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MILLER,C.L. Project Directorate I-2

See Rpts

SUBJECT: Forwards Vols 1 & 2 of rept NE-94-001, "SSES Individual Plant Exam for External Events (IPEEE)," in response to GL 88-20.IPEEE addresses generic regulatory issues USI A-45 & GI 57.

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Director of Nuclear Reactor Regulation
Attention: Mr. C.L. Miller, Project Director
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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

**SUSQUEHANNA STEAM ELECTRIC STATION**
**SUBMITTAL OF THE IPEEE REPORT**
**PLA-4162 FILES R41-2/R41-1D**

**Docket Nos. 50-387**
**and 50-388**

Dear Mr. Miller:

*References:*

1. *Letter, PLA-3280, H.W. Keiser to W.R. Butler, "Proposed Response to Generic Letter 88-20, Individual Plant Examinations," dated October 26, 1989.*
2. *Letter, PLA-3073, H.W. Keiser to C.L. Miller, "Proposed Program for Completion of IPEEE," dated December 20, 1991.*

Enclosed with this letter is PP&L's response to NRC's Generic Letter 88-20, Supplement 4 requesting an Individual Plant Examination for External Events (IPEEE). Our response is documented in a two volume report entitled "Susquehanna Steam Electric Station Individual Plant Examination For External Events", NE-94-001, dated June, 1994. Overall, the IPEEE effort confirms that Susquehanna SES is well designed and capable of withstanding severe external challenges. The physical condition and cleanliness of the plant were found to be good.

The major result of the fire PRA is that defense-in-depth exists for all fires without credit for Thermo-Lag or other type of fire wrap. That is, multiple equipment remains operable for successful core and containment defense from any realistic fire in Susquehanna SES even if all fire wrap is removed. Adequate separation and barriers between different divisions of safety equipment is verified.

The screening approach used in analysis of high winds, external floods, and nearby facilities/transportation accidents shows adequate defense against these threats. No weaknesses or plant modifications were identified by this analysis.

Only one seismic observation was found to be significant enough to require immediate action and it has been corrected.



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The IPEEE report content and format reflects the guidance of NUREG-1407. The risk assessment process utilized to generate the report considered the objectives delineated in Supplement 4 to Generic Letter 88-20: appreciation of severe accident behavior, understanding of the likely event sequences, qualitative understanding of the likelihood of core damage and radioactivity release, and search for cost beneficial risk reduction modifications.

The IPEEE report represents a part of a continuing process of risk evaluation and reduction for Susquehanna Steam Electric Station. PP&L has been active in addressing severe accident issues since the early 1980s. Our first IPE of the Susquehanna Station was completed in 1986. Later a set of defense-in-depth criteria was developed for judging our protection against severe accidents. PP&L's IPE for internal events submitted in response to Generic Letter 88-20 (PLA-3696, dated December 13, 1991) utilized these criteria, and they are also utilized with the IPEEE.

The IPEEE addresses two generic regulatory issues: USI A-45, "Shutdown Decay Heat Removal Requirements" and GI 57, "Effects of Fire Protection System Actuation on Safety-Related Equipment". Defense-in-depth of decay heat removal is demonstrated by the IPEEE and USI A-45 is considered to be satisfactorily resolved. Final resolution of GI-57 for SSES is dependent on the outcome of ongoing analysis of four identified potential equipment impacts from fire protection system water spray. Details regarding this issue are provided in Section 8 of the report.

PP&L believes our IPE and IPEEE work satisfies, and in certain areas, exceeds the requests contained in Generic Letter 88-20. The performance of the IPEEE completes our initial comprehensive assessment of severe accident sequences during power operation and their effect on nuclear safety at Susquehanna SES. We plan to continue our assessments, particularly with respect to application recommendations and modifications. We anticipate applying the process used to conduct these evaluations to our overall program of risk management at Susquehanna SES.

We look forward to the NRC staff's review. Should you have any questions, please contact Mr. W.W. Williams at 610-774-5610.

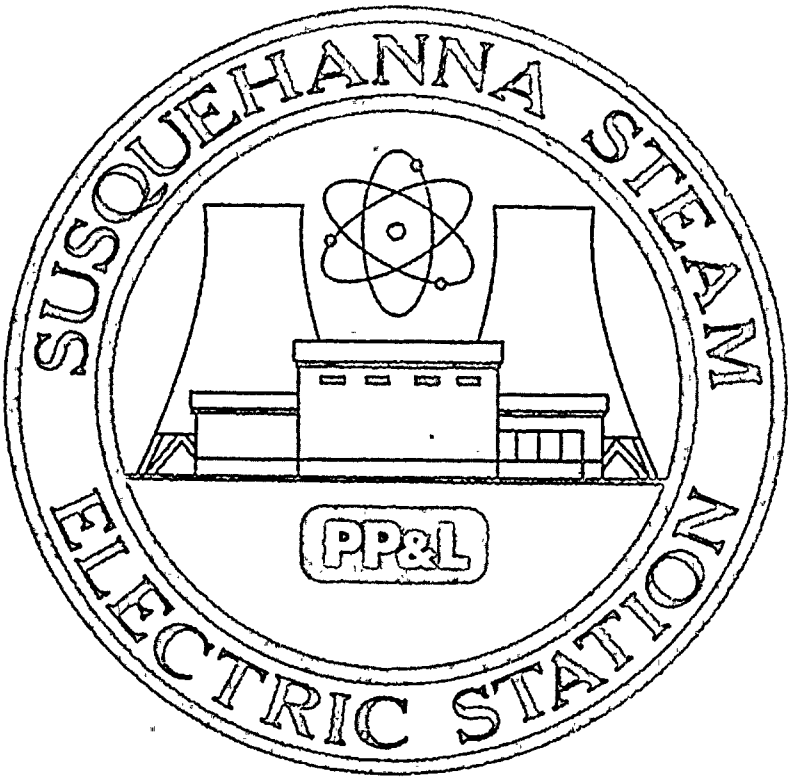
Very truly yours,

R. G. Byram

Attachment

cc: NRC Document Control Desk (original)
NRC Region I
Mr. G. S. Barber, Sr. Resident Inspector - SSES
Mr. C. Poslusny, Jr., Sr. Project Manager - Rockville

# Susquehanna Steam Electric Station Individual Plant Examination for External Events




## Volume 2

**Pennsylvania Power & Light Company**

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Susquehanna Steam Electric Station
Individual Plant Examination of External Events
(IPEEE)

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## List of Acronyms

| | |
|---|---|
| AC | Alternating Current |
| ADS | Automatic Depressurization System |
| AOT | Allowed Outage Time |
| ARCDMS | Appendix R Cable Data Management System |
| ARI | Alternate Rod Insertion. A redundant system for venting the scram air header |
| ATTAC | A computer code used to calculate power in natural circulation ATWS |
| ATWS | Anticipated Transient Without Scram. In this IPE the definition is expanded to include all failures to scram on demand |
| BAF | Bottom of active fuel |
| BNL | Brookhaven National Laboratory |
| BWR | Boiling Water Reactor |
| BWROG | Boiling Water Reactor Owner's Group |
| BWRSAR | The BWR Severe Accident Response computer code used for analyzing BWR fuel and in-vessel transient response |
| BWR-4 | A BWR design of approximately 50 kw/l using HPCI, LPCI and LPCS in the ECCS network with RCIC for normal high pressure shutdown makeup |
| CARTS | Cable and Raceway Tracking System |
| CD | Core Damage |
| CDFM | Conservative Deterministic Failure Margin Approach for defining HCLPF |
| CIF | Containment Isolation Failure |
| CIG | Containment Instrument Gas |
| COMPBRN IIIe | Computer code for compartment fire modeling |
| COPF | Containment Overpressure Failure |
| COTF | Containment Overtemperature Failure |
| COTTAP | The Compartment Transient Temperature Analysis Program used to calculate building compartment temperature transients |

| | |
|---|---|
| CRD | Control Rod Drive |
| CS | Core Spray |
| CSHVAC | Control Structure HVAC |
| CWS | Circulating Water System |
| DC | Direct Current |
| DG | Diesel Generator |
| DHR | Decay Heat Removal |
| DID | PP&L "Defense-in-Depth" Criteria (Table 2.1) |
| ECCS | Emergency Core Cooling System |
| EDR | Engineering Deficiency Report |
| EOP | Emergency Operating Procedure |
| EPG | Emergency Procedures Guideline |
| EPRI | Electric Power Research Institute |
| EQ | Environmental Qualification |
| ESW | Emergency Service Water (system) |
| ETTE | Event Tree Top Event |
| FEDB | Fire Events Data Base |
| FIVE | Fire Induced Vulnerability Evaluation methodology developed by EPRI |
| FFT | Functional Fault Tree |
| FMEA | Failure Mode Effects Analysis |
| FPRR | Fire Protection Review Report |
| FPS | Fire Protection System |
| FRSS | Fire Risk Scoping Study, NUREG-5088 |
| FSAR | Final Safety Analysis Report |
| FZ | Fire Zone |
| GE | General Electric Company |

| | |
|---|---|
| GI | Generic Issue |
| GL | Generic Letter |
| HCLPF | High Confidence of Low Probability of Failure ground acceleration below which equipment is expected to survive |
| HCTL | Heat Capacity Temperature Limit (for avoidance of severe dynamic loads in the suppression pool from SRV operation) |
| HCU | Hydraulic Control Unit |
| HPCI | High Pressure Coolant Injection |
| HPI | High pressure injection (includes all high pressure makeup systems which can contribute adequate core cooling) |
| HPM | High Pressure Makeup to the Reactor Vessel |
| HSD | Hot Shutdown |
| HVAC | Heating, Ventilating, and Air conditioning |
| IA | Instrument Air |
| IDCOR | Industry Degraded Core (An AIF sponsored committee to address degraded core rule making) |
| INEL | Idaho Nuclear Engineering Laboratory |
| IORV | Inadvertently opened relief valve. (Assumed to remain open.) |
| IPE | Individual Plant Evaluation |
| IPEEE | Individual Plant Examination for External Events |
| LCO | Limiting Condition of Operation (Technical Specifications) or limit cycle operation (ATWS) |
| LOCA | Loss of Coolant Accident |
| LOOP | Loss of Offsite Power |
| LPCI | Low Pressure Coolant Injection |
| LPCS | Low Pressure Core Spray |
| LPECCS | Low Pressure ECCS. (LPCI and LPCS) |
| LPM | Low Pressure Makeup to the Reactor Vessel |
| LWR | Liquid Radwaste |

| | |
|---|---|
| L1 | Vessel Water Level 1 (32 inches above TAF) |
| L2 | Vessel Water Level 2 (123 inches above TAF) |
| L3 | Vessel Water Level 3 (174 inches above TAF) |
| MAAP | The Modular Accident Analysis Program used for analyzing BWR core, vessel and containment transient response |
| MARK II | The second generation pressure suppression containment system for GE BWRs |
| MCC | Motor Control Center |
| MG | Motor-Generator |
| MSIV | Main Steam Isolation Valve |
| MSIV-LCS | MSIV Leakage Control System |
| MSS | Main Steam System |
| NEP | Non-Exceedance Probability |
| NSAC | Nuclear Safety Analysis Center of EPRI |
| NSSS | Nuclear Steam Supply System |
| NUS | The Nuclear Utility Services Company |
| NWL | Normal water level (191 inches above TAF) |
| OBE | Operating Basis Earthquake |
| OL | Operating License |
| ORNL | Oak Ridge National Laboratory |
| P&ID | Piping and instrumentation diagram |
| PCIS | Primary Containment Isolation System |
| PCS | Power conversion system |
| PGCC | Power Generation Control Complex |
| PJM | Pennsylvania, New Jersey, Maryland power pool |
| PMF | Probable Maximum Flood |
| PP&L | Pennsylvania Power & Light Company |

| | |
|---|---|
| PRA | Probabilistic Risk Assessment |
| PRAISE | The Piping Reliability Analysis Including Seismic Events computer code used to calculate the frequency of LOCA events |
| PRAC | The Probabilistic Risk Analysis Code used to perform probabilistic systems analyses |
| PWR | Pressurized Water Reactor |
| RB | Reactor building |
| RBCCW | Reactor Building Closed Cooling Water |
| RCIC | Reactor Core Isolation Cooling |
| RETRAN | A computer code used to perform neutronic and thermal-hydraulic plant transient analysis |
| RHR | Residual Heat Removal |
| RHRSW(S) | RHR Service Water (System) |
| RLE | Review Level Earthquake defined in GL 88-20, Supplement 4 (Same as SME) |
| RPS | Reactor Protection System |
| RPV | Reactor Pressure Vessel |
| RRS | Reactor Recirculation System |
| RSCS | Rod Sequence Control System |
| RSP | Remote Shutdown Panel |
| RWM | Rod Worth Minimizer |
| RWCU | Reactor Water Cleanup |
| SA | Service Air |
| SABRE | A computer code used to perform reactor stability analysis |
| SNL | Sandia National Laboratory |
| SBLOCA | Small Break LOCA |
| SBO | Station Blackout |
| SDCM | Shutdown Cooling Mode (of RHR) |
| SDV | Scram Discharge Volume |

| | |
|---|---|
| SGTS | Standby Gas Treatment System |
| SI | System interaction |
| SIMULATE | A computer code used for steady-state 3-dimensional core simulation |
| SJAE | Steam Jet Air Ejector |
| SLCS | Standby Liquid Control System |
| SMA | Seismic Margins Analysis |
| SME | Seismic Margins Earthquake (Same as RLE) |
| SNL | Sandia National Laboratory |
| SOOR | Significant Operating Occurrence Report |
| SORV | Stuck open relief valve |
| SPCM | Suppression Pool Cooling Mode (of RHR) |
| SQRT | Seismic Qualification Review Team program used for SSES seismic design qualification |
| SQUG | Seismic Qualification Users' Group |
| SRV | Safety Relief Valve |
| SSD | Safe Shutdown (Same as HSD) |
| SSE | Safe Shutdown Earthquake. SSES design basis earthquake. |
| SSEL | Safe Shutdown Equipment List |
| SSES | Susquehanna Steam Electric Station |
| SWS | Service Water System |
| TAF | Top of active fuel |
| TB | Turbine building |
| TBCCW | Turbine Building Closed Cooling Water |
| UHS | Ultimate heat sink. (The SSES Spray Pond) |
| USI | Unresolved Safety Issue |
| (US)NRC | (United States) Nuclear Regulatory Commission |
| VAC | Volts, AC |

| | |
|---|---|
| VDC | Volts, DC |
| VF | Vessel Failure |
| VSS | Vapor Suppression System |
| WA | Work Authorization |

# 4. Internal Fires Analysis

## 4.0 Methodology Selection

### 4.0.1 Method

Supplement 4 to Generic Letter 88-20 requests that licensees assess plant vulnerability to severe damage from external hazards including internal fires. The Supplement specifies that "(f)ire initiated events can be treated by performing a Level 1 fire PRA as described in NUREG/CR-2300..." (Reference 4-1). NUREG/CR-2300 is the "PRA Procedures Guide" (Reference 4-2) and includes in Section 11.3 a description of a fire PRA.

The PRA described consists of four parts: fire hazards analysis; fire propagation analysis; plant and systems analysis; and a "release-frequency" analysis. The fire hazards analysis determines the significant fire initiating events and their frequency. The propagation analysis ascertains which fire initiating events will damage targets beyond the fire initiation source. Plant and systems analyses are used to describe the important front line and support systems used in fire/accident mitigation and their inter-relationships. The "release-frequency" is a calculation of the frequency of core damage (Level 1) for each significant fire source.

Given the standard table of contents suggested for the IPEEE fire PRA (Reference 4-7), sections 4.1 and 4.2 below can be considered to describe the fire hazard analysis; sections 4.3, 4.4, and 4.5 the fire propagation analysis; and sections 4.6 and 4.7 the plant/systems and core damage frequency analyses. Most of the plant description and systems analysis, including system failure data, is taken from the PP&L IPE (Reference 4-8). Reference to specific sections of the IPE will be made as required. Detailed description of the methods used in performing the fire PRA is included with the appropriate sections below. This fire PRA is written so that the information requested in section 4.3 of Appendix 4 of G.L. 88-20, Supplement 4 is included in the appropriate section below.

In general, this fire PRA endeavors to uncover "real" fire vulnerabilities from "real" fires. To the extent practical, this study makes use of previous fire safety work at PP&L (e.g. Appendix R) and the actual fire experience at PP&L and within the industry as a whole. By use of data, expert judgment, and bounding analyses this study seeks to minimize analytical fire vulnerabilities which are more a product of supposition than experience. Our purpose here, as in the IPE, is not exclusively to calculate a core damage number. The core damage frequency calculation is almost a consequence of the study and not its most valuable result. The most important results of this PRA are the recommendations for fire risk reduction and their incorporation into SSES equipment, procedures and training.

Fire in industrial facilities is not new. Methods of preventing/mitigating fire are widely known and accepted. Significant effort has been spent, and continues to be spent, in ensuring fire does not destroy or significantly affect the operation of the single largest capital asset at PP&L. PP&L has an enlightened self interest in maintaining SSES "fire safe".

### 4.0.2 Key Assumptions

As with the preceding discussion regarding "methodology", general comments regarding the key assumptions used in the PRA are made here. Further details are provided in the appropriate sections below. The key assumptions are used to make the analysis tractable. However, caution is used to ensure these assumptions do not create analytically easy but physically unlikely scenarios, nor mask real fire

vulnerabilities. While the results of this study are in part a consequence of the assumptions made, all assumptions are supported by either the fire experience of the nuclear industry, tests performed by nationally recognized laboratories (e.g. Sandia National Laboratory), and/or already existent risk and fire analyses performed by PP&L and others.

#### 4.0.2.1 General Discussion of Assumptions in the Fire Hazards Analysis

The fire hazards analysis makes use of several screening criteria to allow removal of risk insignificant fire zones from further consideration. The following assumptions are used in the fire hazards analysis. Detailed discussion is found in Section 4.1 below.

First, fire originating in a fire zone with physical boundaries (walls, doors) is assumed to remain within these boundaries. This assumption is relaxed in the study of cross-zone fires, also described below. However, in general, fire barriers are sufficient to prevent fire in one zone from starting a fire in another. The original design basis of the plant assumed as much. Second, fire induced LOCAs do not occur. Fire induced pipe break is considered incredible, and PP&L analysis for Appendix R compliance shows interfacing system LOCAs are prevented by redundant isolation valves and pressure relief valves on low pressure piping. Because the probability of fire with spurious hot short opening of an isolation valve and failure of pressure relief is estimated to be less than about 3E-9/reactor year, interfacing system LOCA is not considered further. Third, fire induced failure to scram on demand (ATWS) is also removed from consideration based on Appendix R analyses. Cable for scram circuits is run in separate conduit which leaves one or more methods of scramming the plant (normal, ARI, back-up scram) intact. Fourth, because essentially all cable in SSES is qualified to IEEE-383 type testing, self induced cable tray fires are considered sufficiently unlikely so as to be discounted. Fifth, no valve fires in BWRs are recorded in EPRI's Fire Events Data Base and thus valves are considered unlikely sources of fire. Sixth, electrical faults, including so called "high impedance faults" and failure of breaker co-ordination are also deemed sufficiently unlikely so as to be disregarded. Loads assigned to power supplies are generally physically dispersed so as to be immune from impact from a common fire. Data to support the existence of fire induced high impedance faults is not readily available. Discussion with electrical and I&C engineers confirms loss of breaker co-ordination is extremely unlikely. Analysis performed for Appendix R compliance (Reference 4-3) confirms SSES is not vulnerable to high impedance faulting on ESS buses. Because such failures in actual fires are infrequent enough so as to be impossible to predict with certainty, and because there is no defense against such failure because it violates the basic premise behind circuit protection design, loss of breaker co-ordination is not considered further. Finally, because a "snapshot" of plant conditions must be taken to allow the analysis to proceed, combustible loading and SSES fire history are those documented as of April, 1993, supplemented by walkdowns through December, 1993.

#### 4.0.2.2 General Discussion of Assumptions in the Fire Propagation Analysis

The fire propagation analysis determines the detailed impact of source fires on various targets within fire zones. The following is an abbreviated discussion of the assumptions used in this analysis. Details are found in Section 4.3 below.

First, fire originating in an electrical cabinet of any kind (MCC, transformer, charger, distribution panel, load center, I&C cabinet, etc.) is assumed to stay within the cabinet, or, given a full size partition, within the cabinet section of origin. This assumption is supported by the Fire Events Data Base, testing, and COMPBRN IIIe calculations. Second, although SSES cable is qualified to IEEE-383, loss of function is assumed if cable temperature reaches 700 F, ignition at 931 F. These temperatures are consistent with the FIVE methodology and other fire risk analyses. These temperatures apply to cable in tray <u>and</u> conduit. No

detailed internal fire propagation studies are performed for electrical cabinet fires and fire within a cabinet is assumed to disable all devices, including cable, inside. Third, small motors (generally < 50 hp) on pumps, valves, and hoists are ignored as fire sources because they contain minimal amounts of combustibles. The combustibles in these sources are typically a pint or less of oil or a few ounces of grease in metal bearing cups. Fourth, credit for good housekeeping is taken. Based on SSES procedures for housekeeping and combustible material control, and the number of recorded violations of these procedures, the propagation analysis assumes that true "transient" combustibles are insignificant fire sources. The only transients considered in the propagation analysis are fixed (i.e. long term) and permitted.

#### 4.0.2.3 General Discussion of Assumptions in the Plant/Systems/Frequency Analysis

The PRA assumes SSES is as configured in the IPE of December 1991. Review of P&IDs and controlled Appendix R documents used during the performance of the PRA shows this assumption to be good. That is, the plant as configured in December 1992 when the fire PRA began in earnest is the same as that modeled in the IPE. This similarity applies also to the system failure data used. PP&L makes quarterly assessments of safety system performance in compliance with INPO guidelines. Trends of this data from 1991 through 1992 show safety system performance as good or better than the data used in the IPE. Also, because the station is essentially identical to that described in the IPE, the IPE fault trees, event trees, etc. are used to perform the plant systems and frequency analysis. The same assumptions made in performance of the IPE apply to the fire PRA.

Generally, the fire PRA takes credit only for ECCS equipment, the adequate separation of different divisions of safety grade systems, fire barriers, and the actual combustible loadings found in fire zones at SSES. The analysis takes no credit for automatic detection or suppression, nor is any credit given for "Thermo-Lag" or other type of fire protective wrapping.

### 4.0.3 Status of Appendix R Modifications

The modifications performed to ensure compliance with the Appendix R regulations are detailed in the SSES Fire Protection Review Report (Reference 4-3). Currently, all modifications proposed have been completed. The verification of modification completion is embodied in revision 4 to the FPRR.

## 4.1 Fire Hazard Analysis

### 4.1.1 Fire Hazards Methodology

As explained in Section 4.0 above, the fire hazards analysis is part of a PRA process described in Reference 4-2. The goals of the hazards analysis are to determine in which areas of the plant safety significant fires may originate and the frequency of these fires. For the PRA this becomes the initiating event frequency and impact. The methodology consists of partitioning the plant into various fire "zones" for study, determining the equipment available or affected in each zone, screening out zones which are obviously small contributors to fire risk, and finally calculating the frequency of fires for those zones which are not screened out.

#### 4.1.1.1 Fire Zones

To determine significant fires, fire areas or zones must be defined and the safety significant equipment within these zones identified. For convenience, the fire zone designations used in the Appendix R analysis are retained (Reference 4-3). The major advantage to maintaining consistency with the Appendix R work is that existent cable and component data are analyzed and located on a fire zone basis. The fire zones are shown in the figures in Reference 4-3, drawings C-1720 through C-1764. A selection of these drawings is included as figures in this IPEEE report section.

#### 4.1.1.2 Safe Shutdown Equipment

Once fire zones are defined, the equipment used to bring the plant to safe shutdown is located in each zone. Again, existing Appendix R work is referenced. Because of the enormous effort involved in locating specific cables for equipment, only the equipment used for safe shutdown in the Appendix R analysis is considered, plus HPCI and CRD. This equipment selection criterion has important implications for the results of the PRA.

In the IPE for internal events, all manner of equipment, Q and non-Q, is included as part of the "front line" or "support" systems used for fulfilling the four front-line functions of reactivity control, vessel inventory and pressure control, and containment decay heat removal. These include condensate, feedwater, CRD, RWCU and others. Use of this equipment was possible because failure was determined by and limited to the system level interactions or large component losses for which failure data existed. Spatial location of equipment was relatively unimportant. Because system function is actually dependent on a widely distributed system of power and control cables, and because fire in a given zone may destroy cable and thereby disable equipment located in another zone, system failure modeling for fires must account for the multitude of control and power cables required for a given system's operation, typically in a different location than the component affected. The identification, location, and review of cable is painstaking and time consuming. Because this effort had been expended during the Appendix R work to demonstrate SSD from different equipment "paths" (Reference 4-3), the front-line and support systems included in the fire PRA screening are only those from the Appendix R work plus HPCI and CRD. The impact of this equipment selection is that the calculated core damage frequency from the fire PRA is an upper bound. That is, more equipment will probably be available to fulfill the four required safety functions and bring the plant to safe shutdown than is accounted for in the PRA systems models.

The equipment of interest in each zone consists of the components and cables for any of the three reported (Reference 4-3) safe shutdown paths from Appendix R, plus HPCI and CRD. For each unit this equipment is the front line systems of HPCI, RCIC, CRD, ADS, CS, RHR, and their applicable support systems. In each fire zone the components for these systems are identified primarily by review of Reference 4-4, supplemented by review of References 4.3, 4.5, 4.6, and 4.8.

Cable and associated circuits for the protected path, plus cable for the non-protected paths, HPCI, and CRD (if required for Defense-in-Depth) are identified in each zone by sorting the SSES cable data base (CARTS, ARCDMS, Reference 4-11). Where cable appears to affect specific components of interest (e.g. those required to achieve Defense-in-Depth, see "Screening" sections) detailed electrical scheme drawings are studied to determine the effect of hot shorts and opens on the cable. Because of the diverse locations of equipment sharing a common power supply, high impedance faults are generally ignored as a possible cause of power supply failure.

Although not used for the Appendix R safe shutdown paths, CRD is selected for the PRA to establish DID because it is a high pressure system capable of operation even at low vessel pressure, and it is sufficient to prevent core damage with two pumps in operation (Reference 4-8). The CRD pumps are located in the turbine building and CRD flow from the non-fire unit may be cross-tied in the turbine building to the CRD system in the fire unit. Thus, fire in the reactor building will generally not disable CRD pumps. CRD pumps are powered off ESS 4160 VAC buses A and D, however. In zones in which CRD is relied upon for DID, CRD cables are reviewed to ensure that no cables appear in the zone of interest. Besides the CRD pumps, flow control valves on the 719 foot elevation of the reactor building are the only active components required for CRD vessel injection. The support systems for CRD are instrument air, TBCCW, and AC power (channels A and D). The IA and TBCCW equipment are also located in the turbine building. If IA for the fire unit is lost, IA from the non-fire unit may be cross tied. Two loops of TBCCW are available, either one of which is able to cool both pumps. Tests of the CRD pumps show that they will operate at least two hours without TBCCW. Thus, these support systems are not considered in the cable sorts.

#### 4.1.1.3 Screening

"Theoretically, the fire-risk analyst should study the potential contributions to risk of fires anywhere in the nuclear power plant. By screening out unimportant locations, however, he can greatly reduce the amount of work required without sacrificing significant confidence in his results..." (Reference 4-2). Reference 4-2 also suggests three screening methods: presence of safety equipment, FMEA, and FMEA plus combustible loading considerations. The first screen identifies locations as important if they contain SSD equipment, especially multiple trains or divisions of SSD equipment. This screening criterion is also the one specified in NUREG 1407 (Reference 4-7). The second screen removes zones from consideration if loss of all equipment in the zone does not cause a transient or LOCA, or, if it does cause such an initiating event, sufficient equipment remains functional such that all four of the front-line functions can be performed. The third screen of Reference 4-2 is the same as the second or FMEA screen with the added consideration of the type and location of combustibles and targets. With the third screen, fires which may be intolerable if they involve an entire zone are screened out if the actual source or combustible loading is too low or the separation too great for SSD equipment to be failed.

The screening approach used in the SSES IPEEE fire PRA adopts the "three screen" method of Reference 4-2, modified to reflect the evolution of risk assessment at PP&L. The three screens used here are: a "Defense-in-Depth" screen, similar to the second screen of Reference 4-2; an impact screen, a combination of the first and second screens of Reference 4-2; and a combustible loading screen, similar to the third screen of Reference 4-2. These screens are explained in further detail below.

#### 4.1.1.3.1 Defense-in-Depth Screen

At PP&L, margin of safety is judged sufficient if several "Defense-in-Depth" criteria are satisfied (Reference 4-8). These criteria ensure that multiple successive equipment failures must occur for accident severity to increase. Safety is based on physical equipment, not an arbitrarily low number from a PRA. Thus, the first screen used is a "Defense-in-Depth" (DID) screen. Because only a Level 1 PRA is required (Reference 4-1), only the "core damage" level of defense-in-depth is examined. With DID, core damage is eliminated as a concern if, given the loss of all equipment within a fire zone, at least two independent paths remain for injecting sufficient water to the reactor vessel to keep the core cool.

The strength of the DID screen is that it does not rely on calculated low fire initiation frequency. Such frequency calculations are highly uncertain. A "two train survival" screen was suggested by NUMARC (Reference 4-9) and judged acceptable by the NRC if the combined failure probability of the two trains is 1E-6/yr or less, or the combined failure probability of remaining equipment sufficient to shut down the plant is 1E-6/yr or less. The NRC judged that such failure data would be readily available from the IPE. Combining the PP&L DID criteria with the NRC frequency screening criteria, the following core DID screen is adopted for the IPEEE fire PRA. That is, DID is achieved if, given a fire, one of the following sets of equipment is operable:

Table 4.1- Fire PRA Defense-in-Depth Screening Criteria

Success of:

(HPCI or RCIC) and
[2 Divisions of ADS and (2 LPCI pumps in different divisions, or 2 CS pumps in different divisions, or 1 LPCI pump and 1 CS pump, may be in same division)]

or

(HPCI or RCIC) and CRD and
[1 Div ADS and (1 CS pump or 1 LPCI pump)]

or

CRD and 2 Divisions of ADS and
(2 LPCI pumps in different divisions, or 2 CS pumps in different divisions, or 1 LPCI pump and 1 CS pump, may be in the same division)

In addition to core DID, the failure of all equipment in the zone must leave one train of RHR suppression pool cooling intact for containment decay heat removal (DHR). If both the core and DHR criteria are satisfied the zone is screened out from further analysis. The failure probability of RCIC and both

divisions of ADS is ~ 4E-7/demand; of RCIC and two LPM pumps ~ 2E-7/demand. Failure of RCIC, CRD, and 1 Division of ADS is about 6E-7/demand (Reference 4-8). Failure of CRD and two divisions of ADS is ~ 2E-8/demand, and failure of CRD and two LPM pumps is about 1E-8/demand. This screen is conditional, that is, given a fire occurs, given that multiple equipment fails (no detection/suppression), and given that no recovery of equipment is achieved. Thus any calculated core damage frequency for these zones will be lower by orders of magnitude than the above screening numbers. Note that because only one RHR pump per division (pumps A and B) are used in the Appendix R analysis, only these two pumps are credited here. This limitation on RHR is another unquantified conservatism.

Several assumptions are built into the DID screen. First, fires are assumed to be contained in the zone of origination. This assumption is valid because all but the wrap-around zones are contained within concrete walls capable of containing the fire, even though they may not be "fire rated" for Appendix R purposes. (Multiple or cross zone fires are addressed separately.) Second, no LOOP is assumed. There is no guarantee that the fire causes LOOP unless the fire destroys the switch yard, startup transformers, or startup buses (located in the turbine building). This allows us to consider one train of SPCM of RHR sufficient for screening. If the fire causes LOOP, more than one train of SPCM should be available because of the location of the RHR equipment in the reactor building and the off-site circuits either in the turbine building or outside the plant. If the fire destroys one division of SPCM, the BOP equipment (condenser) should remain available to remove decay heat, again because of the separation of RHR and condenser in different buildings. Because of the long time required for containment over-pressurization (about 30 hours, Reference 4-8) and the possibility of re-opening the MSIVs even if closed, one RHR train survival is judged sufficient for screening. While no LOOP is postulated, the core screening criteria rely only on equipment which are supported by emergency AC or DC power. That is, off-site power is not required for success. As mentioned above, the screening criteria are conservative in that more equipment for vessel injection should remain available after the fire (FW, condensate, RHRSW, condensate transfer) than is credited. The third assumption in the DID screen is that LOCAs will not occur. Pipe rupture caused directly by fire is not considered credible. Further, Appendix R analysis shows that interfacing system LOCAs are not likely at SSES (Reference 4-4). Without a LOCA each of the injection sources considered in the DID screen is adequate for core protection (Reference 4-8). Assumption four is that fires will not result in ATWS. Appendix R analysis specifically addresses this concern (References 4.12, 4.13). These analyses show that scram capability remains given any all-encompassing Appendix R type fire. Augmenting this analytical robustness are the operators themselves. Each is charged with protection of the plant and the health and safety of the public. Because fires at SSES are historically slow-developing events, it is expected that operators would manually shut the plant down long before loss of scram is threatened (References 4.14, 4.15). Thus, the plant impact due to fires is limited to transient initiating events: non-isolation, isolation, SORV (fails HPCI) and LOOP.

#### 4.1.1.3.2 Impact Screen

The second screen used for the IPEEE fire PRA is an impact screen. If all equipment in a fire zone is lost because of fire and no plant transient (isolation, non-isolation, or manual shutdown) occurs, the zone is screened out from analysis because of the minimal impact on plant operation. Again, fire induced LOCA is not credible.

#### 4.1.1.3.3 Combustible Loading Screen

The third screen is a combustible loading screen. If the zone contains no significant fire sources or combustibles, the zone is screened out. While certain materials are considered "combustible" for Appendix R or fire protection purposes, historical fire experience data indicates they are not (Reference

4-10). For the fire PRA, zones which contain nothing except cable are screened out. Essentially all the cable at SSES is qualified to IEEE-383 standards (Reference 4-3). Although 2 fires in qualified cable are recorded in Reference 4-10, both occurred in junction boxes and not in cable in tray. If a cable fire occurs in a junction box it will not propagate. Thus, self-igniting and propagating cable fires are expected to be so remote as to be risk-insignificant. Fire zones which are valve galleries, containing only cable and valves, are also screened from consideration. These galleries are normally inaccessible to routine traffic during power operation and the EPRI Fire Events Data Base (Reference 4-10) contains no records of fires caused by valves in BWRs. These sources are risk insignificant based on ignition event history.

#### 4.1.1.4 Fire Frequency

To determine the fire initiation frequency for zones not screened, both the fire history at SSES and the industry as a whole are reviewed. The industry database is obtained from EPRI and accounts for approximately 750 events (Reference 4-10). The SSES fire experience is pieced together from reviews of SSES Fire Protection Reports and SOORs and includes ~ 100 "fire events". SSES Fire Protection Reports are obtained from the PP&L Industrial Safety Group and the SSES Fire Protection Engineer. SOORs are selected by searching the STAIRS electronic data base for all entries related to fire, smoke, or explosion. Using these data sources, cumulative frequency of fire in each fire zone type from each source (e.g. reactor building electrical cabinets) is determined. By finding the fraction of each source in each zone, the cumulative frequency is apportioned to individual fire zones. Sum of the individual source contributions yields a total fire frequency for that zone.

##### 4.1.1.4.1 Fire Frequency in the Nuclear Industry

The industry fire experience has been analyzed and reported in Reference 4-10. Frequency is based on the distribution of recorded fire sources within various nuclear plants. If a source can be assigned to a specific building or room type, the frequency is so reported. If the particular source can be located in any fire zone, it is assigned to a "plant wide" category. The frequencies reported are based, in general, on all fire events, including those which did not occur at power operation. Because the focus of this PRA is on probability of occurrence at power, the industry experience is revised.

To revise the industry frequencies, the specific events for each fire type (e.g. BWR reactor building electrical cabinet fires) are reviewed. Those events which occurred while shutdown are culled and the fire type frequency recalculated. For example, the fire frequency reported in NSAC 178 for electrical cabinet fires in BWR reactor buildings is based on 24 fires in about 479 BWR reactor years. Review of these events shows that only 9 occurred during power operation. The "revised" industry experience of BWR reactor building electrical cabinet fires is based on 9 fires in 479 BWR reactor-years at an average capacity factor of 62%, or 0.03 chance of fire caused by electrical cabinets each year in a BWR reactor building during power operation. Table 4.2 presents these revised industry fire frequencies.

The revision of the industry data does not always result in a reduction in fire initiation frequency. While the number of fire events is reduced in the revision, the number of hours of exposure is also restricted. Thus, the calculated fire initiation frequency may increase, decrease, or remain about the same. NSAC 178 shows the frequency of battery room fires to be 3.2E-3/rx-yr from all events vs. a revised value of 3.8E-3/rx-yr. BWR reactor building fire frequency dropped from 5.0E-2/rx-yr to 3.0E-2/rx-yr in the revision. Switchgear room frequency remains about the same, even though the number of events considered dropped from 19 to 12. Details of the industry frequency revision are found in Reference 4-18.

#### 4.1.1.4.2 Fire Experience at SSES

The SSES fire experience data is presented in Table 4.3. The data is presented chronologically for both units from construction through April 1993. Each fire event is assigned to the applicable unit for those occurring in vital areas of the plant (containment buildings, reactor buildings, control structure, turbine building, EDG buildings, ESW pump house, or rad waste building). For events which occurred in non-vital areas (e.g. S&A building, warehouses, etc.) the unit is "NA". For vital area fire events the unit operating condition is noted, either pre-operational (pre-commercial), critical (regardless of percent power), or SD (shutdown- subcritical). Operating condition is "NA" for unimportant areas. Regardless of the location, the fire event is described, as is the method of detection/suppression. For important locations the specific building and elevation are provided. These are "Other" and "NA", respectively, for non-important areas. For all events the Appendix R fire zone is noted, if known, and a reference is provided. References are either Fire Protection Reports (FPR) or SOORs.

SSES fire experience data is summarized in Figures 4.1 through 4.5. Comparison of Figures 4.1 and 4.2 shows that the majority of fires (~ 70%) occur during off-critical conditions. Review of the data in Table 4.3 shows that none of these fires was risk-significant in terms of damage. SSES fire history shows that fires are likely to be limited to a few components in an equipment cabinet (e.g. circuit cards), smoking pump packing or bearings, smoking MCCs, fires from welding/grinding or cigarettes. In fact, trash can fires linked to cigarette smoking is the single largest category of fires during critical operation (6 total, about 25%). All but one of these occurred in the central access corridor of the control structure (fire zones 0-22A and 0-22C). The SSES data considers all manner of "combustion" events including smokes, EDG crank case explosions, and flaming fires. Fire brigade assistance was used only once (Figure 4.5) All others either self-extinguished or were put out by removal of an electrical power source or by workers in the area. Fire durations were on the order of 5 minutes or less. Based on the non-parametric runs test, the data appears random, exhibiting neither an increasing or decreasing frequency.

Because of the limited number of operating reactor years at SSES (about 15.1 through April 30, 1993), use of only SSES data may result in artificially high calculated fire initiation frequencies. To gain insight on the "true" fire initiation frequency at SSES, the SSES fire history is compared to the industry experience to see if they describe the same population. To compare the two data sources, the industry frequency is multiplied by the actual number of SSES operating reactor years to calculate an "expected" number of fires at SSES. This expected number is compared to the actual SSES experience. If the SSES actual number of fires is within the Poisson distribution 5%-95% confidence limits for the number of expected fires, it is assumed that the industry and SSES data describe the same population and the industry fire frequency can be used to describe SSES. If the SSES frequency lies outside of these bounds, the SSES frequency is used. A similar approach is used in the IPE (Appendix C of Reference 4-8).

As an example, the revised industry frequency of fires in BWR reactor building electrical cabinets is 0.03/critical react.-yr (Table 4.2 above). Through April 30, 1993 SSES units 1 and 2 combined operation is about 15.1 critical reactor years (about 12.1 operating cycles). Multiplication of these two numbers yields an "expected" SSES fire history of 0.453 fires. The actual SSES fire history is two occurrences, both in the unit 2 reactor building (7/6/87 and 1/14/88). The 5%-95% Poisson confidence limits for an observance of 0.453 occurrences are between 0 and 0.051 on the low end and between 3 and 4.74 on the high end (Table C.1-5 of Reference 4-8). Because the observed actual SSES experience of two fires is within 0.051 and 3, the two data sources do not describe different populations and the generic industry frequency is used. Similar comparisons are made for the other equipment categories/fire sources in Table 4.2.

Note that care must be taken in the designation of various rooms because industry fire experience is based on such room definitions. For example, "switchgear rooms" are all switchgear rooms, not just those so called in the reactor building (fire zones 1-4C, 1-4D, 1-5F, and 1-5G). Switchgear rooms are rooms which contain only electrical bus work, load centers, and motor control centers regardless of their location. Review of Tables 4.4 through 4.14 provides fire-zone-to-EPRI-room-type designations.

Using the above comparative procedure, it is observed that generic industry fire frequency data is applicable to SSES in all locations and for all fire sources except transient fire sources (Reference 4-18). The industry transient fire frequency is based on which transients are permitted in which rooms. At SSES, the only transient fires corresponding to the industry categories are:

Cigarettes: 6 Total- 7/15/83 (TSC)
3/28/88
7/27/88
4/06/89
4/15/91
2/12/92

Overheating: 1- 10/12/83 (Papers on stove in TSC)

No hot pipe, candle, heater, or extension cord fires occurred while one of the units was critical. The SSES fire frequency from smoking exceeds the Poisson bounds and is not pooled. In the industry data base both cigarette fires counted occurred in the turbine building. At SSES all but one cigarette fire occurred in the central access corridor of the control structure. While troubling because of their frequency, this fire zone (22-A) is separated from the turbine, reactor, and upper floors of the control structure by 3 hour fire barriers and contains no safety related equipment. Thus, this data is not considered representative of the fire frequency due to cigarettes in risk significant areas and is censored.

Cigarette smoking is permitted at SSES only in the control room and adjacent offices, the TSC and adjacent offices, and the ground floor of the control structure (central access corridor). Smoking is not permitted within other areas of the control structure, the reactor buildings, or the turbine building. Other than those in the central access corridor, only one cigarette fire has occurred. This fire took place in a trash can in the TSC approximately 1 month after commercial operation of Unit 1 (7/15/83) and is not considered representative of the current cigarette fire frequency probability which exists in the control room and TSC areas. This judgment is based on the following factors. First, no fires have occurred in the control room, TSC, or their adjacent offices and conference rooms since the 7/15/83 event. Second, the TSC trash cans now have self-extinguishing or closed lids and the area is posted as "no smoking" (per walkdown). Thus, the "problem" is considered fixed. Third, cigarette smoking is virtually continuous in the control room, and no cigarette fires have occurred. Thus, this data point is considered "infant mortality" and is also censored.

After judging the industry frequency inappropriate and censoring SSES data, the question of what number to use for cigarette fire frequency in the control room must be addressed. We use an approach applied previously at PP&L (Reference 4-8) and consider the probability of fires to be log-normally distributed with an upper bound of 1 fire in the next hour and a lower bound of 1/3 fire in the next hour. The log-normal median is calculated:

$$\text{Median Fire Frequency} = \left(\frac{1}{15.1rx-yrs} \cdot \frac{1/3}{15.1rx-yrs}\right)^{1/2}$$

$$= 0.038 \text{ fires/op. reactor-year}$$

This is the probability of cigarette fires in those areas in which smoking is allowed. (Note that after January 1, 1995, smoking will no longer be allowed in SSES buildings, including the control room.) For all other fire zone types and sources, generic fire frequency data is used (Table 4.2).

#### 4.1.1.4.3 SSES Fire Sources

Ultimately, the fire frequency in each significant fire zone is required to calculate probability of core damage due to fire in that zone. The frequencies shown in Table 4.2 describe the cumulative probability of having a fire in one of those rooms from one of those sources each year. To determine the zone specific fire frequency, the cumulative frequency is pro-rated based on the fraction of applicable sources in that particular zone. For example, if one reactor building zone contains 10% of all reactor building electrical cabinets, then 10% of the cumulative reactor building electrical cabinet frequency is ascribed to this zone. To properly partition the cumulative fire frequencies then, the total number of fire sources in each zone must be determined.

Tables 4.4 through 4.14 provide the total numbers of fire sources in each zone. For zones which are building/room type specific (e.g. reactor building/switchgear room), the number of "plant wide" sources in the zone is also provided. The detailed distribution of "plant wide" sources is also shown separately. The data for these tables is compiled from the PP&L combustible loading report (Reference 4-6), equipment location drawings and electrical schematics current as of April, 1993, and plant walkdowns. Again note that rooms are described by the industry designations. For example, because of the type of equipment located in the DC battery charger rooms (zones 0-28B-I and 0-28B-II) these zones are described as "switchgear rooms".

Generally, fire sources are those which are normally energized or operating during reactor power operation and most source descriptions are self explanatory. "Ventilation subsystems" includes both heaters and air movers. "Hoists" are tracked for information only; they are not normally in use during power operation. A separate table is not provided for "misc. hydrogen" because hydrogen is located only in the turbine building (1 FPRR fire zone) and in two zones in the reactor building (1-4A-W and 1-4A-S). Likewise "transient fires from welding and cutting" are considered possible in all zones except the cable chases, control room, and those zones inaccessible during power operation (e.g. 1-4G, steam tunnel).

The rules governing the selection of mechanical component "combustibles" for Appendix R purposes are also adopted here. These rules are reflected in the component listings of the Combustible Loading Report and result in discounting some small sources as "insignificant". For example, three of the selection rules are:

1. Pumps (motors) with ratings ≤ 50 hp are assumed to have 1/2 gallon of lube oil,

2. Pumps with ratings > 50 hp but ≤ 200 hp are assumed to have 1 gallon of lube oil,

3. Components with 1/2 gallon lube oil or less are discounted as insignificant.

These rules eliminate many smaller pumps which show up on equipment location drawings. For example, the RBCW condensate circ. pumps (1P235A,B), evaporate circulating pumps (1P217A,B), and loop circulating pumps (1P214A,B) in fire zone 1-5A-S are not included in the combustible loading. Review of the IOMs for these pumps shows that they are rated at 40 Hp, 15 Hp, and 40 Hp, respectively. Further, the bearings in these pumps are lubricated by grease enclosed in metal holders. These pumps do seem to represent only small combustible loadings and their elimination from consideration justified. Thus, these smaller sources have been considered, not overlooked.

The following special explanation is provided for "transient" sources. These sources consist of cigarettes, extension cords, portable space heaters, candles, hot pipes, and miscellaneous "overheating" sources (e.g. motor heaters), in accordance with the industry fire data base (Reference 4-10). These fire sources are included only in the zones in which they may occur. No candles are expected to be used at any time and are removed from consideration. Cigarettes are only considered in the control room complex (fire zones 26x) and the central access corridor (22A). Hot pipes are found only where feedwater (~ 380°F water to reactor vessel), steam, or RWCU piping is located. These hot pipes are found predominantly in the turbine building and within the primary containment. However, the steam tunnel (zone 1-4G) and the steam piping to HPCI and RCIC are located in the reactor building (zones 1- 3C-N, 1-1C, and 1-1D). RWCU piping is also at approximately 500°F (reactor building zone 1-5D). Discussion with SSES fire protection personnel indicates that space heaters, extension cords, and "overheating" are possible in all zones. However, because of access controls (alarms in control room) and the nature of the equipment involved (cable only) these sources are not included in the cable chase zones in the control structure. To summarize, "transient" sources are located to some degree in most fire zones and because of their generic applicability are not included in source Tables 4.4 through 4.14. The frequency of fires due to transient sources is included in the total fire frequency for those zones not screened out (Table 4.24).

#### 4.1.1.4.4 SSES Fire Zone Frequency Determination

Given the fire zones, cumulative fire frequency for each zone or source type, and the number of sources within each zone, the specific fire frequency for each zone is calculated. Briefly, the fraction of the unit wide fire frequency from each fire source within a zone is summed to yield the total fire frequency for that zone per year. The steps involved in this calculation are:

1. Pick a zone.

2. Pick a source type within the zone.

3. Count how many of these sources are located within this zone (Unit 1 + Common).

4. Determine the total number of these sources in the entire building/room type or for this unit ("plant wide" sources). Generally for this total the number of the unit 1 identified sources and 1/2 of the common sources are summed. Halving of the common equipment total is consistent with NSAC handling of fire frequency data in which frequencies are calculated on a "per site" not a "per unit" basis (Reference 4-10). Such halving makes the total source number smaller and, to the extent that similar common equipment exists for Unit 2, results in a conservatively larger calculated fire frequency (i.e. because this number appears as a divisor) . Where common equipment symmetries are known or easily

determined (e.g. control room and transformers), the common equipment number shown is applicable to Unit 1 and no halving is done in the "total sources" calculation.

5. Divide the total sources of this type within the zone (step 3) by the total of this type within the building/room type or for this unit (step 4). This is the fraction of these sources for this zone.

6. Multiply the fractional source (step 5) by the industry cumulative frequency for this building/room/source type from Table 4.2. This result is the frequency of fire from this source type in this zone per year.

7. Repeat steps 1 through 6 above for all source types in this zone and sum. This result is the total fire frequency from all sources in this zone per year <u>except transients</u>.

Because of the varied nature of transient combustibles, the total transient contribution from each applicable transient source is determined separately. For overheating, heaters, and extension cords the frequency per zone is calculated:

$$\text{Zonal fire frequency from overheating, heaters, and ext. cords} = \frac{\text{(9 industry events/784 industry yrs @ pwr)}}{\text{94 Unit 1 zones (U1+1/2 Common)}}$$

$$= \text{1.22E-4 overheat,heaters,ext. cord fires/zone-yr}$$

Here the 94 zones includes 62 in the Unit 1 reactor building and 32 in the control structure, turbine, EDG, ESSW pumphouse, and radwaste buildings. This 32 is Unit 1 plus 1/2 of common zones and does not include elevators, stairwells, duct or cable chases. This 1.22E-4 is added to the total in step 7 above for all fire zones.

For "hot pipes" the transient fire frequency is:

$$\text{Zonal fire frequency from "hot pipes"} = \frac{\text{(1 industry event/784 industry yrs @ pwr)}}{\text{5 Unit 1 zones}}$$

$$= \text{2.55E-4 /zone-yr}$$

The 5 zones considered are 1-4G, 1-3C-N, 1-1C, 1-1D, and 1-5D and this frequency contributes to the total for these zones only.

The SSES transient fire frequency from cigarettes in the control room and TSC areas has previously been calculated as 0.038/reactor-yr at power. This frequency applies to the 7 zones in which smoking is allowed: 0-26A,E,G,H,I,K and L. Thus, the frequency of cigarette fires in each zone is:

$$\text{Zonal fire frequency CR/TSC Cigarettes} = \text{(0.038/op. reactor year)x(1 reactor-yr/7 zone years)}$$

$$= \text{5.4E-3/zone-yr}$$

Again, this frequency applies only to these 7 zones.

### 4.1.2 Fire Hazard Results

The results of the fire hazard analysis are a list of fire zones which are not "screened out", that is, loss of all equipment in the fire zone results in violation of defense-in-depth, and the frequency of fires in these zones.

#### 4.1.2.1 Screening Results

The buildings and grounds which comprise SSES are divided into fire areas and zones for the Appendix R analysis (Reference 4-3) and these designations are retained for the PRA. Most of the buildings can be eliminated from the PRA using the screens previously described in the fire hazards methodology section. Elimination of these buildings from consideration is permitted because the impact of their loss has small risk consequences. Table 4.15 lists the buildings which make up SSES and the criteria used to screen them from further consideration. Equipment failure rates are obtained from the IPE. The largest conditional equipment failure rate is 4 E-7/fire. Given that fire frequencies are about 0.01/reactor-year or less, low CDF is assured during screening. Because only existing/post-IPE procedures are used, procedure and interface criteria are also satisfied.

As a result of the building screening exercise, only fire zones in the reactor buildings and the control structure remain to be evaluated. This result is typical of other fire PRAs (e.g. NUREG 1150). The screening of fire zones in these remaining buildings is summarized in Tables 4.16 and 4.17. In these tables each fire zone is listed along with the criteria used to screen it out. Notes in Table 4.18 provide additional detail about the screening. Tables 4.16 and 4.17 are a summary of a considerable amount of detailed analysis which is retained in the base calculations (Reference 4-18). This detail includes listings of SSD components and cable in each fire zone and an evaluation of the impact on defense-in-depth of the assumed loss of this equipment/cable.

Explicit cable location analysis is not performed for Unit 2. At the outset of this examination it was anticipated that such analysis would be performed. However, a review of the Unit 1 and Unit 2 combustible loadings shows that both units are approximately equal. Walkdowns confirm the fire sources in each corresponding location are also similar and the construction of fire zone barriers (walls, doors, penetrations, and ducts) is the same. Although the reactor building results are Unit 1 specific, because of the similarity in construction, the applicability of the same administrative constraints (e.g., house keeping), and the results of detailed fire impact calculations (Reference PP&L Calculation EC-RISK-1021) which show negligible impact on cable from existing fire sources, the reactor building results for Unit 1 are judged generally applicable to Unit 2. That is, the risk from fire in Unit 2 is expected to be similar to that in Unit 1 despite differences in cable routing which may exist.

From Table 4.16 note that of the 62 fire zones in the Unit 1 reactor building, 9 can not be screened out, that is, are potentially risk significant. Most of these zones are on elevations 719' and 749' of the building and contain multiple trains of safety instrumentation or cabling so that Defense-in-Depth (DID) can not be achieved if all of the equipment in the room is destroyed. The zones which are screened out have either DID or low combustible loading. DID is guaranteed either by inspection, i.e. the zone has no SSD components or cables for the required Appendix R safe shutdown path, HPCI, or CRD, or by detailed review of cable within the zone. Low combustible loading is determined using the methods described in the Methodology. Of the 77 fire zones in the control structure, 14 can not be screened out (Table 4.17). Those zones which are screened out satisfy the same criteria used in the screening of the reactor building zones. Of these 14, five are Unit 2 duplications of Unit 1 functions (e.g. relay rooms). Thus on a per unit basis, only 9 fire zones remain to be studied in detail in the control structure.

The 18 zones not screened out (9 reactor building, 9 control structure) are identified in Table 4.25 along with the front-line or support systems failed as a result of loss of all equipment and cable in the zone. This equipment loss is considered "gross" in the sense that it assumes wholesale loss of equipment in the zone. That is, no consideration of the spatial distribution of fire sources or detailed fire impact calculations have been performed. The equipment listed is also not all-inclusive; the complete list of affected equipment is provided in Appendices to Reference 4-18. The equipment noted as failed together with the combustible loading are sufficient, however, to guarantee loss of DID and thereby fail the screening criteria above. This failure to screen requires that further study of these zones be performed (fire propagation analysis).

Note that no credit for Thermo-Lag is taken for screening fire zones. That is, in all screened zones DID exists without crediting Thermo-Lag or other fire wrap. (Conversely, DID may exist in unscreened zones by crediting fire wrap, e.g. 1-2B.)

Credit for fire barriers is significant for this screening, especially in zones located in the lowest levels of the reactor buildings. It is in these lower zones that the large ECCS pumps (HPCI, RHR, CS) are located. It is these pumps and their relatively large lube oil supplies (155 gallons for HPCI, 76 gallons per RHR pump) which constitute the only sources in the reactor building capable of causing widespread damage without the presence of rated fire barriers (floors and ceilings). Sources in other zones are insufficient to cause damage to equipment beyond the fire source (see propagation analysis below). Evaluation of the loss of these barriers is presented in the fire propagation analysis.

#### 4.1.2.2 Fire Initiation Frequency

The results of the fire frequency calculations described in the hazards methodology above are provided in Tables 4.19 through 4.23 for each fire zone in the unit 1 reactor building and the control structure. These tables reflect fire frequencies from all sources except transients. Table 4.24 shows the fire frequencies for the zones which are not screened out and includes the transient fire contribution. Frequencies shown are derived as described above and can be checked via manipulation of the data in Tables 4.2 through 4.14. The fire frequency for welding and cutting is based on a total of 87 zones (the 94 described above less the 7 in the control room). The contribution to fire frequency from welding and cutting is thus 0.031/87. This contribution is from fires in transients due to welding and cutting. The EPRI Fire Events Data Base shows only 4 fires in cable from welding or cutting at power operation, only one of which may have occurred in safety cable (Reference 4-10). All fires lasted less than about 2 minutes and were extinguished by personnel involved with the work. Cable fire frequency from hot work in risk important fire areas is calculated to be one fourth of the 5.1 E-3/reactor-year reported by EPRI for all zones, or 1.3 E-3/zone-year. With 87 fire zones in these areas, cable fire frequency is estimated to be about 1.5 E-5/zone-year. This estimate is considered bounding because the cable involved in the data base fires is non IEEE-383 cable, and the cable in use at SSES is rated to the IEEE-383 standard. The actual cable fire frequency is less than this zone frequency because this zone frequency must be further partitioned among the different cable trays or tray sections within the zone. Thus, the cable fire frequency due to welding and cutting is estimated to be on the order of 1 E-6/cable tray-year. Because this frequency is insignificant compared to fire frequency from other sources, cable fires due to welding are not considered further. For misc. hydrogen fires this contribution is 1.3E-3/3. One of the so-called "switchgear" rooms (0-30A) contains 2 "pumps" shared between units. These are the control structure chillers. Thus, on a "per unit" basis the fire frequency for a single pump from the reactor building analysis is included for 0-30A.

The total fire frequency for each unscreened fire zone is reported again in Table 4.25, along with the significant safety system failures associated with loss of all equipment/cable within the fire zone. It is this equipment loss which causes the zone to violate DID and remain unscreened. The fire frequencies in Table 4.25 are used as the initiating event frequencies in the fire PRA.

## 4.2 Review of Plant Information and Walkdown

### 4.2.1 Plant Information

SSES consists of two BWR-4 reactors in Mark-II containments. The reactors are standard GE design now rated at 3441 MWt. Unit 1 commenced commercial operation in June, 1983; unit 2 in February, 1985. As discussed in the "Key Assumptions" above, the plant configuration used in this fire PRA is the same as described by the IPE issued December, 1991 (Reference 4-8). Volume 2 of the IPE contains a complete description of the plant and the systems used for prevention and mitigation of severe accidents. Except for detailed plant damage state frequency calculations for electrical equipment cabinets, only the emergency AC and DC power supplied ECCS equipment and the CRD system are credited in the fire PRA, however.

For purposes of fire analysis, the buildings at SSES are divided into fire "areas" generally separated by rated fire barriers, and subdivided into "zones" within those areas. The Fire Protection Review Report (FPRR, Reference 4-3) submitted as part of the Appendix R documentation contains fire protection features drawings showing these areas and zones. The FPRR also contains descriptions of the fire hazards in each zone (Section 6 of Reference 4-3) and brief descriptions of the fire detection and suppression systems installed in the plant.

In the IPE the relative physical locations of the various systems and components studied does not affect their failure rates. For example if two pumps occupy the same room, or a pump and a MCC are in close proximity, and the pumps, or pump and MCC, have no "support system" level connection (e.g. one pump cools the other, or the MCC powers the pump) the failure of one component has no effect on the other. For fire, as in seismic events, spatial connection of components is crucial. Further, the cable connections between components are specifically of interest. For fire, fire in one component can definitely affect the operation of other components either by being close enough for direct fire damage, or via cable failure, without any "system level" connection. To determine the physical locations of the components used for shutdown, the data available from the IPE and Appendix R work, along with plant walkdowns, are used.

Once the systems required for shutdown are determined (see "Safe Shutdown Equipment" discussion in the Fire Hazard Analysis) the components within these systems are identified from the IPE and Appendix R system analyses. Because the Appendix R work deals specifically with the impact of fire, equipment and cable location by fire zone is readily available. The components required for safe shutdown are mapped into fire zones in the combustible loading report (Reference 4-6) and the references to the FPRR (Reference 4-3), specifically drawing M1002 (Reference 4-4). Equipment location and cable and raceway drawings are also used. One key information source is an electronic cable conduit and raceway data base developed for the Appendix R analysis (Reference 4-11). By sorting this data the components and associated cabling are correlated to various fire zones. To find the impact of the loss of specific cables or the specific components within a cabinet, electrical schematics and panel drawings are studied. Thus, given a fire in a particular zone or cabinet, the equipment affected is determined. Specific data sources (e.g. drawings, etc.) used can be found in the references to the calculations supporting this fire PRA.

### 4.2.2 Walkdowns

#### 4.2.2.1 Fire Source/Plant Systems Walkdowns

Six walkdowns were performed to gain insight into the magnitude of fire hazards at SSES and the spatial dependencies between components, to verify cable locations and cabinet details, and to confirm the similarity between SSES units 1 and 2. These walkdowns were usually performed by the two engineers

doing the fire PRA analysis, although in one case only a single engineer was involved. The walkdowns were iterative and directed. That is, during the course of the fire PRA, a need for additional information would surface. A walkdown was then performed to satisfy this need. After the walkdown the PRA would progress until another need for specific information would arise, at which time another walkdown would be performed. Typical information requirements were: the locations of instrument racks or cable relative to ignition sources; the existence of drains, dams, or other partitions; location of installed detection and suppression equipment; or cabinet details such as specific equipment inside or the existence of internal partitions. Each walkdown lasted about 1 work day.

Walkdown results are recorded as notes on working copies of the fire protection features drawings found in Reference 4-3, in notebooks maintained by the engineers involved, or on ad hoc walkdown data sheets prepared prior to the walkdowns. These results are collected as part of Reference 4-34. The results of the walkdowns are reflected in the fire propagation analysis, especially the locations of cable (in conduit and tray) and transient combustibles (both long and short term).

#### 4.2.2.2 Fire Risk Scoping Study Issues Walkdowns

Two additional walkdowns were performed as part of the Fire Risk Scoping Study (FRSS) issues resolution. The remaining FRSS issues to be addressed in the IPEEE concern:

1. Seismic/Fire interactions (including seismically induced fires, seismically induced fire suppression actuation, and seismically induced loss of fire suppression;

2. Total environment equipment survival, especially the effects of fire suppression on SSD equipment;

3. Control systems interactions;

4. Fire barrier effectiveness; and

5. Manual fire fighting effectiveness.

Walkdowns are specifically suggested as the best way to address several of the issues (Reference 4-1). The walkdowns performed for the IPEEE specifically address items 1, 2, and 4 and, to a lesser extent, item 3 above. The first FRSS issues walkdown focused on barrier effectiveness and the location of items to be reviewed in the second walkdown. To verify assumptions and analysis of non-Appendix R penetration seals for the study of cross-zone fire potential (IPEEE Section 4.3.2.4) the reactor building penetration seals were identified for HPCI, RCIC, and RHR zone boundary walls. Walkdown of these penetrations was performed with the SSES site engineer responsible for these penetrations. Results of the walkdown showed these penetrations in good repair and acceptable as fire boundary seals. The location of various fire detection and suppression system elements in the reactor buildings, control structure, and other site locations was also observed in preparation for the second walkdown.

The second walkdown was performed roughly one week after the first. This second walkdown team included a member of the Seismic Margins Analysis (SMA) team as well as on-site and general office fire protection personnel. This second walkdown focused on potential sources of seismically induced fire not part of the SMA walkdowns (e.g. diesel fire pump fuel tank), seismic interaction of sprinkler heads and fire suppressant storage tanks (water, CO2, Halon), anchorage of fire suppression components (e.g. fire pumps), and the possibility of fire suppression over-spray and flooding.

The results of the walkdowns are included in the analysis supporting the resolution of the FRSS issues (Reference 4-40). The resolutions are presented here in IPEEE Section 4.8. Of note is that during both walkdowns numerous clean trash and radiation protective clothing barrels were observed to have lids. This observation adds credence to the assumption that barrels may be discounted as significant fire sources.

## 4.3 Fire Growth and Propagation

This report section documents the "fire propagation analysis" portion of the IPEEE fire PRA. The propagation analysis takes as "input" the list of potentially significant fire zones left unscreened from the fire hazards analysis (Table 4.25, see Section 4.1 above) and determines the detailed impact of each fire source within the zone. As in the hazards analysis, zones in which the available fire sources have little impact on SSD targets are screened out as not risk significant. The propagation analysis is thus a continuation of the hazards analysis with a "higher gain" focus on individual sources and targets. Typically the potential source impact is loss of power/control cables for SSD equipment. (It is the loss of cable in cable spreading and relay rooms which dominates the results of typical fire PRA analyses.) The output of the fire propagation analysis is a list of fire zones and the impact that individual fire sources in the zone have on equipment and cable within the zone. Core damage frequencies are calculated for the significant sources/impacts. Thus, the combination of the fire hazards and propagation analyses determine the fire initiating event frequencies and impact vectors used in the PRA.

Note that these studies are "best estimate", not "conservative". As such, every attempt is made to understand the actual fire risk and minimize purely speculative impacts. This is consistent with the intent of the IPEEE process which is (in part) to identify low cost plant improvements which will result in significant risk reduction.

### 4.3.1 Fire Propagation Methodology

#### 4.3.1.1 Approach

"The purpose of a fire-propagation analysis is to determine the likelihood and extent of various levels of damage in a compartment, given that a fire has occurred" (PRA Procedures Guide, Reference 4-2). With this goal in mind, the following approach is used to determine the fire impact:

1. Select an "unscreened" fire zone from the fire hazards analysis, one in which the loss of all equipment within the zone results in loss of core level defense-in-depth (see discussion of DID in Fire Hazards Methodology above);

2. Identify individual fire sources within the zone including electrical cabinets, lube-oil sources, and other potential ignition points;

3. Identify targets within the zone, i.e. SSD equipment and cable;

4. Model the fire impact of each source on the targets, accounting for the mitigating effects of fire detection and suppression (if required); and

5. Document which sources may be ignored for having insignificant impact and which ones must be considered significant and for which core damage frequency calculations will be performed.

