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August 11, 2003

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Arkansas Nuclear One - Units 1 and 2
Docket Nos. 50-313 and 50-368
License Nos. DPR-51 and NPF-6
Request for Additional Information Regarding the July 10, 2003, Fire Protection Regulatory Conference

Dear Sir or Madam:

On July 10, 2003, a Regulatory Conference was held at Arlington, Texas involving personnel from the Nuclear Regulatory Commission and Entergy Operations, Inc. The purpose of the conference was to discuss a preliminary finding of safety significance associated with an apparent violation of fire protection regulation 10 CFR Part 50, Appendix R, Section III.G.2. During the conference, Entergy agreed to provide additional information in response to five NRC questions. The responses are contained in the attachment. The conclusions provided in Entergy's Regulatory Conference presentation remain unchanged as a result of the additional information provided in this letter. Should you have questions or comments, please contact Mr. Glenn Ashley at (479) 858-4617.

There are no new commitments contained in this submittal.

Sincerely,

Sherrie R. Cotton
Director, Nuclear Safety Assurance

SRC/dwb
Attachment

A006

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Responses to NRC Questions from July 10, 2003, Regulatory Conference

NRC Question 1

List the cables in Unit 2 that are thermoplastic, in which fire zones they appear, and the effect that having thermoplastic versus thermoset cables would have on your ability to achieve and maintain hot shutdown conditions in the event of a fire in these fire zones.

ANO Response

Table 1 contains the Unit 2 cables previously identified as containing thermoplastic jacketing and/or insulating materials. These cables were identified based on research conducted prior to the July 10, 2003, Regulatory Conference. This list was developed based upon a review of cable procurement and installation specifications for insulating and jacketing materials used in cable construction. Based on this research, it was determined that a small subset of instrumentation cables may have been supplied with thermoplastic insulating and jacketing materials. This information was summarized and presented during the conference. Note that based on additional research conducted after the conference, two of the cables are verified to be constructed with thermoset insulating materials and are removed from the list.

Subsequent research was conducted that revealed some additional cables located in Unit 1 that may also contain thermoplastic insulation/jackets (i.e., the cables are conservatively characterized as thermoplastic if sufficient evidence is not available to confirm the type of material used). Information from the Plant Data Management System and other databases were merged in order to perform research on a cable-by-cable basis. Over 6000 cable records were reviewed for the risk significant zones (99-M, 100-N, 104-S, 2040-ZZ, 2091-BB, 2096-M, and 2100-Z). These merged databases enabled corroboration of the results of the earlier procurement specification review for approximately 90 percent of the 6000 records reviewed. That is, these cables were confirmed to have thermoset insulation and jacket materials as specified in the procurement documents. Using this information, the cables identified during the regulatory conference as containing thermoplastic materials were verified. However, more focused examination yielded an additional six cables installed in cable trays or exposed which are characterized as containing thermoplastic materials (see Table 2 for the additional cables and associated information). Each of these six additional cables is associated with one wiring scheme and routed in only one of the fire zones, Unit 1 zone 104-S. None of the thermoplastic cables are safe shutdown cables.

In summary, based on cable-by-cable research utilizing available cable information databases, fewer that two-tenths of one percent of the cables are characterized as thermoplastic and none are safe shutdown cables.

Table 1
Thermoplastic Cables in Risk Significant Zones
(based on procurement specification research)

Cable	ANO Cable Type Code	Zone(s)	Mfr	Jacket	Insulation	Raceway
2M035AC	71X	2100-Z, 2091-BB	Raychem	Alkane-Imide Polymer	Polyolefin	Zone 2100-M - Tray DJ121, DJ120, DJ119; Zone 2091-BB - Tray DJ129, DJ128, DJ127, DJ126
2I037E	59X	2040-JJ	Raychem	Polyolefin	Polyarylene	Tray DJ456, BJ014, BJ023
2I386C1	59X	2040-JJ	Belden	P.V.C.	Polyethylene	Tray DJ395, Conduit J4034, 2JB413, Conduit J3001
2I386D1	59X	2040-JJ	Belden	P.V.C.	Polyethylene	Tray DJ395, Conduit J4034, 2JB413, Conduit J3001
2I037D	58X	2040-JJ	Raychem	Polyolefin	Polyolefin	Tray DJ456, BJ014, BJ023

Table 2
Additional Thermoplastic Cables Identified

Cable	ANO Cable Type Code	Zone	Mfr	Jacket	Insulation	Raceway
RJR001C	RTR	104-S	BIW	P.O.-2 (polypropylene)	P.V.C	Conduit ER1001, Tray ER101
RJR001D	RTR	104-S	BIW	P.O.-2 (polypropylene)	P.V.C.	Conduit ER1001, Tray ER101
RJR001E	RTW	104-S	BIW	Polyethylene	P.V.C.	Conduit ER1001, Tray ER101
RJR001J	RTR	104-S	BIW	P.O.-2 (polypropylene)	P.V.C.	Conduit ER1001, Tray ER101
RJR001K	RTR	104-S	BIW	P.O.-2 (polypropylene)	P.V.C.	Conduit ER1001, Tray ER101
RJR001L	RTR	104-S	BIW	P.O.-2 (polypropylene)	P.V.C.	Conduit ER1001, Tray ER101

