any fire compartment will be taken as the highest frequency inspection that actually looks for transient combustibles in the compartment per year. An example would be selecting the inspection program with the highest frequency from housekeeping, transient combustible surveillance inspections, fire protection plant inspections for housekeeping or combustible controls, etc. The frequency should be given in number of inspections per year. It is assumed that, when conducted, these inspections are performed correctly and if any combustibles are found that do not belong or exceed the amounts allowed by the transient combustible controls, corrective action will be taken.

6.3.7.2 Steps 3.5 - 3.8: Procedure

These steps provide a method for establishing the frequency of potentially finding a critical quantity of combustibles within the fire compartment where they could cause damage. The critical quantity of combustibles needed to cause damage from a plume/ceiling jet scenario was determined in Step 3.4 using the fire hazard evaluation worksheets. The frequency is determined by the combination of the following factors:

1. The probability of transient combustibles being located directly below a target (u) where it would be directly in the fire plume/ceiling jet or horizontally next to a target where the target could be damaged by exposure to the radiant energy of the fire. (Step 3.5)

2. The probability of the critical combustible quantity being exposed (p) where it could be involved in a fire. (Step 3.6)

3. The frequency of having the critical combustible loading present in the compartment (F_{ccl}). (Step 3.7)

4. The frequency of combustible material inspections (F_w) that would find the transient combustible exposure before a fire occurred. (Step 3.8)

The probability of having an unsuppressed critical transient combustible fire exposure in the compartment (P_{tc}) can then be calculated as follows:

$$P_{tc} = P_{fs} \times u \times p \times F_{cc1}/F_w$$

where F_{fs} is defined and computed in Section 6.3.5.2.

Step 3.5: <u>Transient Combustibles Located in the Range of Target Components (u)</u>
If transient combustibles can be located in a fire compartment and there is a possibility that they could be stored directly below the target (safe shutdown component or intervening combustible) or within range for radiant energy damage then the probability (u) of storing transient combustibles in damage range of targets will be determined by dividing the sum of the surface area of targets facing the floor (A_s) (where they could be exposed) and critical separation distance from radiant energy exposure from a critical combustible loading fire source to horizontal targets (A_{sr}), by the net area of floor space where combustibles could be stored in the fire compartment.

For example, if the target is horizontal cabling, the exposed area (A_s) will be the width and length of the cable tray routed through the compartment where a fire could expose it from below. Only the surface area of the tray facing the floor needs to be considered.

If the target is a cable tray routed vertically within 10 ft. from the floor, radiant energy from a fire could expose the tray to damage. The critical safe radial separation distance between the target and the fire source must be determined using FSM Worksheet A-1 in Attachment 10.4. The floor area around the target within this critical radial separation distance would be A_{sr} for that target.

$$u = \frac{A_s + A_{sr}}{Net\ Area}$$

List (u) for the fire compartment in Table 4, Step 3.5 of the Fire Compartment Critical Screen Data Sheet (Attachment 10.2) for later calculation.

Step 3.6: <u>Probability of Combustibles Being Exposed (p)</u>

The probability of the critical combustible being exposed (p) is dependent on plant combustible storage and handling practices. A plant specific value for (p) can be obtained by performing a walkdown through the significant areas of the plant and identifying and totalling the number of instances (p_1) where the transient combustible are found exposed and the number of instances (p_2) where they are not, then $p = p_1/(p_1 + p_2)$.

As an alternative, a probability of 10% can be assumed if there is a transient combustible control program which includes features similar to the following:

a. Flammable and combustible liquids stored in approved containers in the fire compartment.

b. Storage of ordinary combustibles or RWP clothing in enclosed metal cabinets or metal containers with fusible link actuated covers or with FM approved self-extinguishing lids.

c. All exposed transient combustibles used by plant personnel while working in the compartment are removed upon completion of the work unless otherwise approved.

The appropriate probability (p) should be listed in Table 4, Step 3.6 of the Fire Compartment Critical Screen Data Sheet (see Attachment 10.2) for later calculation.

Step 3.7 <u>Selection of the Critical Combustible Loading Frequency (F_{ccl})</u>

The critical combustible loading frequency (F_{ccl}) can be assigned by comparing the equivalent units of combustibles calculated from the fire hazard evaluation worksheet with the actual quantities of combustibles listed in Table 5 of the Fire Compartment Critical Combustible Data Sheet. The critical combustible frequency (F_{ccl}) would then be assigned based on the following:

a. If the critical quantity of <u>transient</u> combustibles could be stored in the compartment without review by the transient combustible control program, a potential fire susceptibility has been identified. The frequency that this quantity of combustible is located in the compartment is determined by assuming $F_{ccl}/F_w = 1$.

Further refinement of the fire compartment analysis should be considered to identify simple changes that could be made to reduce the potential for fire damage. Changes such as revising or adding administrative controls or preventing exposure of combustibles could be considered to reduce the combustible quantity.

b. If the critical combustible quantity is not allowed without review by the transient combustible control program, then the frequency F_{ccl} will be chosen as the number of times the critical quantity of combustible was found present in violation of control procedures.

The number of incidents should be compiled from inspection findings from the NRC, QA Department, independent auditors, housekeeping or transient combustible inspections, plant fire protection tours or other operations personnel inspections. The total number of incidents should be divided by the number of years from which the data was gathered to determine an average F_{ccl} = findings/year.

If no records of violations are maintained by the plant, the project team will attempt to obtain this information through interviews with cognizant plant personnel. For each compartment under investigation, plant personnel involved with inspections will be requested to identify the frequency of finding the critical quantity of transient combustibles. An average value will then be computed after rejecting the highest and lowest responses, F_{ccl} = Estimated Findings/year/compartment.

List the F_{ccl} frequency selected for that fire compartment in Table 5 - Fire Compartment Critical Combustible Data Sheet along with the method used to select that number based on the above criteria. In addition, list the F_{ccl} in Table 4, Step 3.7 of the Fire Compartment Critical Screen Data Sheet (Attachment 10.2) for later calculation.

6.3.8 Step 4: Evaluate Potential Fire Vulnerabilities

The Phase II fire screening method is complete at this point. Fire compartments that have not yet been screened out are designated significant fire compartments. For a compartment that is designated significant, the selected course of action taken by the utility and the associated rationale should be documented. Following are three approaches that a utility may consider. These approaches are not intended to be all inclusive; there are other approaches which could be employed by a utility. One approach is perform no further evaluation and implement no plant changes. If a utility selects this approach, they are reminded that their rationale must be documented.

A second approach is to evaluate implementation of administrative and/or hardware modifications. This is done by reviewing the factors considered in the screening process, possible changes in the fire damage sequence of events can be evaluated to determine how they affect the overall likelihood of the fire event to result in an inability to achieve and maintain safe and stable shutdown conditions. For example, the addition of automatic suppression systems may include another factor that could contribute to reducing the fire damage frequency. The change can quickly be estimated by reviewing the order of magnitude and how it would be factored into the fire damage calculation Table 4 - Fire Compartment Critical Screen Data Sheet. Other possible examples of simple changes that could affect the fire damage frequency are:

a. Reduce transient combustibles
b. Restrict storage of combustibles (type/location)
c. Control storage and handling so combustibles are not exposed in the fire compartment. This may include storing combustibles in metal cabinets.
d. Restrict storage of combustibles so that a fire cannot occur resulting in a safe shutdown component being directly in the fire plume.
e. Add fire suppression systems to the fire compartment.
f. Increase the inspection frequency for this fire compartment.
g. Add ignition source controls which would allow the ignition frequency selected for the fire compartment to be reduced.
h. Replace combustible materials with fire retardant materials or other materials with lower heat release rates.
i. increase reliability of alternate train via procedures, training or otherwise.

A third approach is to further evaluate the subject fire compartment with more detailed analyses than those proposed in the Phase II screening method.

6.3.9 Step 5: Evaluate Potential Impact on Containment Heat Removal and Isolation

The FIVE method is essentially based upon the safe shutdown analysis of 10CFR50 Appendix R, which generally required only a review of those containment functions needed to ensure operability of equipment and performance of manual actions inside containment necessary to accomplish safe shutdown functions. Containment heat removal as a function was not an explicit part of Appendix R, Section III.L.2.

Phase II of the FIVE methodology outlines a sequence for quantifying the likelihood of a fire in a given area resulting in an inability to achieve or maintain safe and stable shutdown conditions. By assigning values to the likelihood of fire initiation in a given area, the critical combustible loading (CCL) within spatial proximity of a fire initiator, the potential for damage to safe shutdown systems, the unavailability of redundant/alternative safe shutdown systems, and the success of automatic or manual suppression, the likelihood of being unable to achieve or maintain safe shutdown can be evaluated. If at any time in quantifying the various aspects, the likelihood of not achieving or maintaining safe shutdown conditions was less than 1E-6 per reactor year, that fire compartment was screened out from further consideration. Implicit in this statement is that core damage from that particular fire-initiated event in that fire compartment is negligible.

If the likelihood of loss of safe shutdown capability for a fire compartment is still greater than 1E-6/reactor year after completing Phase II and the plant cannot take appropriate action to reduce the likelihood below this threshold, the fire effects on containment performance must be evaluated.

Justification for limiting containment performance evaluations to only these instances is based upon two considerations:

1. The Commission's Severe Accident Policy Statement specifically requested a "limited scope, accident safety analysis designed to discover instances (i.e. outliers) of particular vulnerability to core melt or to unusually poor containment performance, given core-melt accidents."

2. In the NRC Staff contractor's evaluation of external hazards report (NUREG-5042), it was concluded that "the fraction of fire-initiated core-damage sequences associated with an early containment failure (a "large release") is in every case very small, and in some cases found in the analysis to be zero." NRC and industry studies of other plant-specific risk assessments indicate the same result.

If an evaluation of containment performance is necessary, it should include: (1) An assessment of the potential for a fire in the area of concern to damage equipment or prohibit manual operator actions used to accomplish the containment function, and (2) Identification of a minimum set of equipment and manual actions necessary to achieve the containment function against those lost due to the fire.

In particular, fires leading to the potential loss of safe shutdown function above the threshold value of 1E-6/year and having plant damage states and minimum operable equipment not included in the IPE, should be flagged for containment analysis evaluation.

7.0 SANDIA FIRE RISK SCOPING STUDY EVALUATION

7.1 Background

Sandia National Laboratory, as part of their Fire Protection Research Project, undertook two tasks in what is now referred to as the Fire Risk Scoping Study:

1. Review and update the perspective of fire risk in light of the information developed through the Fire Protection Research Project.

2. Identify and perform initial investigations of any potential unaddressed issues of fire risk.

Sandia reviewed four previously completed fire probabilistic risk assessments (PRAs). The PRA risk scenarios were requantified using the data and information from the Fire Protection Research Project as a basis and included plant modifications made in response to implementations of Appendix R requirements at the plants under study. In performing the second task, Sandia developed a list of issues which they felt represented potential contributors to fire risks that had not been adequately addressed in previous risk assessments. Sandia concluded from these reassessments that fire may represent a dominant contributor to plant core damage risk and that these six issues should be addressed in future risk assessments.

The draft Sandia report was made available to several plant designers, fire researchers, industry representatives, fire protection consultants and regulators. They were asked to review the report and to ensure that, as far as practical, the list of unaddressed issues was complete. The most important industry response, provided to Sandia by the Edison Electric Institute Fire Protection Committee, was that "these issues are unaddressed by the selected method of risk evaluation and do not (necessarily) represent unaddressed risk issues for nuclear plants . . . this document is a report on the inadequacy of current risk assessment and research methodology for fire. There is no basis presented to indicate that regulatory requirements or implemented levels of fire protection are inadequate." Nonetheless, the list of six issues remains.