The first three items above are determined using the results of the fire hazards analysis (Section 4.1) and plant walkdowns (Section 4.2). The hazards analysis provides a list of zones for which loss of all equipment/cable in the zone results in loss of core defense-in-depth. These zones are listed in Table 4.25 along with the reasons for their significance and the cumulative fire frequency from all sources in the zone. The equipment fire <u>sources</u> (mechanical, electrical, miscellaneous) and SSD equipment and cable <u>targets</u> in the zone are also available from the hazards analysis because they are used to determine the fraction of the

cumulative fire frequency in each zone per year, zone significance, and whether or not the zone can be screened out. What is new in the propagation analysis is the modeling of individual source-target interactions, that is, the fire growth phenomenology, and details of relay room and control room cabinets.

With zone fire sources and targets determined, fire impact modeling is performed. This modeling utilizes either the simplistic but conservative bounding analysis found in the FIVE methodology (Reference 4-21) or the more detailed models of the COMPBRN IIIe code available from EPRI (Reference 4-22). The analysis determines the impact of individual sources on targets within the zone. Further details of the modeling are provided below.

The results of the impact modeling provide the answer to "what will happen if a fire occurs in this source in this zone". With this answer in hand, the risk significance of each source is determined. If a source in a zone does not affect SSD equipment, or its effect leaves intact equipment sufficient to satisfy PP&L's defense-in-depth criteria, the source may be screened out as not risk significant. If the source within the zone renders enough equipment inoperable such that DID is lost, the zone is judged "risk significant". The core damage frequency calculation is the next step in the PRA process and is documented in the Plant Systems section 4.6 below.

#### 4.3.1.2 Fire Growth and Propagation Modeling

To find the impact of individual fire sources on individual targets, the physical interaction of source fires and targets is modeled, and equipment details beyond what is required for the fire hazards analysis are determined.

Two methods are used to assess fire damage: FIVE worksheets and the COMPBRN IIIe code. The FIVE methodology (Reference 4-21) uses conservative assumptions about the fire impact to allow analysis to be carried out via simple worksheets and lookup tables. The COMPBRN IIIe code is obtained from EPRI (Reference 4-22) and was developed specifically to model cable damage in compartment fires in nuclear power plants. Although COMPBRN IIIe provides greater detail and a more realistic appraisal of fire damage, both the FIVE screening sheets and COMPBRN IIIe employ the same basic correlations to model fire (Reference 4-21). This COMPBRN IIIe methodology is preferred for fire propagation modeling, according to the PRA Procedures Guide (Reference 4-2). For purposes of the IPEEE fire PRA, the FIVE method is used for those zones in which source loading is low, typically small type A fire sources such as rubber hose, wood, and paper, or small type B liquid sources. The COMPBRN IIIe code is used to model impacts of larger sources such as lube oil, electrical equipment cabinets, batteries, or PC storage racks. Because fires in cabinets are confined to the cabinet of origin (see detailed COMPBRN IIIe model description and discussion under "Assumptions" below), impact of cabinet fires is determined by examination of the equipment within. Note that the fire phenomenology modeled centers on the heat/flame damage due to fire and not on the more uncertain aspects of fire impact, e.g. smoke. Because of the uncertainties associated with smoke generation and its impact, both in terms of distribution within fire zones and effect on equipment, and fire experience and tests which show smoke does not disable equipment in the short term, the subject of smoke "fragility" is not dealt with in this quantitative analysis. Smoke effects are discussed in Section 4.4.

Regardless of the method used to determine the impact of the fire, the first step in the model development is an accurate description of the dimensions of the fire zone and the relative locations of targets and sources. Fire protection features drawings, cable and raceway drawings, the FPRR (Reference 4-3), combustible loading report (Reference 4-6), and plant walkdowns (see above) are used to develop these spatial models. The combustible behavior of materials used as input to these models is obtained from the FIVE and

COMPBRN IIIe documentation, as well as other published and personal references. Sections below detail the models used in the fire propagation analyses for the various sources in those zones not screened out via the fire hazards analysis (Table 4.25). Assumptions used in the fire propagation modeling are also provided in a separate section below.

The objective of this analysis is to determine in a best estimate sense the most realistic impact of fire on the SSD targets within a fire zone, given the combustible loading commonly found in each zone. There is no assumption that the maximum allowable transient combustible loading is located in the most risk significant location, unless the results of walkdowns and document studies show this to be the case. PRAs commonly assume that such loadings are located in such locations, using the relative floor areas in the zone to apportion fire initiation frequency. This approach tacitly assumes that this maximum loading exists somewhere in the zone at all times. It is the experience at SSES that the maximum transient combustible loading does not exist at <u>any</u> time during power operation. Further, the actual most likely location of transient combustibles is generally dictated by ease of access. For example, trash cans and lay down areas are located close to pedestrian pathways and farthest from congested corners where multiple cable trays may be located and head clearances are lowest.

Transient combustible fire experience in the SSES reactor buildings and control structure during power operation of either unit is limited to 6 small waste paper basket fires in non-essential office areas in the control structure due to improperly extinguished cigarettes, and three "ignitions" from welding and grinding which were immediately extinguished by the attendant fire watch (Reference 4-18). The SSES combustible loading experience seems typical of the nuclear industry as a whole. The EPRI Fire Events Data Base (Reference 4-16) shows that, industry wide, transient combustible fires at power operation are typically small sources (notebooks, mops, pieces of plywood) which do not propagate. No fires in trash barrels or temporarily stored combustible liquids beneath multiple divisional cable trays are reported, and, other than the Browns Ferry fire, none in cable spreading rooms. Welding and grinding initiated fires are most common, however the presence of fire watches effectively reduces the severity of these fires to inconsequential. Thus, truly "transient" initiators are considered insignificant contributors to fire risk (see further discussion regarding trash barrels under "Assumptions" below).

This analysis takes full advantage of the housekeeping practices described in SSES procedures (References 4.23 through 4.26). These procedures require: prompt collection and removal of trash, packing materials, etc. as work progresses; location of waste disposal containers where they will not, if ignited, threaten critical equipment; proper storage and dispensing of only required amounts of combustible liquids; regular inspections for fire hazards and cleanliness; permits for storage of combustibles; etc. A search of SOORs generated for violations of these housekeeping/combustible control procedures shows that from commencement of commercial operation through 1993 there were only 3 violations significant for fire, and all were related to ignition of trash or rad waste barrels by grinding or welding activities. All were immediately extinguished by the attendant fire watch. The generally high level of plant cleanliness has also been observed during repeated plant walkdowns at various times in the process of the fire PRA. Thus, the assumptions of housekeeping procedural compliance and minimal "transient combustible" loading are justified.

In a broader sense, no PRA is required to justify good housekeeping. That is, if housekeeping and combustible control were assumed to be abysmal, resulting in large calculated core damage frequencies, the "fix" would be implementation/enforcement of proper combustible material control procedures. The need for such programs is known a priori. These programs currently exist at SSES. With these programs in place, the maintenance of low risk from transient combustibles is reduced to continued vigilance by maintenance, safety, fire protection, compliance, and site management personnel.

#### 4.3.1.2.1 COMPBRN IIIe Code

COMPBRN IIIe is an interactive computer model for the simulation of fires in compartments, developed for EPRI by the University of California at Los Angeles. COMPBRN IIIe is a modification of previous COMPBRN code versions and was developed to specifically address the concerns about these earlier versions expressed by Sandia National Laboratory in the FRSS (Reference 4-35) Detailed model, input, and user's guidelines are provided in Reference 4-22.

The following types of input data are required to simulate fire scenarios using COMPBRN IIIe :

- Dimensions of room
- Dimensions of all objects in room, both fire sources and targets
- Co-ordinates of mid-points of all objects (including walls & ceiling) with reference to any arbitrary origin
- Number of sub-elements of each object
- Mass of each object
- Orientation of each object
- Physical fuel properties for all objects including walls and ceiling
- Location of pilot fuel
- Dimensions of door opening, if any
- Quantity of forced ventilation air
- Miscellaneous thermodynamic properties (e.g., heat transfer coefficients for which suggested values are provided)

The room and all objects in it are required to be rectilinear in shape. Since reactor buildings generally contain rooms that are not rectangular in plan, such rooms have to be modeled as rectangular, while conserving total area and relationships between fire sources and critical targets.

COMPBRN IIIe program disks include a material property database, SAMPLE.DB, containing suggested or default parameters for use in a point value estimation as well as appropriate statistical distributions for uncertainty analysis for some common materials. These include concrete, gypsum board and wood for ceiling and walls; asbestos for ceiling; brick for walls; bimetallic elements for detectors; glass, aluminum, steel and hardboard for barriers; PVC, PE and PVC/PE for cable insulation and jacketing; and heptane, gasoline, kerosene and engine oil for liquid fuels (called Solvents). The following properties are required for each fuel material, with the units in parentheses :

Density (kg/cu.m.)*
Specific Heat (J/kg.K)*
Thermal Conductivity (W/m.K)*
Heating Value (J/kg.)*
Piloted Ignition Temperature (K)
Spontaneous Ignition Temperature (K)
Damage Temperature (K)*
Ventilation Controlled Burning Rate Constant (Dimensionless)
Specific Burning Rate Constant (kg./sq.m.sec.)*
Surface Controlled Burning Rate Constant (kg./J)
Combustion Efficiency (Dimensionless)*
Fraction of Flame Heat Released as Radiation (Dimensionless)

Absorption Coefficient for Flame Gases (1/m.)
Reflectivity (Dimensionless)*

(The parameters marked with an asterisk are considered more significant to the computation than the others and are highlighted on the data entry screens in the interactive mode of program operation). MKS units are included in the discussion of COMPBRN IIIe because code input and output are so defined.

It should be noted that the statistical distributions of the above parameters provided with the code sample input are based on engineering judgment and not on sampling or other methods of testing. It is PP&L's view that rather than using arbitrary distributions, however apparently reasonable, a better approach is to use sensitivity analysis for those parameters in which there is least confidence and select a value that provides results closest to the results of actual fire tests or experience. In general, especially where no test or experience is available, parameter values were chosen for conservatism, i.e., values that result in the least time to damage.

In the performance of the PRA propagation analyses, several changes are made to the material properties data base provided with the code. For ceiling and walls, steel is added as a fuel type, with properties included in COMPBRN in the "Barrier" category. The damage temperature of cable, given as 500 K (440.6 F) in the database, is changed to the value of 644 K (700 F) applicable to IEEE-383 qualified cable, since all cable used at SSES (except for some computer room cabinets) is so qualified (Reference 4-3). The only liquid fuel likely to be present in indoor fire zones at SSES is lubricating oil. The COMPBRN data for lube oil (called Engine Oil) is incomplete, using a default value of 1.0 for several parameters. Changes are made to several parameters including the spontaneous ignition temperature (542 K), specific burning rate constant (0.039 kg/sq.m.-sec.), and surface controlled burning rate constant (2.0E-7 kg/J) (Reference 4-34) In fire zones with significant quantities of lubricating (lube) oil in rotating machinery, the amount of lube oil that could spill and become a pilot and main fire source are estimated on the basis of the floor area over which spilled oil can remain (determined by the location of curbs or drains) and the thickness of an unconfined spill for the fluid.

Properties for several fuel types not included with the received database are added. These fuel types are battery cases, hydrogen, cotton, and "trash". Multiple COMPBRN IIIe calculations are typically performed to study the impact of each material property value on the modeling results. "Best" values for properties for which little data exists are those which minimize time to damage. Details of the properties are found in Reference 4-34.

Materials used for battery cases at SSES were tested by Factory Mutual Research Corporation and it was determined that the heat release rates are lower than the calculated values for polystyrene. The manufacturer of one of the types of batteries states in the material data sheets that the battery cases are polycarbonate. Because it cannot be established with certainty that all the batteries in the fire zones of concern (250 V, 125 V and 24 V) have the more fire-retardant polycarbonate cases, COMPBRN IIIe runs are made for both polycarbonate and polystyrene, constituting lower and upper bounds respectively, of damage likelihood.

In two fire zones of each reactor building, gaseous hydrogen is stored in pressurized bottles for use in the calibration of containment atmosphere monitoring instruments. The combustion characteristics of hydrogen are significantly different from those of the liquid and solid fuels modeled in this fire PRA, requiring detailed study of how material property data is used in code calculations so that proper descriptions of flammable behavior are achieved. Additional details regarding the hydrogen model for COMPBRN IIIe are

described in more detail in the section on fire zone (FZ) 1-4A-W, one of the reactor building FZs containing hydrogen.

Material properties for woven cotton clothing, especially the density, were difficult to establish. Properties for related materials such as cellulose are available, but for the crystalline form, i.e. not applicable to the modeling of folded cotton coveralls. Engineering judgment, consultation with testing organizations, and multiple COMPBRN IIIe calculations are used for material property selection. Again, guessing material property bounds and performing statistical sampling analysis is viewed as providing only uncertain results. Due to such inherent uncertainty, sensitivity runs are made with several values for certain parameters before material property values are determined to be most reasonable.

Anticipating the need for transient combustible calculations, a prototypic trash fire input is created. The contents of such "trash" can vary considerably. Actual materials can include paper, pieces of cloth and some plastics. To cover these miscellaneous combustibles in COMPBRN IIIe models, an attempt is made to categorize the material properties of "generic trash". Sandia National Laboratory conducted tests on different "packages" of trash with a view to characterizing the combustibility parameters of ordinary materials likely to be found in a bag or can of trash. Of several packages tested by Sandia, "Fuel Package Five" was selected as the reference trash package for SSES because it had the maximum total heat release of 202 MJ. Those parameters such as density and heating value that could be derived from the test data were directly calculated; for other parameters, values for polyethylene (PE)) were used because it constituted more than half of the fuel package.

#### 4.3.1.2.2 Fire Zone Models

Details of the fire zone geometric modeling are included with the discussion of COMPBRN IIIe and FIVE fire impact calculations below.

### 4.3.1.3 Fire Propagation Analysis Assumptions

Several assumptions have been made to simplify the propagation analysis. These assumptions are described below, along with their justifications. Some are carried over from the fire hazards analysis. These assumptions are presented in "electrical", "mechanical", and "transients" order.

First, fires originating in electrical cabinets, including switchgear, transformers, inverters, distribution panels, fire protection panels, I&C panels, etc. are assumed to stay in the cabinet of origin. This assumption is consistent with the EPRI Fire Events Data Base, SNL tests (Reference 4-27), Limerick Generating Station tests and NSAC COMPBRN IIIe calculations (Reference 4-28), and PP&L COMPBRN IIIe calculations (see following sections). Plant walkdowns confirm that cable penetrations of electrical cabinets are sealed. Thus, cabinet fires do not propagate and the loss of equipment function due to a cabinet fire is limited to the loss of the equipment supported by the cabinet. Similarly, if a cabinet contains internal partitions which completely separate cabinet sections without through-wall penetrations, a fire originating in one section is assumed not to disable equipment located in adjacent sections. Such an approach is used in the NRC's study of the risk from 5 diverse nuclear plants, NUREG 1150 (noted in Reference 4-28). Note that because most instrument racks consist mainly of delta-P sensors for pressure, level, and flow mounted on "unistrut" type or other metal frameworks, with associated cable in flexible metal conduit, they are considered to have insignificant amounts of combustibles for this PRA.

In fire PRAs cable is frequently considered the largest single combustible load within a fire zone, and cable in tray is considered part of the combustible load in the SSES combustible loading report (Reference 4-6).

However, virtually all cable in the SSES is qualified to IEEE-383 standards (Reference 4-3). Thus, while a fire of sufficient size and duration may indeed initiate a self-propagating fire in SSES cable, the use of IEEE-383 cable makes such propagation difficult. (Self-induced cable fires are considered unlikely enough to be not risk significant, Reference the EPRI Fire Events Data Base.) In two types of cable considered "least fire resistant" yet qualified to IEEE-383, Sandia National Laboratory was able to initiate self propagating fires by exposing them to twice the IEEE-383 heat flux for five minutes (Reference 4-29). The two types of cable SNL researchers were able to ignite were both #12 AWG. One was a single conductor with cross-linked polyethylene (XPE) insulation and no jacketing. The other was a three conductor cable with XPE/silicone glass tape insulation and XPE jacket. Search of SSES environmental qualification (EQ) binders shows that PP&L does use cable with similar insulation and jacketing. These cable types are typically used in lower voltage applications (125 V DC/120 V AC) such as I&C. Such wiring is used in GE instrument panels. The approach used in this PRA is to assume that, for cable in conduit and tray, cable function is lost if the cable temperature reaches 700°F. This is the failure temperature recommended in the FIVE methodology (Reference 4-21). Cable is assumed to ignite if cable temperature reaches 931°F. As quoted in Reference 4-28 this temperature is used for ignition in the NRC risk analysis (NUREG 1150). Once ignited, cable fire propagation is handled on a case by case basis. For example, if the ignited tray has a solid metal top and bottom, propagation is not considered. Such tray covers prevented propagation in SNL tests (Reference 4-29). Note that while cable in conduit is typically not addressed in PRA, this PRA considers such cable in much the same way as cable in tray. That is, if conduit temperature is calculated to reach 700°F the cable within is considered failed. However, because of the enclosure afforded by the conduit, fire propagation is not considered. For cable in cabinets and control panels, all cable is assumed to ignite and fail. No detailed in-cabinet fire propagation studies are performed and all cabinet functions are conservatively assumed to be lost. This is in agreement with SNL and Factory Mutual testing (Reference 4-29) which shows that, given sufficient pilot combustible and proper internals orientation, all-consuming panel fires with IEEE-383 qualified cable are possible. Such treatment of cabinet fires is extremely conservative given the cabinet fire experience of the industry, the presence of electrical protection (fuses), and the presence of fire detection.

The following approach is used here to cover the possibility of "hot shorts" in cable. Although only anecdotal evidence exists to support the occurrence of hot shorts in actual plant fires (e.g. Reference 4-32), inadvertent equipment actuations are generally considered in fire PRAs, and these actuations are typically blamed on "hot shorting" of partially burned conductors. Because three phase hot shorts across the proper phases must occur for inappropriate motor operation, hot shorts are not considered in power cable. The PP&L Appendix R analysis and IPEEE fire propagation studies confirm that fire at SSES will not result in hot shorts that cause a high/low pressure interface LOCA, flow diversion of injection to or inventory from the reactor vessel, or loss of containment isolation capability (References 4-4 and 4-34). Hot shorts, including multiple hot shorts, are considered in control cable, both in cable tray and control cabinets, unless the cable tray/cabinet wiring layout make such shorts unlikely. For example, if conductors are run through flexible metal jacketing, switches are enclosed in cans, the cabinet is normally de-energized with a remote power source, etc. hot shorts are considered infrequent enough to be ignored. The specific equipment affected by any hot shorting is also considered. Hot shorts are considered significant for control circuits for failure of HPCI, RCIC, ADS, RHR, and CS. Inadvertent actuation of any of these systems, except ADS, is not a safety concern because injection to the reactor vessel is limited by isolation valves and reactor pressure (RHR and CS), high reactor vessel level automatic turbine trips and the loss of steam available to drive high pressure turbine systems (HPCI and RCIC), and manual operator action. Inadvertent ADS actuation will fail HPCI and RCIC but guarantees no TQUX sequences. In summary, hot shorting is considered on a case by case basis, depending on the fire scenario.

Based on the EPRI fire experience data and previous fire safety work at PP&L, valves and small motors are assumed to contribute negligibly to fire risk. The EPRI data base (Reference 4-16) shows no valve fires have occurred in BWR plants. Valve motors operate only intermittently and the grease used in the motors for lubrication is contained within the motor casings. Thus, valves are not considered significant fire sources. The same is true of hoist motors used in the reactor building. These motors are generally parked during power operation. Investigation of IOMs and the SSES combustible loading report (Reference 4-6) show that small motors (<50 hp) commonly found on water pumps contain only small amounts of lube oil or grease (generally less than a pint of oil or a few ounces of grease in sealed bearings). The combustible loading report discounts these small motors as sources. For this PRA, small amounts of grease or oil used in bearings are also ignored.

One additional assumption is made regarding "transient" combustibles. At SSES such combustibles may be defined as either truly transient, for example trash barrels, extension cords, etc. or "semi-permanent" such as hydrogen storage bottles, PC storage racks, and rubber hose for SLC. Given that the industry fire experience shows real transients are insignificant as fire sources (mops, notebooks, single cardboard boxes) and that SSES has a very strong housekeeping/combustible material control process, true transient combustibles are judged to be insignificant for fire risk. This is consistent with NRC observations of fire safety significance noted in Reference 4-39. Thus, the final assumption made regarding transient fire sources is that the only sources with risk significance are those which are semi-permanently stored in fixed locations, and whose presence is evaluated and tracked by permits issued by the SSES fire protection engineer.

### 4.3.2 Fire Propagation Results

The results of the fire propagation analysis are presented in the sections below. First the results of COMPBRN IIIe and FIVE fire impact worksheets are shown (section 4.3.2.1). These results include details of the geometric modeling of the fire zones of concern. The two sections (4.3.2.2 and 4.3.2.3) after the COMPBRN IIIe results disposition each unscreened fire zone inherited from the fire hazards analysis. A discussion of cross-zone fire spread is also included (section 4.3.2.4).

#### 4.3.2.1 Results of COMPBRN IIIe and FIVE Worksheet Calculations

COMPBRN IIIe or FIVE worksheet calculations (Reference 4-34) are performed to determine the impact of each fire source in the fire zones left unscreened by the fire hazards analysis. The results of these calculations are discussed below by fire zone.

##### 4.3.2.1.1 Access Corridor (1-2B)

Two rolls of tightly wrapped polypropylene sheeting are stored in this FZ for use in maintenance and DID cannot be established if all cables routed through the FZ are destroyed by a fire. DID exists without detailed examination <u>if</u> credit is taken for Thermo-Lag fire-retardant wrap of conduits carrying cables of one division, esp. of ESW. COMPBRN runs are made to determine if combustion of the polypropylene would damage specific cables if no credit were taken for the Thermo-Lag.

The FZ is 30.2 m. x 8.08 m. (about 99 ft. x 26 ft. 6 in.), with a ceiling height of 3.965 m. (13 ft.) (Figure 4.6). A mass of 104 kg. of rolled polypropylene is included, of which 50 kg. is assumed to be a pilot fire ignited by a separate flame source. A conduit running along the width of the room above the polypropylene is modeled as the critical target. With the conduit modeled as bare cable (ignoring the steel), the fire lasts 6 hours and 58 minutes, the cable reaching a maximum temperature of 545 K (about 522 F),

below the damage temperature of the cable. However, because the temperature is above the minimum of the damage range specified (525 K, engineering judgement), another COMPBRN run is made with the conduit modeled as a steel barrier. As would be expected, the duration of the fire is the same but the conduit stays relatively cool, reaching only 312 K (approx. 102 F). The steel acts as a "heat pipe", effectively conducting energy away from the hot conduit toward its cooler ends. Based on COMPBRN analysis, a conduit directly above the polypropylene will not be damaged by a fire involving the polypropylene and FZ 1-2B can be screened out.

#### 4.3.2.1.2 Equipment Removal Area (1-3B-N)

This FZ contains four cabinets with large quantities of protective clothing (PC) stored within them. The cabinets are multi-shelved steel construction with the front face open (Figure 4.7). Division II ac and dc (HPCI) MCCs are located along the wall across from the storage cabinets in this long, narrow room. Cable trays for division II run above the MCCs. Physically the room has an "L" shape with the PC cabinets located on the leg of the "L" near the inside corner formed with the foot of the "L". The room is equivalent to a 42.7 m. x 7.32 m. (140 ft. x 24 ft.) rectangular room, with a ceiling height of 10.5 m. (about 34 ft. 5 in.). As with other reactor building floors, especially at the higher elevations, there is little division into rooms. Because there is no physical barrier between this FZ and the adjoining FZ 1-3B-W, most of the east wall is modeled as a door opening. Large quantities of trash are modeled in this fire zone, adjacent to one of the PC cabinets (based on walkdowns). Even though no cable trays are routed above the PC cabinets or trash barrels, a 6.1 m. (20 ft.) section of cable tray is included directly above the pilot and main fuel to obtain an upper bound (on temperature) impact from a fire in cotton PCs. Division 1 conduits are present in the zone, however, these conduits are effectively located in the corners of the zone or out of site of the cabinets in the foot of the "L".

Three cabinets are each approximately 7 feet tall and three feet wide. These are modeled as a single cabinet (cabinet 1). The other cabinet is about 4 feet wide and 4 feet high (cabinet 2). Cabinet 1, located between PC cabinet 2 and the trash, is modeled as the pilot source, with half the 1030 kg. of PCs as pilot fuel. PC cabinet 2 contains 895 kg. of PCs and the mass of the trash is 50.5 kg.. The actual orientation of the PC cabinets is vertical and the backs, sides, bottoms and tops are metal sheet, with only the front of the cabinets exposed. However, the cabinets are modeled as composed entirely of cotton PCs, for simplicity and conservatism. Also, COMPBRN IIIe, written primarily to model liquid pool fires, is not ideal for the simulation of solid fuels or vertical fires (Reference 4-22). Sensitivity studies of COMPBRN IIIe modeling are performed with the PC cabinets vertical or on their back sides, with and without the zone door opening, with a smaller door opening, and with different vertical locations for the PC cabinets. The only run in which any object other than that containing the pilot fire source is damaged is the case of a completely closed room.

The most realistic representation of the FZ (the only modeling compromise being laying the PC cabinets on their backs, fronts up) runs for 1000 minutes. The fictitious cable tray above the PC cabinet reaches a temperature of 592 K, less than cable damage temperature. The maximum temperature of an actual target physically in the zone is 342 K (156 F). Even though the fire did not go out, there is confidence that a longer simulation will not show damage to critical targets because a thermodynamic equilibrium is reached about 11 1/2 hours after the start of the fire at which time the temperatures of objects stops increasing. Also, it is extremely unlikely that a fire at SSES will go undetected for as long as 16 hours, even without automatic detection. Thus, fire in PC storage racks located in zone 1-3B-N is not expected to damage either division I or II equipment or cable.

#### 4.3.2.1.3 Equipment Removal Area (1-3B-W)

FIVE worksheet calculations are used to disposition combustible material which may be kept in a locked metal storage cage in FZ 1-3B-W. The combustibles in this cage are the only fire sources in the zone. The zone is a long narrow room about 108 feet long (including contiguous zones 1-3B-S and 21 feet of 1-3B-N not separated by physical barriers), 20 feet wide, with a 34 foot ceiling. Targets are cables in conduit and tray located 2 ft. below the ceiling and above the cage. Per discussion with site personnel, the cage is used to store valve repair tooling and may contain a wood pallet or chemicals required for valve work.

For the purposes of this modeling, it is assumed that two wood pallets and 1 gallon of combustible chemical with a normalized heat release rate of 200 Btu/sec.-sq.ft. are stored in the cage. The heat release rate of the pallets is assumed to be 660 Btu/sec.. This is the maximum heat release rate for "larger" amounts of wood in Appendix A of NSAC/181 (Reference 4-17). It is also assumed that the spill of liquid creates a 3 ft. diameter pool, about 7 sq. ft. (This spill diameter is consistent with NUREG 1150 and other PRAs and is judged reasonable given SSES housekeeping. That is, no larger spill of any duration is considered credible.) The tool cage sits against the east wall on the 683 ft. elevation of the unit 1 reactor building. Based on the FIVE worksheet, maximum cable temperature (target in plume) is less than 700F. No damage to the cable in FZ 1-3B-W is expected.

#### 4.3.2.1.4 Containment Access Area (1-4A-N)

This fire zone contains two compressors for the Containment Instrument Gas System, each with 2.5 gallons of lube oil. Each compressor is mounted on a steel frame skid tight against the floor and capable of retaining any spilled oil. The room is irregular in shape with part of one edge curved. As explained in a previous section it is modeled as rectangular while conserving the total area and the relative positions of important objects. The equivalent room dimensions are 34.2 m. long x 16.2 m. wide x 7.93 m. high (112 ft. x 53 ft. x 26 ft., Figure 4.8). The size of an unconfined spill of lube oil is determined to be 3.66 m. x 0.915 m. (12 ft. x 3 ft.) with a thickness of 0.00075 m. (0.0025 ft.), consisting of 8.5 kg. of oil, which happens to be equal to the total lube oil content of two compressors. Half of this spilled oil is assumed to be ignited by an external flame. Three cable trays, one parallel to the long direction of the spill and the other two normal to the long axis, are included in the model as target objects (modeled as cable, ignoring the metal ladder). No door opening is included. Forced ventilation air at a rate of 1 cu. m./sec. (approx. 2115 cfm) is assumed.

The simulation is performed with a one-second time step interval instead of the default value of 60 seconds (see discussion of FZ 0-30A modeling below). The fire goes out in 35 seconds and the cable tray parallel to the long axis of the spill reaches a maximum temperature of 388 K (approx. 239 F), well below the cable damage temperature of 700 F.

#### 4.3.2.1.5 Containment Access Area (1-4A-W)

In each reactor building, there are two fire zones (1-4A-W and 1-4A-S) that contain gaseous hydrogen in bottles for use in the calibration of containment atmosphere monitoring instrumentation. Zone 1-4A-W was chosen as typical of these zones and modeled with COMPBRN IIIe. Even though FZ 1-4A-W is defined as a corridor 66 ft. long (wrap-around area), there are no barriers between 1-4A-W and the fire zones on either side. FZ 1-4A-W was, therefore, modeled as a rectangular room, 55.7 m. x 6.1 m. (182 ft. x 20 ft.), with a ceiling height of 8.16 m. (26 ft. 9 in.). Two large floor-to-ceiling openings in the west wall are modeled as a door opening. Two hydrogen bottles, each with 0.51 kg. of hydrogen, are included in the model (both bottles leaking their entire contents), as is a storage rack for PCs. A small

quantity (0.001 kg.) leaking from one of the hydrogen bottles is assumed to be ignited by an external flame. A cable tray (E1K2324) running parallel to the width of the room at a horizontal distance of less than 4 ft. from the pilot source hydrogen bottle is modeled as the critical target (Figure 4.9).

The fire burns out in five minutes with all but a minuscule amount remaining in one of the bottles. This time is consistent with recommendations from representatives of the industrial gas production/distribution industry. The cable tray reaches a maximum temperature of 309 K (about 97 F), barely above the initial room temperature of 77 F. Although hydrogen is explosive if confined and capable of ignition from even the smallest spark sources, the specific energy content of hydrogen gas ( 325 Btu/scf) is low. Given the vastness of the room, the hydrogen bottles (215 scf each) do not present a significant threat to safety equipment or cable in the fire zone. Because the hydrogen bottles in zone 1-4A-S are similarly situated (i.e. against a wall, within a cage, seismically restrained, without safety significant equipment nearby) the results for 1-4A-W are considered applicable to zone 1-4A-S.

#### 4.3.2.1.6 Standby Control Systems Area (1-5A-S)

This fire zone contains the two Reactor Building Chillers with a total of 30 gallons of lube oil. The room has equivalent dimensions of 35 m. x 20.3 m. (115 ft. x 66.6 ft.) with a ceiling height of 28 ft. over most of the area. The chillers, however, are in the southwest corner of this large area over which there is a mezzanine floor that limits the ceiling to about 10 ft. A totally enclosed room (fuel pool cooling pump room) about 28 ft. east of where the chillers are located creates a subzone within the FZ. The corner of FZ 1-5A-S where the chillers are located is, therefore almost a separate room with half the north wall open. The chiller area is modeled as a room 20.3 m. long x 8.54 m. wide (66.5 ft. x 28 ft.) with a ceiling height of 3.05 m. (10 ft.) (Figure 4.10). A drain in the floor between the chillers limits the size of an unconfined spill of lube oil to 4.12 m. x 3.36 m. (13.5 ft. x 11 ft.) with a thickness of 0.00075 m. (0.0025 ft.), consisting of 10 kg. of lube oil. Half this amount is assumed to be ignited by a separate flame. Three cable trays, two of them vertical and the other parallel to the long axis of the spill, and a conduit parallel to the long axis were included in the model as cables, ignoring the metal. No door opening was included. Forced ventilation air at a rate of 1 cu. m./sec. (approx. 2115 cfm) was assumed.

The simulation was performed with a one-second interval instead of the default value of 60 seconds as explained in the section on FZ 0-30A. The fire goes out in 14 seconds and the cable tray parallel to the long axis of the spill reaches a maximum temperature of 533 K (500 F), below the cable damage temperature. No cable in the FZ will be damaged by a fire that can occur in the chiller area.

FIVE screening is used to disposition two additional potential fire sources in zone 1-5A-S: paper/polyester filters in a sample station; and rubber hose stored on a spool for use in SLC injection via RCIC during SBO.

Per the combustible loading report (Reference 4-6), the filters occupy 56 sq. ft. (48 paper, 8 polyester) with an average density of 58 lbm./cu. ft. and a total volume of 0.6 cu. ft. With a heat release rate of paper of 8,000 Btu/lbm., polyester heat of combustion (net) about 12,300 Btu/lbm, and ratios of the areas, the total filter heat of combustion is about 3.0E5 Btu. Using the heat release rate of cardboard for the paper (16 Btu/s-sq. ft.), a heat release rate of about 60 Btu/s-sq.ft. for the polyester and using the respective areas, an average heat release rate of about 1250 Btu/s is calculated. A cable damage temperature rise of 610 F is assumed (700 F cable damage temperature and 90 F reactor building temperature). From FIVE look up tables, this damage temperature is reached at about 12.4 ft. or less above a heat release rate of 1250 Btu/s. Because the cable (in conduit) is located more than 20 feet above the filters (cable is about 25 ft. above the floor, filters about 5 feet above the floor), no cable damage is expected.

A spool of rubber hose is stored just outside the SLC area for use during ATWS for injection of SLC boron to the reactor vessel via RCIC in the case of SLC pump/valve failure. The hose is "B F Goodrich Transporter" with a 1.5 in. ID and a 1/4 in. wall. It is stored in two wraps 16 hose diameters long on a metal spool with the top-most rubber about 4 feet off the floor. Per the combustible loading report (Reference 4-6), there are 300 ft. of hose at 1.53E+04 Btu/lbm. and 2.3E+06 Btu total. Because the hose is coiled tightly, it is assumed that only one layer burns at a time and for that layer, only the outer half diameter is exposed. It is assumed the normalized heat release rate is 31.2 Btu/sec. sq.ft., similar to XPE/Neoprene. Using the equations in the FIVE methodology, the heat release rate per coil of cable is 562 Btu/sec (Reference 4.34). Based on the "fire in plume" worksheet in FIVE and a cable damage temperature rise similar to that for the filters, cable damage may be expected to occur at a height of about 9 feet above the fire source, or 13 feet above the floor. Because cable is located greater than 25 feet above the floor in this location, cable above this spool is not expected to fail.

#### 4.3.2.1.7 Relay Rooms (0-24D, 0-24G, 0-27A and 0-27E)

Each relay room contains several cabinets with relays and other control system components for one division of one unit. There are no fixed or transient combustibles in the rooms other than insulation of wiring in the cabinets and cables in raceways. (It is observed during walkdowns that trash barrels have fire safety flame suppression lids.) The EPRI Fire Events Data Base documents 33 cabinet fires during more than 1200 reactor-years of operating experience. No fire in a cabinet without power switchgear spread beyond the affected cabinet. NUREG/CR-4527 documents the results of cabinet fire tests by Sandia National Laboratories and also concludes that for the cabinet configurations tested, fire in a cabinet does not propagate to adjacent cabinets. However, in view of the caveats listed in the NUREG/CR, it is felt that this conclusion needs to be validated for specific cabinet configurations used at SSES. COMPBRN IIIe cabinet fire calculations are made only to determine whether a fire in one cabinet causes damage to components or wiring in adjacent cabinets separated by double steel walls. It is recognized that all-consuming cabinet fires are highly unlikely.

The SSES combustible loading report (Reference 4-6) is used to select the most heavily loaded cabinet in the relay rooms. Cabinet 1C664 "Annunciator Logic Cabinet" with combustible content of 4.8 million BTU is selected as the cabinet in which an internal fire is simulated.

While cabinet fires at nuclear plants have occurred spontaneously due to loose terminations and switching sparks, COMPBRN IIIe requires a pilot fire to start the simulation. An arbitrary but large quantity of lubricating oil is used both as pilot and enduring pool fire to ensure that a vertical cable bundle in the cabinet would be ignited and burn at least partially. Such a pool of liquid fuel was also found necessary to sustain a cable fire in the Sandia cabinet fire tests (Reference 4-27) due to the difficulty experienced in igniting IEEE-383 qualified cable. Except in non-safeguard applications such as computer cabinets, cable at SSES is IEEE-383 qualified (Reference 4-3). The presence of large quantities (about 8 gallons in one simulation, 15 gallons in the other) of liquid fuel is extremely unlikely in an electrical cabinet at a nuclear power plant, so the results are conservative.

Cabinets at SSES are normally closed during power operation of the units. However, for completeness, two situations are modeled: one with the cabinet doors closed and the second with one of two doors open. The selected cabinet, 1C664, is 12 ft. long, 3 ft. deep and 7 ft. 6 in. high. The lubricating oil is assumed to be in a 10 ft. long, 2 ft. wide, 2 ft. deep pan placed on the cabinet's floor in the center. Half the oil in the pan is assumed ignited by a separate flame source. In the first COMPBRN run a closed compartment is modeled, with 13 kg. (3.8 gal.) as a pilot and another 13 kg. in the pan. Ventilation air at 0.1 cu. meters per second (about 211 cfm) is assumed. The cable is calculated to be damaged and burning at the end of one minute. The flames are out at the end of 40 minutes. The maximum cabinet wall temperature is 382 K (228 F). Since the adjacent cabinet would have another steel wall next to the side wall of the cabinet with the fire, and the damage temperature of IEEE-383 qualified cable is 644 K (700 F), the simulation has demonstrated that a fire, more severe than any likely to occur by accident, does not cause damage to cables or electronic equipment (damage temperature of 325 F) in adjacent cabinets.

In the second simulation the same cabinet is modeled with one 6 ft. wide, 7 ft. 6 in. high door open and with 25 kg. (7.3 gal.) of lube oil as a pilot and another 25 kg. in the pan. The upper half of the cable bundle is damaged and burning at the end of one minute. Before the flames are out at the end of five minutes due to depletion of the fuel in the pan, all sections of the cable bundle are damaged and all but the bottom-most section are burning. The peak wall temperature is 392 K (246 F), less than the damage temperature of cables or electronic components. It should be noted that the mass burning rate and heat release rate with a

large open door are about an order of magnitude higher than for the case with the door closed, which explains the shorter duration of the fire even with a larger quantity of liquid fuel.

COMPBRN IIIe calculations for the SSES relay room cabinet with the highest combustible loading confirm with conservatism that a fire in a cabinet will not propagate to or damage equipment in adjacent cabinets separated by double steel barriers.

#### 4.3.2.1.8 Main Control Room (0-26H)

The most heavily loaded cabinet (or benchboard section) in the MCR, 1C651 "Unit Operating Benchboard", is physically the largest and has the most combustible loading; however, because of its horse-shoe shape, it is not considered the best candidate for simulation by COMPBRN IIIe. Instead, a section of 1C601, the Core Cooling Benchboard, about 7 ft. 6 in. long, with a combustible load of 2.25 million BTU and barriers on each end, is selected. A 25 in. section of the same benchboard is also simulated separately to verify the results are applicable to very small enclosures.

As in the case of the relay room cabinet in the previous section, two cases are run for the large section of the benchboard: one with the doors closed and the second with one of two doors open. The selected benchboard, the middle portion of 1C601 (sections 17, 18, 19 and half of section 20), is 89.7 in. (modeled as 90 in.) long, 3 ft. deep and 7 ft. 6 in. high. The sloping bottom section of the benchboard is not modeled because only rectangular shapes can be used in COMPBRN IIIe and the cable bundles are in the back of the benchboard, in the vertical section. Lubricating oil is again assumed to be present in large quantities in the cabinet. The lubricating oil is assumed to be in a 5 1/2 ft. long, 2 ft. wide, 2 ft. high pan on the floor in the center of the benchboard. Half the oil in the pan is assumed to be ignited by a separate flame source. In the closed compartment model 13 kg. (3.8 gal.) is used as a pilot with another 13 kg. in the pan. Ventilation air at 0.15 cu. meters per second (about 317 cfm) is also assumed. The cable bundle is damaged in one minute and burning in two minutes. The fire is out at 43 minutes. The maximum temperature of the cabinet walls is calculated to be 399 K (259 F). Because this value is much less than the damage temperature of IEEE-383 qualified cable (644K) and less than the damage temperature of electronic components (325 F), the simulation demonstrates that a fire, more severe than any likely to occur by accident, will not cause damage to cables or electronic components in adjacent sections separated by a steel barrier.

In the second simulation, the same portion of 1C601 is modeled with a 3 ft. 9 in. wide, 7 ft. 6 in. high door open and with 25 kg. (7.3 gal.) as a pilot and another 25 kg. in the pan. The upper sections of the cable bundle are damaged and burning in one minute; before the fire is self-extinguished in 12 minutes, all sections of cable are burning. The peak wall temperature in this simulation is 401 K (262 F), also less than the damage temperature of cable or electronic components.

A third simulation is performed for the small end section (Section 16, 25 in. long) to determine if there are any effects due to very small size, using 5 kg. of lube oil in a pilot source and another 5 kg. in the pan. In this run the left and right walls were hottest, reaching a temperature of 430 K (315 F), still less than the damage temperature of cable or electronic components. The fire lasts 14 minutes, with all sections of the cable bundle burning in 2 minutes.

The COMPBRN IIIe runs confirm that, as in the previous section for relay room cabinets, fire in one MCR cabinet will not affect cable or components in an adjacent cabinet.

#### 4.3.2.1.9 250 V Battery Room (0-28J)

There are two 250 V battery rooms per unit containing the batteries for HPCI or RCIC valve power. Conduits for SSD cables (125 V DC) are routed through these rooms; there are no cables in tray. The only combustibles in the rooms are the battery casings and the battery cables which, within the room, are not in raceway. A 250 V battery room is selected for simulation with COMPBRN IIIe not only because it contains about twice the combustible loading of a 125 V battery room but also because the power cable for one division of 125 V dc distribution (1D614/1D624, determined to be risk-significant in IPE for internal events) runs in conduit through each 250 V battery room.

The room is 6.6 m. x 4.73 m. (21 ft. 8 in. x 15 ft. 6 in.), with a ceiling height of 3.36 m. (11 ft.). The 120 battery cells are located on four 2-level racks, with two aisles each about 1m. wide, between the rack along either wall and one of the middle racks. Only a few inches separate the top cells of the two racks in the middle. For modeling purposes the two levels of each rack are considered as one row of fuel elements, at a height which is the average of the two. Since the casing of each cell is filled with electrolyte up to 2 in. below the top of the cover, only the top two inches of each cell are considered as combustible. The total mass of battery casing material above the electrolyte in one rack is 54 kg., of which the tops of two cells, with a mass of 3.6 kg. are assumed to be ignited by a separate flame. The conduits (B1K086) are modeled as steel barriers, split into several objects to keep each of the sub-elements approximately of the same length and width, as suggested by the COMPBRN IIIe manual. Two steel support beams run east to west across the room. These beams are modeled by an equivalent beam of the same mass and surface area (Figure 4.11).

As mentioned in a previous section, polystyrene and polycarbonate are considered to represent the upper and lower bounds respectively, of combustibility of thermo-plastic battery casing materials. COMPBRN IIIe cases are run with each material as the battery casing. With polystyrene, the entire rack burns, with the fire lasting 11 minutes and a section of the conduit reaching a maximum temperature of 526 K (approx. 487 F), below the damage temperature of the cable. With a polycarbonate casing, only three pairs of cells (one sub-element, or a fifth of the rack) burns, with the fire lasting 9 minutes and a section of the conduit reaching a maximum temperature of 465 K (approx. 378 F), well below the temperature if the casing were polystyrene.

It is concluded that in the worst case, only the battery rack ignited by an external flame is damaged by the fire and there is no damage to cables in conduit due to a battery fire.

#### 4.3.2.1.10 HVAC Plenum, SBGTS and Associated HVAC Equipment Room (Fire Zone 0-30A)

This fire zone contains the two Control Structure chillers with 15 gallons of lube oil each. The chillers sit in separate bays. The room is 30.5 m. x 18.1 m. (100 ft. x 59.5 ft.), with a ceiling height of 5.18 m. (17 ft.) (Figure 4.12). For modeling, an unconfined spill of lube oil is assumed, with dimensions of 7.78 m. x 4.73 m. (25.5 ft. x 15.5 ft.) and with a thickness of 0.00075 m. (0.0025 ft.), consisting of 25 kg. of lube oil. The spill is limited by the dimensions of the chiller bay, separated from the rest of the zone by a steel curb placed expressly for this purpose as a result of the Appendix R analysis, and by a drain in the floor of the bay. Half this amount is assumed to be ignited (pilot fire) by an external flame. Two cable trays, each 20 ft. long, 2 ft. wide and 6 in. deep, at a height of 10 ft. above the floor are included in the model as target objects (modeled as cable, ignoring the metal ladder). No door opening was included since the two doors leading to stairwells are card-controlled and normally closed. Forced Ventilation air at a rate of 1 cu. m./sec. (approx. 2115 cfm) was assumed.

COMPBRN IIIe normally simulates fire propagation in 60 sec. intervals. However, due to the fact that the fuel is a widespread thin film and the mass burning rate of the fire, proportional to the surface area, is high, a one second interval was specified. The fire burns out in fifteen seconds and the tray closer to the fire plume reaches a maximum temperature of 398 K (approx. 257 F), well below the cable damage temperature.

Based on COMPBRN analysis, no cable in the fire zone will be damaged by a fire that can occur in 0-30A and the FZ can be screened out from further consideration.

#### 4.3.2.2 Reactor Building Zones

The fire propagation disposition of unit 1 reactor building fire zones is presented in Table 4.26. Detailed study of the sources and targets in these zones shows that no zone is risk significant. That is, core level defense-in-depth and sufficient decay heat removal capability exist given a fire in any source in any zone. This result comes about because the sources are either non-propagating by nature (e.g. electrical equipment cabinets), they are too small and too far away from the targets (i.e. large zones), and/or because steps are taken (e.g. administrative housekeeping procedures) to limit the amount and ignition frequency of transient sources. Even large exposed sources like PC storage racks do not cause sufficient room heating to disable cable. This result is consistent with other fire PRAs (e.g. NUREG 1150, NSAC 181) which show fire risk is not dominated by "equipment" rooms such as those in the reactor building, but by switchgear, cable spreading, and control rooms.

This negligible reactor building fire zone risk is shown with credit only for Appendix R SSD equipment plus HPCI and CRD, and without credit for fire protective wrap or installed fire detection and suppression. That is, if fire occurs in a source in the reactor building and is not discovered, it will burn out without affecting the ability to safely shut down. In fact, for the zones studied here and not screened previously in the fire hazards analysis (Reference 4-18) no credit is taken for fire barriers. Reactor building fire sources in the zones studied here are insufficient to affect equipment or cable within each zone and thus are incapable of affecting equipment in other zones, even with no barriers present. Note though that for three of the reactor building elevations studied, (683', 719', and 749') no barrier physically exists between the zones. (The screening done as part of the hazards analysis does rely on fire zone barriers.)

The primary reasons that reactor building fire zones are found to be insignificant contributors to core damage risk are that combustible loadings are small relative to the size of the zones, and that safety equipment and cable are divisionally separated. In zones which contain "significant" sources such as PC storage racks (zone 1-3B-N) or oil from chillers (zone 1-5A-S), zone construction limits target damage. For the examples cited, cable is located away from the source or in conduit (>30 foot ceiling), and floor drains limit the amount of potential oil accumulation. In zones with lower ceilings (1-2B, about 11 feet), combustible loads are non-propagating (MCC) or small enough so that cable is not damaged (two rolls of plastic). No source in the reactor building zones studied here is located sufficiently close to cable to cause cable damage. Thus cable fire propagation, particularly between multiple division trays, is not a significant problem at SSES. Such cable fires dominate other risk studies. However, such damage is typically found in small rooms with high concentrations of cables from different divisions. The most significant fire in the reactor building is one in an MCC which disables multiple pieces of equipment via common cause loss of AC power. Even here, the divisionalization of safety functions, and the non-propagating nature of the fire, allow defense-in-depth to remain intact.

#### 4.3.2.3 Control Structure Zones

The control structure contains those zones typically found to be fire risk significant: cable spreading, relay, and control rooms. This significance results because these zones contain multiple divisions of safety grade equipment and cable, and the zones are small (compared to the reactor building zones). However, even in the control structure, the plant design and limited nature of the combustible load reduce risk to insignificance in all but a few zones. Note that cable spreading rooms have already been screened out on a zone basis because of insignificant combustibles (qualified cable only, Reference 4-18).

Table 4.27 provides the details of the disposition of control structure fire zones. The table is laid out similarly to Table 4.26 for the reactor building. The following paragraphs summarize the control structure results.

Other than the relay rooms and control room, the control structure fire zones remaining after fire hazards analysis screening are associated with DC power and control structure HVAC. There are four zones on the 771' elevation associated with DC power. Two of these zones are the div. I and II 250 V battery rooms. The other two contain the div. I and II 250 V and 125 V DC chargers and load centers, and 125 V distribution panels. The 783' and 806' elevations each contain equipment for both divisions of CSHVAC.

The significance of the 250 V DC battery rooms is not the batteries themselves but the 125 V DC conduit which runs along the ceiling above the batteries. Loss of a 250 V DC battery fails only one high pressure injection source, either HPCI or RCIC. Loss of one channel of 125 V DC fails multiple SSD systems. COMPBRN IIIe calculations show that a fire in one of these battery rooms will not fail the 125 V DC conduit. Defense-in-depth remains and the rooms are thus considered not risk significant. The battery rooms are individual fire areas with 3 hour fire rated boundaries. Because the batteries are immediately adjacent to the charger rooms, and because the batteries are distributed sources capable of involving nearby components, credit for the 3 hour fire barrier wall is assumed.

The two other fire zones associated with DC power are 0-28B-I and 0-28B-II. Each zone contains a single division of 125 V and 250 V DC chargers and load centers. Zone 0-28B-II contains both divisions of 125 V distribution panels. (The division II 125 VDC distribution panels are separated from the rest of the zone by 1 hr rated fire barrier enclosures.) Because only cabinets are located in these zones, only the cabinet of fire origin is assumed to be failed (based on COMPBRN IIIe calculations). As the above discussion regarding the 250 V DC batteries suggests, loss of 250 V chargers and load centers leaves DID intact. However, loss of a single channel of 125 V DC power (spec. channel A or B) results in loss of CIG (may result in inboard MSIV closure), loss of ARI, HPCI or RCIC, one division of ADS and ESW, as well as a CRD, CS, and RHRSW pump (by loss of breaker control), and 2 RHR pumps (breaker control and cooling). The loss of a 125 V DC bus (A or B) with the independent failure of the second yields the largest calculated core damage frequency from transient initiators in the IPE (Reference 4-8). The loss of a channel may be caused by fire in the charger which also shorts the battery, or fire in the load center or distribution panel.

Strictly speaking, the loss of 125 V DC power satisfies core level DID. However, because the loss of the second bus results in complete loss of high pressure vessel makeup (except a single CRD pump) and depressurization capability, and results in loss of containment decay heat removal capability (via loss of ESW and RHR pump cooling), the loss of a 125 V DC bus is judged to be risk significant. This significance is in spite of the limitation of fire damage to individual cabinets. Because the damage is restricted to single cabinets, however, the importance of fire barriers between 0-28B-I and II is limited to ensuring no cross-zone damage from suppression effects.

The two control structure elevations above the battery and charger zones contain equipment for the control structure HVAC (zones 0-29B and 0-30A). Because the fire sources are either contained (MCCs or fans in ducts) or small (pumps) the impact on the zone is generally limited to loss of the source. The only combustible capable of affecting multiple trains of HVAC is the 15 gallons of lube oil per CS chiller. Each chiller sits in a separate bay. COMPBRN IIIe calculations show that a spill of this oil from one chiller will not disable the other chiller or destroy cable (in conduit) near the leaking chiller. Credit for this lack of damage is due to a curb installed as part of the Appendix R modifications which prevents the oil from spilling beyond the affected chiller bay. Effect on plant operation is limited to loss of 1 train of CSHVAC. However, in either zone, even with total loss of control structure HVAC, plant operation may be affected only after a relatively long period of time (about 24 hours, Reference 4-19). Thus, given that fire in 0-29B or 0-30A is limited to a single component/train of CSHVAC, the long term impact even if both trains are lost, and the possibility of providing supplemental cooling to other control structure zones (LOOP or loss of EDG not assumed), a fire in these zones is judged not risk significant.

The analysis of relay room and control room fires is summarized here. The relay room contains the Power Generation Control Complex (PGCC) consisting of the termination cabinets and pre-packaged wiring used for the control and operation of the SSES. These cabinets and their associated wiring are pre-assembled by GE and are "plugged in" during plant construction. The cable between these cabinets lies under a false floor in each room which has its own fire detection and suppression system (Halon). Testing by GE (NEDO 10466A) confirms that when installed as designed, under-floor PGCC fires self extinguish. Although not part of the PGCC, the control room floor is constructed similarly. Because these under-floor areas are generally inaccessible and contain only cable, they are considered cable chases with insignificant chance of fire occurrence and are not considered further.

The cabinets themselves are considered potential sources of fire because they contain energized electrical components such as power supplies, relays, switches, CRTs, etc. Cabinet fires have occurred at nuclear power stations (e.g. SSES control and computer rooms, Nine Mile Point-1 control room). SNL tests show that, under the proper conditions, cabinet fires can destroy all wiring within a cabinet. Because these cabinets perform vital I&C functions for safety equipment, they are studied in detail. As discussed above in the section describing propagation analysis assumptions, several assumptions are made about cabinet fires. First, fire in a cabinet is assumed to stay within the cabinet or, given a full partition within the cabinet, on the side of the partition in which the fire starts. Justification for this assumption is provided in the methodology section above. Second, complete loss of all equipment within the cabinet or cabinet section of origin is assumed. This assumption is very conservative and employed only to simplify the analysis. Third, no automatic evacuation of the control room is assumed. Despite SNL testing which shows dense smoke developing during cabinet fires, actual cabinet fire experience within the industry shows fires are limited to ignition of the component failed, typically printed circuit boards or instrument power supplies. Even during the Browns Ferry fire, approximately 1 hour passed before obfuscation of the fire location became a concern. Further, the SSES control rooms are provided with manually actuated smoke removal capability (Section 9.5.1 of FSAR). Given that the control room is continually occupied by people who are trained in fire detection and suppression, the actual nuclear industry experience with cabinet fires, and the non-propagation of fires between cabinets, continued occupation of the control room is virtually assured. Thus, only in the event that fire within a cabinet disables control of sufficient shutdown equipment from the main control room will the main control room be evacuated (so that control may be regained at the remote SD panel). Detailed discussion of the control room-remote SD panel interaction is deferred to review of the FRSS issues below.

Analysis of relay and control room cabinet fires includes determination of which equipment is lost, and which may be inadvertently actuated via hot shorts, in each cabinet. Details for each cabinet are found in Table 4.27. The results of this analysis show that defense-in-depth is satisfied for any cabinet fire, subject to the assumptions above.

The most risk significant cabinets in the relay rooms are 1C617 (URR) and 1C618 (LRR). In each case fire causes loss of one division of RHR and either HPCI (1C617) or RCIC (1C618). DID remains available via RCIC (or HPCI), and two divisions of ADS and CS.

The most risk significant cabinets in the control room are the reactor core cooling systems benchboard (1C601) and the plant operating benchboard (0C653). The 1C601 cabinet controls the ECCS functions and is divided into divisionalized sections. Fire in the middle section of the panel may cause isolation of the div I MSIVs and loss of RCIC, ADS and all non-ADS SRVs, and div. I RHR and CS. However, HPCI and CRD remain available for HPM. Division II RHR and CS are available from the control room. ADS is available from the relay rooms. Thus, defense-in-depth exists. The plant operating benchboard (0C653) controls circuit breakers for all three power sources (2 off-site, 1 EDG) for all ESS buses for both units. A fire in this cabinet can result in SBO. However, the probability of SBO given a fire in this cabinet is extremely remote because at least 4 hot shorts must occur to cause loss of all three power sources on all 4 ESS buses. Automatic start and load of the emergency diesel generators is not affected; to lose the EDG on a bus the diesel trip circuit must hot short. Even if SBO does occur, because the EDGs themselves are not disabled, power may be restored in short order by taking control of the diesels at local control panels. Even if power is not restored, DID exists here as in other causes of SBO, that is, HPCI, RCIC, and the diesel driven fire suppression water system remain for injection to the reactor vessel (Reference Table 4.27). Because of the significance of SBO however, cabinet 0C653 is not screened out.

One observation worth noting regarding cabinets in the control and relay rooms at SSES is that there is no evidence that cabinet fire ignition will occur, either from transients or electrically, as described by SNL tests (References 4.27, 4.29). Walkdowns of these cabinets and discussions with control room operators indicate no acetone or other flammable materials are used to clean cables. Only occasional vacuum cleaning of cables is reported. During the walkdowns, operators showed extreme sensitivity to walkdown personnel opening cabinet doors or introducing anything (fingers, pens, etc.) into cabinets which might affect instrument/control response. The supposition that combustible containers of flammable liquid would be left carelessly unattended inside a control panel (i.e. the SNL transient fuel package) is not supported by operating experience. Further, the SNL test configuration is designed to maximize fire impact. Individual conductors are well separated to ensure good air/fuel mix and are located immediately above the flame source; cabinet doors are left open to provide unlimited oxygen and allow rapid smoke obfuscation of the enclosure; etc. Further, all "at power" control cabinet fires recorded in the EPRI Fire Events Data Base (Reference 4-16), and all control cabinet fires at SSES (Reference 4-18), result from electrical faults (e.g. circuit board components, power supplies, relays, etc.) and not transient combustibles in the panels. Even with electrical fire sources, no recorded control cabinet fire propagated beyond a few of the components in the cabinet. SNL testing indicates that while electrically induced fires in IEEE-383 control cabinet cable are possible, they are difficult to initiate. In practice the construction and electrical protection of cabinet circuitry is not conducive to fire propagation. And SNL testing does confirm that, regardless of the initiation source, fire propagation beyond the cabinet of origin is very unlikely. Thus, the assumption of an all consuming cabinet fire is very conservative.

### 4.3.2.4 Cross Zone Fires

#### 4.3.2.4.1 Cross Zone Fire Methodology

At the outset of the fire hazards screening methodology described above it was stated that fires are assumed to remain in the fire zone of origin. This assumption is consistent with the construction and original design basis of the plant. Actual combustible loading of individual fire zones also confirms this assumption. It is noted, however, that certain walls credited as fire boundaries are not considered such for the Appendix R analysis, even though actual construction of the boundary (e.g., walls, doors, penetration seals, etc.) may be the same as one so credited. In the interest of completeness, in this section of the IPEEE fire PRA the assumption of fires remaining in their zone of origin is relaxed, and the possibility of cross-zone fire spread is examined.

Several other assumptions about multiple zone fires are made in addition to the base assumption of the possibility of cross-zone fire spread itself. First, the zone of origination must contain a source sufficient to affect equipment or cable in an adjoining zone, assuming the zone boundary is failed. This assumption is consistent with the "best estimate" focus of the PRA. Second, boundaries which delineate "fire areas" for Appendix R analysis purposes are assumed to have their fire ratings intact. The second assumption is in concert with the FIVE methodology and the emphasis on fire safety required by the Appendix R regulation. Third, unless a significant quantity of combustibles exists in the adjacent zone into which the original fire spreads, fire spread is assumed to be limited to this adjacent zone. This assumption is also in keeping with the realistic approach of the PRA.

The consequence of the first assumption is that the only candidates for cross-zone fires are those zones containing sources capable of fire propagation. At SSES, because cable is rated to IEEE-383 type testing and because of control of transients, only lube oil and battery cases are sufficient to affect equipment beyond the source fire. The ability of lube oil to spread far beyond the spill source creates a propagation hazard by the nature of the combustible material. Failure of zone boundaries leaves battery cases immediately adjacent to the 125 V DC battery chargers. The significance of loss of 125 V DC has already been discussed above.

As presented in the fire propagation analysis, however, most sources of oil and grease in the reactor building and control structure are insufficient for damage beyond the spill source, let alone beyond a zone boundary, and are not considered sufficient to cause cross-zone fires. Only "large" concentrations of oil are possible cross-zone initiators. The locations of large amounts of oil at SSES are also the locations of large mechanical equipment: pumps, turbines, and diesel generators. Thus, the locations considered candidates for cross-zone fires are:

Turbine building

645' elevation of the reactor buildings (large ECCS pumps)

Emergency diesel generator zones

ESSW pump house

Circulating water pump house

The second assumption is used to disqualify most of these zones as sources of risk significant multi-room fires. The turbine building is separated from the reactor buildings and control structure by 3 hour rated Appendix R fire walls and loss of the turbine building does not disable any ECCS equipment. The circulating water pump house is remote from the other plant buildings and contains no safety related equipment (but does contain two of the three fire pumps). The two divisions of ESW located in the ESSW pump house are separated into fire areas by three hour fire walls capable of containing a fire in one area. The same is true for the EDG zones (Reference 4-3). Only the lowest level of the reactor buildings contains large quantities of lube oil in safety related equipment in zones not separated by Appendix R fire area boundaries. Because the individual battery rooms are also Appendix R fire areas bounded by 3 hour rated walls, ceilings, and floors, only the lube oil sources on the 645' elevation of the reactor building remain as possible cross-zone fire initiators.

The lowest level of the reactor building contains the CS, HPCI, RCIC and RHR pumps. Each CS pump contains 13 gallons of oil, each RHR pump 76 gallons of oil, and the HPCI pump/turbine about 155 gallons of oil (Reference 4-6). The division I and II CS and RHR pumps are separated by 3 hour rated fire walls. As a result of this separation and the assumed non-propagation across the 3 hour boundary, zones 1-1A (div. I CS), 1-1F (div. I RHR) and the adjacent zones in the same area are assumed to be possible cross- zone fires. Because of the minimal combustibles in these adjacent zones, fire spread is confined to them (assumption 3). Thus, cross zone fires are limited to zones 1-1A, 1-1F, 1-1G (oil sump room), 1-2A (misc. MCCs), 1-2C (RR bay), 1-3B-S (no safety equipment), and 1-3C-S (valve gallery) in fire area R-1A. For equipment in fire area R-1B, again because of minimal combustibles in adjacent zones, cross-zone spread is limited to zones 1-1B (div. II CS), 1-1C (HPCI pump), 1-1D (RCIC pump), 1-1E (div. II RHR), 1-2B (HPCI, RCIC valves, 1 MCC, cable in conduit for ESW control), 1-3C (valve gallery), and 1-3B-N (HPCI MCCs).

The impact of individual zone fires has already been addressed in preceding report sections. To determine the likelihood and impact of cross-zone fires the following approach is used:

1. Assume the failure of all safety equipment/cable in zones possibly affected by cross-zone fire.

2. If defense-in-depth is retained given this wholesale equipment loss, cross-zone fire impact is acceptable, and cross-zone fire is not considered further for the affected zones.

3. If defense-in-depth is not achieved, perform fire propagation analysis to find the actual possibility of cross-zone fire. This analysis may consist of comparing fire barriers in fire rated walls to those in un-rated walls. If the barriers are the same, no fire spread is assumed. If the barriers are not the same, COMPBRN IIIe calculations are performed to determine impact on adjacent zones. If no impact is seen and defense-in-depth is achieved, cross zone fire is again not considered further.

4. Consistent with the analysis of individual fire zones, the initial look at cross-zone fire propagation does not take credit for fire wrapping (e.g. Thermo-Lag) or detection/suppression. If the fire propagation analysis in step 3 shows cross-zone fire results in loss of DID, the propagation analysis is repeated first with credit for fire wrap, then with credit for detection and suppression. If DID exists with credit for either/both, cross zone fires are judged risk acceptable. If credit for either fire wrap or detection/suppression is taken, however, the failure rate of these fire protection measures is estimated and a frequency of core damage is calculated for the cross-zone fire scenario.

5. If fire propagation study with credit for fire wrap and detection/suppression shows DID is still not achieved, the cross-zone fire is considered a risk significant vulnerability.

#### 4.3.2.4.2 Cross Zone Fire Results

Study of Tables 4.16 and 4.18 shows that for the fire zones in area R-1A with cross-zone fire potential (listed previously), loss of all equipment in all zones leaves at least CRD, both divisions of ADS, and division II of CS and RHR available. Defense-in-depth is retained assuming complete cross-zone fire damage in the seven zones. Thus, cross-zone fire damage is considered acceptable and not risk significant in area R-1A. Cross-zone fire in area R-1A is not considered further.

Study of Tables 4.16 and 4.18 for zones in area R-1B with cross-zone fire potential shows that in all zones except 1-2B and 1-3B-N defense-in-depth remains via CRD, both divisions of ADS, and division I of CS and RHR. Because of the way the reactor building rooms are positioned, fire zones 1-1B, 1-1C, 1-1D, and 1-1E are adjacent (via wall or ceiling/floor) to fire zone 1-2B. Zone 1-1C contains the HPCI pump and its 155 gallon lube oil sump. Fire zone 1-1E (division II RHR pumps) is also adjacent to fire zone 1-3B-N (ceiling/floor). Zone 1-2B contains cable for both divisions of ESW and loss of this cable leaves only ESW pump D (1/2 of division II) operable. ESW pump D can cool RHR pumps B and C. Because Appendix R analysis takes no credit for RHR pump C, only RHR pump B cabling has been identified here and only RHR pump B can be assumed to function. Because RHR pump B is in division II and cross zone fire fails division II RHR in other zones, cross zone fire in area R-1B fails all RHR. Equipment failure in zone 1-3B-N includes cable for division II ADS, and loss of this cable causes loss of DID for the cross-zone fires in area R-1B.