A comparison between the zones which contain thermoplastic cables and zone 99-M was made to judge the impact that thermoplastic cables have on safe shutdown capability. Zones 104-S, 2100-Z and 2091-BB are all similar to 99-M in that they are relatively small rooms surrounded by fire barriers which meet or exceed a 3-hour rating (Regulatory or Insurance) and contain only electrical equipment and cabling, similar to that in zone 99-M. A cable fire would be the only source of substantial heat generation in these rooms. The cabling in the rooms is located overhead typically greater than eight feet above the floor. As described in zone 99-M, a fire in the cable trays would be extinguished due to a lack of oxygen and would not result in sustained temperatures of a magnitude that would cause the ignition of a thermoplastic cable located away from the ignition source. The specifics of each of these fire zones are discussed below:

Fire Zone 104-S, Unit 1 Electrical Equipment Room

There are six thermoplastic cables located in this zone. The six enter the zone in conduit (ER1001) which is routed to a single cable tray (ER101) at the east end of the room. Cable tray ER101 is the lowest tray in a three-tray stack that extends down the approximate center of the room from east to west exiting at the west end of the room. This cable tray has a solid bottom over its entire length and a banded cover over the top of the tray for the majority of the distance that the tray passes through the zone. The conduit and tray are located near the ceiling. This room has a sixteen foot ceiling and no external ventilation. All cable trays are located at least eight feet above the floor.

The ignition sources in the room are electrical cabinets. A total of seven electrical cabinets (control type), the largest of which is 2x2.5x8 feet. Four of these cabinets are located under the cable tray stack that contains the thermoplastic cables. The remaining three do not have cable trays located overhead. The room also contains five motor control centers (MCCs), a security multiplexer (MUX) and the makeup pump disconnect switch. The disconnect switch contains a 4 kV breaker and is, therefore, susceptible to a high-energy event similar to the one postulated in fire zone 99-M.

Cable tray ER101, where the six thermoplastic cables reside, is located such that it would be in the plume of four electrical cabinets and the disconnect switch (approximately four feet above the top of the cabinet). A fire in any of the four electrical cabinets, or the disconnect switch, that are located under the ER101 cable tray (in the plume) or a high-energy fire in the disconnect switch will result in ignition of the cable tray regardless of the presence of thermoset or thermoplastic material. A fixed or transient fire anywhere else in the room will need to be intense enough to generate a 425° F hot gas layer to ignite the thermoplastic cable. Given the similarity of this room to zone 99-M (in size and elevated location of cable trays), such a fire will become oxygen limited and the room temperature will not reach the 425° F damage temperature of thermoplastic cables. Rapid fire propagation in cable trays is not expected to occur due to oxygen limitations in the environment surrounding the flames (see fire scenarios 1b through 8 for fire zone 99-M).

Fire Zone 2100-Z, Unit 2 South Switchgear Room

Zone 2100-Z has a single thermoplastic cable located in it. The cable enters the room on the south end in tray DJ-119 and extends the length of the room along the west side exiting through the north wall. Zone 2100-Z is the Unit 2 South Electrical Switchgear room and is similar in construction and content to Zone 99-M. The fixed ignition sources in this room are similar to zone 99-M with generally similar cable raceway locations as they may impact fire growth and propagation. There is no external forced ventilation normally supplied to zone 2100-Z.

Analysis of fire scenarios in zone 99-M resulted in three categories of fires: 1) high-energy fire in the 4 kV switchgear, 2) electrical fire in any switchgear, load center, MCC or inverter, or 3) transient fires. Similar fire scenarios are possible in this fire zone. In the event of a high-energy 4 kV fire, portions of cable tray DJ-119 that pass through the switchgear zone-of-influence will likely be ignited regardless of the cable type. In the case of an electrical panel or transient fire, cable tray DJ-119 will be ignited regardless of the cable type if the cable tray is in the plume of the fire. A fire away from this cable tray will become oxygen limited and the room temperature will not reach the 425° F damage temperature of thermoplastic cables. Based on the conclusions of the fire modeling analysis in room 99M, fires with intensities capable of generating a hot gas layer temperature higher than 425° F will require large heat release rate contributions from cables in a relatively short period of time. A relatively fast growing cable fire is not likely to occur considering that cables are elevated and immersed in a hot gas layer with very low oxygen concentrations. A fire in an electrical cabinet or a transient combustible only is not expected to generate temperatures above 425° F.