One of the objectives in developing the FIVE Methodology was to provide guidance, as appropriate, to plant staff on the proper treatment of these issues.

7.2 Sandia/NRC Fire Risk Scoping Study Issues

The NRC staff has requested, that the following six issues be addressed, in any future fire evaluation methodology.

1. Improved Analytical Codes
2. Seismic/Fire Interactions
3. Fire Barrier Qualifications
4. Manual Fire Fighting Effectiveness
5. Total Environment Equipment Survival
6. Control Systems Interactions

Concerns regarding each of these issues will be discussed below. Four of the six issues are included in the FIVE evaluation. Attachment 10.5 provides a list of typical plant attributes that should be considered. The project team should review and evaluate their plant for similar attributes to demonstrate that these issues are adequately addressed. The plant staff must be able to support its position.

Issue 1 - Improved Analytical Codes

This issue involved questions regarding the adequacy of available fire models for use in IPEEE analyses for fire external events.

After a number of discussions between nuclear industry representatives and the NRC staff regarding this issue, the NRC agreed that the COMPBRN IIIe fire modeling program as developed by UCLA and including modifications recommended by Sandia National Laboratory is adequate for analytical fire modeling and requires no further modification for application in IPE of external events.

The fire modeling techniques incorporated in Phase II of this FIVE methodology are derived from the same basic correlations used in COMPBRN IIIe. There is no additional industry evaluation required for this issue.

Issue 2 - Seismic/Fire Interactions

This issue involves three concerns: (1) Seismically induced fires, (2) Seismic actuation of fire suppression systems, and (3) Seismic degradation of fire suppression systems. The nuclear industry feels that these types of events would not significantly contribute to an increase in external event core damage frequency. The reasons for this conclusion relative to each concern, as well as the limited plant-specific assessment or confirmation we suggest be included as part of the IPEEE, are discussed below.

1. Seismically Induced Fires

   A recent survey of over 100 plant and industrial facilities after 18 major earthquakes indicates that earthquakes generally do not cause fires in such facilities (EPRI-NP6989, "Survey of Earthquake-Induced Fires in Electrical Power and Industrial Facilities", September 1990).

   NRC arrived at a similar conclusion when issuing the Appendix A to Branch Technical Position APSCB 9.5-1, "Guidelines for Fire Protection For Nuclear Power Plants Docketed Prior to July 1, 1976" in February 1977. That document noted in Section 5.1.3 that "Postulated fires or fire protection system failures need not be considered concurrent with other plant accidents or the most severe natural phenomena."

   Nonetheless, concern remains over the potential breakage of flammable liquid or gas vessels during a seismic event that could create fire hazards in the plant. Therefore, review of such fire hazard sources should be included in the seismic walkdown program to verify their seismic ruggedness.

2. Seismic Actuation of Fire Suppression Systems

   The effects of inadvertent suppression system actuation have been previously considered as part of the internal flooding design analysis and I & E Information Notice 83-41, "Actuation of Fire Suppression System Causing Inoperability of Safety Related Equipment," dated June 22, 1983.

   Some plant equipment either credited as being part of the seismic safe shutdown path in a seismic margins assessment (SMA) may not have previously been reviewed relative to the internal flooding design analysis or I & E Notice 83-41. In such instances, utility personnel should evaluate the potential for such inadvertent actuations. If actuation is considered to be possible, then an assessment similar to that performed in I & E Notice 83-41 may be warranted.

3. Seismic Degradation of Fire Suppression System

A report investigating this subject, prepared by Brookhaven National Laboratory, and titled "Performance of Fire Protection Systems under Post Earthquake Conditions, "dated October, 1978 concluded that fire suppression systems installed in accordance with nationally recognized codes and standards generally provide an adequate level of support for piping under seismic conditions.

The NRC's guidance for seismic installation of piping in Regulatory Guide 1.29 recommends use of seismic category II/I design criteria for fire protection piping and components to assure they will not fall and damage safety-related safe shutdown components during a seismic event.

The above assessment notwithstanding, fire suppression systems in close proximity to the seismic margin safe shutdown path components should be evaluated for their "survivability" during the seismic walkdown. The term survivability means the suppression system in question does not disable safety systems required to shutdown and cool the reactor plant. It does not correspond to ensuring fire suppression system operability. The emphasis in these evaluations should be on situations with large deflections; potential interactions (e.g., impact of pipe and sprinkler heads on other objects); behavior of threaded connections and brittle material (e.g., cast iron piping).

Item I of the Sandia Fire Risk Scoping Study evaluation (Attachment 10.5) provides guidance on the types of questions that need to be addressed during the review of fire suppression systems. Further guidance on the review to be performed to assess the response of applicable systems and components to the seismic initiator can be found in EPRI-NP6041, "A Methodology for Assessment of Nuclear Power Plant Seismic Margin."

Issue 3 - Fire Barrier Qualifications

The NRC staff appears to be concerned with determining and quantifying the effectiveness of fire barriers to contain a fire. The staff's main concern seems to be with regard to the installation and maintenance of penetrations through fire barriers that are protected by fire dampers, fire doors and fire rated penetration seal assemblies. However, rated fire barriers should be accepted as being effective if plants demonstrate their fire barriers and associated barrier components are being adequately designed, inspected, tested and maintained.

The nuclear industry believes that properly designed and installed fire barriers are adequate to contain the types of fires expected in nuclear power plants and that rigorous surveillance, testing and maintenance of fire barrier components (i.e. fire doors, fire dampers and penetration seal assemblies) provide an acceptable basis for demonstrating a high level of reliability of barrier effectiveness. Any potential installation problems with fire damper operations and fire penetration seal assemblies of concern to the NRC should be considered compliance issues. Nevertheless, it is prudent for utilities to ensure that issues such as those identified in the following NRC information notices have been adequately addressed.

Fire Dampers

1. I&E Notice 89-52, "Potential Fire Damper Operational Problems," dated June 8, 1989
2. I&E Notice 83-69, "Improperly Installed Fire Dampers at Nuclear Power Plants," dated October 21, 1983.

Fire Penetration Seal Assemblies

1. I&E Notice 88-04, "Inadequate Qualification and Documentation of Fire Barrier Penetration Seals," dated August 9, 1988.

2. I&E Notice 88-04, Supplement 1, "Inadequate Qualification and Documentation of Fire Barrier Penetration Seals," dated August 9, 1988.

3. I&E Notice 88-56, "Potential Problems with Silicon Foam Fire Barrier Penetration Seals," dated August 4, 1988.

The comparison attributes in Item II of the Sandia Fire Risk Scoping Study Evaluation (Attachment 10.5) are intended to demonstrate that the plant has programs in place to ensure a high level of confidence that fire barriers and their components are being adequately maintained so they will function in the event of a fire. They are written in a general fashion to help plant personnel understand the intent. The plant must be able to support and demonstrate their ability to satisfy that intent.

Issue 4 - Manual Fire Fighting Effectiveness

The comparison attributes presented in Item III of the Sandia Fire Risk Scoping Study Evaluation (Attachment 10.5) are provided to demonstrate that there are programs and procedures for promptly identifying fires and calling out the fire brigade, training plant personnel who might be able to extinguish the fire in its early stages of development using portable fire extinguishers, and an adequately manned and equipped fire brigade team that is trained and prepared to respond to fire events. In addition, there should be records and documentation programs showing the level of training that each brigade member has received.

Each plant has a fire hazard awareness and fire fighting training program. The intent of the items provided in the evaluation can be satisfied in different ways by different plants. If the plant can demonstrate how their program satisfies that intent, they can take credit for manual fire suppression response in their fire risk evaluation.

Issue 5 - Total Environment Equipment Survival

The NRC staff has expressed three major concerns regarding this issue:

1. The potential for adverse effects on plant equipment caused by combustion products released from the fire causing damage, and possible loss of safe shutdown functions.

2. The spurious or inadvertent actuation of fire suppression systems resulting in the loss of safe shutdown functions.

3. Operator effectiveness in performing manual safe shutdown actions and potential misdirected suppression effects in smoke filled environments.

With regard to item 1 above, there have not yet been enough studies performed with respect to non-thermal fire effects on industrial plant equipment to adequately quantify the potential problems and identify solutions each utility should consider for those problems. The FIVE methodology does not currently allow for an evaluation of non-thermal environmental effects of smoke on equipment. However, the detrimental short term effects of smoke on equipment are not believed to be significant.

With regard to item 2, NRC Staff is currently investigating this concern in Generic Safety Issue 57, "Effects of Fire Protection Systems Actuation on Safety Related Equipment." Industry investigation of 75 LERs cited in the Draft NUREG/CR-5432 prepared by Sandia National Laboratory as instances of inadvertent actuations found only 13 involved damage to safety-related equipment. Of these 13 events, none involved a situation where the redundant equipment was lost, much less loss of safe shutdown capability.

Nevertheless, the FIVE methodology includes, as part of the Phase III Walkdown Verification Checklist, a plant-specific evaluation of the susceptibility of both trains providing a safe shutdown function being simultaneously damaged from inadvertent actuation of one suppression system. Specifically, in the event suppression coverage could reach equipment of both safe shutdown trains, the analyst should assess the susceptibility of the safe shutdown equipment to damage from the suppressant.

With regard to item 3 on operator effectiveness, demonstrations of operator action effectiveness, most likely conducted as part of the Appendix R analysis, must have included an evaluation of the capability to perform safe shutdown manual actions should operators have to pass through or perform manual actions in plant areas where fire or smoke may be present. If potential smoke filled conditions are expected, adequate operator aids should be provided to allow the operator to perform his tasks. Operator aids may include such things as:

1. Color-coded equipment to better allow the operator to identify equipment locations.
2. Portable lights for operator use if he must pass through areas darkened by smoke or use an alternate route to avoid the smoke.
3. SCBA and other protective equipment for operators with corresponding training.

In accordance with Appendix R, all plants are required to develop safe shutdown procedures for any fire area requiring implementation of alternative shutdown capability. Implementation of alternative safe shutdown capability is generally a more difficult evaluation than that associated with using the typical safe shutdown systems, hence the need for procedures. If the operators have been trained in the use of these procedures, the plant should be able to demonstrate that the operators are aware of the conditions they could expect when required to implement the procedures during a fire.

The items in Item IV of the Sandia Fire Risk Scoping Study Evaluation (Attachment 10.5) are presented to show that the plant has evaluated these concerns.

Issue 6 - Control Systems Interactions

The intent of this issue is to verify the ability to achieve safe shutdown from either the control room or remote shutdown panel cannot be threatened by a single fire. The primary concern is for plants which do not have independent "remote" control or monitoring circuits. The NRC staff would like to verify that one fire would not disable control room control of these circuits because they were split off from the control room feeder circuit and not run separately outside the control room fire area.

Plants which do not have independent "remote" control and monitoring circuits independent of the control room must review their Appendix R analysis to verify that safe shutdown circuits have been located physically independent of, or can be isolated from the control room for an exposure fire that causes a loss of control from the control room.

8.0 PHASE III FIVE METHODOLOGY WALKDOWN/VERIFICATION

The purpose of this phase in the methodology is to walkdown/verify the plant to gather data and confirm information and assumptions made while performing Phase II and completing the Sandia Fire Risk Scoping Study Evaluation. A walkdown/verification guide is provided in Attachment 10.6 as an outline for performing the plant walkdown and records review of plant fire areas. Documentation of previous walkdowns and evaluations which address the referenced concerns may be used to satisfy those concerns where applicable.

