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U-602512
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November 3, 1995

Docket No. 50-461

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

Subject: Illinois Power's (IP's) Response to the NRC's Requests for Information Regarding Thermo-Lag

Dear Sir:

IP has prepared this letter in response to NRC letters dated August 30 and October 4, 1995. These letters requested IP to submit additional information regarding Thermo-Lag installations. The information requested is contained below and in subsequent attachments. This information is based in part on the 50.59 safety evaluations provided to the NRC on March 16, 1995, in letter U-602425.

Attachment 2 provides an Executive Summary of IP's position with respect to Thermo-Lag. Attachment 3 contains the information that was requested by NRC regarding Thermo-Lag installations. Attachment 4 contains information regarding ampacity derating requested in NRC letter dated October 4, 1995. The 50.59 safety evaluations themselves are provided as Attachment 5. Fire Endurance calculations requested in NRC letter dated August 30, 1995, have been provided as Attachment 6.

Clinton Power Station (CPS) was licensed on September 29, 1986 and as such is not an Appendix R plant. However, CPS has committed to 10 CFR 50 Appendix R as a part of the plant licensing basis. Therefore, CPS is authorized to deviate from Appendix R by 1) performing a safety evaluation in accordance with 10 CFR 50.59 and 2) CPS Operating License Condition 2.F.

The original design of CPS utilized Thermo-Lag 330-1 to meet the separation requirements of Appendix R in certain locations. In response to NRC concerns regarding the use of Thermo-Lag, CPS analyzed each Thermo-Lag installation. The 10 CFR 50.59 safety evaluations identify the deviations from specific barrier ratings stated in Appendix R, Section III.G.2. The 50.59 safety evaluations justify the acceptability of the deviations.

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The basis for the acceptability of the deviations is that the fire zones do not contain credible fire hazards of sufficient magnitude to damage both redundant safe shutdown divisions. The 10 CFR 50.59 safety evaluations identified the credible fire hazards and explain why they are of insufficient magnitude and thereby justify the acceptability of the deviations. This justification is based on utilization of classical fire protection and analytical fire modeling techniques.

The fire models in the 50.59 safety evaluations conclude that CPS can achieve and maintain safe shutdown without dependence upon Thermo-Lag for the most severe credible fire.

The 50.59 safety evaluations identify additional defense-in-depth features which provide overall robust fire protection:

Administrative Controls	-	Control of transient combustibles and ignition sources.
Fire Brigade	-	Demonstrated ability to provide prompt response to fires.
Fire Protection	-	Detection in all zones and wet pipe sprinkler systems in fire zones A-1a and CB-1e.
Thermo-Lag	-	Provides some degree of barrier worth.

This defense-in-depth philosophy does not rely solely on any one feature to conclude that safe shutdown could be achieved and maintained. Additionally, CPS is atypical in that it has a safety-related Division 3 providing hot shutdown capability. This division is unaffected by fires that could affect Divisions 1 and 2 in the subject fire zones.

Probabilistic Risk Assessment (PRA) was not used to determine acceptability of Thermo-Lag installations. Instead, Thermo-Lag was evaluated using analytical tools, such as fire modeling which is primarily deterministic in nature and utilizes test data and methods specifically developed for commercial nuclear power plants.

The NRC has questioned whether the important attributes have been identified for the Thermo-Lag installed at CPS. Even though Thermo-Lag is not safety-related, Thermo-Lag was procured and installed in accordance with a Quality Assurance (QA) program at CPS. The Thermo-Lag installation contractor used a QA program that satisfied 10 CFR 50 Appendix B requirements. Based on these facts, IP believes that there is adequate confidence that the installed Thermo-Lag conforms with specifications. Additional verification of important attributes is not necessary as IP's 50.59 safety evaluations have shown that CPS can achieve and maintain safe shutdown without dependence upon Thermo-Lag for the most severe credible fire.

The NRC has raised a supplemental issue about the ampacity of cables installed within Thermo-Lag. This issue was reviewed at CPS. The review concluded that the installed condition is acceptable and no modifications are required. Attachment 4 and the 50.59 safety evaluations provide the basis for this conclusion.