Because, given complete loss of all equipment/cable, defense-in-depth is not achieved for cross-zone fires in area R-1B, the boundaries of the zones are examined to determine if they may be considered credible fire stops. Review of the construction of the walls of these boundaries shows they are concrete greater than 2 feet thick similar to that used in the construction of Appendix R fire area walls. Penetrations of these walls are of the same type (Bisco) and generally have the same three hour fire rating as those installed in the Appendix R boundaries. Those having less than a three hour rating are sufficient to contain a fire involving the actual combustible loading within a zone. The doors between all zones on the 645' elevation are flood doors certified by Factory Mutual as 1.5 hour rated; the same as those between Appendix R fire zones. The pressure rated doors from zones 1-1C and 1-1D to the 670' elevation (1-2B) are the same as those rated as 1.5 hour doors by Factory Mutual (Reference 4-3). The flood doors are all normally closed with mechanical dogs and the pressure rated doors on 670' elevation are all normally locked closed. No failures of these doors have ever been recorded at SSES. No failures of the Appendix R penetrations on these elevations have been recorded. SSES procedures for modifications work require restoration of all penetrations (even those not required by Appendix R analysis) to original specifications. Because: the construction of the zone boundaries is identical to that used in the Appendix R fire area boundaries or found to be sufficient to cope with actual fire duration; no failures of these boundaries have been experienced; the minimum fire duration of any component in the boundary is 1.5 hours (door); and because the maximum fire duration of any zone is 22 minutes (HPCI, Reference 4-6); then it is expected that fire originating in any zone in area R-1B will remain in the zone and no cross-zone fire will occur. Cross-zone fire in area R-1B does not appear to be risk significant.

Analysis of the those zones with cross-zone fire potential shows that cross-zone fires are not expected to occur and, given cross zone fires, equipment sufficient to safely shutdown SSES will survive. With limited exceptions, DID is satisfied even if all-consuming cross-zone fires are postulated. Further discussion of

fire barrier effectiveness is found in Section 4.8.2.1 of this report which deals with the FRSS issue. Cross-zone fire is not considered further.

### 4.3.3 Summary of Fire Propagation Results

The fire PRA phenomenological studies (fire hazards-Reference 4-18 and this propagation analysis) show that core level equipment defense-in-depth (DID) is satisfied in all zones in the unit 1 reactor building and control structure. The PP&L DID criteria for the core is that, given an initiating event, core damage shall not occur without multiple failures of redundant or diverse equipment, and, given two equipment failures, no additional fission product boundary loss beyond core damage will occur without additional independent equipment loss. Procedural and interface criteria are also satisfied. All equipment use is addressed in the EOPs and fire damage is insufficient to cause loss of I&C sufficient to prevent effective monitoring and control. The core level DID criteria is only a restatement of the single failure criteria, i.e. no single failure results in CD. The fire PRA confirms that there are no design basis vulnerabilities to fire.

The forgoing is not to say that all fires have inconsequential impact on SSD equipment. Despite satisfaction of DID, certain fires can result in loss of multiple SSD equipment. Because of the large room areas involved and the limited combustible loading, equipment loss due to reactor building fires is expected to be minimal. While the loss of cable in the reactor building fire zones has the potential to fail multi-divisional SSD equipment, the actual ignition sources, generally small pumps, valves, and limited long-term transients, are insufficient to cause extensive cable damage. Based on these analyses and plant walkdowns, the results for the unit 1 reactor building are considered applicable to the unit 2 reactor building as well. This minimal risk contribution from the reactor buildings is consistent with other fire PRAs. Also consistent with other fire studies is the result that the most significant zones are those which are smaller and contain large numbers of instrument and control cabinets. The most risk significant zones are the battery charger rooms (0-28B-I and II) because of the loss of 1 division of 125 V DC. Loss of one division of 125 V DC with the independent loss of the other results in the largest calculated frequency of core damage for transient initiators in the IPE. For cabinet fires, those which cause loss of 1 train of high pressure and low pressure vessel injection, or those which cause loss of AC power are the most risk significant. Despite the multiple SSD equipment failures which may result from some cabinet fires, separation criteria appear adequate (separate divisional relay rooms, fully partitioned control room cabinets) to guarantee DID. The most significant fire locations, in terms of SSD equipment loss, and the reasons for their significance, are listed in Table 4.28.

These propagation results are based on credit for: Appendix R equipment, HPCI, and CRD; actual combustible loadings; and PP&L housekeeping and combustible control procedures. No credit is taken for equipment or systems not listed above, fire protective wrap, or installed fire detection and suppression. While these results are in part consequences of the assumptions made for this analysis, all assumptions made are firmly based on actual fire experience, tests, other studies, calculations, and/or the actual plant construction of SSES. Essentially the sources available for ignition at SSES are too small and equipment available for safe SD too widely separated to jeopardize core cooling and decay heat removal.

## 4.4 Evaluation of Component Fragilities and Failure Modes

In this fire PRA, loss of component function from direct fire impact is limited to overheating. Although smoke, soot, caustic gases etc. are also products of combustion, their effect is uncertain enough to render worthless any conclusions based on assumed impact. Evidence from actual fires and SNL testing (Reference 4-29) shows that smoke, soot, etc. do not cause failure of equipment, at least in the short term. It is expected that after a fire the zones affected will be inspected and equipment suffering from soot deposition will be cleaned or replaced. The effect of water spray on safety related equipment is addressed in the discussion of FRSS issues. Again, the separation of equipment by room or cabinet limits the impact of combustion products.

As discussed previously, cable loss of function is assumed at 700 F. For I&C equipment in cabinets, loss is assumed at 325°F. This temperature is established by SNL testing of relays and is consistent with failure temperatures used in other risk assessments (i.e., Reference 4-17). Again, no detailed in-cabinet fire propagation analysis is performed. Fire within a cabinet, MCC, etc is assumed to fail all equipment within the cabinet. Ignition of fire sources is handled on a case specific basis with ignition data derived from various industry sources. Specifics are found in the detailed propagation (e.g. COMPBRN IIIe) calculations. Non-fire induced failure, that is, independent and dependent equipment failures, are considered in the plant systems analysis through equipment failure rates and equipment dependency matrices.

## 4.5 Fire Detection and Suppression

Fire detection and suppression at SSES are comprised of both automatic and manual systems using heat, flame, and combustion products for detection, and water, $CO_2$, and Halon for suppression. Complete descriptions of these systems are found in Section 9.5.1 of the FSAR, and Section 4 of the FPRR (Reference 4-3). Failure data is collected in Reference 4-33. Although not credited in the PRA, the following discussions about detection and suppression are provided for information.

### 4.5.1 Fire Detection

#### 4.5.1.1 SSES Fire Detection System

SSES fire detection is comprised of automatic systems and, failing these, roving and continuous (stationary) fire watches. The automatic systems are comprised of the Simplex system and others. The Simplex system has two functions: to provide ionization and photo-electric detection in all monitored zones; and to relay alarms of the Simplex detection, water systems, CO2 systems, Halon systems, and valve position to the control room. CO2, Halon, and some preaction/deluge systems have their own heat detection systems for actuation, and some preaction systems use the Simplex detection system for actuation. All detection systems provide alarm signals to the control room. Indicating lights and printouts enable operators to identify the location of the fire. The Simplex system performs numerous self-diagnostics and also alarms on loss of detector/detector string function, loss of normal power (Simplex is backed by a 24 hour battery independent of the station batteries), and various losses of Simplex oversight functions. The system is comprised of two redundant 100% panels. Loss of 1 alarms in the control room. Swap to the other is performed manually. Various surveillances (T.S. 3/4.3.7.9) are regularly performed on both the Simplex system and individual fire detectors. Further details of the system are found in PP&L procedure "Fire/Smoke Detection and Alarm System" (Reference 4-37). All zones of safety significance or with combustible materials in them in both the control structure and the reactor buildings are monitored by automatic detection. Locations of individual detectors are found on the fire protection features drawings (C-1700 series).

Fire detection system operation is governed by the Technical Specifications (T.S. 3/4.3.7.9). If insufficient detectors are available for monitoring fire zone(s), fire watches are required to be posted. These watches may be roving, covering several fire zones, or continuous, i.e. posted at a fixed location. Fire watches are required when hot work (grinding or welding) or cable pulling operations are performed. Watches are also established when fire barriers are breached, e.g. for maintenance or modifications work. For purposes of the fire PRA, these fire watches are considered equivalent to the installed automatic detection systems.

#### 4.5.1.2 Loss of Fire Detection at SSES

Loss of fire detection is not loss of the Simplex system alone. Although the Simplex system detects loss of function of transponders, detector strings, detector electrical continuity, system power, etc., it is incapable of detecting failure of sensing capability of individual detection devices. The Technical Specifications (3/4.3.7.9) mandate that individual detectors be surveilled at 6 month intervals. Loss of automatic detection is thus loss of Simplex or loss of sensing capability of individual detectors in a zone. Because of the equivalency of fire detection represented by Simplex and fire watches, both must be lost for the detection function to be failed. That is, it is assumed for this analysis that fire watches are at least as reliable as the automatic Simplex system for the detection of fires. Given that all fires at SSES have been detected by humans, this reliability is demonstrated. The NRC staff recognizes the importance of human action in preventing fire damage. An NRC re-examination of fire protection (Reference 4-39) observes that

human action is the "first line of defense" for fire, and that "fire watches may be more valuable... than previously recognized."

The Simplex system function has been lost at various times, mostly due to severe weather (lightning). At such times, Simplex alarms alert operators to the loss and fire watches are established. Technical Specifications require establishment of required fire watches within 1 hour of loss of the Simplex system. No losses of Simplex have gone undetected. Thus, for the purposes of this analysis, loss of detection is governed by failure to set or perform required fire watches within the times allowed, or by loss of sensing capability of individual detectors.

Search of SSES SOORs reveals the occasions of Simplex loss, failures of individual detector surveillances, and the frequency of failure to set fire watches. This data is summarized in Table 4.29. The data in Table 4.29 for each SOOR is presented on 2 pages. Page 1 presents the date, operating mode, and failure description. Page 1.A presents mitigating actions taken and the location of the failure. The criteria used in defining importance of detector/fire watch failure are that the loss must occur during power operation, and the zones affected must be in the control structure or reactor buildings. Because no loss of Simplex has gone undetected, these losses are not presented. The data shows that in two cases, fire detector surveillances found failed detectors not seen by Simplex and which required posting of fire watches (i.e. detector loss reduced sensing capability below the minimum considered acceptable.) On 9/16/83, 1 detector was found affecting one fire zone (SOOR 1-83-281). On 6/10/87 three detectors were found which affected three fire zones. Because surveillances are performed every 6 months, we assume that the detectors failed halfway through the surveillance interval and thus are failed three months each. Five SOORs document times that fire watches were not performed in the time required:

| Date | SOOR No. | Affect |
|---|---|---|
| 6/19/88 | 2-88-251 | 26 fire zones for 1 hour |
| 10/25/88 | 2-88-288 | 52 fire zones for 48 hours |
| 1/13/90 | 1-90-006 | 4 fire zones for 6 hours |
| 1/14/90 | 1-90-008 | 139 fire zones for 32 hours |
| 7/1/92 | 1-92-253 | 1 fire zone for 5 hours |

The total probability of detection failure is taken as the combination of the loss of detectors unseen until surveillances are performed, or failure to set fire watches as required:

Prob. loss of detection (per zone)= (Prob. loss of sensing) + (Prob. failure to set fire watch)

Prob. loss of sensing= No. of zone-hours without sensing/Total zone-hours operational

Prob. failure of fire watches= No. zone-hours without watch when req'd/ Total zone hours op.

The number of zone-hours affected by loss of sensing is 4 zones for three months or 8760 zone-hours. The number of zone hours affected by failure to set fire watches is the sum of the products of the zones and hours in the table above, or 6999 zone-hours. Total zone-hours operational is taken to be 15.1 reactor-years for 191 fire zones (77 control structure, 62 unit 1 reactor building, 52 unit 2 reactor building-Reference 4-3) or 2.53 E7 zone-hours. Thus, the point estimate of failure of detection in the control structure and reactor buildings zones is:

Prob. loss of detection = (8760 + 6999)/2.53 E7
= 6.23E-4/demand (i.e. per fire in a zone)

### 4.5.2 Fire Suppression

As described in the screening and hazards analyses sections above, because of the nature of plant design and operation no credit is taken for fire suppression in showing adequate defense-in-depth against fires. The fire screening and propagation analyses show that fires originating in any zone will, undetected and unsuppressed, burn out without destroying equipment sufficient to violate DID. In reality, given the occurrence of fire, the automatic Simplex system or fire watches will alert plant personnel to the fire and automatic or manual fire suppression will occur. Because only cabinet fires are shown to be risk significant (battery charger rooms, relay rooms, or control room, Table 4.28) and because fire within a cabinet is shown to be limited to the cabinet, only cabinet suppression systems have direct impact on plant fire risk. Data for other suppression systems is provided for information. Effects of inadvertent activation are described in Section 4.8.

#### 4.5.2.1 Automatic Suppression

Three types of automatic suppression are available: water, carbon dioxide, and halon. At SSES wet pipe, dry pipe, deluge, and pre-action water systems are used. In the reactor building, deluge systems are employed in locations where large oil fires are possible, that is, on the 645' elevation above the HPCI and RCIC oil sumps. Deluge systems mitigate the consequences of the potentially largest fires and the ones most likely to spread beyond the zone of origination. Because of the presence of electrical equipment (MCCs) above the 645' elevation, pre-action water systems are generally used. No sprinkler systems are used where actuation may fail large electric motors for ECCS pumps (CS or RHR). Deluge and pre-action systems are also employed in selected locations in the control structure, e.g. above the control structure chillers and the cable spreading rooms, respectively. Location details are provided in FSAR section 9.5.1.

The water used for fire suppression is supplied from the clarified water storage tank or the cooling tower basins. Two diesel driven fire pumps (0P511 and 0P592) and a motor driven fire pump supply a buried ring header off which the various supply lines for both automatic suppression and manual hose stations are tapped. 0P592 takes suction from its own 500,000 gallon water supply, tank 0T594. (Manual valve alignment is required to supply ring header.) A jockey pump is used to maintain header pressure against any leakage. (Additional details are found in Appendix A of Reference 4-8). Because sprinkler nozzle operation is virtually 100% reliable, and because all valves other than active water delivery valves are manual and normally open, water system reliability is limited by pre-action or deluge valve operation, or by fire pump reliability. Search of SOORs reveals only a single pre-action valve failure recorded for SSES (XV-22255, SOOR 2-90-151) for the 719' elevation of the unit 2 reactor building. No deluge valve failures have occurred at SSES. Because of the lack of sufficient failure data for these valves, and because these valves are essentially solenoid piloted check valves, the failure rate is estimated based on generic industry failure data for solenoid valves (0.001 per demand) and failure of check valves to open (1.1 E-4/demand) (Appendix C of Reference 4-8). Total deluge and pre-action valve failure to open on demand is thus about 0.0011. Data gathered for the IPE for fire pump operability shows that frequency of failure of all fire pumps (loss of motor driven pump assumed) is 4.0 E-4/demand (Reference 4-8). This pump failure rate also assumes a 6.7% common mode couple for the two diesel pumps. Because failure of automatic fire suppression water in a zone can be caused by either failure of the fire pumps or by failure of the delivery valve, the failure rate of suppression is the sum of the individual failure rates or 1.5 E-3 per demand. Automatic suppression loss is dominated by valve failure.

Carbon dioxide and Halon systems are used for automatic suppression of fires in cable chases and electrical cabinets. No automatic suppression is provided in the battery charger rooms. Thus, only the fire suppression systems used in the relay rooms and control room are examined.

The underfloor area of the relay rooms and the cabinets containing safety related equipment (i.e. PGCC) are protected by separate Halon 1301 systems. Heat detectors in the cabinets and under the floor trigger automatic actuation of the appropriate Halon 1301 system. The Halon systems are designed to suppress fires within specific PGCC cabinets and under-floor cable sections. To suppress fire outside of cabinets or involving substantial sections of the relay rooms, total $CO_2$ flooding is provided. Flooding is automatic on heat detection within the relay room involved, after predischarge alarms are sounded. FSAR section 9.5.1 provides additional details.

The carbon dioxide and Halon systems in the relay rooms are governed by Technical Specifications (3/4.7.6). Data from SOORs shows that, except for a design deficiency discovered and corrected early in plant life (SOOR 1-84-023, 1/17/84) no losses of $CO_2$ have occurred during power operation. Four separate incidents of partial or full loss of Halon to a zone during power operation are recorded: SOOR 2-85-98 (partial loss unit 2 lower relay room); SOOR 2-86-060 (partial loss unit 2 lower relay room, failed by and corrected during surveillance); SOOR 1-92-353 (total loss to unit 1 and 2 upper and lower relay rooms for 20 minutes- tripped power breaker); and SOOR 1-92-378 (partial loss unit 1 upper relay room). Fire watches are stationed when loss of Halon system operability is detected. (Again, the establishment of fire watches is assumed to return suppression capability to that which would exist with automatic actuation fully operable.) No loss of Halon occurred without plant staff knowledge and setting of required fire watches.

The carbon dioxide systems are required to be functional during all modes of operation. Carbon dioxide delivery to a zone requires successful operation of the CO2 tank, master pilot and selector valves (1 each), local pilot and hazard selector valves (1 each), fire protection dampers in room HVAC ductwork (2), and the associated sensors and electronics. Because of the passive nature of tank operation, failure is dominated by active components, i.e. valves, dampers, and I&C. Because of the lack of SSES failure data, generic data from the IPE is used (Appendix C of Reference 4-8). The pilot valves are all solenoid operated (failure prob. 0.001/demand), the selector valves are all fluid operated (failure prob. 2.2 E-3/demand), and the fire protection dampers are essentially solenoid operated valves. The failure of detection is taken to be the same as determined above, 6.2 E-4/demand. Combination of these failure rates yields the estimated failure probability of CO2 delivery to a zone:

$$\text{Prob. } CO2 \text{ Loss} = (0.001 + 0.0022) + (0.001 + 0.0022) + 2*(0.001) + 6.2\text{ E-4}$$

$$= 9.0\text{ E-3/demand.}$$

This failure rate is also applicable to the under-floor area of the control room. Common cause failure of the CO2 delivery system is the failure of the master pilot or master selector valve, 0.0032/demand.

The Halon delivery system consists of the Halon tank, a solenoid valve, and associated instrumentation. Failure probability of a Halon system is calculated as above and is the failure rate of the valve or the instrumentation. Failure of Halon delivery is estimated to be about 1.6 E-3/demand.

#### 4.5.2.2 Manual Suppression

Manual suppression is provided by the fire brigade, hot work fire watches, and others who may discover fires at SSES. Generally, while fires are most likely to be caused by human action (e.g. grinding, welding, improper disposal of cigarettes), the presence of humans is also the reason such fires are quickly suppressed. (Note that all trash can fires were suppressed by passers-by who discovered the smoldering trash.) For the purposes of this report section, only the equipment available for manual suppression is discussed. The training of the fire brigade is presented in the FRSS issues section below.

Hand held and wheeled fire extinguishers are located throughout the station for use in suppressing incipient and small fires (Reference 4-3). The type of extinguisher in each location reflects the type of combustible material in the area. For example, BC type extinguishers are generally located throughout the reactor building because oil, or electrical fires may occur. Extinguisher location is consistent with NFPA and OSHA regulations and recommendations (Reference 4-3 and FSAR 9.5.1).

Hose stations are distributed throughout the plant for use by the fire brigade in fighting larger fires. Hose stations are situated so that there is no inaccessible area of the reactor building or control structure (Reference 4-3). Because the only active (non-manual) components in the fire suppression water delivery system used in hose stations are the fire pumps, failure of fire suppression due to mechanical failure is taken as the failure rate of the pumps, 4.0 E-4/demand.

### 4.5.3 Summary of Detection and Suppression

Review of fire detection and suppression systems in place at SSES shows that the probability of not having these systems when required is quite small. Failure of detection is estimated to be approximately 6.0 E-4 per demand. This failure estimate is probably high considering the success of human detection of fire at SSES. Detection of control room fires is expected to be 100% because of continuous manning of the control room by fire-brigade trained personnel. Failure of automatic water suppression systems is estimated to be about 1.5 E-3/zone-fire. Failure of both automatic and manual water suppression is dominated by the common cause failure of the fire pumps at approximately 4.0 E-4 per demand. Failure of carbon dioxide and Halon systems is estimated to be 9.0 E-3/demand and 1.6 E-3/demand, respectively. Although fire suppression is possible only after detection, detection/suppression loss is dominated by failure of suppression at about 1.5 E-3/demand to 9.0 E-3/demand, depending on the suppression system.

The above calculated automatic suppression system failure rates are approximately 0.5 to 1.5 decade less than reported elsewhere for industrial and commercial facilities (Reference 4-21). The following explanations are offered as possibilities for these differences, although no work has been done to verify them. First, the above failure analysis assumes that detectors are situated so that fires will in fact be detected. If detectors are located so that local fires may grow without detection then failure of the suppression system is assured. Partial support for this position is given in a foot note to the above Reference which indicates that all automatic deluge and preaction system failures were corrected by manual actuation of these systems. Second, much of the data appears to come from non-nuclear industry sources such as high-rise buildings, etc. Higher failure rates may be a function of the attention paid to these systems. That is, detection and suppression systems in nuclear facilities are included in Technical Specifications which require regular surveillances. Thus, nuclear power plant installations in particular may have failure rates closer to those calculated here than to those experienced in general for all industries.

Although no credit for detection or suppression systems is required to show adequate defense-in-depth for the core, there is no call for neglect or removal of the detection and suppression systems in SSES. The

purpose of SSES is the safe, economic, generation of electricity. While core defense is independent of detection/suppression, the ability to generate electricity is not. That is, detection and suppression systems allow timely knowledge and mitigation of fires which, left to themselves, might impair the station's ability to produce electricity. While obvious examples include the turbine and generator, not so obvious is the potential for extended Technical Specification required shutdown if significant ECCS equipment is lost. Thus, fire detection/suppression are important for generation and capital asset preservation. Further, these systems provide defense-in-depth against the loss of equipment which can be used for vessel and containment protection.

## 4.6 Analysis of Plant Systems, Sequences, and Plant Response

The fire hazards and propagation analyses described previously are used to determine safety significant fire zones and direct fire damage. The plant systems analysis is used to study the impact of this direct damage on the ability of the plant to reach a point of safe shutdown and the frequency of core damage.

### 4.6.1 Plant Systems Analysis

The plant systems analysis portion of the fire PRA is taken directly from the IPE for internal events (Reference 4-8). The term "plant systems analysis" as used here is the modeling of the physical equipment in SSES, its interconnections, and the core and containment response during a severe accident. This modeling becomes an exercise in defining "front line systems" which satisfy the requirements of reactivity control, reactor vessel inventory and pressure control, and core and containment decay heat removal. "Support systems" which provide power (AC, DC, pneumatic, or steam), component cooling, room cooling, and I&C for the front line systems and other support systems are defined, and the interconnections between all these systems are determined. Phenomenological calculations to determine BWR severe accident processes and timing are performed to verify the efficacy and timing of equipment and to provide feedback on appropriate operator responses. All of this modeling takes the form of event trees, fault trees, dependency matrices, and equipment/system failure data. This data is used as input to the PP&L written Probabilistic Risk Assessment Code (PRAC) described in Appendix B of the IPE. PRAC calculations determine plant damage state frequency.

All of the modeling done for the IPE for internal events is still applicable for the fire PRA. That is, this fire PRA assumes SSES is as configured in the IPE of December, 1991. Review of P&IDs and controlled Appendix R safe shutdown equipment lists used during the performance of the PRA, and work to develop the safe shutdown equipment list for the SMA, shows this assumption to be good. The plant as configured in December 1992 when the fire PRA began in earnest is the same as that modeled in the IPE. This similarity applies also to the system failure data used. PP&L makes quarterly assessments of safety system performance in compliance with INPO guidelines. Trends of this data from 1991 through 1992 show safety system performance about the same as that modeled in the IPE. Treatment of HRA and common cause failure is also identical to the treatment in the IPE.

The IPE studied the plant response to four types of challenges: transients, LOCAs, ATWS, and internal flooding (Volume 4, Appendix F of the IPE, Reference 4-8). As explained in the general discussion of assumptions used in the fire hazards analysis (Section 4.0.2.1 of this report), fire induced LOCAs and ATWS are judged sufficiently unlikely so as not to be considered. Discussion of internal flooding related to fire is deferred to the review of FRSS issues below. Thus, the plant systems analysis used for the fire PRA is strictly limited to the modeling of fire induced transients.

Three basic types of transients are possible: non-isolation, in which the FW system and main condenser remain available for vessel injection and decay heat removal, respectively; isolation, in which closure of the MSIVs results in loss of FW and the main condenser; and LOOP which causes, in addition to MSIV closure, loss of balance of plant systems. MSIV closure causes vessel pressure to increase. SRVs open to relieve this pressure with the consequential deposition of decay heat in the suppression pool and containment heatup. Unmitigated, decay heat induced pressurization will cause containment failure in approximately 30 hours. The mission time of the analysis modeling is the 72 hours from the on-set of the fire. The isolation and LOOP models consider the possibility of stuck open SRV (results in HPCI failure). Complete descriptions of the transient initiator event trees, fault trees, dependency matrices, and front line system applicability are provided in Appendix F.1 of the IPE. Descriptions of the plant systems, both front

line and support systems, are found in Appendix A of the IPE. Failure data for these systems is provided in Appendix C of the IPE. Descriptions of BWR severe accident phenomenology are provided in IPE Appendix E.

To those not familiar with the IPE it may not be obvious how fire damage impact can be investigated with models developed for study of LOOP (or other transient initiators). First, LOOP results in loss of all equipment not powered from emergency diesel generators or steam from the reactor itself (HPCI and RCIC). This loss leaves only ECCS equipment and CRD. This equipment is exactly that selected for use in the fire PRA. The use of LOOP ensures that only ECCS equipment is modeled in PRA fault trees. Second, while it was initially anticipated that IPE partition event trees would need revision to include the effects of fire detection and suppression, the lack of credit given these systems in the fire PRA renders modification of partition trees unneeded. Third, and perhaps most important, is the IPE methodology itself.

PRA modeling, that is the calculation of plant damage state frequencies, at PP&L is a "support state" method. With this method, the logic and frequency portions of the PRA are split. The logic model is solved first by imposing an initial set of equipment failures on the plant (impact vector) and then assuming various subsequent independent equipment failures. Equipment failure combinations having similar plant impact are grouped into "support states". With support states determined, frequency of each failure combination is calculated and summed to yield a frequency of plant damage. PRAC is used to perform this calculational sequence. Once the plant equipment required for mitigation of core and containment damage is identified, the equipment dependencies determined, and equipment failure rates calculated, the plant model is complete. Plant response to, and plant damage states resulting from, various challenges are determined in a straight forward manner by imposition of the impact vector, part of the PRAC input. Different challenges are studied by changing the impact vector. The fire hazard and propagation analyses determine the fire impact vectors. Thus, with the plant modeled for LOOP, and the fire hazard and propagation analyses complete, fire impact is studied by imposing the direct fire damage on the LOOP model via the impact vector. The same is true with other transient initiators. If propagation analysis shows that a given fire will not result in LOOP but will require a manual shutdown (a non-isolation transient), the fire damage is cast in the form of an impact vector and imposed on the non-isolation model.

### 4.6.2 Dominant Accident Sequences from Fire

The most risk-significant fire locations, in terms of loss of ECCS and CRD equipment, are determined via the fire hazards and propagation analyses. These locations and the equipment lost are summarized in Table 4.28. It has already been determined from these analyses that the PP&L defense-in-depth criteria are satisfied given this equipment loss. This result means that the conditional (that is, given the fire) core damage frequency is less than 1E-6 (see discussion of defense-in-depth screen in fire hazard analysis above). Regardless, core damage frequencies are calculated for completeness.

Note in Table 4.28 that all fires occur in electrical cabinets of various kinds: DC power transformers, load centers, and distribution panels; control room I&C panels; and relay room cabinets. From the propagation analysis it is determined that cabinet fire impact is limited to the cabinet of origin. No suppression is modeled and complete equipment loss/most risk significant hot shorting is assumed. Because equipment loss is limited to individual cabinets, and cabinet contents are relatively easy to determine, no assumption of LOOP is made. That is, the transient response expected (non-isolation, isolation, or LOOP) is the transient model used.

To calculate frequency of various plant damage states, the impact vectors defined by the equipment losses shown in Table 4.28 are used as input to PRAC. While it is true that only Appendix R, HPCI, and CRD

are considered for screening, the other systems such as condensate, FW, etc. are not removed from the IPE models (Note: containment vent is removed from IPE system modeling). The initiating events for which PRAC calculations are made are all cabinet fires. Because the impact of such fires is limited to the cabinet of origin, and cabinet contents are relatively easy to determine, these other systems are considered available unless failed by the fire (or independently during the 72 hour "mission time"). The sections below describe the significant results for the plant damage state calculations. Details are found in the calculation documentation (Reference 3.38).

#### 4.6.2.1 DC Power

The impact of the loss of 125 V DC power from fire is identical to loss from any other source. The loss of power to either of two distribution panels (D614 or D624) with the independent loss of power to the other represents a significant challenge to SSES. The coincidental loss of these two panels causes a plant response similar to that of long term SBO and results in the largest calculated core damage frequency for transient initiators in the IPE.

The distribution panels are supplied by load centers fed by either transformers or station batteries. The equipment for both divisions of this power is located in two fire zones on the 771' elevation of the control structure, 0-28B-I and 0-28B-II, separated by a three hour fire barrier. Walkdown of these zones reveals that fire in the battery rooms will not short the transformers because of physical separation of battery cables. Fire in the transformer is assumed to short the battery supply to the load center, however. Only channel "B" power equipment resides in 0-28B-I: charger 1D623 and load center 1D622. Both channel "A" and "B" components are located in 0-28B-II: charger 1D613, load center 1D612, and distribution panel 1D614 for channel "A"; and distribution panel 1D624 for channel "B". All distribution panels are physically separated and enclosed in individual cabinets. 1D624 and 1D644 are enclosed in 1 hour rated cabinets.

Because there is no difference in plant response to loss of DC power caused by fire vs. loss by other means, frequency of core damage and containment failure are calculated by the ratio of the frequency of power loss due to fire and frequency from independent failure shown in the IPE. To calculate the frequency of fire in these zones due solely to "A" and "B" 125 V DC cabinets, the fire frequencies determined in the fire hazards analysis are de-composed into the individual fire source frequency contributors.

For zone 0-28B-I, table 4.20 shows the individual contribution from the four cabinets and 8 battery chargers in the zone. Fire may also be caused by welding or grinding. Conservatively it is assumed that transients may cause fires in these cabinets. The frequency of loss of either 1D623 or 1D622 is:

(0-28B-I Loss
125 V DC) = (Loss of panel 1D622) or (loss of charger 1D623) or (loss of either due to weld/trans.)

$$=\left(\frac{\text{Frequency Cabinet Fire}}{\text{4 Cabinets}}\right)+\left(\frac{\text{Frequency Charger Fire}}{\text{8 Chargers}}\right)+\left(\frac{(\text{Frequency Weld/Transient Fire})*2}{\text{12 Sources in Zone}}\right)$$

$$=\left(\frac{8.82E-4}{4}\right)+\left(\frac{2.53E-3}{8}\right)+\left(\frac{(4.78E-4)2}{12}\right)$$

= 6.1 E-4/reactor year

= 7.7 E-4/cycle

Above, loss due to welding/grinding or transients is 3.56 E-4/reactor year plus 1.22 E-4/reactor year, respectively.

The loss of 125 V DC power channel "A" or "B" in zone 0-28B-II is calculated similarly. Zone 0-28B-II contains 21 cabinets, 3 of interest for loss of 125 V DC: load center 1D612 and distribution panels 1D614 and 1D624. The zone contains 6 chargers, 1 of interest (1D613). Zone fire frequency due to welding/grinding or transients is assumed to be the same as 0-28B-I.

(0-28B-II Loss
125 V DC) = (Loss of 1of 3 cabinets) or (loss of charger 1D613) or (loss any 1 of 4 due to weld/trans.)

$$=\left(\frac{(\text{Frequency Cabinet Fire})*3}{21\text{ Cabinets}}\right)+\left(\frac{\text{Frequency Charger Fire}}{6\text{ Chargers}}\right)+\left(\frac{(\text{Frequency Weld/Transient Fire})*4}{27\text{ Sources in Zone}}\right)$$

$$=\left(\frac{(4.63E-3)*3}{21}\right)+\left(\frac{1.88E-3}{6}\right)+\left(\frac{(4.78E-4)*4}{27}\right)$$

= 1.05 E-3/reactor year

= 1.31 E-3/cycle

Total loss of one channel of 125 V DC is the sum of the above two frequencies:

Loss DC bus = (7.7 E-4 + 1.31 E-3)/cycle ≈ 2.1 E-3/cycle

The loss of power to one of these two DC distribution panels given in the IPE is 2.6 E-2/cycle. The frequency of core damage or COPF due to fire loss of these panels is the frequency shown in the IPE multiplied by the ratio of 2.1 E-3/2.6 E-2 (about 8%). Using the data in Reference 4-8 the calculated frequency of core damage due to fire induced loss of a DC distribution panel is 1.3 E-9/cycle. COPF without core damage is calculated to be 6.2 E-12/cycle. Core damage with vessel failure is calculated as 6.4 E-12/cycle. Other plant damage states have negligibly small frequencies (Table 4.30).

#### 4.6.2.2 Control Room Cabinets

Since the specific Initiating Events (IEs) which would occur due to a fire in a cabinet in the Main Control Room (MCR) or the Upper or Lower Relay Room (URR or LRR respectively) are not included in the IPE, PRAC runs are used to determine the plant damage state (PDS) frequency for these IEs instead of ratioing IPE results as is done for the battery charger room fire zones in the previous section.

#### 4.6.2.2.1 Methodology

The basic PRAC methodology uses Support States and Functional Fault Trees, with system and component dependencies explicitly accounted for in the support state development. PRAC includes evaluation of vessel and containment integrity in addition to core damage (Level 1 PRA with enhancements), and even though only core damage frequency evaluation is required for the IPEEE, the same code that was used for the internal events IPE is used for risk calculations in the IPEEE. The use of the same code and basic input decks (system dependencies, event trees etc.) is appropriate because a fire imposes no unique accident progression on SSES. Fire is simply a different "impact vector". Use of the same basic plant model enables meaningful comparisons of results between the IPE and the IPEEE. The following types of input data are used by PRAC :

1. Initiating Events (IEs), frequency and impact on support and front-line systems.

2. Support system unavailabilities, Allowed Outage Times (AOTs) and dependencies on other support systems.

3. Front-line systems, their inherent unavailabilities and dependencies on support systems.

4. Success criteria as defined by event tree top event (ETTE) or functional fault trees (FFTs).

5. Timing data associated with equipment recovery used when computing the probability of plant damage.

The specific input decks used from the IPE were for cases with Unit 2 electrical equipment available; since fire is not postulated in both units simultaneously, these failures were removed from the initiating event impact vectors for the IPEEE.

The output from PRAC includes a matrix of resolved support system dependencies, a list of support states with component failure strings in each support state, front-line function failure probabilities in each support state (initial, without recovery), and plant damage state frequencies by support state and event tree event sequence. The organization of the output is designed so that compliance with PP&L's Defense in Depth (DID) criteria can be efficiently verified and insights gained into important sources of plant risk. Reference 4-8 provides detailed information on the algorithms and the computational sequence, which will not be repeated here.

#### 4.6.2.2.2 Development of PRAC Input Files

Initiating Events (IEs)

The risk-significant cabinets and benchboards in the MCR for which plant damage frequency calculations are necessary are :

1. Middle Section of Core Cooling Benchboard (1C601/2C601) consisting of Inserts 17, 18, 19 and half of Insert 20.
2. Right Section of 1C601/2C601 consisting of the other half of Insert 20 and Inserts 21 and 22.
3. NSSS Temperature Recording and Leak Detection Vertical Board (1C614/2C614).
4. Plant Operating Benchboard (0C653).

In developing the input data files for these cabinets (generic term used in this calculation for Benchboards, Vertical Boards and any other panels), it is assumed that a transient with scram (automatic or manual) will occur whenever there is a fire. This is consistent with prior treatment of fire and ATWS. Two cases are run for each cabinet other than 0C653, one in which an independent Loss of Offsite Power (LOOP) occurs together with the fire and one in which a LOOP does not occur.

Plant models in the form of input "decks" or data files from the Internal Events IPE (Ref. 4-8) are used for the IPEEE to reduce the computational burden and so that conclusions can be drawn regarding the risk-significance of fire initiating events relative to the baseline risk from equipment and system failures in the absence of external events. Credit is given for manual actions such as opening valves and actuating depressurization if they are called for by Emergency Operating Procedures (EOPs) or if sufficient time and information regarding accident progression are available to the operator. Since simultaneous fires in both units need not be postulated, credit is also given for the use of available ac and dc power sources from the other unit (i.e., Unit 2 because the analyses are for Unit 1, validated for Unit 2 by identity of design, except where differences exist). No credit for containment venting is taken.

A fire in either the middle or right section (between fire barriers) of 1C601/2C601 (Core Cooling Benchboard) can cause an Isolation transient due to spurious closing of either inboard or outboard MSIVs; therefore the IPE input deck for Isolation transients is used for these two cabinets for the cases without LOOP. Fire occurrence frequencies per cabinet for the three rooms of concern are taken from Ref. 4-18 and the frequency of LOOP (7.1 E-02) from Ref. 4-8. Except in the case of 0C653 (Plant Operating Benchboard), there is no mechanism for a fire in the MCR or either relay room to cause a LOOP, so the IE for the fire with LOOP cases is the simultaneous independent occurrence of fire and a LOOP; the coincident frequency is calculated as :

Frequency of fire w/LOOP = Freq. of fire/cycle • freq. of LOOP/cycle • 72/10957,

10957 being the number of hours per 15-month cycle and 72 being the "mission time" or the interval after the IE during which hot shutdown needs to be achieved.

Freq. of LOOP during the
mission time following a fire = 7.1 E-02 • 72/10957 = 4.7 E-04/fire

Per Ref. 4-18, the frequency of fire in a cabinet in the MCR is 3.33 E-04 per cycle; the frequency of fire with independent LOOP is :

Freq. of fire w/LOOP in MCR cabinet = 3.33 E-04 • 4.7 E-04 = 1.6 E-07/cycle

In the middle section of 1C601/2C601, a hot short caused by fire can result in spurious actuation of ADS and consequent failure of HPCI. The probability of a hot short per conductor in a cable, given the occurrence of a fire involving the cable is 0.07 (Ref. 4-47, NUREG/CR-2258). The IE frequency for this fire location becomes 2.3 E-05 without a LOOP and 1.1 E-08 with LOOP.

The Safe Shutdown (SSD) functions, components and systems that fail due to the IE are input to PRAC as row vectors of Support and Front-line systems, referred to as "Impact Vectors". No

recovery from these failures is allowed during the mission time, except in the case of offsite power, and for 0C653, DGs and ESW system.

#### 4.6.2.2.2.1 Middle Section of 1C601/2C601

This section of C601, consisting of Inserts 17, 18, 19 and half of Insert 20, contains controls for all SRVs and Division I of MSIVs, RHR and Core Spray (CS) systems and for the RCIC system. An Isolation transient could occur due to an open circuit in the circuits for inboard MSIVs, but automatic isolation remains available if a hot short occurs. Damage to the ADS circuits and components will not disable manual opening of the ADS SRVs from the relay room, but could cause spurious opening of one ADS valve due to a hot short. An Isolation transient and a LOOP case were run for this cabinet, both with HPCI failed in addition to the above systems. Thus, failure of HPCI and RCIC are assumed as part of the IE (HPM for core defense is success of HPCI, RCIC or 2 CRD pumps).

#### 4.6.2.2.2.2 Right Section of 1C601/2C601

This section of C601 consists of half of insert 20, and inserts 21 and 22 and contains controls for HPCI and Division II of MSIVs, RHR and CS systems. Isolation and LOOP cases were run for this cabinet also, as explained in the previous section. Because SRV control is not affected, loss of RCIC by inadvertent ADS is not assumed.

#### 4.6.2.2.2.3 NSSS Temperature Recording and Leak Detection Vertical Board 1C614/2C614

A spurious leak detection signal due to fire damage to circuits in this cabinet could cause unavailability of HPCI and RCIC. Non-Isolation and LOOP cases were run with the loss of HPCI and RCIC in the impact vector.

#### 4.6.2.2.2.4 Plant Operating Benchboard 0C653

This cabinet contains all MCR controls for the supply breakers to the medium voltage emergency buses, from both offsite sources as well as from the Emergency Diesel Generators (EDGs). It also contains the controls for ESW pumps and valves. Multiple hot shorts due to a fire in this cabinet, such as in the trip circuits of the two offsite supply breakers and either in the trip circuits of four EDGs or close circuits of two ESW valves can cause a Station Blackout (SBO). Two input decks from the IPE, SBODG and SBOESW were used to analyze the impact of a fire in this cabinet. It should be noted that for the SBODG case, while an SBO can be caused due to a fire in this cabinet, it does not involve the loss of the offsite power grid or the EDGs due to major equipment problems in those systems but is entirely due to the spurious tripping of closed circuit breakers or the spurious closing of normally open motor-operated valves. All the medium voltage circuit breakers involved have the capability at the switchgear of isolating the MCR control circuits and control fuses, and of being closed. Due to this reason, the SBODG case was run with both a standard recovery schedule (more than 3 hours for 90% probability of recovering offsite power) and an accelerated recovery schedule (99.95% probability in 1 hour). The SBOESW case is different in that physical damage to the EDGs is likely to occur if the DGs start on LOOP and ESW is not available for cooling within 8 minutes.

Therefore, only one SBOESW case was run, with quick recovery of ESW but no recovery of EDGs.

#### 4.6.2.2.3 Analysis of Results

The PRAC runs for fire IEs in MCR cabinets are described in detail in Ref. 4-38 and a summary of the results presented in Table 4-30 of this report. Ref. 4-38 also describes how the results demonstrate conformance with PP&L's DID criteria for frequency, equipment, procedures and interface requirements. The frequencies of occurrence of various PDSs are summarized here.

##### 4.6.2.2.3.1 Middle Section of 1C601/2C601

The total plant damage frequency due to a fire in this cabinet without coincident LOOP is 3.3 E-10 (including fire occurrence frequency of 3.3 E-04/cycle and one hot short @ 0.07 per conductor), dominated by the No Core Damage (CD), Containment Overpressure Failure (COPF) damage state and less than 1% contribution from the Core Damage, Vessel and Containment Intact damage state (1.1 E-12).

For the fire with LOOP case, the total plant damage frequency is 8.2 E-13, dominated by the Core Damage, Vessel and Containment Intact damage state (8.1 E-13) but with five other damage states contributing a very small amount: Core Damage, Vessel Intact, Containment Overpressure Failure (3.2 E-15); Core Damage, Vessel Failure (VF), Containment Intact (7.9 E-17); Core Damage, Vessel Failure, Containment Overtemperature Failure (COTF) (1.5 E-18); Core Damage, Vessel Failure, Containment Overpressure Failure (2.5 E-17) and No Core Damage, Containment Overpressure Failure (1.0 E-14).

##### 4.6.2.2.3.2 Right Section of 1C601/2C601

The total plant damage frequency due to a fire in this cabinet without a coincident LOOP is 4.3 E-09, dominated by the No Core Damage, Containment Overpressure Failure PDS and less than 1% contribution from the Core Damage, Vessel and Containment Intact PDS (1.0 E-12).

For the case with independent LOOP, the total plant damage frequency is 3.4 E-12, dominated by the Core Damage, Vessel and Containment Intact PDS (3.3 E-12), but with four other damage states contributing a very small amount : Core Damage, Vessel Intact, Containment Overpressure Failure (2.3 E-15); Core Damage, Vessel Failure, Containment Intact (1.2 E-20); Core Damage, Vessel Failure, Containment Overpressure Failure (6.1 E-22); and No Core Damage, Containment Overpressure Failure (8.4 E-14).

##### 4.6.2.2.3.3 NSSS Temperature Recording and Leak Detection Vertical Board 1C614/2C614

The total plant damage frequency due to a fire in this cabinet without coincident LOOP is 4.4 E-12, dominated by the Core Damage, Vessel and Containment Intact damage state and less than 1% contribution from the No Core Damage, Containment Overpressure Failure damage state (2.1 E-14).

For the fire with independent LOOP case, the total plant damage frequency is 1.6 E-13, also dominated by the Core Damage, Vessel and Containment Intact damage state but with four other damage states contributing a very small amount: Core Damage, Vessel Intact, Containment Overpressure Failure (4.0 E-16); Core Damage, Vessel Failure, Containment Intact (1.3 E-15);

Core Damage, Vessel Failure, Containment Overpressure Failure (5.8 E-18) and No Core Damage, Containment Overpressure Failure (8.4 E-15).

#### 4.6.2.2.3.4 Plant Operating Benchboard 0C653

Since the initiating event for all the cases for a fire in this cabinet involve an SBO caused by a combination of LOOP and failure of EDGs due to hot shorts in control circuits for offsite source breakers and either DG breakers or ESW valves, these cases will be referred to either as SBODG or SBOESW with a qualifier denoting the different power recovery schedules.

For the SBODG case with standard recovery, the total plant damage frequency is 1.3 E-14, almost entirely in the Core Damage, Vessel and Containment Intact PDS (1.3 E-14), with five other PDSs contributing negligible amounts: Core Damage, Vessel Intact, Containment Overpressure Failure (4.7 E-18); Core Damage, Vessel Failure, Containment Intact (4.3 E-20); Core Damage, Vessel Failure, Containment Overtemperature Failure (1.1 E-20); Core Damage, Vessel Failure, Containment Overpressure Failure (9.4 E-23) and No Core Damage, Containment Overpressure Failure (1.0 E-16).

The total plant damage frequency for the SBODG with accelerated recovery case is 6.6 E-19, in six PDSs: Core Damage, Vessel and Containment Intact (2.9 E-19); Core Damage, Vessel Intact, Containment Overpressure Failure (5.6 E-21); Core Damage, Vessel Failure, Containment Intact (1.3 E-22); Core Damage, Vessel Failure, Containment Overtemperature Failure (1.4 E-25); Core Damage, Vessel Failure, Containment Overpressure Failure (3.6 E-26) and No Core Damage, Containment Overpressure Failure (3.7 E-19).

Finally, for the SBOESW with no DG recovery case, the total plant damage frequency is 3.9 E-11, dominated by the No Core Damage, Containment Overpressure Failure (3.7 E-11) PDS, with small contributions from three other PDSs: Core Damage, Vessel Intact, Containment Overpressure Failure (2.3 E-12); Core Damage, Vessel Failure, Containment Overtemperature Failure (9.6 E-18) and Core Damage, Vessel Failure, Containment Overpressure Failure (2.5 E-17).

### 4.6.2.3 Relay Room Cabinets

#### 4.6.2.3.1 Methodology

The methodology for quantification of risk due to fires involving Relay Room cabinets is identical to that described in the previous section for MCR cabinets.

#### 4.6.2.3.2 Development of PRAC Input Files

Appendix B to Ref. 4-34 identified 1C617/2C617, Division I RHR Relay Vertical Board in the LRR and 1C618/2C618, Division II RHR Relay Vertical Board in the URR as fire locations of risk significance in the Relay Rooms.

#### 4.6.2.3.2.1 Division I RHR Relay Vertical Board

In addition to relays for Div. I of RHR, this cabinet (in the Upper Relay Room) also contains Div. I logic of HPCI which, though not divisionalized, is considered a Div. II system. Div. II logic of HPCI is on the HPCI Relay Vertical Board 1C620/2C620 in the Lower Relay Room. The impact vector for this cabinet, therefore, includes the loss of HPCI in addition to all support and front-line systems and components required for Div. I of RHR.

#### 4.6.2.3.2.2 Division II RHR Relay Vertical Board

This cabinet (in the Lower Relay Room) is similar to C617 in that in addition to Div. II logic of RHR, it contains Div. II logic for RCIC, also a non-divisionalized system but considered as Div. I. The redundant (Div. I) logic of RCIC is on 1C621/2C621, in the Upper Relay Room. The impact vector for this cabinet includes the failure of the RCIC system in addition to the loss of support and front-line systems and components required for Div. II RHR.

#### 4.6.2.3.3 Analysis of Results

The PRAC runs for fire IEs in Relay Room cabinets are described in detail in Ref. 4-38 and a summary of the results presented in Table 4-30 of this report. Ref. 4-38 also describes how the results demonstrate conformance with P P & L's DID criteria for frequency, equipment, procedures and interface requirements. The frequencies of occurrence of various PDSs are summarized here.

#### 4.6.2.3.3.1 Division I RHR Relay Vertical Board 1C617/2C617

The total plant damage frequency due to a fire in this cabinet without coincident LOOP is 8.5 E-12, all in the No Core Damage, Containment Overpressure Failure PDS.

For the fire with independent LOOP case, the total plant damage frequency is 2.8 E-14, dominated by the No Core Damage, Containment Overpressure Failure damage state (2.6 E-14), with four other damage states contributing a small amount: Core Damage, Vessel and Containment Intact (2.3 E-15); Core Damage, Vessel Intact, Containment Overpressure Failure (7.3 E-18); Core Damage, Vessel Failure, Containment Intact (2.8 E-21) and Core Damage, Vessel Failure, Containment Overpressure Failure (2.9 E-27).

#### 4.6.2.3.3.2 Division II RHR Relay Vertical Board 1C618/2C618

The total plant damage frequency due to a fire in this cabinet without coincident LOOP is 1.2 E-11, all in the No Core Damage, Containment Overpressure Failure PDS. It should be noted that this frequency is higher than that for the corresponding Div. I cabinet; one factor causing this difference is the higher frequency of the fire IE (6.79 E-05 vs. 6.52 E-05 in C617), the other factor is the difference in the SSES-specific repair times (out-of-service hours for maintenance) between the Div. I and Div. II RHRSW heat exchangers (Div. I, whose failure is part of the event sequence for the Div. II cabinet has a repair time of 48 hours, while the Div. II heat exchanger, in the event sequence for the Div. I cabinet, has a repair time of 20.8 hours).

For the fire with independent LOOP case, the total plant damage frequency is 1.9 E-14, dominated by the No Core Damage, Containment Overpressure Failure (1.7 E-14) PDS, with four other PDSs contributing a small amount: Core Damage, Vessel and Containment Intact (1.6 E-15); Core

Damage, Vessel Intact, Containment Overpressure Failure (3.8 E-18); Core Damage, Vessel Failure, Containment Intact (2.8 E-23) and Core Damage, Vessel Failure, Containment Overpressure Failure (1.4 E-24).

These values are judged to be low enough to satisfy the frequency criterion, with the frequency of damage states involving the breach of more than one barrier, insignificant.

### 4.6.3 Summary of Plant Response

This report section summarizes the results of the plant damage state frequency calculations. Based on the results of fire PRA screening and Appendix R analyses, only plant transients are expected from fire (i.e. no ATWS or LOCA). From the fire PRA screening and detailed fire propagation calculations, all fire zones at SSES may be screened out as not risk significant because sufficient equipment exists, given the fire and independent equipment loss, to shutdown and cool the core and remove decay heat from the containment. Regardless, plant damage state frequency calculations are performed for those zones judged most risk significant: relay rooms, control room, and battery charger rooms. These rooms are small and contain cables from both divisions of SSD equipment. These zones, plus the cable spreading rooms, form the "nerve center" of the plant and are those typically found in PRAs to be risk significant.

The fires in these zones all occur in electrical cabinets and are assumed confined to the cabinet of origin. The frequency of core damage for the battery charger rooms is (found by multiplying the IPE results by the ratio of initiating event frequencies for fire and the random failure rate from the IPE for internal events) about 1E-9/cycle. Frequency of COPF without core damage is about 6 E-12/cycle. The PRAC calculation output is summarized in table 4.30. Total calculated core damage frequency is negligible at about 1 E-11/cycle. Frequency of COPF without core damage is about 5 E-9/cycle. Total calculated core damage frequency from the IPE is approximately 1 E-7/cycle and COPF is 4.5 E-8. Thus, calculated core damage frequency due to fire in the most risk significant zones is roughly 1% of that calculated in the IPE. COPF without core damage due to fire is about 10% of that calculated in the IPE. To estimate the core damage contribution from fires in other fire zones, the fire frequencies of the fire zones in the reactor building containing large lube oil sources (1-1A through 1-1F) are multiplied by the failure rates of the DID equipment remaining in each of these zones given a fire. This total estimated core damage frequency is about 8.9 E-10/cycle. This estimate is conservative because it assumes that all fires, even in non-safety electrical cabinets, cause failure of the equipment assumed failed in the zone for screening purposes. Only large lube oil sources are considered because damage in other zones is limited to the source, generally a portion of one channel of AC power. Based on the detailed fire propagation calculations performed for this fire PRA, it is expected that detailed study of the sources in the zones without lube oil sources would result in little, if any, damage to SSD equipment. Because of the conservatism of this approach, the estimated total calculated core damage frequency due to fire is about 1% that calculated in the IPE for internal events, that is 1E-9/cycle. Even this estimate is conservative because of lack of credit given to detection and suppression and the assumption of all-consuming cabinet fire.

## 4.7 Analysis of Containment Performance

Although a "level 1" fire PRA is performed with a focus on core damage frequency, because of the key role played by the containment in preventing the spread of radioactive material to the environment, it is appropriate to review containment performance. Appendix 2 of the Generic Letter 88-20 Supplement 4 IPEEE information request provides guidance for the review of containment performance for fire initiating events. Appendix 2 indicates licensees are expected to evaluate the insights gained as part of the Containment Performance Improvement Program (CPIP). These insights deal with using existing, non-safety grade equipment to enhance containment DHR. Because containment performance is studied in the IPE (Reference 4-8), the emphasis here is on modes of failure unique to fire.

Each SSES reactor vessel is surrounded by a GE Mark II containment. This containment design consists of a drywell which houses the reactor vessel and recirculation pumps, and a wetwell containing a suppression pool of water which serves as a heat sink for quenching of vessel steam directly from SRVs or from the drywell in the unlikely event of a LOCA. Water for ECCS injection to the reactor vessel, especially for low pressure systems, is drawn from the suppression pool. A concrete diaphragm slab separates the drywell from the wetwell. The containment is inerted with nitrogen during power operation. Complete descriptions of the containment are found in Appendix A of the IPE, as well as the FSAR.

Physically, the containment building is comprised of a steel-reinforced concrete structure lined with a continuous membrane of welded steel plate. The containment function is performed by the steel plate; the building providing strength. The containment building is penetrated to allow the passage of pipe and cable required for power operation and accident prevention/mitigation. A "drywell head" bolted to the top of the drywell provides access for refueling. Four hatches (two to the drywell, two to the wetwell) provide access for maintenance/inspection. Another hatch is used for removal of CRDs for maintenance. The containment is normally inaccessible during power operation. "Containment" is provided by the containment structure, the hatches/drywell head and their seals, the penetration seals, and the piping and associated isolation valves. To evaluate the possible fire impacts, the structures/components which comprise the containment are reviewed and the fire effect on each is considered. Damage is expected only from heat. Because the containment is inerted during power operation, only fires external to the containment building are considered.

Fire impact on the containment structure itself is expected to be minimal. The containment building external walls are 6 feet thick. Even the largest unmitigated fire (HPCI room, fire zone 1-1C) is expected to last less than 1 hour and affect only the outer most concrete. The deluge system installed in this zone will probably actuate as designed and limit any fire to inconsequence. The containment hatches and drywell head seals do not rely on gas pressure, electricity, or other active means for function. Seals are formed by bolting and mechanical deformation of "O" rings. The penetrations are welded to the drywell liner inside the containment. The hatches (683' elevation, zones 1-3A and 1-3B-N for wetwell; 719' elevation zones 1-4A-N, 1-4A-W, and 1-4A-S for drywell) and drywell head (779' elevation, zone 0-8A) are located in zones with low combustible loading away from mechanical equipment. "O" ring seal failure is expected above 700F. The drywell hatches and drywell head are surrounded by concrete missile shielding blocks during power operation. Because of the sealing mechanisms used and low combustible loading nearby, no fire damage is expected to the hatches or drywell head. The piping/cable penetrations are made of steel and cast in place in the containment walls. They are welded to the containment liner. Piping passing through is welded to the penetration. Fire is not expected to fail piping or welds. The largest fires can occur only in the lowest levels of the reactor building, adjacent to the portion of the wetwell containing the suppression pool. The suppression pool water mass serves as a heat sink for any heat transferred to the penetrations in these zones. Electrical penetration seals are provided pre-assembled

by the manufacturer (Westinghouse). Cable assemblies are inserted into penetration sleeves and either welded or bolted to the containment liner. Because of the thickness of the containment, seals inside the containment are not expected to be damaged by external fires. Review of electrical penetration locations shows that only three (#s 300, 301, and 330B) enter the wetwell at greater than 17 feet above the suppression pool level. These penetrations are located in the 683' elevation of the reactor building. Because the largest oil sources are located on the 645' elevation of the building, no impact on these penetrations from fire is expected. All other electrical penetrations enter the drywell at higher elevations in the reactor building. Because COMPBRN IIIe calculations show fire sources on these floors have no damaging effect on cable nearby, failure of penetrations is also not expected. As with the hatches, the containment penetrations/penetration seals are passive, i.e. they do not rely on pneumatic pressure or electricity for function. Isolation of piping passing through the containment walls is accomplished either by series isolation valves or, for piping systems originating and terminating in the containment, by single valves. Series isolation valves are located with one valve inside and one outside the containment. While fire attack of the external valve is possible, the physical separation and inert nature of the containment atmosphere leaves the internal valve intact. Appendix R analysis (Reference 4-3) and IPEEE fire propagation analysis confirm that electrical faulting, including hot shorting, will not result in loss of both isolation valves. In the case of a single valve, the piping itself forms a containment boundary and fire induced pipe failure is judged incredible. Thus, because fire is not expected to result in loss of the containment components, overall containment function is not expected to fail.

Because fire is not expected to result in containment failure modes different than those identified in the IPE for internal events (Reference 4-8), only those modes identified in the IPE are considered: Containment Over Pressure Failure (COPF) and Containment Over Temperature Failure. COPF results when stress due to containment internal pressure is greater than the ultimate strength of the structure. This pressure is about 150 psig. COTF is postulated after vessel failure with no overlying water pool on the drywell floor and is caused by corium attack of the drywell liner. Both modes are considered in the event trees used in the plant systems/plant damage state frequency analysis. Although a level 1 PRA, frequency of containment failure due to these modes is calculated in the IPEEE for completeness. While venting of the containment is incorporated in the IPE plant damage state frequency analysis, no venting is considered in this IPEEE study because of current uncertainty about venting procedure and capability. (However, see discussion of USI A-45 below.)

## 4.8 Treatment of Fire Risk Scoping Study Issues

The request for information contained in NRC's Generic Letter No. 88-20, Supplement 4 (Ref. 4-1) requires licensees to address the issues raised by Sandia National Laboratories (SNL) in the Fire Risk Scoping Study (NUREG/CR-5088, Ref. 4-35), while performing the fire portion of the IPEEE. Also, according to NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities" (Ref. 4-37), issues identified in the Fire Risk Scoping Study (FRSS) are the primary reasons for including internal fires in the scope of the IPEEE. This report section addresses these FRSS issues as well as those delineated in GI-57 "Effects of Fire Protection System Actuation on Safety Related Equipment".

### 4.8.1 Generic FRSS Issues

In addition to the six specific issues listed in the next section, the FRSS identifies the following generic issues, based on reviews of four fire PRAs, due to which internal fires are included in the IPEEE:

1. Fires represent a "dominant risk contributor."

2. Fire initiating frequencies were underestimated in these PRAs.

3. The PRAs assume higher fire suppression probabilities than were determined in the FRSS.

4. Thermal damage thresholds assumed for cable may be too high.

5. Not all the PRAs took into account the impact of Appendix R modifications to the plant.

6. The six specific "FRSS Issues," if taken into account, could raise the fire-induced core damage frequency.

#### 4.8.1.1 Disposition of Generic FRSS Issues

1. Fires as Dominant Risk Contributors:

   The fire portion of the SSES IPEEE is a quantitative, Level 1 PRA., in accordance with the PRA Procedures Guide, NUREG/CR-2300 (Ref. 4-2). The methodology, assumptions and data used to determine the plant fire zones with the potential to cause core damage if a fire occurred there are described in detail in PP&L Calculation EC-RISK-1018 (Ref. 4-18). The calculation of the fire event initiating frequency for risk-significant fire zones is also included in Ref. 4-18. Calculation EC-RISK-1021(Ref. 4-34) documents analyses to determine the components, systems or functions that will fail as a result of fire in each of the risk-significant fire zones. Calculation EC-RISK-1022 (Ref. 4-38) describes the input data to and results from PP&L's Probabilistic Risk Assessment Code (PRAC) used for the quantitative evaluation of plant risk due to fire initiating events. In addition to quantification of plant risk due to internal fires, Ref. 4-38 also provides descriptions of the accident sequences and support states identified as dominant risk contributors as well as an analysis of compliance with PP&L criteria for Defense In Depth (DID). The process and analyses briefly described above provide a high degree of confidence that the contribution of internal fires to SSES risk will be identified and quantified.

2. Estimates of Fire Initiating Frequencies:

Subsequent to the publication of the FRSS (Jan. 1989), EPRI published NSAC/178L, Fire Events Database for U.S. Nuclear Power Plants (FEDB), in June 1992. This database (Ref. 4-10) is a compendium of fire events in commercial nuclear power plants between Feb. 1965 and Dec. 1988, covering 753 fire events during more than 1260 Reactor-years of operation for both PWR and BWR units after issuance of a low power operating license, making it the most comprehensive database of fire events currently available. Fire experience data at SSES from the construction period up to the present time has been meticulously documented. The SSES fire history data, on comparison with the EPRI FEDB, is determined to fall within the 90% confidence bounds of the FEDB data, on the basis of hypothesis testing, with the exception of transient fires due to cigarettes. On the basis of the homogeneity or poolability thus established, fire initiating frequencies from the much larger FEDB are used in this fire PRA. SSES-specific data is used for transient fires due to cigarettes. The use of a comprehensive and current database, specifically validated for applicability to SSES, resolves the concern regarding the accuracy and realism of the fire initiating frequencies.

3. Estimates of Fire Suppression Probability:

The fire propagation analysis for the SSES IPEEE, documented in Ref. 4-34 takes no credit for installed fire detection and suppression systems. Credit is taken only for the effectiveness of fire watches in preventing or suppressing (with 100% reliability) transient fires (e.g., trash can fires) during "hot work" such as welding. The concern regarding non-conservative estimates of suppression probability or suppression time are, therefore, not applicable to the SSES IPEEE.

4. Cable Thermal Damage Thresholds:

The criterion used for determining whether cable would be damaged is a surface temperature of 700 F or higher; however, in using COMPBRN IIIe, a conclusion that a cable is not damaged in a fire scenario is not made unless the cable surface temperature is significantly below the damage criterion temperature, e.g., 500 F. Similarly, when the damage criterion is a critical value of the heat flux impinging on the cable, a significant margin is assured. In either case, conclusions about the occurrence of cable damage are not based on an exact criterion and sufficient margin is included to obviate the concern regarding the uncertainty in cable damage criteria.

5. Impact of Appendix R Modifications:

The IPEEE analyses for SSES are based on the plant configuration in mid-1993, using controlled copies of plant drawings and other design documents, thus ensuring that all modifications completed by that time frame are taken into account.

### 4.8.2 Specific FRSS Issues

The six specific issues considered to have been unaddressed in the reviewed PRAs are :

1. Control Systems Interactions.

2. Seismic/Fire Interactions.

3. Manual Fire Fighting Effectiveness (including Smoke Control.)

4. Total Environment Equipment Survival (including Spurious Operation of Suppression Systems.)

5. Adequacy of Fire Barriers.

6. Adequacy of Analytical Tools for Fire.

The following are brief descriptions of SNL/NRC concerns regarding the above issues:

1. Control Systems Interactions:

   a) Combinations of fire-induced failures and random failures could occur that would not be found by deterministic analyses such as Appendix R reviews.

   b) Independence of remote shutdown control systems.

   c) Level of indication and control provided on remote shutdown panel.

2. Seismic/Fire Interactions :

   a) Fires initiated by earthquakes, e.g., by pulling cables loose.

   b) Spills of flammable liquids.

   c) Release and ignition of flammable gases.

   d) Impacts on safety systems of fires caused in nearby non-seismic, non-safety systems, e.g., suppression activity, smoke generation, fire spread and high temperatures.

   e) Seismic-induced unavailability of suppression systems.

3. Manual Fire Fighting Effectiveness:

   a) Variations in responsiveness of fire fighting teams.

   b) Practices with respect to staffing, equipping and training of fire brigades.

   c) Scenarios with critical damage times too short for even a well-prepared fire response team to prevent damage.

4. Total Environment Equipment Survival:

   a) Effects of spurious actuation of fire suppression systems.

   b) Damaging effects of smoke, low level heat and water sprays.

5. Adequacy of Fire Barriers :

   a) Fire barrier reliability (an order of magnitude increase in core damage frequency possible if reliability is 90% instead of 99%.)

6. Adequacy of Analytical Tools for Fire :

   a) Errors in, and nonphysical behavior of, models in COMPBRN III, the version in use at the time the FRSS was performed.

#### 4.8.2.1 Disposition of Specific FRSS Issues

1. Control Systems Interactions:

   a) The probabilistic risk assessment model used in the IPEEE is the same as the model developed for the IPE (Internal Events), and uses a "support state" methodology, in which dependencies such as those due to power supply or instrument air are explicitly included in dependency matrices. The fire-induced failures are input to the model as an "impact vector" for that initiating event, or list of support and front-line systems which will fail with a probability of 1.0 as a result of a fire at the postulated location. The code then generates combinations of independent and initiating event-caused failures with the probability of the random failures based on the data on support and front-line systems included in the basic plant model. This calculation process provides assurance that combinations of random failures and failures caused by the fire initiating event are considered in the risk quantification, producing a realistic set of accident sequences and their frequency of occurrence.

   b) Remote shutdown control systems at SSES have been demonstrated to be independent of normal control room controls, and documented in Ref. 4-41. Independence is achieved by the use of a different set of fuses on transfer to the Remote Shutdown Panel (RSP) as well as switch contacts on both sides of control circuits common to the Main Control Room Panel and the RSP.

   c) The SSES FPRR (Reference 4-3) demonstrates that sufficient control and indication are provided on the RSP to achieve and maintain cold shutdown after a fire in the Control Room.

