UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
611 RYAN PLAZA DRIVE, SUITE 400
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April 11, 2003

EA-03-016

Craig G. Anderson, Vice President,
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Entergy Operations, Inc.
1448 S.R. 333
Russellville, Arkansas 72801-0967

SUBJECT: ARKANSAS NUCLEAR ONE - NRC TRIENNIAL FIRE PROTECTION INSPECTION REPORT 50-313/01-06; 50-368/01-06 - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Dear Mr. Anderson:

In a letter dated March 25, 2003, the NRC informed you that the finding discussed in the subject inspection report was preliminarily determined to be Greater-Than-Green (i.e., a finding whose safety significance is greater than very low). As stated in our March 25, letter, you were provided with the opportunity to present your position on the finding to the NRC at a Regulatory Conference or in writing, before a final decision on the significance of this finding is reached. In a subsequent phone conversation, you informed us of your preference to present your position at a Regulatory Conference.

As an enclosure to our letter of March 25, 2003, we provided you a summary of our Phase 3 significance determination evaluation. In a letter dated April 2, 2003, you stated that additional information was necessary to ensure a productive exchange of information at the Regulatory Conference. In Attachment 1 of that letter, you provided four specific information requests concerning our significance determination evaluation. In response to Item 1 of this request, enclosed is a copy of the fire modeling of Fire Zones 98-J and 99-M, which we used in our Phase 3 significance determination of the finding. In determining the significance of this finding, we started with your Phase 3 significance evaluation and modified certain aspects of it to better assess the significance of the finding. Troy Pruett of NRC Region IV discussed these changes with Mike Cooper and Jessica Walker of your staff. In Enclosure 2 we are providing to you our Phase 3 significance determination analysis, which in conjunction with the aforementioned discusion between your staff and Troy Pruett should satisfy Items 2 and 3 of your Attachment 1. The information requested in Item 4 is addressed in the Significance Determination Process Phase 3 Summary, which is an enclosure to our March 25, 2003 letter.

If you have any further questions, you may contact me at 817-860-8185.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

/RA/

Charles S. Marschall, Chief
Engineering and Maintenance Branch
Division of Reactor Safety

Dockets: 50-313; 50-368
Licenses: DPR-51; NPF-6

Enclosures:
1. Fire Modeling of Fire Zone 98-J, Emergency Diesel Generator Corridor and 99-M, North Electrical Switchgear Room, Arkansas Nuclear One - Unit 1
2. Phase 3 SDP Analysis: Arkansas Nuclear One, Unit 1

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Regional Administrator **(EWM)**
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DRP Director **(ATH)**
DRS Director **(DDC)**
Deputy Director, DRP **(GMG)**
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Branch Chief, DRS/EMB **(CSM)**
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ENCLOSURE 1

Fire Modeling of Fire Zone 98-J, Emergency Diesel Generator Corridor and 99-M, North Electrical Switchgear Room Arkansas Nuclear One - Unit 1

SUMMARY

Fire modeling of the Fire Zones 98J, Emergency Diesel Generator Corridor and 99-M, North Electrical Switchgear Room have been performed to evaluate the potentially hazardous conditions (increased temperature and smoke layer level) that could be caused by a fire and assess the associated damage potential to cables or equipment of redundant trains of systems for safe shutdown. The multi-zone fire model CFAST (Consolidated Model of Fire Growth and Smoke Transport) was used to evaluate the different fire scenarios in the Emergency Diesel Generator Corridor and North Electrical Switchgear Room.

IGNITION SOURCES

The primary combustibles of concern in the Fire Zone 98-J and 99-M are the in-situ electrical cabinets, cables, and electrical equipment.

A potential electrical cabinet and subsequent cable tray fire will pose a significant hazard to these Fire Zones. The most likely scenario is dominated by the cable trays that are closest to the ignition sources i.e., the electrical cabinet and electrical equipment.

The main ignition sources in the Fire Zone 98-J include, but are not limited to, the electrical wall-mounted cabinets, 125V DC distribution panels, and instrumentation cabinets (see Table 1). Ignition sources in the Fire Zone 99-M include, but are not limited to, the 4160V switchgear (vital and non-vital) 480V MCC, 480V load center, 120V instrument panel/transformer Y4/X62, inverter panels Y28, Y22, Y24, and Y25 (see Table 1).

Table 1
List of Ignition Sources in Fire Zone 98-J and 99-M
ANO Triennial Fire Protection Inspection, Attachment 2, “Phase 2 Significance Determination” (ADAMS Accession # ML012530361)

Ignition Sources	
Fire Zone 98-J, Emergency Diesel Generator Corridor	Fire Zone 99-M, North Electrical Switchgear Room
Electrical wall-mounted cabinets 125V DC distribution panels Instrumentation cabinets Emergency chiller water pump Switchgear room emergency chiller Battery charger room A/C unit North batter room/Charger room unit cooler South battery room/Charger room unit cooler	4160V switchgear (vital and non-vital) 480 V motor control center 480V load center 120V instrument panel/transformer Y4/X62 Inverter panels Y28, Y22, Y24, and Y25 Switchgear room cooler, VUC 2C and 2D Transformer X6

Other ignition sources such as a power cable failure in a tray, or other failures of electrical origin (distribution panel, circuit boards, electrical wiring, internal cable fault, electrical circuit fault in switchgear cabinets, etc.) will produce similar results. The electrical failure is postulated in this analysis to ignite the in-situ combustibles (cables). Outside ignition sources such as hot work or transient sources are also possible, but not included in the scope of this analysis.

FIRE GROWTH RATE

Testing has shown that the overall heat release rate (HRR) during the fire growth phase of many fires can often be characterized by the simple time dependent polynomial or exponential function (Heskestad and Delichatsios 1978). The total heat release of fuel packages can be reasonably approximated by the power law fire growth model for both a single item burning and for multiple items involved in a fire. The proposed model of the environment generated by fire in an enclosure is dependent on the assumption that the fire grows according to:

$$\dot{Q} = \alpha t^2 \qquad (1)$$

where

$\dot{Q}$ = the rate of heat release of fire (kW),
t = the time (sec), and
α = a constant governing the speed of fire growth (kW/sec^2)

The growth rate approximately follows a relationship proportional to time squared for flaming and radially spreading fires and is referred to as t-squared (t^2) fires. The t^2 fires are classed by speed of growth, labeled ultra-fast, fast, medium, and slow. Where these classes are used, they are defined on the basis of the time required for the fire to grow to a rate of heat release of 1000 kW (1 MW). The intensity α, and growth time t, related to each of these classes shown in Table 2.

Table 2
Summary of t^2 Fire Parameter

Type of Fire Growth	Intensity Constant α (kW/sec^2)	Growth Time t (sec)
Slow	0.00293	600
Medium	0.01172	300
Fast	0.0469	150
Ultra-fast	0.1876	75

The t^2 relationship has proven to be useful and has been adopted into the National Fire Protection Association NFPA 72 to categorize fires for detector spacing requirements and into NFPA 92B for design of smoke control system.

The modeled fire can be represented as one where the HRR per unit area is constant over the entire ignited surface and the flame is spreading with a steadily increasing area. In such cases, the burning area increases as the square of the steadily increasing fire radius. Fires that do not have a regular fuel array and consistent burning rate might or might not actually produce a t^2 curve; however, the t^2 approximation appears to be reasonable for use in this case to produce a realistic approximation of the expected fire growth.

HEAT RELEASE RATE ESTIMATE

This analysis is used to determined the extend of potential fire damage associated with a realistic, potential fire scenario in Fire Zones 98-J and 99-M. The analysis evaluates whether the postulated fire can lead to failure of safety-related cables or equipment of redundant trains of systems for safe shutdown. The impact of the fire scenario is analyzed using fire dynamics principles or fire model (e.g., CFAST). Different fire scenarios were considered in the analysis. Table 3 provides a summary of fire scenarios considered in this analysis.

Table 3
Summary of the Fire Scenarios

Fire Zone	Fire Scenario		Ventilation Condition
	Electrical Cabinet Fire Input HRR, Test # 23 & 24, NUREG/CR-4527, Volume 2, Figure 1 & 2	Electrical Equipment Fire t^2 Fast Fire Growth Figure 3	
98-J, Emergency Diesel Generator Corridor	1300 kW Peak HRR 1235 kW Peak HRR	500 kW 400 kW 300 kW 200 kW	Vent open and closed
99-M, North Electrical Switchgear Room	1300 kW Peak HRR 1235 kW Peak HRR	500 kW 400 kW 300 kW 200 kW	Door open and closed

Figure 1 and 2 show the input HRR used in CFAST fire simulation predicts the effects of a electrical cabinet fire in Fire Zone 98-J and Fire Zone 99-M. This HRR is based on the full-scale test results reported in NUREG/CR-4527, Volume 2, Test # 23 and 24. As shown in Table 1 several small electrical ignition sources are present in Fire Zones 98-J and 99-M. There is no direct data available on the burning of these ignition sources at full or intermediate scale, so a range of HRR were used. For the purpose of this analysis a t^2 fast fire growth rate for these fires was assumed for fire modeling (see Figure 3).

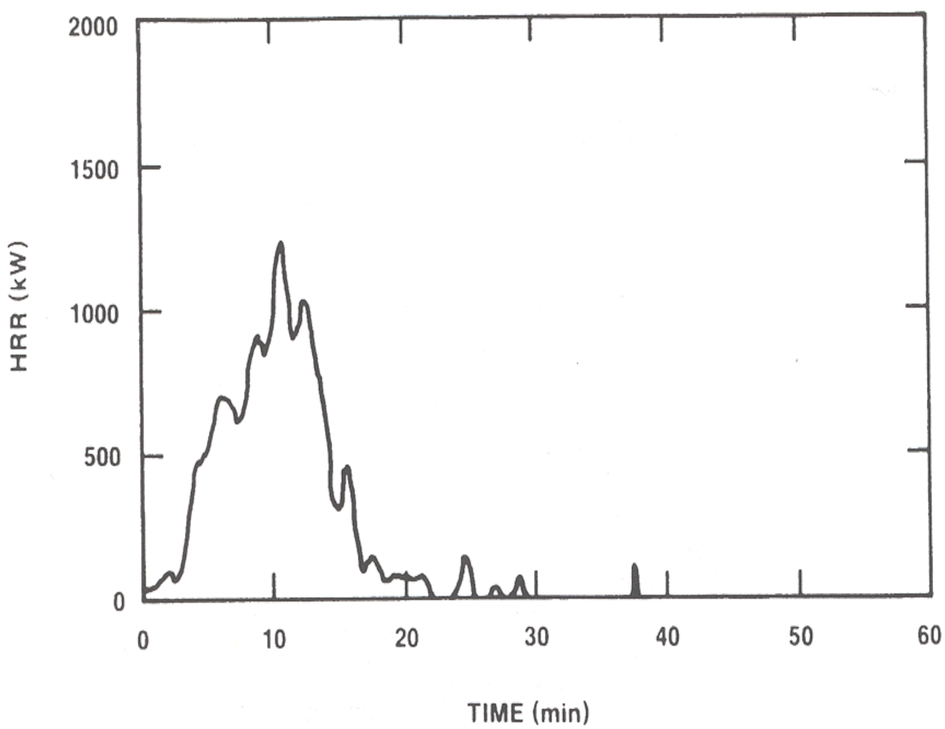

Figure 1 Measured Heat Release Rate for Electrical Cabinet Fire
NUREG/CR-4527, Volume 2, Test # 23

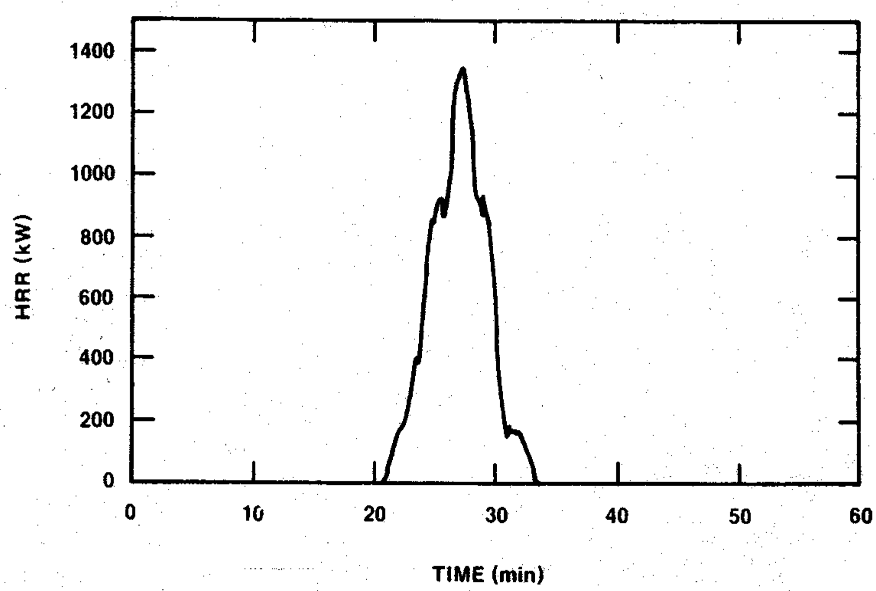

Figure 2 Measured Heat Release Rate for Electrical Cabinet Fire
NUREG/CR-4527, Volume 2, Test # 24