IP believes that the referenced safety evaluations provide a technically sound basis for accepting Thermo-Lag installations at CPS. After the NRC has had an opportunity to review the enclosed information, NRC personnel are invited to CPS to observe the Thermo-Lag installations and to discuss any questions on IP's safety evaluations.

Attachment 1 provides an affidavit supporting the facts set forth in this letter.

Sincerely yours,

J. G. Cook
Vice President

JSP/csm

Attachments

cc: NRC Clinton Licensing Project Manager
NRC Resident Office, V-690
Regional Administrator, Region III, USNRC
NRC Associate Director for Technical Review
NRC Director of Division of Systems, Safety and Analysis
NRC Deputy Director of Division of Systems, Safety and Analysis
Illinois Department of Nuclear Safety

Attachment 1
to U-602512

R. E. Wyatt, being first duly sworn, deposes and says: That he is Manager-Nuclear Assessment for Illinois Power and has been duly authorized to submit this information for Generic Letter 92-08; that this letter supplying information for Generic Letter 92-08 has been prepared under his supervision and direction; that he knows the contents thereof; and that to the best of his knowledge and belief said letter and the facts contained therein are true and correct.

Date: This 3RD day of November 1995.

Signed: R E Wyatt
R. E. Wyatt

STATE OF ILLINOIS } SS.
DeWitt COUNTY }

" OFFICIAL SEAL "
Richard F. Pharas
Notary Public, State of Illinois
My Commission Expires 11/24/97

Subscribed and sworn to before me this 3rd day of November 1995.

Richard F. Pharas
(Notary Public)

Executive Summary of
Illinois Power's (IP's) Position Regarding Thermo-Lag

Clinton Power Station (CPS) Licensing Basis

CPS is not an Appendix R plant. 10 CFR 50 Appendix R is only applicable to plants operating prior to January 1, 1979. CPS, however, committed to meet 10 CFR 50 Appendix R requirements. Deviations from those commitments are governed by the provisions of 10 CFR 50.59 and the CPS Operating License. Specifically, the CPS Operating License Condition 2.F states, "IP may make changes to the approved fire protection program without prior approval of the commission only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire."

IP has Thermo-Lag installations in ten fire zones at CPS. Probabilistic Risk Assessment (PRA) results were not the bases for accepting the CPS Thermo-Lag installations. The PRA results were utilized to identify which of the ten fire zones with Thermo-Lag installations should be modified due to their safety significance. IP has committed to implement hardware modifications in four of these fire zones so that reliance on Thermo-Lag would not be needed to protect safe shutdown capability in these fire zones. The six fire zones for which the PRA results did not show an identifiable safety benefit due to Thermo-Lag were subjected to deterministic evaluations. These evaluations are the bases for the 10 CFR 50.59 safety evaluations which conclude that safe shutdown can still be achieved. Therefore, IP has determined that deviations from our commitment to Appendix R separation requirements are acceptable.

Fire Modeling

The CPS fire modeling portions of the safety evaluations included the following steps: 1) fixed and transient combustibles in the fire zone were identified, 2) credible ignition sources for these combustibles were identified, 3) based upon these ignition sources, temperature changes were identified accounting for the effects of direct flame, plume impingement, ceiling jet, radiant energy transfer, and hot gas layer and 4) the impacts of these temperature changes on the Thermo-Lag and enclosed cables were determined. Therefore, fire modeling of the safety evaluations of the fire zones was primarily deterministic in nature.

In performing the deterministic safety evaluations of the six fire zones in question, IP utilized quantitative fire modeling tools recently developed by EPRI. The modeling method includes the Fire-Induced Vulnerability Evaluation (FIVE) plume/ceiling jet/hot gas layer modeling methods developed by EPRI, which has shown good agreement with experimental data.

Recognizing there are uncertainties associated with application of the method, IP has consistently applied the method in a conservative manner. For example:

- Materials were assumed to burn at their maximum heat release rate (HRR).
- Transient fires were assumed to potentially occur at all locations where transients may exist.
- The modeling was performed without taking quantitative credit for any manual or automatic suppression.