   The following additional activities reinforce confidence that risk-significant control systems interactions have not been overlooked in the performance of the IPEEE.

   In addition to systems and components required to operate to achieve Safe Shutdown (SSD), those components (valves) whose failure could cause flow diversion from the reactor vessel were also included in the SSD component list. Control systems interactions that could result in the spurious opening of two valves in series were checked and found to be not significant.

   While reviewing fire zones for risk significance and to determine the equipment that would fail due to a fire in a room or compartment, it is assumed that any cables routed through the room, for components not in the room, will also be damaged unless COMPBRN IIIe or FIVE calculations show no cable damage with a margin for uncertainty in cable damage thresholds. For all such cables but especially for cross-division cables, i.e., Div. II cables in Div. I equipment rooms and vice versa,

schematic diagrams are reviewed to ascertain the impact on affected equipment due to fire-caused short- or open-circuits of cables in such fire zones.

In establishing the impact vectors for a fire in a Control Room or Relay Room cabinet, all components in the cabinet are considered. As an example, it was found that a fire in an auxiliary relay cabinet for one division of RHR would also cause failure of one of the high pressure injection systems (HPCI or RCIC) because while HPCI and RCIC are not divisionalized systems, their control logic is divisionalized and one of the divisions of logic for each system is located in one of the RHR relay cabinets. HPCI is considered a Div. II system, but Div. I relays for HPCI are located in the RHR Div. I relay cabinet. Similarly, Div. II relays for RCIC are located in the Div. II RHR relay cabinet (Div. I relays for RCIC are in the RCIC relay panel C621 in the Upper Relay Room and Div. II relays for HPCI are in the HPCI relay panel C620 in the Lower Relay Room). The impact vector for each RHR relay cabinet includes failure of the affected high pressure system in addition to the division of RHR.

Based on the above, it is concluded that control systems interactions, both the obvious and subtle, are taken into account in the SSES Fire IPEEE.

2. Seismic/Fire Interactions:

a) EPRI NP-6989, "Survey of Earthquake-Induced Fires in Electric Power and Industrial Facilities" (Ref. 4-42) reviewed data on 18 recent earthquakes and the consequences at 108 power and industrial facilities. It appears that "The incidents of fire identified were all localized events within the facilities in which they occurred and did not appear to result in significant damage." One of the findings of the survey is that fires at power and industrial facilities occur due to the toppling of energized electrical equipment. All safety-related electrical equipment and their anchorage at SSES is seismically qualified. The seismic anchorage of switchgear cabinets was verified during extensive SMA walkdowns.

b) The only flammable liquids in significant quantities in risk-significant buildings of SSES (Reactor Buildings, Control Structure, Diesel Generator Buildings and Engineered Safeguards Service Water (ESSW) Pumphouse) are diesel fuel and lubricating oil. Emergency diesel fuel tanks, both in-ground storage and above-ground day tanks, as well as connecting fuel lines between them, are seismically qualified and supported. The seismic support of these tanks was also verified during SMA walkdowns. Diesel fuel is stored also in a room in the circulating water pumphouse, for the diesel-driven fire pump. During the walkdown for seismic-fire interactions it was concluded that the tank's anchorage will not survive an SSE or DBE, making a seismically induced fire in this room possible. However, no equipment for SSD is located in this room. Small storage lockers for combustibles are present in several fire zones; they could topple during a seismic event. The combustible content in these metal lockers is small, typically less than a quart of solvent. The lockers do not pose a significant risk.

There is a large lube oil sump in one fire zone of each reactor building, but the tank is below ground at the lowest elevation of the building and a solid steel cover is provided over the sump. Large ECCS pumps, especially the turbine-driven HPCI and RCIC pumps have large quantities of lube oil but a complete spill of the oil from the HPCI pump was studied using COMPBRN IIIe, and fire damage is found to be confined to the room. COMPBRN IIIe was also used to model fires due to spillage of lube oil from the control structure chillers and it was confirmed that there would be no damage beyond the chiller room.

c) The major mechanism of seismically-induced fires is the rupture of gas pipelines. There are no gas pipelines on site or within buildings at SSES. The only flammable gas stored in risk-significant buildings at SSES is hydrogen in bottles in two fire zones of each reactor building for the calibration of the hydrogen analyzers. It was verified during walkdowns including one specifically to evaluate the potential for seismic-fire interactions that the bottles are seismically supported to the floor and in Unit 1, enclosed by a metal cage. Even though a gross breach of integrity is unlikely due to this, COMPBRN IIIe runs for one of the fire zones, assuming the total release of the two 100% hydrogen bottles (the other two in each fire zone contain 30% hydrogen, with the remainder being nitrogen), show no damage to any cables in the vicinity. The same conclusion, that hydrogen in bottles does not constitute a strong enough fire source to be of concern, is also documented in Ref. 4-43 (NUREG/CR-5759). While this NUREG addresses flammable gas storage at PWR plants, the finding that the effects of a hydrogen fire involving commercial storage containers are local unless the room is small, has general applicability. The areas at SSES containing bottles of hydrogen are very large.

d) A walkdown was conducted to determine if nonsafety, non-seismic equipment in the vicinity of safety-related equipment has the potential to catch fire during a seismic event, resulting in damage to the safety-related equipment. The results of the walkdown are documented in an attachment to Ref. 4-40. Cabinets containing protective clothing (PCs) could fall during an earthquake but would neither impact SSD components nor ignite without an external flame source. No situations were found where non-seismic equipment could cause damage to SSD equipment either by toppling or causing a fire.

e) It was shown in Appendices to Ref. 4-34 that fires in risk-significant zones at SSES will not spread beyond the zone or cabinet of fire origin and that the impact vectors for these fires were determined without taking credit for detection or suppression of fires. It was also demonstrated that seismically-induced fires in risk-significant zones are unlikely at SSES. However, the major components of the water, $CO_2$ and Halon systems were inspected during the seismic/fire interaction walkdown (Attachment 2 to Ref. 4-40 is a report on this walkdown). Suppression systems, especially the water and CO2 systems, are likely to fail. However, since fires in risk-significant zones of the plant are unlikely because of source minimization and seismic design; and no credit is assumed for the availability of suppression systems in the risk calculation, the potential failure of the water and $CO_2$ suppression systems is acceptable for the IPEEE.

It is concluded from the foregoing that seismic/fire interactions at SSES are not risk-significant.

3. Manual Fire Fighting Effectiveness :

a) The fire sources in risk-significant fire zones at SSES are weak enough and the rooms large enough that no credit is required to be taken for automatic or manual fire suppression to assure safe shutdown (Ref. 4-18). COMPBRN IIIe and FIVE evaluations show that a fire involving lube oil, cotton pc's or hydrogen will burn out without damaging safe shutdown cables. If the fire is in a cabinet, the components of the cabinet will be destroyed before the fire can be suppressed but by the time the postulated fuel burns out, the walls of the cabinet do not reach a temperature that could endanger wiring or components in adjoining cabinets separated by the existing steel barriers.

A review of fire event history at SSES also indicates that all fires were quickly suppressed by plant personnel, in most cases with the use of portable extinguishers, without significant damage even to the component involved in the fire.

b) Ref. 4-3 demonstrates that SSES practices with respect to staffing, equipping and training of fire brigades comply with the requirements of BTP 9.5-1, Appendix A. Attachment 1 to Ref. 4-40 contains a description of manual fire fighting attributes in the format of Attachment 10.5 of NUMARC's FIVE methodology. SSES maintains a large (~ 200 members) fire brigade and provides training in excess of App. R requirements to all members. SSES also makes available training to the members of 3 offsite (public) fire departments which would respond to a fire emergency at the station.

c) This concern has no impact on the fire PRA because no credit is taken for manual fire fighting to assure safe shutdown. It is conservatively assumed that all equipment and cables in a fire zone will be lost due to any potential fire in the fire zone or sources are shown to be non-propagating, i.e., full impact of source is assumed.

4. Total Environment Equipment Survival:

a) Ref. 4-44 documented a review of the effects of suppression actuation on Category I components (defined as components required for safe shutdown for a fire in the fire zone in which the component is located) and concluded that after completion of DCP 88-30160 and revision of Fire Brigade Training Procedures and Fire Preplans, fire suppression activities will not cause damage to redundant safe shutdown components. DCP 88-30160 and all other Appendix R Modifications are now completed (Ref. 4-3) as are the required revisions to the Procedures and Preplans. If suppression systems are actuated as required, i.e., because a fire has occurred, the damage due to suppression system operation is bounded by the damaging effects of the fire in most cases. A situation at the 783' elevation of the control structure where spray from a fire hose may splash a div. I MCC and a div. II HVAC control panel was observed; a modification was installed with the erection of a 10' heat shield. During the seismic-fire interaction walkdown, it was also confirmed that the tops of all electrical switchgear and control cabinets are sealed and doors gasketed. While the construction is not that required for outdoor use, it is expected to drastically reduce the potential for water damage. Also, no mercury relays are used in suppression system actuation circuits.

Per Attachment 2 to Ref. 4-40, spurious actuation of suppression systems is likely in a seismic event; however, the sprinkler heads discharge a spray pattern which is not a straight stream. A situation was identified in the cable spreading rooms that could cause the unavailability of both trains of reactor vessel instrumentation; inverters for 120 V instrumentation power supplies to 1(2)Y115 and 1(2)Y125 can be shorted out simultaneously due to spurious preaction valve actuation and sprinkler head failure in the cable spreading rooms due to a seismic event. The provision of drip shields over the rear of the inverter chassis is being evaluated as part of the engineering discrepancy program. It was also observed that the drains on the cable spreading room floors are closed. A modification to provide the capability to open the drains remotely is planned (DCP 92-9063). The potential for flooding the room below the lower cable spreading room was evaluated; during the walkdown, it was observed that even though the floor, unlike that of the upper cable spreading room, does not have rated water seals, the penetrations are of the same design. Combined with the fact that the relay cabinets in the lower relay room (below

the cable spreading room) are sealed at the top, flooding from water on the floor of the cable spreading room is judged not risk-significant.

b) The immediate effects of smoke and low level heat are bounded by fire damage since they cannot cause worse effects than the failure (short/open circuits) assumed to occur when a component or cable is involved in a fire, and the effects are local. Ref. 4-29, a summary of SNL's fire safety research, found that switches and relays covered with moderate to heavy smoke particulates in cabinet fire tests did not experience loss of function. In any case, after any fire , all components in the involved fire zone as well as adjoining rooms will be inspected, cleaned and if damage is suspected, they will be replaced promptly. The effect of water sprays is addressed as described in the paragraph above.

5. Adequacy of Fire Barriers:

The likelihood of cross-zone fire propagation through non-fire rated barriers is examined and the results documented in an appendix to Ref. 4-34. Of the five plant areas with such cross-zone propagation potential, only the lowest elevation of the Reactor buildings, which houses large ECCS pumps which contain pressurized lubrication oil systems, can realistically have an impact on safe shutdown after a fire. The involved fire areas for Unit 1 are R-1A and R-1B, and for Unit 2, R-2A and R-2B. Appendix E to Ref. 4-34 documents the conclusion that if a fire causes failure of equipment in all fire zones in one of these fire areas not separated by rated fire barriers from fire zones with significant combustible loading, Defense in Depth (DID) for safe shutdown is available, primarily due to divisional separation, and availability of systems such as CRD for which cables are not routed through the lower levels of the Reactor Buildings. During a walkdown by IPEEE analysts together with a penetration engineer (Attachment 3 to Ref. 4-40 is a report on the walkdown), non-Appendix R barriers and penetrations for piping and raceways in walls and floors were inspected and found to be identical in construction to fire-rated barriers and penetrations. Special attention was focused on the barriers around the HPCI and RCIC pump rooms. The barriers are in good condition. Doors separating the HPCI and RCIC rooms from fire zones 1-2B and 2-2B open into the pump rooms so that pressurization due to fire tends to hold these doors closed. An analysis of barrier failure rates at SSES (Ref. 4-45)) shows the failure probability of doors to be less than 1% and that of penetrations to be between 1% and 2%. The FRSS indicates that a barrier failure rate of the order of 1% does not constitute a vulnerability. Therefore, door and penetration failure at SSES does not appear to be risk-significant.

6. Adequacy of Analytical Tools for Fire:

At the time the FRSS was being developed, the version of the fire propagation code in use was COMPBRN III, of which SNL seems to have had, not the final published version but an intermediate one. In response to the comments in the FRSS, a modified version, COMPBRN IIIe was developed by the authors (at UCLA) and published as EPRI NP-7282, "An Interactive Computer Code for Fire Risk Analysis" in May 1991 (Ref. 4-22). The seven specific modeling deficiencies seem to have been corrected in consultation with the SNL reviewers resulting in the same modifications as made by SNL before using the code for requantification in the FRSS. Additionally, a large number of trial runs of COMPBRN IIIe were made in the preliminary phase of the SSES IPEEE to find and avoid where possible, the situations leading to non-physical behavior. When such behavior was observed, the configuration or parameters causing the shortest damage time or the highest surface temperatures at critical objects (if critical objects were not damaged in any trial run) were used for the final runs of the code. Appendices to Ref. 4-34 document the bases for the input parameter selection (some

parameters in the COMPBRN IIIe database were modified and parameters for types of fuels not included in the code database were added to an SSES-specific database.). There is sufficient conservatism in the parameter selection and the modeling to provide assurance that the results of COMPBRN IIIe when used to reach conclusions regarding the impact of a fire in a fire zone are realistic if not pessimistic.

### 4.8.3 Conclusion

The generic and specific FRSS issues and concerns are addressed adequately at SSES either through original plant fire protection efforts or Appendix R compliance analyses. IPEEE analyses and walkdowns have demonstrated that no vulnerabilities exist at SSES due to the FRSS "issues".

## 4.9 USI A-45 and other Safety Issues

Section 5 of the G.L. 88-20 Supplement 4 information request provides a summary of other external event safety issues which may be resolved by information provided with the IPEEE report. Several of these issues do not pertain either to BWR plants or to fire PRA. Those issues which are applicable to the SSES fire PRA are: USI A-45 "Shutdown Decay Heat Removal Requirements"; GI 57 "Effects of Fire Protection System Actuation on Safety-Related Equipment"; and the six issues raised by NUREG/CR-5088, the "Fire Risk Scoping Study" (FRSS). The FRSS issues and GI-57 are addressed in the preceding report section. USI A-45 is specifically subsumed into the IPEEE process and is addressed here.

Even with successful scram, heat continues to be generated by the reactor core due to fission product decay. This heat load is significant; approximately 6% of full power immediately after scram and remaining above 1% several hours afterward. With SSES uprated full power at 3441 MWt, it is seen that several MW must be continuously removed from the core. If the containment is isolated from the condenser, containment pressurization will occur from SRV blowdown to the suppression pool. Unmitigated, containment heat up will result in COPF in approximately 30 hours (transient initiators). Thus, decay heat removal, both from the core and, if isolated, from the containment, is considered an essential part of successful event response. The objective of USI A-45 is the determination of the adequacy of decay heat removal systems and whether cost-beneficial enhancements to decay heat removal are possible.

USI A-45 is also addressed in the IPE for internal transient initiating events (Section 4.3.1 of Reference 4-8). The IPE presents a strategy for removal of decay heat which is capable of success despite increasing plant damage. Most desirable is removal of decay heat from the core directly, without first depositing this heat in the containment. The main condenser or the shutdown cooling mode of RHR are used. If the condenser is isolated from the containment or the reactor is above 98 psig these systems can not be used, and heat is deposited to the suppression pool via SRV lifts. The suppression pool cooling mode (SPCM) of RHR is used to move this heat from the containment to the environment. If SPCM is failed, the IPE considers use of the containment sprays to increase containment heat sink, allowing time for SPCM equipment repair. If SPCM continues unavailable, the drywell vent is used with drywell sprays to provide a controlled violation of containment, but only if other methods of DHR are failed and no core damage has occurred. Finally, if all other methods of DHR are unsuccessful, reactor vessel water makeup sources external to the reactor building (e.g. fire suppression water injection) are aligned to prepare for containment failure. Because containment failure will release approximately 1 billion BTUs of steam to the reactor building, equipment in the building is expected to be lost. The support systems required are also reviewed in the IPE. The IPE concludes that significant independence and diversity of DHR systems exists, and no upgrade is necessary.

For the fire PRA, because of the effort required in cable identification, only ECC systems are considered for core damage mitigation (see fire hazards analysis above). Thus, only the SPCM of RHR is specifically verified as being available for DHR. In screening of fire zones in the fire hazards analysis at least one channel of SPCM is required to be operable. However, because fire damage is localized, in fact confined to the fire source itself in most cases, diversity of DHR systems remains intact.

Only lube oil sources are capable of damaging large amounts of equipment or cable. The only significant lube oil sources are located in the reactor or turbine buildings. Fire sources in the control structure are generally limited to electrical equipment cabinets. The only significant oil source in the control structure is the control structure chillers, and COMPBRN IIIe analysis shows this source incapable of damaging cable. Fire in the turbine building will fail the condenser as a source of DHR. However, because no safety related

equipment is located in the turbine building, both divisions of SPCM remain available. COMPBRN IIIe analysis shows that, other than those on the 645' elevation, fire sources in the reactor building will not damage cable remote from the source. Reactor building fires will at worst fail only 1 division of SPCM. Power supplies and cable associated with the condenser are located in the control structure and the turbine building. Thus, fire in the reactor building leaves at least one division of SPCM, as well as the condenser available.

Review of the cabinet fires considered most risk significant (Table 4.28) shows that fire may fail one division of RHR/result in containment isolation by loss of AC or DC power. However, this equipment loss is only one of electrical switching. That is, the equipment required for SPCM operation remains physically whole. For SPCM operation success, one RHRSW pump, one RHR pump, and the proper division of ESW must function for RHR pump cooling. Once the pumps are started no speed or other adjustments are necessary. Valves required to be positioned are all external to the containment. Because of the relatively long time required for containment failure (about 30 hours), ample time exists for local actuation of SPCM equipment. For fires in the control or relay rooms, division I and II ESW and RHRSW pumps may be started at the remote shutdown panels (division II in the unit 1 RSD panel, division I in the unit 2 RSD panel). Because of common discharge headers, both divisions of ESW and RHRSW supply both units. Only a single division RHR pump may be started in each unit's RSD panel. However, all pumps may be started via local control at the ESS switchgear. Thus, despite loss of control from the control room or via relay room cabinets, SPCM may be established by local equipment operation. Guidance for such local operation is provided in the FPRR (Reference 4-3).

The local starting of ECCS pumps relies on 125 V DC control power. For loss of 125 V DC power due to fire/independent failure on unit 1 (e.g. 1D614 and 1D624) control power for ESW, RHRSW, and RHR pumps is available from unit 2 125 V DC distribution panels via transfer switch in the control room. For loss of this power due to fire on unit 2, ESW and RHRSW pump breakers can be closed using unit 1 DC power. However, unit 1 power can not be used to close unit 2 RHR pump breakers. Fire damage to one unit 2 125 V DC supply (e.g. 2D614) and independent failure of another (e.g. 2D624) leaves two channels of 125 V DC power intact (2D634 and 2D644 in this example). Power from these surviving sources can be used to close breakers for the two corresponding unit 2 RHR pumps. Thus, even loss of multiple DC control power sources leaves sufficient equipment available for containment DHR.

As described above, any fire plus an independent failure leaves sufficient equipment available for DHR, either by RHR-SPCM or the condenser. If this remaining source also fails, the alternate methods described in the IPE are still available. That is, if an RHR pump is operable drywell sprays can be used. The manual venting of the containment remains. If all else fails, after fire suppression is complete, the diesel powered fire suppression water system can be aligned for vessel injection. Thus, because redundant and diverse methods exist for removing decay heat from the containment, DHR is judged sufficient.

## 4.10 Summary and Conclusions for Fire PRA

This fire PRA shows that SSES fire risk is small, about 1% of the total core damage frequency calculated in the IPE. More importantly, the PRA demonstrates that defense-in-depth against core damage exists for any fire. That is, no fire with a single independent equipment failure results in core damage. Containment decay heat removal is also robust. From the fire PRA screening and detailed fire propagation calculations, all fire zones at SSES may be screened out as not risk significant because sufficient equipment exists, given the fire and independent equipment loss, to shut down and cool the core and remove decay heat from the containment. Regardless, plant damage state frequency calculations are performed for those zones judged most risk significant: relay rooms, control room, and battery charger rooms. These rooms are small and contain cables from both divisions of SSD equipment. These zones, plus the cable spreading rooms, form the "nerve center" of the plant and are those typically found in PRAs to be risk significant. However, no PRA is required to justify keeping these zones free from all unnecessary combustibles. The most risk significant fires are those in individual control, relay, or battery charger room electrical equipment cabinets which result in loss of multiple ECCS equipment. In some respects this result is conservative because generally all equipment except ECCS and CRD are assumed to be unavailable, cabinet fires are assumed to be all consuming, and no credit is taken for installed fire detection/suppression or any type of fire protective wrapping (e.g., Thermo-Lag). It is estimated (using the guidelines of NUREG CR-0654) that the assumption of all-consuming cabinet fires is conservative by a factor of 100, and the lack of credit given to detection/suppression is conservative (especially in the control room) by a factor of 10 to 100. Thus, the SSES fire risk is probably decades lower than the IPEEE calculations indicate.

In this study, very careful consideration is given to actual fire sources, their locations, and their impacts. Detailed assessment of fire sources is achieved by multiple plant walkdowns. No assumption of "worst case" transient combustible loading in the "worst case" location is made unless such loading is typical. Credit is taken for IEEE-383 rated cable. Adequate fire barriers (walls, floors, doors, and penetration seals) are confirmed by detailed review of barrier construction and placement. Fire impacts are determined by use of FIVE worksheets and COMPBRN IIIe calculations. Fire effects are verified by detailed review of affected cable. Actual fire experience of the nuclear industry is used to provide "reality checks".

Other assumptions forming the basis of this study are that, first, although specific to unit 1, these results also describe the fire risk from power operation of unit 2. Because results from the unit 1 study show only minimal risk from sources in the reactor buildings and only cabinet fires likely in the control structure, and because walkdowns of units 1 and 2 show similar construction, fire sources, doors, and penetration seals in both units, this assumption is justified. Specific unit 1/unit 2 differences are investigated in detailed plant damage state frequency calculations. Second, equipment failure data and plant configuration are assumed the same as described in the IPE completed in December, 1991. Review of the safety system failure data accumulated since that time, and analyses to investigate the impact of uprated power operation show this assumption valid. Third, excellent plant housekeeping is assumed. That is, transient combustibles are assumed to be only those fixed by permit. Other than PC storage, transients are assumed to be confined in metal boxes, cabinets, or in approved safety cans. Walkdowns throughout both units provide confidence in this assumption.

While defense-in-depth is confirmed, some improvements in fire protection have been identified and are in the process of implementation. Housekeeping improvements include the removal of magnetic tape storage from the unit 1 upper cable spreading room. Enhancements of existing housekeeping procedures are being pursued. A modification is on-going to allow opening of drains in the cable spreading rooms for removal of fire suppression water after pre-action system actuation. As of 1/1/95 smoking will no longer be allowed at SSES.

Investigation of the FRSS issues shows that SSES has concern only for seismic-fire interactions. That is, total equipment environment survival is expected and the independence of the remote shutdown panel has been shown. Barriers are in good condition and manual fire fighting capability is adequate. For seismic fire interaction, significant loss of the water and CO2 fire suppression systems may occur in a severe seismic event. However, because of the size, location, and separation of fire sources, risk significant fires following a seismic event are not expected.

In terms of barriers, those considered most valuable confine sources of lube oil. Thus, the zone boundaries around the HPCI and RHR pump rooms, the EDGs, the ESSW pump house, and those which separate the turbine building from the reactor and control buildings are of primary importance. In fact, because fires involving turbine-generators are large and almost routine (e.g. Salem, Vandellos, Perry, etc.), the barriers separating the turbine building from the rest of the plant, and the elimination of all SSD equipment from the turbine building may be the single greatest fire protection feature of SSES.

The objectives of the SSES fire PRA are the determination of and proposed solutions for fire risk vulnerabilities, that is, the establishment of defense-in-depth for all fires. Fires in nuclear power stations have occurred and will continue to occur because of the nature of the equipment in the stations (e.g. lube oil, circuit cards) and the maintenance work required. At SSES approximately 27 "fire events" have occurred at power operation. However, all of these fires were trivial in terms of core damage risk and impact on the health and safety of the public. The insignificance of these fires is due to the vigilance currently placed on ensuring fire safety. Our insurance against large fire losses results from the design (installed fire barriers, separated divisions of safety equipment) and operation/maintenance (housekeeping, combustible controls, firewatches) of the station. Because of the low fire risk found as a result of this study, it appears that the current body of fire safety rules and regulations is more than adequate for ensuring SSES is "fire safe".

## 4.11 References for Fire PRA


4-1 "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities", Generic Letter 88-20, Supplement. 4, June 28, 1991.

4-2 "PRA Procedures Guide", NUREG/CR-2300, January, 1983.

4-3 "Susquehanna Steam Electric Station Units 1 & 2 Fire Protection Review Report", Rev. 4, May 1993.

4-4 "Susquehanna Steam Electric Station Unit 1 & 2 Appendix 'R' Safe Shutdown Component List", AE Dwg. No. M-1002, Rev. 2, Approved December, 1991.

4-5 "Safe Shutdown Path by Fire Zone", AE Dwg. No. M-750, Rev. 1, October 31, 1989.

4-6 "Fire Load Summary", (Combustible Loading Rep.), PP&L Recorded Study SEA-CE-007, Approved December 4, 1989.

4-7 "Procedural and Submittal Guidance for the Individual Plant Examination of External Events...", NUREG 1407, June, 1991.

4-8 "Susquehanna Steam Electric Station Individual Plant Evaluation", PP&L Report NPE-91-001, December, 1991.

4-9 Letter: Warren Minners, USNRC, to William Rasin, NUMARC, "NRC Comments on Draft NUMARC Fire Induced Vulnerability Evaluation (FIVE) Methodology", September 18, 1990.

4-10 "Fire Events Database for U.S. Nuclear Power Plants", NSAC-178L, Rev. 1, January,1993.

4-11 Cable and Raceway Tracking System (CARTS) and Appendix R Cable Database Management System (ARCDMS).

4-12 "Affect of Fire on Operation of the Scram Pilot Solenoid Valves, and Backup Scram Valves, and ATWS/ARI Solenoid Valves", SEA-EE-016, Rev. 3, September 5, 1989..

4-13 "Affect of Fire on the Operation of the Scram Discharge Volume Vent and Drain Valves", SEA-EE-017, Rev. 1, February 1, 1987.

4-14 "Conduct of Operations", Section 4.13.4.e, NDAP-QA-0300, Rev. 1, September 18, 1992.

4-15 David M. Smith, SRO, Supervisor of Operations Technical Support for SSES, personal communication, September 7, 1993.

4-16 "Fire Events Database for U.S. Nuclear Power Plants", NSAC 178L, June 1992.

4-17 "Fire PRA Requantification Studies", NSAC 181, March, 1993.

4-18 "Fire Hazards Analysis for IPEEE Fire PRA", PP&L Calculation EC-RISK-1018, June, 1994.

4-19 "IPEEE Seismic Margins Analysis Safe Shutdown Equipment List", PP&L Calculation EC-RISK-0500, Rev. 0, October 8, 1993.

4-20 "Permissible Locations for Transient Combustibles in Unscreened Fire Zones Without In-Situ Combustibles", PP&L Calculation EC-RISK-1020, June, 1994.

4-21 "Fire Induced Vulnerability Evaluation Methodology (FIVE) Plant Screening Guide", Enclosure 1 to NUMARC letter from William H. Rasin dated December 19, 1991.

4-22 "COMPBRN IIIE: An Interactive Computer Code for Fire Risk Analysis", EPRI NP-7282, May, 1991.

4-23 "Housekeeping Control", PP&L Procedure NDAP-QA-0503, Rev. 0, October 19, 1992.

4-24 "Control of Transient Combustible/Hazardous Materials", PP&L Procedure NSEP-QA-140, Rev. 0, March 19,1992.

4-25 "Non-radiological Waste Management", PP&L Procedure AD-00-448, Rev. 1+PCAF, March 3, 1993.

4-26 "Foreign Material Exclusion", PP&L Procedure NDAP-QA-0506, Rev. 0, October 19, 1992.

4-27 J. M. Chavez, "An Experimental Investigation of Internally Ignited Fires in Nuclear Power Plant Control Cabinets: Part 1: Cabinet Effects Tests", NUREG/CR-4527, April, 1987.

4-28 "Fire PRA Requantification Studies", NSAC 181, March, 1993.

4-29 S. P. Nowlen, "A Summary of Nuclear Power Plant Fire Safety Research at Sandia National Laboratories, 1975-1987", NUREG/CR-5384, December 1989.

4-30 "Risk Evaluation of Appendix R MOV Hot Short Modification", PP&L Calculation SA-CAK-002, June 15, 1993.

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4-37 "Fire/Smoke Detection and Alarm System", PP&L Procedure OP-013-002, Rev. 7, December 22, 1992.

4-38 "Plant Damage State Frequency Calculations for IPEEE Fire PRA", PP&L Calculation EC-RISK-1022, June, 1994.

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4-40 "Dosposition of Fire Risk Scoping Study Issues for IPEEE Fire PRA", PP&L Calculation EC-RISK-1031, June, 1994.

4-41 "Verification of Equipment Isolation at the Remote Shutdown Panel in the Event of a Control Room Fire", PP&L Calculation SEA-EE-018, Rev. 0, July, 1987.

4-42 "Survey of Earthquake-Induced Fires in Electric Power and Industrial Facilities", EPRI Report NP-6989, September 1990.

4-43 "Risk Analysis of Highly Combustible Gas Storage, Supply, and Distribution in PWR Plants", NUREG/CR-5259, June 1993.

4-44 "Examination of Appendix R Safe Shutdown components with Regard to Fire Suppression Activities", PP&L Calculation SEA-CE-014, Rev. 2, April 24, 1991.

4-45 "Analysis of Component Outage and Failure Data for Use in the SSES IPE", PP&L Calculation EC-RISK-0503, June, 1994.

Table 4.2 Revised Industry Fire Frequencies

| Plant Location | Ignition Source | Number of Events | Frequency (per op. reactor-yr) |
|---|---|---|---|
| Reactor Building: | Electrical Cabinets<br>Pumps | 9<br>3 | 3.0E-2<br>1.0E-2 |
| Switchgear Rooms: | Electrical Cabinets | 12 | 1.5E-2 |
| Battery Rooms: | Batteries | 3 | 3.8E-3 |
| Control Room: | Electrical Cabinets<br>Kitchen | 3<br>1 | 3.8E-3<br>1.3E-3 |
| Relay/Cable Spreading Rooms: | Electrical Cabinets | 3 | 3.8E-3 |
| "Plant Wide": | Fire Protection Panels | 2 | 2.6E-3 |
| | RPS MG Sets | 2 | 2.6E-3 |
| | Transformers | 5 | 6.4E-3 |
| | Battery Chargers | 4 | 5.0E-3 |
| | Misc. Hydrogen | 1 | 1.3E-3 |
| | Air Compressors | 2 | 2.6E-3 |
| | HVAC | 6 | 7.7E-3 |
| | Transients | Same as NSAC 178 | 1.3E-3 |
| | Transients from Welding/Cutting | 24 | 3.1E-2 |

## Table 4.3
## SSES Fire Event History

| DATE | UNIT | OPER COND | EVENT DESCRIPTION | DETECT/SUPPRESS | BUILDING | LEVATIOI | FIRE ZONE | REFERENCES |
|---|---|---|---|---|---|---|---|---|
| 2/16/81 | NA | Pre-Op | extensive fire,smoke, and water damage to trailer | bechtel fire brigade, tanker truck | Other | NA | 0-00 | FPR |
| 3/10/81 | NA | Pre-Op | hydraulic hose on backhoe ruptured and sprayed oil which ignited | co2 fire extinguisher | Other | NA | 0-00 | FPR |
| 3/31/81 | NA | Pre-Op | welder ignited trailer insulation | co2 fire extinguisher | Other | NA | 0-00 | FPR |
| 4/7/81 | NA | Pre-Op | hydraulic hose rupture sprayed oil on engine igniting it | co2 fire extinguisher | Other | NA | 0-00 | FPR |
| 4/22/81 | NA | Pre-Op | oil line on backhoe ruptured and ignited on manifold | dry chemical extinguisher | Other | NA | 0-00 | FPR |
| 7/17/81 | NA | Pre-Op | propane nozzle on mapp gas tank caught fire | dry chemical extinguisher | Other | NA | 0-00 | FPR |
| 10/30/81 | NA | Pre-Op | electrical heater caused trailer fire | bechtel fire brigade, co2/dry chem. ext. | Other | NA | 0-00 | FPR |
| 1/9/82 | Common | Pre-Op | rags were ignited by a cutting torch | fire extinguisher- Type A | Turbine | 699 | 0-TB | FPR |
| 4/6/82 | NA | Pre-Op | car left running, engine compartment destroyed by fire | dry chemical fire extinguisher | Other | NA | 0-00 | FPR |
| 4/25/82 | U1 | Pre-Op | sparks from welding ignited drywell cooler filter | abc fire extinguisher | U1 Contain | 704 | 1-4F | FPR |
| 5/11/82 | U1 | Pre-Op | small heater was smoldering | workers | U1 React | unknown | unknown | FPR |
| 6/30/82 | U1 | Pre-Op | vacuum motor burned out on a health physics monitor | co2 fire extinguisher | U1 React | 818 | 0-8A | FPR |
| 9/22/82 | Common | Pre-Op | ground wire shorted to feed-in to a motor control center | workers/ portable fire extinguisher | ESSW Pumphouse | NA | 0-51 OR 0-52 | FPR |
| 11/3/82 | NA | Pre-Op | heat lamp burst and a toluene soaked filter was ignited | worker/ fire extinguisher | unknown | unknown | unknown | FPR |
| 11/4/82 | NA | Pre-Op | tar heating buggy was coated with extinguishing agent | worker/fire extinguisher | Other | NA | 0-00 | FPR |
| 11/11/82 | NA | Pre-Op | mop smoldering in machine shop | worker/doused with water | Other | NA | 0-00 | FPR |
| 12/8/82 | U2 | Pre-Op | welding machine rectifier shorted out and caught fire | self-extinguished | U2 React | 645 | 2-1G | FPR |
| 12/29/82 | NA | Pre-Op | truck tractor exhaust ignited a broom and fire extinguisher cover | policeman's fire extinguisher | Other | NA | 0-00 | FPR |
| 3/22/83 | Common | Pre-Op | breaker contact for control structure chiller was arcing | worker/co2 fire extinguisher | Cont Str | 783 | 0-29B | FPR |
| 5/27/83 | U2 | Pre-Op | rags on a scaffold smoldering and smoking | worker knocked to floor and stomped out | U2 React | unknown | unknown | FPR |
| 7/6/83 | NA | U2 Pre-Op | welder sparks ignited ground cover | worker/dc extinguishers | Other | NA | 0-00 | FPR |
| 7/15/83 | Common | U1 Critical, U2 Pre-Op | trash can in technical support center caught fire-cigarette | worker/halon fire extinguisher | Cont Str | 741 | 0-26K | FPR |
| 10/12/83 | Common | U1 Critical, U2 Pre-Op | papers on top of cooking stove were ignited | extinguished immediately, smoke activated sprinklers | Cont Str | 741 | 0-26K | FPR |
| 12/16/83 | U2 | Pre-Op | transformer in panel 2C664 overheated and smoked | worker/self extinguished | U2 Cont Str | 754 | 0-27A | FPR |
| 1/14/84 | Common | U1 SD, U2 Pre-Op | explosion in "D" EDG crankcase | worker/self extinguished | Diesel Gen | 677 | 0-41D | SOOR 1-84-020 |
| 2/15/84 | NA | NA | microwave melt down due to cooking itself | alarm/ co2 fire extinguisher used | Other | Other | 0-00 | FPR |
| 4/2/84 | NA | NA | smoke coming from trailer outside sses fence | security/portable fire extinguishers | Other | NA | 0-00 | FPR |
| 7/23/84 | Common | U1 Critical, U2 Pre-Op | smoking outboard seal packing, diesel fire pump | worker/self-extinguished | Other | NA | 0-00 | SOOR 1-84-240 |
| 1/21/85 | U1 | Critical | breaker in mcc overheated and released a large puff of smoke | self extinguished | U1 Turbine | unknown | 0-TB | FPR |
| 2/27/85 | NA | NA | small fire near chlorine and sulfuric acid building | security/dry chemical fire extinguisher | Other | NA | 0-00 | FPR |
| 3/7/85 | NA | NA | trash can found smoldering in circulation water pump house-cigarette | worker/ extinguished w/eye wash unit | Other | NA | 0-00 | FPR |
| 3/21/85 | U1 | SD | welding cable heats mirror insulation, odor detected | worker/dry chem. | U1 Contain | 719 | 1-4F | SOOR 1-85-102 |
| 3/26/85 | U2 | Critical | smoke in 2C616, URR, RPIS lost, failed capacitor | self-extinguished | U2 Cont Str | 754 | 0-27A | SOOR 2-85-076, FPR |
| 4/3/85 | U1 | SD | smoke from north HCU solenoids, hi current during PM's | self extinguished | U1 React | 719 | 1-4A-N | SOOR 1-85-113 |
| 4/19/85 | Common | U2 Critical, U1 SD | smoke from control room SPING terminal, circuit board repl. | self-extinguished/worker shut off power | Contr Str | 729 | 0-26H | SOOR 1-85-125 |
| 11/6/85 | U1 | Critical | fire supply brkr for turbine bldg. fan 1V101B, defect. brkr | fire brigade extinguished 4 minutes | U1 Turbine | 762 | 0-TB | SOOR 1-85-322,FPR |
| 11/30/85 | NA | NA | RWMU "A" pump was smoking | CR fire alarm/dry chemical and co2 extinguishers | Other | NA | 0-00 | FPR |
| 12/13/85 | NA | NA | truck in parking lot caught fire | halon extinguisher | Other | NA | 0-00 | FPR |
| 1/18/86 | Common | U1 Critical, U2 SD | explosion in "B" EDG crankcase | self extinguished | Diesel Gen | 677 | 0-41B | SOOR 1-86-015 |
| 1/28/86 | Common | Both Critical | smoke in "A" EDG room, oil accumulation | Diesel Gen SD | Diesel Gen | 677 | 0-41A | SOOR 1-86-028 |
| 3/24/86 | U1 | SD | fire "A" condenser water box, drop light hits solvent | worker/fire brigade ext 5 min. | U1 Turbine | 676 | 0-TB | SOOR 1-86-091,FPR |

Table 4-8
SSES Fire Event History

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4/1/86 | NA | NA | butt can smoldering outside south gate house | water extinguishers | Other | NA | 0-00 | FPR |
| 5/12/86 | Common | Both Critical | smoke in U2 "A" TIP drawer, Control Room, computer logic card, fuse repl | worker/powered down TIP panels | Cont Str | 729 | 0-26H | SOOR 2-86-068 |
| 5/22/86 | Common | Both Critical | fire in computer room I/O panel, ground | self extinguished | Cont Str | 698 | 0-24E | SOOR 1-86-176 |
| 6/3/86 | Common | Both SD | smoke in air in computer room and 2 PC boards on fire | worker/blew flames out | Cont Str | 698 | 0-24E | FPR |
| 8/12/86 | NA | NA | electrical short -parking lot car fire | worker/halon 1211 extinguishers | Other | NA | 0-00 | FPR |
| 9/6/86 | U2 | SD | smoke from "B" swing bus MG set, motor heater heats bearing grease | supply breaker racked out | U2 React | 719 | 2-4A-N | SOOR 2-86-138 |
| 11/21/86 | NA | NA | garbage dumpster in surplus yard found burning | extinguished trash | Other | NA | 0-00 | FPR |
| 12/21/86 | U1 | SD | smoke wisp from dust on resistors in control room, TIP panel 18 Mo. SI | worker/self-extinguished | U1 Cont Str | 729 | 0-26H | SOOR 1-86-345 |
| 1/23/87 | NA | NA | electrical cable in truck portal monitor caught styrofoam on fire | co2 fire extinguisher | Other | NA | 0-00 | FPR |
| 3/22/87 | U2 | Critical | smoking RWCU pump insulation , oil from prev. maint. | detection system activated/co2 fire ext. | U1 React | 749 | 1-5D | SOOR 1-87-85, WA S64299 |
| 4/12/87 | U1 | Critical | unusually high temp. in "B" offgas guard bed | worker/ shutdown and isolate guard bed | Radwaste | 676 | W-1 | SOOR 1-87-106 |
| 7/4/87 | NA | NA | florescent light fixture smoking & burning | light de-energized | Other | NA | 0-00 | FPR |
| 7/6/87 | U2 | Critical | unit 2 refueling bridge power cable caught fire | power disconnected-self extinguished | U2 React | 818 | 0-8A | FPR |
| 10/20/87 | U1 | SD | fire in drywell, welding slag ignites isopropanol | worker/dry chemical fire extinguisher | U1 Contain | 719 | 1-4F | SOOR 1-87-300, FPR |
| 10/20/87 | U1 | SD | welding heats panel door 1C280, causing paint to char | welding machine SD | U1 React | 719 | 1-4A-S | SOOR 1-87-302 |
| 10/26/87 | NA | NA | oil on packing follower stud of B circ. water pump caught fire | worker/dry chemical fire extinguisher | Other | NA | 0-00 | FPR |
| 1/14/88 | U2 | Critical | fire in panel 2C277 pwr supply xfrmr, internal short | CR fire alarm/self extinguished | U2 React | 779 | 0-6C | SOOR 2-88-003, WA V80032, FPR |
| 3/15/88 | U2 | SD | smoke from refuel bridge emerg. brake, coil failed | self extinguished | U2 React | 818 | 0-8A | SOOR 2-88-061 |
| 3/28/88 | Common | U1 Critical, U2 SD | cigarette butt container caught fire | worker/extinguished with water | Cont Str | 676 | 0-22A | FPR |
| 4/25/88 | U2 | SD | worker shorted bus bar in 2C278B, arc and smoke | CR alarm, fire brigade responded, bkr 2B250-42 tripped | U2 React | 779 | 2-6D | SOOR 2-88-106 |
| 7/27/88 | Common | Both Critical | cigarette butt container caught fire | worker/extinguished with water, corridor C-117 | Cont Str | 676 | 0-22A | FPR |
| 1/22/89 | NA | NA | smoke from indicating light panel | halon fire extinguisher | Other | NA | 0-00 | FPR |
| 2/10/89 | U1 | Critical | spark from welding started temporary air filter fire | fire watch/chemical fire extinguisher | U1 Turbine | 729 | 0-TB | FPR |
| 4/6/89 | Common | U2 Critical, U1 SD | waste can smoking due to improperly extinguished cigarette | worker/water fire extinguisher | Cont Str | 676 | 0-22C | FPR |
| 4/13/89 | NA | NA | plastic bag of cleaning rags caught fire, combo shop | worker/water fire extinguisher | Other | NA | 0-00 | FPR |
| 4/22/89 | NA | NA | brush fire at south end of lake in Riverlands | worker/extinguished brush fire | Other | NA | 0-00 | FPR |
| 5/1/89 | U1 | SD | smoke- 2 buckets of epoxy mixture self heated | fire brigade responded, move buckets outside, self ext. | U1 Contain | 656 | 1-4F | SOOR 1-89-155 |
| 6/2/89 | U1 | SD | smoke from brkr 1D264061, overload relay failed | self extinguished | U1 React | 683 | 1-3B-N | SOOR 1-89-212 |
| 9/11/89 | NA | NA | fire in light socket due to short in security diesel generator load center | extinguished by blowing | Other | NA | 0-00 | FPR |
| 9/16/89 | Common | U1 Critical, U2 SD | explosion in "B" EDG crankcase | self extinguished | Diesel Gen | 677 | 0-41B | SOOR 1-89-309 |
| 10/5/89 | U1 | Critical | fire in trash barrel from grinding on 719' Rx. bldg. | fire watch/ extinguish via portable dry chem. | U1 React | 719 | 1-4A-N | SOOR 1-89-327,FPR |
| 10/6/89 | U2 | SD | smoke from UPS xfrmr wire in 2D666, loose connection | alarm, ops&fire brigade responded | U2 Cont Str | 771 | 0-28A-II | SOOR 2-89-152 |
| 10/7/89 | Common | U1 Critical, U2 SD | explosion in "C" EDG crankcase | self extinguished | Diesel Gen | 677 | 0-41C | SOOR 1-89-324 |
| 10/20/89 | U2 | SD | smoke from panel 2C692 (CR) after fuse repl., human error | operator/fuses removed | U2 Cont Str | 729 | 0-26H | SOOR 2-89-170 |
| 11/13/89 | NA | NA | car fire in the engine compartment, due to gas on manifold | chemical extinguisher | Other | NA | 0-00 | FPR |
| 11/22/89 | NA | NA | smoldering fire in aperture card printer | area ventilated, machine de-energized | Other | NA | 0-00 | FPR |
| 4/10/90 | NA | NA | fire on cloth piece from welding spark | fire watch extinguished | Other | NA | 0-00 | SOOR 1-90-092,FPR |
| 6/1/90 | NA | NA | fire in off-site vehicle, south warehouse loading dock | fire brigade responded/dry chem and water hose | Other | NA | 0-00 | SOOR 1-90-140,FPR |
| 1/18/91 | NA | NA | paper towels caught fire after being removed from microwave oven | stepped out | Other | NA | 0-00 | FPR |
| 2/3/91 | U1 | Critical | fire in "A" condensate x-fer pump bearing, pump SD | worker/self extinguished | U1 Turbine | 656 | 0-TB | SOOR 1-91-023 |
| 3/4/91 | NA | NA | smoke in S&A bldg., pwr supply to fan 0V705 failed | fire alarm/self extinguished | Other | NA | 0-00 | SOOR 1-91-049,FPR |
| 4/2/91 | U2 | SD | fire in wall outlet "A" RFPT room, faulty outlet | worker/fire extinguisher | U2 Turbine | 676 | 0-TB | SOOR 2-91-078,FPR |

## Table 4.3
## SSES Fire Event History

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4/8/91 | U2 | SD | explosion in Rx. bldg. acetylene gas | workers/isolate gas bottles | U2 React | 749 | unknown | SOOR 2-91-085 |
| 4/15/91 | Common | U1 Critical, U2 SD | fire in control structure trash can-cigarette | worker/CO2 extinguisher | Cont Str | 676 | 0-22A | SOOR 1-91-085,FPR |
| 4/16/91 | U2 | SD | fire in drywell, welding ignites rags | fire watch stepped on and exting. | U2 Contain | unknown | 1-4F | SOOR 2-91-100,FPR |
| 8/2/91 | NA | NA | brush fire burned 1/2 acre-cigarette | fire extinguisher, local fire department | Other | NA | 0-00 | FPR |
| 9/10/91 | NA | NA | fire in "second sort" machine, machine jammed | HP techs put out w/portable ext., trailer | Other | NA | 0-00 | SOOR 1-91-226,FPR |
| 9/19/91 | NA | NA | smoke in fluorescent light, overheated ballast, trailer | fire brigade resp., light turned off | Other | NA | 0-00 | SOOR 1-91-233,FPR |
| 1/18/92 | U1 | Critical | explosion, H2 recombiner, contam. injury, un. event | self extinguished | U1 Turbine | 656 | 0-TB | SOOR 1-92-019 |
| 2/12/92 | Common | Both Critical | smoking trash can central access corridor, cigarettes | ops put out /putting water in can | Cont Str | 676 | 0-22A | SOOR 1-92-052 |
| 3/22/92 | Common | Both SD | smoke from chem. computer, failed xfrmr | power shut off, smoke stopped | Cont Str | 676 | O-22A | SOOR 1-92-117 |
| 3/29/92 | U1 | SD | fire in rags due to welding spark RWCU pump room | workers put out | U1 React | 749 | 1-5D | SOOR 1-92-124 |
| 3/30/92 | U1 | SD | fire in drywell, welding ignites tape | fire watch extinguished | U1 Contain | unknown | 1-4F | SOOR 1-92-125 |
| 8/3/92 | NA | NA | fire in forklift at compressed gas store | worker/dry chem ext. | Other | NA | 0-00 | SOOR 1-92-281,FPR |
| 8/30/92 | NA | NA | smoke from motor driven fire pump packing | adjusted packing | Other | NA | 0-00 | SOOR 1-92-299 |
| 9/15/92 | Common | U1 Critical, U2 SD | smoke from U2 control room CRT, PCO desk | worker/CRT power disconnected | Cont Str | 729 | 0-26H | SOOR 1-92-313 |
| 9/27/92 | U2 | SD | fire Rx Bldg 749' near elevator, 120 VAC outlet | power removed, fire went out | U2 React | 749 | 2-5A-S | SOOR 2-92-111,FPR |
| 11/22/92 | U2 | Critical | smoke from "B" CRM panel 2C227B, drive belt, bearing | pump shutdown, smoke stopped | U2 React | 719 | 2-4A-W | SOOR 2-92-162 |
| 1/8/93 | U2 | Critical | fire in air monitor sample pump motor,switch failed and burned, 719' Rx. Bldg | worker/motor unplugged and fire went out | U2 React | 719 | 2-4A-N | SOOR 93-008, FPR |
| 1/10/93 | NA | NA | smoke from "C" circ water pump and brkr (1A10105) | worker/pump shutdown | Other | NA | 0-00 | SOOR 93-009 |
| 4/28/93 | NA | NA | pile of leaves were burning near cemetery | security/local fire department, fire extinguisher | Other | NA | 0-00 | FPR |
| | | | | | | | | |
| | | | | | | | | |

Table 4.4
Reactor Building
Composite
Unit 1

| Fire Zone | Total Cab. | Pumps | Valves | Transform | FPP | RPS MG | Battery | Air Comp. | Vent Sub. | Bat. Chargers | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| 1-1A | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @ Power |
| 1-1B | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @ Power |
| 1-1C | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @ Power |
| 1-1D | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @ Power |
| 1-1E | 0 | 2 | 10 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @ Power |
| 1-1F | 0 | 2 | 10 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @ Power |
| 1-1G | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-1I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-1J | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-2A | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-2B | 1 | 0 | 3 | 0 | 5 | 0 | 0 | 0 | 1 | 0 | Welding and Cutting @ Power |
| 1-2C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 1 hoist, Welding and Cutting @ Power |
| 1-2D | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-3A | 8 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 hoist, Welding and Cutting @ Power |
| 1-3B-N | 10 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-3B-S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 hoists, Welding and Cutting @ Power |
| 1-3B-W | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-3C-N | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-3C-S | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-3C-W | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-4A-N | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 4 | 0 | 1 hoist, Welding and Cutting @ Power |
| 1-4A-S | 8 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 2 | 0 | Misc. H2, Welding and Cutting @ Power |
| 1-4A-W | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Misc. H2, Welding and Cutting @ Power |
| 1-4B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-4E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-4G | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| 1-5A-N | 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-5A-S | 10 | 5 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-5A-W | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Welding and Cutting @ Power |

Table 4.4
Reactor Building
Composite
Unit 1

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-5B | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-5C | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-5D | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-5E | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-6A | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @ Power |
| 1-6E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-6F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-6I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 1-7A | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @ Power |
| 1-7B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @ Power |
| 0-6G | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 0-6H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @ Power |
| 0-8A | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 crane, 1 hoist, Welding and Cutting @ Power |
| | | | | | | | | | | | |
| Total | 86 | 20 | 67 | 8 | 8 | 2 | 1 | 3 | 29 | 1 | |

Table 4-5
Switchgear Rooms
Composite
Unit 1

| Fire Zone | Total Elec. Cab. | Pumps | FPP | Air Comp. | Vent. Sub. | Trans. | Bat. Char. | Other |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 0-22A | 2 | 0 | 1 | 0 | 7 | 0 | 0 | Welding and Cutting @ Power |
| 0-24B | 1 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @Power |
| 0-24C | 2 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @Power |
| 0-28B-I | 4 | 0 | 0 | 0 | 0 | 0 | 8 | Welding and Cutting @Power |
| 0-28B-II | 21 | 0 | 0 | 0 | 0 | 0 | 6 | Welding and Cutting @Power |
| 0-29B | 9 | 0 | 0 | 0 | 12 | 1 | 0 | Welding and Cutting @Power |
| 0-30A | 4 | 2 | 0 | 2 | 19 | 0 | 0 | Welding and Cutting @Power |
| 1-4C | 3 | 0 | 0 | 0 | 1 | 1 | 0 | Welding and Cutting @Power |
| 1-4D | 3 | 0 | 0 | 0 | 1 | 1 | 0 | Welding and Cutting @Power |
| 1-5F | 3 | 0 | 0 | 0 | 0 | 1 | 0 | Welding and Cutting @Power |
| 1-5G | 4 | 0 | 0 | 0 | 0 | 1 | 0 | Welding and Cutting @Power |
| 1-6B | 4 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @Power |
| 1-6C | 2 | 0 | 0 | 0 | 0 | 2 | 0 | Welding and Cutting @Power |
| 1-6D | 7 | 0 | 0 | 0 | 25 | 2 | 0 | Welding and Cutting @Power |
| 0-TB | | | | | | | | |
| I-33 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @Power, Misc. H2 |
| I-220 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @Power, Misc. H2 |
| I-301 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | Welding and Cutting @Power, Misc. H2 |
| | | | | | | | | |
| Total | 77 | 2 | 1 | 2 | 65 | 11 | 14 | |
| | | | | | | | | *There are no batteries, RPS MG sets, |
| | | | | | | | | or valves. |

Table 4.6
Batteries
Unit 1

| Fire Zone | Battery Room | Num. of Batteries (U1) | Num. of Batteries (Common) | Total Num. of Batteries * | Other |
|---|---|---|---|---|---|
| 0-28I | YES | 1 | 0 | 1 | Welding and Cutting @ Power |
| 0-28J | YES | 1 | 0 | 1 | Welding and Cutting @ Power |
| 0-28K | YES | 1 | 0 | 1 | Welding and Cutting @ Power |
| 0-28L | YES | 1 | 0 | 1 | Welding and Cutting @ Power |
| 0-28M | YES | 1 | 0 | 1 | Welding and Cutting @ Power |
| 0-28N | YES | 1 | 0 | 1 | Welding and Cutting @ Power |
| 1-5A-N | NO | 1 | 0 | 1 | Counted under Reactor Building Zones |
| Other ** | NO | 2 | 1 | 3 | |
| | | | | | |
| TOTAL | | 9 | 1 | 10 | |
| | | | | | |
| | | | | * There was one extra battery found | |
| | | | | for other fire zones for Unit 2. | |
| | | | | ** Other is any fire zone that is not a | |
| | | | | battery room or a fire zone of interest . | |
| | | | | | |
| | | | | | |
| | | | | | |
| | Fire Zone | Batteries | | | |
| | | | | | |
| | 0-28I | 1D650 | | | |
| | 0-28J | 1D660 | | | |
| | 0-28K | 1D610 | | | |
| | 0-28L | 1D630 | | | |
| | 0-28M | 1D620 | | | |
| | 0-28N | 1D640 | | | |
| | 1-5A-N | 1D243 | | | |
| | OTHER ** | 1D135, 1D133, 2D140 | | | |
| | | 0D510 | | | |
| | | | | | |

## Table 4.7
## Control Room
## Electrical Cabinets

| Fire Zone | Elect. Cabinets | Counted | Reason |
|---|---|---|---|
| | | | |
| 0-26H | 0C650 | No | Fire Protection Panel |
| | 0C653 | Yes | Normally Powered Cabinet |
| | 0C656 | Yes | Normally Powered Cabinet |
| | 0C657 | Yes | Normally Powered Cabinet |
| | 0C658 | Yes | Normally Powered Cabinet |
| | 0C659 | Yes | Normally Powered Cabinet |
| | 0C669 | No | Removed |
| | 0C671 | Yes | Normally Powered Cabinet |
| | 0C673 | Yes | Normally Powered Cabinet |
| | 0C681 | Yes | Normally Powered Cabinet |
| | 0C683 | Yes | Normally Powered Cabinet |
| | 0C693 | Yes | Normally Powered Cabinet |
| | 0C695 | Yes | Normally Powered Cabinet |
| | 0C696 | Yes | Normally Powered Cabinet |
| | 0C697 | Yes | Normally Powered Cabinet |
| | 0C698 | Yes | Normally Powered Cabinet |
| | 1C600 | Yes | Normally Powered Cabinet |
| | 1C601 | Yes | Normally Powered Cabinet |
| | 1C607 | Yes | Normally Powered Cabinet |
| | 1C610 | Yes | Normally Powered Cabinet |
| | 1C614 | Yes | Normally Powered Cabinet |
| | 1C644 | Yes | Normally Powered Cabinet |
| | 1C645 | Yes | Normally Powered Cabinet |
| | 1C650 | No | Fire Protection Panel |
| | 1C651 | Yes | Normally Powered Cabinet |
| | 1C652 | Yes | Normally Powered Cabinet |
| | 1C654 | Yes | Normally Powered Cabinet |
| | 1C656 | Yes | Normally Powered Cabinet |
| | 1C668 | Yes | Normally Powered Cabinet |
| | 1C681 | Yes | Normally Powered Cabinet |
| | 1C684 | Yes | Normally Powered Cabinet |
| | 1C690 | Yes | Normally Powered Cabinet |
| | 1C692 | Yes | Normally Powered Cabinet |
| | 1C693 | Yes | Normally Powered Cabinet |
| | 1C694 | Yes | Normally Powered Cabinet |
| | 1Z651 | Yes | Normally Powered Cabinet |
| | 1Z652 | Yes | Normally Powered Cabinet |
| | 2C600 | Yes | Normally Powered Cabinet |
| | 2C601 | Yes | Normally Powered Cabinet |
| | 2C607 | Yes | Normally Powered Cabinet |
| | 2C610 | Yes | Normally Powered Cabinet |
| | 2C614 | Yes | Normally Powered Cabinet |
| | 2C644 | Yes | Normally Powered Cabinet |
| | 2C645 | Yes | Normally Powered Cabinet |
| | 2C650 | No | Fire Protection Panel |

Table 4.7
Control Room
Electrical Cabinets

| | | | |
|---|---|---|---|
| | 2C651 | Yes | Normally Powered Cabinet |
| | 2C652 | Yes | Normally Powered Cabinet |
| | 2C654 | Yes | Normally Powered Cabinet |
| | 2C656 | Yes | Normally Powered Cabinet |
| | 2C668 | Yes | Normally Powered Cabinet |
| | 2C674 | Yes | Normally Powered Cabinet |
| | 2C681 | Yes | Normally Powered Cabinet |
| | 2C684 | Yes | Normally Powered Cabinet |
| | 2C690 | Yes | Normally Powered Cabinet |
| | 2C692 | Yes | Normally Powered Cabinet |
| | 2C693 | Yes | Normally Powered Cabinet |
| | 2Z652 | Yes | Normally Powered Cabinet |
| | 0C691 | Yes | Normally Powered Cabinet |
| | 2C694 | Yes | Normally Powered Cabinet |
| | 0C630 | Yes | Normally Powered Cabinet |
| | | | |
| | | | |
| | | | |
| Electrical Cabinets (U1) = 20 | | | |
| Electrical Cabinets (U2) = 20 | | | |
| Electrical Cabinets (C) = 16 | | | |
| Total Cabinets = 36 | | | |

Table
Cable Spreading Rooms
Composite
Unit 1

| Fire Zone | Total Elect. Cab. | Fire Prot. Panels | Other |
|---|---|---|---|
| | | | |
| 0-24D | 28 | 0 | Welding and Cutting @ Power |
| 0-24E | 33 | 0 | Welding and Cutting @ Power |
| 0-25E | 2 | 2 | Welding and Cutting @ Power |
| 0-26K | 7 | 0 | - |
| 0-27C | 3 | 1 | Welding and Cutting @ Power |
| 0-27E | 32 | 0 | Welding and Cutting @ Power |
| | | | |
| | | | |
| Total | 105 | 3 | |
| | | | *There are no pumps, valves, |
| | | | air compressors, ventilation subsystems, |
| | | | batteries, battery chargers, MG sets, |
| | | | or transformers. |

## Table 4.9
## Fire Protection Panels
## Unit I

| Fire Zone | Fire Prot. Panel (U1) | Fire Prot. Panel (Com) | Total Fire Prot. Panels |
|---|---|---|---|
| | | | |
| 1-1G | 0 | 1 | 1 |
| 1-2B | 5 | 0 | 5 |
| 1-3A | 1 | 0 | 1 |
| 1-4A-S | 1 | 0 | 1 |
| 0-21B | 0 | 1 | 1 |
| 0-22A | 0 | 1 | 1 |
| 0-24F | 0 | 4 | 4 |
| 0-25E | 0 | 2 | 2 |
| 0-26C | 1 | 0 | 1 |
| 0-26H | 3+1(U2) | 2 | 5 |
| 0-27C | 1 | 0 | 1 |
| 0-28H | 1 | 0 | 1 |
| Other | 14 | 28 | 42 |
| | | | |
| Total | 27+1(U2) | 39 | 66 |
| | | | |
| | | | |
| | | | |

| Fire Zone | Fire Protection Panel |
|---|---|
| | |
| 1-1G | 0C502C |
| 1-2B | 1C230, 1C231, 1C218A, 1C218B, 1C218C |
| 1-3A | 1C233 |
| 1-4A-S | 1C234 |
| 0-21B | 0C649 |
| 0-22A | 0C514 |
| 0-24F | 0CB607, 0CB608, 0CB610, 0CB611 |
| 0-25E | 0C548, 0C551 |
| 0-26C | 1CB627 |
| 0-26H | 0CB617, 1CB617, 1CB615, 0C650, 1C650, 2C650 |
| 0-27C | 1CB602 |
| 0-28H | 1CB618 |
| Other | 0C584, 0C688, 0C689, 0C707, 0C708, 0C502A, 0C502D, 0C502E, 0C322D, 0C586, |
| | 0C508A, 0C583, 0CB508, 0C501A, 0C501E, 0CB609, 0CB600, 0CB612, 0CB606, |
| | 0C102, 0C505, 0C591A, 0C591B, 0C591C, 0C592A, 0C592B, 0C979, 0C978 |
| | 1C685,1C686, 1C160A, 1C160D, 1C160E, 1C160H, 1C160J, 1C160K 1C161, |
| | 1CB633, 1CB630, 1CB639, 1CB636, 1CB600 |

Table 4.10
RPS MG Sets
Unit 1

| Fire Zone | RPS MG Sets | Total |
|---|---|---|
| | | |
| 1-5A-S | 1S237A -1G210A | 2 |
| | 1S237B-1G210B | |

Table 4.11
Transformers
Unit 1

| Fire Zone | Transformers (U1) | Transformers (Com) | Total Transformers |
|---|---|---|---|
| | | | |
| 1-3A | 1 | 0 | 1 |
| 1-3B-N | 1 | 0 | 1 |
| 1-4A-N | 1 | 0 | 1 |
| 1-4A-S | 4 | 0 | 4 |
| 1-4C | 1 | 0 | 1 |
| 1-4D | 1 | 0 | 1 |
| 1-5A-S | 1 | 0 | 1 |
| 1-5F | 1 | 0 | 1 |
| 1-5G | 1 | 0 | 1 |
| 1-6B | 2 | 0 | 2 |
| 1-6C | 2 | 0 | 2 |
| 1-6D | 2 | 0 | 2 |
| 0-29B | 0 | 1 | 1 |
| Other | 13 | 10 | 23 |
| | | | |
| TOTAL | 31 | 11 | 42 |
| | | | |
| | | | |
| | | | |
| Fire Zone | Transformers | | |
| 1-3A | 1X216 | | |
| 1-3B-N | 1X226 | | |
| 1-4A-N | 1X246 | | |
| 1-4A-S | 1X236, 1X218, 1X291, 1X294 | | |
| 1-4C | 1X240 | | |
| 1-4D | 1X230 | | |
| 1-5A-S | 1X201A | | |
| 1-5F | 1X220 | | |
| 1-5G | 1X210 | | |
| 1-6B | 1X250, 1X260 | | |
| 1-6C | 1X270, 1X280 | | |
| 1-6D | 1X810, 1X820 | | |
| 0-29B | 0X620 | | |
| Other | 0X700, 0X501, 0X330, 0X551, 0X570 | | |
| | 0X103, 0X202, 0X201, 0X211, 0X212 | | |
| | 1X190, 1X180, 1X170, 1X160, 1X120 | | |
| | 1X130, 1X140, 1X150, 1X110, 1X100 | | |
| | 1X101, 1X102, 1X105 | | |
| | | | |

Table 4.12
Battery Chargers
Unit 1

| Fire Zone | Battery Chargers | Num. of Battery Chargers (U1) | Num. of Battery Chargers (Common) | Total Battery Chargers |
|---|---|---|---|---|
| | | | | |
| 0-28B-I | 1D623, 1D643, 1D663, 1D683, 1D684 | 5 | 3 | 8 |
| | 0D673, 0D683, 0D685 | | | |
| 0-28B-II | 1D653A, 1D653B | 6 | 0 | 6 |
| | 1D633, 1D613, 1D673, 1D674 | | | |
| 1-5A-W | 1D240 | 1 | 0 | 1 |
| Other | 1D137, 1D130 | 2 | 2 | 4 |
| | 0D513, 0D523 | | | |
| | 2D143A, 2D143B | | | |
| | | | | |
| Total | | 14 | 5 | 19 |
| | | | | |
| | | | | * There are two battery chargers |
| | | | | that go with the one extra battery |
| | | | | in other fire zones for Unit 2. |
| | | | | ** Other is any fire zone that is not a |
| | | | | battery room or a fire zone of interest . |

## Table 4.13
## Air Compressors
## Unit 1 and Common

| Fire Zone | Air Compressors (Unit 1) | Air Compressors (Common) | Total Air Compressors |
|---|---|---|---|
| | | | |
| 0-8A | 1 | 0 | 1 |
| 0-30A | 0 | 2 | 2 |
| 1-4A-N | 2 | 0 | 2 |
| Other | 6 | 3 | 9 |
| Diesel Gen. | 0 | 8 | 8 |
| | | | |
| Total | 9 | 13 | 22 |
| | | | |
| | | | |
| | | | |
| | | | |
| Fire Zone | Air Compressors | | |
| | | | |
| 0-8A | 1K203 | | |
| 0-30A | 0K115A, 0K115B | | |
| 1-4A-N | 1K205A, 1K205B | | |
| Other | 0K305, 0K503A, 0K503B, | | |
| | 1K107A, 1K107B, 1K108A, | | |
| | 1K108B, 1K114A, 1K114B | | |
| Diesel Gen. | 0K507A1, 0K507A2, 0K507B1 | | |
| | 0K507B2, 0K507C1, 0K507C2 | | |
| | 0K507D1, 0K507D2 | | |