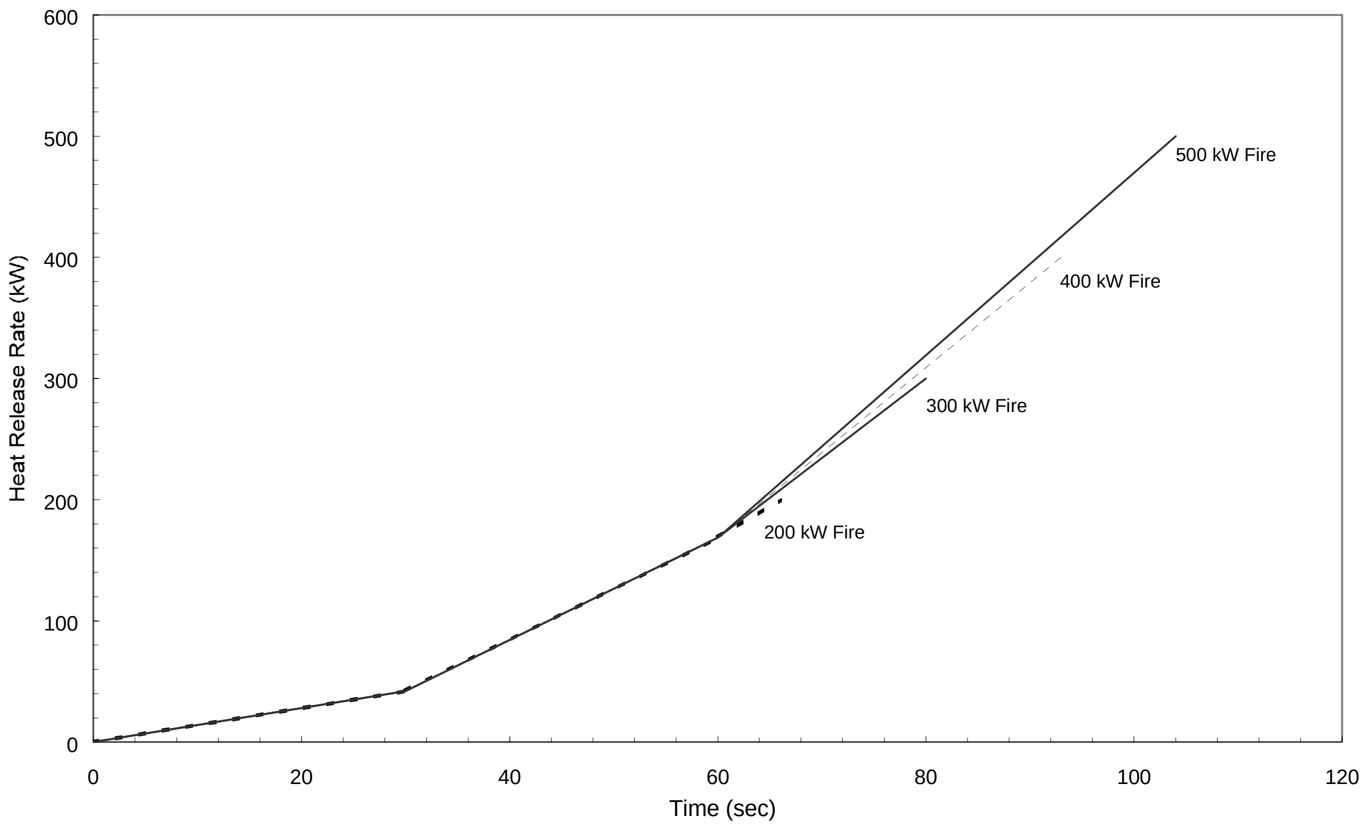

Figure 3 Input Heat Release Rate, Electrical Equipment Fire, t^2 Fast Fire Growth Rate

CFAST - CONSOLIDATED MODEL OF FIRE GROWTH AND SMOKE TRANSPORT

The multi-zone computer fire model CFAST was used to calculate the temperature in the Fire Zones 98-J and 99-M [Peacock *et al.,* 1997; Peacock *et al.,* 1993]. CFAST was developed by the Building and Fire Research Laboratory (BFRL) at the National Institute of Standards and Technology (NIST) for fire modeling steady and unsteady state burning rates in multiple compartment configurations (multiple room capability, up to 15 rooms can be modeled). The initiating fire is user specified, but adjusted by CFAST based on the available supply of oxygen. CFAST allows fires to be constrained or unconstrained. A fire specified as unconstrained in CFAST will not be limited by the availability of oxygen. When a constrained fire is specified, the chemically required oxygen is calculated and the available oxygen and unburned gases are tracked. A mass balance calculation of individual species is performed for each zone to track the available oxygen and unburned gases. Multiple compartments and vents can be modeled as well as the mechanical ventilation. Mechanical ventilation is addressed by CFAST in terms of fan/ductwork that includes consideration of fan pressure/flow characteristic curves and duct friction losses. The model divides each compartment into two zones, an upper zone containing the hot gases produced by the fire and a lower zone containing all space beneath the upper zone. The lower zone is a source of air for combustion and usually the location of the fire source, the upper zone can expand to occupy virtually all of the space in the compartment. The upper zone is considered a control volume that receives both mass and energy for the fire and loses energy to the surfaces in contact with the upper zone by conduction and radiation, by radiation to the floor, and by convection or mass movement of gases through openings. The two layer zone approach used by the CFAST has evolved from observations of such layering in full-scale fire experiments (Jones *et al.,* 2000). While these experiments show some variation in conditions within the layers, they are small compared to the differences in conditions between the layers themselves. Thus, the zone model can produce a fairly realistic simulation of the fire environment within a compartment under most conditions. CFAST has the capability to calculate the upper and lower layer temperature, the smoke density, the vent flow rate, the gas concentrations, and compartment boundary temperatures, the heat flux from the smoke layer to objects, the internal compartment pressure, and the interface elevation, all as a function of time.

A number of efforts of CFAST model comparison, verification and validation have been undertaken. Many of these efforts involved comparisons between measured and calculated parameters, primarily temperatures, mass flow rates and smoke layer interface positions. Duong, 1990, Peacock, et al., 1988, Mowrer and Gautier, 1997, Nelson and Deal, 1991, and EPRI TR-108875, 1998, compared CFAST model predictions with experimental data.

LIMITATIONS AND UNCERTAINTIES ASSOCIATED WITH FIRE MODELING

Fire models permit development of a better understanding of the dynamics of building fires and can aid in the fire safety decision-making process. There are certain limitations and uncertainties associated with the current fire modeling predictions. Extreme care must be exercised in the interpretation of the fire modeling results. For scenarios where the level of predicted hazard is well below the damage threshold, the results can be used with high level of confidence provided there is a high level of confidence that all risk-significant scenarios have been considered. For scenarios where the level of predicted hazard is near the damage threshold, the results should be used with caution in view of the uncertainties that exist.

A primary method of handling modeling uncertainties is the use of engineering judgment. Among other things, this judgment is reflected in the selection of appropriate fire scenario, hazard criteria, and fire modeling techniques. A slightly more formal application of engineering judgment is the use of safety factors. The safety factors can be applied in the form of fire size, increased or decreased fire growth rate, or conservative hazard criteria (Custer and Meacham, 1997). Experimental data obtained from fire test, statistical data, from actual fire experience, and other expert judgment can be used improve the judgment and potentially decrease the level of uncertainty.

CFAST MODELING OF FIRE ZONES 98-J AND 99-M

Fire modeling of the Fire Zones 98-J and 99-M was performed using CFAST. All CFAST input files used in this analysis are contained in Appendix A. With the parameters selected, CFAST provided information on the temperature in the room and the smoke interface height.

CFAST input data includes the physical dimensions of the compartment, the compartment construction materials, the opening dimensions and their elevations, the fire HRR, and the position of the fire in the specified room, gas species production rate, and exterior wind conditions (see input file).

To perform this analysis, several HRR curves were developed for the CFAST fire model. The input HRR assumes complete combustion and an ample supply of oxygen. Experimental HRR curves (NUREG/CR-4527, Vol. 2) and electrical equipment fire with a t^2 fast fire growth rate (i.e., energized failure) was used in the fire modeling.

The fire environment created in the Fire Zones 98-J and 99-M involving electrical cabinet and electrical equipment was determined using the data provided in Table 3. HRR data in Figures 1, 2, and 3, and Table 3 were used as input into CFAST, which will reduce this nominal HRR based on the availability of oxygen. In Fire Zone 99-J, fires were evaluated first with the vent open (3' x 2') then closed. In Fire Zone 99-M fires were evaluated first with the door open then closed. In the cases of the vent or door closed, a small vent was assumed near the floor to prevent an excessive pressure buildup and possible numerical instability in the model. This small vent assumption is reasonable and realistic since no compartment is air tight. For the model a summation of small leakage paths such as door gaps are assumed. The walls, floor, and ceiling of Fire Zones 98-J and Fire Zone 99-M are thermally thick concrete.

CFAST FIRE MODELING RESULTS

Results from the CFAST simulation of the fire scenarios in the Fire Zone 98-J and 99-M are provided in Figures 4 through 19 and summarized in Table 4. Figure 4 show the smoke layer temperature in Fire Zone 98-J using the input HRR from Test # 23 with vent open and closed. In this figure cable failure temperature 425 °F was reached in approximately 30 minutes when vent is open. In the case of vent closed the fire become ventilation limited with the smoke layer temperature reaching 400 °F in about 30 minutes. Figure 6 show the smoke layer temperature in Fire Zone 99-M using input HRR from Test # 23 with door open and closed. In both case the smoke layer temperature reach 425 °F approximately 11.5 minutes. The limiting temperature of 425 °F was used since this temperature can, cause failure of non IEEE-383 rated cables.

Figure 8 show the smoke layer temperature in Fire Zone 98-J using input HRR from Test # 24 with vent open and closed. In both fire scenarios, the smoke layer temperature reach in 425 °F approximately 6 minutes. In Figure 10 the smoke hot layer temperature in Fire Zone 99-M to reach 425 °F within 7 minute of the fire.

Figure 12 and 14 show the smoke layer temperature in Fire Zone 98-J with door open and then closed with HRR ranging from 200 to 500 kW. The temperatures reached during these fire scenarios exceeds 425 °F only for 300 and 400 kW fire when vent is open. In case when vent is closed, smoke layer temperature exceeds 425 °F only for 500 kW fire, other fires become ventilation limited and decayed.

Figure 16 and 18 show the smoke layer temperature in Fire Zone 99-M with door open and closed with HRR ranging from 200 to 500 kW. With the door open, in all cases the smoke layer temperature was below the non IEEE-383 rated failure temperature, therefore failure of the cables would not be expected. However, with the door closed, fires with HRR of 400 and greater could damage the cables in Fire Zone 99-M. Fires with HRR of 200 and 300 kW tend to become ventilation limited and decayed.

Table 4
Summary of Fire Modeling Results for Electrical Cabinet and Electrical Equipment Fire in Fire Zone 98-J and 99-M

Fire Scenario HRR (kW)	Fire Zone 98-J, Emergency Diesel Generator Corridor		Fire Zone 99-M, North Electric Switchgear Room	
	Smoke Layer Temperature (°F)		Smoke Layer Temperature (°F)	
	Vent Open	Vent Closed	Door Open	Door Closed
1300	**425** @ 6 min	**425** @ 6 min	**425** @ 7 min	**425** @ 7 min
1235	400 @ 9 min **425** @ 30 min	400 @ min	**425** @ 11.5 min	**425** @ 11.5 min
500	**425** @ 4 min	**425** @ 3.5 min	363 @ 60 min	**425** @ 5 min
400	**425** @ 19 min	408 @ 6 min	325 @ 60 min	**425** @ 10 min
300	390 @ 60 min	336 @ 14 min	284 @ 60 min	369 @ 27 min
200	305 @ 60 min	291 @ 19 min	230 @ 60 min	294 @ 27 min

Boldface indicate the non IEEE-383 rated cable failure temperature.

CONCLUSION

As expected and illustrated by Table 4, the damaging fire scenarios will be governed by the energetic faults in the electrical cabinets (HRR) and influenced by the compartment's ventilation conditions. Energetic electrical faults producing a HRR 400 kW or greater, can lead to fire growth and subsequent fire damage of concern in the compartment. Based on operating experience (e.g., the recent event at San Onofre Nuclear Generating Station (SONGS)(ADAMS Accession # ML011130255)) and laboratory testing (e.g., “An Experimental Investigation of Internally Ignited Fires in Nuclear Power Plant Control Cabinets, Part II: Room Effects Tests” NUREG/CR-4527, Volume 2) fires in excess of 1 MW (1000 kW) are creditable from electrical cabinets. This HRR is further validated by the February 2002, NRC Office of Nuclear Regulatory Research Report “Operating Experience Assessment Energetic Faults in 4.16 kV to 13.8 kV Switchgear and Bus Ducts That Caused Fires in Nuclear Power Plants 1986–2001” (ADAMS Package # ML021290364, Report Accession # ML021290358), which states,

> *“These events demonstrate that fires from energetic electrical faults contain more energy than assumed in fire risk models as evidenced by explosions, arcing, smoke, ionized gases, and melting and vaporizing of equipment. The energy release exceeds HRRs assumed in fire risk models, possibly by a factor of 1000. Lower HHR values currently used may explain why current fire risk models have not identified the potential larger effects of fires from energetic electrical faults which may include the following: bypass of the fire initiation and growth stages, propagation of the fire to other equipment and across vertical fire barriers, ac power system designs that may be vulnerable to an SBO, failed fire suppression attempts with dry chemicals and the need to use water, longer restoration time to recover, and unexpected challenges and distractions to the operator from fire-induced failures.*
>
> *Fire risk models may underestimate the risks from fires due to energetic faults in 4.16 kV to 13.8 kV switchgear and bus ducts by not considering: (1) development of HRR values corresponding to energetic electrical energy levels; (2) the effects of propagation from the fault location to other switchgear compartments, bus ducts, or overhead cables; (3) plant ac safety bus and circuit breaker configuration; (4) failed fire suppression attempts; (5) additional recovery actions; and (6) multiple accident sequences from fire induced equipment failures or operator error”.*

Therefore, based on the realistic fire scenarios developed in this analysis, unacceptable fire damage due to an energized electrical cabinet ignited fire is credible.