<u>Fire Zone 2091-BB, Unit 2 Electrical Equipment Room</u>

The same single thermoplastic cable routed through zone 2100-Z extends through zone 2091-BB in tray DJ-126 through 129. This tray extends east to west the entire length of the room and is the nearest tray to the ceiling in a stack of four trays for the most part. Two trays diverge from the stack near the west side of the room. The room has a single double-door on the east end. The cable trays in this room are located greater than eight feet above the floor and above the door opening.

A difference between this zone and the above described zones is the presence of a thermostatically controlled ventilation system. Two exhaust fans are located in this room, one approximately six feet from the ceiling and the other at the ceiling. These units start when the room temperature reaches 120° F as measured approximately five feet above the floor. The fans remove 9,000 CFM each from the room and exhaust into the turbine building through a common duct which contains a fire damper with a fusible link designed to isolate when the temperature reaches 165° F. The impact of the exhaust fans is both positive and negative with respect to the formation of a damaging hot gas layer. The negative impact is that the fans introduce turbulence and fresh air to the upper portion of the room where the cables are located thus promoting combustion. The positive impact is that the fans take suction in the upper elevation of the room, exhausting the hot gases and replacing them with cooler air thus reducing the hot gas layer temperature. Since the exhaust duct has a fire damper that will close when the exhaust temperatures reach 165° F, un-ventilated conditions are assumed for the most challenging fires.

The fixed ignition sources and cable tray configuration in this room are similar to 104-S with the exception that this room does not contain any control cabinet or 4 kV disconnect switches

The cable tray containing the thermoplastic cable, DJ-126 through 129, is the top tray in a four-stack cable tray that is routed above an MCC.

1. A fire in the MCC will first have to ignite the three thermoset cable trays shielding the thermoplastic cable. Ignition of one thermoplastic cable will be of no additional consequence if three thermoset cable trays are already burning.

2. A fire anywhere else in the room will exhibit the same oxygen limited conditions as the fire scenarios 1b-6 in fire zone 99-M and will not reach 425° F temperature in the hot gas layer.

Fire Zone 2040-JJ, Unit 2 Auxiliary Building Elevation 335'

Unlike the other zones discussed above, zone 2040-JJ is a large area made up of multiple small rooms and corridors. Its total volume is approximately 20 times that of zone 99-M. This zone contains electrical wiring, motors and pumps associated with the radioactive waste and demineralizer systems and the three charging pumps. Combustibles in this zone consist of limited quantities of oil, cable insulation, and transients. There are a total of four thermoplastic cables located in this zone which are not required for safe shutdown.

Under an ideal cable bundle configuration, a thermoplastic cable reaching its ignition temperature (piloted ignition temperature in the presence of flames, or auto-ignition temperature) can become the ignition source of the thermoset cables in the bundle. However, if the geometry and configuration of the room are considered when evaluating a scenario involving thermoplastic cables igniting a thermoset cable, the following conclusions are made:

1. This fire zone contains only four thermoplastic cables (two in the same tray) mixed in with 1026 thermoset cables. The likelihood that these four thermoplastic cables, when mixed in with over 100 times more thermoset cables, are arranged in such an optimum configuration that contributes significantly to the ignition profile of the room is very unlikely.

2. If the thermoplastic cable is located in the plume of at least a 200 kW fire (control panels with moderate to large loading or liquid fires such as pumps) ignition will result regardless of thermoset or thermoplastic material. Considering the size of the room and the potentially long routing of the thermoplastic cable, it is likely that it may be exposed to the plume of one such fire.

3. The damage threshold for thermoplastic cable is 425° F. If the thermoplastic cables were not exposed to the fire plume, a fire that generates 425° F hot gas layer in the entire volume would be needed for inducing cable ignition. In order for a fire to generate conditions that would approach this threshold, it would have to be quite large given the very large volume of this fire zone. For example, under adiabatic conditions, a 2 MW fire lasting for 30 minutes can generate temperatures in the 425° F range. A fire of this magnitude is either a large oil fire or large cable fire. It is unlikely that such a large fire could initiate in the first place, much less continue to burn without a prompt response by the station's fire brigade.

NRC Question 2

Provide the thermo-hydraulic time line that defines when critical safety functions must be established for all operator recovery actions for Fire Zone 99M. In addition, please provide data sheets from your simulated operator actions, including the times recorded.

ANO Response

The following excerpts from the Accident Sequence Analysis calculation Calc 98-E-0039-01, Revision 2, Supplement 1 for the ANO-1 Probabilistic Safety Assessment model detail the thermo hydraulic basis for the available time used for the operator actions performed after a plant trip.