Table 4.14
Ventilation Subsystems
Unit 1

| Fire Zone | Fans (U1) | Fans (C) | Heaters (U1) | Heaters (C) | Total Vent Subsystems |
|---|---|---|---|---|---|
| | | | | | |
| 1-1A | 2 | 0 | 0 | 0 | 2 |
| 1-1B | 2 | 0 | 0 | 0 | 2 |
| 1-1C | 2 | 0 | 0 | 0 | 2 |
| 1-1D | 2 | 0 | 0 | 0 | 2 |
| 1-1E | 2 | 0 | 0 | 0 | 2 |
| 1-1F | 2 | 0 | 0 | 0 | 2 |
| 1-2B | 1 | 0 | 0 | 0 | 1 |
| 1-2C | 0 | 0 | 4 | 0 | 4 |
| 1-4C | 0 | 0 | 1 | 0 | 1 |
| 1-4D | 0 | 0 | 1 | 0 | 1 |
| 1-4A-N | 0 | 0 | 4 | 0 | 4 |
| 1-4A-S | 2 | 0 | 0 | 0 | 2 |
| 1-6A | 2 | 0 | 0 | 0 | 2 |
| 1-6D | 6 | 0 | 19 | 0 | 25 |
| 1-7A | 2 | 0 | 0 | 0 | 2 |
| 1-7B | 0 | 2 | 0 | 0 | 2 |
| 0-22A | 0 | 1 | 0 | 6 | 7 |
| 0-26E | 0 | 0 | 0 | 1 | 1 |
| 0-26G | 0 | 0 | 0 | 1 | 1 |
| 0-29B | 0 | 6 | 0 | 6 | 12 |
| 0-30A | 0 | 14 | 0 | 5 | 19 |
| Other | 29 | 41 | 21 | 119 | 210 |
| | | | | | |
| Total | 54 | 64 | 50 | 138 | 306 |

Table 4.15 Building Screening Results

| Building | Fire Area | Screening Criteria |
|---|---|---|
| Unit 1 Primary Containment | R-1C | Low Combustibles: $N_2$ Inerted Atmosphere |
| Unit 2 Primary Containment | R-2C | Low Combustibles: $N_2$ Inerted Atmosphere |
| Unit 1 Reactor Building | Various | Not Screened Out |
| Unit 2 Reactor Building | Various | Not Screened Out |
| Control Structure | Various | Not Screened Out |
| Diesel Generator Buildings | D-1 through D-5 | Defense-in-Depth and Impact: Loss of 1 EDG part of design basis; leaves HPCI, RCIC, 2 divisions of ADS, and 1 division of LPCI and CS intact plus BOP (no LOOP assumed). |
| ESSW Pumphouse | E-1, E-2 | Defense-in-Depth and Impact: Loss of one fire area leaves similar equipment available as loss of 1 EDG. |
| Turbine Building | T-1 | Defense-in-Depth: Loss of the turbine building leaves all ECCS equipment functional. |
| Radwaste Building | W-1 | Defense-in-Depth: Loss of the radwaste building leaves all ECCS equipment functional. |
| Outside Areas | A-1 | Defense-in-Depth: Loss of the S&A buildings, circulating water pump house, warehouses, etc leaves all the ECCS intact. |

Table 4.16 - Unit 1 Reactor Building Screening Results

| Fire Zone/ Fire Area | Basis for Screening Out | | | | | Adjacent Fire Zones in Same Fire Area | Notes |
|---|---|---|---|---|---|---|---|
| | No Impact or No Significant Combustibles | No Combustibles other than Cables in Tray or Valves | D.I.D. Available No SSD Comp's or Cables for Required Path or HPCI or CRD | D.I.D. Available Review of Cable Hits & Schematics (see note) | Not Screened Out | | |
| 1-1A/R-1A | | | | ✓ | | 1-1G, 1-1F | 1 |
| 1-1F/R-1A | | | | ✓ | | 1-1G, 1-1A | 33 |
| 1-1G/R-1A | | | | ✓ | | 1-1A, 1-1F | 2 |
| 1-2A/R-1A | | | | ✓ | | 1-2C, 1-1F | 14 |
| 1-2C/R-1A | | | ✓ | | | 1-2A, 1-1F, 1-3A, 1-3B-S, 1-3C-S, 1-4A-S, 1-4A-W, 1-4E, 1-5A-S, 1-5A-W | |
| 1-3A/R-1A | | | | | ✓ | 1-2C, 1-3C-S | |
| 1-3B-S/R-1A | | | ✓ | | | 1-2C, 1-3C-S, 1-3B-W | |
| 1-3B-W/R-1A, R-1B | | | | | ✓ | 1-3B-S, 1-3B-N, 1-3C-W | |
| 1-3C-S/R-1A | | | | ✓ | | 1-3C-W, 1-3B-W, 1-2C, 1-3A | 3 |
| 1-3C-W/R-1A, R-1B | | | | ✓ | | 1-3C-S, 1-3C-N, 1-3B-W | 4 |
| 1-4A-S/R-1A | | | | | ✓ | 1-4A-W, 1-4E, 1-2C | |
| 1-4A-W/R-1A, R-1B | | | | | ✓ | 1-4A-S, 1-4A-N, 1-2C, 1-4E | |
| 1-4E/R-1A | ✓ | | | | | 1-4A-W, 1-2C | |
| 1-5A-S/R-1A | | | | | ✓ | 1-2C, 1-5A-W | |
| 1-5A-W/R-1A, R-1B | | | | | ✓ | 1-5A-S, 1-5A-N, 1-5E, 1-5H, 1-2C | |
| 1-5E/R-1A | | | | ✓ | | 1-5A-S, 1-5A-W | 5 |
| 1-5H/R-1A | ✓ | | | | | 1-5A-W | |
| 1-6B/R-1A, R-1B | | | ✓ | | | 1-6A, 1-6C, 1-6D, 0-8A | |
| 1-6C/R-1A, R-1B | | | ✓ | | | 1-6B, 1-6D | |
| 1-6D/R-1A, R-1B | | | | ✓ | | 1-6B, 1-6C, 1-6D, 1-6F, 0-8A | 6 |

Table 4.16 - Unit 1 Reactor Building Screening Results
(Continued)

| Fire Zone/ Fire Area | Basis for Screening Out | | | | | Adjacent Fire Zones in Same Fire Area | Notes |
|---|---|---|---|---|---|---|---|
| | No Impact or No Significant Combustibles | No Combustibles other than Cables in Tray or Valves | D.I.D. Available No SSD Comp's or Cables for Required Path or HPCI or CRD | D.I.D. Available Review of Cable Hits & Schematics (see note) | Not Screened Out | | |
| 1-6E/R-1A | ✓ | | | | | 1-6D, 1-2C, 1-6F, 0-6H | |
| 1-6F/R-1A, R-1B | ✓ | | | | | 1-6A, 1-6D, 1-6E, 0-6G, 0-6H, 0-8A | |
| 1-7A/R-1A, R-1B | | | ✓ | | | 1-6B, 1-6F, 1-7B, 0-8A | |
| 1-7B/R-1A, R-1B | ✓ | | | | | 1-7A | |
| 0-6G/R-1A, R-1B | ✓ | | | | | 0-6H, 1-6F, 1-6A, 0-8A | |
| 0-6H/R-1A, R-1B | ✓ | | | | | 1-6F, 0-6G | |
| 0-8A/R-1A, R-1B | | | ✓ | | | Several | |
| 1-1B/R-1B | | | | ✓ | | 1-1C, 1-1I | 7 |
| 1-1C/R-1B | | | | ✓ | | 1-1B, 1-1D, 1-2B | 8 |
| 1-1D/R-1B | | | | ✓ | | 1-1C, 1-1E | 9 |
| 1-1E/R-1B | | | | ✓ | | 1-1D | 10 |
| 1-1I/R-1B | ✓ | | | | | 1-1B | |
| 1-1J/R-1B | ✓ | | | | | 1-1D, 1-1E | |
| 1-2B/R-1B | | | | | ✓ | 1-1C, 1-1D, 1-2D, 1-1I, 1-1E, 1-1J | 11 |
| 1-2D/R-1B | | | | ✓ | | 1-2B, 1-1I | 12 |
| 1-3B-N/R-1B | | | | | ✓ | 1-3C-N, 1-3B-W | |
| 1-3C-N/R-1B | | ✓ | | | | 1-3C-W, 1-3B-W, 1-3B-N | 13 |
| 1-4A-N/R-1B | | | | | ✓ | 1-4A-W, 1-4B, 1-4C | |
| 1-4B/R-1B | | ✓ | | | | 1-4A-N, 1-4G | |
| 1-4G/R-1B | | | | ✓ | | 1-4B | 15 |

Table 4.16 - Unit 1 Reactor Building Screening Results
(Continued)

| Fire Zone/ Fire Area | Basis for Screening Out | | | | | Adjacent Fire Zones in Same Fire Area | Notes |
|---|---|---|---|---|---|---|---|
| | No Impact or No Significant Combustibles | No Combustibles other than Cables in Tray or Valves | D.I.D. Available No SSD Comp's or Cables for Required Path or HPCI or CRD | D.I.D. Available Review of Cable Hits & Schematics (see note) | Not Screened Out | | |
| 1-5A-N/R-1B | | | | ✓ | | 1-5A-W, 1-5C, 1-5D | 16 |
| 1-5C/R-1B | | | | ✓ | | 1-5A-N, 1-5D | 17 |
| 1-5D/R-1B | | | ✓ | | | 1-5C, 1-5A-N | |
| 1-6A/R-1B | | | | ✓ | | 1-6B, 1-6F, 1-6I, 0-6G, 0-8A | 18 |
| 1-6I/R-1B | | ✓ | | | | 1-6A | |
| 1-1H/R-1C<br>1-4F/R-1C | ✓ | | | | | | 19 |
| 1-5B/R-1D | | | | ✓ | | | 20 |
| 1-4C/R-1E | | | | ✓ | | | 21 |
| 1-4D/R-1F | | | | ✓ | | | 22 |
| 1-5F/R-1G | | | | ✓ | | | 23 |
| 1-5G/R-1H | | | | ✓ | | | 24 |

Table 4.17 - Control Structure Screening Results

| Fire Zone/ Fire Area | Basis for Screening Out | | | | | Adjacent Fire Zones in Same Fire Area | Notes |
|---|---|---|---|---|---|---|---|
| | No Impact or No Significant Combustibles | No Combustibles other than Cables in Tray or Valves | D.I.D. Available No SSD Comp's or Cables for Required Path or HPCI or CRD | D.I.D. Available Review of Cable Hits & Schematics (see note) | Not Screened Out | | |
| 0-21B/CS-1 | ✓ | | | | | 0-29A | |
| 0-29A/CS-1 | ✓ | | | | | 0-21B | |
| 0-22B/CS-2 | ✓ | | | | | 0-29C | |
| 0-29C/CS-2 | ✓ | | | | | 0-22B | |
| 0-21A/CS-3 | | | ✓ | | | - | |
| 0-22A/CS-3 | | | | ✓ | | 0-22C, 0-23 | 25 |
| 0-22C/CS-3 | ✓ | | | | | 0-22A | |
| 0-23/CS-3 | ✓ | | | | | 0-22A | |
| 0-24A/CS-3 | | | ✓ | | | 0-24B | |
| 0-24B/CS-3 | | | | ✓ | | 0-24A, 0-24C, 0-24F | 26 |
| 0-24C/CS-3 | | | ✓ | | | 0-24B | |
| 0-24F/CS-3 | | ✓ | | | | 0-24B | |
| 0-24I/CS-4 | ✓ | | | | | 0-29B | |
| 0-24K/CS-4 | ✓ | | | | | 0-29B | |
| 0-28S/CS-4 | ✓ | | | | | 0-29B | |
| 0-29B/CS-4 | | | | | ✓ | 0-24I, 0-24K, 0-28S | |
| 0-29D/CS-4 | ✓ | | | | | - | |
| 0-30A/CS-4 | | | | | ✓ | 0-30B | |
| 0-30B/CS-4 | ✓ | | | | | 0-30A | |
| 0-24G/CS-5 | | | | | ✓ | - | |
| 0-24J/CS-6 | | ✓ | | | | - | |

Table 4.17 - Control Structure Screening Results
(Continued)

| Fire Zone/ Fire Area | Basis for Screening Out | | | | | Adjacent Fire Zones in Same Fire Area | Notes |
|---|---|---|---|---|---|---|---|
| | No Impact or No Significant Combustibles | No Combustibles other than Cables in Tray or Valves | D.I.D. Available No SSD Comp's or Cables for Required Path or HPCI or CRD | D.I.D. Available Review of Cable Hits & Schematics (see note) | Not Screened Out | | |
| 0-25B/CS-6 | | ✓ | | | | - | |
| 0-26B/CS-6 | | ✓ | | | | - | |
| 0-27F/CS-6 | | ✓ | | | | - | |
| 0-28P/CS-6 | | ✓ | | | | - | |
| 0-26S/CS-6 | | ✓ | | | | - | |
| 0-24L/CS-7 | | ✓ | | | | 0-24M | |
| 0-24M/CS-7 | | ✓ | | | | 0-24L | |
| 0-25C/CS-7 | | ✓ | | | | 0-25D | |
| 0-25D/CS-7 | | ✓ | | | | 0-25C | |
| 0-26C/CS-7 | | ✓ | | | | 0-26D | |
| 0-26D/CS-7 | | ✓ | | | | 0-26C | |
| 0-26T/CS-7 | | ✓ | | | | 0-26V | |
| 0-26V/CS-7 | | ✓ | | | | 0-26T | |
| 0-27G/CS-7 | | ✓ | | | | 0-27H | |
| 0-27H/CS-7 | | ✓ | | | | 0-27G | |
| 0-28Q/CS-7 | | ✓ | | | | 0-28R | |
| 0-28R/CS-7 | | ✓ | | | | 0-28Q | |
| 0-24E/CS-8 | | | | ✓ | | - | 27 |
| 0-26A/CS-9 | | | ✓ | | | 0-26H | |
| 0-26E/CS-9 | | ✓ | | | | 0-26H, 0-26F | |
| 0-26F/CS-9 | ✓ | | | | | 0-26E, 0-26G, 0-26H, 0-26M | |

Table 4.17 - Control Structure Screening Results
(Continued)

| Fire Zone/ Fire Area | Basis for Screening Out | | | | | Adjacent Fire Zones in Same Fire Area | Notes |
|---|---|---|---|---|---|---|---|
| | No Impact or No Significant Combustibles | No Combustibles other than Cables in Tray or Valves | D.I.D. Available No SSD Comp's or Cables for Required Path or HPCI or CRD | D.I.D. Available Review of Cable Hits & Schematics (see note) | Not Screened Out | | |
| 0-26G/CS-9 | | | | ✓ | | 0-26F, 0-26H, 0-26M | 31 |
| 0-26H/CS-9 | | | | | ✓ | 0-26A, 0-26E, 0-26G, 0-26K, 0-26I, 0-26N, 0-26P, 0-26J | |
| 0-26I/CS-9 | | | | ✓ | | 0-26H, 0-26J | 32 |
| 0-26J/CS-9 | ✓ | | | | | 0-26H, 0-26I, 0-26R | |
| 0-26K/CS-9 | | | ✓ | | | 0-26H, 0-26L, 0-26R | |
| 0-26L/CS-9 | | | ✓ | | | 0-26H, 0-26K, 0-26M, 0-26N | |
| 0-26M/CS-9 | | ✓ | | | | 0-26L, 0-26F, 0-26G | |
| 0-26N/CS-9 | | ✓ | | | | 0-26H, 0-26L, 0-26P | |
| 0-26P/CS-9 | | ✓ | | | | 0-26H, 0-26N | |
| 0-26R/CS-9 | | ✓ | | | | 0-26J, 0-26K | |
| 0-27C/CS-10 | ✓ | | | | | 0-27D | |
| 0-27D/CS-10 | | | ✓ | | | 0-27C | |
| 0-28A-I/CS-11 | | | | | ✓ | - | |
| 0-28C/CS-12 | | | ✓ | | | - | |
| 0-28E/CS-13 | | | ✓ | | | - | |
| 0-28G/CS-14 | | | | ✓ | | - | 28 |
| 0-28H/CS-15 | | | ✓ | | | - | |
| 0-28J/CS-16 | | | | | ✓ | - | |
| 0-28B-I/CS-17 | | | | | ✓ | - | |
| 0-28M/CS-18 | | | ✓ | | | - | |
| 0-28N/CS-19 | | | ✓ | | | - | |

Table 4.17 - Control Structure Screening Results
(Continued)

| Fire Zone/ Fire Area | Basis for Screening Out | | | | | Adjacent Fire Zones in Same Fire Area | Notes |
|---|---|---|---|---|---|---|---|
| | No Impact or No Significant Combustibles | No Combustibles other than Cables in Tray or Valves | D.I.D. Available No SSD Comp's or Cables for Required Path or HPCI or CRD | D.I.D. Available Review of Cable Hits & Schematics (see note) | Not Screened Out | | |
| 0-28A-II/CS-20 | | | | | ✓ | - | |
| 0-28T/CS-21 | | | ✓ | | | - | |
| 0-28D/CS-22 | | | ✓ | | | - | |
| 0-28F/CS-23 | | | | | ✓ | - | |
| 0-28B-II/CS-24 | | | | | ✓ | - | |
| 0-28I/CS-25 | | | | | ✓ | - | |
| 0-28K/CS-26 | | | ✓ | | | - | |
| 0-28L/CS-27 | | | ✓ | | | - | |
| 0-24D/CS-28 | | | | | ✓ | | |
| 0-25A/CS-29 | ✓ | | | | | - | 29 |
| 0-25E/CS-30 | ✓ | | | | | - | 30 |
| 0-27A/CS-31 | | | | | ✓ | - | |
| 0-27B/CS-32 | ✓ | | | | | - | 30 |
| 0-27E/CS-33 | | | | | ✓ | - | |

Table 4.18 - Notes to Screening Results

1. Cable for ADS is for permissive on RHR pump discharge pressure; permissive from CS pumps remains available. Cables for ESW Pumps B&D are for indication on remote shutdown panel; normally isolated on both sides by Sel. SW. contacts. HPCI cables are for steam line vacuum breaker valve; HPCI will operate successfully without the barometric condenser (IPE Vol. 2, P.A-72).

   D.I.D. by (HPCI or CRD) and ($ADS_{II}$ with $CS_{II}$ & $LPCI_{II}$)

2. See Note 1 for ADS and HPCI cables. The cable for ESF buses and pumps is for a load shed initiation signal from Unit 2; its failure has no impact on SSD of Unit 1.

   D.I.D. by (HPCI or CRD) and ($ADS_{I\&II}$ with $CS_{II}$ & $LPCI_{II}$)

3. RHR pseudo-component cable is for interlock between same letter pumps on U1 & U2 - starts U1 pump and stops U2 pump. The instrumentation cables affect 4 of 12 TC's for SPM. The CRDS cables affect one of two redundant solenoids on SDV drain and vent valves.

   D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_{II}$ & $LPCI_{II}$)

4. D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_{I\&II}$)

5. RHR pseudo-component cable is for interlock between same letter pumps on U1 and U2. ADS cable could spuriously close SV-12654A; Div. II CIG line with SV-12654B remains available.

   D.I.D. by (HPCI or $CRD_B$) and ($ADS_{II}$ with $CS_{I\&II}$ & $LPCI_{II}$)

6. Cable for CSS could provide spurious Div. I high drywell pressure signal or make one or both Div. I signals unavailable; spurious signal will cause actuation of Div. I CS, failure of signal leaves manual initiation available. The RHR pseudo-component cable is for interlock between U1 & U2 same letter pumps. One ADS cable has no effect since another device is in series. The other ADS cable can disable $ADS_I$.

   D.I.D. by (HPCI or RCIC or CRD) and ($ADS_{II}$ with $CS_{I\&II}$ & $LPCI_{I\&II}$)

7. Required SSD path is 1 and there are no SSD comp's or cables for path 1 that will be affected. However, since HPCI cables in the FZ can make the system unavailable due to fire-induced failure, path 2 & 3 cables for RCIC, RHR, ESWS and RHRSW were checked. LPCI and DHR Div. II will be unaffected; one cable for RCIC (in a conduit by itself) could cause the opening of a 4" bypass line valve off a 6" RCIC line. Even though more than 50% RCIC flow would still be available, no credit is taken for RCIC.

   D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_{I\&II}$)

Table 4.18 - Notes to Screening Results
(Continued)

8. Required SSD path is 1, which remains fully available with a fire in this FZ. However, since it is the HPCI pump room, HPCI will be lost and cables for RCIC, $CS_{II}$ and $RHR_{II}$ were checked. These systems would all be affected. There are no cables for ADS in the FZ and $ADS_{I\&II}$ remain available.

   D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

9. This FZ is the RCIC pump room. In addition to RCIC, HPCI also can be lost due to a fire in this FZ. Cables for SSD path 3 (required path is 1) were checked and it was determined that $RHR_{II}$ would also be lost. Either all of $CS_{II}$ or a half (pump D) will remain available depending on whether a LOOP occurs concurrently with a fire in this FZ. No ADS comp's or cables are present and $ADS_{I\&II}$ remain available.

   D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

   (There are no cables in tray in this FZ, which reduces both available combustibles and the probability of damage to cables).

10. RHR pseudo-component cable that impacts $RHR_I$ could cause F009 and F022 to spuriously open. RHR remains available because the lines can be isolated or remain isolated by another valve in series. Cable for CSS and RHRSW is actually aux. load shed initiation signal to ESF buses from Unit 2 and has no impact on SSD. No ADS comp's or cables are in this FZ.

    D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_{I\&II}$ & $LPCI_I$)

11. The cable for ADS, on a hot short, could cause 6 SRV's to open; no failure of the cable prevents them from opening. The cables for RHR pseudo-component do not prevent RHR I from functioning. Cables for ESW I could fail the A&C pumps and disable RHR Pump A; they are in wrapped conduits, one for CR and one for RSP control. No credit for wrapping is taken. ESW Pumps B&D cable in conduit is also in the fire zone. Loss of this cable disables ESW pump B and RSP indication for pump D. Because of loss of 3 ESW pumps and potential for inadvertent ADS, the zone is not screened.

12. This fire zone is the remote shutdown panel room. All Div. I & II control cables in the room are isolated from the normal control circuits by selector switches in the control room. Therefore, $ADS_{I\&II}$, $RHR_{I\&II}$ and $CS_{I\&II}$ are unaffected by a fire in this FZ, because the control room is in a different fire <u>area</u>. Also the cables for HPCI running through this FZ are power cables for F007; this valve is normally open and any fire-induced cable failure will only prevent the valve from closing.

    D.I.D. by (HPCI) and ($ADS_{I\&II}$ with $CS_{I\&II}$ & $LPCI_{I\&II}$)

Table 4.18 - Notes to Screening Results
(Continued)

13. The only combustible other than cables in tray in this FZ is grease in eight valve operators. The grease is in reservoirs at each valve with no piping and large leaks are unlikely, and will be noticed if it happens. EPRI fire DB does list pump fires due to lube oil leaks, but no valve fires. If a fire occurs in spite of these factors:

    D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

14. $RHR_{II}$ cable is for interlock between Unit 1 and Unit 2 pumps. Cable for 1A202 affects only off-site supply, EDGs are not affected. Cables for SRVs do not affect ADS.

    D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_2$ & $LPCI_2$)

15. The cable for RHR pseudo-component is for an ESW transfer scheme, voided now. The ADS cable, on hot short or open circuit, makes the CIG valve fail open; $ADS_{I\&II}$ remain available. MSIV's, with solenoids in FZ are normally open, fail closed.

    D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

16. Cables for $ADS_I$ will cause 12654 or 12643 to open on hot short or open circuit. Cables for $ADS_{II}$ will disable auto-initiation but manual actuation remains available.

    D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

17. Cable for HPCI is for indication only. Non-safeguard cables do not impact SSD.

    D.I.D. by (HPCI) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

18. Cables for RHR pseudo-components are for an ESW transfer scheme that has been deleted. The primary containment pressure switches and associated cables, for ADS permissive on high drywell pressure can prevent auto-initiation of $ADS_{II}$ but $ADS_{II}$ can be actuated manually. CS HVAC is affected but the one damper which does not fail in the position required for SSD can be manually opened and is listed in E-690 as an operator action for App. R fires.

    D.I.D. by (HPCI) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

19. The inerted nitrogen atmosphere inside primary containment will prevent combustion at power operation.

20. Non-safeguard cables for HPCI & RCIC are for position indication only. Other non-safeguard cables, for electrical distribution system, are used only during diesel testing and not required for SSD. Cables for pseudo-components in $RHR_{II}$ and RCIC cannot fail these functions without another cable failure outside the FZ or, manual actuation remains available. Cables for ADS, shared with RCIC have the same effect on $ADS_{II}$. $RHR_{II}$ drywell spray valve is unlikely to open spuriously since the valve and its power cable are in the FZ.

    D.I.D. by (HPCI or RCIC) and ($ADS_{I\&II}$ with $LPCI_{I\&II}$)

Table 4.18 - Notes to Screening Results
(Continued)

21. No cables or components for HPCI or ADS are involved.

D.I.D. by (HPCI) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

22. No HPCI, RCIC or ADS components or cables involved. Cable for RHR pseudo-component ($RHR_{II}$) does not impact SSD. Failure of cable for CS HVAC makes all dampers to go to the position required for SSD. Loss of $ESW_I$ causes loss of RHR Pump D (1/2 $RHR_{II}$).

D.I.D. by (HPCI or RCIC) and ($ADS_{I\&II}$ with $CS_{II}$ & 1/2 $RHR_{II}$)

23. No HPCI, RCIC or ADS components or cables involved. Cable for RHR pseudo-component ($RHR_I$) is for auto-start of Pump B. Cable for ADS opens one valve from CIG bottles and closes a redundant valve, upon its failure.

D.I.D. by (HPCI or RCIC) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

24. No HPCI or ADS components or cables involved. Cable for RHR pseudo-component does not affect operability of $RHR_{II}$. Cable for CS HVAC does not cause spurious operation of affected damper. The cable for RCIC, on a hot short, will open RCIC suction valve from suppression chamber, open circuit leaves manual opening available (manual override provided).

D.I.D. by (HPCI or RCIC) and ($ADS_{I\&II}$ with $CS_{II}$ & $LPCI_{II}$)

25. The only cables other than for CRD HCU's in this fire zone are instrumentation cables for Div. II. No core cooling or decay heat removal functions are affected. There are no SSD comp's in FZ. Scram function remains available (SEA-EE-016).

D.I.D. by (HPCI or RCIC) and ($ADS_{I\&II}$ with $CS_{I\&II}$ & $LPCI_{I\&II}$)

26. Cable for B diesel generator is for auto-start backup circuit, auto & manual start remain available. Cables for ESW pumps B & D are for auto-start; manual start remains available. No components or cables for HPCI, RCIC or ADS are involved.

D.I.D. by (HPCI or RCIC) and ($ADS_{I\&II}$ with $CS_{I\&II}$ & $LPCI_{I\&II}$)

27. The cables for Unit 1 RHR pseudo-component do not affect the path (1) required for SSD. Unit 2 ADS cables do not disable the ADS function for either division; manual actuation remains available.

D.I.D. for Unit 1 by (HPCI or RCIC) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)
D.I.D. for Unit 2 by (CRD) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$)

Table 4.18 - Notes to Screening Results
(Continued)

28. Cables for RHR pseudo-components do not affect system availability. There are no components or cables for RCIC or $ADS_{I\&II}$ in the FZ.

    D.I.D. for Unit 2 by (RCIC) and ($ADS_{I\&II}$ with $CS_I$ & $LPCI_I$) ($CS_{II}$ and $LPCI_{II}$ are available to half capacity; EDG D could be lost)

29. The only combustibles other than cables in tray are three cabinets with a total combustible loading of about 1.14 million Btu. Of these, the smallest (50,000 Btu) contains switching devices (120V AC circuit breakers). The cabinets are metal enclosed, and the largest cabinet (1 million Btu) is separated from the other two. There is no source in the FZ for a pilot fire. For reference, the total Btu loading in the three cabinets is equivalent to 26 kg or less than 8 gals. of lube oil. A COMPBRN simulation shows cabinet walls will not be hotter than 220°C if a large heptane pool were inside the cabinet and was ignited. Therefore, propagation to cable tray is not expected, and fire damage is limited to the cabinet of origin.

30. The only combustibles other than cables in tray are five cabinets with a total combustible loading of about 1.3 million Btu. Of these, the smallest (50,000 Btu) contains switching devices (120V AC circuit breakers). The cabinets are metal enclosed, and the largest cabinet (1 million Btu) is separated from the others. There is no source in the FZ for a pilot fire.

31. There are no cables or components for HPCI or $CS_{II}$ in FZ. The cable for $RHR_{II}$ pseudo-component can cause NSSS isolation (open circuit) or prevent manual isolation of one channel (hot short). In either case, isolation for RHR permissive remains available.

    D.I.D. by (HPCI) and ($ADS_{I\&II}$ with $CS_{II}$ & $LPCI_{II}$)

32. Cables for Unit 2 ADS are for auto-initiation; manual control is not affected. Cables for SRV's are for manual control of Div. I valves; automatic operation remains available.

    D.I.D. for Unit 2 by (CRD) and ($ADS_{I\&II}$ with $CS_{II}$ & $LPCI_{II}$)

33. Cables for $RHR_{II}$ in the fire zone include three cables from thermocouples for steam leak detection and RHR isolation. A hot short or open circuit of these cables will, however, indicate low temperature and prevent isolation of $RHR_{II}$. The other cables for $RHR_{II}$ will not disable $RHR_{II}$ by their failure.

    D.I.D. by (CRD) and ($ADS_{I\&II}$ with $CS_{II}$ & $LPCI_{II}$)

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Table [illegible]
Reactor Building
Composite
Fire Frequencies
Unit 1

| Fire Zone | Total Cabinets | Pumps | Transform | FPP | RPS MG | Battery Chg. | Battery | Air Comp. | Vent Sub. | Other | Total Fire Frequency * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| 1-1A | 0 | 9.52E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.51E-05 | 3.56E-04 | 1.38E-03 |
| 1-1B | 3.57E-04 | 9.52E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.51E-05 | 3.56E-04 | 1.74E-03 |
| 1-1C | 0 | 4.76E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.51E-05 | 3.56E-04 | 9.07E-04 |
| 1-1D | 0 | 4.76E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.51E-05 | 3.56E-04 | 9.07E-04 |
| 1-1E | 0 | 9.52E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.51E-05 | 3.56E-04 | 1.38E-03 |
| 1-1F | 0 | 9.52E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.51E-05 | 3.56E-04 | 1.38E-03 |
| 1-1G | 7.14E-04 | 0 | 0 | 5.53E-05 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 1.13E-03 |
| 1-1I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-1J | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-2A | 2.14E-03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 2.50E-03 |
| 1-2B | 3.57E-04 | 0 | 0 | 2.77E-04 | 0 | 0 | 0 | 0 | 3.76E-05 | 3.56E-04 | 1.03E-03 |
| 1-2C | 0.00E+00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.50E-04 | 3.56E-04 | 5.06E-04 |
| 1-2D | 3.57E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 7.13E-04 |
| 1-3A | 2.86E-03 | 9.52E-04 | 1.73E-04 | 5.53E-05 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 4.39E-03 |
| 1-3B-N | 3.57E-03 | 0 | 1.73E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 4.10E-03 |
| 1-3B-S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-3B-W | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-3C-N | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-3C-S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-3C-W | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-4A-N | 2.50E-03 | 0 | 1.73E-04 | 0 | 0 | 0 | 0 | 3.25E-04 | 1.50E-04 | 3.56E-04 | 3.50E-03 |
| 1-4A-S | 2.86E-03 | 0 | 6.92E-04 | 5.53E-05 | 0 | 0 | 0 | 0 | 7.51E-05 | 7.89E-04 | 4.47E-03 |
| 1-4A-W | 3.93E-03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.89E-04 | 4.72E-03 |
| 1-4B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-4E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-4G | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1-5A-N | 2.14E-03 | 0 | 0 | 0 | 0 | 0 | 3.80E-04 | 0 | 0 | 3.56E-04 | 2.88E-03 |
| 1-5A-S | 3.57E-03 | 2.38E-03 | 1.73E-04 | 0 | 2.60E-03 | 0 | 0 | 0 | 0 | 3.56E-04 | 9.08E-03 |
| 1-5A-W | 0 | 0 | 0 | 0 | 0 | 3.13E-04 | 0 | 0 | 0 | 3.56E-04 | 6.69E-04 |

Table 4.19
Reactor Building
Composite
Fire Frequencies
Unit 1

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-5B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-5C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-5D | 0 | 9.52E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 1.31E-03 |
| 1-5E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-6A | 1.43E-03 | 4.76E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.51E-05 | 3.56E-04 | 2.34E-03 |
| 1-6E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-6F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-6I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 1-7A | 1.07E-03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.51E-05 | 3.56E-04 | 1.50E-03 |
| 1-7B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.51-5 | 3.56E-04 | 3.56E-04 |
| 0-6G | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 0-6H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 3.56E-04 |
| 0-8A | 2.86E-03 | 0 | 0 | 0 | 0 | 0 | 0 | 1.63E-04 | 0 | 3.56E-04 | 3.38E-03 |
| | | | | | | | | | | | |
| Total | 3.07E-02 | 9.52E-03 | 1.38E-03 | 4.43E-04 | 2.60E-03 | 3.13E-04 | 3.80E-04 | 1.63E-04 | 1.01E-03 | 1.55E-02 | 6.20E-02 |
| | | | | | | | | | | | |
| | | | | | | | | | | | * Not including Transients |

Table [illegible]0
Switchgear Rooms
Composite
Fire Frequencies
Unit 1

| Fire Zone | Cabinets | Pumps | FPP | Air Comp. | Vent. Sub. | Trans. | Bat. Char. | Other | Total Fire Frequency * |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| 0-22A | 4.23E-04 | 0 | 5.53E-05 | 0 | 2.63E-04 | 0 | 0 | 3.56E-04 | 1.10E-03 |
| 0-24B | 2.11E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 5.67E-04 |
| 0-24C | 4.23E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 3.56E-04 | 7.79E-04 |
| 0-28B-I | 8.82E-04 | 0 | 0 | 0 | 0 | 0 | 2.50E-03 | 3.56E-04 | 3.74E-03 |
| 0-28B-II | 4.63E-03 | 0 | 0 | 0 | 0 | 0 | 1.88E-03 | 3.56E-04 | 6.87E-03 |
| 0-29B | 1.90E-03 | 0 | 0 | 0 | 4.51E-04 | 1.73E-04 | 0 | 3.56E-04 | 2.88E-03 |
| 0-30A | 8.45E-04 | 4.76E-04 | 0 | 3.25E-04 | 7.14E-04 | 0 | 0 | 3.56E-04 | 2.72E-03 |
| 1-4C | 6.34E-04 | 0 | 0 | 0 | 3.76E-05 | 1.73E-04 | 0 | 3.56E-04 | 1.20E-03 |
| 1-4D | 6.34E-04 | 0 | 0 | 0 | 3.76E-05 | 1.73E-04 | 0 | 3.56E-04 | 1.20E-03 |
| 1-5F | 6.34E-04 | 0 | 0 | 0 | 0 | 1.73E-04 | 0 | 3.56E-04 | 1.16E-03 |
| 1-5G | 8.45E-04 | 0 | 0 | 0 | 0 | 1.73E-04 | 0 | 3.56E-04 | 1.37E-03 |
| 1-6B | 8.45E-04 | 0 | 0 | 0 | 0 | 3.46E-04 | 0 | 3.56E-04 | 1.55E-03 |
| 1-6C | 4.23E-04 | 0 | 0 | 0 | 0 | 3.46E-04 | 0 | 3.56E-04 | 1.12E-03 |
| 1-6D | 1.48E-03 | 0 | 0 | 0 | 9.39E-04 | 3.46E-04 | 0 | 3.56E-04 | 3.12E-03 |
| 0-TB Rooms: | | | | | | | | | |
| I-33 | 2.11E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.89E-04 | 1.00E-03 |
| I-220 | 6.34E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.89E-04 | 1.42E-03 |
| I-301 | 8.45E-04 | 0 | 0 | 0 | 0 | 0 | 0 | 7.89E-04 | 1.63E-03 |
| | | | | | | | | | |
| Total | 1.65E-02 | 4.76E-04 | 5.53E-05 | 3.25E-04 | 2.44E-03 | 1.90E-03 | 4.38E-03 | 7.35E-03 | 3.34E-02 |
| | | | | | | | | | |
| | | | | | | | | | * Not including Transients |

Table 4.21
Batteries
Composite
Fire Frequencies
Unit 1

| Fire Zone | Battery Room | Num. of Batter. (U1) | Num. of Batter. (Com) | Total Num. of Batteries | Fraction of Batt. | Fire Freq.(Batt) | Other | Total Fire Freq. *** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 0-28I | YES | 1 | 0 | 1 | 1/10 | 3.80E-04 | 3.56E-04 | 7.36E-04 |
| 0-28J | YES | 1 | 0 | 1 | 1/10 | 3.80E-04 | 3.56E-04 | 7.36E-04 |
| 0-28K | YES | 1 | 0 | 1 | 1/10 | 3.80E-04 | 3.56E-04 | 7.36E-04 |
| 0-28L | YES | 1 | 0 | 1 | 1/10 | 3.80E-04 | 3.56E-04 | 7.36E-04 |
| 0-28M | YES | 1 | 0 | 1 | 1/10 | 3.80E-04 | 3.56E-04 | 7.36E-04 |
| 0-28N | YES | 1 | 0 | 1 | 1/10 | 3.80E-04 | 3.56E-04 | 7.36E-04 |
| 1-5A-N | NO | 1 | 0 | 1 | 1/10 | 3.80E-04 | 0 | 3.80E-04 |
| Other | NO | 2 | 1 | 3 | 3/10 | 1.14E-03 | 0 | 1.14E-03 |
| | | | | | | | | |
| TOTAL | | 9 | 1 | 10 | | | | |
| | | | | | | | | *** Not including |
| | | | | * There was one extra battery | U1 + (1/2) Common = | 10 | | transients |
| | | | | found for other fire zones for | Frequency (per op. | | | |
| | | | | Unit 2. | react. year) = | 3.80E-03 | | |
| | | | | ** Other is any fire zone that is | | | | |
| | | | | not a battery room or a fire | | | | |
| | | | | zone of interest. | | | | |

Table 4.22
Control Room
Composite
Fire Frequencies

| Fire Zone | Electrical Cabinets | Fire Protection Panels | Total Fire Frequencies * |
|---|---|---|---|
| | | | |
| 0-26H | 3.80E-03 | 2.77E-04 | 4.08E-03 |
| | | | |
| | | | *Not including Transients |

Table 4.23
Cable Spreading Rooms
Composite
Fire Frequencies
Unit 1

| Fire Zone | Total Elect. Cabinets | Fire Protection Panels | Other | Total Fire Frequency * |
|---|---|---|---|---|
| | | | | |
| 0-24D | 1.04E-03 | 0 | 3.56E-04 | 1.40E-03 |
| 0-24E | 1.23E-03 | 0 | 3.56E-04 | 1.59E-03 |
| 0-25E | 7.45E-05 | 1.11E-04 | 3.56E-04 | 5.42E-04 |
| 0-26K | 2.61E-04 | 0 | 0 | 2.61E-04 |
| 0-27C | 1.12E-04 | 5.53E-05 | 3.56E-04 | 5.23E-04 |
| 0-27E | 1.19E-03 | 0 | 3.56E-04 | 1.55E-03 |
| | | | | |
| | | | | |
| Total | 3.91E-03 | 1.66E-04 | 1.78E-03 | 5.86E-03 |
| | | | | |
| | | | | *Not including Transients |

Table 4.24 Fire Frequencies in Unscreened Fire Zones

| Unscreened Fire Zones | Fire Frequencies (Not including Transients) | Transient Fire Frequencies | Total Fire Frequencies PRA IE Fires/Zone-Year |
|---|---|---|---|
| 0-24D | 1.40E-3 | 1.22E-4 | 1.52E-3 |
| 0-26H | 4.08E-3 | 5.52E-3 | 9.60E-3 |
| 0-27E | 1.55E-3 | 1.22E-4 | 1.67E-3 |
| 0-28B-I | 3.74E-3 | 1.22E-4 | 3.86E-3 |
| 0-28B-II | 6.87E-3 | 1.22E-4 | 6.99E-3 |
| 0-28I | 7.36E-4 | 1.22E-4 | 8.58E-4 |
| 0-28J | 7.36E-4 | 1.22E-4 | 8.58E-4 |
| 0-29B | 2.88E-3 | 1.22E-4 | 3.00E-3 |
| 0-30A | 2.72E-3 | 1.22E-4 | 2.84E-3 |
| 1-2B | 1.03E-3 | 1.22E-4 | 1.15E-3 |
| 1-3A | 4.39E-3 | 1.22E-4 | 4.51E-3 |
| 1-3B-N | 4.10E-3 | 1.22E-4 | 4.22E-3 |
| 1-3B-W | 3.56E-4 | 1.22E-4 | 4.78E-4 |
| 1-4A-N | 3.50E-3 | 1.22E-4 | 3.62E-3 |
| 1-4A-S | 4.47E-3 | 1.22E-4 | 4.59E-3 |
| 1-4A-W | 4.72E-3 | 1.22E-4 | 4.84E-3 |
| 1-5A-S | 9.08E-3 | 1.22E-4 | 9.20E-3 |
| 1-5A-W | 6.69E-4 | 1.22E-4 | 7.91E-4 |

Table 4.25 IPEEE Fire PRA Fire Hazard Summary

| Fire Zone | Gross Fire Impact | PRA Fire Frequency Fires/Zone-Year |
|---|---|---|
| Control Structure: | | |
| 0-24D | Lower Relay Room- Div II I&C | 1.52E-3 |
| 0-26H | Control Room- Normal Control | 9.60E-3 |
| 0-27E | Upper Relay Room- Div. I I&C | 1.67E-3 |
| 0-28B-I | Div. II 125 & 250 VDC Chargers | 3.86E-3 |
| 0-28B-II | Div I Chargers and Div. I & II 125 VDC buses (1D614 & 1D624) | 6.99E-3 |
| 0-28I | Div I 250 VDC battery (shorts charger); cable for 1D614. | 8.58E-4 |
| 0-28J | Div II 250 VDC battery (shorts charger); Cable for ESW Div I, RHR I & II control (in conduit). | 8.58E-4 |
| 0-29B | Div. I & II CSHVAC | 3.00E-3 |
| 0-30A | Div. I & II CSHVAC | 2.84E-3 |
| | | |
| Unit 1 Reactor Bldg.: | | |
| 1-2B | Div. I and II ESW cable in conduit | 1.15E-3 |
| 1-3A | HV-08693A & B: ESW valves for CSHVAC | 4.51E-3 |
| 1-3B-N | HPCI; RCIC; CIG for ADS | 4.22E-3 |
| 1-3B-W | Channel A,B,C AC; Div 1 ESW cable | 4.78E-4 |
| 1-4A-N | North HCUs; HPCI; LPCI I & II; CRD pump B | 3.62E-3 |
| 1-4A-S | South HCUs; HCPI; ADS; ESW Div II | 4.59E-3 |
| 1-4A-W | EDGs B,C,D; RCIC; CRD skid | 4.84E-3 |
| 1-5A-S | Div I & II vessel inst; HPCI; RPS buses A & B | 9.20E-3 |
| 1-5A-W | Div I CIG, EDGs B,C,D | 7.91E-4 |

Table 4.26- Disposition of Reactor Building Fire Zones

Zone 1-2B

Fire Sources:

1 cabinet
5 Fire Protection Panels
1 ventilation subsystem
Welding and Cutting at power
Misc. Transients: Trash Barrel, 2 rolls plastic.

Reason not screened: Potential loss of 3 of 4 ESW pumps; inadvertent ADS (all cable)

Disposition of sources:

Cabinets: 1B247- partial loss of ESS 480 VAC power channel D

FPP: 1C230, 1C231, 1C218A,B,C - no safety impact

Ventilation: 1V223- Remote SD panel room fan; normally not operating. Fan motor is 0.5 hp, i.e. negligible fire source.

Transients: Administrative control eliminates potential propagation from trash barrel. COMPBRN IIIe modeling of fire in plastic rolls shows that cable in conduit will not be damaged if the rolls are ignited.

Impact summary:

The loss of 1B247 results in loss of power to div. II ECCS pump room coolers and several div. II ECCS valves. The ECCS pumps and valves are normally not operating and no immediate impact on plant operation occurs (no transient or LOCA). Affected valves include normally open RHRSW div II heat exchanger valves, normally open RHR pump D suction valve, and normally closed div. II suppression pool return valve. Failure of this power leaves DID via HPCI, RCIC, both divisions of ADS, and div. I LPCI and CS. No plant isolation occurs and decay heat removal is available from div. I RHR in suppression pool cooling mode, as well as the main condenser. Time of containment heat up to failure (about 30 hours) is sufficient to allow operator action (manual opening of 1F024B valve return to the suppression pool) to restore div. II suppression pool cooling. Thus, loss of 1B247 is considered not risk significant.

Only cabinets and transients are potentially risk significant fire sources in 1-2B. Cabinet fires do not propagate and do not cause loss of defense-in-depth. COMPBRN IIIe calculations show no damage to conduit if transients are ignited. The reason for not screening out this fire zone in the fire hazard analysis is seen to be invalid, i.e. no loss of ESW and no inadvertent ADS will occur. The zone is for all intents and purposes a valve gallery with minimal combustible load. This zone is judged not risk significant and is not considered further.

Table 4.26- Disposition of Reactor Building Fire Zones

Zone 1-3A

Fire Sources:

8 cabinets
2 pumps (1P210A&B)
1 Fire Protection Panel
1 transformer
Welding and Cutting at power
Misc. Transients: Trash Barrel

Reason not screened: Potential loss of both ESW valves for CSHVAC (HV-08693A&B)

Disposition of sources:

Cabinets:
1B216- partial loss of ESS 480 VAC power channel A
1B262- non-safety grade, no impact
1C007- CRD and RPV temperature recorders, no safety impact
1C030- SRM/IRM pre-amp panel, no safety impact
1C031- SRM/IRM pre-amp panel, no safety impact
1C203- non-safety, no impact
1C215A- containment hydrogen recombiner, norm. not op, no source
1Y216- partial loss of ESS 120 VAC power channel A

Pumps: 1P210A&B- small pumps (30 hp), no source, partial loss RBCCW only

FPP: 1C233- no safety impact

Transformer: 1X216- partial loss of ESS 120 VAC power channel A

Transients: Only potential propagation source is trash barrel; administrative control eliminates.

Impact summary:

Partial loss of ESS AC power channel A. This power is required for CIG compressor operation. Loss of 1Y216 results in loss of CIG (but not ADS), and drywell cooling. Isolation transient may result in closure of MSIVs but defense-in-depth remains intact.

Partial loss of RBCCW. Loss of both channels of RBCCW will result in an isolation transient because of failure of CIG compressors on loss of cooling and closure of inboard MSIVs. Impact of loss of RBCCW analyzed in IPE. Fire frequency of about 6E-3/cycle in this zone is much less than frequency of isolation transients analyzed in IPE (about 0.35/cycle). No impact on risk profile.

No impact on the ESW valves for CSHVAC is expected and thus the original reason for not screening this zone is invalidated. Defense-in-Depth is expected for loss of equipment in this zone by use of HPCI, RCIC, both divisions of ADS, and division II RHR and CS. Zone 1-3A is judged to be not risk significant.

Table 4.26- Disposition of Reactor Building Fire Zones

Zone 1-3B-N

Fire Sources:

10 cabinets
1 transformer
Welding and Cutting at power
Misc. Transients: Racks of PCs, plastic on rolls

Reason not screened: Potential loss of HPCI, RCIC (cable), and CIG for ADS (cable)

Disposition of sources:

Cabinets:
1B226- partial loss of ESS 480 VAC power channel B
1B252- non-safety, no impact
1C032- SRM/IRM pre-amps; not required for safety
1C033- SRM/IRM pre-amps; not required for safety
1C212B- not required for safety
1C215B- containment hydrogen recombiner, norm. not op, no source
1C222- indication/interlocks for multiple channels of RHR, CS, ESW, RHRSW. Equipment normally not operating; no immediate impact on plant operation. Manual actuation available if required.
1D264- 250 VDC power for HPCI valves
1D274- 250 VDC power for HPCI valves
1Y226- partial loss of ESS 120 VAC power channel B; trips A and B IA compressors.

Transformer- 1X226- partial loss of ESS 120 VAC power channel B.

Transients- Per COMPBRN IIIe calculations, fire propagating through PC storage racks causes no damage to conduit or tray necessary for shutdown without severe distortion of the physical realities of the zone (e.g. enclosing the zone, rotating the orientation of the PC racks).

Impact Summary:

Cabinet fires result in partial loss of one channel of ESS power or loss of HPCI. This power is required for normal plant operation (IA) and may result in closure of MSIVs. Defense-in-Depth for loss of AC power is provided by HPCI, RCIC, both divisions of ADS, and RHR and CS division I. Defense-in-Depth for loss of HPCI is from RCIC, both divisions of ADS, RHR, and CS. Individual cabinet fires are not risk significant.

Transients: Cable in 1-3B-N is predominantly div. II. The only div. I equipment is cable in conduit located radially greater than 20 feet from the transient sources. Fire in the PC storage racks does not fail the div. I cable and defense-in-depth is provided by RCIC, CRD, div I ADS, and div I CS/RHR.

Because defense-in-depth is assured for any fire source in this zone, the zone is judged not risk significant and is not considered further.

Table 4.26- Disposition of Reactor Building Fire Zones

Zone 1-3B-W

Fire Sources:

Welding and Cutting at power
Misc. transients: valve tooling storage cage

Reason not Screened: Potential loss ESS AC power channels A, B, C; and Div. I ESW (all cable).

Disposition of sources:

Transients: The impact of a fire in the transient loading assumed for the valve tooling cage is evaluated using the screening methodology developed for the "fire in plume" scenario in the EPRI "FIVE". This evaluation shows that a fire in the tooling cage has no impact on the cables located approximately 30 feet above along the ceiling of zone 1-3B-W.

Impact Summary:

Because the transient source in the tooling cage does not damage cables located in this zone, Defense-in-Depth is assured and zone 1-3B-W is not risk significant.

Table 4.26- Disposition of Reactor Building Fire Zones

Zone 1-4A-N

Fire Sources:

7 cabinets
1 transformer
4 heaters
2 compressors
1 mg set
Welding and Cutting at power
Misc. Transients: Trash barrel

Reason not screened: Potential loss of north HCUs, and cable for HPCI, LPCI div. I and II, CRD pump B.

Disposition of sources:

Cabinets:
1ATS229- switching for preferred and alternate sources for "B" swing bus, remote operation of div. II LPCI injection valves. Manual operation available.
1B229- partial loss of ESS 480 VAC power channel B, loss of remote operation of div. II LPCI injection valves . Div. I and Manual operation available.
1C209- Liq. rad waste, drywell leak det., no ECCS loss, defense-in-depth exists.
1C215D- containment hydrogen recomb. norm not op, no safety impact.
1C239- CIG compressor panel, not req'd for SD, ADS available.
1C247- Div. II swing bus MG control panel. Loss is loss of one of two redundant power supplies for 1B229. No immediate impact on plant.
1Y246- Partial loss of 120 VAC ESS power, channel "D". See "Impact Summary" below

Transformer:
1X246- powers 1Y246, similar impact.

Heaters:
1E270A,B,C,D- metal enclosed space heaters mounted to wall about 15 feet above floor. Not req'd for shutdown and no combustibles in close proximity. No impact on plant op.

Compressors:
1K205A&B- CIG compressors. Loss of one results in loss of 1/2 non-ADS CIG supply.

MG set:
1S247:1G203- preferred supply for Div. II swing bus. Failure results in loss of one of two redundant power supplies for this bus. MG set is metal enclosed with bearings containing about 4 oz. grease. Fire damage limited to MG set itself, i.e. no propagation.

Transients:
Trash and Rad barrels only transient sources; administrative controls eliminate.

Impact summary:

Partial loss of ESS power channel "B" limited to failure of div. II swing bus and loss of automatic opening of LPCI injection valves. Because no LOCA is postulated because of the fire, time exists for manual operation of these valves. Even without manual valve operation, DID exists via HPCI, RCIC, ADS I and II, and div. I LPCI and CS.

Loss of 1Y246 results in loss of CIG (MSIVs drift close), drywell cooling, and partial loss of CSHVAC and post-accident monitoring. Isolation occurs but core defense-in-depth remains as above.

Table 4.26- Disposition of Reactor Building Fire Zones

Each CIG compressor contains about 6 quarts of lube oil which will be contained in the CIG compressor skid. COMPBRN IIIe analysis shows that fire will damage only the compressor and no surrounding cabling. Loss of 1 compressor will not affect plant operation. Loss of both will result in an isolation transient. (Note that this treatment of CIG is consistent with that in the IPE but is actually conservative. During an actual loss of the "C" ESS bus, which causes loss of CIG, operators successfully tied in instrument air and avoided MSIV closure. Reference SOOR-2-92-024.) DID exists via HPCI, RCIC, and both divisions of ADS, LPCI, and CS.

Adequate Defense-in-Depth exists for fire loss of any piece of equipment in zone 1-4A-N. Fire damage is limited to the source component and no loss of cabling is expected. Thus, the potential loss of equipment given as the reason for not originally screening this zone is shown to be not credible and zone 1-4A-N is judged not risk significant.

Table 4.26- Disposition of Reactor Building Fire Zones

Zone 1-4A-W

Fire Sources:

11 cabinets
4 gas bottles containing hydrogen
Welding and Cutting at power
Misc. Transients: Trash and other barrels, 1 PC storage rack

Reason not screened: Potential loss of CRD (valve skid and control) and cable for EDGs B,C,D and RCIC.

Disposition of Sources:

Cabinets: 1C008- SRM/IRM drive control panel, not req'd for operation or SD.
1C038- RCIC leak detection. Loss of RCIC leaves DID intact via HPCI and 2 divisions of ADS with RHR/CS.
1C219- non-safety, no impact.
1C226B- $H_2O_2$ analyzer, not req'd for safe SD of core.
1C227B- contain rad monitor, not req'd for safe SD.
1C228B- contain rad monitor, not req'd for safe SD.
1BC291,also B, C, and D- heat trace for CRM, not req'd for safe SD.
1BC294- heat trace, not req'd for safe SD.

Hydrogen: 4 bottles- 2 @ 100% hydrogen, 2 @ 30% hydrogen, for calibration of hydrogen analyzer. Bottles not required for safe shutdown. COMPBRN IIIe analysis shows that fire consuming two bottles of hydrogen will not damage cable located above and will not involve the small PC storage rack located within two feet of the bottles.

Transients: Barrels administratively controlled; not a significant source. COMPBRN IIIe for PC rack in zone 1-3B-N shows that the smaller rack in 1-4A-W will not fail cable.

Impact summary:

No cabinet fire will have a safety impact. Loss of both RCIC and CRD leaves DID via HPCI and both divisions of ADS, LPCI, and CS.

Hydrogen is shown to be not capable of destroying cable within the zone. This finding is consistent with NUREG/CR-5759 "Risk Analysis of Highly Combustible Gas Storage, Supply, and Distribution Systems in PWR Plants". The NUREG/CR analysis demonstrates that for portable gas bottles, a single bottle contains insufficient energy to cause other than local damage and "that the risk to plant safety due to fires or explosions in portable gas bottle storage areas is insignificant and does not warrant further investigation (p. 17 of the NUREG/CR).

Because the loss of CRD can be sustained without loss of defense-in-depth, and because the loss of cable due to sources in the zone does not seem possible, the original reason for not screening out the zone is invalidated. Zone 1-4A-W is judged not risk significant and is not considered further.

Table 4.26- Disposition of Reactor Building Fire Zones

Zone 1-4A-S

Fire Sources:

8 cabinets
4 transformers
1 fire protection panel
2 ventilation systems
4 gas bottles containing hydrogen
Welding and Cutting at power
Misc. transients: Trash barrel

Reason not screened out: Potential loss of south HCUs, cable for HPCI, ADS, ESW Div II.

Disposition of sources:

Cabinets:

1ATS218- switch for 1Y218, non-Q, all ECCS available.
1C215C- H2 Recombiner norm not op, no safety impact.
1C227A- Containment radiation monitor channel A - not required for DID
1C228A- Containment radiation monitor channel A - not required for DID
1C280- HVAC Drywell temperature monitor, all ECCS available.
1Y218- Non-Q not required for shutdown, all ECCS available.
1Y236- partial loss CSHVAC, post acc. mon., defense in depth exists.
1Y219- Non-Q, not required for shutdown
1X236- transformer for 1Y236, as above.
1X218- transformer for 1Y218, non-Q, defense-in-depth as above.
1X291- supply heat trace BC291 and BC294, not required for safe shutdown.
1X294- supply heat trace BC291 and BC294, not required for safe shutdown.
1C234- Fire protection panel- no core impact, defense in depth exists

Ventilation Systems:

1V222A&B- ESGR cooling,- not required for safe shutdown. Each is 15 HP, less than 0.5 gallons lube oil. Fire in one will not disable other.

Transients: Trash and rad barrels only; administrative controls eliminate.

Impact Summary:

Cabinet fires result only in partial losses of AC power or systems not required for safe shutdown. Defense-in-depth exists for loss of any single cabinet via HPCI, RCIC, both divisions of ADS, and RHR and CS div. II.

Calculations of reactor building and ESGR heatup (Reference 4-19) show ESGR cooling is not required for 72 hours after a transient. Loss of ESGR cooling also has no direct impact on plant operations. Defense-in-depth exists because no loss of ECCS occurs.

Table 4.26- Disposition of Reactor Building Fire Zones

Hydrogen bottle analysis for zone 1-4A-W shows that hydrogen fires will not destroy cable located above the bottles. Essentially, the energy content of a bottle of hydrogen is too low to damage equipment or cable located beyond several feet of the bottle. Given the zone 1-4A-W results and a similar configuration for zone 1-4A-S, hydrogen is considered not risk significant.

The source disposition shows that cable will not be damaged and the reason for originally not screening invalid. Zone 1-4A-S is not risk significant and is not considered further.

Zone 1-5A-W

Fire Sources:

1 battery charger
Welding and cutting at power
Misc. transients: hazardous & oily waste barrels

Reason not screened out: CIG bottles div. I, cable for EDGs B,C,D.

Disposition of sources:

Battery Charger:
1D240- Vital AC instrument power, non-Q, feeds 1Y218 (SRM's & IRM's), not required for shutdown.

Transients: 1 barrel oily waste, 1 barrel hazardous waste, both with lids.

Impact summary:

Loss of 1D240 disables only 1Y218 (zone 1-4A-S), a non -Q instrument power supply (lose CRD). No loss of ECCS occurs and defense-in-depth is assured. Other combustibles (barrels) in the zone will not affect the CIG bottles. Thus zone 1-5A-W is judged not risk significant and no further study is required.

Table 4.26- Disposition of Reactor Building Fire Zones

Zone 1-5A-S

Fire Sources:

10 cabinets
2 RPS MG sets
1 transformer
5 pumps (3 fuel pool, 2 reactor building chillers)
Welding and Cutting at power
Misc. Transients: Rad barrels, filter paper in sample station, rubber hose for SLC

Reason not screened out: Div. I and II vessel instrumentation, HPCI cable, RPS buses A & B.

Disposition of sources:

Cabinets:

1C011- standby liquid control system panel. Loss results in no plant transient, defense-in-depth exists.
1C206- Fuel pool cooling, no core impact.
1C235A&B- Drywell and recirculation pump seal coolant instrumentation- CRD still operable to cool recirculation pump seals. No loss of ECCS.
1C279- Reactor building chilled water, not needed in emergencies, i.e. will use ESW. Core defense-in-depth intact.
1CB290- No safety impact, defense-in-depth maintained
1C210A&B- Sample station, not required for safe shutdown
1Z201- computer, not required for safe shutdown
1K207- chiller for sample station, not required for safe shutdown

Transformer:

1X201(A) not required, is alternate RPS supply. RPS buses not required for safe SD

RPS MG set (typ):

1S237A:1G201A- 25 HP motor:15 HP generator, small amounts of grease in metal bearing cups. Insignificant fire source, RPS buses not required for safe shutdown.

Pumps:

1P211A,B,C- Fuel pool cooling pumps, 1 gal lube-oil each per comb. loading rept. These pumps are located in a room separate from the remainder of zone 1-5A-S and are not required for safe shutdown. Core defense-in-depth exists.
1K206A&B- Reactor building chillers for reactor building chilled water. Chillers are not required for safe shutdown and their loss does not disable any ECCS equipment in 72 hours (Reference 4-19).

Transients: Administrative control eliminates barrels as significant sources. FIVE screening sheets for filter paper and rubber hose show fires from these sources will not disable ECCS equipment.

Impact Summary:

Electrical cabinet fires will not cause transients, fail safe, or are not required for safety (i.e. meet defense in depth screening).

Loss of 1 RPS MG set or 1 RPS bus will cause a half scram. No ECCS equipment is lost, scram capability is not jeopardized, and core defense-in-depth exists.

Only lube oil in the reactor building chillers (15 gallons each) has the potential to cause a large fire in the zone. However, a drain located immediately between the chillers limits the extent of any oil accumulation on the zone floor. COMPBRN IIIe calculations for a lube oil spill fire from the chillers show that such a fire will not disable the other chiller or affect cable in conduit or tray. Other pumps have only small amounts of grease or lube oil in bearings and are not significant fire sources.

Transient fires will not affect equipment or cable in the zone. Further, detailed analysis of trash can fires (Reference 4-20) shows that a trash can fire can not disable both divisions of reactor vessel instrumentation (1C004 and 1C005, or 1C224 and 1C225).

Because detailed analysis of fire sources in zone 1-5A-S shows that no safe shutdown equipment or cable would be disabled in the event of fire, the zone is considered not risk significant and is not treated further.

Table 4.27 - Disposition of Control Structure Fire Zones

Zone 0-24D (lower relay room)

Fire Sources:

28 Cabinets
Welding and Cutting at power
Misc. Transients: Trash barrel (administrative control eliminates)

Reason not screened: Lower relay room, division II I&C

Disposition of sources:

Cabinets:

Detailed evaluations of all cabinets are found in Reference 4-34. Only the most risk significant are included in this table.

1C661B (H12-P802) - Engineering Safeguard Aux. V.B. Div.II
Div. II instrumentation for monitoring core cooling such as RPV level will probably fail; Div. I instrumentation is not affected. Another potential impact is the spurious opening of HV-15768; the redundant isolation valve controlled by relays in the Div. I cabinet is unaffected and provides isolation of the line.
No SSD functions fail; DID available

1C618 (H12-P618) - Div.II RHR Relay V.B.
In addition to Div.II RHR Relays, this cabinet houses Div.II relays for RCIC. On the conservative assumption that before fire damage causes open circuits of relay coils and wiring it could cause wiring hot shorts and/or welding shut of relay contacts, a RCIC turbine trip and closure of steam supply isolation valves would result. HPCI, CRD, ADS I & II, RHR I, CS I & II provide DID.
Div.II RHR and RCIC fail; DID available

1C620 (H12-P620) - HPCI Relay Vertical Board
The VB has no interfaces with systems other than HPCI, therefore HPCI is the only SSD system that is expected to fail due to a fire in this cabinet. Two high pressure systems (RCIC & CRD), both divisions of ADS, RHR and CS are available for DID.
HPCI fails; DID available

1C627 (H12-P627) - Div.II Core Spray Relay V.B.
Failure of one division of auto-initiation signal of RHR and permissive signal to RHR valves is possible but the other division signal and manual initiation of RHR remain available. A spurious unit trip due to recirculation. pump trip on RBCCW isolation is possible. Also, Div.II HPCI auto-initiation logic might be disabled but redundant logic from 1C626 remains available. DID available through HPCI, RCIC, CRD, ADS I & II, RHR I & II and CS I.
Loss of Div.II Core Spray; DID available

1C631 (H12-P631) - Automatic Depressurization System Relay V.B. Div.II

One or both channels of division II logic and power to one set of solenoids might be lost, but div.I logic and power to the redundant solenoids remains available, as well as manual initiation of div. II solenoids. Mechanical (pressure relief) operation of non-ADS SRVs also is not affected. Spurious actuation of ADS

is possible and will disable high pressure steam powered injection systems (HPCI & RCIC). In this case, DID is available because both divisions of Core Spray and RHR systems are unaffected and remain available.
Loss of ADS redundancy .OR. Loss of HPCI and RCIC; DID available in either case

Impact Summary:

| CABINET | IMPACT OF FIRE | DID |
|---|---|---|
| 1C661 | Partial loss of Div. II RPV monitoring instrumentation | All ECCS available |
| 1C618 | Loss of Div.II RHR & RCIC | HPCI, CRD, ADS I & II, RHR I, CS I & II |
| 1C620 | Loss of HPCI | RCIC, CRD, ADS I & II, RHR I & II, CS I & II |
| 1C627 | Loss of Div.II Core Spray | HPCI, RCIC, CRD, ADS I & II, RHR I & II, CS I |
| 1C631 | Loss of Div.II ADS OR Loss of HPCI & RCIC | CRD, ADS I & II, RHR I & II, CS I & II (worst case) |

Table 4.27- Disposition of Control Structure Fire Zones

Zone 0-26H (control room)

Fire Sources:

36 electrical cabinets (Unit 1 and common)
5 Fire Protection Panels

Reason not screened: Control Room, potential loss of normal equipment control

Disposition of sources:

Cabinets:

Detailed evaluations of all control room panels are found in Reference 4-34. Only the most risk significant are included here.