The FIVE methodology project team should perform the walkdown/verification to review whether or not their assumptions and calculations, particularly fire barrier effectiveness, can actually be supported by the physical conditions that exist in the plant.

This will require taking each of the Phase II Fire Compartment Critical Screen Data Sheets and associated Critical Combustible Data Sheets into the plant. The data sheets will be used to gather necessary data to verify data compiled from drawings or other past studies and to examine potential fire vulnerabilities revealed through performing the evaluation. The practicality of possible alternative corrective actions to reduce those vulnerabilities should also be reviewed during this phase.

8.1 Documentation for the IPEEE

The implementation of the FIVE methodology should be documented in a traceable manner to provide the basis for the findings. This can be dealt with most efficiently by a two-tier approach. The first tier consists of the results and conclusions of the plant-specific application of the FIVE methodology which will be reported to the NRC for review. The second tier is the documentation of the process itself (e.g., detailed worksheets for each analyzed compartment), which should be retained by the licensee for the duration of the license unless superseded.

These documentation recommendations provide guidance for documenting the plant's IPEEE for fire using the FIVE Methodology. These recommendations are not intended to supercede or conflict with the NRC Staff's submittal and documentation requests that are to be finalized in Generic letter 88-20, Supplement 4 and/or NUREG-1407.

8.1.1 First Tier Documentation to the NRC

The following items should be included in the documentation forwarded to the NRC:

1. Major results of the fire IPEEE and conclusions concerning potential fire induced vulnerabilities and their disposition.

2. A list of fire areas screened-out during Phase I process and a brief explanation justifying the decision to screen-out. Table 1 in Attachment 10.1 could be used to support this documentation.

3. A list of assumptions made during the course of the implementation that differ substantially from those discussed in the FIVE report and a brief discussion justifying these assumptions.

4. A list of the fire compartments with the highest value of the parameter F, computed in Phase II (Section 6.0).

5. The worksheets utilized to document utility consideration of the applicable Sandia Fire Risk Scoping Study Issues. (Attachment 10.5)

6. A list of documents used as reference to evaluate parameters used in the study (e.g. Appendix R documentation) or supporting assumptions made in the study (e.g. Admin. procedures, fire brigade training guidelines, response to I&E Notice 83-41, etc.).

7. A description of the plant-specific initiating events database if a plant-specific database is selected instead of the generic database proposed in Tables 1.1 and 1.2 of attachment 10.3.

8.1.2 Second Tier Documentation for Plant Reference

The following documentation should be retained by the utility:

1. Worksheets developed for each analyzed fire compartment (See Attachment 10.2 and Fire Modelling Worksheets, Attachment 10.4).

2. Worksheets developed to evaluate the Sandia's Fire Risk Scoping Issues (Attachment 10.5).

3. Basis for working assumptions differing from those made in the FIVE document.

4. Interviews with operators, fire inspectors, etc. leading to the determination of quantitative information (e.g. parameter p in Section 6.3.7.2 Step 3.6).

5. Walkdown findings

6. Remedial actions to eliminate potential vulnerabilities.

7. List of supporting documentation references (Appendix R, etc.)

8. List of planned plant modifications at the time the study is performed and for which credit is taken in the study.

9.0 REFERENCES

9.1 Cohn, B. M. and R.E. Hall, Performance of Fire Protection Systems Under Post Earthquake Conditions, Brookhaven National Laboratory under inter-agency agreement EY-76-C-02-0016 NRC Fin. No. A-3107, October 1978

9.2 Dungan, K. W., Design Guide for Fire Protection of Grouped Electrical Cables, EPRI Electric Power Research Institute, Palo Alto, CA, October 1989

9.3 EPRI Fire Frequency Data base

9.4 Klameras, L. J., A Preliminary Report on Fire Protection Research Program SAND77-1424, Sandia National Laboratories, Albuquerque, NM, October 1977

9.5 Tewarson, A., J.L. Lee, and R.F. Pion, Categorization of Cable Flammability Part 1: Laboratory Evaluation of Cable Flammability Parameters, Interim Report, EPRI NP-1200, Part 1, Project 1165-1, Electric Power Research Institute, Palo Alto, CA October 1979

9.6 Wheelis, W.T.: "User's Guide for a Personal Computer Nuclear Plant Fire Database" NUREG/CR-4586-Aug. 1986.

9.7 V. Ho, N. Siu, G. Apostolakis, "COMPBRN III - A Computer Code for Modelling Compartment Fires," NUREG/CR-4566 USNRC, November 1985.

9.8 V. Ho, N. Siu, G. Apostolakis, "COMPBRN III - A Fire Hazard Model for Risk Analysis". Fire Safety Journal Vol 13 pp 137-154 1988.

9.9 V. Ho, S. Chien, G. Apostolakis, "COMPBRN IIIe - An Interactive Computer Code for Fire Risk Analyses - EPRI Report to be published.

10.0 ATTACHMENTS

10.1 Phase I - Fire Area Screening Guide and Tables 1 and 2

10.2 Phase II - Fire Compartment Screening Guide

- Table 3 - Fire Compartment Ignition Source Data Sheet (ISDS)
- Table 4 - Fire Compartment Critical Screen Data Sheet (CSDS)
- Table 5 - Fire Compartment Critical Combustible Data Sheet (CCDS)

10.3 Phase II - Data Reference Tables

- Reference Tables 1.1 and 1.2 - Ignition Source Frequency Data
- Reference Table 2 - Suppression System Unavailability Probabilities
- Reference Table 3 - Examples of Typical Transient and Fixed Combustibles and Their Related Heat Release Rates

10.4 Fire Hazard Evaluation Worksheet and User's Guide

10.5 Sandia Fire Risk Scoping Study Evaluation

10.6 Phase III - Walkdown Verification Evaluation

10.7 Nomenclature

ATTACHMENTS

LIST OF FIGURES

ATTACHMENT 10.1

PHASE I

Fire Area Screening Guide

and Matricies 1 and 2

FIVE PLANT SCREENING GUIDE
PHASE I
SIGNIFICANT FIRE AREA SCREEN

ITEM	INFORMATION RESOURCES
Step 1: Identify Plant Fire Areas	
1.1 List all plant fire areas down Column B in Table 1 based on the fire area Definition 2.2.	Fire Hazard Analysis Plant Fire Protection/Architectural Drawings Penetration Seal/Fire Door/Fire Damper Surveillance Procedures
1.2 Fire Barrier Qualifications	
a. Is each fire area barrier included in the plant's surveillance program for inspection of fire barrier and barrier components? 1. fire dampers 2. fire penetration seals 3. fire doors	Plant Fire Protection Surveillance Procedures
b. Can the plant verify their fire barrier qualifications and effectiveness. See Sandia Scoping Checklist Issue II.	Sandia Scoping Study Checklist
c. If a or b is "No" then credit cannot be taken for these fire barriers.	
Step 2: Identify Plant Safe Shutdown Systems	
List all the safe shutdown systems associated with the Appendix R shutdown paths along the top row in Table 1 and down Column B in Table 2.	Appendix R Safe Shutdown Report
Step 3: Perform Fire Area vs. Safe Shutdown System Screen	
3.1 For each fire area listed in Column B of Table 1, place an "x" in each column corresponding to the safe shutdown system(s) associated with equipment, cables or components located in that fire area.	
3.2 For each fire area in Table 1, evaluate whether either of the following conditions are true. If true, the fire area can be screened out. An "x" should be placed in Column C if the fire area can be screened out. The basis for screening should be listed in Column D (e.g. "a" no safe shutdown equipment.)	Fill in Table 1
a. There are no safe shutdown system equipment, cables or components in this fire area.	
b. There are at least <u>two</u> independent alternative shutdown trains or paths located outside this fire area that could replace the [illegible]ction of the listed in this fire area.	
Step 4: Perform Fire Area vs. Safe Shutdown Function Comparison	
4.1 For each Fire Area listed in Column B of Table 1, identify the type(s) of safe shutdown function(s) that are needed to maintain safe and stable reactor conditions by reviewing the "x"ed systems in that fire area and assuming:	Review Table 1
a. A fire damages all equipment, cables and components in the fire area within the Appendix R framework.	Review Table 1
b. The component/system primary Appendix R redundant or alternate path outside the area is not available.	

ITEM	INFORMATION RESOURCES
4.2 Identify Plant Systems Available to Mitigate the Loss of that Safe Shutdown function	
4.2.1 List any plant systems that could be used to mitigate the loss of that safe shutdown function(s) along the top row of Table 2 in the following order from left to right:	Fault tr from Level 1 PRA Meet with lant Operators or Systems Engineers EOP's
a. Appendix R Safe Shutdown Systems which may be safety related, non-safety or other systems.	Appendix R Safe Shutdown Report
b. Non-Appendix R Safety Related Systems.	
c. Other plant systems	
4.2.2 Place an "x" in Table 2 for each plant system that could be used to replace the safe shutdown function(s) in Column B assumed lost by a fire in that fire area.	Fill in Table 2
4.3 For each fire area in Table 1 evaluate whether either of the following conditions are true. If true, the fire area can be screened out and an "x" placed in Column C of Table 1 for that fire area along with the reason from below in Column D (e.g. "b1"-there is another plant system available outside this fire area that can replace the loss of the safe shutdown function(s) in this fire area).	Fill in Table 2
a1. There are no safe shutdown components in this fire area whose function(s) are needed to maintain safe and stable reactor conditions	Fill in Table 1 Column C and D
b1. After reviewing Table 2, there are at least two plant systems located <u>outside</u> this fire area that are available to mitigate each safe shutdown function that might be lost due to a fire in this fire area.	Using Table 2 Appendix R Safe Shutdown Fire Hazards Analysis
Note: Station must be able to demonstrate that all cables, equipment and components associated with this mitigating system are outside this fire area. Therefore it is preferable to choose Appendix R systems or other systems for which cable routing etc. have already been located through the plant or that have fewer cables and support systems whose locations can quickly and easily be evaluated.	
<u>Step 5</u>: <u>Continue on to Critical Fire Area Screen - Phase III</u>	
The fire areas that are not screened out are now considered significant fire areas.	
The next step is to perform the critical fire area screen to determine the conservative probability that a fire in any one of these remaining significant fire areas can prevent safe and stable reactor conditions.	
This is accomplished by evaluating the potential for a fire initiated event within each compartment of that fire area, (the entire fire area may make up a single fire compartment).	