Several studies by both NRC contractors and Babcock and Wilcox (B&W) have been performed related to the effectiveness of high pressure injection (HPI)-cooling [Ref. 22, 31 and 32] at B&W plants. In addition to verifying the effectiveness of HPI-cooling, the success criteria timing for HPI-cooling can also be developed from these studies (although it should be noted that Ref. 31 did not assess minimum acceptable HPI-cooling timing). Section 4.1 of reference 32 concludes that "one HPI pump delivering flow at the setpoint pressure of the pressurizer safety relief valves is sufficient to prevent core uncovery if initiated by 2400 sec." This statement refers to a case involving a total loss of feedwater initiated event (T2) with reactor coolant pumps (RCPs) operating and is used for the timing noted in Table 4. For reactor trips which develop into a total loss of feedwater (non-T2 events) with RCPs not operating, reference 22, Table III and V, can be used to develop an estimate of the time available to initiate HPI-cooling. Table III presents a loss-of-offsite-power case (main feedwater ramp-down with RCPs not operating) with HPI actuated by "containment overpressure" (engineered safeguards actuation signal set point reached) at 1950 seconds. Table V presents a total loss-of-MFW/emergency feedwater (EFW) with RCPs operating continuously that reaches "containment overpressure" at 900 seconds. Since the time to core heat up is not presented in Table III, extrapolation to the time just prior to core heat-up can be made by comparing the times between steam generator dry-out and "containment overpressure", as shown below:

Event Times	***NUREG/CR-4471 Table III***	***NUREG/CR-4471 Table V***
Steam Generator Dry-out	*1000 sec* $= t_1$	*200 sec* $= t_3$
Containment Overpressure	*1950 sec* $= t_2$	*900 sec* $= t_4$
Core Heat-up	*3714 sec = 61.9 min* $= T^*$	*2200 sec* $= t_5$

** estimated by either of the following:*

$T = t_1 + (t_5 - t_3)\{(t_2 - t_1)/(t_4 - t_3)\}$

or

$T = t_2 + (t_5 - t_4)\{(t_2 - t_1)/(t_4 - t_3)\}$

Therefore, if HPI-cooling is not initiated within approximately 40 minutes from a T2 induced reactor trip with RCPs operating until loss-of-sub-cooling-margin, or within about 60 minutes from a non-T2 induced reactor trip with RCPs not operating, core heat-up and core damage is expected to occur.

Due to the effectiveness of once-through-steam generator boiler-condenser mode cooling, the original probabilistic risk analysis work assumed the HPI cooling requisite times for the MFW and EFW recovery timing. During the development of revision 1, additional MAAP runs were performed to determine the timing of MFW/EFW recovery [Ref. 39]. It was determined that for T2 events with the RCPs operating, a MFW or

EFW pump must be recovered within 36 minutes and within 54 minutes when the RCPs do not continue to run. These new values form the basis for the primary-secondary heat removal success criteria.

It should be noted that ANO-1 specific MAAP code analysis [Ref. 23] has been performed which indicates that these timing estimates are accurate. From Reference 23, core uncovering is not expected if HPI-cooling is initiated within approximately 60 minutes after a station black-out (SBO) induced total loss of feedwater (i.e., non-T2 events with RCPs not operating). If HPI-cooling is not initiated, core damage (e.g. heat-up beyond approximately 2500 K) is not expected until approximately 90 minutes after a SBO induced total loss of feedwater (i.e., non-T2 events with RCPs not operating).

ANO-1 LEVEL 1 PRA SUCCESS CRITERIA

INITIATOR	*REACTIVITY CONTROL*	*PRIMARY-SECONDARY HEAT REMOVAL*	*RCS INTEGRITY*	*HPI COOLING*	*COMMENTS*
Transient (T1 to T16)	*RPS*	*1/2 EFW Pumps* *OR* *1/2 MFW Pumps within 36 minutes (T2 events with RCPs operating) or within 54 minutes (non-T2 events without RCPs operating)*	*ERV and SRVs reclosed (if opened)* *AND* *ICW to RCP seal cooling* *or* *HPI seal injection to RCP seals* *or* *Operator trips RCPs within 40 minutes of loss of RCP seal cooling and seal injection*	*1/3 HPI pumps from BWST* *and* *1/1 ERV or 1/2 SRVs* *and* *Operator initiates HPI Cooling within 40 minutes of primary-secondary heat removal loss (T2 events where RCPs continue running) or within 60 minutes (non T2 events where RCPs do not continue running, such as T3 events)*	*1. Secondary Steam Relief assumed available* *2. EFW or MFW to 1 SG is sufficient* *3. Failure of RPS transfers to ATWS tree* *4. 3/4 injection lines adequate for HPI*

References

22. B.E. Boyack, et al, Los Alamos PWR Decay-Heat-Removal Studies Summary Results and Conclusions, NUREG/CR-4471, March 1986.

23. Entergy Nuclear Engineering Analysis Calculation NEAD-NS-92/015.R0, Revision 0, ANO-1 MAAP Analysis to Support PRA Level 1 and 2 Assumptions and Severe Accident Management, November 13 1992.

31. B&W Owners Group, Transient Information Document Owners Group Task AS-5, Evaluation of HPI Cooling, Document No. 86-1173989-01, February 1989.