1C601 (H12-P601) - Reactor Core Cooling Systems Benchboard (BB)
This BB consists of 7 sections, numbered 16 through 22, with each section made up of three inserts A, B, and C. The A inserts, at the top of the BB, contain annunciator light boxes and pushbuttons for annunciator display control. The middle vertical insert B contains indicators and recorders for process variables such as pressure, flow etc. The bench section at the bottom, the C insert, contains devices such as control switches and pushbuttons for auto-manual control selection, pump and valve control, manual actuation and reset of core cooling systems etc. The evaluation of fire damage primarily involves consideration of the effects of open and short circuits of these devices and the wiring to them.

There are two full metal separation barriers in the BB, one between sections 16 & 17, the other in the middle of section 20. Controls for Division I systems and RCIC are located in the middle sections between the two barriers and Division II and HPCI are located between the barrier in the middle of section 20 and the end of the BB. Section 20 contains control devices for both divisions of Main Steamline Isolation Valves, with the barrier in the middle separating Div. I from Div. II. Either divisional logic will close both inboard and outboard MSIVs.

1C601 "Left Section"
Insert 16C in this section contains controls for the CRD pumps and isolation valves B21-F001 & B21-F002 (RPV head vent). The CRD pumps are not required for Appendix R SSD, but are considered in the evaluation of available Defense-In-Depth (DID) for the IPEEE as a source of high pressure make-up. If insert 16C is destroyed by fire, the other high pressure injection sources (HPCI, RCIC) as well as both divisions of ADS and all low pressure sources (CS, RHR in LPCI mode) remain available to assure DID.
No SSD functions fail; DID available

1C601 "Middle Section"
The middle section of the BB consists of inserts 17C (RCIC), 18C (div. I of CS and RHR), 19C (both divisions of ADS and non-ADS SRVs) and half of 20C (div. I MSIVs, div. I CIG isolation valves and HV-15766 & B21-F016-main steam line drain). While RCIC and division I of CS & RHR will be lost to a fire in this section, manual initiation of both divisions of ADS remain available from the relay rooms. Isolation as well as a CIG supply also remain available. HPCI, CRD, ADS I & II, RHR II and CS II provide DID.
Loss of Div. I of CS & RHR , RCIC; DID available

1C601 "Right Section"
The right section of the BB consists of half of 20C (div. II MSIVs, CIG valves HV-12643, -12648, -12644, -12649 and isolation valves HV-15768 & B21-F019), 21C (div. II CS and RHR), and 22C (HPCI).

Isolation and a CIG supply remain available for a fire in this section of the BB. RCIC, CRD, ADS I & II, RHR II and CS II provide DID.

Loss of Div. II of CS & RHR, HPCI; DID available

1C614 (H12-P614) - NSSS Temperature Recording & Leak Detection VB
It was ascertained during a walkdown that a full metal barrier is provided for divisional separation. A fire in either section will disable both RCIC and HPCI; however, both divisions of RHR in the LPCI mode remain available. DID available via CRD pumps as a source of high pressure injection, both divisions of ADS and both divisions of CS and RHR in LPCI mode.

Loss of RCIC and HPCI; DID available

0C653 (H12-P853) - Plant Operating Benchboard
Bench board 0C653 controls breakers for both sources of offsite power, as well as EDG power, to all 4 ESS buses for each unit. Fire induced loss of power to any one ESS bus results in a unit trip and isolation. Isolation comes from loss of instrument air or CIG required to open MSIVs. Fire in this cabinet may result in SBO. To result in SBO the following scenario is postulated. First, fire causes hot short tripping of the normal supply to each startup bus (0A103 and 0A104). Two hot shorts are required because a single hot short will fail only a single division of offsite power. Because each division is powered from a different offsite source, hot shorting of one fails only one supply. If fire causes opens in the control circuit for the other source no power loss will occur because these breakers are already closed. Loss of voltage on the ESS buses starts all four EDGs. Autostart is not affected by fire in 0C653. Second, EDGs are prevented from closing on their respective ESS busses by hot shorting of trip circuits for the 04 breakers. Four hot shorts, one per ESS bus, are required to cause loss of all EDG power. Alternately, hot shorting of ESW spray pond bypass valves (2) causes these valves to drive closed, shutting off ESW flow. Without ESW flow, EDGs must be shutdown or they will fail from loss of cooling. SBO results. Again, to achieve SBO a fire in the cabinet and either 6 hot shorts (2 for LOOP, 4 for EDG loss) or 4 hot shorts (2 for LOOP, 2 for ESW loss) must occur. Because hot short frequency is estimated at 0.07/conductor of interest, the probability of achieving SBO is judged remote.

The short term response to SBO from fire is the same as from other initiating events. Emergency procedures (EO-100-102) direct operators to use HPCI, RCIC, and the water fire suppression system for vessel injection and core cooling. SBO procedures (EO-100-030) direct specific actions to extend SBO coping time. With use of the portable diesel generator and CST re-supply, these sources are adequate until containment over pressure failure at about 2 days. Recovery from SBO is also proceduralized and should be quick, given that no offsite power sources or EDGs are actually failed. That is, the fire only causes temporary loss of control. Circuit breakers are provided with transfer switches at the switchgear which isolate both ends of the control circuits. Power to all ESS buses can be restored by local breaker operation. The SBO procedure has directions for local starting of EDGs. Fire response procedure ON-013-001 also directs operators to the SBO procedure and states that loss of EDG power may result from control room fires, requiring local breaker operation at the switchgear. "Station Power Restoration" (EO-000-031) provides direction for preferential loading of ESS buses, either from offsite or EDG sources. Both the fire and SBO procedures refer to EDG operating procedure OP-024-001 which provides guidance for local EDG starting and requirements for EDG cooling. This procedure directs operators to ESW procedure OP-054-001 which in turn refers to OP-116-001 for operation of the spray pond spray networks. Greater than 24 hours are available to complete these procedures. Thus, even though the probability of SBO from fire in cabinet 0C653 is very low (about 2E-5/fire for four hot shorts, given that the fire has occurred), sufficient equipment and procedures exists for adequately coping without core damage or containment failure.

Possible SBO with quick recovery likely; DID available before and after recovery

Impact Summary:

| CABINET | IMPACT OF FIRE | DID |
|---|---|---|
| 1C601 (Middle Section) | Loss of CS I, RHR I, RCIC | HPCI, CRD, ADS I & II, RHR II, CS II |
| 1C601 (Right Section) | Loss of CS II, RHR II, HPCI | RCIC, CRD, ADS I & II, RHR I, CS I |
| 1C614 | Loss of RCIC, HPCI | CRD, ADS I & II, RHR I & II, CS I & II |
| 0C653 | Loss of RHR I & II, CS I & II until recovery from SBO | HPCI, RCIC, diesel fire pump. All systems after recovery from SBO |

Table 4.27- Disposition of Control Structure Fire Zones

Zone 0-27E (upper relay room)

32 cabinets
Welding and Cutting at Power
Misc. Transients: Trash barrel (administrative control eliminates)

Reason not screened: Upper relay room, div. I I&C.

Disposition of sources:

Cabinets:

Detailed evaluations of all upper relay room cabinets are found in Reference 4 34. Only the most risk significant results are supplied here.

1C661A (H12-P 801) - Engineering Safeguards Aux. V.B. Div. I
Division I instrumentation for monitoring core cooling, such as RPV level will probably fail; Div. II instrumentation is unaffected. Another potential SSD impact is the spurious opening of HV-15766 (suppression pool pump out line, normally closed); the redundant isolation valve controlled by relays in the Div. II cabinet is unaffected and provides isolation of the line.
Div. I Instrumentation fails; DID available

1C617 (H12-P617) - Div.I RHR Relay V.B.
In addition to Div.I RHR relays, this cabinet also houses Div.I relays for control of the HPCI system. On the conservative assumption that before fire damage causes open circuits of relay coils and wiring it could cause wiring hot shorts and/or welding shut of relay contacts, a HPCI turbine trip and closure of steam supply isolation valves might occur. RCIC, CRD, both divisions of ADS, Div. II of RHR and both divisions of Core Spray provide DID.
Loss of Div.I RHR and HPCI; DID available

1C621 (H12-P621) - Reactor Core Isolation Cooling V.B.
The VB has no interfaces with systems other than RCIC, therefore RCIC is the only SSD system that is expected to fail due to a fire in the cabinet.
Loss of RCIC; DID available

1C626 (H12-P626) - Div.I Core Spray V.B.
Failure of one division of auto-initiation signal of RHR and permissive signal to RHR valves is possible but the other division signal and manual initiation of RHR remain available. A spurious unit trip due to recirculation pump trip on RBCCW isolation is possible. Also, Div.I of HPCI auto-initiation logic might be disabled but redundant logic from 1C627 remains operable. DID is intact because all high pressure systems, both divisions of ADS, Div. II Core Spray and both divisions of RHR remain functional.
Loss of Div.I Core Spray; DID available

1C628 (H12-P628) - Automatic Depressurization System Relay V.B. Div.I
One or both channels of automatic actuation logic (Div.I only) and power to one set of solenoids might be lost, but Div.II logic and power to the redundant solenoids remains available, as well as manual initiation. Mechanical (pressure relief) operation of non-ADS SRVs also is not affected. Spurious actuation of ADS is possible resulting in loss of steam driven high pressure injection systems (HPCI, RCIC). Spurious actuation of ADS guarantees vessel depressurization, however, allowing low pressure systems to inject. Fire in 1C628 does not affect Core Spray and LPCI, and these systems remain available.
Loss of ADS redundancy .OR. Loss of HPCI and RCIC; DID available in either case

Table 4.27- Disposition of Control Structure Fire Zones

Impact Summary:

| CABINET | IMPACT OF FIRE | DID |
|---|---|---|
| 1C661A | Partial loss of RPV instrumentation | All ECCS remains available |
| 1C617 | Loss of Div.I RHR & HPCI | RCIC, CRD, ADS I & II, CS I & II, RHR II |
| 1C621 | Loss of RCIC | HPCI, CRD, ADS I & II, RHR I & II, CS I & II |
| 1C626 | Loss of Div.I Core Spray | HPCI, RCIC, CRD, ADS I & II, RHR I & II, CS II |
| 1C628 | Loss of Div.I ADS OR Loss of HPCI & RCIC | CRD, ADS I & II, RHR I & II, CS I & II (worst case) |

Table 4.27- Disposition of Control Structure Fire Zones

Zone 0-28B-I

Fire Sources:

4 cabinets
8 battery chargers
Welding and Cutting at Power

Reason not screened: Div II 125 & 250 VDC battery chargers

Disposition of sources:

Cabinets:

1D622- 125V DC class 1E load center "B", lose CIG, 1/2 (Div II) ECC control
1D642- 125V DC class 1E load center "D", lose "D" RHR and CS pumps; defense-in- depth exists (HPCI,RCIC, ADS I&II,RHR and CS div. I)
1D662- 250V DC class 1E load center - lose HPCI, Defense-in-depth exists via all other ECCS
1L640- Lighting Panel, defense-in-depth Ok.

Chargers:

0D673- 125V DC Spare Battery Charger, no safety impact
0D683- 250V DC Spare Battery Charger, no safety impact
0D685- 24V DC Spare Battery Charger, no safety impact
1D623- 125V DC class 1E channel B lose 1D622 (shorts battery also)
1D643- 125V DC class 1E channel D lose 1D642, same impact as above
1D663- 250V DC class 1E Division II- lose 1D662, same impact as above
1D683- 24V DC Positive Battery Charger B, no safety impact
1D684- 24V DC Negative battery charger B, no safety impact

Impact Summary:

The only equipment loss which is risk significant is the loss of the channel "B" 125 VDC load center, either directly or by loss of charger 1D623. Loss of this load center fails CIG (causing an inboard MSIV isolation), ARI, HPCI, half of ADS and ESW, as well as a CRD (if not already operating), RHR, CS, and RHRSW pump (by loss of breaker control). An additional RHR pump fails because ESW cooling is gone. Loss of this bus (or 1D612) yields the largest calculated core damage frequency for plant transient initiators in the IPE (Reference 4-8). DID is maintained via HPCI, the remaining CRD pump and manual cross tie with unit 2 CRD, the remaining division of ADS and CS/RHR. The independent failure of 1D612 fails HPCI and ADS but leaves CRD available for core injection. Because of the significant SSD equipment loss, cabinet 1D622 and charger 1D623 cannot be screened out.

The fire loss of the other cabinets and chargers in zone 0-28B-I does not cause such extensive loss of equipment and defense-in-depth remains. There are no other sources of fire in the zone.

Table 4.27- Disposition of Control Structure Fire Zones

Zone 0-28B-II

Sources

21 Cabinets
6 battery chargers
Welding and Cutting at Power

Reason not screened: Div. I 125 and 250 VDC battery chargers and all 125 VDC distribution panels

Disposition of sources:

Cabinets:

1D612- 125V DC class 1E load center, channel A, lose CIG, 1/2 (div. I) ECCS
1D614- 125V DC class 1E distribution panel, powered by 1D612, as above
1D615- 125V DC Non-Q, distribution panel, lose BOP
1D624- 125V DC class 1E distribution panel channel B, lose 1/2 (div II) ECCS, powered off 1D622 in 0-28B-I
1D625- 125V DC Non-Q, distribution panel, lose BOP
1D632- 125V DC class 1E load center channel C; lose ESS bus, RHR, and CS pump C breaker control, no immediate plant impact
1D634- 125V DC class 1E, distribution panel off 1D632, loss as above
1D635- 125V DC Non-Q, distribution panel BOP, lose channel C BOP
1D644- 125V DC class 1E load center channel D; lose ESS bus, RHR, and CS pump D breaker control, off 1D642 in 0-28B-II, no immediate plant impact
1D645- 125V DC Non-Q, distribution panel channel D, lose BOP breaker control
1D652- 250V DC class 1E load center - Div I, lose RCIC, defense-in-depth remains
1D666- Vital AC UPS Power Supply, off 250 VDC load center 1D662; non-Q, no safety impact
1D672- 24V DC distribution panel div. I, no safety impact
1L610, 620, 630, 650, 660, 666, 670, 680- lighting panels, no safety impact.

Chargers:

1D613- 125V DC class 1E channel A charger; fails both charger and battery, lose distribution panel 1D612 (see above)
1D633- 125V DC class 1E channel C; fails both charger and battery supply to 1D632 (see above)
1D653A- 250V DC class 1E Div I, lose 1D652, lose RCIC, defense-in-depth remains
1D653B- 250V DC class 1E Div I, lose 1D652, as above
1D673- 24V DC positive battery charger system A, no safety impact
1D674- 24V DC Battery Charger System A, no safety impact

Impact Summary:

The only fire sources in zone 0-28B-II are cabinets. Because of the potential fire loss of channel A or B of 125 VDC (1D614 or 1D624), and because this initiator results in the highest calculated transient initiated core damage frequency in the IPE, this zone is considered risk significant. Specific equipment lost as a result of these bus failures is discussed above for zone 0-28B-I. While core level DID remains available, the loss of 125 V DC results in substantial loss of SSD equipment. Other than the loss of power to these two buses, all other cabinets can fail without loss of defense-in-depth.

Table 4.27- Disposition of Control Structure Fire Zones

Zone 0-28I

Sources:

1 battery

Reason not screened: Div. I 250 VDC battery (may short charger), cable (in conduit) for 1D614

Disposition of sources:

Battery: 1D650- 250 VDC class 1E div. I, lose power to 1D652 and RCIC valves; defense-in-depth intact (via HPCI, 2 divisions of ADS and low pressure makeup)

Impact Summary:

COMPBRN IIIe calculations for zone 0-28J, which contains a battery identical to that in zone 0-28I, show that a battery fire in the zone will not disable cable in conduit located within the same zone above the battery. Because the loss of the battery itself or 1D652 does not cause loss of defense-in-depth, zone 0-28I is considered not risk significant for fire.

Table 4.27- Disposition of Control Structure Fire Zones

Zone 0-28J

Sources:

1 battery

Reason not screened: Div. II 250 VDC battery (may short charger), cable (in conduit) for ESW div. I and RHR I & II control

Disposition of sources:

Battery: 1D660- 250 VDC class 1E div. II, lose power to 1D662 and HPCI valves; defense-in-depth intact (via RCIC, 2 divisions of ADS and low pressure makeup)

Impact Summary:

COMPBRN IIIe calculations for zone 0-28J show that a battery fire in the zone will not disable cable in conduit located within the same zone above the battery. Because the loss of the battery itself or load center 1D662 does not cause loss of defense-in-depth, zone 0-28J is considered not risk significant for fire.

Table 4.27- Disposition of Control Structure Fire Zones

Zone 0-29B

Sources:

9 cabinets
12 HVAC
1 transformer
Welding and Cutting at power
Misc. Transients: Trash barrels, locked metal storage cabinets- no significant source

Reason not screened: Div. I and II control structure HVAC

Disposition of sources:

Cabinets:

0B136- Control Structure HVAC 480V MCC fed from 1B230
0B146- Control Structure HVAC 480V MCC fed from 1B240
0B610- Control Building load center- 480V, non-Q
0B611- Control Structure H&V room MCC- 480V, non-Q off 0B610
0B620- Control Building load center- 480V, non-Q
0B621- Control Structure H&V room MCC - 480V, non-Q off 0B620
0C887A- SGTS heater SCR control panel
0C887B- SGTS heater SCR control panel
0C879- Control Structure HVAC alternate control panel

HVAC:

0V103A&B- 50 HP each
0V115A&B- 40 HP each
0V116A&B- 5 HP each
0E108- Control room humidifier- 30KW, 480V
0E145A1&A2- 0V103A heating coils, 65KW
0E145B1&B2- 0V103B heating coils, 65KW
0E168- Control Structure Computer and control room pre-heating (16KW)

Transformers:

0X620- Load center transfer Control Structure

Impact Summary:

This zone contains equipment required for control structure HVAC and SGTS. Miscellaneous small pumps on this elevation (783': 0P162A&B, 0P170A&B, 0P171A&B) are all less than 50 hp and the maximum of any is 30HP. All fan motors on this elevation are less than or equal to 50 hp with the maximum being 0V103A&B at 50 HP each. Loss of 1 cabinet, fan, or heater will not affect the other division of CSHVAC because they are metal enclosed and separated from each other. The pumps are sufficiently small to be discounted as significant fire sources and there are no distributed combustibles capable of affecting both HVAC trains. Even with total loss of control structure HVAC, plant operation may be affected only after a relatively long period of time (about 24 hours). Thus, given that fire in 0-29B is limited to a single component/train, the long term impact even if both trains are lost, and the possibility of providing supplemental cooling (LOOP or loss of EDG not guaranteed) fire in this zone is judged not risk significant.

Table 4.27- Disposition of Control Structure Fire Zones

Zone 0-30A

Sources:

4 cabinets
2 pumps
2 air compressors
19 HVAC components
Welding and cutting at power
Misc. Transients: Charcoal in metal vessel- contained, no propagation
trash barrel- administrative control eliminates significance

Reason not screened out: Div. I and II of CSHVAC

Disposition of sources:

Cabinets:
0B876A- control structure HVAC panel, 120V, lose div I CSHVAC
0B876B- control structure HVAC panel 120V, lose div II CSHVAC
0C883A- standby gas treatment system panel - div. I, 120V
0C883B- standby gas treatment system panel- div. II, 120V

Pumps:
0P112A&B- control structure pump out unit for 0K112, 2HP each, lose div I or II CSHVAC chiller

Air Compressors:
0K115A&B- oil pumpout compressors for chiller 0K112A&B, lose div I or II CSHVAC chiller

HVAC
0V101A&B- control structure emergency outside air supply, 20HP each
0V104A&B- control structure smoke removal fan, 7.5 HP each
0V107- control room toilet exhaust fan, 1HP
0V112- Access control area toilet exhaust fan 1.5 HP
0V113 - Access control general exhaust fan, 7.5 HP
0V114A&B- containment filter units exhaust fan, 30 HP each
0V118A&B- standby gas treatment system equipment room, 5HP
0V119- control room relief air fan, 1HP
0V144A&B- SGTS equipment room heating unit fan, 5HP each
0E143A&B- control room emergency outside air heater, 30 KW
0E144A&B- standby gas treatment equipment room heater, 30KW
0E166- control structure SGTS floor mechanical room unit, 4KW

Impact Summary:
This zone contains equipment required for control structure HVAC and SGTS. All pump and fan motors on this elevation are less than 50 hp and the maximum of any is 30 hp (0V114A&B). Loss of 1 cabinet, fan, or heater will not affect the other division of CSHVAC because they are metal enclosed and separated from each other. The only combustible capable of affecting multiple trains of HVAC is the 15 gallons of lube oil per CS chiller. COMPBRN IIIe calculations show that a spill of this oil

from one chiller will not disable the other chiller or destroy cable (in conduit) near the leaking chiller. Credit for this lack of damage is due to a curb installed as part of the Appendix R modifications which prevents the oil from spilling beyond the chiller. However, as in zone 0-29B, even with total loss of control structure HVAC, plant operation may be affected only after a relatively long period of time (about 24 hours). Thus, given that fire in 0-30A is limited to a single component/train, the long term impact even if both trains are lost, and the possibility of providing supplemental cooling (LOOP or loss of EDG not assumed), a fire in this zone is judged not risk significant.

Table 4.28- SSD Equipment Loss Significant Fires

| Fire Zone | Direct Fire Damage | Dependent Fire Damage |
|---|---|---|
| 0-24D (LRR) | 1C661B:<br>div. II RPV/core cooling instrumentation<br><br>1C618:<br>div. II RHR and RCIC relays | 1/2 control room indication for RPV<br><br>Div. II RHR and RCIC |
| 0-26H (CR) | 1C601 middle:<br>div. I ECCS control, inserts 17,18,19, half of 20.<br><br>1C601 right:<br>div. II ECCS control, inserts 21, 22, and half of 20.<br><br>0C653:<br>Control switches for all power feeds for all ESS buses | RCIC, 1/2 control room ADS actuation, div I RHR and CS<br><br>HPCI, div. II RHR and CS.<br><br>Short term loss of AC power from all ESS buses (SBO). |
| 0-27E (URR) | 1C661A:<br>div. I RPV/core cooling instrumentation<br><br>1C617:<br>div I RHR and HPCI relays | 1/2 control room indication for RPV<br><br>Div. I RHR and HPCI |
| 0-28B-I | 125 V DC channel "B":<br>1D622, 1D623 | CIG (Inboard MSIVs close), ARI, HPCI, div. II ADS solenoids, 1/2 ESW (normal breaker control) and 2 RHR pumps, 1 CS pump, "B" CRD pump if not operating. |
| 0-28B-II | 125 V DC channel "A":<br>1D612, 1D613, 1D614,<br><br>or<br>125 V DC channel "B":<br>1D624 | CIG(Inboard MSIVs close), ARI, RCIC, div I ADS solenoids and all non-ADS SRV solenoids, 1/2 ESW (normal breaker control) and 2 RHR pumps, 1 CS pump, "A" CRD pump if not operating.<br>or<br>As above for channel "B" |

**Table 4.29**
**Detection Loss Summary**

| Date | Unit | Mode Oper. | Description |
|---|---|---|---|
| 9/16/83 | Common | U1 Power Oper., U2 Pre-Op. | During the performance of a surveillance detector 0I-183 failed to trip |
| 5/10/87 | Common | Both Power Operational | Fire Detection smoke detectors 0I-184, 0I-185, & 0I-188 failed surveillance (SI-013-203) |
| 5/19/88 | Unit 2 | Power Operational | Fire Protection watches were missed for the Unit 2 Reactor Building due to a personnel error |
| 10/25/88 | Unit 2 | Power Operational | Cable pulling activities without fire watch. Fire penetration seal in the EHC room was breached |
| 1/13/90 | Unit 1 | Power Operational | Continuous Fire Watch not established within 1 hour, after failure of power/supply ground fault circuit to transponders 102 and 103 |
| 1/14/90 | Unit 1 | Power Operational | Not all required fire watch rounds were completed (32 hours X 139 zones) |
| 7/1/92 | Unit 1 | Power Operational | Control Room Emergency Outside Air Supply System charcoal filter fire protection OS&Y valve was closed without fire watch |

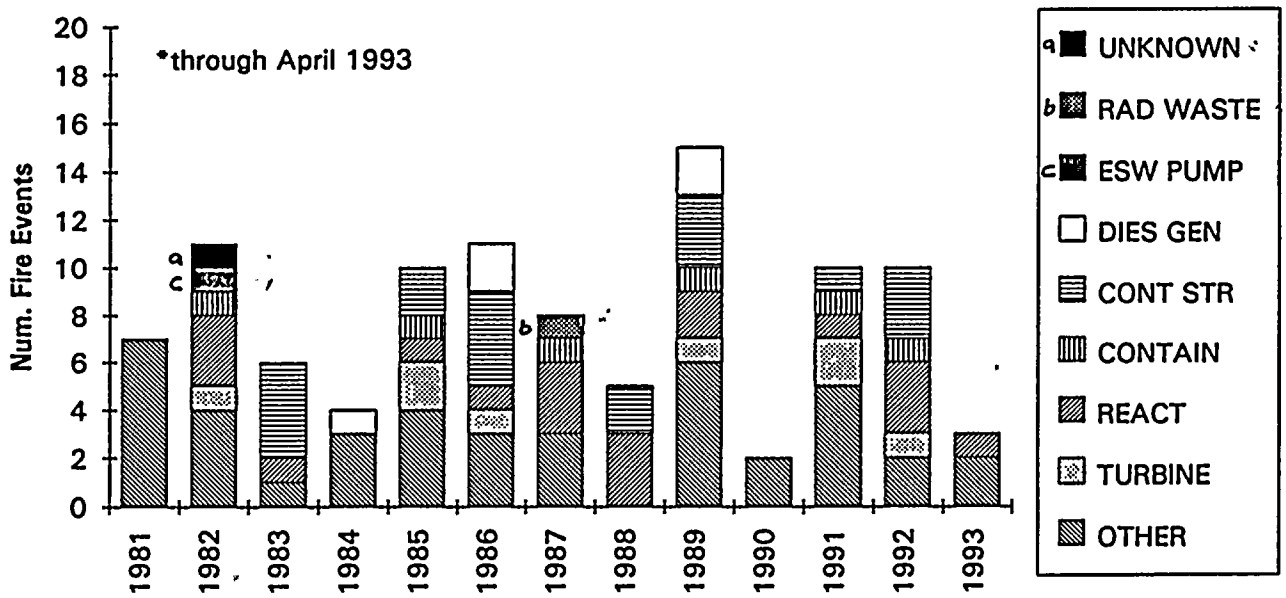
Table 4
Detection Lo mmary

| Actions Taken | Date | Building | Elevat. | Fire Zone(s) | Reference(s) |
|---|---|---|---|---|---|
| Hourly fire watch, detector replaced | 9/16/83 | Control Str. | 771 | 0-28L | SOOR 1-83-281 |
| Fire detector 0I-184 was replaced | 5/10/87 | Control Str. | 771 | 0-28M, 0-28N, 0-28I | SOOR 1-87-152 |
| The watch was reviewed with the individual and the walkdown performed, all detection/suppression operable | 5/19/88 | Reactor | 683, 670, 645 | All | SOOR 2-88-151 |
| A Fire watch was established within 48 hours | 10/25/88 | | | | SOOR 2-88-288 |
| It took slightly over six hours to establish a fire watch in four of ten zones | 1/13/90 | Control Structure | 698-806 | All | SOOR 1-90-006 |
| A Key station system was implemented for additional supervision | 1/14/90 | Various | - | Various | SOOR 1-90-008 |
| A fire watch was established | 7/1/92 | Control Str. | 729 | 0-26H | SOOR 1-92-253 |

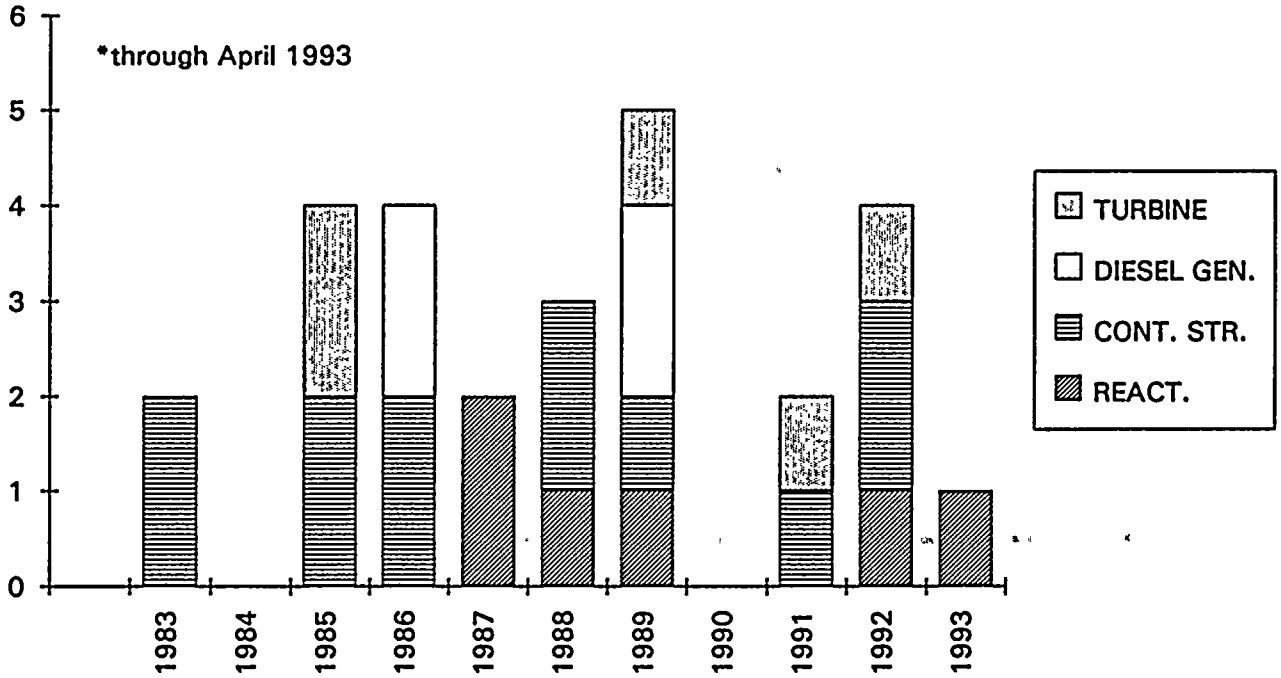
Table 4.30
Frequency of Plant Damage States
(per cycle)

| Initiator | Core Damage | | | | | No Core Damage |
|---|---|---|---|---|---|---|
| | Vessel Intact | | Vessel Failed | | | Vessel Intact |
| | Cont. Intact | COPF | Cont. Intact | COTF | COPF | COPF |
| 1D614 or 1D624 Power | 1.3E-9 | ε | 6.4E-12 | 5.7E-16 | ε | 6.2E-12 |
| C601 Middle: | | | | | | |
| w/o LOOP | 1.1E-12 | ε | ε | ε | ε | 3.3E-10 |
| w LOOP | 8.1E-13 | 3.2E-15 | 7.9E-17 | 1.5E-18 | 2.5E-17 | 1.0E-14 |
| C601 Right: | | | | | | |
| w/o LOOP | 1.0E-12 | ε | ε | ε | ε | 4.3E-09 |
| w LOOP | 3.3E-12 | 2.3E-15 | 1.2E-20 | ε | 6.1E-22 | 8.4E-14 |
| C614 | | | | | | |
| w/o LOOP | 4.3E-12 | ε | ε | ε | ε | 2.1E-14 |
| w LOOP | 1.5E-13 | 4.0E-16 | 1.3E-15 | ε | 5.8E-18 | 8.4E-15 |
| C617 | | | | | | |
| w/o LOOP | ε | ε | ε | ε | ε | 8.5E-12 |
| w LOOP | 2.3E-15 | 7.3E-18 | 2.8E-21 | ε | 2.9E-27 | 2.6E-14 |
| C618 | | | | | | |
| w/o LOOP | ε | ε | ε | ε | ε | 1.2E-11 |
| w LOOP | 1.6E-15 | 3.8E-18 | 2.8E-23 | ε | 1.4E-24 | 1.7E-14 |
| OC653 | | | | | | |
| SBO DG, Std. Recov. | 1.3E-14 | 4.7E-18 | 4.3E-20 | 1.1E-20 | 9.4E-23 | 1.0E-16 |
| SBO DG, Quick Recov. | 2.9E-19 | 5.6E-21 | 1.3E-22 | 1.4E-25 | 3.6E-26 | 3.7E-19 |
| SBO ESW | ε | 2.3E-12 | ε | 9.6E-18 | 2.5E-17 | 3.7E-11 |
| Σ Worst of Each Cabinet | 1.3E-9 | 2.3E-12 | 6.4E-12 | 5.8E-16 | 5.6E-17 | 4.7E-09 |

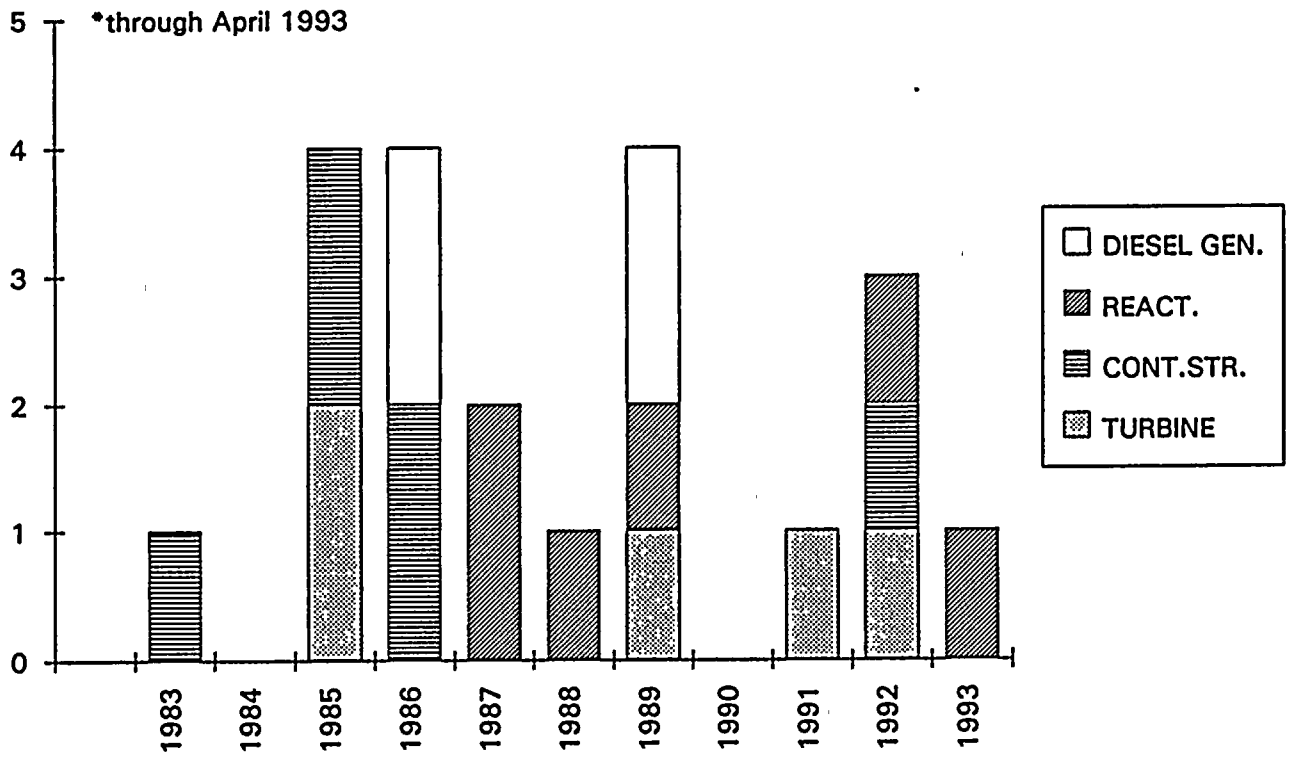
## Figure 4.1 - All Fire Events by Area



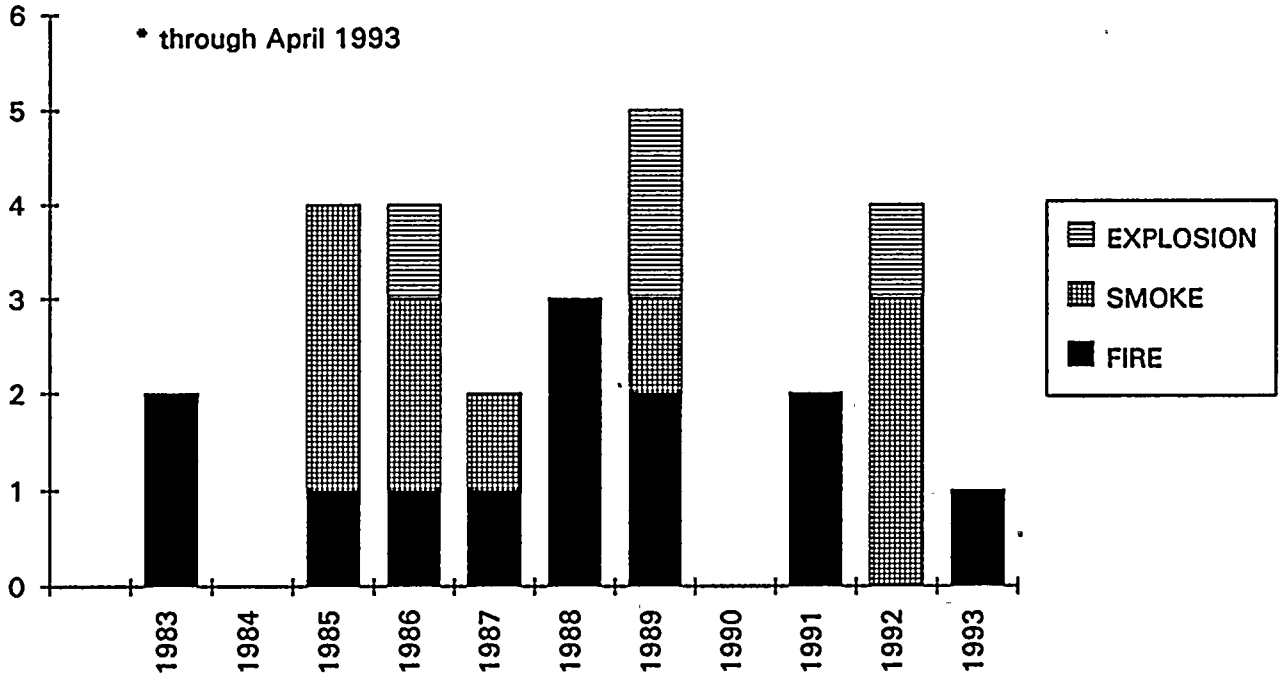
## Figure 4.2 - Fire Events While Critical (Important Areas)



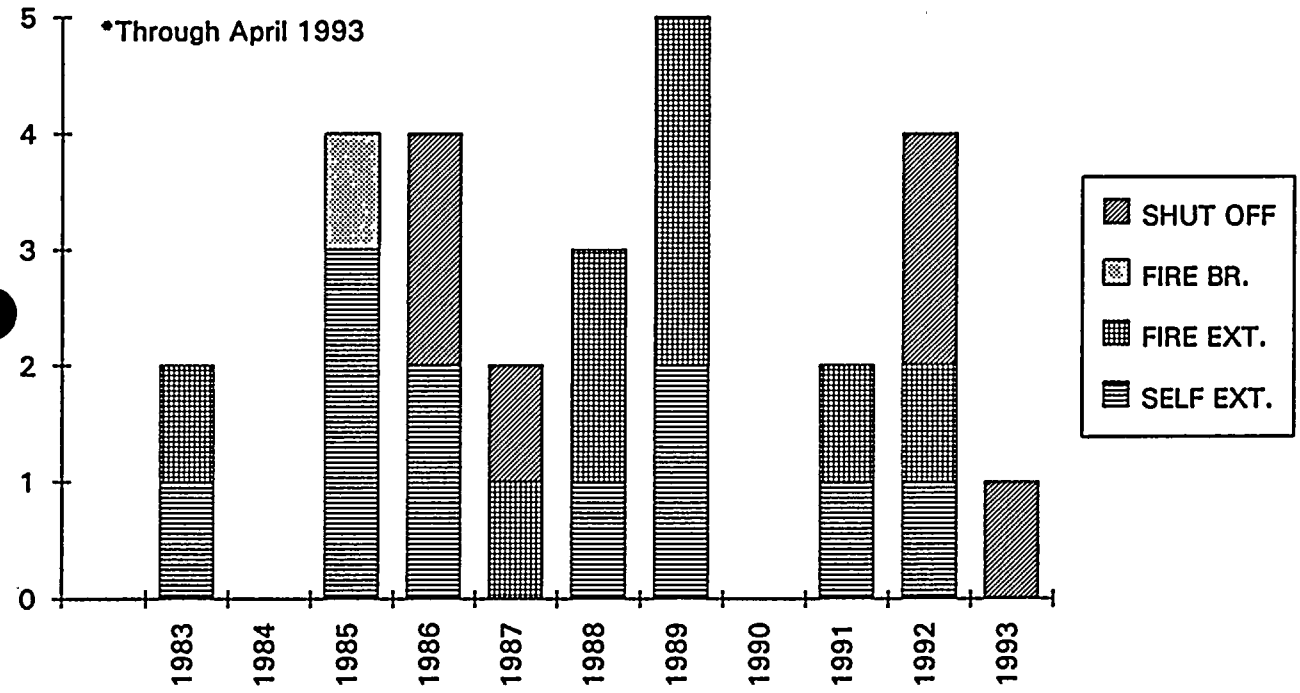
## Figure 4.3 - Critical Fire Events except Cigarettes (Important Areas)



## Figure 4.4 - Fire Events by Type (Critical, Important Area)



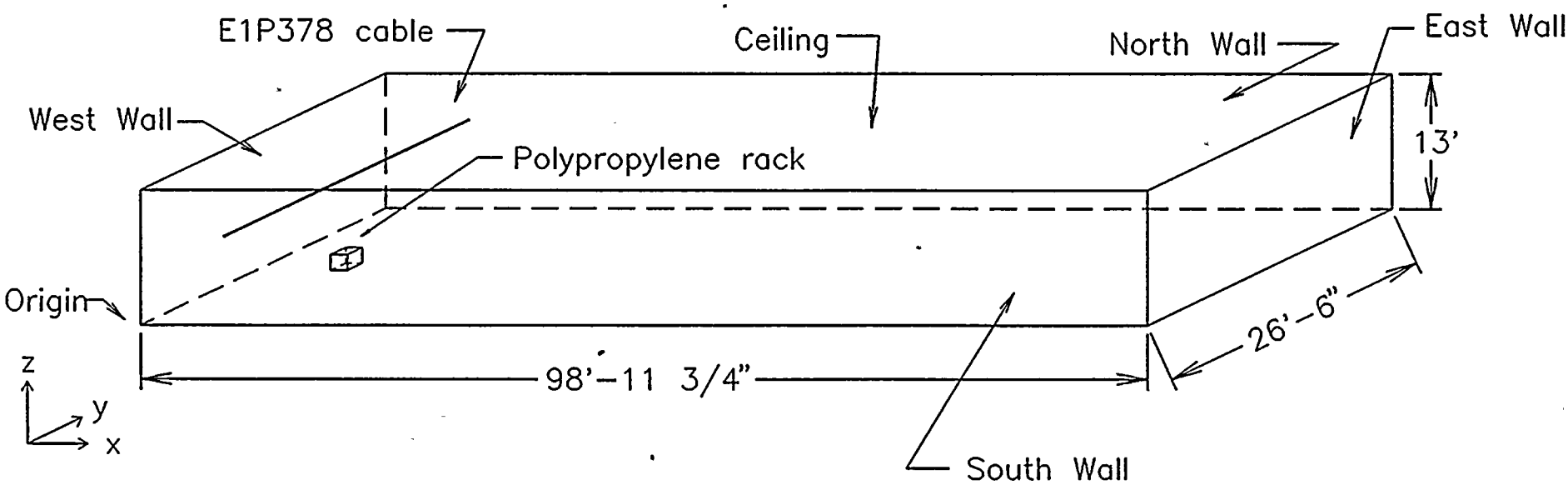
## Figure 4.5 - Fire Event Suppression (Critical, Important Areas)



# Figure 4.6

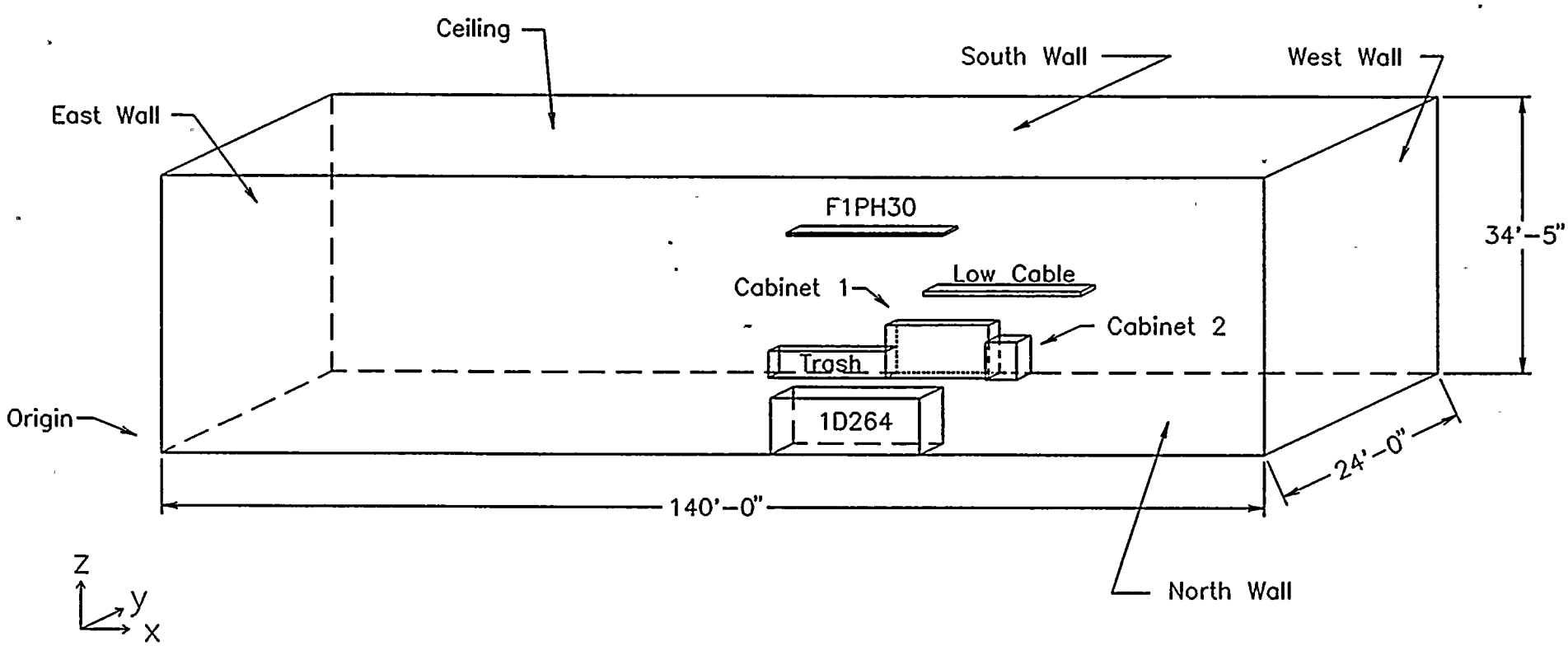
## Access Corridor

## FZ 1–2B (670' elevation)



# Figure 4.7

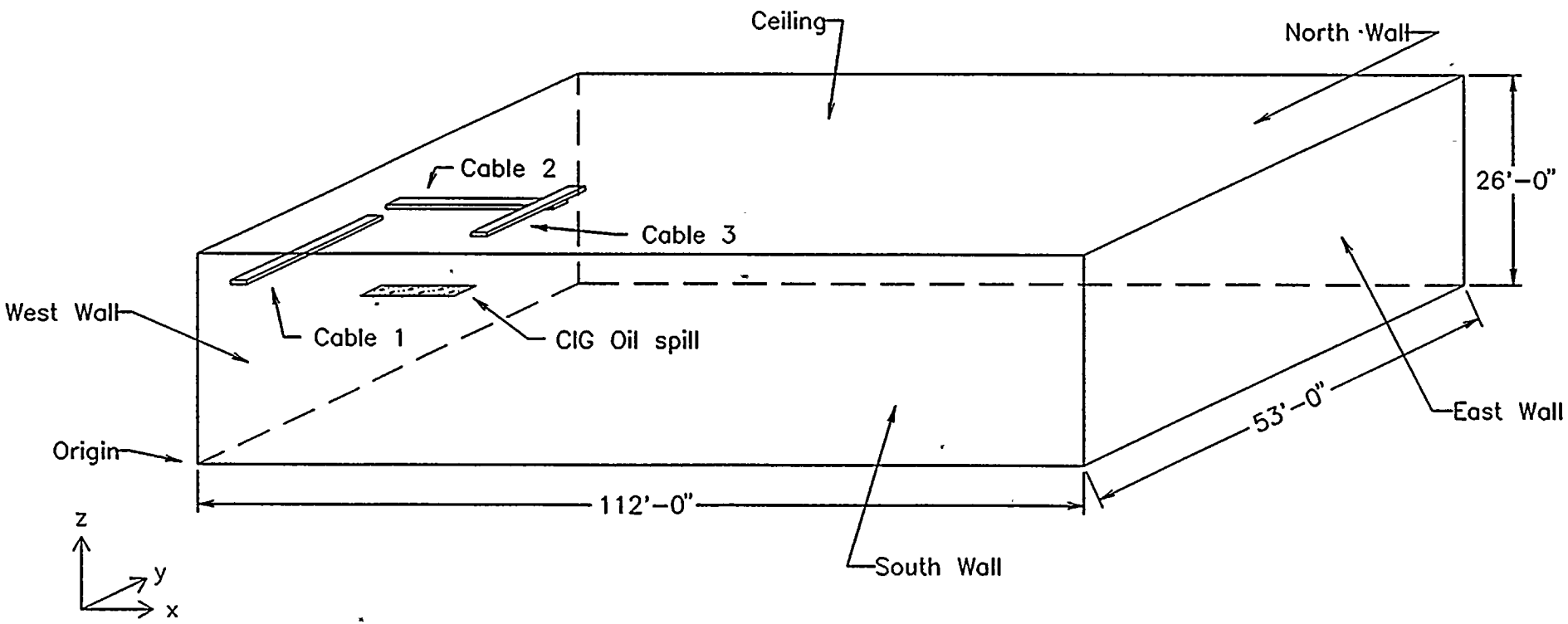
## Equipment Removal Area
## FZ 1–3B–N (683' elevation)



# Figure 4.8

North HCU Area

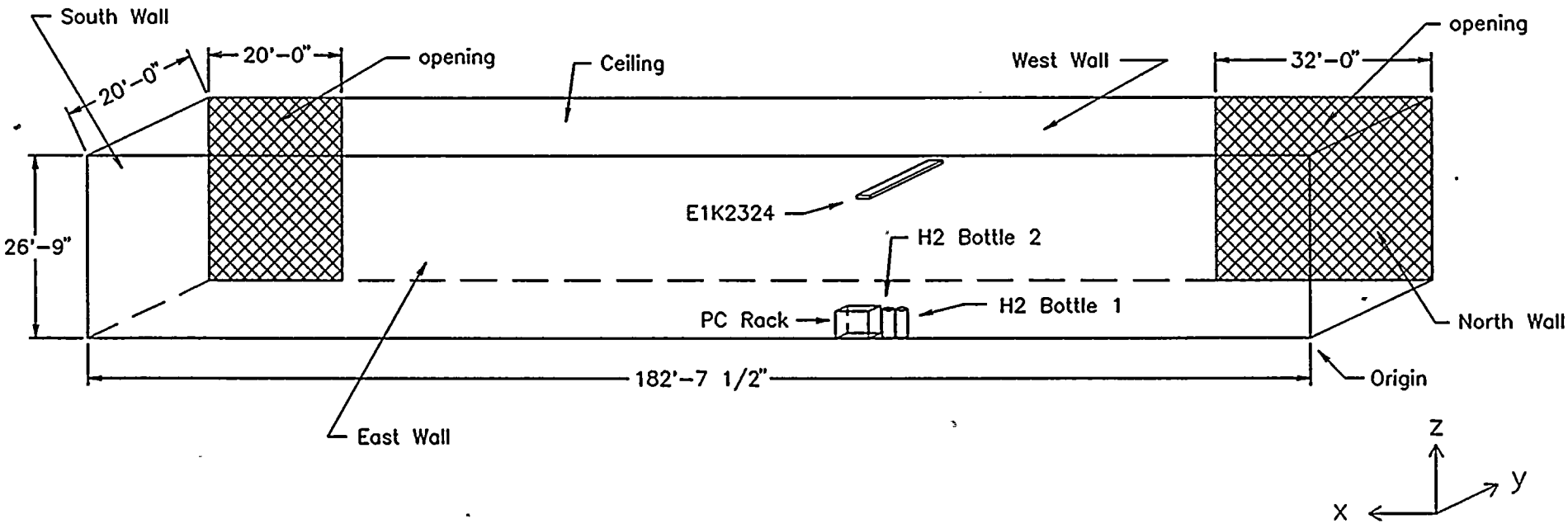
FZ 1–4A–N (719' elevation)



# Figure 4.9

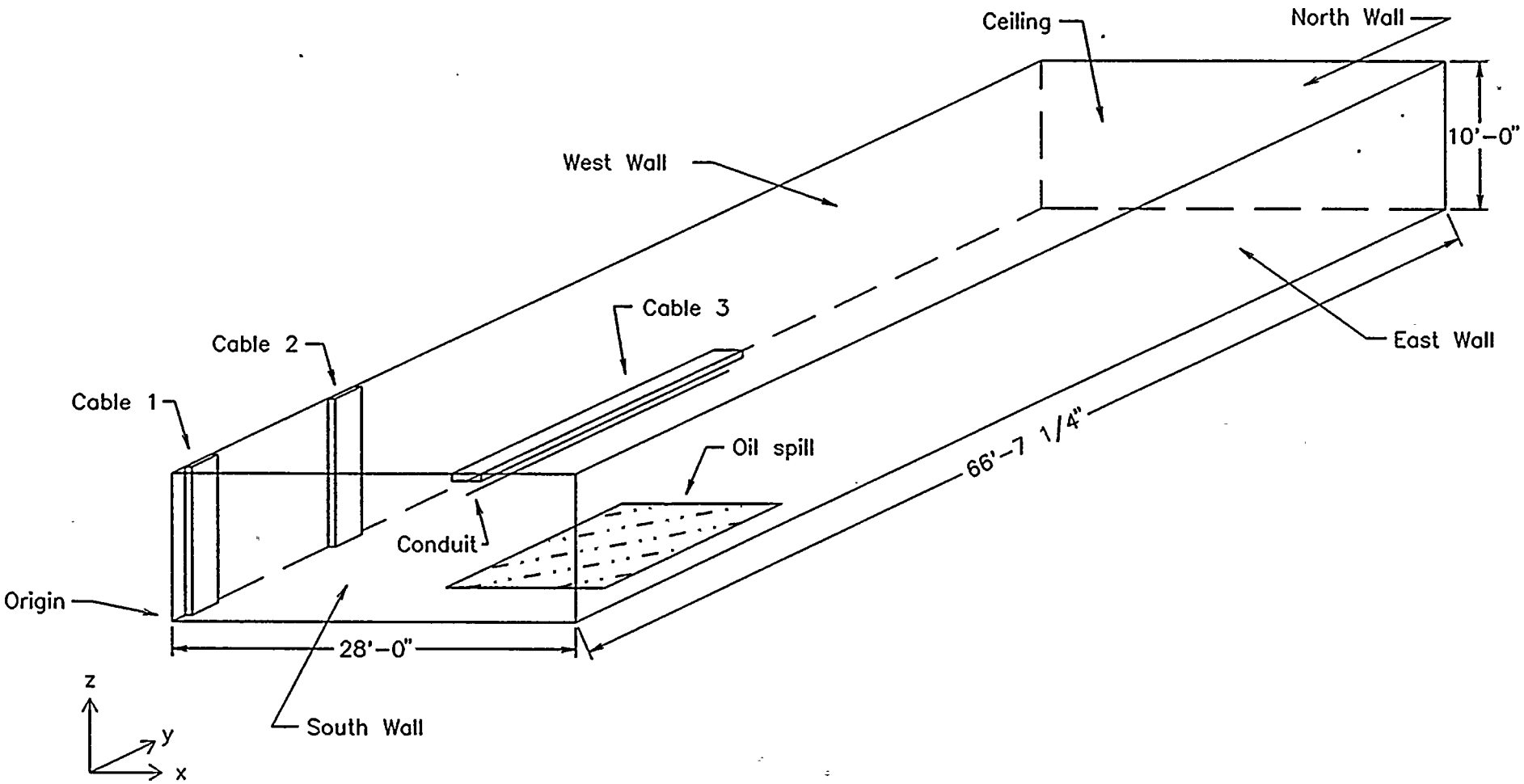
## Containment Access Area

## FZ 1-4A-W (719' elevation)



# Figure 4.10

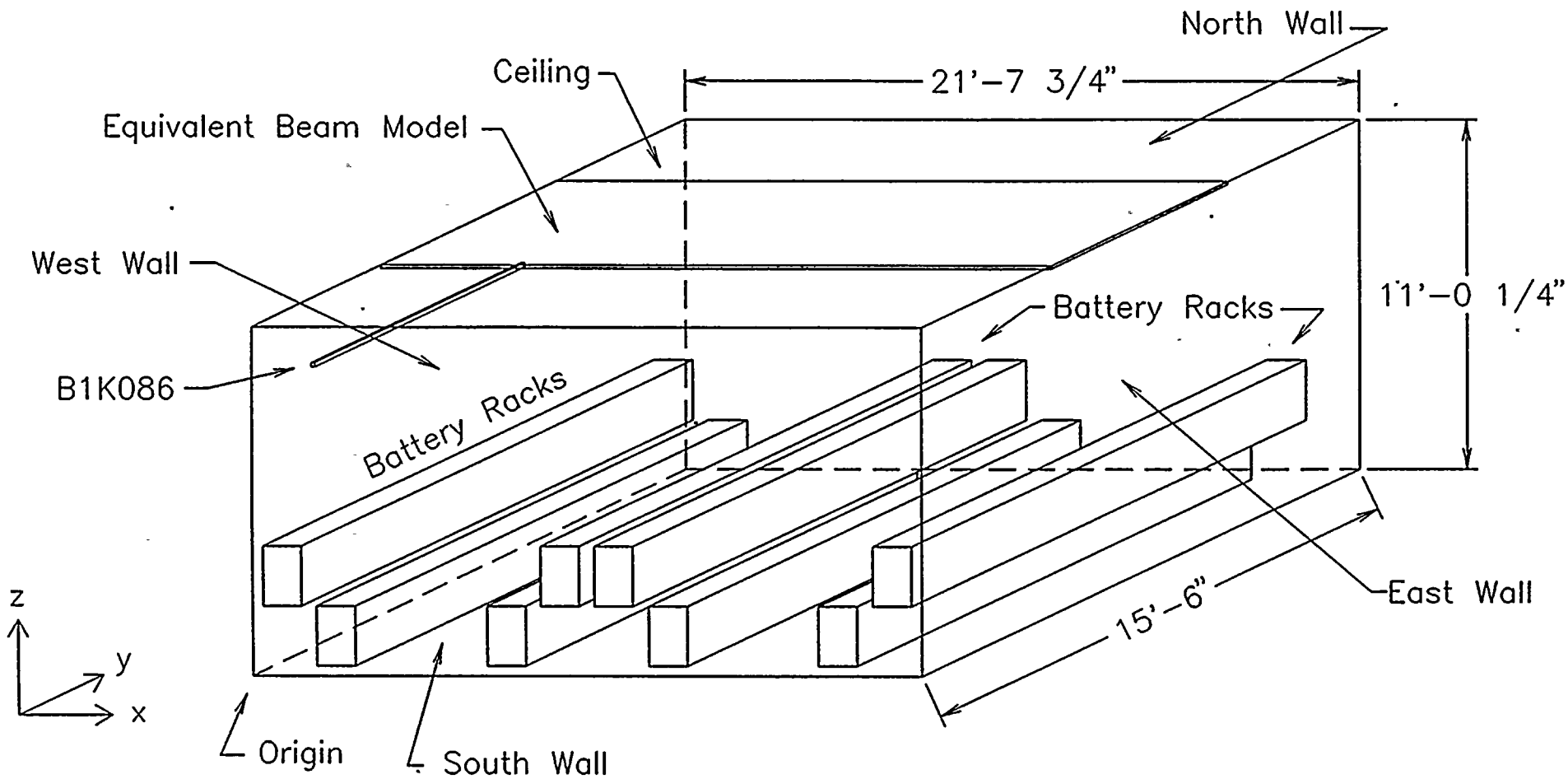
## Control Structure Chiller
## FZ 1–5A–S (749' elevation)



# Figure 4.11

250 V Battery 1D660

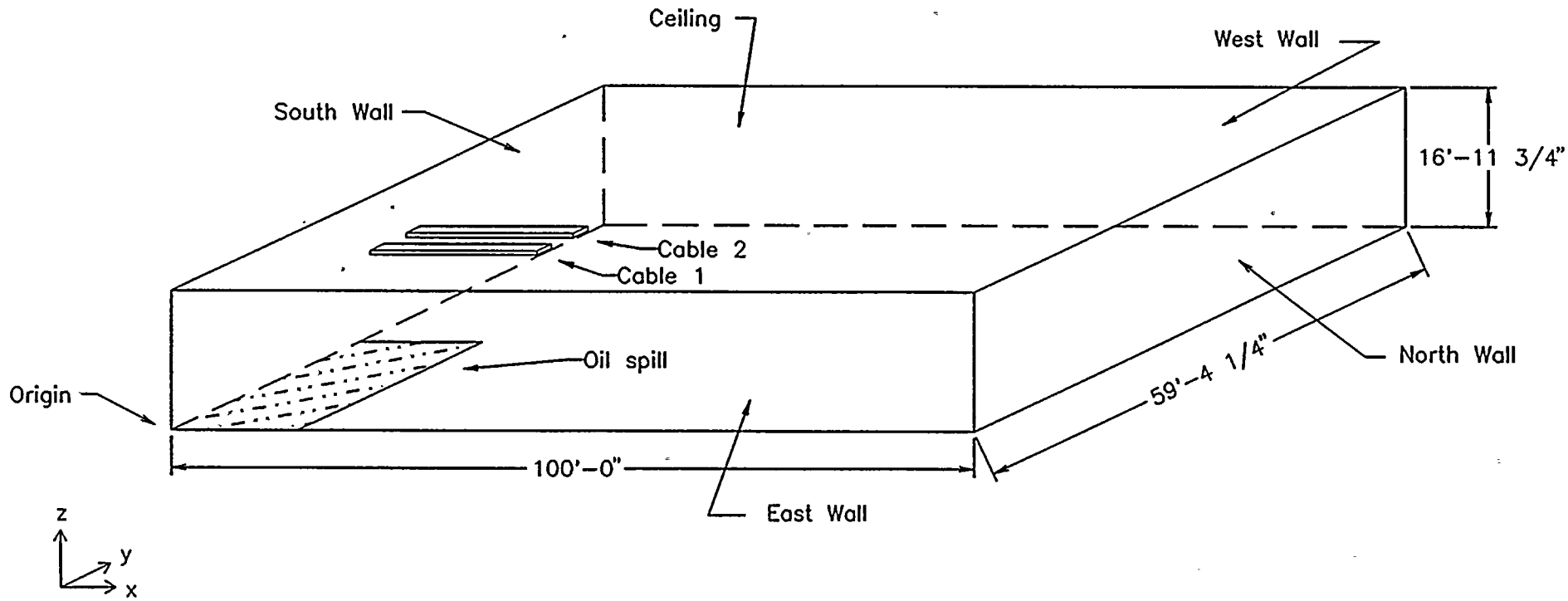
FZ 0–28J (771' elevation)

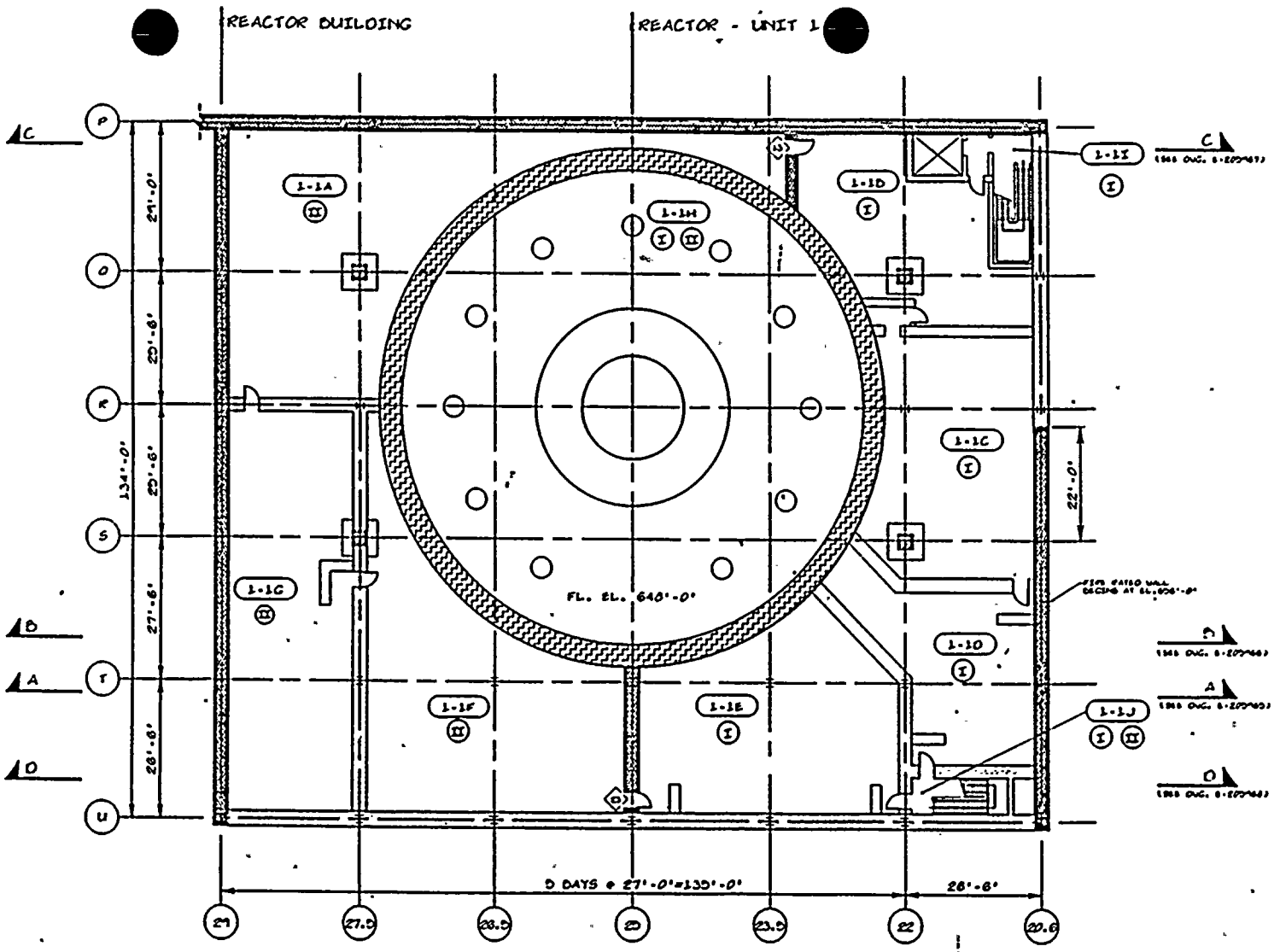


# Figure 4.12

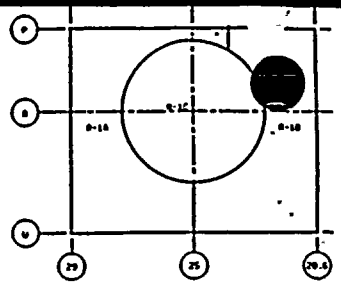
## Control Structure Chillers

## FZ 0–30A (806' elevation)






FLOOR PLAN @ EL. 645'-0"



FIRE AREA KEY PLAN

NOTES

1) PROTECTED SAFE SHUTDOWN PATH (I.E. DIVISION I) IS DEFINED AS THOSE SAFE SHUTDOWN CABLES AND COMPONENTS WHICH MUST BE PROTECTED FROM FIRE DAMAGE WITHIN THE DESIGNATED FIRE ZONE. WHEN BOTH DIVISIONS ARE SHOWN, BOTH DIVISIONS MUST BE PROTECTED.