TABLE1 - SAFE SHUTDOWN SYSTEM VS. FIRE AREAMATRIX

SAFE SHUTDOWN SYSTEMS											
A	Fire Area[B]	Screen Out[C]	Basis[D]	E	F	G	H	I	J	K	L
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											

ATTACHMENT 10.2

PHASE II

Fire Compartment Screening Guide

Table 3 -Fire Compartment Ignition Source Data Sheet (ISDS)

Table 4 - Fire Compartment Critical Screen Data Sheet

Table 5 - Fire Compartment Critical Combustible Data Sheet

FIVE PLANT SCREENING GUIDE
PHASE II
CRITICAL FIRE COMPARTMENT SCREEN

ITEM	INFORMATION RESOURCES (Best Sources on Top)
INTRODUCTION	
1. Complete a critical screen data sheet for each fire compartment.	
2. The following steps are provided to allow for an evaluation of each significant fire compartment. The steps can be combined in any order. At the end of each step the fire damage frequency (F_i) will be evaluated. If after any step, F_i is less than 1E-6, that fire compartment can be screened out.	
3. Use a blank critical screen data sheet for each new fire compartment.	
4. List the boundaries of the fire compartment in the space provided or attach a copy of a plant drawing highlighting the boundaries.	
Step 1 - Determine Ignition Source Frequency (F_1)	
1. List the potential ignition sources in that fire compartment.	Fire Hazards Analysis Final SER Pre-fire plans
2. Look up the typical ignition frequency (F_1) for that building or equivalent compartment type from Reference Table 1 and list on the data sheet.	Reference Table 1 - Attachment 10.3
3. If F_1 < 1E-6 then screen out the compartment.	
Step 2 - Evaluate Automatic Suppression Systems	
1. List the types of automatic fire suppression system(s) installed in this fire compartment.	Fire Hazards Analysis Plant Fire Protection Drawings Appendix R Documentation Technical Specifications
2. Look-up system unavailability from Ref. Table 2.	
3. List unavailability (P_2) for each suppression system on the Data Sheet. If no automatic suppression system, or if the target can be located directly above a combustible (in the flume) then P_2=1. If there are redundant systems, P_2 = product of each system unavailability.	Reference Table 2 - Attachment 10.3
4. Calculate $F_2 = F_1 \times P_2$; If F_2 is < 1E-6 then screen out compartment.	

ITEM	INFORMATION RESOURCES (Best Sources on Top)
Step 3 - Evaluate Redundant/Alternate Path Availability	
1. On the data sheet list all redundant safe shutdown systems or alternate shutdown path systems for this compartment.	Appendix R Documentation NRC Final SER
2. Final (non-fire) availability for each redundant system or alternate shutdown path from the front end IPE.	Front End IPE
3. List these probabilities (P_3) on the Data Sheet.	
4. Calculate $F_3 = F_2 \times P_3$ If F_3 is < 1E-6 then screen out compartment. If IPE Data not available $P_3 = 1$.	
Step 4 - Critical Combustible Exposure	
1. For each fire compartment not yet screened complete a Fire Compartment Critical Combustible Data Sheet (CCDS Table 5) and attach to the related Critical Screen Data Sheet.	
2. Fixed Combustibles	
a. List the type and quantity of fixed combustibles on the CCDS. If located below targets enter distance between target and combustible.	
b. Mark "X" next to exposed if the combustibles are not normally enclosed in a metal enclosure (eg. oil in pump, cables in solid back trays with covers, cable trays wrapped or enclosed with a fire rated assembly, cables coated w/ mastic material or in conduit).	
3. Transient Combustibles	
3.1 Identify Expected Combustibles	
a. List the expected types and quantities of transient combustibles that might be found in this area.	
b. Does the plant administratively control transient combustibles in this area while the plant is operating?	
c. List the maximum quantity of each material expected in this room without review based on the transient combustible procedure.	
d. Can combustibles be stored in the area without a permit or procedural review?	
e. Mark "X" next to exposed if the combustibles are not kept in metal cabinets or approved containers when stored in the area.	
f. If combustibles can be located directly below targets enter the distance between the expected location of the combustible and the target.	
4. Critical Combustible Loading	

ITEM	INFORMATION RESOURCES (Best Sources on Top)
Step 5a - Probability of Combustibles Underneath Target	
1. Are there procedural restrictions on the location where combustibles can be stored in the compartment?	Transient Combustible Procedure
2. Do procedures restrict storage of transient combustibles in the compartment without review by plant personnel cognizant of associated fire hazards through the issuance of a transient combustible permit or similar means?	Transient Combustible Procedure
3. If the answer to any of the questions above is NO then the probability of combustibles being underneath the target should be listed as u=1 on the Critical Screen Data Sheet. If yes, compute u = sq. ft. exposed target/sq. ft. exposed floor space.	
Step 5b - Frequency of Critical Combustible Loading	
1. Determine Critical Combustible Loading (CCL) Complete the Fire Hazards Evaluation Worksheet for the fire compartment. Convert the critical heat release into terms of equivalent units of typical fixed or transient combustibles expected in that fire compartment. Attach the Worksheet to the associated CCDS.	Complete the Fire Hazards Evaluation Worksheet
2. Assign the (F_{ccl}) List the frequency for allowing this critical quantity of combustibles (calculated in 1 above) in this fire compartment on the CCDS and Critical Screen Data Sheet. a. If the amount of fixed combustible exceeds the critical quantity then, P_5 = 1 b. If the current transient combustible procedure allows the critical quantity or if this level always exists then F_{ccl} = Estimated events/yr. c. If the equivalent amount of transient combustibles needed to reach the critical heat release is twice that which would ever be expected even if control procedures broke down, then F_{ccl} = 1/event yr.	
d1 If this quantity is possible but is controlled by the transient combustible procedure, then list the number of times transient combustibles were found in excess of the critical amount by either the NRC, QA Dept. independent auditors or plant fire protection/operations personnel. F_{ccl} = No./Yr (Average), or d2 If records are not available, interview plant personnel responsible for transient combustible and housekeeping inspections etc. to determine the frequency that 1/2 the critical quantity is found in the compartment. F_{ccl} = Avg. No./yr (neglect the highest and lowest responses) d3 If no records found, then assume F_{ccl} = 10 events/yr.	Past Audit Reports Transient Combustible Procedure Findings Housekeeping Surveillance Findings Maintenance/Operations Interviews
3. Determine Inspection Frequency (Fw) List the regular frequency for inspection of combustibles in this fire compartment on the Critical Data Sheet. F_w = No/yr.	Plant Housekeeping Procedure Plant Transient Combustible Surveillances Plant Operator Tours (if appropriate)

ITEM	INFORMATION RESOURCES (Best Sources on Top)
4. Determine Probability of Combustibles being Exposed (p) Are there restrictions for the storage and handling of combustibles such as: a. flammable and combustible liquids stored in approved containers while in the compartment. b. storage of ordinary combustibles in metal cabinets while stored in the compartment c. all exposed transient combustibles not stored in the compartment and removed upon completion of the work. If all of the above are "yes", then assign $p = 10\% = 0.1$ If no, then $p = 1$ List the exposure probability (p) on the Critical Screen Data Sheet. 5. Calculate Probability of Critical Combustible (P_5) $P_5 = p \times F_{cci}/F_w$ (Hot Gas Layer) $P_5 = p \times u \times F_{cci}\ F_w$ (Transient Plume Scenario) 6. Calculate Fire Damage Frequency (F_5) $F_5 = F_3 \times P_5$; If $F_5 < 1E{-}6$ screen out the fire compartment. If not, continue. Step 6 - Manual Suppression Availability 1. Fire damage occurs in less than 30 min. $P_6 = 50\% = 0.1$ 2. If fire damage not reached before 30 min., evaluate brigade response times and preparedness using Sandia Fire Risk Scoping Study Evaluation Item III. 3. If 2 is correct, use conservative probability of $P_6 = .5$ Step 7 - Evaluate Fire Vulnerabilities 1. Evaluate the frequency and probability numbers gathered in the Fire Compartment Data Sheet for those with the greatest impact. 2. Propose recommended changes that could change the frequency below 1E-6, for example: • Adding an automatic suppression system. • Improving the transient combustible procedure by increasing the restrictions on combustibles (type and quantity or storage location). • Control storage of combustibles in area outside the range of high frequency ignition sources. • Increase Inspection Frequency Step 8 - Evaluate Containment Heat Removal & Isolation If F_1 still > 1E-6 than evaluate fire effects on containment performance.	

TABLE 3
Fire Compartment
Ignition Source Data Sheet (ISDS)

COMPARTMENT DESCRIPTION						
Fire Compartment Boundaries:						
Inside Fire Area:						
FIRE IGNITION FREQUENCY						
STEP 1.1 Selected Fire Location (Ref. Table 1.1)						
STEP 1.2 Location Weighting Factor (WF_L) (Ref. Table 1.2)						
STEP 1.3 IGNITION SOURCE WEIGHTING FACTOR (WF_{LS}) = SOURCES IN COMPARTMENT/SOURCES IN SELECTED LOCATION						
POTENTIAL FIXED IGNITION SOURCES	DISTANCE TO COMBUSTIBLE TARGETS	# of Ignition Sources in Compartment (A)	Total # of Ignition Sources in Selected Location (B)	WF_{LS} = A/B	F_f[1]	F_{if}[2]
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
TRANSIENT IGNITION SOURCES						
1.						
2.						
3.						
4.						
5.						
6.						
7.						
STEP 1.4 Calculate Fire Compartment Fire Frequency (F_1)						
Fire Compartment Fire Frequency (F_1) = Σ [$F_f \times WF_L \times WF_{LS}$] for each fire ignition source in compartment.						

[1] F_f = Fire Frequency from (Ref. Table 1.2)

[2] Ignition Source Fire Frequency (F_{if}) = $F_f \times W_{LS} \times W_L$

File Ref: 779866-Table3

TABLE 4

FIRE COMPARTMENT CRITICAL SCREEN DATA SHEET (CSDS)

Fire Compartment Location:______________________________

Barrier Boundary Description:___________________________

PROCEDURE		REFERENCE	DATA
Step 1	Determine Ignition Frequency in this Compartment List F_i, from ISDS	Use Reference Table 1.1 and 1.2 and Figure 6.3.1.2 Complete ISDS to find F_i.	Frequency of ignition (F_i) Selected for this Compartment from ISDS. F_i = __________
Step 2	Non-Fire Related Shutdown System Unavailablity Redundant/Alternate Safe Shutdown Systems (SSS) 1. 2. 3. 4. Calculate $F_2 = F_1 \times P_2$ If F_2 < 1E-6 Screen out otherwise continue	Use Front End IPE Data	SSS Unavailability (P_2) 1. 2. 3. 4. 5. F_2 = __________
Step 3	Evaluate Probability for Critical Combustible Loading Damage (P_{ccl})	See Figures 6.3.3.2(a) and (b)	
Step 3.1	Evaluate Probability of Fixed Exposure Damage (P_f)	Use Figure 6.3.3.2(a) and FSM Worksheets 1,2 and 3	
Step 3.2	Determine Automatic Suppression (AS) Unavailability for Fixed Combustibles 1. 2.	Use Figure 6.3.5 See Ref. Table 2 If no AS then P_{as} = 1	P_{as} = __________
Step 3.3	Determine Manual Suppression Unavailability (P_m) 1. Time for Fire Detection t_d = 2. Time for Manual Response t_r = 3. Time to critical damage t_{crit} = 4. Number of drills where $t_d + t_r < t_{crit}$ = 5. Total number of drills = a. Find Probability of Fire Suppression for Fixed Exposure P_{fs} b. Find Probability of Fixed Exposure Damage P_f	Use Figure 6.3.5 $P_{ms} = \frac{1\text{-Drills } t_d+t_r \le t_{crit}}{\text{Total Drills}}$ P_{ms} > 0.1 $P_{fs} = P_{ms} \times P_{as}$ P_f = 0, P_{fs} or 1 Use Figure 6.3.3.2(a)	P_{ms} = __________ P_{fs} = __________ P_f = __________
Step 3.4	Evaluate Probability of Transient Combustible Exposure P_{tc}) a. Find CCL b. Evaluate Radiant Energy Exposure c. Find Q_r and Critical Separation Distance	Use Figure 6.3.3.2(b) Use FSM Worksheets	
Repeat Step 3.2 and 3.3	Repeat Steps 3.2 and 3.3 for Transient Combustible Exposure	Use Figure 6.3.5 and Reference Table 2 $P_{ts} = P_{ms} \times P_{as}$	P_{as} = __________ P_{ms} = __________ P_{ts} = __________