The CPS fire load calculations account for the combustible load of the Thermo-Lag fire barrier. The fire modeling considers the Thermo-Lag burning characteristics taken from the test data included in the NEI Thermo-Lag Combustibility Guide. The fire modeling considered Thermo-Lag to be combustible. Based upon fire modeling, IP determined that the temperature changes in some fire zones were not sufficient to ignite the Thermo-Lag.

NRC has questioned the bases for several assumptions used on IP's fire modeling. For example, NRC stated that IP's cable failure and ignition temperatures are too high. IP believes that its cable failure temperature is appropriate given the type of cable and conditions at CPS. In any case, the results of the safety evaluations would be equally valid using the temperatures cited by NRC. Similarly, the ignition temperatures do not have any impact on the results of the safety evaluations.

NRC also questioned the technical bases for excluding cables, junction boxes, and motors of five horsepower or less as ignition sources. Cables are excluded because they are IEEE-383 qualified cables operating at amperages well below those observed to ignite fires. Junction boxes are excluded because their solid metal, unvented construction would prevent a fire from propagating. Small motors are excluded based upon historical data and their low heat content.

Additional Defense-in-Depth

The CPS Thermo-Lag safety evaluations discuss and describe a number of plant-specific features which ensure that safe shutdown is achievable despite reduced capabilities of Thermo-Lag. These plant-specific features cumulatively provide defense-in-depth. In particular, IP has utilized a defense-in-depth approach to fire protection to prevent fires from occurring, to detect, control, and extinguish those fires that do occur, and to provide protection for structures, systems, and components so that a fire that is not promptly extinguished will not prevent the safe shutdown of the plant. For example, IP has administrative controls in place to help prevent fires, such as limiting the amount and types of transient combustibles and controlling transient oil. In some cases, reference was made to these administrative controls as additional support for the low likelihood of a fire

occurring. In other cases, these controls were considered in determining the credible transient fire hazards. Evaluations were performed for each affected fire zone to determine the impact of these fire hazards on Thermo-Lag and cables. In no cases were administrative controls the sole basis for accepting a Thermo-Lag installation.

The evaluations show that the most severe, credible fire in each fire zone will not prevent safe shutdown of the plant due to the design features and fire protection program, including a combination of the following elements:

- Effective administrative controls to limit storage of common combustible and flammable material which could propagate fire, and to prevent storage of materials that are highly combustible, flammable, explosive or toxic;

- Relatively few installed pieces of plant equipment which could act as ignition sources in the Thermo-Lag fire zones;

- Installed fire detection and suppression equipment within fire zones containing Thermo-Lag;

- Timely response of the onsite fire brigade to a potential fire at a Thermo-Lag installation as demonstrated during CPS fire drills;

- Large compartment (large floor area and tall ceiling) which minimizes the ambient temperature rise in the event of a fire;

- Distance between the Thermo-Lag and ignition sources;

- Demonstrated ability of Thermo-Lag material to provide some protection against fires;

- Effective operator responses as demonstrated during CPS simulator training.

CPS is somewhat unique in plant survivability during events affecting multiple divisions of safety-related equipment due to the provision of Division 3 systems. The Division 3 diesel generator and the associated High Pressure Core Spray System allow CPS to achieve and maintain hot shutdown with a total loss of core cooling and heat removal capability from Divisions 1 and 2 and a concurrent loss of all Non-Division 3 power.

Thermo-Lag Barrier Worth

IP is not taking credit for Thermo-Lag as a one-hour or three-hour barrier. However, fire endurance tests and the NEI application guide demonstrate that Thermo-Lag does have some ability to protect against fires. In performing its safety evaluations, IP considered this factor, in conjunction with the other factors discussed above.

Given the nature of IP's safety evaluations, variations in the quality of procured and installed Thermo-Lag (with associated effects on fire rating) would not invalidate IP's conclusion that the plant can achieve and maintain safe shutdown. Nevertheless, there is adequate confidence that the as-installed Thermo-Lag at CPS conforms with its specifications and therefore is able to provide protection for the period of time specified for the associated configuration in the NEI Fire Endurance Application Guide. The procurement and installation of Thermo-Lag was governed by a Quality Assurance (QA) program satisfying the requirements of 10 CFR 50, Appendix B. The QA program provides adequate confidence that the installed Thermo-Lag conforms with its specifications. Many of the important Thermo-Lag attributes were covered by the program and/or in subsequent walkdowns, and IP has made conservative assumptions regarding the remaining attributes.