LEGEND

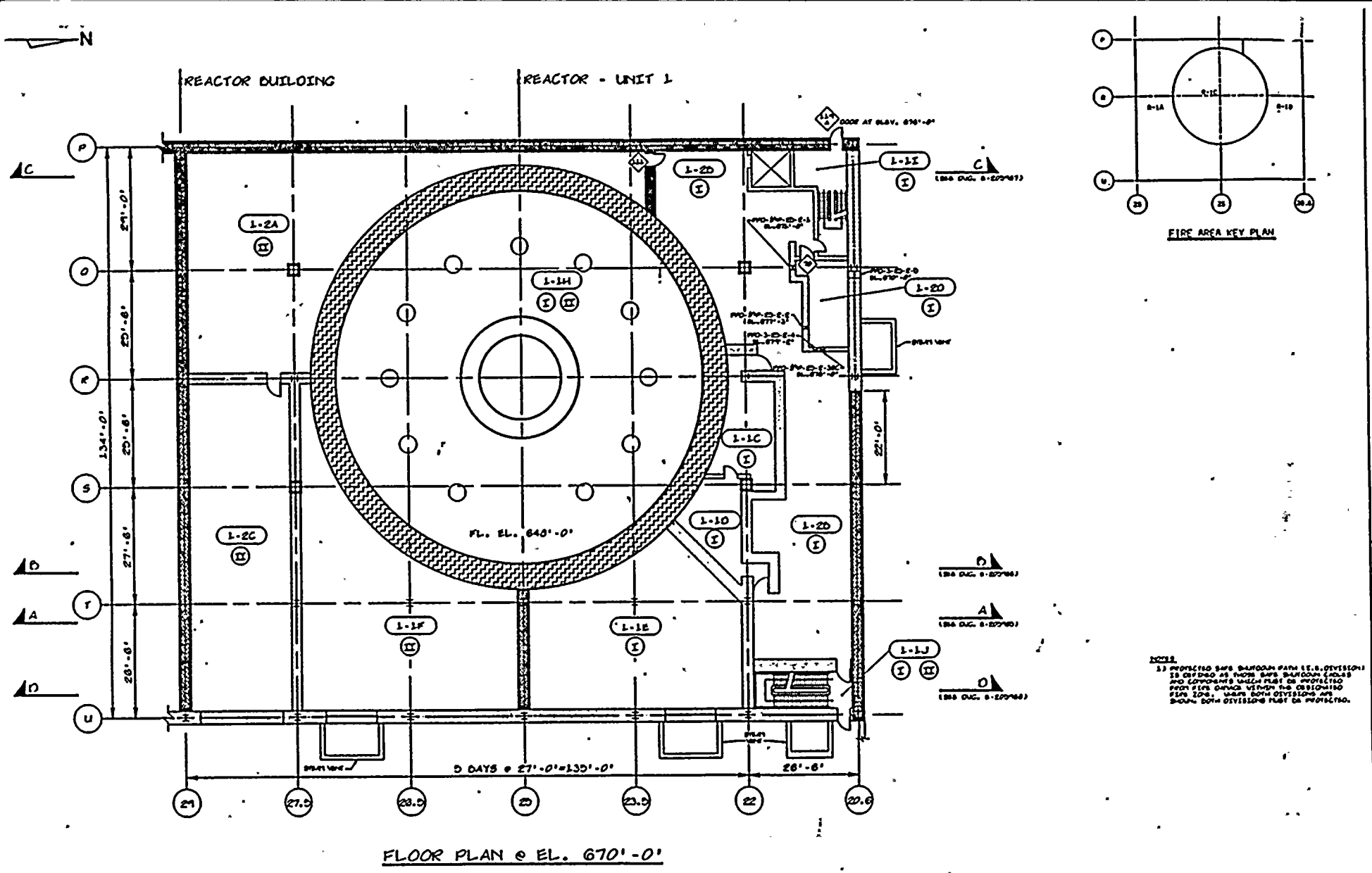
- FIRE ZONE
- DIVISION I PROTECTED SAFE SHUTDOWN PATH
- DIVISION II PROTECTED SAFE SHUTDOWN PATH
- 3 HR. FIRE RATED WALLS
- FIRE DOOR MARKER
- FIRE ZONE BOUNDARY
- INDICATED CONTAINMENT BOUNDARY

SUSQUEHANNA S.E.S.
UNIT 1
REACTOR BUILDING
FIRE ZONE PLAN OF
ELEVATION 645'-0"

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA

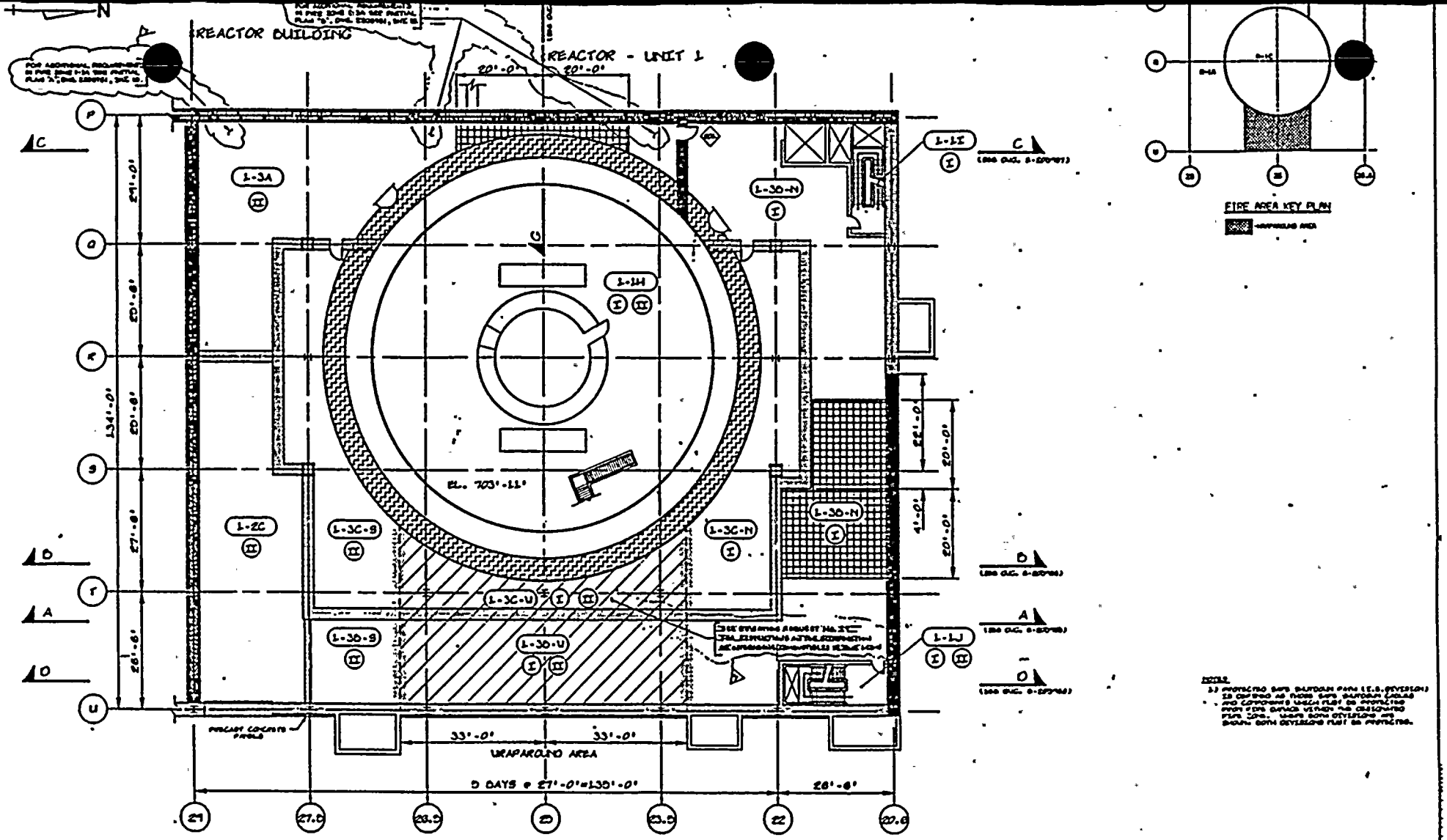
E205949 | SHEET NO. 1 | REV. NO. 2
C-1720 | SHEET NO. 1

Figure 4.13



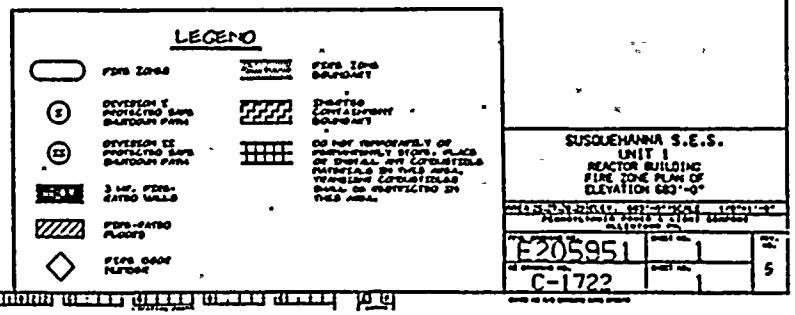

FLOOR PLAN @ EL. 670'-0"

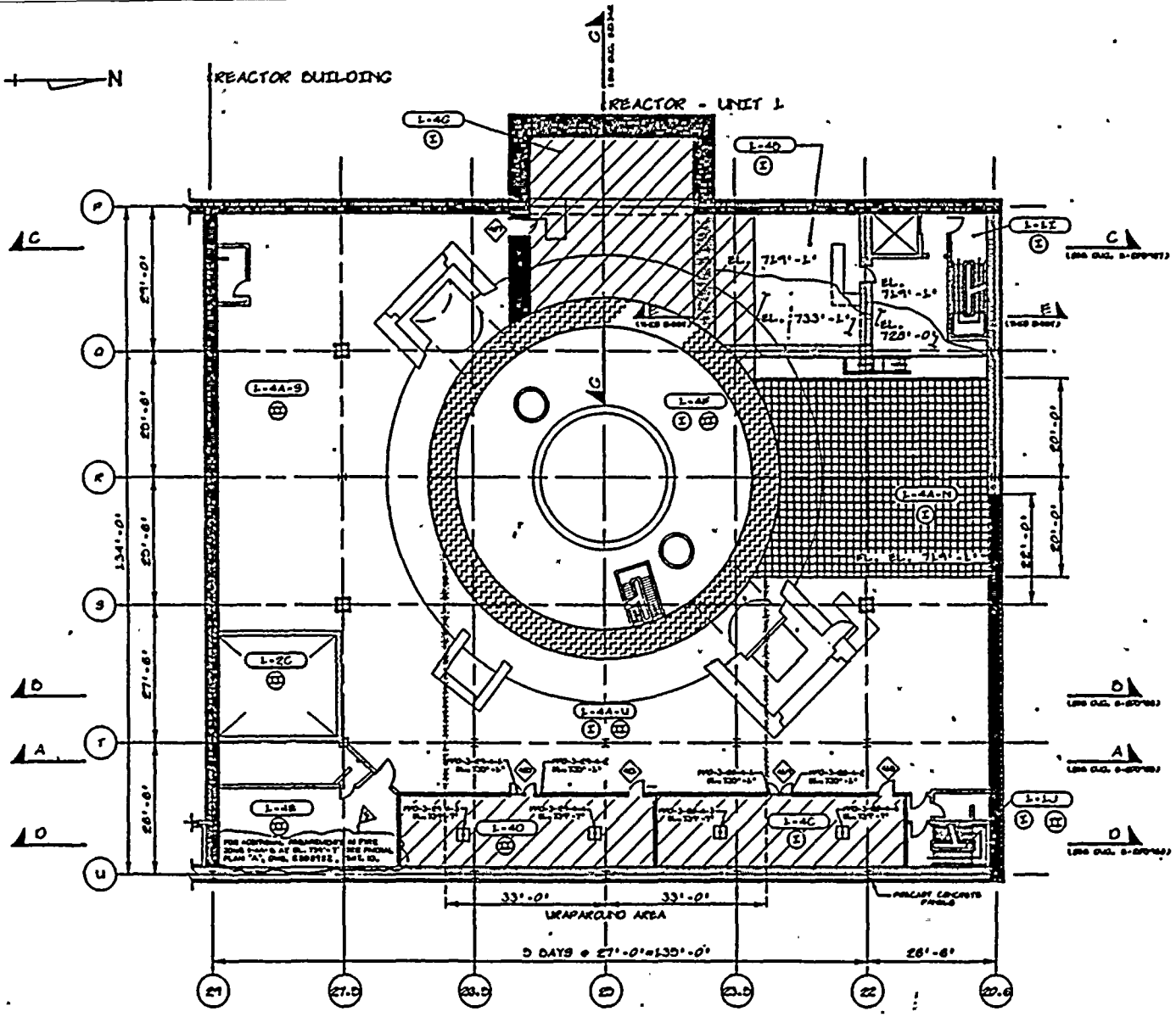
Figure 4.14

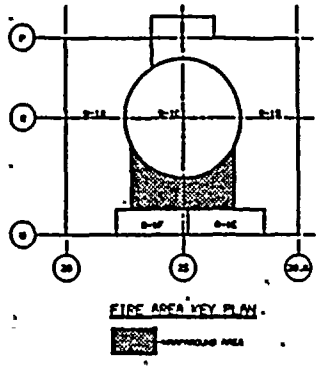


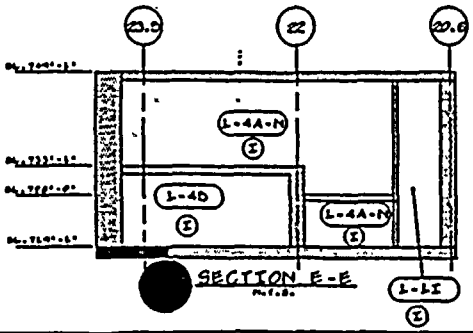

FLOOR PLAN @ EL. 683'-0"

Figure 4.15



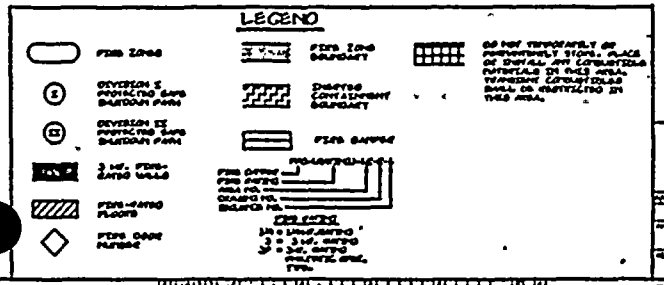


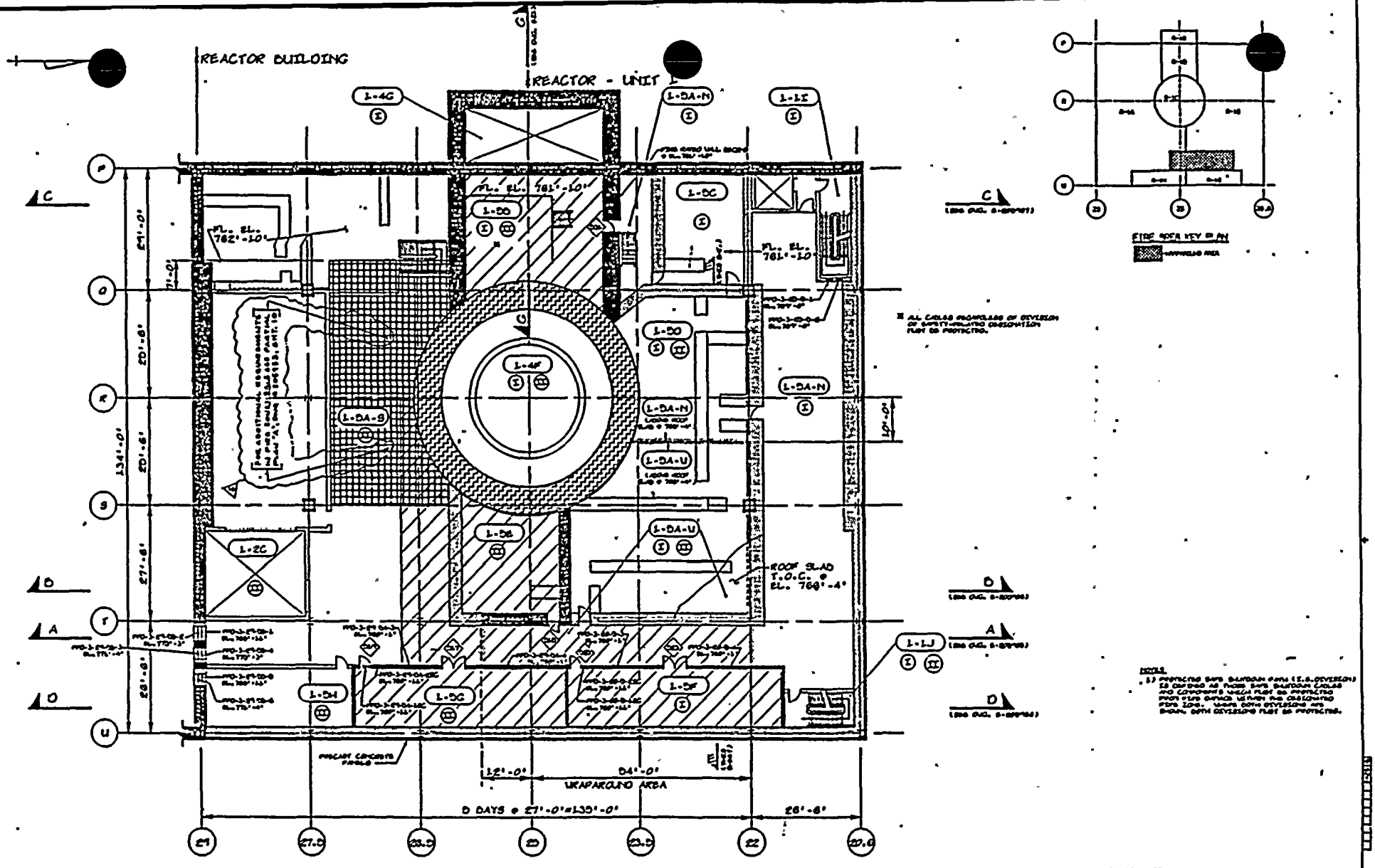

FLOOR PLAN @ 719'-1'

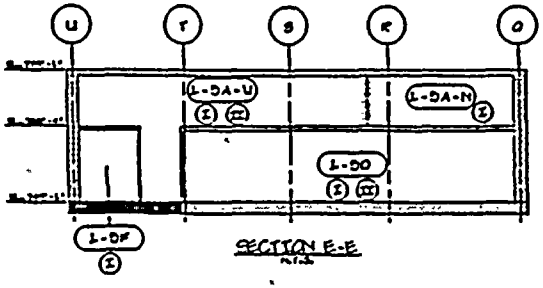
Figure 4.16




SUSQUEHANNA S.E.S.
UNIT 1
REACTOR BUILDING
FIRE ZONE PLAN OF
ELEVATION 719'-1"

F205952
C-1723



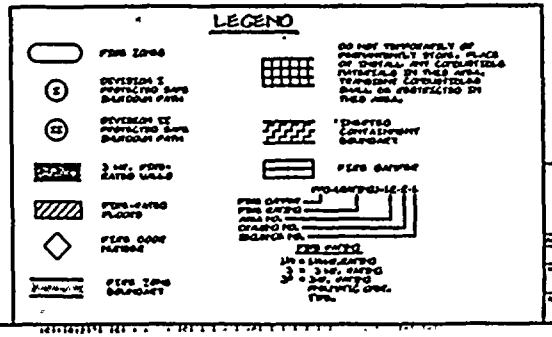
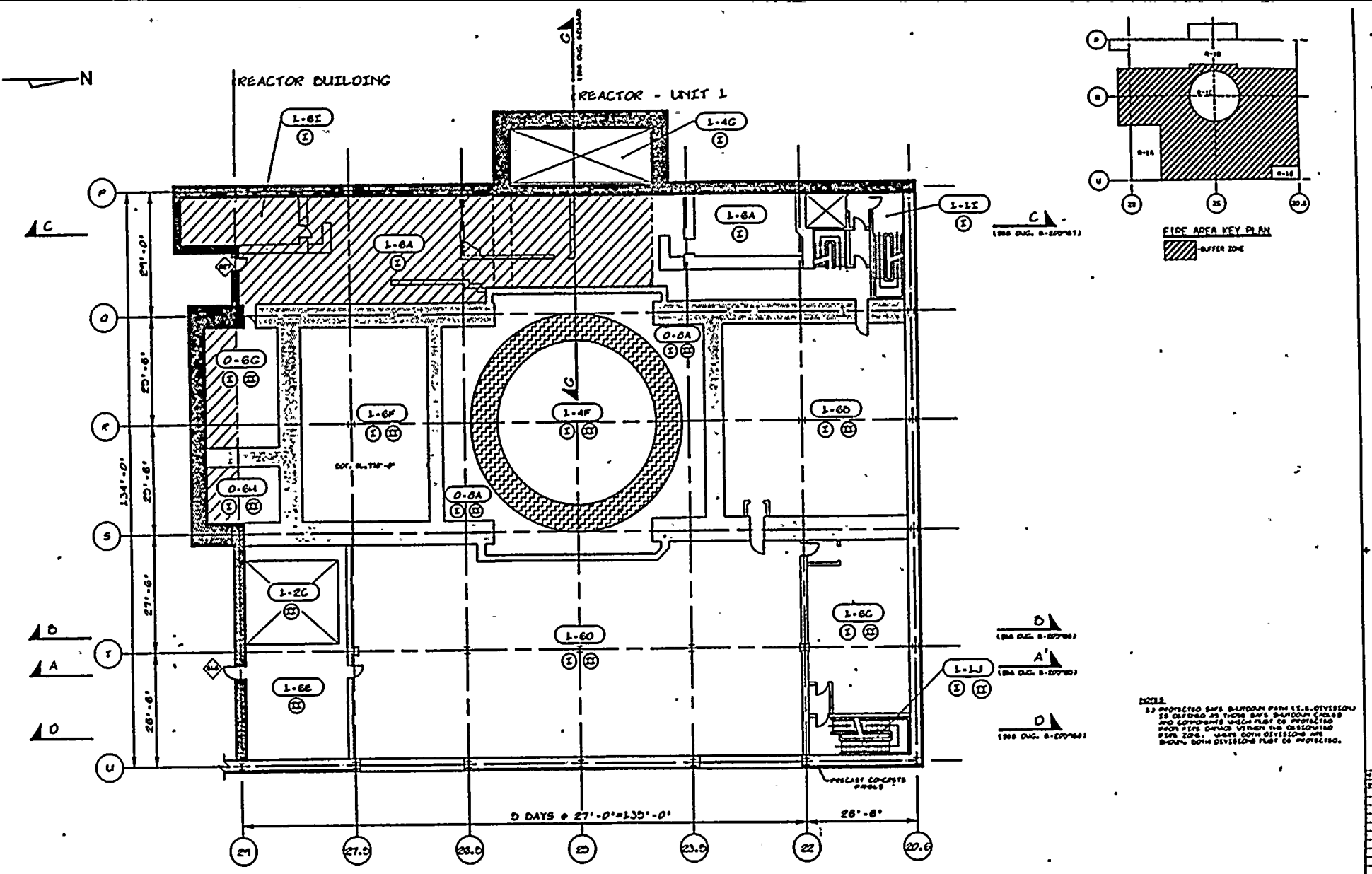




Figure 4.17

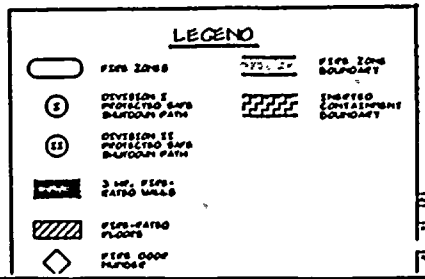
SUSQUEHANNA S.E.S.
UNIT 1
REACTOR BUILDING
FIRE ZONE PLAN OF
ELEVATION 749'-1"

E205953 | 1 | 5
C-1724 | 1




FLOOR PLAN @ EL. 779'-1"

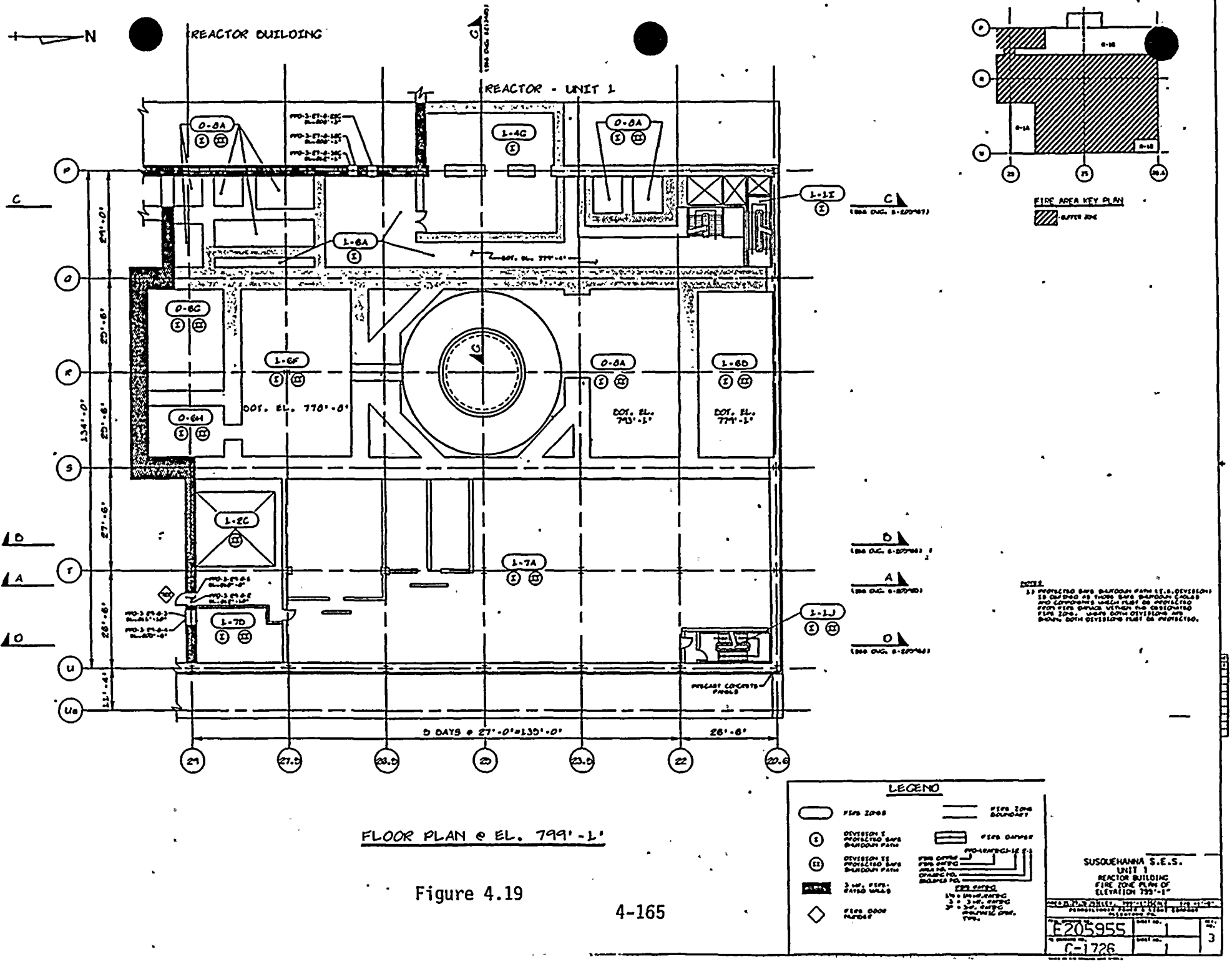
Figure 4.18




SUSQUEHANNA S.E.S.
UNIT 1
REACTOR BUILDING
FIRE ZONE PLAN OF
ELEVATION 77

E205954

C-1725




FLOOR PLAN @ EL. 799'-1'

Figure 4.19

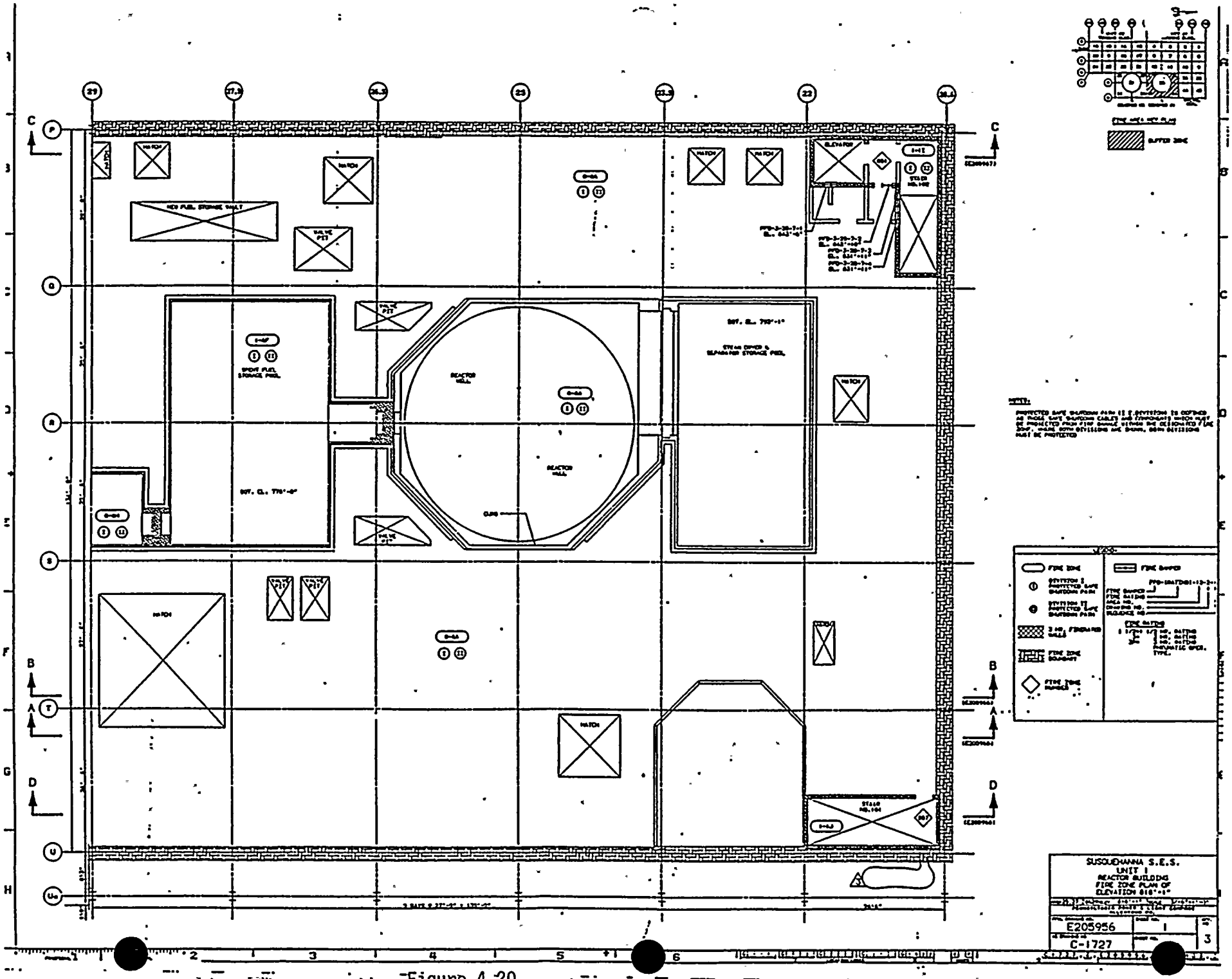
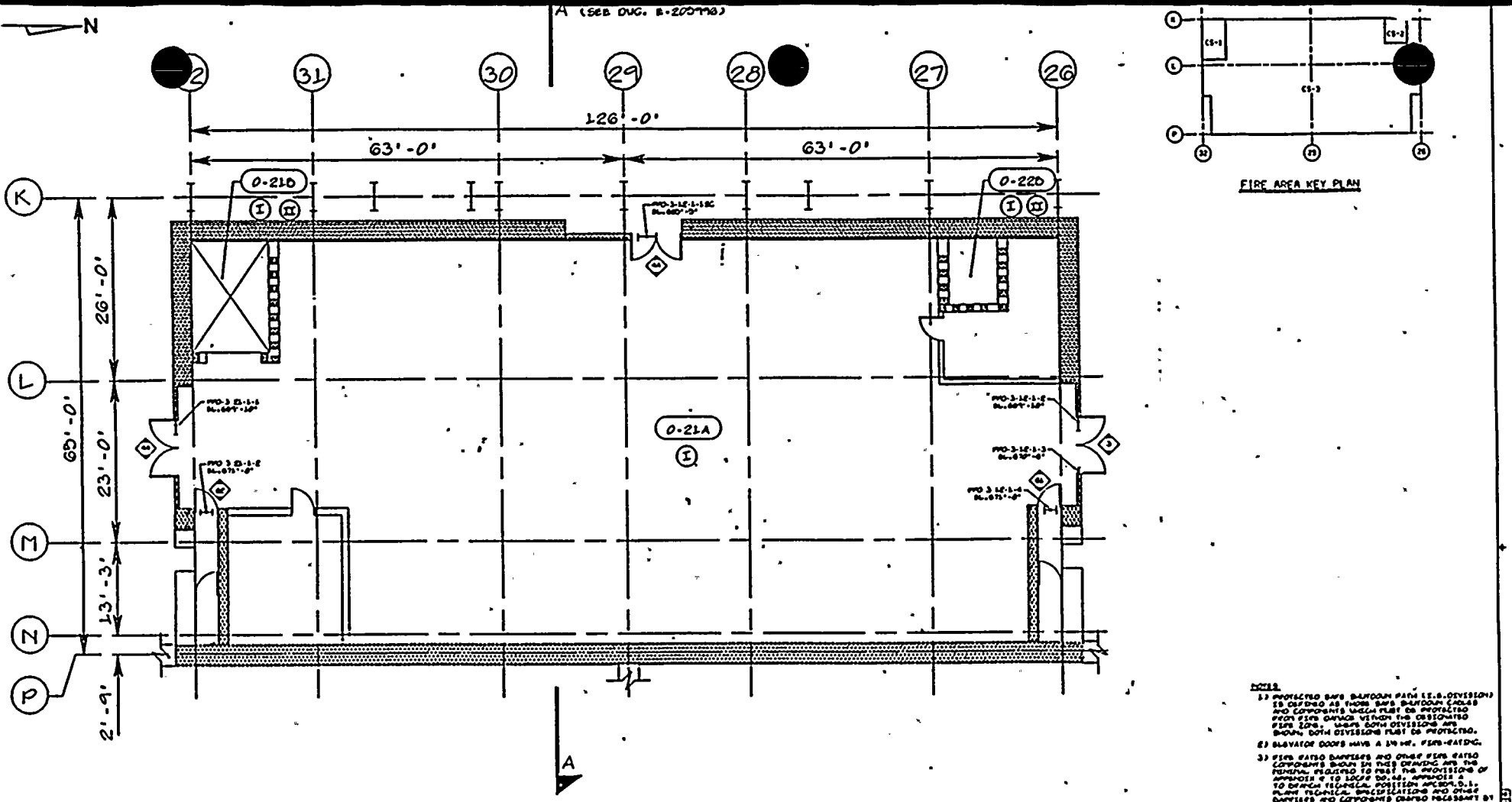
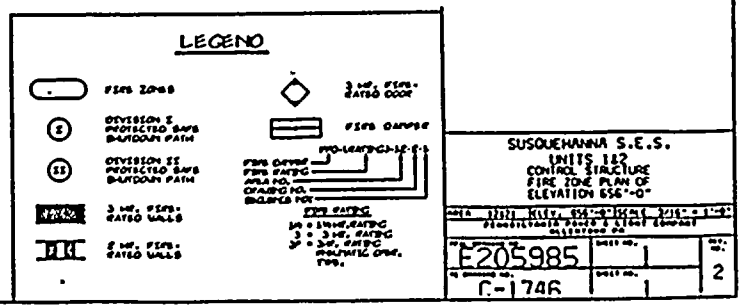

SUSQUEHANNA S.E.S.
UNIT 1
REACTOR BUILDING
FIRE ZONE PLAN OF
ELEVATION 818'-1"
E205956
C-1727
REACTOR WELL
SPENT FUEL STORAGE POOL
HATCH
VALVE PIT
ELEVATOR
STAIR NO.102
STAIR NO.101
FIRE ZONE
FIRE BARRIER
FIRE ZONE BOUNDARY
FIRE ZONE SUBZONE
BUFFER ZONE

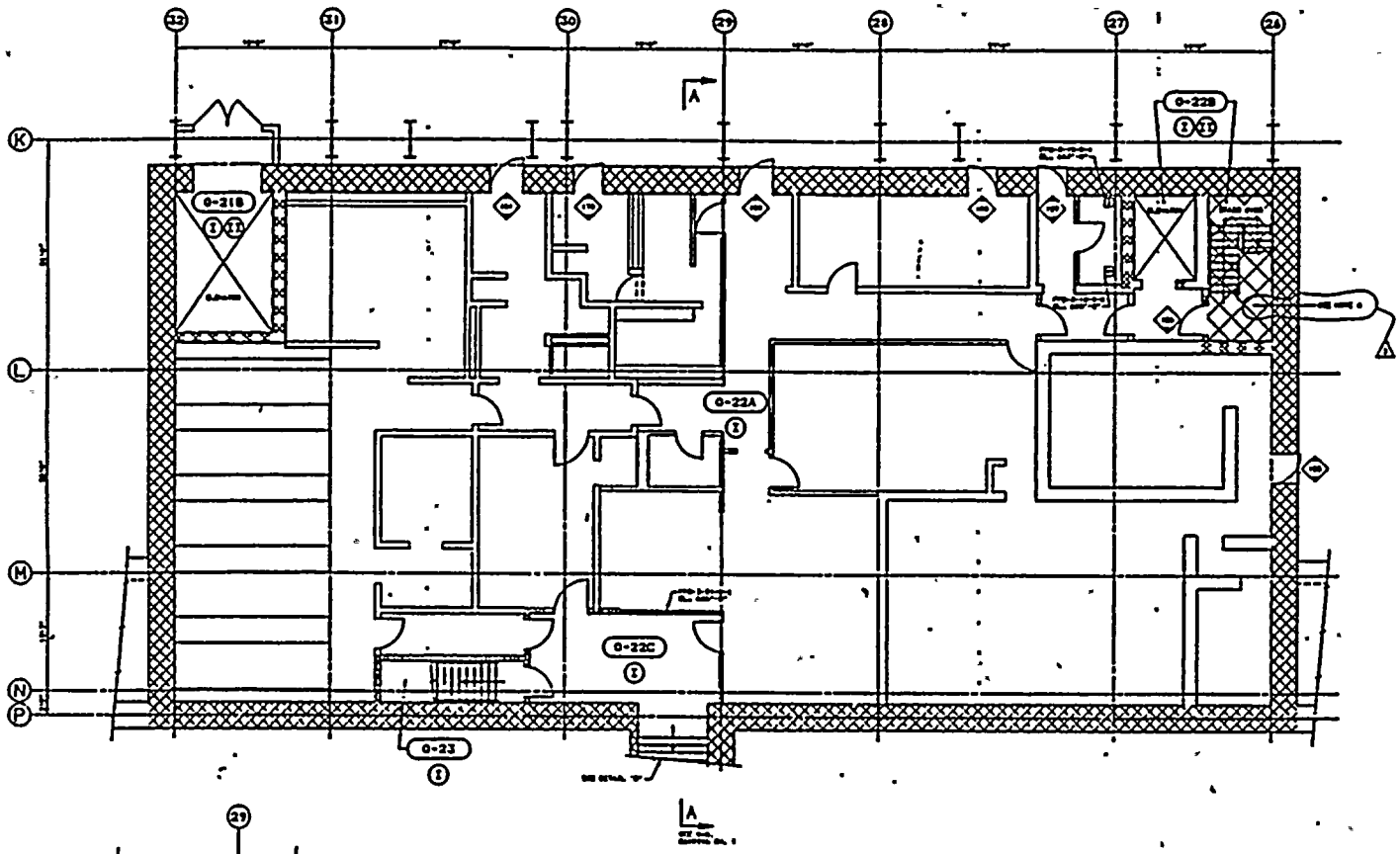
Figure 4.20

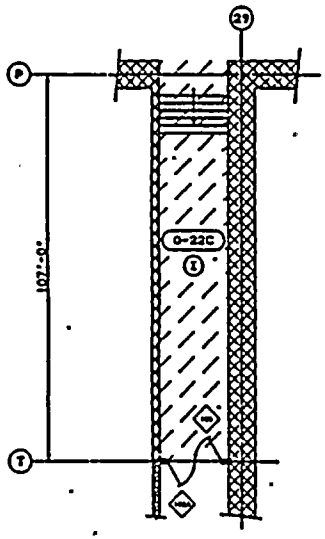



FLOOR PLAN @ EL. 656'-0"

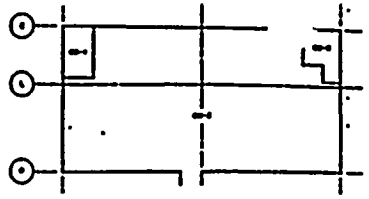
Figure 4.21






DETAIL 'B'

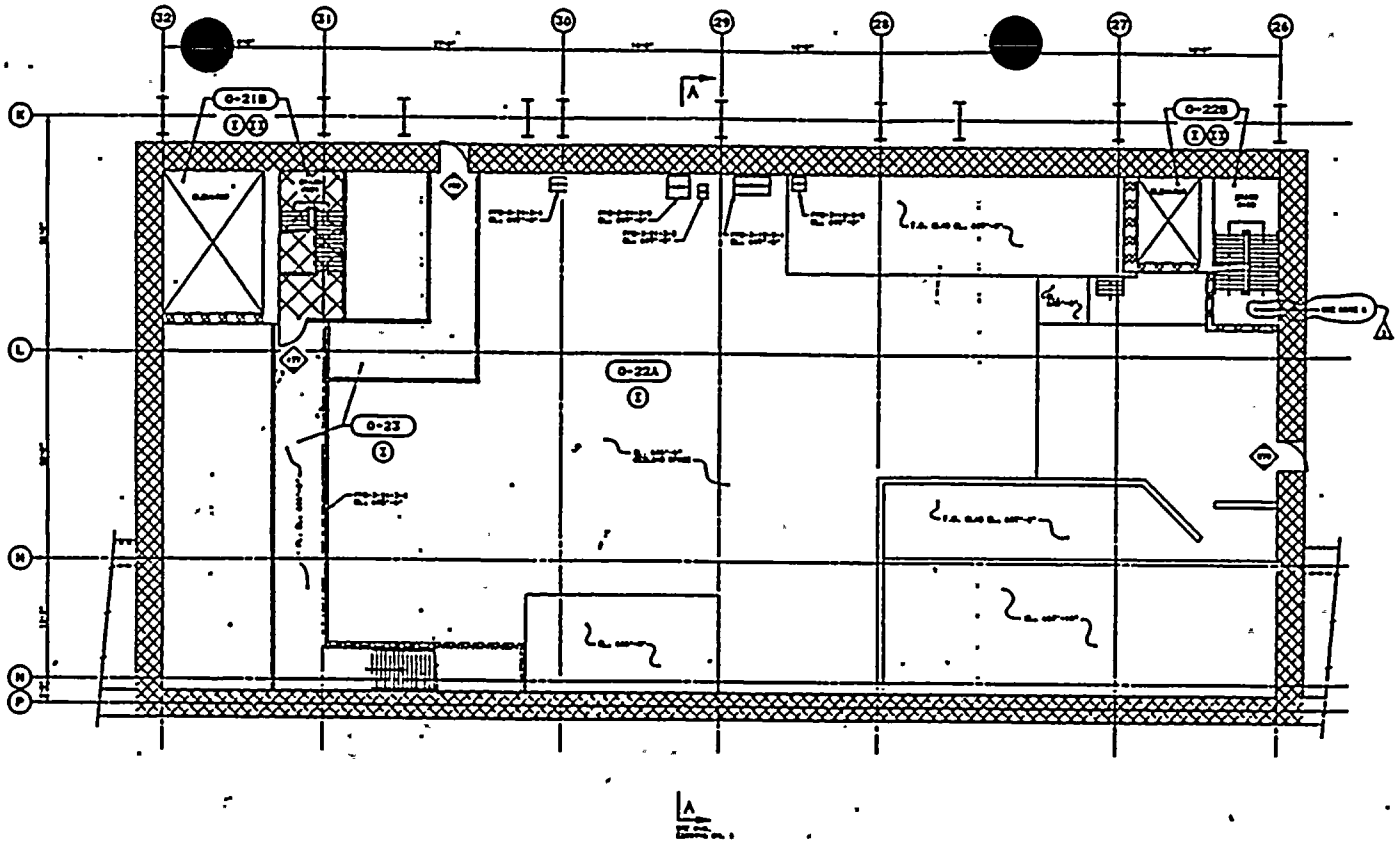


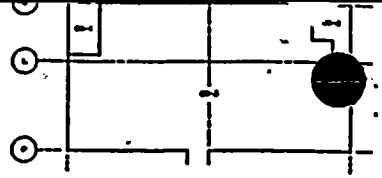
FIRE AREA KEY PLAN

Figure 4.22

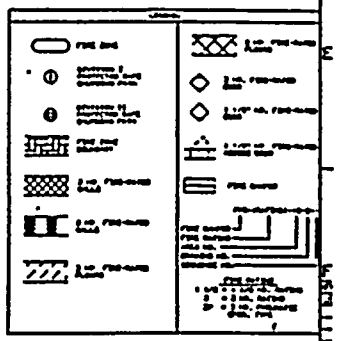
SUSQUEHANNA S.E.S.
UNITS 1 & 2
CONTROL STRUCTURE
FIRE ZONE PLAN OF
ELEVATION 676'-0"

E205986
C-1747
1
3



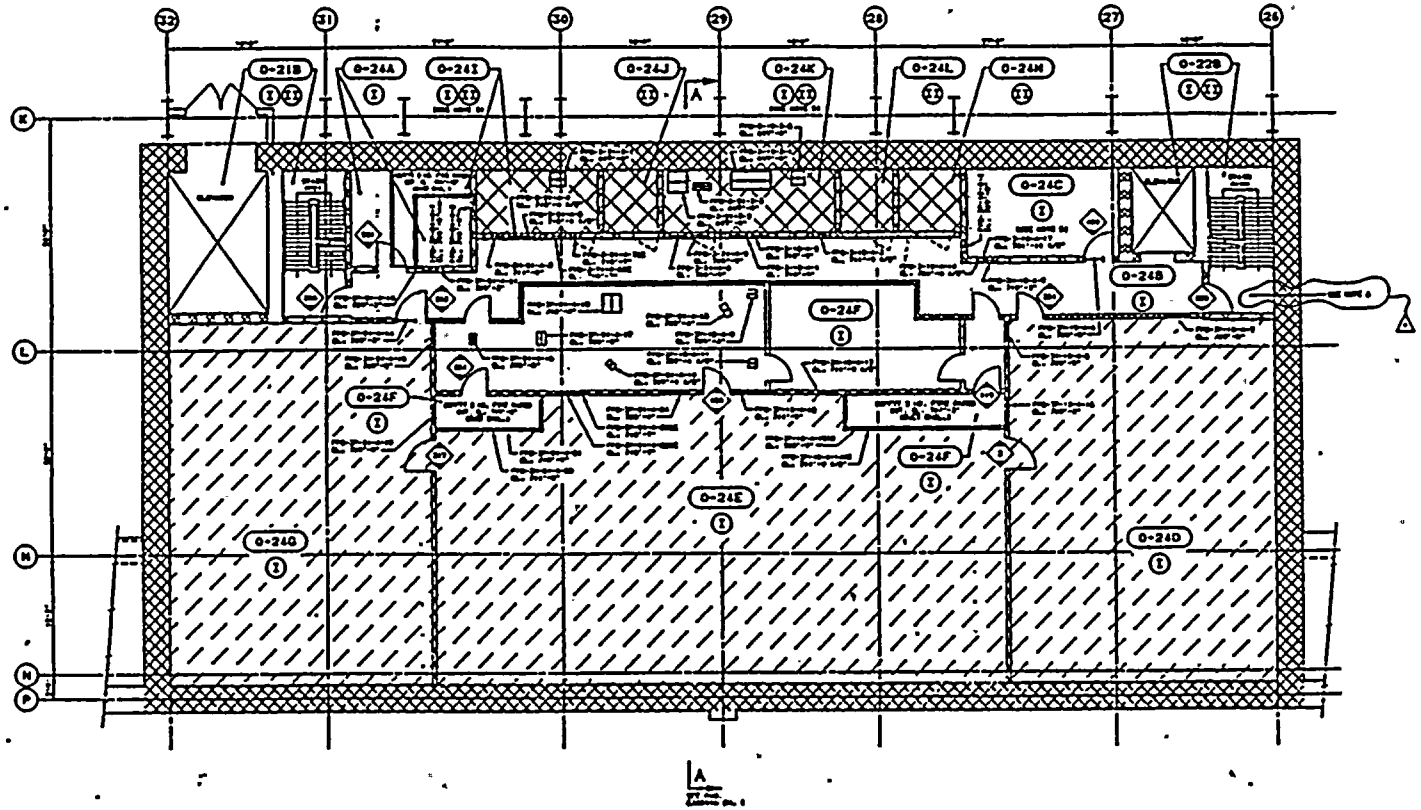
FIRE AREA KEY PLAN

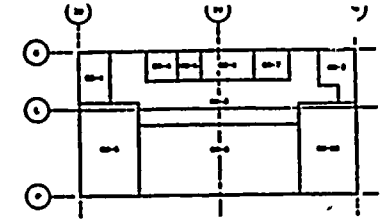


SUSQUEHANNA S.E.S.
UNITS 1 & 2
CONTROL STRUCTURE
FIRE ZONE PLAN OF
ELEVATION 646'-6"

E205987 | 1 | 3
C-1748 | 1

Figure 4.23



FIRE AREA KEY PLAN

SUSQUEHANNA S.E.S.
UNITS 1 & 2
CONTROL STRUCTURE
FIRE ZONE PLAN OF
ELEVATION 698'-0"

E205988

C-1749

1

4

Figure 4.24

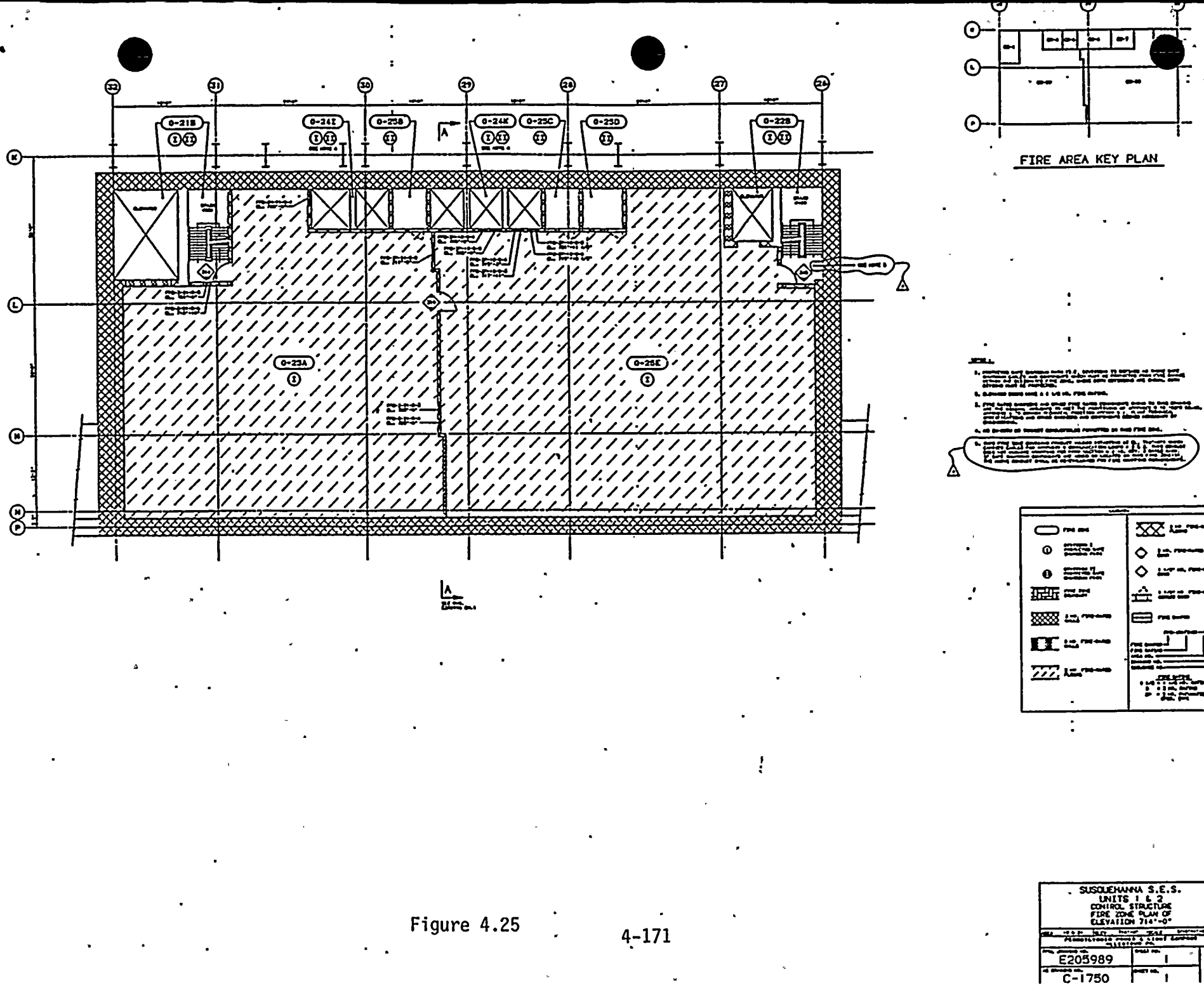
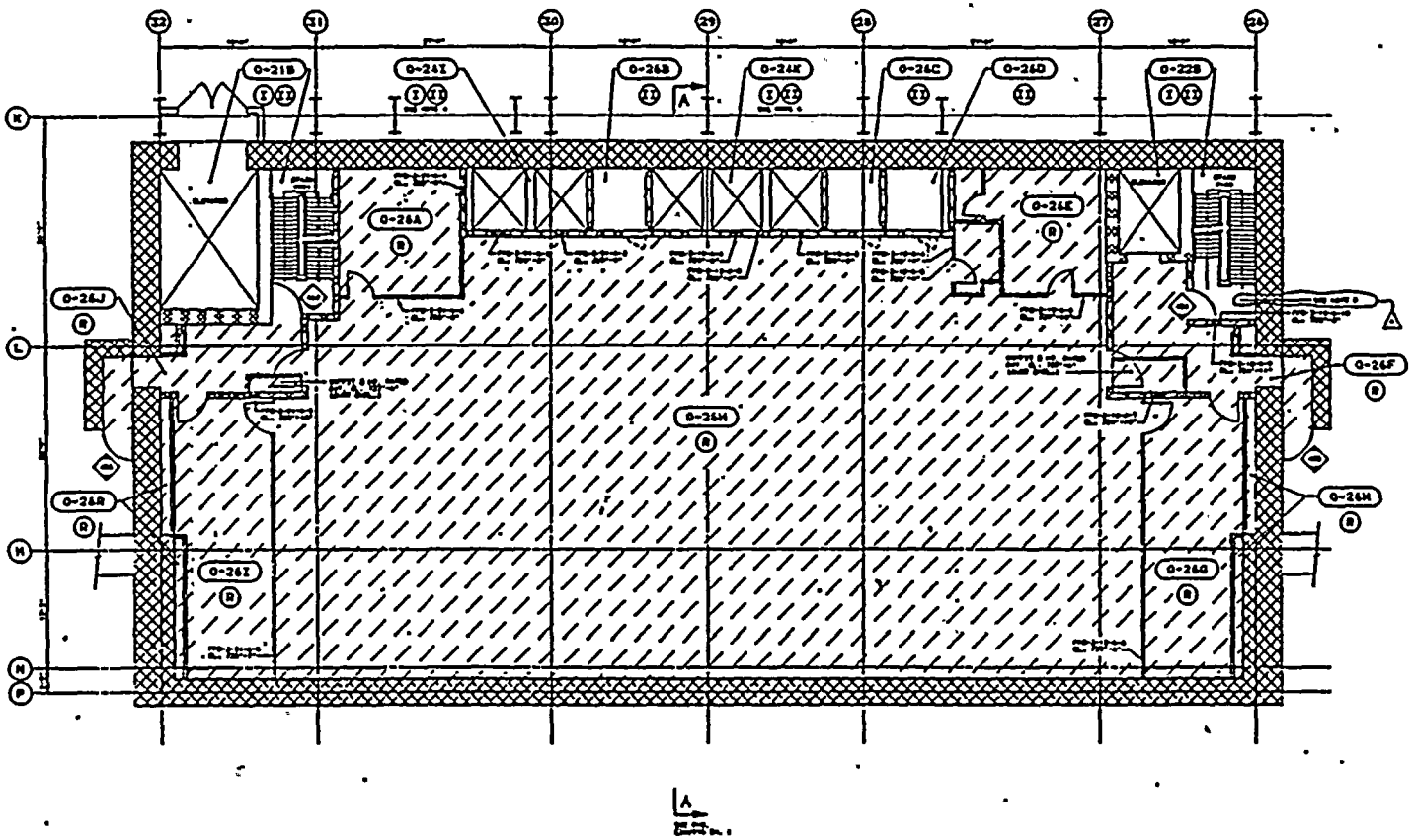
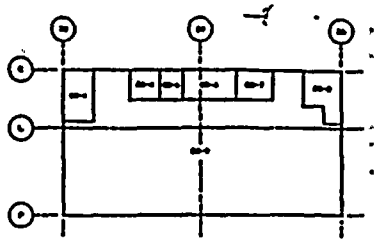
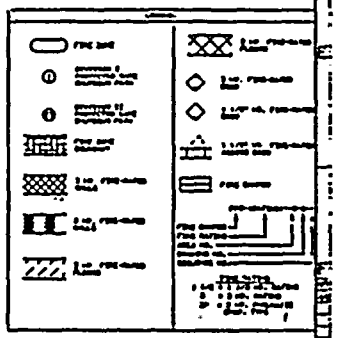

FIRE AREA KEY PLAN
SUSQUEHANNA S.E.S.
UNITS 1 & 2
CONTROL STRUCTURE
FIRE ZONE PLAN OF
ELEVATION 714'-0"
E205989
C-1750

Figure 4.25



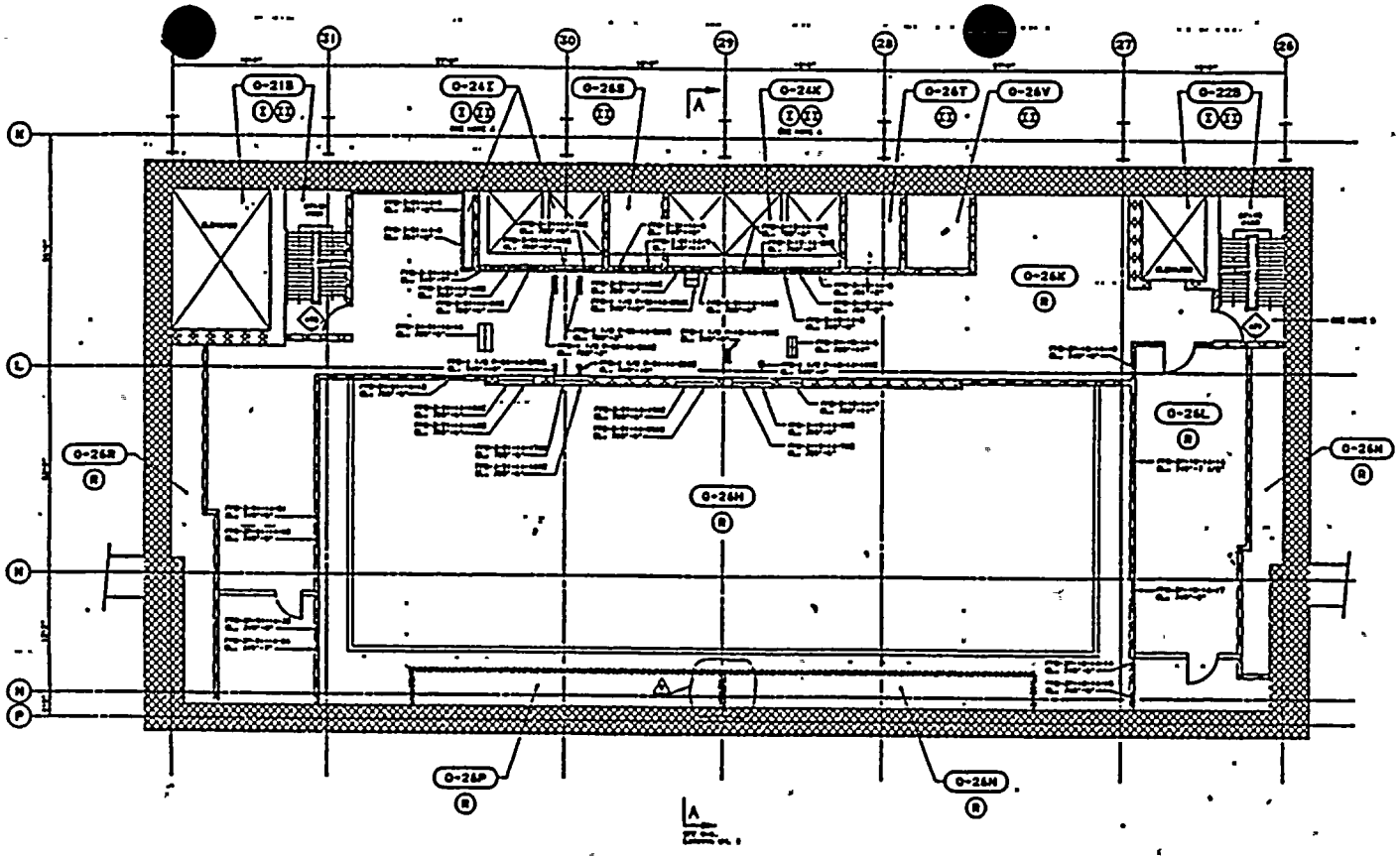
FIRE AREA KEY PLAN

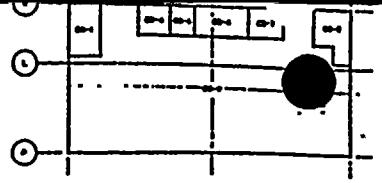


SUSQUEHANNA S.E.S.
UNITS 1 & 2
CONTROL STRUCTURE
FIRE ZONE PLAN
ELEVATION 727'