TABLE 4

FIRE COMPARTMENT CRITICAL SCREEN DATA SHEET (CSDS)
(Continued)

PROCEDURE		REFERENCE	DATA
Step 3.5	Evaluate CCL Location a. Find A_s Surface Area of Ceiling Targets b. Find A_{sr} Radial Separation Distance c. Calculate Net Area d. Calculate $u = \frac{A_s + A_{sr}}{\text{Net Area}}$	Use Plant Drawings	u = ______
Step 3.6	Select (p) Probability of CCL being Exposed	See Section 6.3.7.2	p = ______
Step 3.7	Select (F_{cci}) Frequency of CCL	See CCDS Use walkdowns or personnel interviews	F_{cci} ______ events/yr
Step 3.8	Select F_w Inspection Frequency	Use Plant Procedures	F_w = ____ inspections/yr
Step 3.9	Calculate $P_{tc} = P_{ts} \times u \times p \times F_{cci}/F_w$ Calculate $P_{cci} = P_t + P_{tc} = P_3$ Calculate $F_3 = F_2 \times P_3$ If F_3 < 1 E-6 Screen Out Otherwise Continue		P_{tc} = ______ P_{cci} = ______ F_3 = ______
Step 4	Eva.uate Vulnerabilities Evaluate significant frequencies for simple fixes, for example: 1. Reduce transient combustibles 2. Restrict storage of combustibles type/location 3. Add suppression system 4. Increase Inspection Frequency		Recommend Changes to reduce Freq. of vulnerability. 1. 2. 3.
Step 5	Evaluate Containment Heat Removal & Isolation	Evaluate Areas F_3 > 1E-6	

TABLE 5

Fire Compartment
Critical Combustible Data Sheet (CCDS)

Fire Compartment Boundaries: ______________________________

Inside Fire Area: ______________________________

FIXED COMBUSTIBLES	EXPOSED	QUANTITY
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
Any Flammable Liquid or Gas Storage Vessels?		Yes/No
If yes, are they subject to leakage during seismic events?		Yes/No

TRANSIENT COMBUSTIBLES	EXPOSED	QUANTITY	
		Expected	Maximum w/o Review
1.			
2.			
3.			
4.			
5.			
6.			
7.			

Critical Combustible Loading Evaluation

1. Maximum Heat Release converted to Equivalent Units of Expected Fixed and Transient Combustibles(ccl): ____________________
(Use Fire Hazards Evaluation Worksheet & Tables)

2. Selected F_{ccl} ______________________________

Reason ______________________________

File Ref: 779866-Table 5

ATTACHMENT 10.3

PHASE III

Data Reference Tables

Reference Tables 1.1, 1.2, 2 and 3

List of Reference Tables

REFERENCE TABLE 1.1 Weighting Factors for Adjusting Generic Location Fire Frequencies for Application to Plant-Specific Locations	
PLANT LOCATION	WEIGHTING FACTORS[1] (WF_L)
Auxiliary Building (PWR)	The number of units per site and divide by the number of buildings.
Reactor Building (BWR)[2]	The number of units per site and divide by the number of buildings.
Diesel Generator Room	The number of diesels and divide by the number of rooms per site.
Switchgear Room	The number of units per site and divide by the number of rooms per site.
Battery Room	The number of units per site and divide by the number of rooms per site.
Control Room	The number of units per site and divide by the number of rooms per site.
Cable Spreading Room	The number of units per site and divide by the number of rooms per site.
Intake Structure	The number of units per site and divide by the number of intake structures.
Turbine Building	The number of units per site and divide by the number of buildings.
Radwaste Area	The number of units per site and divide by the number of radwaste areas.
Transformer Yard	The number of units per site and divide by the number of switchgards.
Plant-Wide Components (cables, transformers, elevator motors, hydrogen recombiner/analyzer)	The number of units per site.

[1] The analyst must identify the number of like locations when determining the number of buildings, e.g, a 480 volt load center is "like" a switchgear room.

[2] Reactor building does not include containment

REFERENCE TABLE 1.2

Fire Ignition Sources and Frequencies
By Applicable Plant Location

PLANT LOCATION	FIRE IGNITION SOURCE	IGNITION SOURCE WEIGHTING FACTOR METHOD	FIRE FREQUENCY[1,2]
Auxiliary Building (PWR)	Electrical cabinets	B	2.0×10^{-2}
	Pumps	B	1.9×10^{-2}
Reactor Building[2] (BWR)	Electrical cabinets	B	4.9×10^{-2}
	Pumps	B	2.5×10^{-2}
Diesel Generator Room	Diesel generators	A	2.5×10^{-2}
	Electrical cabinets	A	2.3×10^{-3}
Switchgear Room	Electrical cabinets	A	1.6×10^{-2}
Battery Room	Batteries	A	3.1×10^{-3}
Control Room	Electrical cabinets	A	9.3×10^{-3}
Cable Spreading Room	Electrical cabinets	A	3.9×10^{-3}
Intake Structure	Electrical cabinets	A	2.3×10^{-3}
	Fire Pumps	A	3.9×10^{-3}
	Others	A	3.1×10^{-3}
Turbine Building	T/G Excitor	B	3.9×10^{-3}
	T/G Oil	B	1.4×10^{-2}
	T/G Hydrogen	B	5.4×10^{-3}
	Electrical cabinets	B	1.3×10^{-2}
	Other pumps	B	7.0×10^{-3}
	Main feedwater pumps	A	4.3×10^{-3}
	Boiler	B	1.6×10^{-3}
Radwaste Area	Miscellaneous components	A	8.5×10^{-3}
Transformer Yard	Yard transformers propagating to Turbine Building	A	3.9×10^{-3}
	Yard transformers (LOSP)	A	1.6×10^{-3}
	Yard transformers (Others)	F	1.5×10^{-2}
Plant-Wide Components	Fire protection panels	F	2.3×10^{-3}
	RPS MG sets	F	5.4×10^{-3}
	Non-qualified cable run	E	6.2×10^{-3}
	Junction box/splice in non-qualified cable	E	$1.6 X 10^{-3}$
	Junction box in qualified cable	E	$1.6 X 10^{-3}$
	Transformers	F	$7.8 X 10^{-3}$
	Battery Chargers	F	$3.9 X 10^{-3}$
	Off-gas/H_2 Recombiner (BWR)	G	$8.4 X 10^{-2}$
	Hydrogen Tanks	G	$3.1 X 10^{-3}$
	Other Hydrogen Fires	C	$3.1 X 10^{-3}$
	Gas Turbines	G	$3.1 X 10^{-2}$
	Air Compressors	F	$4.7 X 10^{-3}$
	Ventialation Subsystems	F	$9.3 X 10^{-3}$
	Elevator motors	F	$6.2 X 10^{-3}$
	Dryers	F	$8.5 X 10^{-3}$
	Transients[3,4]	D	$1.4 X 10^{-3}$
	Cable fires caused by welding[4]	C	$5.6 X 10^{-3}$
	Transient fires caused by welding and cutting[4]	C	$2.8 X 10^{-2}$

Foot Notes and notes for Table 1.2

[1] Frequencies are per reactor year unless otherwise noted

[2] Fire frequencies are per fraction of ignition sources per year

[3] Fire frequency represents one event. Tı · thirteen transient events which occurred during power operation are considered by the weighting factor.

[4] Fire frequency represents years at power operation.

[5] Fire frequency represents an estimate 130 gas-turbine-operating years.

Notes for Ignition Source Weighting Factor Method:

Zone specific ignition sources should be verified in the Phase III walkdown. In Phase II, values can be estimated using methods other than direct counting, including engineering judgement. Attempt to estimate values within about 25%.

A No ignition source weighting factor is necessary.

B Obtain the ignition source weighting factor by dividing the number of ignition sources in the fire area by the number in the selected location.

C Obtain the ignition source weighting factor by calculating the inverse of the number of Appendix R fire areas in the location for which this fire ignition source could be present. Exclude any areas contained in other locations in this table.

D Obtain the ignition source weighting factor by summing to D factors for ignition sources which are allowed in the zone and dividing by the number of zones in the locations in this table. For example, if cigarette smoking is prohibited do not include the cigarette smoking factor in the calculation. The factors are:

• Cigarette Smoking	3
• Extension Cord	3
• Heater	2
• Candle	2
• Overheating	2
• Hot pipe	1

Overheating addresses errors while heating potential combustibles, e.g., battery terminal grease.

E Obtain the ignition source weighting factor by dividing the weight (or (BTUs) of cable insulation in area by the total weight (or BTUs) of cable insulation in Appendix R fire areas not including fire areas in either the radwaste area or the containment. Cable insulation weight (or BTUs) are provided in Appendix R combustible loadings. (Junction boxes and splices are assumed to be distributed in proportion to the amount of cable.)

F Obtain the ignition source weighting factor by dividing the number of ignition sources in the fire area by the total number in all the locations in this table.

G Obtain the ignition source weighting factor by dividing the number of ignition sources in the fire area by the total number in all plant locations including locations that were not specified in this table.

REFERENCE TABLE 2[1]

AUTOMATIC SUPPRESSION SYSTEM UNAVAILABILITY

System Type	Unavailability Probability of System
Wet Pip : Sprinkler[1]	2.0×10^{-2}
Preacticn Sprinkler[4]	5.0×10^{-2}
Deluge Sprinkler[4]	5.0×10^{-2}
CO_2 [2]	4.0×10^{-2}
Halon[3]	5.0×10^{-2}
Redundant Systems: Failure Prob. of Both Systems = Prob. of System 1 x Prob. of System 2.	

1 Principle Wet Pipe Data Sources

NFPA, "Automatic Sprinkler Performance Tables 1970 Edition", NFPA Fire Journal, July, 1970

Marryat, H.W., Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886 - 1986, Australian Fire Protection Association, Melbourne, Australia, Rev. Ed. 1988.

Powers, W.R., "Sprinkler Experience in High-rise Buildings (1969-1979), "SPFE Technology Report 79-1, Society of Fire Protection Engineers, Boston, MA.

2 Principle CO_2 Data Sources

Steciak, J. and Zalosh, R.G., "A Reliability Analysis of Halon 1301 Systems in Computer Rooms," to be presented at the ASTM Symposium on Fire Hazard and Fire Risk Assessment, December 3, 1990, San Antonio, Texas.

Stronach, R.I., "Reliability of Carbon Dioxide Extinguishing Systems," presented to the Fire Suppression Systems Association, Baltimore, MD, at the Annual Meeting, January, 1987.

3 Principle Halon Data Sources

Maybee, Walter W., "Summary of Fire Protection Programs of the United States Department of Energy, Calendar Year 1987," U.S. Department of Energy, Frederick, MD, August, 1988.

Miller, M.J. U.S. Navy and FMRC, "The Reliability of Fire Protection Systems," AIChE Loss Prevention Symposium, November 11-15, 1973.

4 Data gathered primarily from Nuclear Plant Experience under EPRI Contract No. 3114-29, "Fire Events Database".

NOTE: Many of the automatic system failures including all deluge and preaction system Nuclear Plant experience were manually actuated locally. This ability to recover operation of the suppression systems may be credited in the manual response evaluation.