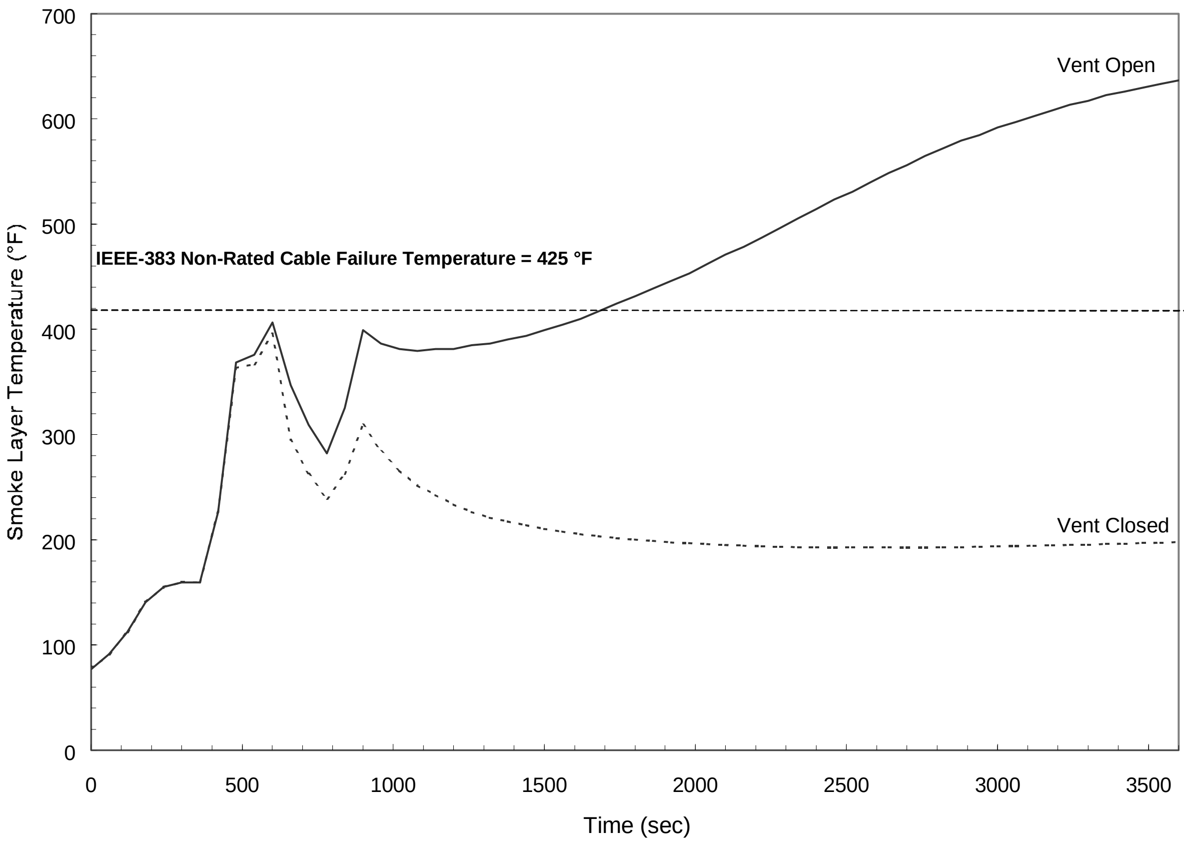

Figure 4 Smoke Layer Temperature in Fire Zone 98-J. Input Heat Release Rate Test # 23, NUREG/CR-4527, Volume 2

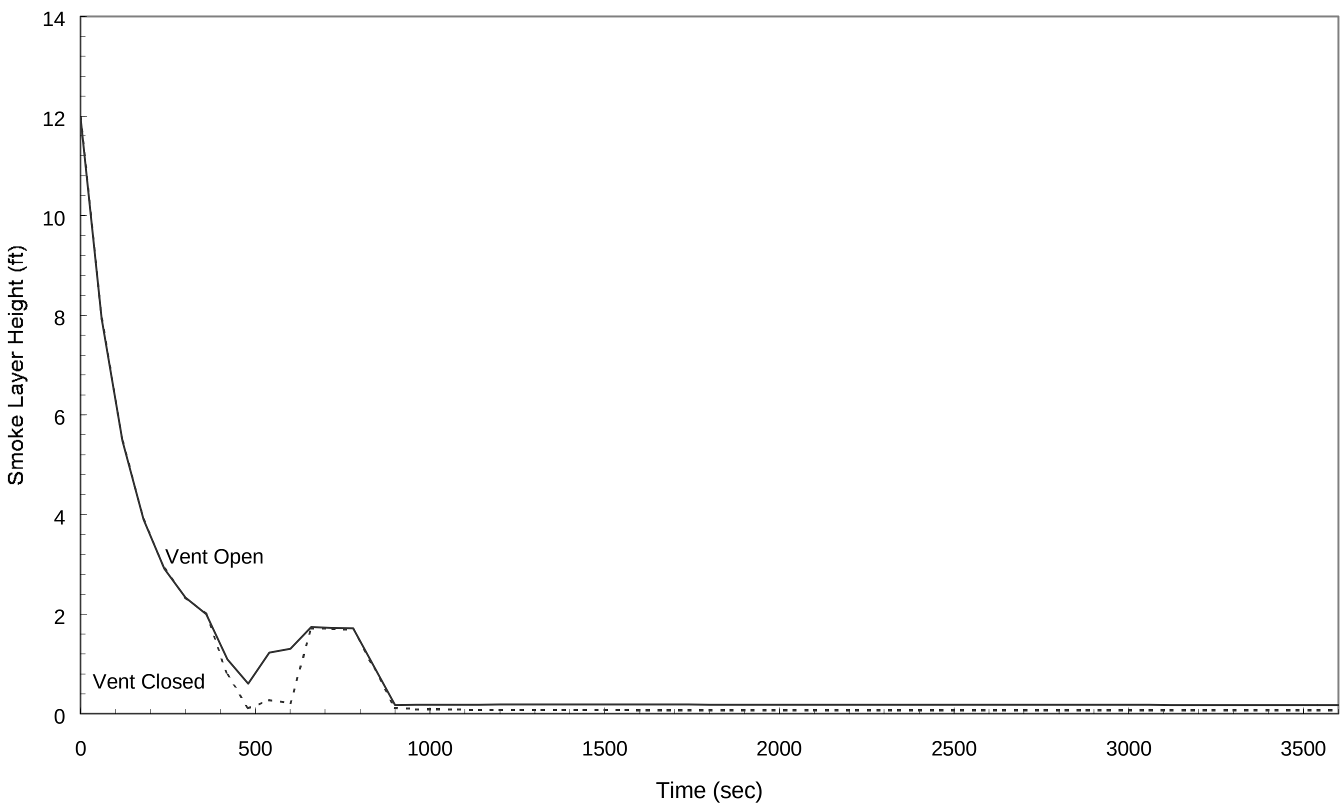

Figure 5 Smoke Layer Height in Fire Zone 98-J. Input Heat Release Rate Test # 23, NUREG/CR-4527, Volume 2

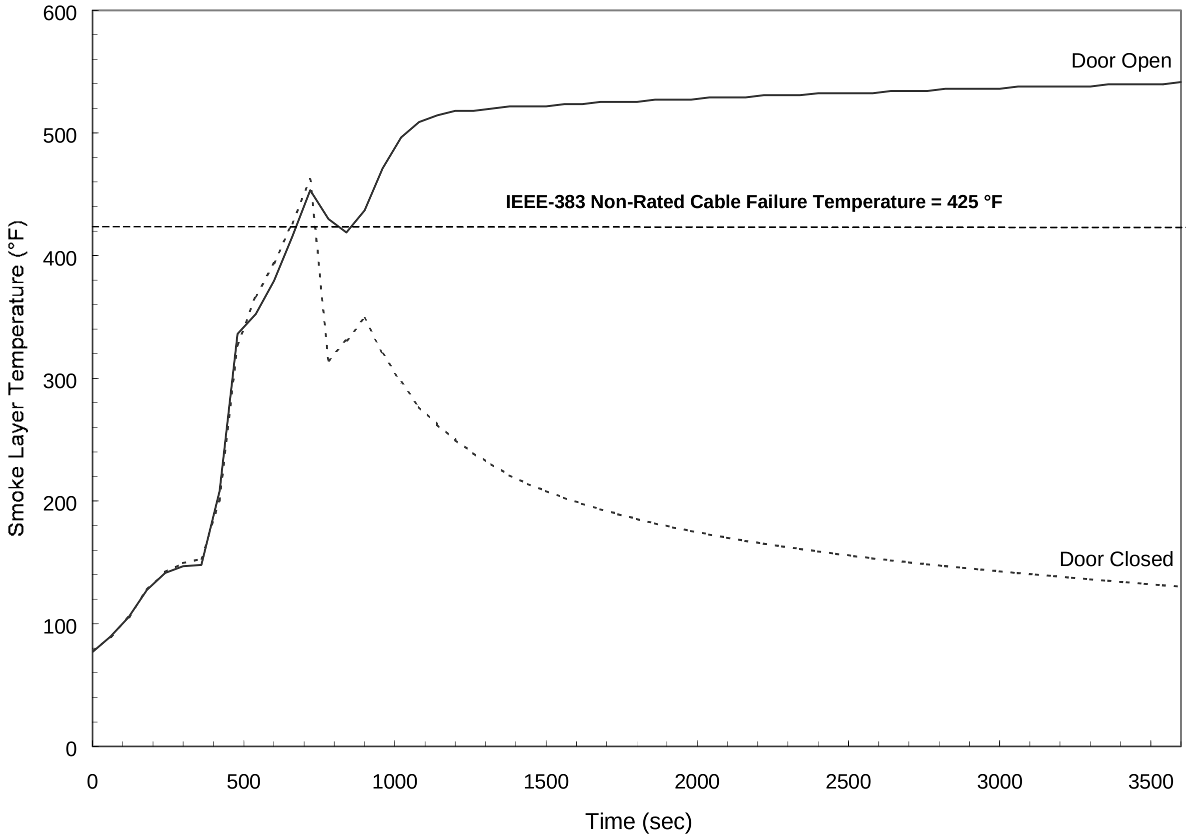

Figure 6 Smoke Layer Temperature in Fire Zone 99-M. Input Heat Release Rate Test # 23, NUREG/CR-4527, Volume 2

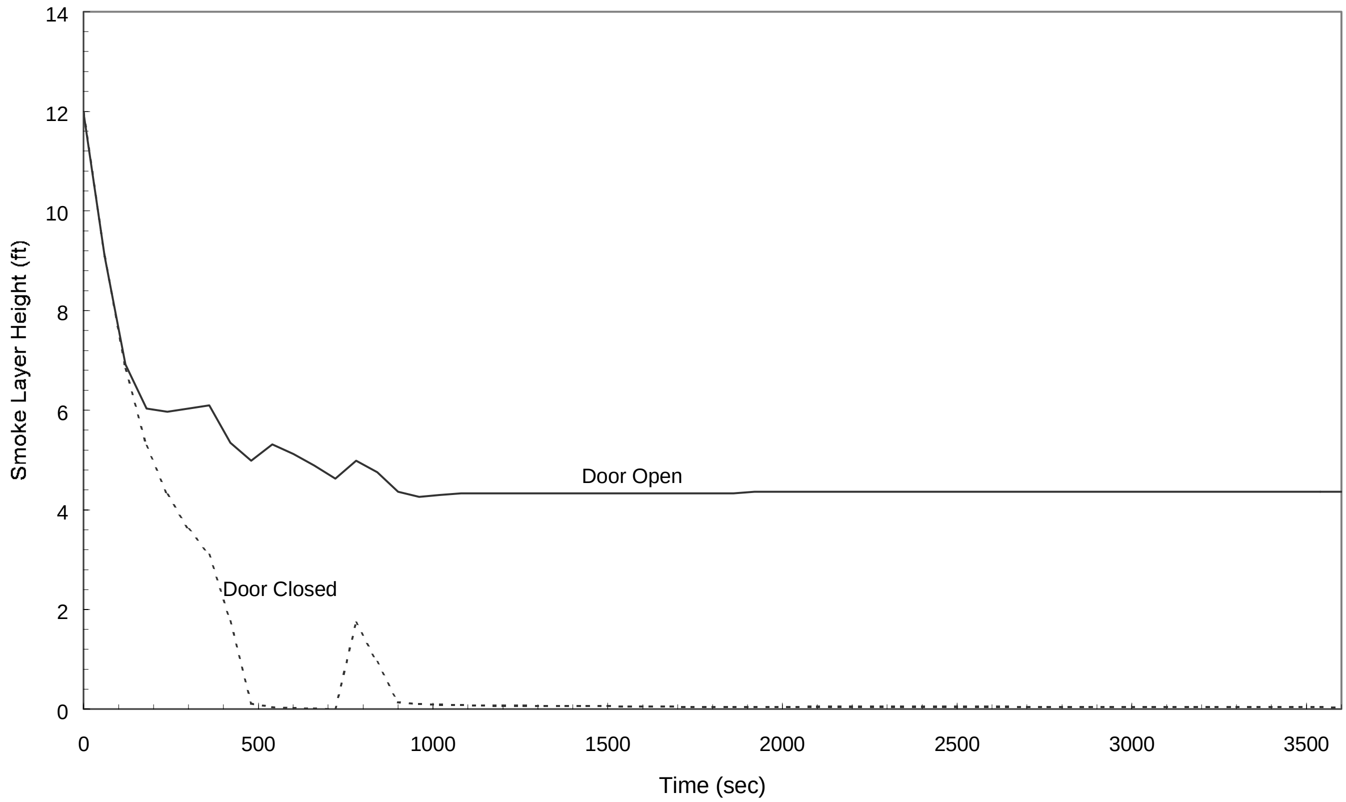

Figure 7 Smoke Layer Height in Fire Zone 99-M. Input Heat Release Rate Test # 23, NUREG/CR-4527, Volume 2