E205990

Figure 4.26



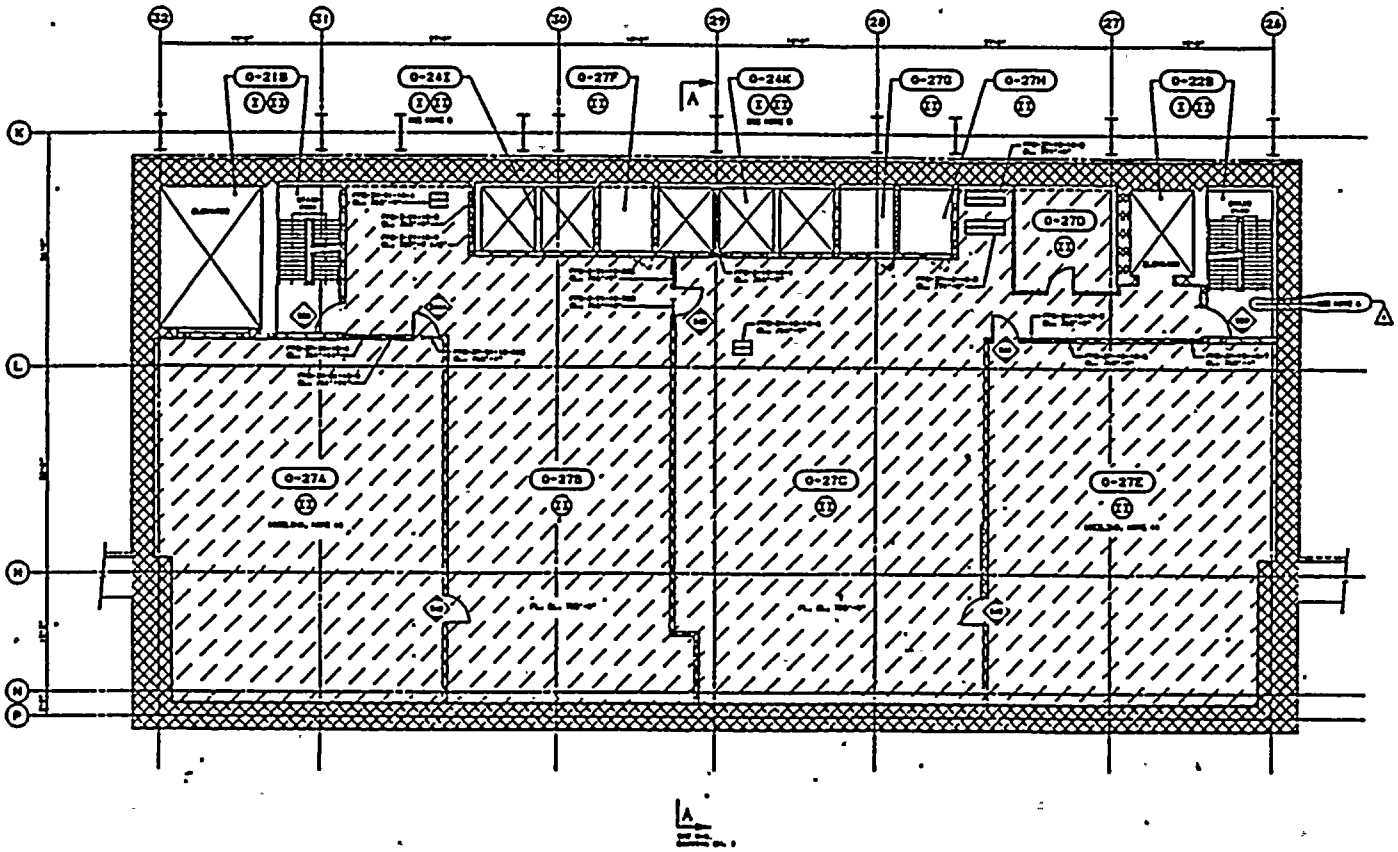


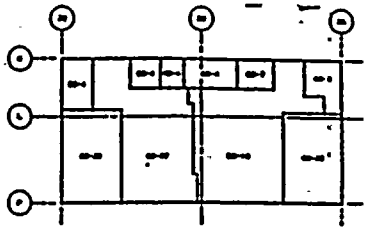
FIRE AREA KEY PLAN

SUSQUEHANNA S.E.S.
UNITS 1 & 2
CONTROL STRUCTURE
FIRE ZONE PLAN OF
ELEVATION 741'-1"

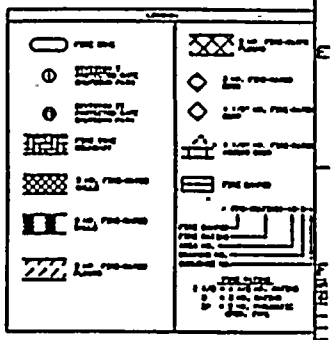
E205991 | 1 | 5
C-1752 | 1

Figure 4.27



FIRE AREA KEY PLAN



SUSQUEHANNA S.E.S.
UNITS 1 & 2
CONTROL STRUCTURE
FIRE ZONE PLAN OF
ELEVATION 7

E205992

C-1753

Figure 4.28

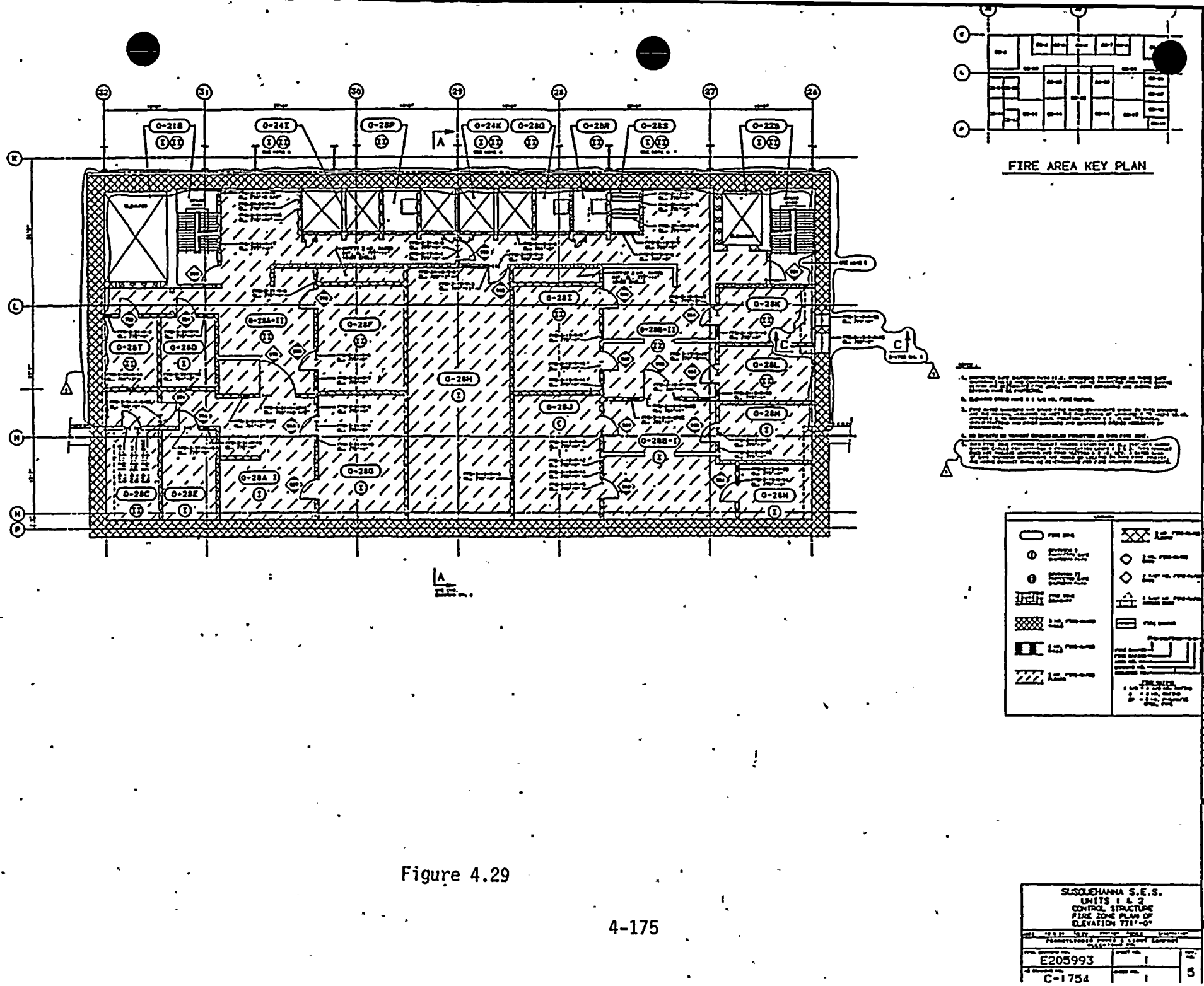
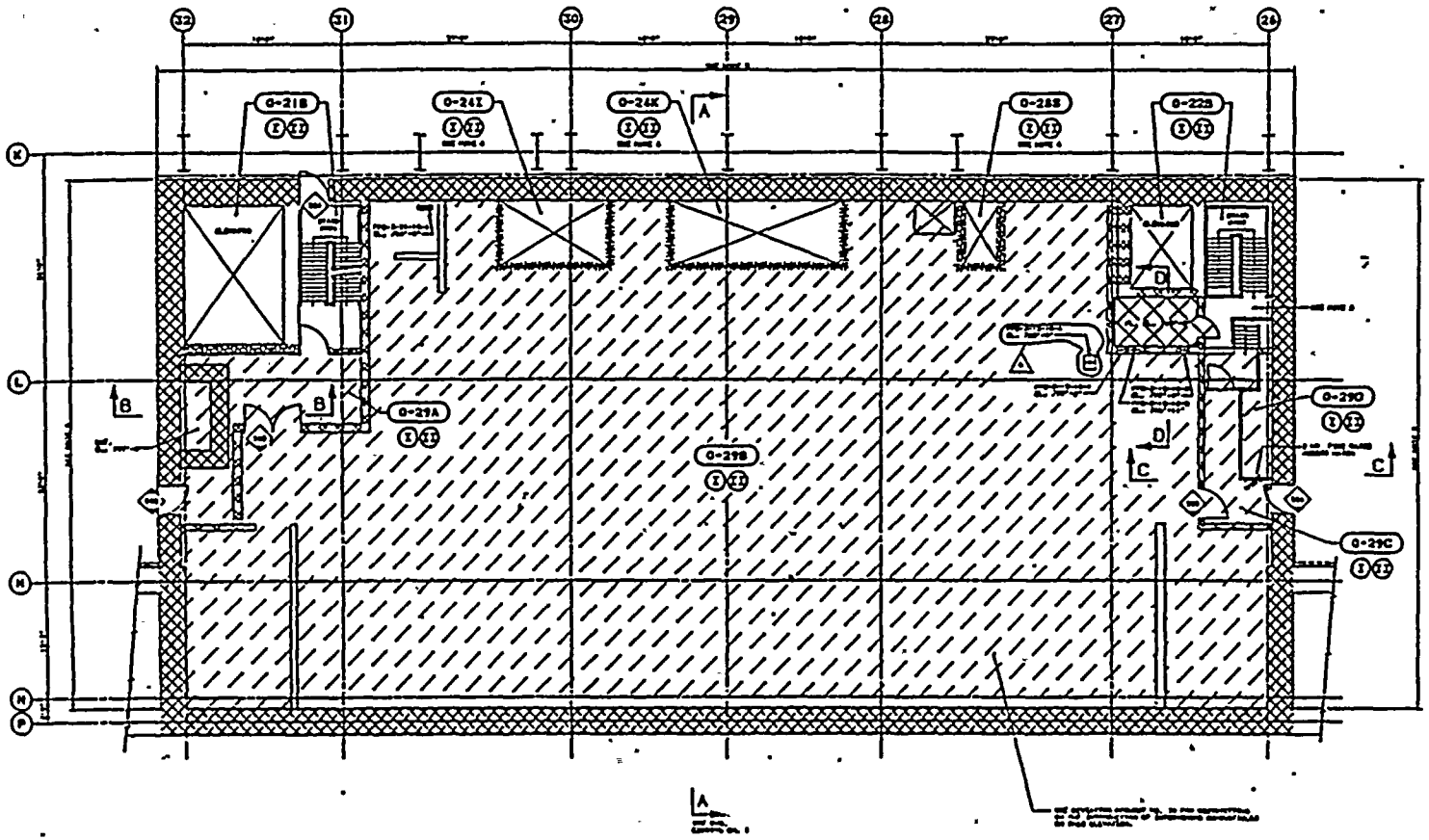
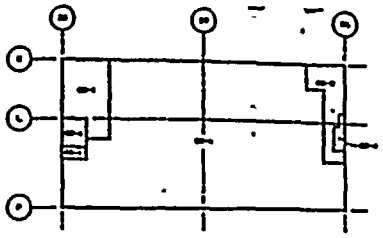
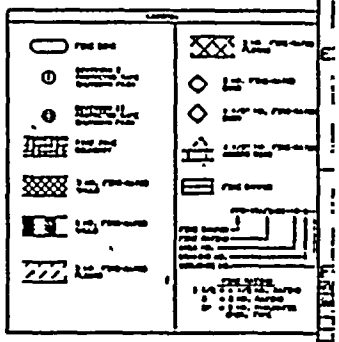

FIRE AREA KEY PLAN
SUSQUEHANNA S.E.S.
UNITS 1 & 2
CONTROL STRUCTURE
FIRE ZONE PLAN OF
ELEVATION 771'-0"
E205993
C-1754

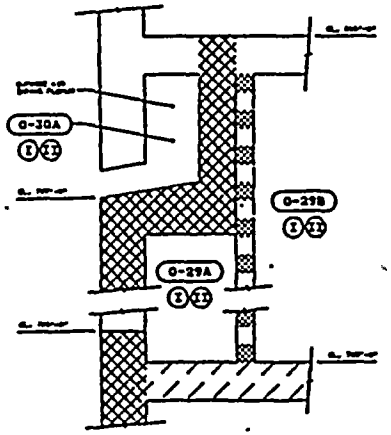
Figure 4.29



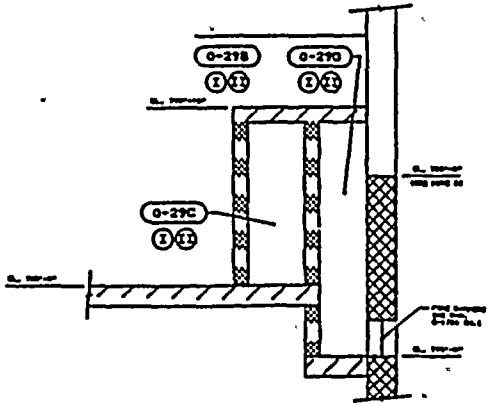



FIRE AREA KEY PLAN

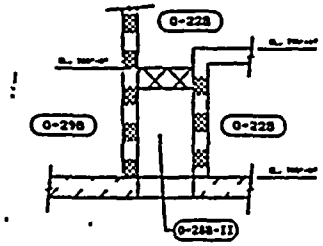





SECTION B-B




SECTION C-C




SECTION D-D

SUSQUEHANNA S.E.S.
UNITS 1 & 2
CONTROL STRUCTURE
FIRE ZONE PLAN OF
ELEVATION -0"

E205994

Figure 4.30

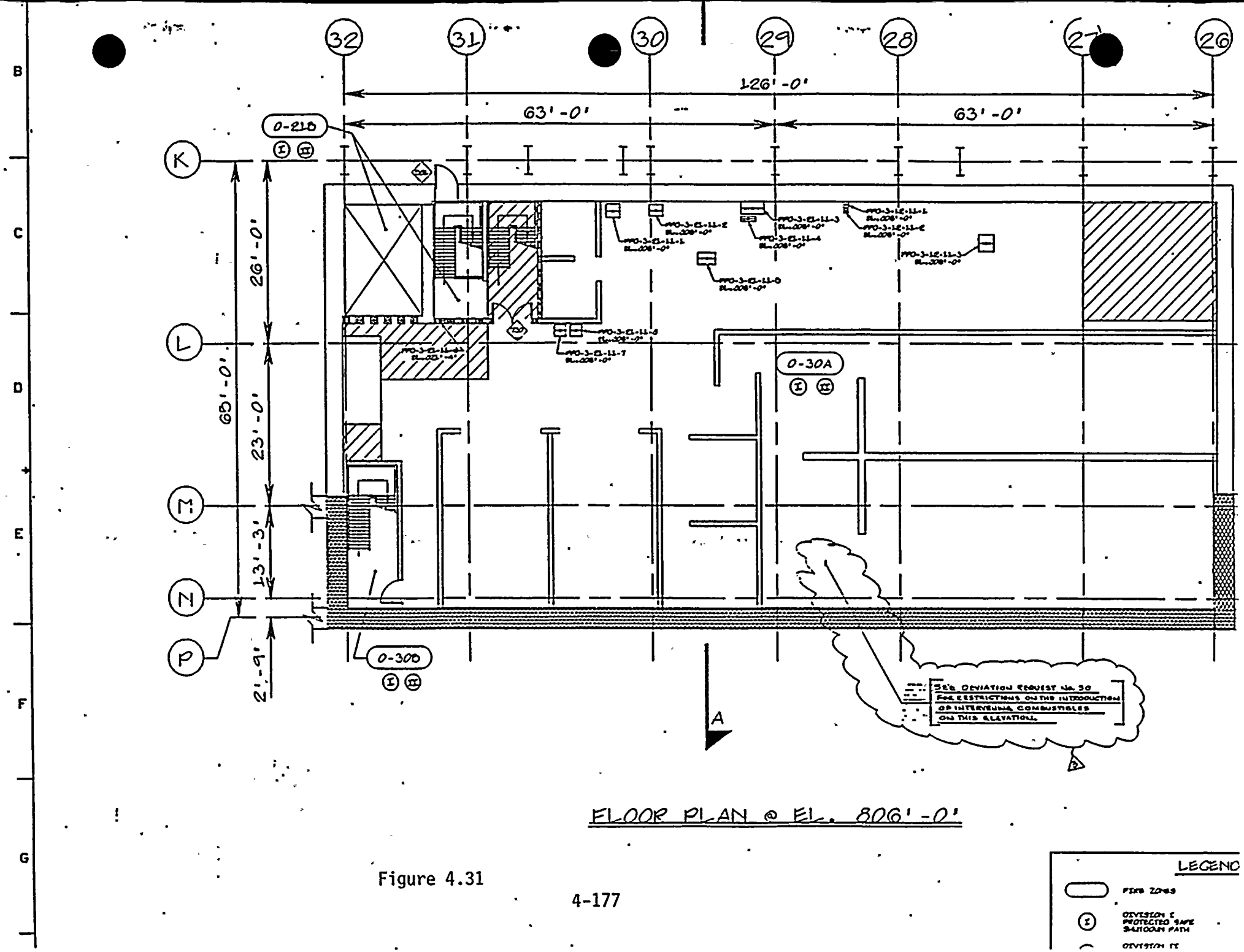

126'-0"
63'-0"
63'-0"
26'-0"
23'-0"
13'-3"
2'-9"
0-21D
0-30A
0-30D
A
SEE DEVIATION REQUEST No. 30 FOR RESTRICTIONS ON THE INTRODUCTION OF INTERVENING COMBUSTIBLES ON THIS ELEVATION.
FLOOR PLAN @ EL. 806'-0"
LEGEND
FIRE ZONES
DIVISION I PROTECTED SAFE SHUTDOWN PATH
DIVISION II

Figure 4.31

## 5. High Winds, Floods, and Others

### 5.0 Methodology Selection

Supplement 4 to Generic Letter 88-20 "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities" requests that licensees assess plant vulnerability to severe damage from external hazards including high winds, external floods, and transportation and nearby facility accidents. The supplement indicates that the impact of high winds, floods, and transportation and nearby facility accidents can be addressed by performing a progressive screening approach. A seven-step screening approach is recommended which represents a series of analyses in increasing level of detail, effort, and resolution. The first three steps consist of: 1) review of SSES specific hazard data and licensing basis; 2) identification of significant changes since OL issuance; and 3) verification that SSES design meets 1975 Standard Review Plan (SRP) criteria. The next three steps consist of determining the hazard frequency and consequence. They are considered optional and can be bypassed provided the prerequisite steps are satisfied and any identified vulnerabilities are demonstrated to be insignificant. The seventh step is documentation. In addition, it is recommended that the examination of external events be coordinated with any other related ongoing external event programs.

For the SSES IPEEE, the recommended progressive screening approach methodology is used in the evaluations of the high winds, external floods, and transportation and nearby facility accidents. Note that no other unique external hazards (eg. volcanic activity) exist for SSES.

### 5.1 High Winds

An evaluation of high winds is performed in accordance with the recommended progressive screening approach. Documentation of this evaluation is provided in PP&L Calculation EC-RISK-1001. Data, information, and results of the evaluation are summarized below.

#### 5.1.1 Licensing Bases

The licensing bases with regard to wind and tornado loadings are identified in Section 3.3 of the SSES FSAR.

Section 3.3.1 of the SSES FSAR addresses wind loadings and indicates that all permanent exposed structures have been designed for wind loadings. The design wind velocity for all structures has been considered as 80 mph at 30 feet above ground with a 100-year recurrence interval. A gust factor of 1.1 is typically applied to the design wind velocity. Effective dynamic design pressures, which are applied to the exposed surfaces of the structures, are determined by transforming the wind velocity into a pressure based on a ratio of the square of the velocity.

Appropriate pressure and shape coefficients are applied to address windward and leeward effects along with considerations for sloping surfaces.

Section 3.3.2 of the SSES FSAR addresses tornado loadings. Applicable tornado design parameters are defined therein and include dynamic wind velocities, design pressure differentials between the inside and outside of a building, and considerations for tornado-generated missiles.

The tangential wind velocity is defined as 300 mph (290 mph for the diesel generator E building) while the translational velocity is 60 mph (70 mph for the diesel generator E building). The same method used for

transforming wind velocity into an effective design pressure for the design wind loading is also used for tornado wind loadings. There are, however, two adjustments made in determining the tornado-generated effective design pressures. The gust factor is considered as unity and there are no variations in velocity or velocity pressure considered due to the height above ground.

A pressure drop of 3 psi is applied to all tornado resistant structures. Typically, blow-out panels are utilized as necessary on safety-related structures to minimize differential pressure.

Tornado-generated missiles such as wood planking, steel pipe, automobiles, steel rods, or utility poles have been evaluated in the design of the tornado-resistant structures. Table 3.3-2 of the FSAR identifies tornado wind protected systems with the corresponding tornado-resistant enclosure that protects that system.

Total tornado loadings are obtained by combining the three individual effects of tornado wind, tornado differential pressure load, and tornado missile load. The appropriate method for determining the total tornado load is provided in the specific load combination equations identified in the FSAR.

### 5.1.2 Significant Changes Since OL Issuance

A site review is performed to identify any significant changes since issuance of the operating license that might be affected by the high winds issue. The addition of new facilities/structures or changes in existing facilities/structures are the only developments that could potentially affect the original design conditions. Most, but not all, of these additions/changes have been designed to resist the high wind loading conditions associated with the extreme wind and tornado. Those additions/changes not designed to resist the high wind loading conditions are not considered to serve any safety-related function or importance to the continued safe operation of the plant. Although the potential exists for a portion of these additions/changes to become tornado-generated missiles, it is judged that any such missiles are enveloped by the existing postulated missiles considered in the design of the safety-related facilities/structures.

### 5.1.3 Licensing Bases Comparison to 1975 SRP Criteria

A direct comparison of the SSES licensing bases to the acceptance criteria of the 1975 SRP was performed with regard to the high winds issue. This comparison demonstrates that the acceptance criteria of the 1975 SRP are almost identical to the design basis in the SSES FSAR. This strict conformance with the 1975 SRP provides a reasonably high level of assurance that the SSES design basis, with respect to high winds, is sufficient. Therefore, because the progressive screening approach criteria have been met, it is concluded that no potential severe accident vulnerabilities exist at SSES with regard to the high wind issue of the IPEEE.

### 5.1.4 Onsite Confirmatory Walkdown

In addition to the progressive screening approach evaluation, an onsite confirmatory walkdown by civil/structural engineers was performed to identify any potential vulnerabilities that were not included in the original design basis analysis. This walkdown concentrated on the outdoor facilities in an attempt to determine if high winds might adversely affect their integrity. The outdoor review was performed with recognition that the original SSES design basis compares very favorably to the acceptance criteria of the 1975 SRP. With this in mind, the walkdown was simplified to concentrate on two basic concerns. The first concern is whether the safety-related facilities/structures appear to be vulnerable to an extreme high winds or tornado event. The second concern is the potential for the existing onsite non-safety related facilities/structures to fail and adversely affect the integrity of the safety-related facilities/structures.

The results of the onsite walkdown confirm that the safety-related facilities/structures are considered sound and structurally adequate with no specific evidence of any areas of vulnerability or concern with regard to the high winds issue. In addition, the non-safety related facilities/structures are considered to be subject to failure during a high winds or tornado event. However, the effects of such failures are not considered to be adverse to the safety-related facilities/structures and subsequently the continued safe operation of the plant. This conclusion is based on an engineering assessment during the onsite walkdown which confirms that the potential for non-safety related facilities/structures collapsing onto or against safety-related facilities/structures with subsequent adverse damage is not a credible condition. However, one exception to this walkdown assessment is the potential for a cooling tower to overturn and impact safety-related facilities/structures. Investigation after the walkdown determined that an existing analysis addressing the mode of failure for the cooling tower (Calculation IQ-C-SJS-005) indicates that failure of the non safety-related cooling towers due to high wind and tornado can be eliminated from concern for adjacent safety-related facilities/structures.

### 5.1.5 Screening Results

The evaluation of the high winds external event has identified no reportable items. The review and confirmatory walkdown provide reasonable assurance that the SSES plant conforms to the 1975 SRP criteria and, therefore, the original design basis analysis for the high winds issue is considered adequate and acceptable. Based on the results of the progressive screening approach, high winds are not considered significant contributors to severe accident risk at SSES.

## 5.2 Floods

An evaluation of the external flooding issue was performed in accordance with the recommended progressive screening approach methodology. Documentation of that evaluation is also provided in PP&L Calculation EC-RISK-1024. Data, information, and results of the evaluation are summarized below.

### 5.2.1 Licensing Bases

The licensing bases with regard to external flooding is identified in Sections 2.4 and 3.4 of the SSES FSAR. Section 2.4 provides information regarding flooding due to the probable maximum flood (PMF) of the Susquehanna river or the probable maximum precipitation (PMP) on the area surrounding the plant. Based on this information, SSES is classified as a "dry" site with regard to external flooding events. Consequently, Section 3.4 provides only a very limited discussion regarding external flood design conditions. Therefore, the plant licensing bases with regard to external flooding conditions consists primarily of the contents in FSAR Section 2.4.

FSAR Section 2.4, entitled "Hydrologic Engineering," provides the specific data and information regarding the SSES flood design condition. Subsections are provided therein to address the local flood history/records, the probable maximum flood (PMF) for adjacent streams or rivers, potential upstream dam failures, surge and seiche flooding, tsunami flooding, ice effects, flooding of cooling water reservoirs, potential natural diversion of streams or rivers, and the requirements for flooding protection. A detailed description of each of these subsections will not be provided here. The FSAR information is incorporated by reference. However, selected key design bases criteria will be identified below.

Historical data on the most severe flood events on record for this portion of the Susquehanna river in the vicinity of SSES is considered during the development of the flood design basis. All individual potential

flood-producing phenomena and the appropriate combinations of such phenomena are considered in establishing SSES as a "dry" site, secure from the effects of external flooding concerns.

The probable maximum flood (PMF) water elevation, coincident with wind-generated waves, for the Susquehanna river is defined as 548.0 feet MSL which is over 120 feet below the site grade elevation of 670.0 feet MSL. The Susquehanna river is the only water system adjacent to SSES that could have an impact on site flooding and subsequently is the only consideration, except for local runoff, in deriving the PMF-generated water elevation. The guidelines provided in Appendix A of Regulatory Guide 1.59 were followed throughout the SSES PMF analyses.

The potential for seismically induced dam failures upstream of the SSES plant is investigated to determine if they could contribute to a flooding event for the Susquehanna river in the vicinity of SSES. In lieu of the more rigorous considerations defined in Appendix A of Regulatory Guide 1.59, a simplified but more conservative approach is taken which demonstrates a significant margin of safety at SSES for flooding resulting from upstream dam failures. Singular as well as multiple dam failures for the Susquehanna river and its tributaries are evaluated.

Considerations for seiche flooding are deemed inappropriate and not applicable to the SSES flood design basis. Likewise, flooding due to the propagation of an open coast surge upstream to the site is not considered a credible occurrence and, therefore, is eliminated from the SSES flood design basis.

Tsunami flooding is not applicable to the Susquehanna site.

Flood stages due to an ice jam-related event are found to be comparable to the normal precipitation flood stages and appreciably lower than the PMF-related water level which is itself over 120 feet below the plant grade.

The design basis flood level for the spray pond is determined in accordance with Regulatory Guide 1.59 by superimposing the effects of coincident wind-generated wave activity for various types of flood levels. The effects of coincident wind-generated wave activity are addressed by evaluating the resulting increase in water level as well as the wave forces and splash effects developed at the ESSW pumphouse walls. It is determined that neither of these conditions pose a threat to any of the safety-related features of SSES. The uncontrolled emergency spillway provided at the east end of the spray pond consists of a channel that discharges into a natural waterway leading to the Susquehanna river. The channel is designed to preclude affecting any safety-related structures even in the event that the natural water course becomes blocked. In addition, a minimum of 3 feet of freeboard is provided along the length of the spillway channel.

The Susquehanna river, in the vicinity of SSES, is not subject to major realignment or diversion due to natural causes and, therefore, the potential for natural stream or river channel diversions is eliminated from the SSES flood design basis.

Since the governing flood design level is significantly below the plant grade level, the safety-related structures and facilities at SSES are considered to be secure from flooding and the site is considered "dry". Therefore, no external flooding protection requirements are identified. Additional confidence of successful coping with flooding from on-site external water sources, including cooling tower basins and circulating water piping, is provided by: the lack of SSD equipment within the turbine building; no below-grade doors between the turbine and reactor buildings; location of safety equipment in the control structure at 698' elevation or above, and flood rated seals/doors in the lowest elevations of the reactor buildings (FSAR Section 2.4.2.3).

### 5.2.2 Significant Changes Since OL Issuance

There have been no significant changes since issuance of the operating license that would directly affect or increase the potential vulnerabilities due to the external flood design basis. SSES remains a "dry" site, secure from any adverse effects of external flooding.

### 5.2.3 Licensing Bases Comparison to 1975 SRP Criteria

A direct comparison of the SSES licensing bases to the acceptance criteria of the 1975 SRP was performed with regard to the external floods issue. That comparison demonstrates that the acceptance criteria of the 1975 SRP is essentially identical to the design basis in the SSES FSAR. This strict conformance with the 1975 SRP provides a reasonably high level of assurance that the SSES design basis with respect to external floods is sufficient. Because the progressive screening approach criteria have been met, it is concluded that no severe accident vulnerabilities exist at SSES with regard to the external floods issue of the IPEEE effort.

### 5.2.4 Onsite Confirmatory Walkdown

In addition to the progressive screening approach evaluation, an onsite confirmatory walkdown was performed to identify any potential vulnerabilities that were not included in the original design basis analysis. This walkdown concentrated on the outdoor facilities in an attempt to determine if external floods might adversely affect their integrity. The outdoor review was performed with recognition that the original SSES design basis compares very favorably to the acceptance criteria of the 1975 SRP and the SSES site is considered "dry" or well above any required flood protection levels. The only natural water system adjacent to SSES that could have an impact on site flooding is the Susquehanna river. However, because its maximum potential flood elevation is demonstrated to be well below the SSES site grade elevation, the walkdown was reduced to a review that addressed only local runoff considerations.

The results of the onsite walkdown confirm that there are no potential flooding vulnerabilities for the safety-related facilities/structures due to local stormwater runoff. In addition, it is confirmed that a spray pond flooding event would not create any potential vulnerabilities for the safety-related facilities/structures. These assessments are consistent with the original design basis analysis.

### 5.2.5 Coordination with Ongoing Programs

The only ongoing program relevant to the external flooding hazard is documented in Generic Issue (GI) 103 which is addressed by the NRC in Generic Letter 89-22. The issue consists of using revised PMP criterion based on more recent data published by the National Weather Service. An assessment evaluation is provided to determine the effects of applying the new PMP data to the existing onsite flooding and roof ponding evaluations to determine if the potential/risk of a severe accident exists.

The results and conclusions of that assessment indicate that the effects of applying the revised PMP data to the existing SSES onsite flooding and roof ponding evaluations can be considered insignificant. Therefore, no increased risk to plant safety in general or core damage in particular would result. This assessment is based on the conservative approach and analysis techniques considered in the original design basis analysis. Included in the original conservative existing design basis is the redundancy in the safety-related buildings' roof drain system as well as the onsite flooding drainage system which assumed that the primary drainage systems were totally ineffective and the peak runoff was accommodated through secondary/supplemental drainage systems.

### 5.2.6 Screening Results

The evaluation of the external floods external event has identified no reportable items. The review and confirmatory walkdown provide reasonable assurance that the SSES plant conforms to the 1975 SRP criteria and, therefore, the original design basis analysis for the external floods issue is considered adequate and acceptable. In addition, the assessment evaluation for the revised PMP criteria indicates no increased risk to plant safety. Finally, based on the results of the progressive screening approach, onsite confirmatory walkdown, and revised PMP assessment, the contribution from the external floods hazard to severe accident risk is insignificant.

## 5.3 Transportation and Nearby Facility Accidents

### 5.3.1 Licensing Bases

The Licensing Bases with regard to Nearby Industrial, Military and Transportation Facilities are identified in Section 2.2 of the SSES FSAR.

Section 2.2.1 of the SSES FSAR addresses transportation routes located within five miles including highways and railway lines, as well as the locations and routes of oil and natural gas pipelines, locations of industrial and military (none identified) facilities, and the locations of airports and control areas.

Section 2.2.2 provides a description of the nature and operations of the facilities, pipelines, waterways and airports as well as their possible impact on SSES.

### 5.3.2 Significant Changes Since OL Issuance

There have been no changes to transportation routes within five miles of SSES since OL issuance. A new natural gas pipeline owned by Pennsylvania Gas and Water Company (PGW), which was not covered in the original SER (NUREG-0776), is included and its impact analyzed in Section 2.2.2 of the SSES FSAR and covered by a SER supplement. Industrial facilities using or storing hazardous materials within five miles of SSES are described in Table 2.1-13 of the FSAR, last revised in June, 1992.

### 5.3.3 Licensing Bases Comparison to 1975 SRP Criteria

#### 5.3.3.1 1975 SRP Criteria

The following are the acceptance criteria listed in SRP Sections 2.2.1 and 2.2.2 on Identification of Potential Hazards in Site Vicinity:

1. Data in the FSAR adequately describes the locations and distances of industrial, military, and transportation facilities in the vicinity of the plant, and is in agreement with data obtained from other sources, when available.

2. Descriptions of the nature and extent of activities conducted at nearby facilities, including the products and materials likely to be processed, stored, used, or transported, are adequate to permit evaluations of possible hazards in Part 3 review sections dealing with specific hazards.

3. Where potentially hazardous materials may be processed, stored, used, or transported in the vicinity of the plant, sufficient statistical data on such materials are provided to establish a basis for evaluating the potential hazard to the plant.

SRP Section 2.2.3, Evaluation of Potential Accidents, states the acceptance criteria as :

The identification of design basis events resulting from the presence of hazardous materials or activities in the vicinity of the plant is acceptable if the design basis events include each postulated type of accident for which the expected rate of occurrence of potential exposures in excess of 10 CFR Part 100 guidelines is estimated to exceed the NRC staff objective of approximately 1.0 E-07 per year. Because of the difficulty of assigning accurate numerical values to the expected rate of unprecedented potential hazards generally considered in this review plan, judgment must be used as to the acceptability of the overall risk presented.

The probability of occurrence of the initiating events leading to potential consequences in excess of 10 CFR Part 100 guidelines should be estimated using assumptions that are as representative of the specific site as is practicable. In addition, because of the low probabilities of the events under consideration, data are often not available to permit accurate calculation of probabilities. Accordingly, the expected rate of occurrence of potential exposures in excess of the 10 CFR Part 100 guidelines of approximately 1.0 E-06 per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower.

### 5.3.3.2 Compliance with 1975 SRP Acceptance Criteria

The acceptance criteria of SRP Sections 2.2.1 and 2.2.2 are met because the SSES FSAR provides adequate descriptions of the locations and distances of nearby (within five miles of the plant) industrial, military, and transportation facilities, the nature and extent of activities conducted at the identified facilities, the products and materials likely to be processed, stored, used, or transported at the facilities or to and from the facilities, and statistical data or worst case assumptions on the potential hazard from the materials.

The SSES FSAR also provides analyses either to establish that the probability of accidents such as exposure to hazardous chemical releases (sulfur dioxide and ammonia) is less than 1.0 E-07 above which the event has to be included in the plant design basis, or that under pessimistic assumptions the consequences of accidents such as explosions, fires, or liquid spills do not adversely affect plant safety, because the nearest safety-related structures and components of the plant are at a greater distance from the hazard than the damage zone of the hazard. The acceptance criteria of SRP Section 2.2.3 are, therefore, met.

### 5.3.4 Screening Results

The evaluation of Nearby Industrial, Transportation and Military Facilities has not resulted in the identification of any vulnerabilities. SSES conforms to the 1975 SRP Criteria and, therefore, the original design basis analysis of potential hazards in the site vicinity is considered adequate and acceptable. Using the progressive screening approach outlined in NUREG 1407 and Supplement 4 to GL 88-20, Nearby Industrial, Transportation and Military Facilities can be screened out for the SSES IPEEE, and no further analyses of these potential hazards are necessary.

## 5.4 Others

Only the five external hazards specifically suggested in the GL supplement are evaluated in detail in this IPEEE: seismic, fire, high winds, external floods, and transportation and nearby facility accidents. The effects of other external hazards listed in Section 2 of NUREG 1407 are either included in other analyses (e.g., IPE or SBO) or are not applicable to the SSES site (e.g., volcanic activity). No site unique external hazards exist at SSES and thus it is appropriate that only the five suggested hazards are studied in the IPEEE.

## 5.5 Summary

The SSES specific hazards and licensing bases for high winds, external floods, and transportation and nearby facility accidents are reviewed. Changes since the OL issuance are evaluated either specifically for the IPEEE or as part of regular updates of the FSAR. Conformance with the criteria of the 1975 SRP is shown. Thus, based on the results of the screening approach suggested in the IPEEE generic letter supplement, no significant hazards exist at SSES from these specific external threats.

## 6. Licensee Participation and Internal Review Team

As in the IPE, the maximum benefits from the performance of the IPEEE are obtained if the licensee staff is involved in all aspects of the examination. Such involvement typically provides a more accurate picture of the as-built, as-designed facility and helps the integration of knowledge gained into plant equipment and procedures by allowing early ownership of the IPEEE process and results. This section describes the PP&L involvement in the IPEEE and its review, including major review comments and resolutions.

### 6.1 IPEEE Program Organization

At the conclusion of the IPE in December, 1991 PP&L established an IPEEE team. The team is composed of individuals with risk, seismic, and fire analysis expertise chosen from the Systems Analysis group of the Nuclear Engineering department at PP&L. Overall project management is provided by the supervisor of Systems Analysis. The Systems Analysis group incorporates subgroups with responsibility for reliability/risk, civil/seismic, fire, electrical and I&C engineering, mechanical engineering, and thermal-hydraulic analyses. Personnel in these groups include those involved in the IPE, Appendix R analyses/compliance, and SQRT programs. Thus, additional expertise to conduct the IPEEE is available to the IPEEE team as required. Expertise of on-site engineers is utilized throughout the IPEEE including access to and evaluation of SSEL components during the SMA, and evaluations of fire barriers and detection and suppression systems during the fire PRA. Personnel at SSES have also been instrumental in achieving plant improvements designed to reduce risk due to seismic and fire events. The names and education degrees of the PP&L individuals on the IPEEE team are identified in Table 6.1.

PP&L members of the IPEEE team have been involved in all aspects of the IPEEE methodology including determination of the SSEL, seismic demand, and seismic margins, including walkdowns, for the SMA. PP&L involvement in the fire PRA includes: systems analysis and cable evaluation for fire hazards determination; walkdowns, FIVE worksheets, and COMPBRN IIIe calculations for fire propagation analyses; and systems analysis and frequency calculation evaluations for plant damage state determination. Because all analyses are performed at PP&L offices, PP&L retains all analysis, notes, and calculation packages.

Consultants are used to supplement the IPEEE team. One consultant with risk and fire analysis expertise is used for the fire PRA. Three consultants with civil/seismic backgrounds are used in the SMA. More consultants are used in the SMA because of the increased level of expert judgment required and to ensure at least two seismically knowledgeable engineers are involved in all seismic walkdowns. These individuals are also listed in Table 6.1.

### 6.2 Composition of Independent Review Team

Independent review of the IPEEE is achieved in three ways. First, the calculation packages which form the bases of the examination undergo independent evaluation as part of the calculation process. The reviewers of these packages include members of the IPEEE team not involved in the package preparation and others from the Systems Analysis group having expertise in risk, seismic, and fire areas. Second, the IPEEE report is distributed widely within the PP&L nuclear department, including SSES, prior to publishing. This distribution includes various engineering functions, operations, maintenance, licensing, training, and quality assurance. The comments received, and their resolutions, are incorporated as appropriate. Selected comments are provided in Section 6.3 which follows. Third, the recommendations for changes to plant equipment and procedures (including training) designed to reduce the risk from external initiating events

must receive extensive review prior to implementation as part of the PP&L modifications process. Table 6.2 provides a list of the organizations and number of reviewers involved in the IPEEE report review.

### 6.3 Areas of Review and Major Comments

Approximately 400 comments were generated by reviewers of IPEEE report drafts. These comments improved both the technical accuracy and the general readability of the report. Many reviewers had similar comments about the same report sections. The major comments received are included in this report section, along with the comment responses. Although the standard table of contents calls for separate sections for comments and responses, the two are grouped together for ease of review.

The major comments concern the two largest pieces of the IPEEE analysis, that is, the SMA and the fire PRA. The comments are grouped to reflect this result.

#### 6.3.1 Major Comments and Resolutions for SMA

Q1. The SSEL equipment paths selected do not include two divisions of suppression pool cooling. How is defense against loss of 1 division provided?

A1. Although specific equipment for a second division of SPCM is not included in the SSEL, the second division is expected to be available after the SME, based on similarity in layout and design, and the results of walkdowns of the listed division. Further discussion is provided in report section 3.5.

Q2. RCIC flow alone is not sufficient for core protection for all "small break LOCAs" analyzed in the IPE.

A2. For purposes of the IPEEE seismic analysis, LOCA effect is assumed bounded by a 1" diameter break. The IPE analysis shows RCIC sufficient for core protection for breaks of this size or less.

Q3. The "Natural Phenomena" off-normal procedure is not used for post-seismic event plant shutdown. If an earthquake severe enough to cause LOOP and LOCA occurs, operators will be using EOPs for plant control.

A3. Acknowledged and included in section 3.5.

Q4. How are containment isolation valves evaluated for seismic ruggedness?

A4. Containment isolation valves included in the SSEL are specifically evaluated for SME survival in the IPEEE SMA. In addition, isolation valves internal to the containment were evaluated for seismic interaction concerns as part of snubber reduction work. Containment isolation capability is expected to remain intact after the SME.

Q5. Designation of "low seismic ruggedness" relays as "bad actors" is misleading. Seismic response of these relays may be acceptable in our application.

A5. Agreed. The relays will be referred to as "low ruggedness" relays rather than "bad actors" relays. These relays are not expected to chatter as they are installed in locations that have a low seismic demand.

Q6. How are hydrodynamic LOCA loads considered in the SMA?

A6. Per the EPRI guidance, hydrodynamic LOCA loads were not combined with SME and SRV loads because intermediate or large LOCAs are not considered credible. Hydrodynamic loads from the seismic-induced small LOCA occur after earthquake motion.

### 6.3.2 Major Comments and Resolutions for Fire PRA

Q1. Have outstanding changes to the electronic cable data base been considered?

A1. Yes, outstanding changes as of April, 1993 are included in the PRA analysis.

Q2. The orientation of protective clothing storage racks is not "controlled" by procedure.

A2. The racks considered most significant are large and historically have remained for years in fixed locations.

Q3. The PRA assumes that fire in the reactor building leaves the condenser available. Are the necessary procedures in place?

A3. Fire in the reactor building will not disable equipment required to maintain the condenser except for losses of CIG which may result in MSIV isolation. Operators have successfully avoided closure of the MSIVs on loss of CIG by tie-in of the instrument air system (SOOR 2-92-024). Procedures are in place (e.g. "Loss of Containment Instrument Gas" ON-125-001 and "Main Steam Line Isolation and Quick Recovery" ON-184-001) to allow use of the condenser as a heat sink during off-normal conditions

Q4. Although both division I and II 125 V DC distribution panels are located in fire zone 0-28B-II, the division II panels are separated from the rest of the zone by enclosure in 1 hour fire rated construction of gypsum board and a fire door.

A4. This information has been included in the fire PRA report section.

Q5. Preaction fire suppression systems are installed in the cable spreading rooms, and preaction valve actuation alone will not result in spray of instrument power supplies in the rooms.

A5. Acknowledged. However, during a severe seismic event inadvertent preaction valve actuation and damage to sprinkler heads is possible.

Q6. Table 4.26 indicates that no loss of normal plant functions occurs on failure of 120 V AC power (e.g. 1Y216). Engineering studies show that loss of normal functions (e.g. drywell cooling) will occur on loss of this power.

A6. Information about loss of normal functions has been included in the table.

Q7. How is compliance with other defense-in-depth criteria (procedures and interface) assured?

A7. Only those procedures in place at SSES are assumed. Procedural DID conformance has been verified by the IPE for internal events. Failure of interface DID is dominated by loss of DC instrument power. Indication and control functions are available on multiple cabinets in the control room and in the remote shutdown panel. Fire does not disable sufficient I&C equipment to destroy monitoring and control functions.

Q8. Why are lube-oil fires considered in instrument cabinets?

A8. To verify that cabinet fires do not propagate, an amount of lube-oil equal to or greater than the combustible loading shown in the combustible loading report is modeled in a cabinet using the COMPBRN IIIe code. Lubrication oil is used in simulations only to ensure the modeled fire occurs and is not a description of physical conditions at SSES.

Q9. How are effects of heat and smoke on cabinet electronics considered?

A9. Based on SNL testing and the fire experience at PP&L (e.g. Martins Creek fire), smoke does not disable electrical equipment in the short term. Although instrument drift may occur in electronics at elevated temperatures, little data exists to support modeling of such effects. The approach taken here is similar to that in NSAC-181 in that the failure of electrical equipment is assumed at 325 F, the lower end of the relay failure temperature range established in SNL tests.

Q10. Based on a non-parametric "runs" test, fire frequency at SSES appears random (Figures 4.1 and 4.2), showing neither an increasing or decreasing frequency.

A10. Acknowledged.

Q11. Current housekeeping procedures appear effective in reducing transient combustible fire risk to inconsequence.

A11. Current housekeeping procedures are effective, and credit has been taken for good SSES experience.

### 6.4 Resolution of Comments

Resolutions of major comments are included in the section above.

Table 6.1 IPEEE Project Team Participants

PP&L

| Name/Title | Professional Certification | College Degree | Years of Experience |
|---|---|---|---|
| Philip W. Brady<br>Supervisor- Systems Analysis | Registered Professional Engineer | B.S.-Electrical Engineering | 18 |
| David H. Cassel<br>Senior Project Engineer | Registered Professional Engineer | B.S.-Mechanical Engineering | 25 |
| John A. Swankoski<br>Senior Project Engineer | Registered Professional Engineer | B.S.-Civil Engineering | 21 |
| Thomas A. Gorman<br>Senior Project Engineer | Registered Professional Engineer | B.S.-Civil Engineering | 20 |
| Eric R. Jebsen<br>Project Engineer | Registered Professional Engineer | B. S.-Nuclear Engineering | 14 |
| John D. Vernarr<br>Project Engineer | Registered professional Engineer | B.S.-Civil Engineering<br>M.S.-Structural Engineering | 16 |

Consultants

| Name/Title | Professional Certification | College Degree | Years of Experience |
|---|---|---|---|
| James D. Caherly | Registered Professional Engineer | HNC-Structural Engineering<br>MI-Structural Engineering | 23 |
| Surya N. Maruvada | Registered Professional Engineer | B.E.-Electrical Engineering<br>M.E.-Power Engineering | 30 |
| William P. Gettel | Registered Professional Engineer | B.S.- Engineering | 15 |
| Samir J. Serhan | - | B.S.-Civil Engineering<br>M.S.-Structural Engineering<br>Ph.D.-Engineering Mechanics | 11 |
| Yogesh S. Shah | Registered Professional Engineer | B. S.-Civil Engineering<br>M.S.-Soil Mechanics and Foundation Engineering | 30 |

Table 6.2 PP&L IPEEE Report Review Participants

| Functional Organization | Primary Focus of Comments |
|---|---|
| Nuclear Technology | Correctness/accuracy of IPEEE representation of SSES plant design and application of prior analyses (e.g. IPE, Appendix R). |
| Nuclear Systems Engineering | Correctness/accuracy of IPEEE representation of SSES plant design and as-built configuration. |
| Nuclear Fuels | Impact on fuel design/operation. |
| Nuclear Modifications | Impact of IPEEE report findings/ recommendations on modifications. |
| Operations | Off-Normal Procedures |
| Maintenance | Impact of IPEEE report findings on Maintenance Department practices. |
| Nuclear Plant Services | Impact of IPEEE report findings on Nuclear Plant Services practices. |
| Training | Review of IPEEE representation of plant design and procedural guidance. |
| Licensing | IPEEE compliance with NRC requirements and assessment of commitments. |
| Quality Assurance | Consistency within IPEEE report and review of IPEEE method/findings. |
| Nuclear Safety Assessment | Check on IPEEE methods and results. |

## 7. Plant Improvements and Important Safety Features

This section highlights those plant improvements identified as a result of performing the IPEEE. Some of these improvements are required to meet the SSES design basis. Others are enhancements to add margin beyond the design basis requirements. Also described in this report section are those features of SSES design and operation considered especially important for external event safety.

### 7.1 Plant Improvements

#### 7.1.1 Seismic Analysis

Recommended plant improvements identified from the IPEEE seismic margin assessment (SMA) fall into two categories: miscellaneous equipment issues and equipment modifications. These recommended plant improvements by the Seismic Review Team are currently being tracked, evaluated, and dispositioned under the SSES Deficiency Management Program. A brief description of the identified seismic-related problems and the recommended plant improvements are documented below.

- Miscellaneous Equipment Issues

  These issues are associated with housekeeping and general work practices. They are:

  - Office type furniture found in the control room which could interact with nearby safety related equipment.
  - Housekeeping items which mainly involve placing of transient items in close proximity to safety related equipment.
  - Equipment with missing or loose screws, missing nuts, and missing or broken latches.

  Actions taken and the recommended improvements are:

  Housekeeping items have been transmitted to the plant for corrective action and are currently being tracked and dispositioned under SOOR 94-341. These items can be handled readily outside of the modification process. As part of the SSES Deficiency Management Program, corrective actions to minimize recurrence will be developed. Consideration will be given to the following:

  - Review and revise, if necessary, existing procedures, programs, and specifications which deal with location of transient equipment and associated safety impact.
  - Performance of periodic inspections of safety related equipment by an appropriate walkdown team in an effort to reduce occurrence of similar dynamic interaction concerns.
  - Training to help in the improvement of plant staff's seismic awareness. Two training presentations have already been provided at the time of this report submittal. Training of maintenance personnel is currently being pursued. It is expected that increased awareness will minimize recurrence of safety impact and housekeeping problems which could adversely affect seismic qualification of equipment.

At the time of this report submittal, more than 50% of the identified specific concerns have been corrected through the Work Authorization Process.

- Equipment Modifications

Several plant physical deficiencies were noted during the SME walkdowns. These deficiencies and associated corrective actions taken are:

- Small "trolleys" used to assist the removal of breakers from AC and DC switchgear cabinets were located on the top of some of these cabinets. Although introduced as part of the original plant construction, these lifting devices were not part of the original equipment qualification. The trolleys were removed shortly after they were identified via EDR 94-018 and SOOR 94-222.

- At several locations inside the control and relay rooms, the walkdowns identified control cabinets and instrumentation panels in close proximity that are not fastened together. Since these panels were qualified in a "stand alone" test configuration, the effect of potential impact loads on internal components was not addressed in the existing dynamic qualification documentation. It is extremely difficult to quantify the additional dynamic loads due to potential impact and, therefore, dynamic qualification of internal components is judged to be indeterminate. This condition is currently being tracked and dispositioned under EDR 94-030.

- The SMA walkdowns identified that the color video CRTs in Control Room panels #C651 and C601 are resting on but are not fastened to the panel internal supports. These color video CRTs could affect the existing dynamic qualification of the other internal components during a dynamic event should they slide off of their internal panel supports. This condition is currently being tracked and dispositioned under EDR 94-039.

### 7.1.2 Fire Analysis

No changes are identified as a result of the IPEEE fire PRA which are required for conformance with the design basis. Several potential enhancements to equipment and procedures have been identified and are described in further detail below.

As a result of the Appendix R compliance effort several plant modifications have been put in place. A curb is now installed on the floor in front of the control structure chiller bays on the 806' elevation of the control structure which limits lube oil and fire suppression water spread, confining it to the affected chiller. A heat shield has been erected on the 783' elevation of the control structure which separates division I and II control structure HVAC electrical switchgear. The wall ensures fire suppression water spray does not affect both divisions. In the unit 1 reactor building, directional spray nozzles in the pre-action system provide a water curtain around valve HV-08693B. This valve directs ESW flow to the control structure chillers. A modification is on-going (DCP 92-9063) to allow opening of drains in the cable spreading rooms for removal of fire suppression water after pre-action system actuation.

Good housekeeping and transient combustible controls are credited in the fire PRA. The existing administrative procedures are effective as witnessed by the low historical frequency of transient combustible fires at SSES. During performance of the IPEEE fire PRA walkdowns, storage of magnetic tape was noted in the unit 1 upper cable spreading room. These tapes have been removed. Unrelated to the fire PRA, clean-up of a valve tool storage cage on the 683' elevation of the unit 1 reactor building was also noted. Although existing procedures for control of transient combustibles are effective, enhancements in

housekeeping procedures, including the addition of fire protection personnel on walkdowns, are being pursued as part of SOOR 94-393.

Details of the treatment of FRSS issues and resolutions are provided in section 4.8 of this report. The only weaknesses observed are related to seismic-fire interactions. As part of the resolution of the FRSS issues, a walkdown was performed to address, in part, seismic-fire interaction concerns. As a result of this walkdown the following enhancements are identified:

1. where H2/O2 bottles are restrained only by a single ring attached to the wall, add a second ring at the bottom of the bottle (SOOR 94-393);

2. investigate alternate instrumentation availability/drip shields for 1(2)Y115 and 1(2)Y125. (incorporated in the SSES engineering discrepancy management process, EDR 94-040).

3. revise "Natural Phenomena" off-normal procedure (ON-000-002) to include discussion that a severe seismic event may result in numerous alarms, water spray throughout the plant, and the loss of the water and CO2 fire suppression systems (currently in the bi-annual revision process).

### 7.1.3 High Winds, External Floods, and Others

No safety vulnerabilities to high winds, external floods, or nearby facilities/transportation accidents are identified.

## 7.2 Important Safety Features

This section highlights those features of Susquehanna SES considered most important for safety defense against severe external threats. In general, the basic plant design ensures adequate defense against external initiating events. Effective operations, maintenance, and training ensure these design features are utilized and not compromised.

### 7.2.1 Seismic

The important safety features for seismic defense described below are a result of a seismic design process which ensures that seismic considerations are built into new plant installations. An invaluable piece of this safety feature is the high quality and completeness of seismic design documentation available. SSES was built at a time when the worth of this information was recognized. As a result, qualification details of safety equipment and components are readily available for reference. Also, essentially all of the original Bechtel design calculations are retained by PP&L providing increased depth of understanding of the plant design and enabling seismic design work to be kept in-house.

Specific design details are provided in Section 3 of this report. Several are re-iterated here. Multiple divisions of equipment are available following a seismic event to allow controlled plant shutdown, core cooling, and continued decay heat removal. Safety equipment is located only in seismically designed buildings. Large components such as pumps are located low in these buildings. Electrical switchgear is mounted in cabinets which are adequately anchored. Non-safety related structures are designed so that their failure does not affect the function of safety related equipment. Safety equipment is powered only from safety grade emergency diesels, operated using the as-written/as trained emergency procedures. The most important safety feature for earthquakes is equipment survivability. It is the robust seismic design of

multiple divisions of equipment, and its effective implementation within SSES, that provide "defense-in-depth" against severe earthquakes.

### 7.2.2 Fire

Because the nature of fire is different than that of earthquakes, additional site features become important. Essentially nothing can be done to prevent the occurrence of earthquakes. In contrast, the elimination or limitation of fire sources is generally within the control of station personnel. Seismic events affect all site locations simultaneously. Fires affect only one or a limited set of locations (at least initially). For this reason, boundaries between fire zones are important. An earthquake occurs and, except for after-shocks, is over. Although fire initiates at a single source, the "fire event" continues until fuel or oxygen is exhausted, or until suppression occurs. Thus, steps to limit fire spread are important. One aspect of defense common to both seismic and fire events is the existence of multiple divisions of equipment capable of plant shutdown and decay heat removal. The important fire safety features at SSES are thus:

1. Good housekeeping to limit fire sources, including storage of combustibles away from safety related equipment and cable and especially in cable spreading rooms.

2. Functional fire barriers in both Appendix R and non-Appendix R rated boundaries, most importantly those surrounding large sources of lubrication oil. Those separating the reactor, control, and turbine buildings are most safety significant.

3. Fire watches for hot work because most fires are initiated as a result of welding and grinding activities. Recent NRC publications emphasize the importance of these fire watches.

4. The use of IEEE-383 rated fire resistant cable to limit fire related equipment loss and fire progression.

5. Wide physical separation of different divisions of safety related equipment and cable. Physical separation is key to equipment survivability and provides assurance of "defense-in-depth" for fires.

### 7.2.3 High Winds, External Floods, and Others

The important safety features for high winds, external floods, and nearby facility/transportation accidents are similar to those for seismic events. Because the effect of these initiating events is site-wide, multiple division equipment survival is the important safety feature. Again, proper design ensures this capability is built into the station. Effective operation, maintenance, and training ensure this capability is not diminished.

## 8. Summary and Conclusions (including resolution of USIs and GIs)

The major results of the IPEEE are summarized here for each of the three analyses:

1. Seismic Margins Assessment (SMA),
2. Fire PRA,
3. High winds, external floods, and nearby facilities/transportation analyses

Results of the SMA are summarized first for those actions required to restore SSES equipment to as-tested conditions and second, for enhancements which may be implemented to add margin beyond the design basis requirements. Four issues were identified during the course of plant walkdowns where actual field installation did not conform with seismic design qualification test configuration. These issues are: small trolley cranes attached to the top of switchgear cabinets to aid in the maintenance of breakers; control room and relay room cabinets which were originally qualified as individual units, but which are installed in long rows; instances of missing or broken fasteners on electrical equipment cabinets and proximity of transient equipment; and anchorage of control room cabinet CRTs. Resolution of these issues is required to ensure SSES equipment meets SSE design (0.1 g) conditions. The trolley cranes issue is the only one requiring immediate rectification and these trolleys have been removed. Evaluation of the other issues shows their risk significance to be low. These issues have been included in the SSES Discrepancy Management Program and will be resolved.

Four items (2 valves and 2 electrical cabinets) which are acceptable in terms of the SSES seismic design basis are considered "outliers" when screened against the SME of 0.3 g.. None are judged to have a HCLPF low enough to be considered for possible modification to remove seismic interaction or safety impact concerns. These items are either not strictly required for the SSEL or may be manually operated after the SME. Considering the limited number of manual actions required after the SME, and given resolution of the items identified in the paragraph above, both SSD paths identified in the SSEL pass the screening criteria of 0.3 g. Although seismically sensitive relays are located in safe shutdown equipment, evaluation of the locations of these relays shows that relay chatter is not expected to cause equipment loss in a seismic event. It must be emphasized that no programmatic weaknesses in the PP&L seismic design process were discovered. Equipment problems all date from initial plant startup and involve equipment whose physical mounting/location has not been altered since that time. These equipment discrepancies are considered to constitute the complete set of such anomalies for the SSEL items. A re-awareness of this importance is a significant result of the SMA. Training has been initiated for plant staff engineers, maintenance, and operations personnel which is expected to preclude recurrence of the problems noted.

The major result of the fire PRA is that defense-in-depth exists for all fires without credit for Thermo-Lag or other type of fire wrap. That is, multiple equipment remains operable for successful core and containment defense from any realistic fire in SSES even if all fire wrap is removed. Adequate separation and barriers between different divisions of safety equipment is verified. As in other PRAs, the most risk significant fires are those which affect power and control of multiple pieces of safe shutdown equipment. For SSES, fires in 125 V DC chargers/distribution panels (D614/D624), or control room panels for ECCS equipment (C601) or AC power control (0C653) are most risk significant.

Total calculated core damage frequency due to fire is about 1 E-9/cycle. This value is 1% of the total calculated for internal events in the IPE. However, because of the significant conservatisms taken in the fire PRA (only Appendix R, HPCI and CRD systems used, and no fire detection or suppression systems credited), direct comparison of these numbers is inappropriate. Although these results are less than the 1 E-6/yr reporting criteria of the GL, significant sequences are discussed and core damage frequencies are

estimated for completeness. Because of the lack of separation between front-end and back-end analyses in the PP&L support state method, containment failure frequencies are also reported for those sequences quantified. Incidence of containment failure without core damage is estimated to be about 5 E-9/cycle for fire. This value is about 10% of the total calculated for internal events in the IPE. The cumulative core damage frequency calculated for fire is an upper bound. Because of the emphasis placed on fire safety in complying with the requirements of Appendix R, many of the improvements which may have been identified during the fire PRA are already in place in the plant. No modifications are required to establish defense-in-depth. However, clarification of housekeeping procedures, off-normal seismic response procedures, and the possible addition of four "drip shields" are being addressed as enhancements through appropriate change mechanisms. The fire PRA re-affirms that divisional separation, maintenance of fire zone boundaries, and good housekeeping are the keys to ensuring adequate fire defense.

The screening approach used in analysis of high winds, external floods, and nearby facilities/transportation accidents shows adequate defense against these threats. No weaknesses or plant modifications were identified from this analysis.

Section 5 of the G.L. 88-20 Supplement 4 information request provides a summary of other external event safety issues which may be resolved by information provided with the IPEEE report. Several of these issues do not pertain either to BWR plants in general or Susquehanna in particular (USI A-46), or to fire PRA. Those issues which are applicable to SSES are: USI A-45 "Shutdown Decay Heat Removal Requirements" and GI 57 "Effects of Fire Protection System Actuation on Safety-Related Equipment". The resolution of these USIs/GIs (and the six issues raised by NUREG/CR-5088, the "Fire Risk Scoping Study") are addressed in detail in preceding sections of this report (sections 3.12, 4.8, and 4.9). Results for USI A-45 and GI-57 are summarized here.

Post accident shutdown decay heat removal is nominally provided by the RHR system, part of the ECCS. This system consists of two independent divisions, either of which is capable of successfully removing decay heat from the core/containment. The RHRSW and ESW systems are designed to remove the decay heat from both units. Loss of either division is not expected as a result of the RLE. In the case of fire, loss of one division leaves the other available and, because of the limited damage expected from a fire, in all likelihood also leaves the condenser operable. In the case of fire loss of the condenser/turbine building, both divisions of RHR are expected to remain available. Thus, for both seismic and fire events, two trains of RHR-DHR are expected to survive. Thus, defense-in-depth of DHR is shown and satisfactory resolution of USI A-45 achieved. Note that reliance on only RHR for DHR ignores other methods of removing decay heat such as the RWCU system, containment vent etc. which may be available, especially after fire. A more complete discussion of these other sources is found in section 4.3.1 of the IPE for internal events.

Appendix R evaluation of the impact of water spray on SSD equipment shows that spray anywhere in the reactor building does not disable equipment sufficient to jeopardize the ability to shutdown and remove decay heat. The effect of water spray is specifically considered in the layout of water suppression piping. The use of pre-action systems provides protection against inadvertent spray. Mechanical equipment and cable are expected to be little affected by spray. Electrical switchgear cabinets are closed at the top and sealed at cable penetrations. Only fog type nozzles are available at hose stations, reducing the possibility of long-distance over-spray. Thus, little vulnerability is seen in the reactor buildings. In the control structure, fire is generally expected to be confined to electrical equipment, specifically the cabinet of origin. Because of the localized nature of such fires, fire suppression effects are also expected to remain localized. Pre-action systems are installed in the two upper elevations of the control structure and in the cable spreading rooms. Plant Shutdown and decay heat removal are not immediately affected by pre-action

operation on the upper elevations of the control structure. Only CSHVAC equipment is located on these elevations and loss of this equipment has only long term (after about 24 hours) affect on equipment operability. Further, modifications installed as part of Appendix R compliance are designed to ensure both divisions of CSHVAC are not affected simultaneously. Pre-action operation in the cable spreading rooms may affect control room instrumentation operability. A modification currently in progress will open floor drains to allow removal of pre-action system water. Inspection of floor seals in the cable spreading rooms shows these penetrations to be tight so that minimal flooding of the rooms below is expected. The only equipment in these rooms which may be compromised by water spray are instrument power supplies (again, cable wetting is acceptable). The availability of alternate instrumentation or installation of drip shields above this equipment is still under evaluation. Given successful resolution of this potential equipment damage concern, the effects of inadvertent fire suppression system actuation are shown not to compromise the ability of achieving shutdown and decay heat removal, and GI-57 is resolved.

In conclusion, the IPEEE effort confirms that SSES is well designed and capable of withstanding severe external challenges. After nearly a decade of operation for both units, physical condition of the plant, including cleanliness, is good. Only a single seismic design situation was found to be significant enough to require immediate correction. All other seismic observations, and all observations related to fire, high winds, external flooding, and nearby facility and transportation accidents are of low risk significance. The findings of this report provide confidence that SSES has significant safety margin in terms of design and defense-in-depth.