REFERENCE TABLE 3 EXAMPLE OF TYPICAL TRANSIENT COMBUSTIBLES			
Definition: Combustible materials brought into an area that are not normally kept in the area	Typical Units	Density Conversion	Net Heat of Combustion BTU/lbm
1. Paper Towels			
2. Cleaning Solvents (Acetone, Mineral spirits)			
3. Radiation Protection Clothing (Paper coveralls, Rubber booties, Gloves, Hats.)			
4. Combustible Scaffolding			
5. Radiation Protection Change Out Areas/Step Off Pad Clothing Bins			
6. Lubricating Oil			
7. Dry Ion Exchange Resins in Cardboard Drums			
8. Wooden Pallets			
9. Cable or Wooden Spools			
10. Paint			
11. Plastic Sheeting			
12. Parts Storage in Combustible Cartons			
13. Rags			

File Ref: WP51\EPRI.II

ATTACHMENT 10.5

Sandia Fire Risk Scoping Study Evaluation

SANDIA FIRE RISK SCOPING STUDY EVALUATION

ATTRIBUTES OF ADEQUATE FIRE PROTECTION PROGRAM

I. SEISMIC/FIRE INTERACTIONS

Seismic/Fire Interactions

1. Seismically Induced Fires:

As part of the seismic assessment walkdown, verify hydrogen or other flammable gas or liquid storage vessels in areas with seismic safe shutdown or safety related equipment are not subject to leakage under seismic conditions. Examples would be improperly anchored hydrogen or oxygen bottles, hydrogen tanks used for primary coolant chemistry control, etc.

2. Seismic Actuation of Fire Suppression Systems:

As part of the seismic assessment, verify that the design of water suppression systems considers the effects, if appropriate, of inadvertent suppression system actuation and discharge on that equipment credited as part of the seismic safe shutdown path in a margins assessment that was not previously reviewed relative to the internal flooding analysis or concerns such as those discussed in NRC I & E Information Notice 83-41.

3. Seismic Degradation of Fire Suppression Systems

As part of the seismic assessment walkdown, verify fire suppression systems have been structurally installed in accordance with good industrial practice and reviewed for seismic considerations such that suppression system piping and components will not fall and damage safe shutdown path components nor is it likely that leaking or cascading of the suppressant will result.

II. FIRE BARRIER QUALIFICATIONS

Fire Barriers

1. Fire barriers and components such as fire dampers, fire penetration seals and fire doors for fire barriers considered in the FIVE Methodology are included in the plant surveillance program.

Fire Doors

2. A fire door inspection and maintenance program.

Penetration Seal Assemblies

3. A penetration seal inspection and surveillance program.

4. Fire barrier penetration seals have been installed and maintained to address concerns such as those identified in NRC Information Notice No. 88-04.

Fire Dampers

5. An inspection and maintenance program for fire dampers.

6. Damper installations address concerns such as those identified in NRC Information Notice No. 89-52, "Potential Fire Damper Operational Problems," dated June 8, 1989 and NRC Information Notice No. 83-69, "Improperly Installed Fire Dampers at Nuclear Power Plants," dated October 21, 1983.

SANDIA FIRE RISK SCOPING STUDY EVALUATION

ATTRIBUTES OF ADEQUATE FIRE PROTECTION PROGRAM

III. MANUAL FIREFIGHTING EFFECTIVENESS

Reporting Fires

1. Appropriate plant personnel knowledgeable in the use of portable fire extinguishers.
2. Portable extinguishers located throughout the plant.
3. A plant procedure for reporting fires in the plant.
4. A plant communication system that includes contact to the control room.

Fire Brigade

1. A fire brigade made up of at least 5 trained people on each shift?
2. The brigade leader and at least two other brigade members on each brigade shift are knowledgeable in plant systems and operations?
3. Each brigade member receives an annual review of physical condition to evaluate his ability to perform fire fighting activities.
4. Minimum equipment provided for the brigade includes the following:
    a. Personal protective equipment such as SCBA, turnout coats, boots, gloves, and hard hats.
    b. Emergency communications equipment.
    c. Portable lights.
    d. Portable ventilation equipment.
    e. Portable extinguishers.

Fire Brigade Training

5. Brigade members receive an initial classroom instruction program consisting of the following:
    a. Review of the plant fire fighting plan and identification of each individual's responsibilities.
    b. Identification of typical fire hazards and associated types of fires that may occur in the plant.
    c. Identification of the location of fire fighting equipment and familiarization with the layout of the plant including access and egress routes.
    d. The proper use of available fire fighting equipment and the correct method of fighting each type of fire. The types of fires covered should include fires in energized electrical equipment, fires in cables and cable trays and fires involving flammable and combustible liquids and gases.
    e. The proper use of communication, lighting, ventilation, and emergency breathing equipment.
    f. Fighting fires inside buildings and confined spaces.
    g. Review of fire fighting strategies and procedures.

SANDIA FIRE RISK SCOPING STUDY EVALUATION

ATTRIBUTES OF ADEQUATE FIRE PROTECTION PROGRAM

Practice

6. Fire brigade members receive hands-on structural fire fighting training at least once per year to provide experience in actual fire extinguishment and the use of emergency breathing apparatus.

Drills

7. Fire brigade drills are performed in the plant so that each fire brigade shift can practice as a team.

8. Drills performed at regular intervals for each shift fire brigade.

9. At least one unannounced fire drill for each shift fire brigade performed per year.

10. At least one drill per year performed on a "backshift" for each shift fire brigade.

11. Drills pre-planned to establish training objectives and critiqued to determine how well the training objectives have been met?

12. At least triennially, an unannounced drill is performed for and critiqued by qualified individuals independent of the liscencee's staff.

13. Pre-fire plans are developed for safety related areas of the plant (as a minimum).

14. The pre-fire plans are updated and used as part of the brigade training.

15. Fire brigade equipment is maintained.

Records

16. Records are provided for each fire brigade member demonstrating the minimum level of training and refresher training has been provided.

IV. TOTAL ENVIRONMENT EQUIPMENT SURVIVAL

Operator Action Effectiveness

1. There are safe shutdown procedures identifying the steps for planned shutdown when necessary in the event of a fire.

2. Operators receive training on these procedures.

3. If in performance of these procedures operators are expected to pass through or perform manual actions in areas that may contain fire or smoke suitable SCBA equipment and other protective equipment are available for operators to perform their function.

V. CONTROL SYSTEMS INTERACTIONS

1. Safe shutdown circuits are physically independent of, or can be isolated from, the control room for a fire in the control room fire area.

ATTACHMENT 10.6

PHASE III

Walkdown Verification Evaluation

FIVE PLANT SCREENING GUIDE
PHASE III
WALKDOWN VERIFICATION CHECK LIST

ITEM	REFERENCE
1.0 INTRODUCTION	
1. Use the following in reviewing the data compiled in the Phase II screening methodology. The guide will provide a list of items to consider when walking down each fire compartment data sheet.	
2. After reviewing the data sheet for a specific fire compartment during the plant walkdown, if any data is found incorrect or missing, the necessary changes should be made on the Phase II data sheets.	Phase III Step 1
2.0 IGNITION SOURCES	
1. Check for any ignition sources in this fire compartment that could significantly change the probability of fire occurrence in this area as compared to the types of ignition sources already listed in the critical screen data sheet.	
2. If there are, on the critical screen data sheet list the new potential ignition sources or delete ignition sources if they no longer exist.	Phase II Step 2
3.0 FIRE PROTECTION SYSTEMS	
1. Review and verify the existence of Fire Protection Systems listed on the critical screen data sheet for this fire compartment. Add or delete to this list as appropriate.	Sandia Study Evaluation Issue II
4.0 FIRE BARRIER QUALIFICATIONS	Def. 2.2
1. For fire areas screened out in Phase I (Table 1): a. Verify the fire barriers, and fire dampers, fire doors and penetration seals for this fire area are being maintained under the plant surveillance and maintenance program (See SANDIA Scoping Study Evaluation).	Def. 2.3
2. Verify that the boundaries identified for this fire area/compartment satisfy the expectations in the critical screen data sheet meaning: a. Fire areas appear to satisfy the definition for fire area and fire area boundaries. b. Fire compartment boundaries satisfy the definition for fire compartment as identified in this methodology. Take into consideration anticipated smoke movement with respect to barriers and openings in the compartment.	

ITEM	REFERENCE
5.0 CRITICAL COMBUSTIBLE LOADING	Phase II Step 4 Table 5 CCDS
1. Fixed Combustibles	
Identify any additional fixed combustibles located in this compartment that are not listed on the critical screen data sheet.	
By visual comparison, the quantities in Table 5 CCDS should appear to represent those which are located in the field.	Sandia Study Evaluation Issue I
Identify any flammable liquid or gas storage vessels (e.g. H_2)? and whether these vessels are subject to leakage under seismic conditions?	
List this information in Table 5 of the critical combustible data sheet and verify the response to issue 1.3 of the Sandia Scoping Study Evaluation.	
2. Expected Maximum Transient Combustibles	Phase II Step 4 Table 5 CCDS
Review the types of operations that are expected in this area/compartment. Identify any expected transient combustibles in the area that were not considered in the critical screen data sheet.	
By visual comparison, the estimated quantities listed in the critical screen should data sheet appear to be appropriate for the operations in this compartment.	
Verify the approximate distance between fire sources and targets is correct.	Attachment 10.4
Revise the numbers estimated as appropriate on the critical screen data sheet.	
6.0 VERIFY FIRE HAZARDS EVALUATION WORKSHEET INPUTS (See Blank Worksheet)	
1. Worst Case Height of Target above Fire Source	
a. Closest to floor for Plume Scenario	
b. Closest to ceiling for Hot Gas Layer Scenario	
2. Types of Combustibles and associated Heat Release Rates	
3. Fire Location Factor	
4. Compartment boundaries and construction	

Enclosure 2

DRAFT RESPONSE TO NRC COMMENTS ON NUMARC/EPRI FIRE VULNERABILITY EVALUATION (FIVE) METHODOLOGY

1. Successive Screening Criteria

Comment: The staff believes that the successive-screening approach in FIVE methodology can be viable approach for accomplishing the objectives of the fire IPEEE. The screening method has been structured such that it has taken advantage of past PRA insights. It is important, however, that the guidance should provide documentation and traceability requirements.

Response: We agree with the recommendation. A section on documentation has been added in Phase III.

2. Screening Criterion

Comment: The choice of 1E-6 per year frequency as the screening criterion is considered acceptable. The Staff recognizes that for the purposes of identifying fire vulnerabilities, the 1E-6 range is about as low as the methodology can support well. Nevertheless, it is important to recognize that systems, components, and procedures could contribute to many sequences and result in a substantial cumulative effect. Screening procedures should consider the potential cumulative effect of dominant contributors, and uncertainties.

Response: The comment is phrased in terms of a PRA analysis. The FIVE methodology does not identify "sequences" leading to core melt and therefore cannot identify such cumulative effects. The same comment applies to uncertainties. FIVE is not meant to be a PRA. Nevertheless, we consider the threshold value of 1E-6 per year to be already conservative for several reasons. First, it is implicitly assumed in the FIVE methodology that losing a safe shutdown component or system will lead to a core melt event. In practice, it is not likely the conditional probability of core melt would have a value of unity. Second, the fire modeling techniques employed in FIVE assume instantaneous fire growth to the maximum heat release rate. Therefore, the lack of treatment of uncertainties or cumulative effects should not be considered shortcomings.

3. Reliance on Appendix R-Type Compliance and Documentation

Comment: The utilities' attempt to reduce the cost of the IPEEE analyses by utilizing Appendix R documentation is judged to be acceptable, not only because their own in-house staff will be familiar with this documentation but also because it is an excellent starting point for any follow-on analysis.