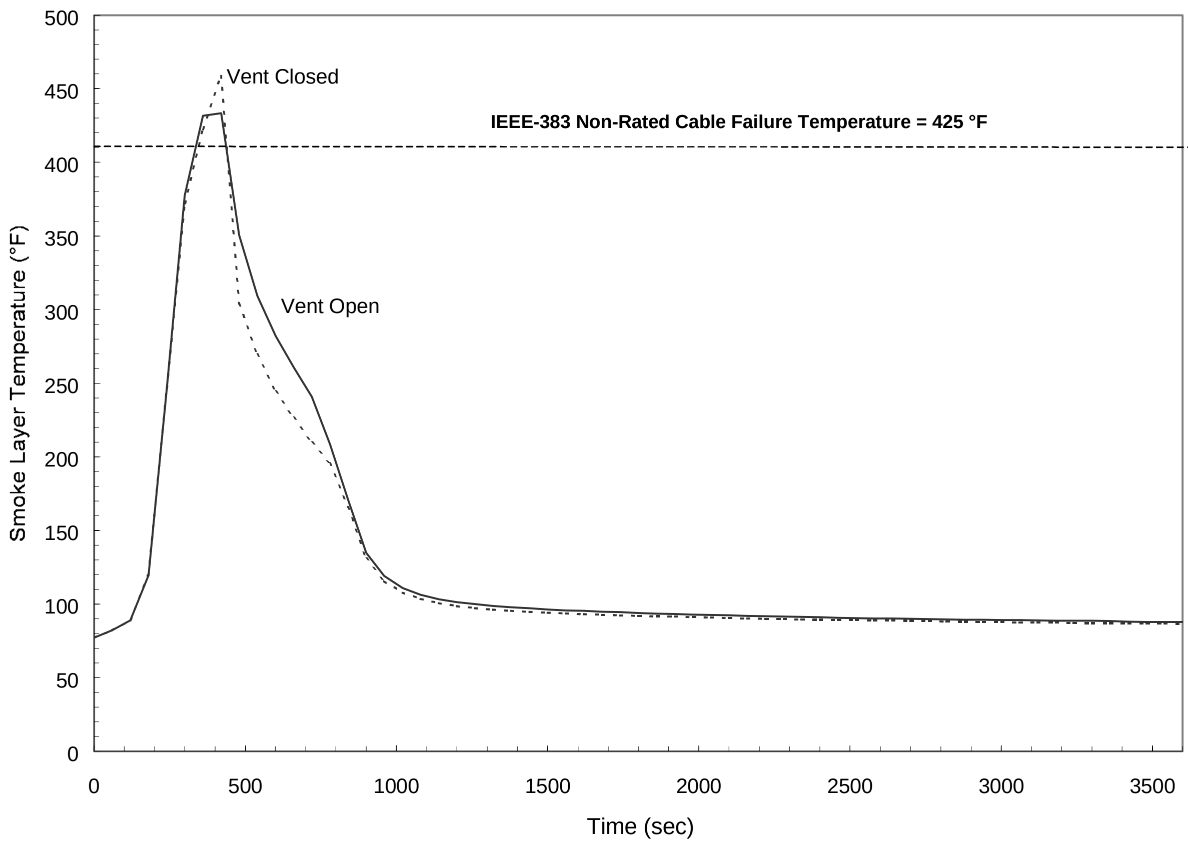

Figure 8 Smoke Layer Temperature in Fire Zone 98-J. Input Heat Release Rate Test # 24, NUREG/CR-4527, Volume 2

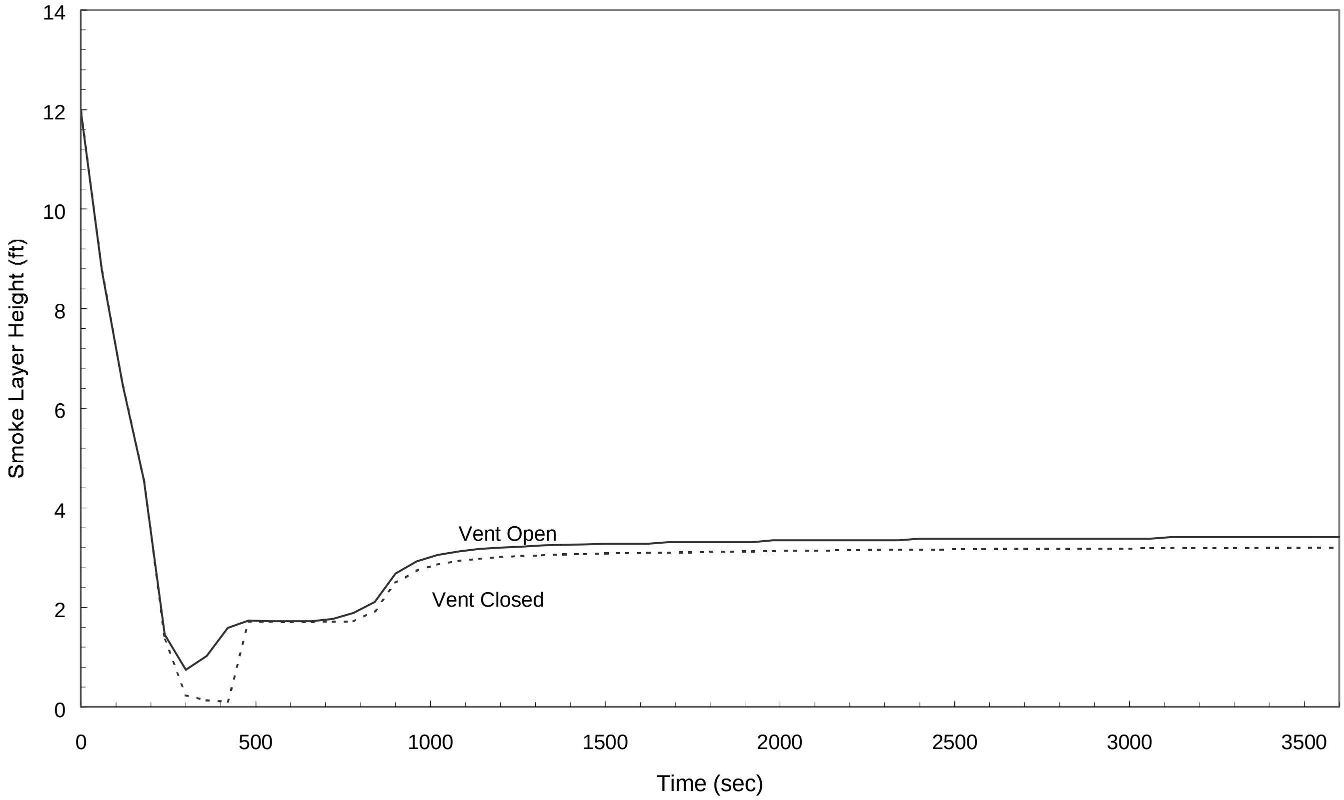

Figure 9 Smoke Layer Height in Fire Zone 98-J. Input Heat Release Rate Test # 24, NUREG/CR-4527, Volume 2

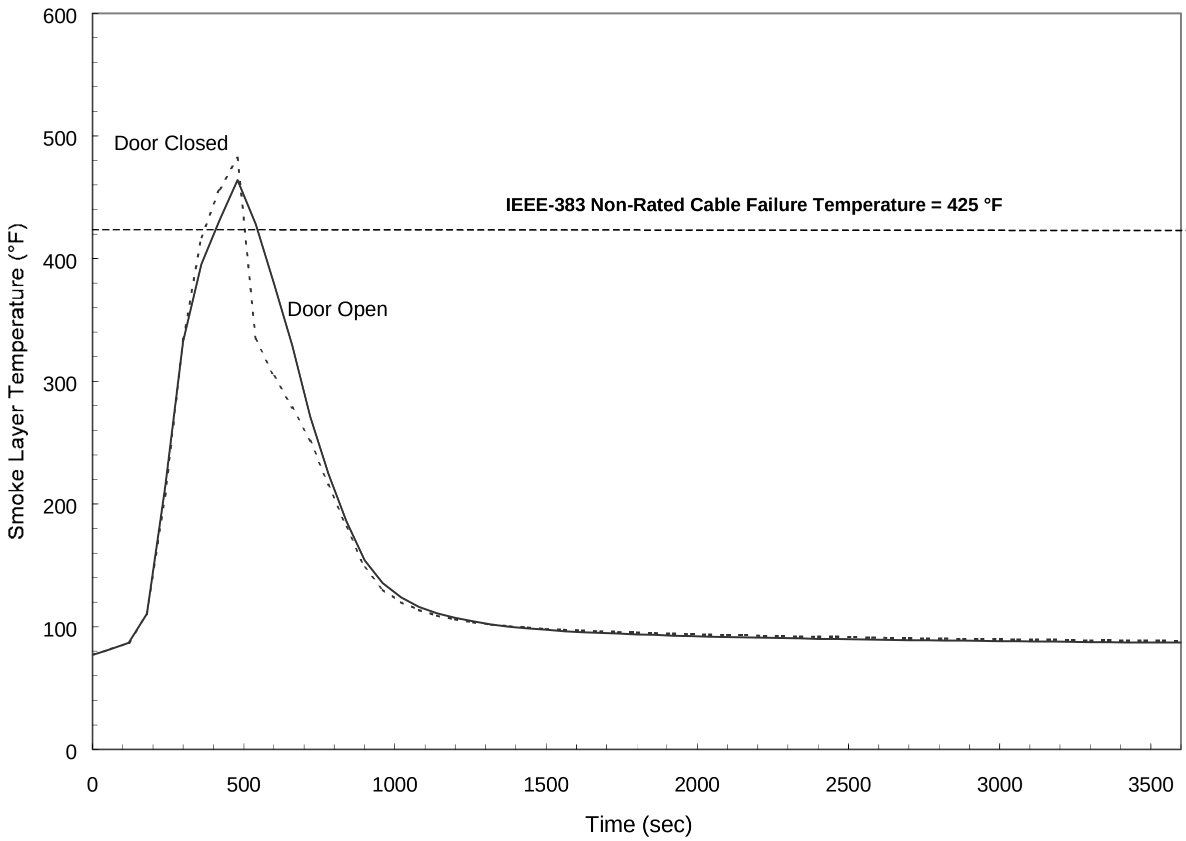

Figure 10 Smoke Layer Temperature in Fire Zone 99-M. Input Heat Release Rate Test # 24, NUREG/CR-4527, Volume 2

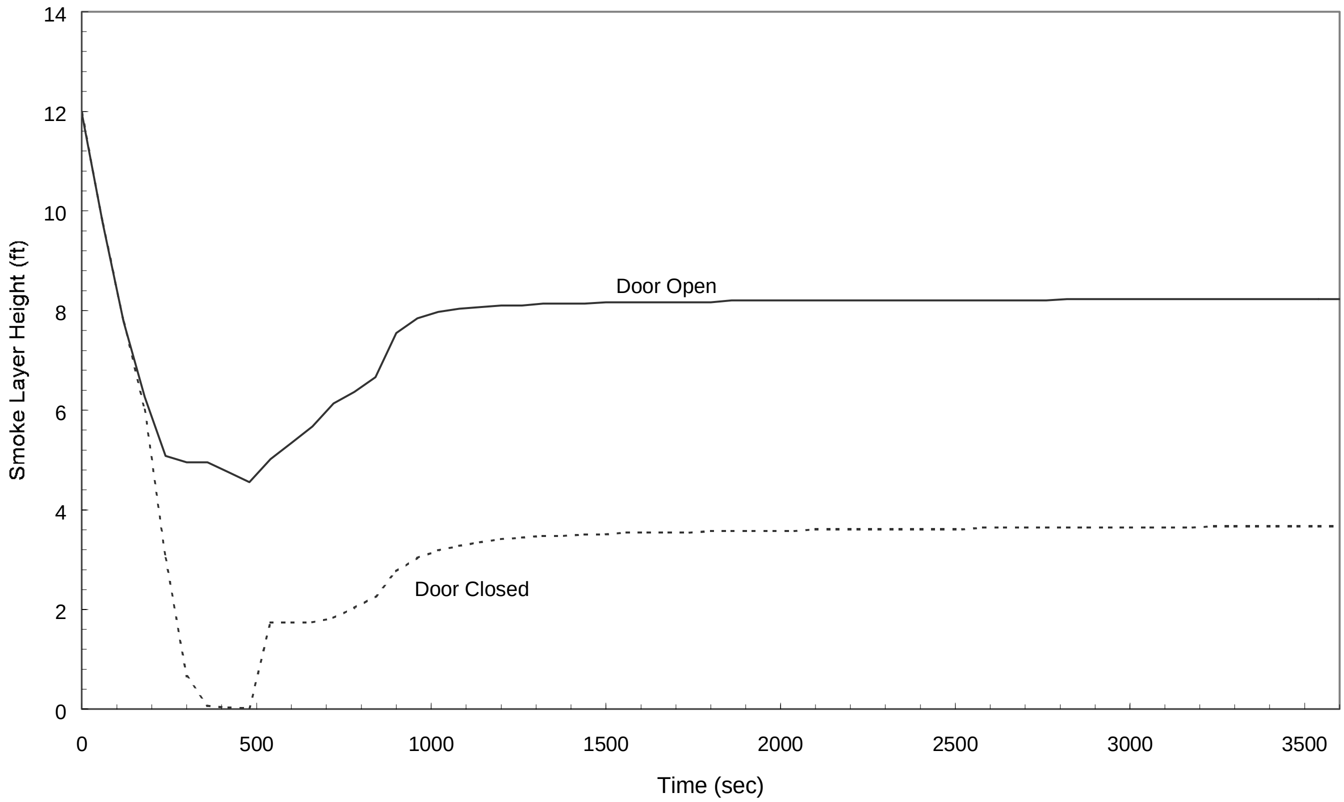

Figure 11 Smoke Layer Height in Fire Zone 99-M. Input Heat Release Rate Test # 24, NUREG/CR-4527, Volume 2