NRC has questioned whether the NEI application guide accounts for hose stream tests on the Thermo-Lag. The NRC letter to NEI dated April 7, 1994, stated that the purpose of the hose stream test is to evaluate the structural integrity of the fire barrier and its ability to protect the enclosed raceway from damage caused by in-plant firefighting and falling external objects during a fire. All of the NEI tests used as the basis for determining barrier worth of the CPS Thermo-Lag installations did include the impact, cooling, and erosion effects of a hose stream applied immediately following removal of the assembly from the test furnace. In the cases where an opening was created in the barrier during the fire test, it was always at the radial bend or on the bottom of the box or tray, locations not prone to damage of cables due to the presence of the bottom or siderails of the cable tray. Cable trays wrapped in Thermo-Lag at CPS have solid steel sides and bottoms, which would protect against hose streams.

Ampacity Derating

IP has performed ampacity evaluations for cable in the Thermo-Lag that will remain in place. The majority of the cables are very lightly loaded. Those few cables that are not lightly loaded have sufficient margin in their ampacity to accept a sizeable ampacity derating. Therefore, the capability of the cables (to carry their design loads and perform their design functions) was evaluated and found to be adequate.

In performing these evaluations, IP compared the actual loads on the installed cables to the nominal design ampacity of that type of cable. This provides the existing ampacity margin in the cables. The cables with the smallest margins were then compared to the cables reported in NRC Information Notice (IEIN) 94-22 by determining the heat intensity of each. As stated in the evaluations, the heat intensity of the cables with the smallest margin is lower than the heat intensity of the derated cables of IEIN 94-22, therefore all of the cables were determined to be acceptable.

CLINTON POWER STATION
DOCKET NO. 50-461
FOLLOW-UP TO REQUEST FOR ADDITIONAL INFORMATION REGARDING GENERIC LETTER 92-08 "THERMO-LAG FIRE BARRIERS" AND LICENSEE SAFETY EVALUATIONS OF THERMO-LAG INSTALLATIONS

NRC COMMENT

1.0 September 19, 1994, Request for Additional Information

In the response dated December 16, 1994, Illinois Power (IP), the licensee stated that the unknown parameters would not be evaluated for Thermo-Lag barriers that are eliminated or are determined to be acceptable as-is. Section II of the RAI, dated December 21, 1993, requested that the licensee provide information regarding the important parameters for each Thermo-Lag barrier installed in the plant, and the licensee's methodology for the evaluation of barriers whose important parameters are not known or have not been verified. Please provide the information requested in Section II of the RAI for Thermo-Lag barriers that were determined to be acceptable as-is.

The licensee's response to Section III "Thermo-Lag Barriers Outside the Scope of the NUMARC Program" is acceptable.

2.0 December 28, 1994, Request for Additional Information

In the response dated March 28, 1995, IP stated that it does not consider it necessary to verify: (1) material thickness, (2) material weight and density, (3) the presence of voids cracks and delaminations, (4) fire endurance, (5) combustibility and flame spread, (6) mechanical properties, and (7) important installation parameters. This determination was based on the original purchase specifications for Thermo-Lag installed at the Clinton Power Station (CPS), the installation contractors quality assurance program, installation procedures, walkdown inspections, and the licensee's safety evaluations. In the December 28, 1994, RAI the staff stated licensees must have valid information on the specific Thermo-Lag materials installed at its plant and that some of the installation parameters cannot be verified by walkdowns or by comparing as built barriers with installation records or procedures. The licensee is requested to provide the information requested in the December 28, 1994 RAI.

The response concerning chemical testing of Thermo-Lag materials at CPS is acceptable.