However, it is very important that the methodology guidance strongly exhort the analysts to check or validate this prior requirements will usually be acceptable to prevent fire spreading, but occasionally it won't be.

Also, the plant must be analyzed "as is". For IPEEE purposes, an exemption to the NRC regulations does not constitute an exemption to the IPEEE and the "as built" condition must be modeled in the analysis.

Response: We agree with the comment that the plant must be analyzed "as is". A statement clarifying this point has been added at the end of Section 1.0 and Section 4.1.

4. **Screening Approach for Non-Fire-Affected Function/Systems**

Comment: In the proposed system screening in FIVE, a fire area can be screened out if two independent means of achieving safe shutdown can be shown to exist assuming that the postulated fire will damage everything within its own area. This is not acceptable. With today's understanding of system behavior, mostly derived from PRA studies, potentially important scenarios exist that would be screened out using the proposed approach. The PRA literature has several examples of sequences of this type with frequencies much higher than 1E-6 per year. The reliability and the availability of the two independent means of safe shutdown alternatives must be assessed rather than assuming it was adequate. An unavailability of the two systems, taken together, of 1E-6 per year is the logical choice, given the NRC's reporting criterion.

An approach suggested by Dr. R. Budnitz during the meeting of August 16, 1990 is a reasonable alternative. The suggested approach is to use the models and frequency numbers acquired from the internal events IPE as the method for determining whether the rest of the plant, outside the fire damaged area, can adequately bring the plant to a safe shutdown. The principle advantages are that (1) the use of the IPE is more rigorous and thorough than the use of an arbitrary deterministic criterion such as the two-separate-systems criterion; (2) in most cases, the models and data should be readily available; and (3) decision-making about what to fix, if anything, can be more rational if the insights from the IPE are available. (It should be noted, however, that in cases involving the remote shutdown panel, explicit quantification may be necessary if not performed as part of the IPE.)

If a potential vulnerability were to be identified by this process, it would involve fire-caused and non-fire-caused failures together. Such accident sequences can be fixed either by addressing the fire aspect, or the non-fire aspect, or both. Surely the broader perspective can be of great benefit to decision-makers.

Response: We have elected to delete the step from Phase I (Section 5.3) that allowed the screening out of an area if two other independent means of achieving safe shutdown existed. While the approach suggested by Dr. Budnitz is appealing, investigation revealed the necessary quantifications would unduly complicate what was intended to be a quick, qualitative screening process. Although we consider the suggestion impractical relative to the intent and structure of the Phase I screening, the use of IPE models and frequency values may very well enter into a plant-specific decision-making process when evaluating potential vulnerabilities identified during Phase II.

5. Fire Fighter Effectiveness

Comment: The guidance (page 41) on determining the time required for manual firefighters to arrive at and to control a fire is difficult to follow, and seems to have errors. It is important that the analyst be told that the relevant elapsed time is the time from fire initiation until the fire is controlled.

Also, the current text is confusing about how to determine from "data" the likelihood that firefighters can reach a given area before the fire has spread. The section describing use of drill data is particularly hard to understand. The guidance should be made much more explicit here, including a warning about difficulties in using or combining surprise-drill, planned-drill, and other information. The impact of heat and smoke on manual firefighting effectiveness, the fire fighter preparation time, and the time needed to locate the fire in a smoke filled environment should all be considered (page 42).

Response: We agree that the relevant elapsed time is the time from fire initiation until fire is controlled. The proposed method is, however, conservative because we assume virtually no fire growth time (the fire is assumed to have reached its maximum intensity instantaneously.)

A clarification has been added to confirm that the response time (t_r) should include both the time to arrive on the scene and the time to control the fire. Determining this response time is, however, a difficult issue which has not been completely resolved. Past PRAs, including the fire PRA proposed in NUREG-1150 do not provide useful guidance. The best available plant specific "data" would be from drills. We recognize that this data is not perfect but it is better than no data. We do not believe, on the basis of discussions with fire protection specialists, that there is a significant difference between "unannounced" drills and other drills. Fire brigades are usually composed of personnel who have other duties at the plant. When a drill is initiated they would still have to dress into their protective clothing and assemble their gear. The time difference between unannounced drills and anticipated drills seems minor relative to the time to assemble, don protective gear and set up at the scene of the postulated fire. We have emphasized the value of the former in the revised text, but are reluctant to ignore information provided by the latter.

Finally, we agree with the comment that - in principle - the impact of heat, smoke and the time needed to locate the fire in a smoke-filled environment should be considered, but are not aware of a good, objective way to do it. The IPEEE is recognized by both Staff and industry not to be the vehicle for advancing the state-of-the-art. We have, therefore, provided a clear indication of these concerns in the text and exhorted the analyst to provide a conservative estimate of the fire brigade effectiveness which qualitatively includes these aspects in establishing brigade response.

6. **Non-thermal Effects**

Comment: There is no methodology that could be used today for assessing, with any degree of reliability, the non-thermal effects of fires, such as from spreading smoke. The quantitative analysis of such effects is not feasible today, and indeed the insights available on a qualitative level are not very robust.

Nevertheless, the existence of such potential effects is something that can often be identified by the analyst. It is prudent that the guidance provide instructions to identify such situations, even though the analysis of their effects cannot be done. This identification will assist decision-makers, either in the utility or in NRC, who may be faced with determining which of several available remedies might best improve the plant's resilience against fires.

Response: We agree with the comment that non-thermal effects are impossible to analyze with today's technology. The best that can be done is to alert analysts to incorporate their best judgement in analyzing potential operator actions where smoke might be present. Section 4.2.2 has been revised to include this point.

7. Thermal Ignition Threshold for Cables

Comment: 700-degree F is cited as a threshold for cable damage (page 31). This value is appropriate for certain type cables, however, there is no discussion about the thresholds for other electrical components, such as integrated circuitry and components using integrated circuits, penetration seals or other types of cables. The use of a single cable damage threshold across the board sounds inappropriate considering that some cables are qualified and other are not.

Response: The use of a single threshold for electrical equipment is consistent with past fire PRA practice. All fire PRAs that we have surveyed provide similar guidance in this respect. Should Staff be aware of other suitable data, we would consider it and, if appropriate, incorporate it into the methodology as an additional table.

8. Self-Ignited Cable Fires

Comment: There seems to be some inconsistency with regard to self-ignited cable fires. On page 30, it is stated that self-ignited cable fires can be ignored. However, Reference Table 1.2 of Attachment 10.3 specifically identified cables as potential fire ignition sources for several plant areas, implying that some analysis is needed.

The Staff believes that self-ignited cable fires can be ignored for plants which can verify that all cables in a given area are certified IEEE-383 low flame spread cables because testing has demonstrated that self-induced fires in such cables are not likely to spread beyond the tray of origin. However, plants which cannot verify the presence of only certified cables should consider the impact of self-induced fires as stated in Reference Table 1.2 of Attachment 10.3.

Response: Reference Table 1.2 of Attachment 10.3 includes cables as an entry to be complete. The data indicates a likelihood of initiation of a self-ignited cable fire on the order of 6E-3 per reactor year. Yet, when considering the weighting factor for cable in a given fire compartment, which is the cable insulation weight for the particular compartment being evaluated divided by the total cable insulation in Appendix R fire areas, excluding the cables in the turbine building and containment, the weighting factor is on the order of five percent or less. The resulting frequency of self-ignited cable fires for any given area is well below that of other sources. Therefore, development of a procedure for self-ignited cables, whether they are certified or not, is unwarranted. This assumption is consistent with all fire PRAs surveyed to date.

9. **Fire Initiation Data**

Comment: A fire-initiation database is being developed by EPRI. The EPRI database should be presented in terms of means values. Also, since the Sandia fire events database was utilized as the base in the development of the EPRI database, it should be referenced. The Staff believes that it is a good idea to develop such a common database, and that after it is reviewed, its use will result in great economies for the implementing utilities.

The exclusion of fire events from the database, because they occurred during construction or pre-operation phases may be reasonable, but the rationale or criterion for omission should be explicitly stated in the methodology document.

Foreign plant fire events, such as occurred in Taiwan and Spain, should be examined to determine whether the insights are relevant for consideration in the fire IPEEE.

Response: We agree to present the data in terms of mean values and we have referenced the very significant contribution by Sandia to this database.

We would be pleased to present to the Staff our rationale and criterion for excluding fire events that have occurred during construction or preoperation, but we do not feel that this discussion belongs in the FIVE report.

Finally, given limited resources and time we did not pursue examination of foreign fire events. Experience has taught us that it takes quite a bit of effort to understand such an event, even when it occurred at a domestic plant. Obtaining information from operators in foreign countries, determining whether differences in design, maintenance or operation procedures could make this fire possible in the United States, identifying the impact of different regulations, or the lack thereof, in these foreign plants makes the task very difficult, expensive and at times, frustrating. We believe that NRC Information Notices are the appropriate vehicle for informing the utilities of any special consideration related to these issues.

10. **Seismic/Fire Interactions**

Comment: This issue needs careful attention. There are three principal concerns: seismically induced fires, seismic actuation of detection and suppression systems, and seismic degradation of detection and suppression system. The lack of significant seismic experience in the nuclear industry does not negate the potential risk. In the non-nuclear industry, significant experience of this type has been demonstrated. The Staff believes that a carefully planned walkdown of the plant is the way to collect relevant information to address this issue. Hence, the guidance provided in the FIVE methodology (page 56) should be expanded to take this issue into account. However, if one wants to address this issue from a design point of view, the option is always open.

Response: A recent study of the available database, EPRI Report NP-6989, "Survey of Earthquake-Induced Fires in Electric Power and Industrial Facilities," clearly indicates that the concern with seismic/fire interactions in nuclear power plants is overly estimated. There is little evidence to suggest that a seismic event could cause a serious fire or could cause fire equipment to initiate a transient that would challenge the ability of the plant staff to achieve safe shutdown. Nevertheless, the methodology calls for an evaluation of this issue along the lines proposed by the Fire Risk Scoping Study (see Section 7.2 and Attachment 10.5 of the FIVE report). It is expected that this explicit evaluation should be more than adequate to highlight any potential vulnerability associated with this issue.

11. **Transient Combustibles**

Comment: The method of determining the frequency of critical combustibles and inspection for such combustibles, requires clarification. Also, the method for calculating the fraction of transient combustibles uncovered should account for the relative size of the transient combustibles in an exposed state.

"The probability of having a critical transient combustible fire exposure in the compartment ..." (page 44) should read "The probability of having a critical transient combustible fire exposure that is not suppressed in the compartment ..."

Response: Following discussions with the Staff during our August 16 meeting, the frequency of inspection for transient combustibles has been revised. It will be limited to the highest periodical inspection directly related to fire protection or transient combustible housekeeping (i.e. if there are weekly and monthly inspections, the monthly inspections will be ignored for the purpose of evaluating F_v; similarly, if there are daily general inspections and weekly inspections related to transient combustibles, the daily inspections will be ignored because they are not specifically directed to transient combustibles). These points have been included in Section 6.3.7.2, Step 3.8.

The size of transient combustibles in an exposed state is taken into account in determining F_{cct} (Step 3.7) but not in determining the probability of combustibles being exposed (the parameter p). If any, the procedure for evaluating p is conservative since it is much less likely to find a critical amount of combustible in an exposed state than a subcritical amount.

Finally, the word "unsuppressed" has been added in the definition of P_{tc} (Section 6.3.7.2, Item 4).