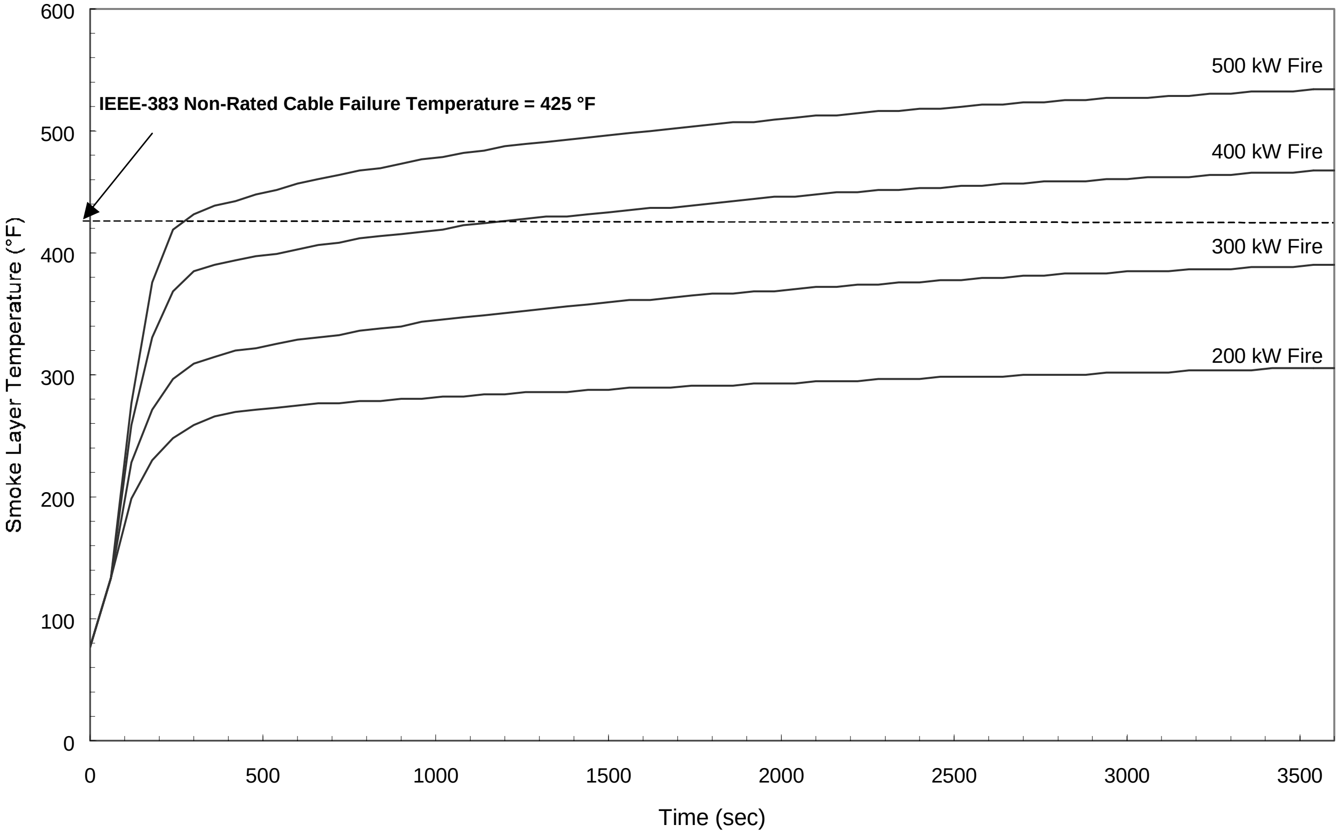

Figure 12 Smoke Layer Temperature in Fire Zone 98-J, Emergency Diesel Generator Corridor, Vent Open

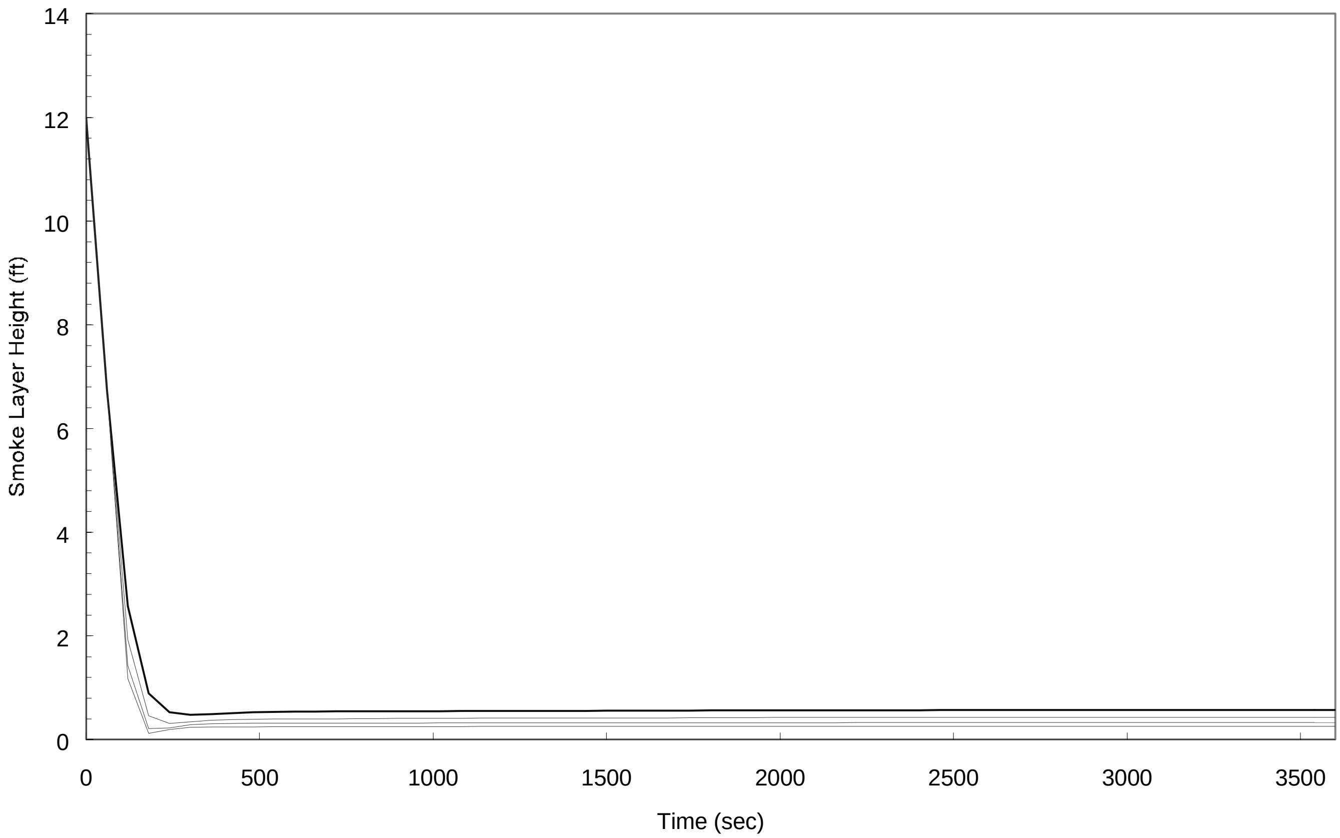

Figure 13 Smoke Layer Height in Fire Zone 98-J, Emergency Diesel Generator Corridor, Vent Open

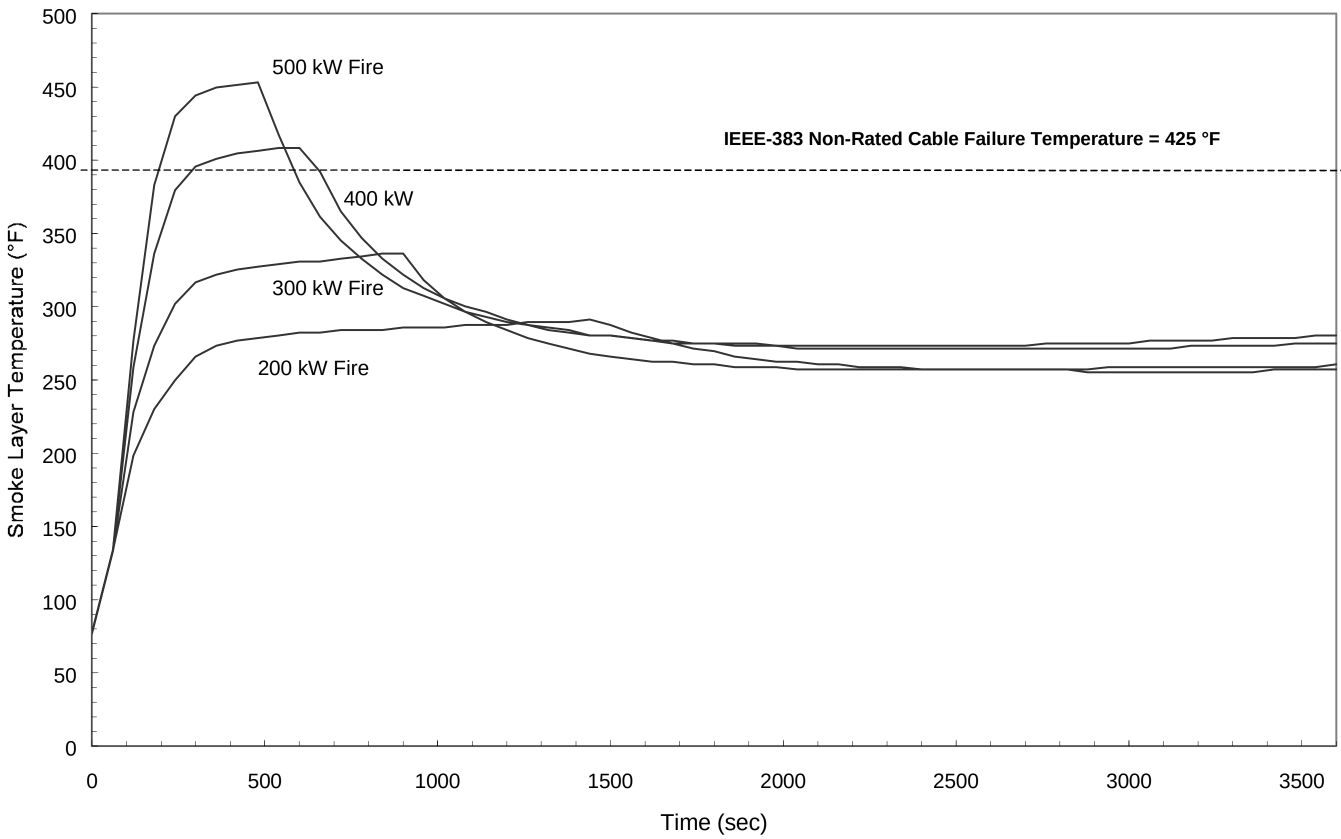

Figure 14 Smoke Layer Temperature in Fire Zone 98-J, Emergency Diesel Generator Corridor, Vent Closed

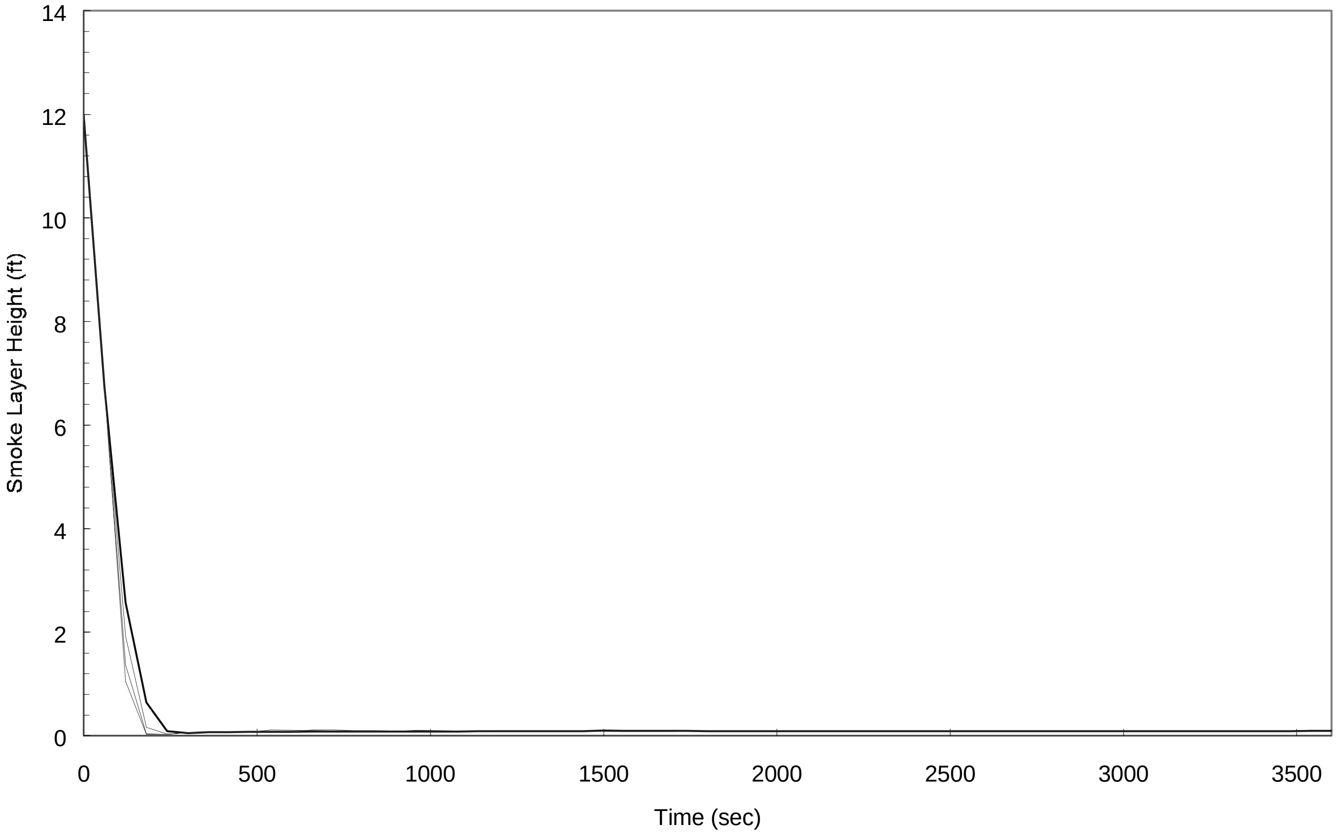

Figure 15 Smoke Layer Height in Fire Zone 98-J, Emergency Diesel Generator Corridor, Vent Closed