IP RESPONSE

1.0 and 2.0 September 19, 1994 and December 28, 1994 Requests for Additional Information

Thermo-Lag is not a safety-related component and there is no requirement that Thermo-Lag be procured or installed in accordance with a Quality Assurance (QA) program satisfying the requirements of 10 CFR 50, Appendix B. Nevertheless, as discussed in IP's letters dated December 16, 1994 and March 28, 1995, IP and its contractors utilized a QA program under 10 CFR 50, Appendix B to procure and install Thermo-Lag at CPS. This QA program provides adequate confidence that the Thermo-Lag received and installed at CPS conforms with applicable specifications and it provides information regarding important Thermo-Lag attributes. Furthermore, in addition to the QA program for procurement and installation, IP has performed walkdowns to provide additional assurance regarding some Thermo-Lag attributes. Therefore, there is no need to perform additional verifications, such as destructive examinations, for the Thermo-Lag installed at CPS.

IP understands that the NRC is concerned that nonconformances have been identified in some Thermo-Lag installations at other plants. However, those plants used other installation contractors under other QA programs. It would be inappropriate to impute nonconformances at other plants to the Thermo-Lag installed at CPS.

Background

In Attachment 3 to IP's February 9, 1994 letter to the NRC, IP provided detailed information concerning the Thermo-Lag installations at Clinton Power Station. That information was obtained through non-destructive examination (i.e., walkdown or construction document search) of the CPS Thermo-Lag installations. Several parameters in that matrix were listed with an asterisk or question mark (*, ?) in their columns which denotes that configuration of the parameter was unknown. Subsequently, IP stated in the December 16, 1994 letter that "IP made conservative assumptions regarding the plant specific information that was not available. Consequently, consistent with IP's position stated in the February 9, 1994 letter, IP does not need to obtain or evaluate the unknown Thermo-Lag parameters." This position was based on the following:

- The original purchase specification for the Thermo-Lag material required that all fire protection-related work be controlled by the contractor's quality assurance (QA) program, which was required to meet the requirements of 10 CFR 50 Appendix B and ANSI N45.2-1971. Brand Industrial Services Co. (BISCO) did have such a program established and did comply with its program during the installation. Specifically, BISCO's QA program required the following:

a) material traceability of all Thermo-Lag by lot number, both in the construction documentation and on the material itself
b) certification of installation and inspection personnel
c) 100% inspection of each commodity section in each installation to verify that it conformed to the installation procedures and design details
d) identification and resolution of installation problems in accordance with BISCO's corrective action (non-conformance) program
e) documentation of these activities (i.e., turnover packages)

Additionally, IP's construction QA program, which also meets the requirements of 10 CFR 50, Appendix B, and ANSI N45.2, required qualification of the contractor and inspection of all Thermo-Lag installations at time of turnover.

° The original purchase specification for CPS Thermo-Lag installation required the contractor to submit installation and inspection procedures for review and approval. BISCO's procedures and design details were reviewed and approved by IP's architect/engineer, Sargent & Lundy (S&L). Based in part on Thermal Science Inc. (TSI) Technical Manual 1130-83A and 20684, the BISCO procedures were revised to contain more detail than the TSI manuals. Specifically, the BISCO installation procedures and details contained requirements for:

a) approved materials
b) cleanliness and primer adhesion requirements
c) minimum sizes for tie wires, banding, and anchors
d) stress-skin orientation
e) minimum spacing between tie wires or banding
f) minimum thickness of prefabricated panel
g) use of butt-joint or score-and-fold joints
h) amount of precoating (prebuttering) for butt joints
i) minimum thickness of preshaped conduit sections
j) minimum anchor penetration, anchor spacing, and flange width for attachment to concrete
k) minimum thickness of material to cover anchors
l) minimum thickness and length of material for thermal shorts
m) minimum overlap to cover penetration seal interface
n) minimum thickness of material for in-tray fire breaks
o) minimum depth of caulk-and-fiber for internal conduit seals
p) requirement to fill gaps or joints prior to completion

The actual thickness or measurements for the above parameters were not recorded in the Thermo-Lag turnover packages for CPS; however, BISCO installation and inspection personnel did verify and initial that the minimum requirements for these parameters had been satisfied.