32. P.D. Wheatley, et al, Evaluation of Operational Safety at Babcock and Wilcox Plants, Volume 2 - Thermal-Hydraulic Results, NUREG/CR-4966, November 1987.

39. Central Design Eng., NEAD-NS-94/063, Rev. 0, MAAP Analysis to Support ANO-1 PRA Model Update dated May 14, 1994.

The timings for the simulator operator actions, along with the data sheets, were provided in the July 3, 2003, ANO Phase 3 Significance Determination Process submittal (0CAN070302). Pages 98-99 of this submittal contain the operator actions required and the times they were performed. Page 101 is the beginning point for the data sheets.

NOTE: The data sheets were condensed into two tables from the original hand written sheets. The tables provided in the report represent the data sheets from multiple observers.

NRC Question 3

Provide cable construction information (i.e., insulation and jacket material, such as XLPE/PVC) for all cables installed in cable trays or exposed (such as air drops) in Fire Zone 99M, including vendor and/or manufacturer.

ANO Response

The insulating and jacketing materials for cables installed in cable trays or exposed in fire zone 99-M are detailed in the table below. These cables are constructed with thermoset materials.

**CABLE CONSTRUCTION INFORMATION
FOR ZONE 99-M**

MFR	JACKET	INSULATION
EATON	HYPALON (chlorosulfonated polyethylene - CSPE)	FR-EPDM (ethylene propylene diene monomer)
OKONITE	OKOPRENE (NEOPRENE - polychloroprene)	OKONITE (ethylene propylene rubber - EPR)
OKONITE	OKOLON (VULCANIZED CSPE)	OKONITE (EPR)
BRAND-REX	HYPALON (CSPE)	XLPE (cross linked polyethylene)
ROCKBESTOS	HYPALON (CSPE)	XLPE
ROCKBESTOS	HYPALON (CSPE)	FIREWALL III (CSPE)
ANACONDA	CSPE	FR-EP (ethylene propylene)
GENERAL CABLE CORP	NEOPRENE	EPR
BOSTON INSULATED WIRE	BOSTRAD 7 (CSPE)	BOSTRAD 7 (CSPE)

NRC Question 4

Provide the extent to which cables and cable trays in Fire Zone 99M are coated with flamemastic 71A. Include a list of which cables are coated, the amount of flamemastic installed, and date of installation, ignition temperature and heat release rate of flamemastic 71A.

ANO Response

During the July 10, 2003, Regulatory Conference ANO demonstrated, using conservative techniques and assumptions, that a realistic fire in zone 99-M would not result in the development of a hot gas layer that would cause room-wide circuit damage. The presentation also specified the types of unrealistic conditions that must occur for a damaging hot gas layer to develop and noted other conservatisms which were not credited in the evaluation. One of the conservatisms noted was that some of the cable trays in zone 99-M are coated with flamemastic which both delays ignition and slows propagation of cable fires. Because the application of the fire retardant coating was not credited in the evaluation, extensive review of the specific product was not conducted. In response to the NRC's request for additional information, the following details have been identified with respect to the fire retardant coating used:

The fire retardant coating is applied to thermoset cables in two cable trays located above the A-4 4160V switchgear cabinets (see Figure 5 on the last page of the letter). These same trays curve around the north end of the zone and then travel south between the B-56 and B-55 MCCs as shown in the attached figure. As these trays begin their southward track, only the lower tray is coated. The cables are coated with the fire retardant material over their entire length. The jacket and insulation materials located in these trays are a subset of the thermoset materials described in response to question 3 above.

The fire retardant coating was manufactured by Carboline and is not flamemastic as previously believed. The material is Carboline Intumastic 285 which is a water-based mastic used to retard fire propagation.

The cable coating material was installed in 1979 to meet compliance with Branch Technical Position 9.5-1, Appendix A, for separation of redundant safety related trains. This material was approved by the NRC as a form of fire barrier although its specific application at ANO was not subsequently inspected since Appendix R was issued in 1980 and the cable coating was not credited to meet the requirements of this new rule. Our records indicate that the choice of this material was based on its fire retardant properties and not the characteristics of the cable material to which it was applied (i.e., thermoset vs. thermoplastic).

The vendor of the material was contacted to obtain the specific information requested in this RAI (i.e., heat release rate and ignition temperature). The vendor does not have test data to provide this information. However, as stated, the purpose of the material is to prevent fire propagation should it occur. In 1977 and 1978, Sandia National Laboratory conducted a number of tests to measure the effectiveness of coatings in preventing initiation or propagation of fires. The results of these tests were published in 1978 in NUREG/CR-0281, SAND 78-1456, *A Preliminary Report on Fire Protection Program Fire Barriers and Fire Retardant Coatings Tests*. By direct contact with Sandia Laboratories we confirmed that Carboline Intumastic 285 was represented by "coating E" in these tests. In a two tray test with diesel fuel as the combustible material (ref. page 43) with non-rated cabling, the bottom tray demonstrated no apparent cable damage. The diesel fuel burned for 13 minutes before it self extinguished. The purpose of the test was to determine the ability of the cable coating to prevent fire propagation from the first to the second cable tray. The results of the test (ref. page 52) are as follows:

- The maximum barrier temperature of the bottom tray was 1430° F while the top tray was 1180° F,
- The maximum cable temperature recorded was 485° F and 255° F for the bottom and top tray, respectively, and
- No ignition of the cables in the top or bottom trays was noted nor was any propagation from the bottom tray to the top tray observed.