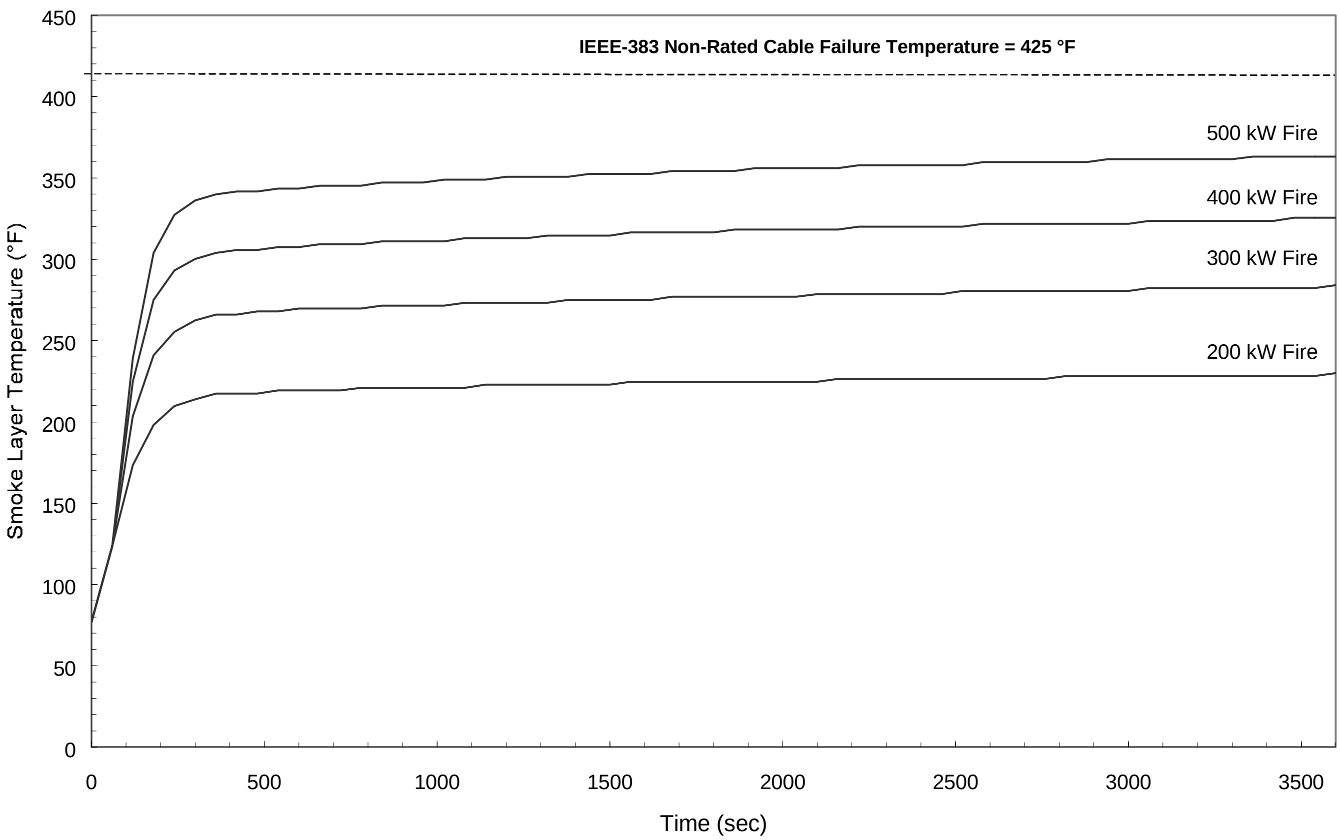

Figure 16 Smoke Layer Temperature in Fire Zone 99-M, North Electrical Switchgear Room, Door Open

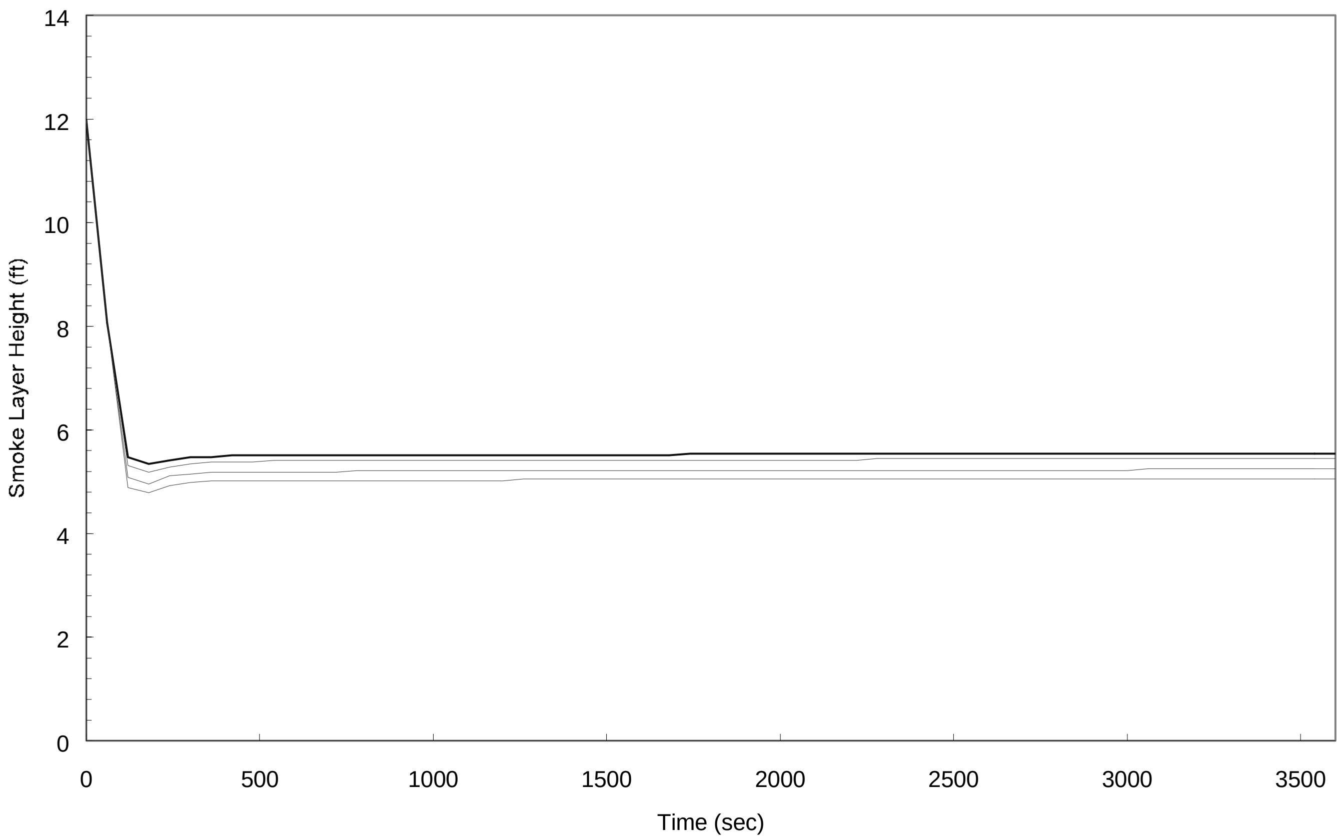

Figure 17 Smoke Layer Height in Fire Zone 99-M, North Electrical Switchgear Room, Door Open

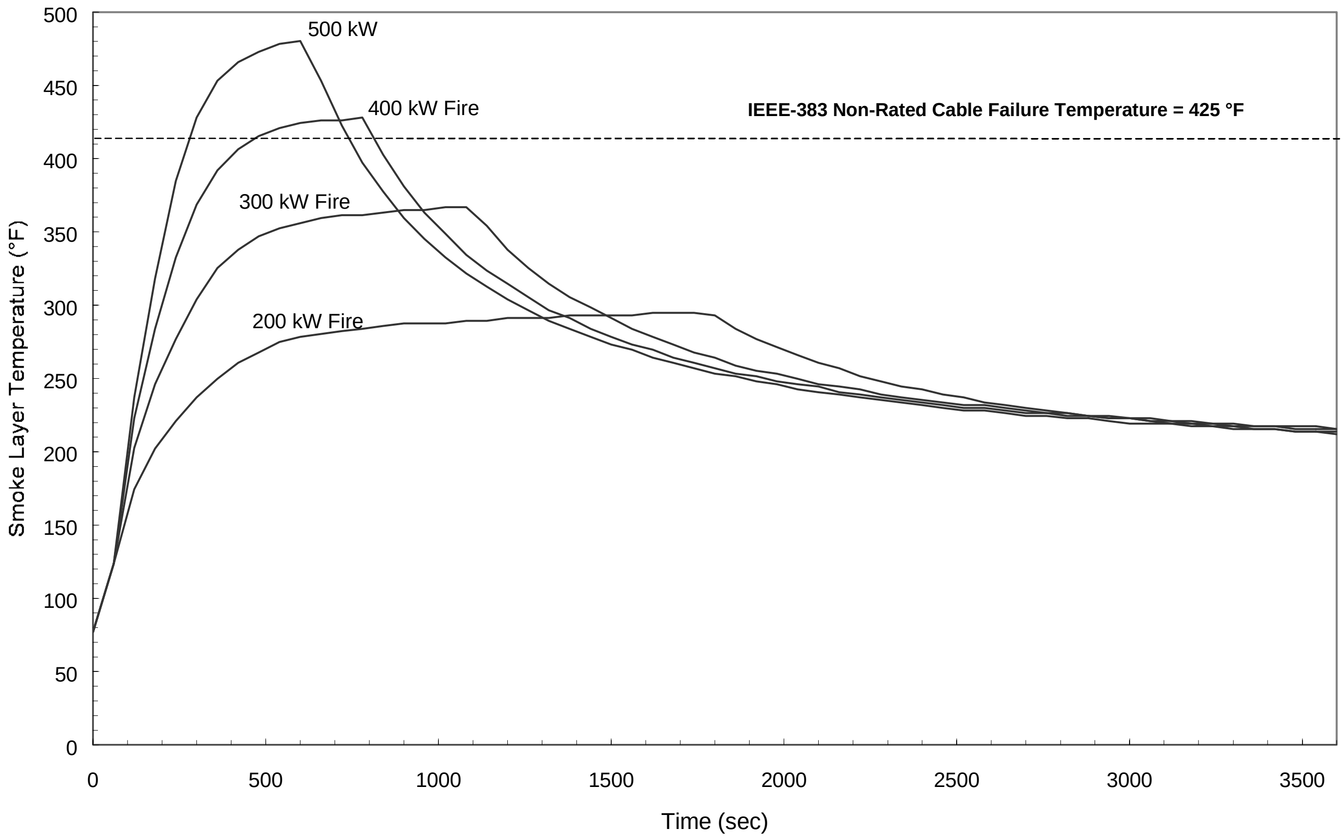

Figure 18 Smoke Layer Temperature in Fire Zone 99-M, North Electrical Switchgear Room, Door Closed

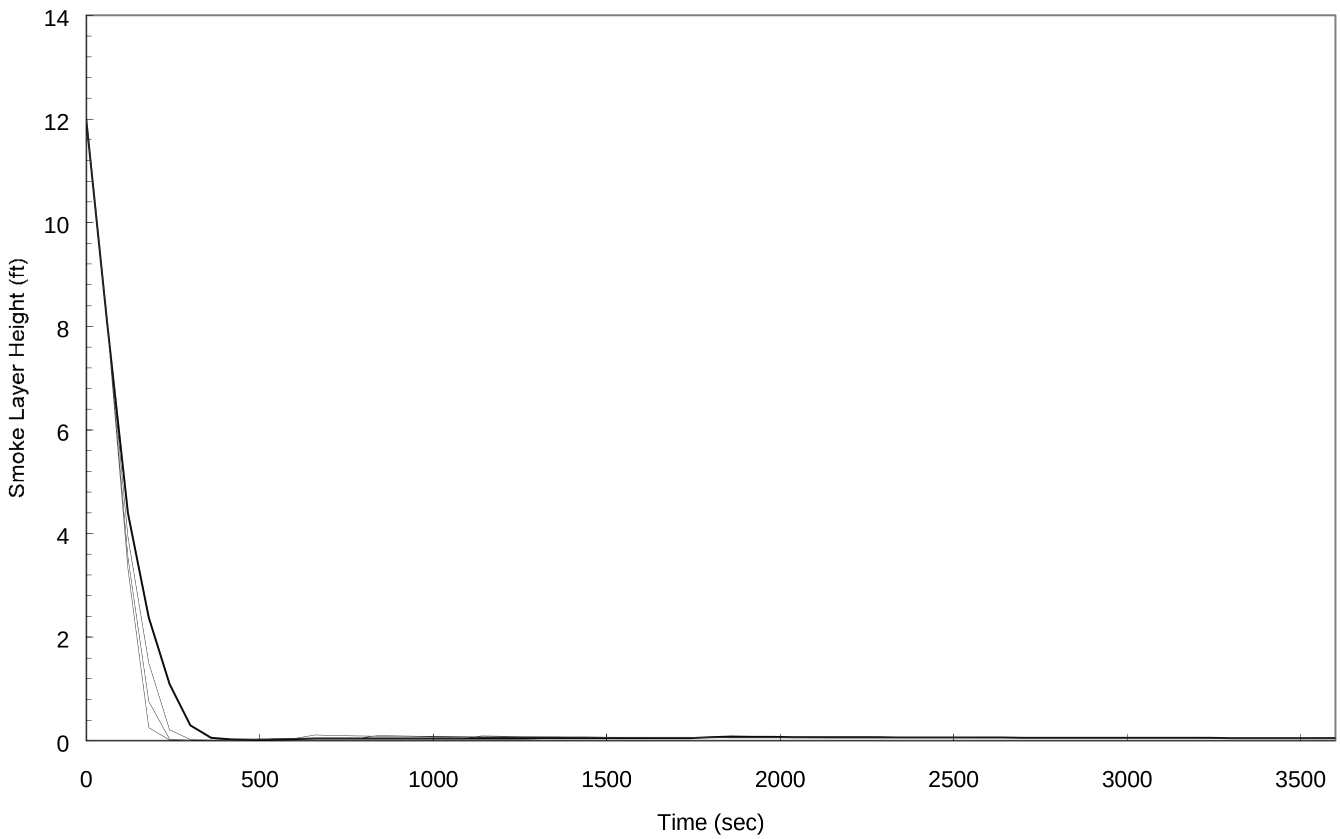

Figure 19 Smoke Layer Height in Fire Zone 99-M, North Electrical Switchgear Room, Door Closed