12. Phase III Walkdown

Comment: The Phase III walkdown should include a check of things possibly missed or wrong assumptions used in the earlier Phase I and II analyses. Another important aspect of the plant walkdown is confirmation of the adequacy of fire barriers. The walkdown should check for missing or degraded penetration seals, open conduits which could transmit water to various locations, damaged fire doors and dampers, etc. Credit should not be given for barriers that have not been confirmed as-built, as operated. The walkdown process used to confirm that the barriers represent the as-built, as-operated configuration should be described as part of the submittal. Some statements should be added to reflect these objectives and provide specific guidance.

Response: We agree with the Staff on the objective of Phase III, i.e. checking for things possibly missed or wrong assumptions used in the earlier phases. The statement at the beginning of Section 8 provides direction consistent with the Staff comment. We disagree that the FIVE walkdown should also check for degraded fire barriers. This type of walkdown (surveillance) is performed under existing regulations. It would be inappropriate to ask a utility to duplicate that activity under the IPEEE. Similarly, the documentation regarding the status of these fire barriers is maintained as part of the existing regulations and need not be duplicated.

13. Hydrogen Fires

Comment: Hydrogen fires from turbine-generator hydrogen cooling systems should be included in the "turbine" fires listed under turbine building.

Response: Agreed, Reference Table 1.2 has been modified accordingly.

14. Plant Demonstration

Comment: The plant demonstrations should provide a way to assess the validity of the "look up tables" to be used in the FIVE methodology. This can be accomplished by applying both the look up tables and COMPBRN computer code to assess the degree of agreement between them.

Response: We do not agree that the plant demonstration is the best way to demonstrate the validity of the "look-up tables", because a comparison with COMPBRN in the absence of experimental data would be inconclusive. Instead, we intend, to perform a comparison of the look-up tables against the Underwriters Laboratory/Sandia National Laboratory (SNL) and the Factory Mutual/SNL data. The results should be more meaningful in terms of establishing conservatism and biases. These results will be documented and presented to the Staff as they become available.

15. **Secondary Fuel Sources**

Comment: In developing the look up tables, the treatment of secondary fuel sources (i.e., heat released from initial fire source causes a combustible material at a second location to burn, which in turn adds sufficient heat to the overall fire to cause the environmental temperature at the target material to exceed its limits) is not clearly described.

Response: Secondary fire sources are taken into account in Section 6.3.3 (Point Source Fires). An example of how to apply the methodology is provided in Attachment 10.4 - Example 7 (page 27). We believe that the approach is clearly described, but we would welcome any specific suggestion for improving this description.

16. Submittal Documentation

Comment: Include guidance on the documentation of assumptions and the results of the analysis. Use NUREG-1407 as a baseline to identify documentation needs.

Response: Please see response to Comment i.

17. Initial Screening

Comment: The methodology states that plant areas where a fire cannot create a fire initiated event or cause the loss of safe shutdown functions will be screened from further evaluation (page 8).

The documentation defines a fire initiated event as one that requires a plant trip. This could result from fire induced system interactions impacting balance of plant (BOP) components, or operator response (manual trip) in response to spurious instrument readings or the fire itself. The methodology appears to focus on safe shutdown components only, and these by themselves may not result in a plant trip or fire initiated event as defined by FIVE. Fires that result in damage to safe shutdown components should not be screened out because they fail to generate a reactor trip but rather should be carefully evaluated and documented in tier II.

Response: The Staff concern is not clear to us. The impact of equipment unavailability caused by fire or otherwise is already analyzed under the internal events IPE. Only if the fire which causes the unavailability of the equipment also causes a plant trip does it become a matter for consideration in the fire-induced vulnerability evaluation. Let's consider two types of fires:

1) Fires that may result in a plant trip (automatic or a delayed manual shutdown).

2) Fires that may damage safe shutdown equipment that is not safety-related (e.g. a fire pump or certain charging pumps) and does not cause a plant trip/shutdown.

Under normal operating conditions, placing non-safety related equipment out-of-service (e.g. for maintenance or repair) would not result in plant shutdown. We believe that - from a risk standpoint - the cause of the unavailability of this type of equipment (i.e., whether or not it is related to a fire) would not alter the consequences. Thus, a fire of type 2 above should be treated as a typical unavailability of this particular equipment, and this is already taken into account in the IPE. Hence, there is no need to repeat the analysis here. However, we reiterate that if the operator believes there is any chance to shutdown or trip the plant as a result of the fire, then the compartment cannot be screened out without further analysis. This point is now clarified in Section 4.2.1.

18. Non-Appendix R Systems

Comment: "Non-Appendix R" systems should not only meet the independence criteria, but should include procedures for use, and should be included in a training program. Qualification of the availability of "non-Appendix R" systems will also have to be provided.

Response: We believe this comment was meant to address two different facets of the FIVE methodology: (1) crediting alternative systems for achieving safe shutdown in lieu of the damaged safe shutdown train, as part of the Phase I screening process, and (2) crediting alternative systems as a means of resolving potential fire vulnerabilities. With our deletion of the step suggesting credit for alternative systems as part of the Phase I screening process (see response to Comment 4), no amplifying remarks in response to the above comment were necessary for Section 5.3. Regarding the second facet, Section 6.3.8, Item i, has been added that suggests the analyst consider the need to improve the reliability of alternative trains via procedures or training.

19. Generic Fire Database

Comment: We propose in the FIVE report that the Generic Fire Data Base Reference Tables be used directly for implementation of the fire IPEEE (page 23). The Staff believes that only in cases where plant specific data are not available should generic data be used. An attempt should always be made to improve the applicability of generic data to plant specific cases through consideration of past operating experience.

Response: The application of a plant-specific database can be very misleading. Past experience may not reflect future trends. A given plant may have had repeated problems with a particular electrical component (i.e., a switchgear) and, after performing a root-cause analysis, decides to change all components of the same type. What would be, under these conditions, the value of the plant-specific data? For example, consider the case of 40 year-old man who has had an appendicitis. The "plant specific" approach would assume that man has a probability of 1/40 to get a second appendicitis before his 41st birthday - clearly an incorrect conclusion. On the other hand, if one takes a sample of 100 men who are 40 years old and determine that 2 have had appendicitis, then one can make the reasonable guess that 2/4000 men may have the surgery within the next year.

Secondly, it is highly desirable to start from a comprehensive database, with adequate sampling size, that represents average trends and that therefore has a much higher likelihood to represent future trends. The larger sample size has the added benefit of providing statistically more robust values with less uncertainty than that provided by a sample of sparse data from any given plant. In other words, the sampling basis of a single plant may be inadequate and could be highly misleading.

The above argument not withstanding, we believe it is incorrect to suggest the FIVE methodology simply applies generic data directly. As discussed in Section 6.3.1.2, fire initiator frequencies are developed for fire areas based upon the generic data and enumeration of the plant-specific components considered to be potential fire ignition sources that are present in a given fire compartment. This allows one to calculate a likelihood of fire initiation that reflects both the broader industry experience regarding fires and the plant-specific collection of ignition sources in a given location. The FIVE methodology does what the Staff suggests; that is "improve the applicability of generic data to plant specific cases."

20. Critical Distance

Comment: The "10 Kw/m-squared or more," should read "10 Kw/m-squared or less." (page 37).

Response: We agree that there is an ambiguity, depending on how one reads the sentence. The sentence has been changed to clarify the intent (the sentence now reads: "If the exposure fire is located beyond the critical distance, such that the target will see a heat flux less than 10 Kw/m-squared, then no damage is considered to occur".)

21. Comment: **Page 46, Item C is Not Understandable**

Response: Agreed. We have simply eliminated this paragraph. It does not, in practice, serve any purpose.

22. Availability of the Alternate Shutdown System(s)

Comment: Although it is not mentioned, increasing the availability of the alternate shutdown system(s) is an important approach to reducing fire induced core damage frequency (page 48). Add "increase reliability of alternative train via procedures or training" as another examples of possible changes to consider to address a vulnerability (p.49).

Response: We agree with the comment. Section 6.3.8 has been altered accordingly.

23. Removing Conservatism

Comment: Page 49 state that: "A third approach is to further evaluate the subject fire compartment by removing conservatism of the Phase II screening method." Conservatism was not defined, nor is guidance provided on how to remove the conservatism.

Response: We agree with the comment. "removing conservatism" has now been deleted and replaced with: "With more detailed analysis of the fire growth and propagation, and/or unavailabilities associated with the different factors of this methodology."

24. Containment Performance

Comment: The containment needs to be assessed to determine if sequences different from those obtained in the internal event analyses are predicted. If they are, the internal event analyses provide the containment insights. If different sequences are predicted, a containment analysis, of the type done for the internal event analysis, is required.

Response: The intent of the Staff comment, as it relates to FIVE, is not totally clear. It appears to be oriented toward one performing a fire PRA. From the meeting on August 16, 1990, we believe the Staff agreed with our position that containment performance be assessed only if warranted. With regard to the FIVE methodology, if a utility is able to demonstrate for a fire in a particular area the likelihood of not achieving safe shutdown is less than the threshold value of 1E-6 per year, then there is no need to assess containment performance. That aspect of FIVE remains unchanged.

However, the Staff's comment seems to request identification of situations in which the likelihood of not achieving safe shutdown is greater than the threshold criteria and the plant damage state and remaining operable equipment may not have been previously analyzed as part of the internal events analysis. Thus, the last paragraph of Section 6.3.9 has been amended to include the following: "In particular, fires leading to the potential loss of safe shutdown function above the threshold value of 1E-6 per year and having plant damage states and minimum operable equipment not included in the IPE, should be flagged for further containment analysis evaluation."

25. Attachment 10.5

Comment: Page 52 states that: "Attachment 10.5 provides a list of typical plant attributes that would satisfy the NRC's concerns regarding these issues (page 52)". This statement should be removed or clarified as to how this list would satisfy NRC's concerns or resolve issues stemming from the Fire Risk Scoping Study.

Response: Agreed.

26. Fire Protection Systems

Comment: The assumption is made that fire protection systems (FPS) are designed and installed "correctly". Even if FPSs are installed according to vendor's specifications they are still subject to failures and inadvertent actuation that may result in damage to equipment important to safety in more than one fire area and/or in more than one train at a time.

The plant walkdown should include guidance for spotting design and maintenance deficiencies that would allow the identification of potential problems such as not sealed conduits, floor/wall openings, etc.

Response: Existing procedures and regulations already call for this type of review. We believe that a utility should simply need to document the existence of these reviews as opposed to duplicating them as part of the IPEEE. Should a utility identify areas or components not previously evaluated, the methodology directs that one be performed. An example is that contained under Item 2 of the Seismic/Fire Interactions discussion on Page 53 of the FIVE report.

27. Availability of Safety Systems

Comment: Page 14 states: "This [phase 1 method] assumes that any safe shutdown component within the fire area of concern could be damaged, the normal (Appendix R) alternative or redundant component or system is unavailable for some reason other than the fire. and yet at least one additional Appendix R system or mitigating system will be available at the same time that could replace the function of the safe shutdown component assumed lost in the fire. The fire area can then be screened from further evaluation (page 14)."

Quantification of the availability of a third system following the unavailability of the second system, should be performed and used to justify the screening process. No credit should be given for alternate shutdown methods that do not contain procedures, or operator training.

Response: Please see response to Comment 4.

28. Browns Ferry Fire

Comment: The Staff is concerned that the inspection table proposed in the FIVE methodology does not include a place for the Browns Ferry type fire.

Response: The table has been revised and now provides an entry for the Browns-Ferry fire.