In a comparative ranking of seven materials tested, the Carboline Intumastic 285 ranked either first or second in each test category.

Based on these results it is concluded that Carboline Intumastic 285 is an effective cable coating material for the prevention of fire propagation.

In regard to the question of combustibility of the Carboline Intumastic 285 and its potential contribution to the heating of the room, our analysis of fire scenarios in zone 99-M resulted in two temperature profiles. For scenario 1b, an energetic fire in the A4 switchgear, the temperature exceeded 425° F for a couple of minutes before the fire became oxygen-controlled and the temperature dropped to below 300° F in less than 5 minutes. The non-energetic fire scenarios developed slower and required a longer duration to reach the peak temperature (277-340° F depending on the scenario). In either case the fire became oxygen-controlled. Therefore, adding more fuel to the fire (if the coating was to be combustible) for an oxygen-controlled fire would only tend to deplete the oxygen faster. Neither of the fire scenarios was fuel-controlled due to the nature of the floor-based fires (electrical) and location of the combustibles (below the ceiling).

In our analysis of the fires involving the cable trays partially coated with Carboline Intumastic 285 we did not credit the flame retardant capability of the coating. The Sandia test results demonstrate the conservatism in this assumption. The test demonstrates that a fire's propagation within a cable tray, regardless of its origin, would be significantly impeded by the application of the Carboline material.

A list of cables that are coated was determined to be unnecessary based on discussions with the NRC during a teleconference on August 4, 2003.

NRC Question 5

Please provide the CFAST model results for Fire Zone 99M, assuming forced ventilation is not secured and continues to supply air to the fire throughout the duration. In addition, please provide the input files you used in the CFAST fire simulation in all fire scenarios for Fire Zone 99M.

ANO Response

Mechanical Ventilation in Switchgear Room 99-M

Switchgear room 99-M has a supply vent located at the south wall near the ceiling. The vent supplies 440 CFM (≈ 2.5 air changes per hour) of fresh air into the room. No return vent is present in the room. It is assumed that the system will continue to operate during a fire event.

CFAST Simulation Results

CFAST runs for zone 99-M were performed adding an air injection system to the previously prepared base case files. Inputs other than those related to mechanical ventilation remained the same for these runs.

Figure 1 describes the results for Scenario 1a which consists of an elevated growing fire. The results indicate that if the door to zone 99-M is assumed open, the smoke layer will reach four feet high and temperatures in the room will reach a peak of 160° F. However, because the fire is immersed in smoke, the available oxygen in the room is consumed and the combustion process cannot be sustained. The temperature of the room is expected to return to ambient in around ten minutes. In this case, the ventilation system does not supply enough oxygen for supporting the fire. Furthermore, the injected air increases the size of the smoke layer, which completely covers the fire. This injected air also reduces the temperature of the hot gas layer.

Figure 1:CFAST results for scenario 1a with open doors and mechanical ventilation