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APPENDIX - A

Computational Fire Modeling CFAST Input Data
Fire Zone 98-J, Emergency Diesel Generator Corridor and
99-M, North Electrical Switchgear Room
Arkansas Nuclear One - Unit 1

```
VERSN  3   Fire Zone 98-J, 200 kW fire, Vent Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.9144  0.6096  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 10  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  66.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  200000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-1.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, 300 kW fire, Vent Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.9144  0.6096  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 10  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  80.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  300000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.03
STPMAX  1.00
DUMPR ANO-2.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, 400 kW fire, Vent Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.9144  0.6096  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 10  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.  60.0  93.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  400000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-3.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, 500 kW fire, Vent Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.9144  0.6096  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 10  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  104.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  500000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-4.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, 200 kW fire, Vent Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.6096   0.3048   0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 10  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  66.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  200000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-5.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, 300 kW fire, Vent Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.6096  0.3048  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 10  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  80.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  300000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.03
STPMAX  1.00
DUMPR ANO-6.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, 400 kW fire, Vent Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.6096  0.3048  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 10  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.  60.0  93.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  400000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-7.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, 500 kW fire, Vent Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.6096  0.3048  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 10  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  104.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  500000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-8.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, 200 kW fire, Door Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.82  2.44  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  66.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  200000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-9.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, 300 kW fire, Door Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.82  2.44  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  80.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  300000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-10.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, 400 kW fire, Door Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.82  2.44  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  93.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  400000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-11.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, 500 kW fire, Door Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.82  2.44  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  104.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  500000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-12.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, 200 kW fire, Door Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.0  0.15  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  66.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  200000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-13.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, 300 kW fire, Door Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.0  0.15  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  80.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  300000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-14.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, 400 kW fire, Door Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.0  0.15  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  93.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  400000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-15.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, 500 kW fire, Door Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.0  0.15  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 30.0  60.0  104.0
FHIGH 0.5  0.5  0.5
FAREA 0.5  0.5  0.5
FQDOT 0.0  42210  168840  500000
CJET OFF
CO    0.14  0.14  0.14
OD    0.05  0.05  0.05
HCR   0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-16.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, Electrical Cabinet Fire, Test # 23, Vent Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.9144  0.6096  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 90.0  156.0  372.0  450.0  525.0  630.0  720.0  780.0  900.0
FHIGH 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FAREA 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FQDOT 0.0  40000  85000  70000  690000  600000  900000  1235000  925000  1050000
300000
CJET OFF
CO    0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14
OD    0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05
HCR   0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-17.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, Electrical Cabinet Fire, Test # 23, Vent Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.6096  0.3048 0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 90.0  156.0  372.0  450.0  525.0  630.0  720.0  780.0  900.0
FHIGH 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FAREA 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FQDOT 0.0  40000  85000  70000  690000  600000  900000  1235000  925000  1050000
300000
CJET OFF
CO    0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14
OD    0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05
HCR   0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-18.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, Electrical Cabinet Fire, Test # 23, Door Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.82  2.44  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 90.0  156.0  372.0  450.0  525.0  630.0  720.0  780.0  900.0
FHIGH 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FAREA 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FQDOT 0.0  40000  85000  70000  690000  600000  900000  1235000  925000  1050000
300000
CJET OFF
CO    0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14
OD    0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05
HCR   0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-19.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, Electrical Cabinet Fire, Test # 23, Door Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.0  0.15  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 90.0  156.0  372.0  450.0  525.0  630.0  720.0  780.0  900.0
FHIGH 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FAREA 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FQDOT 0.0  40000  85000  70000  690000  600000  900000  1235000  925000  1050000
300000
CJET OFF
CO    0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14
OD    0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05
HCR   0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-20.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, Electrical Cabinet Fire, Test # 24, Vent Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.9144  0.6096  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 150.0  270.0  450.0  480.0  519.0  612.0  720.0  810.0  840.0
FHIGH 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FAREA 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FQDOT 0.0 20000  600000  1200000  1300000  1000000  600000  190000  100000  0.0
CJET OFF
CO    0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14
OD    0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05
HCR   0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-21.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 98-J, Electrical Cabinet Fire, Test # 24, Vent Closed
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  2.76
DEPTH  18.28
HEIGH  3.65
HVENT  1  2  1  0.6096  0.3048 0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 150.0  270.0  450.0  480.0  519.0  612.0  720.0  810.0  840.0
FHIGH 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FAREA 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FQDOT 0.0 20000  600000  1200000  1300000  1000000  600000  190000  100000  0.0
CJET OFF
CO    0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14
OD    0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05
HCR   0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-22.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```

```
VERSN  3   Fire Zone 99-M, Electrical Cabinet Fire, Test # 24, Door Open
TIMES 3600  60  60  60   0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.0
WIDTH  10.56
DEPTH  7.72
HEIGH  3.65
HVENT  1  2  1  1.82  2.44  0.0  0.0
CEILI  CONCRETE
WALLS  CONCRETE
FLOOR  CONCRETE
CHEMI 16. 10. 12.  24000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  -1.0  -1.0  0.0
FTIME 150.0  270.0  450.0  480.0  519.0  612.0  720.0  810.0  840.0
FHIGH 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FAREA 0.5  0.5   0.5   0.5   0.5   0.5   0.5   0.5  0.5
FQDOT 0.0 20000  600000  1200000  1300000  1000000  600000  190000  100000  0.0
CJET OFF
CO    0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14  0.14
OD    0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05  0.05
HCR   0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30  0.30
STPMAX  1.00
DUMPR ANO-23.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRA
```

ENCLOSURE 2

Phase 3 SDP Analysis: Arkansas Nuclear One Unit 1 (ANO-1)

Lack of Adequate Procedures for Manual Actions to Achieve Post-Fire Safe Shutdown Following Fire Damage in Fire Zones 98J and 99M

1. Performance Deficiency

The Arkansas Nuclear One Unit 1 (ANO-1) fire zone 98-J (Diesel Generator Corridor) and fire zone 99-M (North Electrical Switchgear Room) did not meet regulatory requirements for separation of electric cables and equipment of redundant trains of systems necessary to achieve post-fire safe shutdown. The licensee did not have adequate procedures for manual actions to achieve post-fire safe shutdown following a fire in fire zones 99-J and 98-M. This condition has existed since the issue was identified as Unresolved Item 50-313;368/0106-02 in the Inspection Report 50-313;368/01-06, August 20, 2001.

2. Fire Scenario

The primary combustibles in the ANO-1fire zones 98-J and 99-M are the safety-related non-qualified IEEE-383 electrical cables routed in open cable trays that are located above numerous potential ignition sources. The height of the lowest cable tray in fire zone 98-J is approximately 6 ft. from the floor; while in the case of fire zone 99-M, the height of the lowest cable tray from the floor is about 8 ft. In fire zone 98-J, the potential ignition sources include a battery charger, 480V motor control centers, 125V DC distribution panels, wall-mounted electrical cabinets, emergency ventilation units, and an emergency chiller unit (VUC4A/C51). The potential ignition sources in fire zone 99-M include an air-cooled transformer (X6), a 120V instrument transformer (X62), 4.16kV switchgear cabinets, 480V motor control centers, a 480V load center, inverter cabinets, and ventilation units. Other potential ignition sources, such as a power cable failure in a tray, or other electrical originated failures (in distribution panels, circuit boards, electrical wiring, internal cable fault, electrical circuit fault in switchgear cabinets, etc.) leading to ignition of the in-situ combustibles (cables), are considered in the fire scenario. Other ignition sources such as hot work (welding) or a limited 100-lb transient combustible source are also possible, but are not considered within the scope of this analysis.

The combustible loading in fire zone 98-J consists of mostly cables in the cable trays. According to licensee-provided information and calculations, the fire duration in fire zone 98-J was estimated to be 2 hours and 15 minutes by considering all available in-situ combustibles and the potential 100-lb transient combustible source. The combustible loading in fire zone 99-M also consists primarily of cable insulation in open cable trays. Considering all available in-situ combustibles and a potential 100-lb transient combustible source, the fire duration in 99-M was estimated to be 30 minutes.

The credible fire scenario is based on postulating that a fire develops from any one of the potential ignition sources, **if undetected and unsuppressed (i.e., no immediate intervention from plant operators)**, would grow to a rate of heat release of 400 kW (or 380 BTU/s) and ignite the cable insulation of electrical cables resulting in challenging fires. The Diesel Generator Corridor in fire zone 98-J is provided with smoke detection and a partial-coverage automatic water suppression system that is actuated by crosszoned smoke and in-tray linear heat detectors. The ionization smoke detectors are provided at the ceiling level that only alarms in the Main Control Room (MCR). The linetype heat detectors (trade named Protectowire) are installed on the top of the cables in each cable tray, and also alarm in the MCR. The automatic deluge sprinkler system provides partial protection to the fire zone 98-J, and will activate upon receiving successful cross-zone detection signals from both of the smoke and linear heat detectors. A fire hose reel and portable carbon dioxide extinguishers are located in the vicinity of the fire zone for manual fire fighting purposes when needed. Fire zone 98-J is normally unoccupied except for inspections, shift tours and maintenance activities. The fire zone 99-M (North Electrical Switchgear Room) is only protected with a smoke detection system. The smoke detectors are provided at the ceiling level which alarm in the MCR. There are no fixed automatic fire suppression systems in this switchgear room. A fire hose reel and portable carbon dioxide extinguishers are also provided in the vicinity of the fire zone for manual fire fighting purposes when needed. Fire zone 99-M is normally unoccupied except for inspections, shift tours and maintenance activities.

In the fire scenario development, it is assumed that a credible fire starts from a specific ignition source (e.g., transformers, electrical cabinets, 4.16kV switchgear, 480 V motor control centers, 480V load center, 125V DC distribution panels, or cables) and has sufficient flame spread (i.e., flame height and radius) to ignite a cable tray closest to the ignition source. The SPLB fire hazards and fire modeling analyses (see ADAMS Accession #ML021490005*, #ML021990405*) postulated that energetic electrical faults in electrical cabinets, producing a fire with heat release rate (HRR) of 400kW or greater, can lead to fire growth and subsequent fire damage to target cables depending on the ventilation conditions in the compartment. Two different cases of fire compartment conditions were considered to define the fire damaging scenarios for the two fire zones: (1) vent open and closed in Fire Zone 98-J, and (2) door open and closed in Fire Zone 99-M.

The CFAST (Consolidated Model of Fire Growth and Smoke Transport) computer code was used to model the fire growth of fire involving electrical cabinet and equipment that would lead to a challenging fire in the fire zones 98-J and 99-M. In each of the fire scenarios, a range of HRR curves from 200 kW to 500 kW were used as input to the CFAST fire modeling analyses because no direct data on the burning of the specific electrical ignition sources at full or intermediate scale were available. As documented in NUREG/CR-4527, the selected range of HRR curves were developed for electrical cabinet fires from full-scale fire tests conducted on electrical cabinets in a large (e.g., actual control room size) enclosure. In the fire modeling analyses, the fire was assumed to develop with a "t_2 fast fire growth rate" due to the electrically energized fire environment (see ADAMS Accession #ML021990405*). It is also assumed that there is complete combustion and an ample supply of oxygen for the fire with the given HRR.

In modeling the fire growth and damage potential, results of SPLB fire modeling analyses show that fires with HRR of 400kW could damage the overhead cables in fire zone 98-J with open vent conditions, and in fire zone 99-M with closed door conditions. In the fire scenario for fire zone 98-J with open vent conditions, the smoke layer temperature reaches 425 °F in approximately **19 minutes.** In the case of fire zone 99-M with closed door conditions, the smoke layer temperature reaches 425 °F in approximately **10 minutes.** The limiting temperature of 425 $_0$F was used in the fire modeling analyses because this temperature condition can cause failure of non-IEEE-383 rated cables. The results of the fire modeling analyses also indicate that fires with HRR of 200 kW and 300 kW in the two fire zones tend to become ventilation limited and decay with time. A fire with HRR of 200kW could only result in a maximum smoke layer temperature of 305 $_0$F in about one hour for the fire zone 98-J with open vent conditions. This result indicates that the overhead cables may remain undamaged in fire zone 98-J for an hour under the postulated conditions.

Based on results of the fire hazards analysis, SPLB fire protection staff also postulated a fire scenario involving a lube oil spill fire resulting from a breach or leak in the lube oil system for the emergency chiller chilled water pump located in fire zone 98-J. The fire modeling analysis for this scenario indicates that a single gallon of lube oil spill, if ignited, could form a pool fire with a diameter of approximately 1.5 feet, flame height of 6 feet, and burn duration of 7.5 minutes. The flame height of the postulated pool fire is sufficiently high to impinge on the cable insulation of the non-IEEE-383 rated cables on the lowest cable tray that is located about 6 feet from the floor. It was concluded that the turbulent diffusion flame impingement on the cables would cause potential ignition and flame spread along the cable trays, and thereby further increases the HRR in the fire zone 98-J.

3. Assumptions

(a) Fire Barriers - In fire zone 98-J, the walls and doors are 3-hour rated fire barriers. A one-hour rated barrier surrounds the Red train AC instrumentation power supply cables, while other Red train power cables in fire zone 98-J are unprotected. The Red train redundant cables are not separated from the Green train cables by a minimum of 20 feet distance free of intervening combustibles. In fire zone 99-M, the Red train cables are not protected with one-hour rated barrier, and are not separated from the Green train cables by a minimum of 20 feet distance free of intervening combustibles. As such, the cables in both fire zones could be damaged by a floor based fire.

(b) Automatic Fire Suppression - The East portion of fire zone 98-J is protected by a cross-zoned, pre-action deluge system that is actuated by cross-zoned smoke and intray linear heat detectors. Periodic surveillance is performed on the cable tray detection system and room smoke detection system to ensure that the suppression system remains operable. The sprinkler heads in the corridor are open heads, and water will be available as soon as the sprinkler valve opens in approximately 5 seconds (according to manufacturer's information). The suppression system response time is assumed to be approximately 7 minutes because the actuation time for the line-type heat detection system to sense a temperature of 190$_0$F was estimated to be less than 7 minutes. Therefore, the raceways that required more than 10 minutes to sustain damage can be assumed to be protected by the suppression system. The probability of pre-action sprinkler system being unavailable is assumed to be 0.05 for the normal operating state based on the EPRI database (EPRI FIVE report, page 10.3-7). This unavailability value includes the consideration for failure of the system to operate on demand and the system being out of service at the time of a fire (due to shut control valve, etc.). In fire zone 99-M, **no** automatic fire suppression system is provided.

(c) Fire Detection and Manual Fire Suppression - Both fire zones 98-J and 99-M are equipped with ionization detection systems that will detect fires in the incipient stages and provide alarm conditions in the Main Control Room (MCR). Alarms from the ionization detection system would result in the dispatch of an operator to investigate any of the two fire zones. The central fire brigade locker is located one elevation above the fire zones 98-J and 99-M, and therefore, the travel time of the fire brigade from the locker to the fire scene is considered to be reasonably short.

Based on recent fire drills performed on fire zone 100-N, which is adjacent to fire zone 99-M, the response times of the entire fire brigade arriving at the fire zone averaged less than 10 minutes. There are two access points to the fire zones, which are easily accessible by the fire brigade response team. Based on these factors, it was assumed that any fire scenario requiring greater than 20 minutes to sustain cable damage may be suppressed by the fire brigade.

The fire-induced core damage frequency equation for the fire zones can be defined as follows:

$$F_{CDF} = F_i * S_f * P1 * P2 * P3$$

where: F_i = Fire ignition frequency of ignition source
S_f = Severity factor for a challenging fire
P1 = Probability of automatic fire suppression system being unavailable
P2 = Failure probability of manual suppression by fire brigade
P3 = Conditional core damage probability, with or without recovery actions

4: Fire Ignition Frequencies

The various ignition sources in the fire zones 98-J and 99-M respectively, and their associated fire ignition frequency estimates, as calculated using the EPRI FIVE methodology and listed on the Ignition Source Data Sheet (ISDS) for the two ANO-1 fire zones, are shown below:

Fire Zone 98-J Ignition Sources	Generic Frequency	WF_L	WF_I	ISDS Ignition Frequency
Electrical Cabinets	1.9 E-2	1	1.01 E-1	1.9 E -3
Battery Charger	4.0 E-3	2	9.52 E-2	7.6 E -4
Ventilation Subsystems	9.5 E-3	2	1.12 E-2	2.1 E-4
Fire Protection Panels	2.4 E-3	2	2.33 E-2	1.1 E-4
Emergency Chiller Pump	9.5 E-3	2	2.80 E-3	5.3 E-5

Fire Zone 99-M Ignition Sources	Generic Frequency	WF_L	WF_I	ISDS Ignition Frequency
Electrical Cabinets	1.5 E-2	0.25	1.0	3.8 E-3
Transformers	7.9 E-3	2	2.04 E-2	3.2 E-4
Ventilation Subsystems	9.5 E-3	2	5.60 E-3	1.1 E-4

The ISDS ignition frequency estimates of each identified ignition source were derive based on adjusting the generic fire ignition frequencies by a location weighting facto(WF_L) and an ignition source weighting factor (WF_I). The generic fire ignition frequencies used in this analysis were based on the EPRI database (EPRI Fire PRA Implementation Guide, pages 4-7 & 4-8, Table 4.2). A comparison of the generic fire ignition frequency estimates against the NRC updated fire events database (Houghton, RES) showed that the generic frequency estimates were slightly higher.

With the exception of the electrical cabinets, all of the above listed sources were considered as “Plant Wide “ components and therefore, were assigned a $WF_L = 2$ (i.e., number of units per site). For fire zone 98-J in the auxiliary building, the electrical cabinets were assigned $WF_L = 1$ because of the number of units per site divided by the number of auxiliary buildings. For fire zone 99-M (which is a switchgear room), the electrical cabinets were assigned $WF_L = 0.25$ because of 2 units per site divided by 8 switchgear rooms.

The weighting factor, WF_I, for plant-wide components is obtained by dividing the number of components in the specified room by the total number of components in the plant. In fire zone 98-J, $WF_I = 0.101$ is derived for the electrical cabinets by dividing 147 cabinets in the corridor by the total number of 1452 cabinets in the auxiliary building. Similarly, the WF_I factors for the other ignition sources in both fire zones 98-J and 99-M were derived from plant-specific data (as provided in ANO-1 licensee response package). In fire zone 98-J, there are 4 ventilation subsystems, whereas there are two ventilation units in fire zone 99-M. In fire zone 98-J, there are 2 fire protection panels, whereas there are none in fire zone 99-M. In fire zone 98-J, there are no transformers, whereas there are two transformers in fire zone 99-M. In fire zone 98-J, there are 2 battery chargers, whereas there are none in fire zone 99-M. Based on licensee Calculation 85-E-0053-47, the total number of ventilation subsystems is 357, the total number of fire protection panels is 86, the total number of transformers is 98, and the total number of battery chargers is 21 (increased from 19 due to recent modifications).

The ignition frequency of the emergency chiller pump was derived using the generic frequency for the ventilation subsystems because there was no plant-specific ignition frequency data. The WF_I factor for the emergency chiller pump was based on a single ventilation subsystem in the fire zone. Therefore, WF_I = 1/357 = 2.8 E-3 was used in deriving the ignition frequency for the emergency chiller pump. The emergency chiller unit in fire zone 98-J is a standby component and its operability is demonstrated on a monthly basis by a surveillance test with duration of less than 30 minutes. The test is performed by Operations personnel who are trained fire brigade members.

5: Conditional Core Damage Probability (CCDP)

In the various fire scenarios considered (i.e., each scenario initiated by a different ignition source), conditional core damage probabilities (CCDPs) were calculated for the two fire zones using the ANO-1 IPEEE fire risk model for two cases: (a) no operator recovery actions were credited, and (b) credit for operator actions to recover the Emergency Feedwater (EFW) system and other required actions for safe shutdown. In both cases, the CCDP calculations were performed for two conditions: (i) one Red equipment train is available to perform mitigating functions, and (ii) both Red and Green equipment trains are unavailable due to the severe, challenging fire. In the event that both redundant equipment trains in a fire zone are affected by fire, the CCDPs would be dominated by operator actions to achieve safe shutdown outside of the main control room.

In the licensee's PSA analyses to estimate the CCDPs with no operator recovery actions (ANO-1 Calculations 02-E-0004-01 and 02-E-0004-02), the following operator recovery actions were not credited (i.e., set to logical TRUE in the cutsets of the risk model) to analyze the impact of inability to accomplish these operator actions outside of the control room by operations during the fire:

1. Operator fails to isolate ICW after automatic SW isolation fails on ES
2. Operator fails to start and control EFW pump P-7A manually when offsite power is available
3. Operator fails to start and control EFW pump P-7B from control room when offsite power is available
4. Operator fails to open breaker locally at A1 from the unit auxiliary transformer and close the breaker from startup transformer SUT1
5. Operator fails to manually close breaker 152-308 or 152-408 for EDG recovery
6. Operator fails to de-energize CV-2646 and CV-2648 (with consideration of hot-short probability for CV-2646 or CV-2648)

As shown in the ANO-1 Calculations 02-E-0004-01 and 02-E-0004-02, the CCDPs calculated for the two fire zones for the different fire scenarios are provided below:

Fire Zone 98-J East Area	CCDP with No Operator Recovery	CCDP with Operator Recovery
All Redundant Cable Trains Failed	1.13 E-2	2.18 E-4
Red Train Protected	8.10 E-3	1.97 E-4

Fire Zone 98-J West 1 Area	CCDP with No Operator Recovery	CCDP with Operator Recovery
All Redundant Cable Trains Failed	5.38 E-4	1.39 E-4
Red Train Protected	5.38 E-4	1.39 E-4

Fire Zone 98-J West 2 Area	CCDP with No Operator Recovery	CCDP with Operator Recovery
All Redundant Cable Trains Failed	2.49 E-3	1.85 E-4
Red Train Protected	5.38 E-4	1.26 E-4

Fire Zone 99-M	CCDP with No Operator Recovery	CCDP with Operator Recovery
All Redundant Cable Trains Failed	5.76 E-2	1.27 E-3
Red Train Protected	7.96 E-3	8.32 E-4

6. ***Integrated Assessment of Fire-Induced Core Damage Frequency***

The fire-induced CDF estimate for fire in the fire zones 98-J and 99-M with no operator recovery actions is calculated as shown below:

Fire Zone 98-J Ignition Sources	F_i	S_f	P1	P2	P3	F_{CDF}
Electrical Cabinets	1.9 E-3	0.75	0.05	0.5	9.2E-3	3.3E-7
Battery Chargers	7.6 E-4	0.75	0.05	0.5	9.2E-3	1.3E-7
Ventilation Subsystems	2.1 E-4	0.08	0.05	0.5	9.2E-3	3.0E-9
Fire Protection Panels	1.1 E-4	0.12	0.05	0.5	9.2E-3	3.0E-9
Emergency Chiller Pump	5.3E-5	0.08	0.05	0.5	1.4E-2	1.0E-9
Total CDF						4.7E-7

Fire Zone 99-M Ignition Sources	F_i	S_f	P1	P2	P3	F_{CDF}
Electrical Cabinets	3.8 E-3	0.12	1.0	0.5	5.8E-2	1.3E-5
Transformers	3.2 E-4	0.10	1.0	0.5	5.8E-2	9.3E-7
Ventilation Subsystems	1.1 E-4	0.08	1.0	0.5	5.8E-2	2.6E-7
Total CDF						1.4E-5

(a) Severity Factors, S_f - A fire severity factor is a fractional value (between 0 and 1) that is used to adjust fire frequency estimates to reflect some specific mitigating pattern of behavior of the fire event. The severity factor is applied to reflect a split in large versus small fires. In the absence of plant-specific information, the severity factors for the electrical cabinets, ventilation systems, and fire protection panels were based on the EPRI Fire PRA Implementation Guide (FPRAIG), December 1995 (Section D.3). The FPRAIG severity factors ranged from 0.08 to 0.2, and engineering judgment was used to determine these severity factors.

In the case of the electrical cabinets and battery chargers in fire zone 98-J, the EPRI FPRAIG did not provide specific severity factor values for electrical cabinets and battery chargers in the Auxiliary building. Therefore, the licensee's assigned severity factor of 0.75 was assumed in this analysis.

(b) Probability of automatic suppression system being unavailable, P1 - As discussed in Section 3(b), the probability of pre-action sprinkler system in fire zone 98-J being unavailable is assumed to be 0.05 for the normal operating state based on the EPRI database (EPRI FIVE report, page 10.3-7). This unavailability value include the consideration for failure of the system to operate on demand and the system being out of service at the time of a fire (due to shut control valve, etc.). In fire zone 99-M, **no** automatic fire suppression system is provided. Therefore, the P1 value was assumed to be 1.0.

(c) Manual Suppression by Fire Brigade, P2 - Recent fire drills performed on fire zone 100-N, which is adjacent to fire zone 99-M, indicated that the response times of the entire fire brigade arriving at the fire zone averaged less than 10 minutes. There are two access points to the fire zones, which are easily accessible by the fire brigade response team.

Based on these considerations, it was assumed that any fire scenario requiring greater than 20 minutes to sustain cable damage may be suppressed by the fire brigade. However, the SPLB fire modeling analyses indicate that severe fires with HRR greater than 400 kW in fire zones 98-J and 99-M could cause damage to the overhead cables in approximately 19 minutes and 10 minutes, respectively. Therefore, the failure probability of manual suppression by the fire brigade associated with severe fires was estimated to be 0.5 in this risk analysis.

(d) Conditional Core Damage Probability, P3 - For the fire scenarios in fire zone 98-J involving ignition of the electrical cabinets, battery chargers, ventilation systems, and fire protection panels, it is assumed that one equipment train would be available to perform mitigating functions because a one-hour rated barrier surrounds the Red train AC instrumentation power supply cables. Although other Red train power cables in fire zone 98-J are unprotected, the estimated time of 19 minutes to cable damage allows the arrival of the fire brigade in 10 minutes to control the fire. It is not likely that a fire from these sources would damage both equipment trains at the same time. Therefore, the CCDP estimate of 9.2E-3 (summed over all portions of fire zone 98-J) was used in the risk analysis of the fire scenarios involving these ignition sources. In the case of the fire scenario involving the emergency chiller pump, the pool fire with a flame height of 6 feet and burn duration of 7.5 minutes was postulated to impinge on the cable insulation of the non-IEEE-383 rated cables on the lowest cable tray that is located about 6 feet from the floor. It was concluded that the turbulent diffusion flame impingement on the cables would cause potential ignition and flame spread along the cable trays, and thereby further increases the HRR in the fire zone 98-J. It is likely that a fire from this pool fire may damage both equipment trains at the same time. Therefore, the CCDP estimate of 1.4E-2 (summed over all portions of fire zone 98-J) was used in the risk analysis of this fire scenario.

For the fire scenarios in fire zone 99-M involving ignition of the electrical cabinets, transformers, and ventilation systems, it is assumed that both equipment trains would not be available to perform mitigating functions because the Red train cables are not protected with one-hour rated barrier, and are not separated from the Green train cables by a minimum of 20 feet distance free of intervening combustibles. Therefore, the CCDP estimate of 5.8 E-2 was used in the risk analysis of the fire scenarios in fire zone 98-M.

7: Incremental Fire-Induced CDF

The baseline CDF (conforming case) for the fire scenarios in the fire zones 98-J and 99-M with credit of operator recovery actions is calculated by assuming the manual suppression failure probability of 0.1. This value is used for the manual suppression capability because it is considered to be appropriate for the entire population of fires, including severe fires, arising from an ignition source. The fire protection SDP methodology, which uses the entire population of fires as the basis to derive an ignition frequency, also uses the probability value of 0.1, in general, for the failure probability of nondegraded manual suppression capability. The baseline CDF with credit of operator recovery actions for the conforming-case analyses are shown below:

Fire Zone 98-J Ignition Sources	F_i	P1	P2	P3	F_{CDF}
Electrical Cabinets	1.9 E-3	0.05	0.1	4.6E-4	4.0E-9
Battery Charger	7.6 E-4	0.05	0.1	4.6E-4	1.0E-9
Ventilation Subsystems	2.1 E-4	0.05	0.1	4.6E-4	5.0E-10
Fire Protection Panels	1.1 E-4	0.05	0.1	4.6E-4	3.0E-10
Emergency Chiller Pump	5.3E-5	0.05	0.1	5.4E-4	1.0E-10
Total CDF					6.0E-9

Fire Zone 99-M Ignition Sources	F_i	P1	P2	P3	F_{CDF}
Electrical Cabinets	3.8 E-3	1.0	0.1	1.3E-3	4.9E -7
Transformers	3.2 E-4	1.0	0.1	1.3E-3	4.1E-8
Ventilation Subsystems	1.1 E-4	1.0	0.1	1.3E-3	1.4E-8
Total CDF					5.5E-7

Therefore, the incremental CDF changes due to taking credit for operator recovery actions for fire scenarios in fire zones 98-J and 99-M are estimated as follows:

A. Fire zone 98-J: (4.7E-7) - (6.9E-9) = 4.6E-7
B. Fire zone 99-M: (1.4E-5) - (5.5E-7) = 1.3E-5

CONCLUSION: The change in CDF due to taking credit for operator recovery actions for fire scenarios in fire zone 98-J is 4.6E-7, and the significance characterization is GREEN. The change in CDF due to taking credit for operator recovery actions for fire scenarios in fire zone 99-M is 1.3E-5, and the significance characterization is **[redacted]**.

* Please note that ML021990405 is Enclosure 1, "Fire Modeling of Fire Zone 98-J, Emergency Diesel Generator Corridor and 99-M, North Electrical Switchgear Room, Arkansas Nuclear One - Unit 1, to this letter.

ML021490005 is not provided.