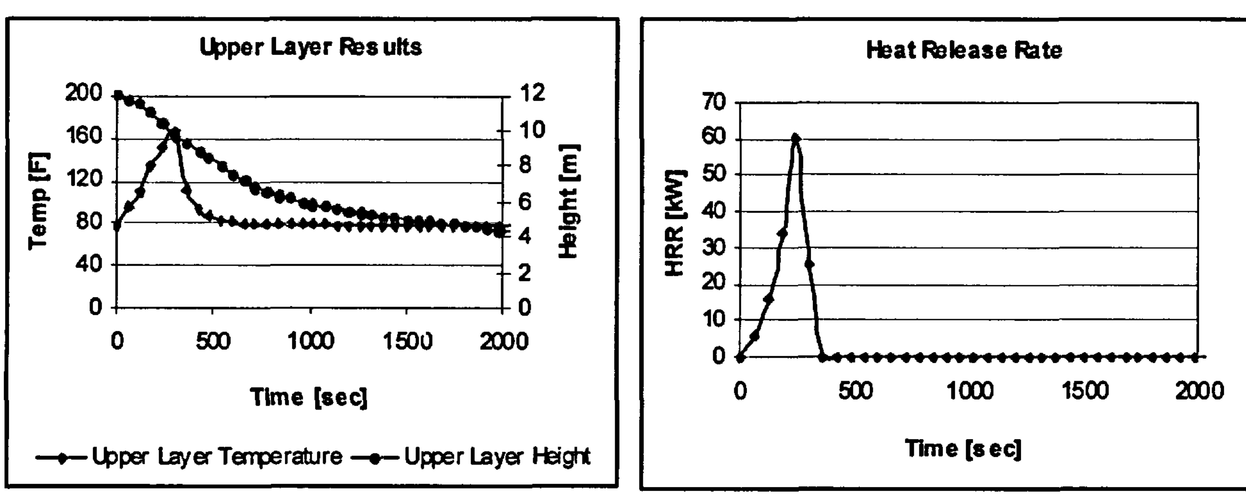
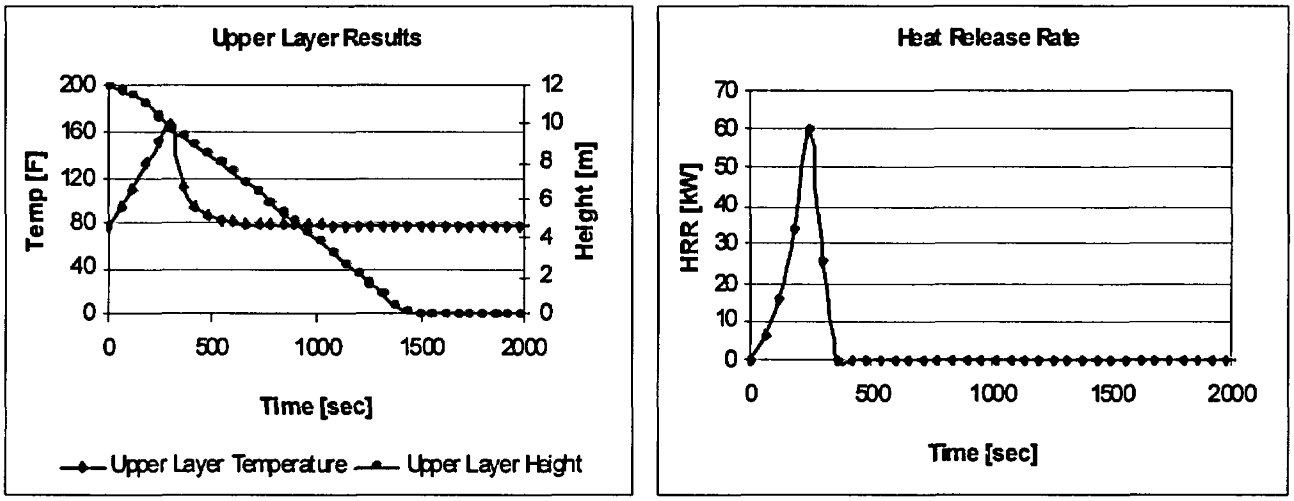
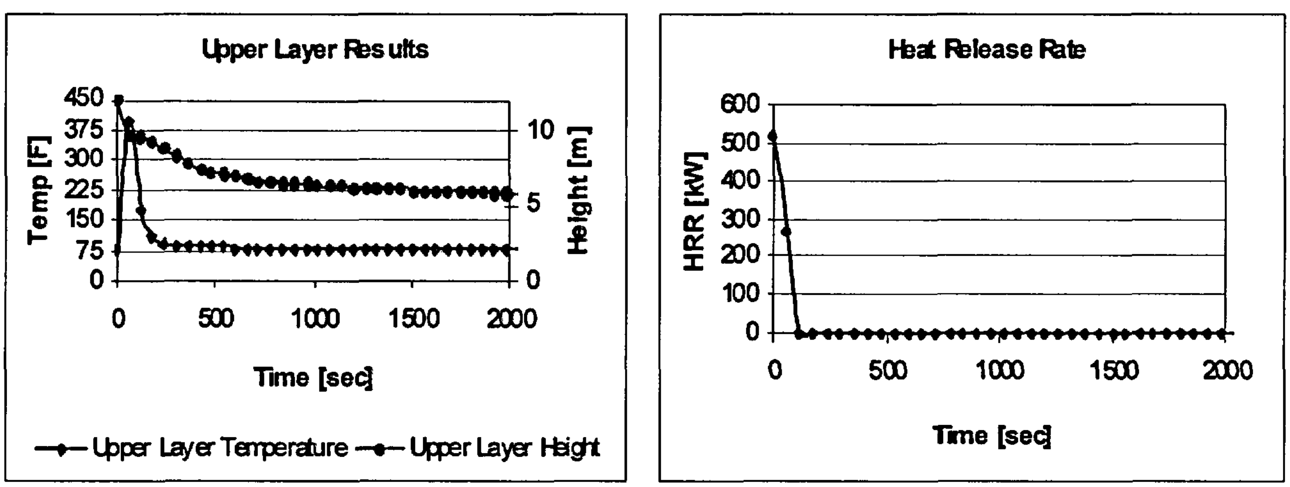


Figure 2: CFAST results for scenario 1a with closed doors and mechanical ventilation



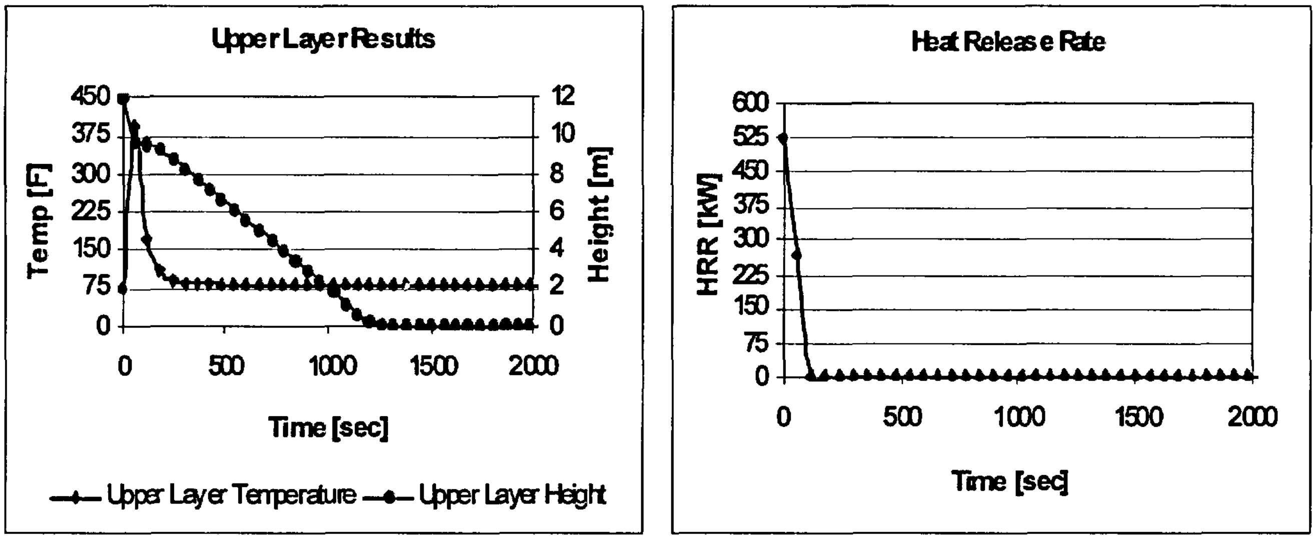
A similar behavior is observed in Scenario 1a evaluated with closed doors. In this case, although the smoke layer reaches the floor, there isn't enough oxygen to sustain burning, resulting in almost identical thermal conditions. The only effect a closed door has in this scenario is allowing the hot gas layer to reach the floor. Results are summarized in Figure 2.

Figure 3: CFAST results for scenario 1b with open doors and mechanical ventilation



Scenario 1b involves fire initiation as a result of a high-energy electrical fault event. This was modeled in CFAST assuming a 500 kW fire at the beginning of the simulation. If a door is assumed open, the smoke layer is expected to reach six feet high. Temperatures can reach 375° F. According to CFAST, the fire is expected to be extinguished in less than five minutes due to oxygen limitations. The air injection system is not enough to keep the fire burning. Furthermore, as the fire intensity decreases, it is expected that the injected air will help reduce the temperature of the hot gas layer. Results are presented in Figure 3.

Figure 4: CFAST results for scenario 1b with closed doors and mechanical ventilation



Finally, a closed door in scenario 1b will have minimal effect on the generated thermal conditions in the room if compared with results assuming an open door. Thermal conditions are essentially the same. The smoke layer reached the fire elevation in less than five minutes and the floor in twenty minutes. Results also suggest that the fire will not have enough oxygen to burn. Figure 4 illustrates the results of this case.

The low smoke layer temperatures obtained in scenarios 1a and 1b suggest that the effects of any radiation feedback from hot gases on different surfaces in the room enhancing the burning rate of the fire is negligible.

Conclusions

Results suggest the following conclusions related to the presence of an air injection system in switchgear room 99-M:

1. 440 CFM will not considerably alter fire-generated conditions in the room when compared with results without mechanical ventilation. Although some effects are noticeable, the system does not supply the required oxygen to maintain the combustion process.

2. CFAST results related to fire extinction (i.e., how low oxygen levels affect the fire heat release rate) should be considered with caution. Although it can be concluded that fires with the evaluated intensities will not burn at the specified heat release rate due to oxygen limitations, it is likely that a small fire will remain after the time CFAST predicts extinction. This is because the oxygen, which is constantly being injected into the room, may support some combustion. As a conservative conclusion, peak temperatures are assumed to be maintained longer than predicted by CFAST.

3. Predicted temperatures in the room do not reach levels that would damage targets located away from the fire, even assuming that targets are subjected to fire conditions for a duration longer than that predicted by CFAST.

Figure 5 – Coated Cable Trays in Fire Zone 99-M