Destructive Examination

Four Thermo-Lag fire barrier installations are scheduled to be replaced by plant modifications prior to startup from RF-7 currently scheduled for 1998. One of these fire barriers is a four-sided vertical construction around three conduits; this installation utilizes Thermo-Lag panels. A section representing approximately 25% of this installation was dismantled on August 25, 1995 in order to obtain some as-built information regarding the conduits inside the Thermo-Lag enclosure. This dismantling process was performed to provide design input information for Plant Modification FP-093. This Thermo-Lag dismantling afforded an opportunity to make certain observations relative to the Thermo-Lag construction. The Thermo-Lag panels and the construction of the fire barrier were observed to be as expected and were consistent with the design and procedural documentation (e.g., minimum barrier thickness, stress skin location, joint construction). IP believes that this destructive examination provided confirmation of the adequacy of the extensive construction quality assurance program.

Chemical Composition Test

In letter U-602491, dated September 5, 1995, IP provided the results of the chemical composition testing program coordinated by the Nuclear Energy Institute (NEI). IP provided nine samples, extracted from CPS installations, to the NEI test program. The test results indicated that the nine CPS Thermo-Lag samples were consistent with the other utility samples tested as part of the NEI test program. Based on the high degree of chemical consistency exhibited by the NEI tests, IP believes that the CPS Thermo-Lag material is equivalent to the materials tested in the NEI fire endurance tests. IP does not plan to conduct any additional chemical composition testing.

NRC COMMENT

3.0 <u>Licensee Safety Evaluations</u>

For five of the six fire zones analyzed by the licensee (Zone A-1a, Zone C-2, Zone CB-1e, Zone CB-1f and Zone D-8), the following six common justifications regarding the defense-in-depth features provided at the plant were specified: (1) Due to administrative controls and the physical design of the fire zone it is not credible to postulate a fire capable of affecting safe shutdown cables, (2) Fire modeling has shown that fixed and transient combustibles present no credible risk of damage to safe shutdown cables, (3) Fire damage to both redundant trains is not credible due to the location of the cable trays, (4) Thermo-Lag will protect the safe shutdown cables until fire extinguishment is achieved by the plant fire brigade, (5) The probabilistic risk assessment did not identify any safety benefit, with regard to

core damage, containment isolation, containment heat removal or containment hydrogen control, from the installed Thermo-Lag, and (6) In the event that both redundant trains of safe shutdown equipment are damaged by fire, operator training and the actuation of the plants emergency response organization will ensure plant safety. Please provide a response with a technical basis for each of the following staff comments and questions (3.1 through 3.15).

IP RESPONSE

3.0 Licensee Safety Evaluations

The corresponding response with technical basis to each of the NRC comments (3.1 through 3.14) is provided in the applicable section (3.1 through 3.14) of this document. No response from IP is provided for the NRC's comment 3.15 because IP understands that the NRC has no concerns relative to the safety evaluation for the Thermo-Lag installation in fire zone F-1p.

A number of NRC's comments state or imply that the CPS Thermo-Lag safety evaluations rely upon a single plant feature to justify a deviation from its commitment to Appendix R. However, the CPS Thermo-Lag safety evaluations discuss and describe a number of plant-specific features which help ensure that safe shutdown is achievable despite the reduced capabilities of Thermo-Lag. These plant-specific features cumulatively provide defense-in-depth. Contrary to the implications in NRC's comments, IP does not rely upon any single plant feature to provide adequate fire protection for achieving and maintaining safe shutdown. Instead, IP relies on those features in combination.

NRC COMMENT

3.1 <u>Administrative Controls</u>

These justifications do not form an adequate basis for concluding that these six existing Thermo-Lag installations at CPS are acceptable as-is. Administrative controls, which are an important part of the plants overall fire protection program to minimize fire hazards, are not sufficient to ensure that a fire, that effects the plants ability to achieve and maintain safe shutdown, will not occur. Industry experience has demonstrated that a reportable fire occurs in most plant areas at a frequency of 10^{-3} to 10^{-2} per year. The licensee did not specify why the administrative controls and physical design of the fire zones at CPS are significantly superior to those at other nuclear power plants, to justify its conclusion. Therefore, the staff believes that it is credible to postulate a fire capable of affecting safe shutdown components at CPS.

IP RESPONSE

3.1 Administrative Controls

Administrative controls and the physical layout of the fire zones are not intended in and of themselves to justify that the CPS Thermo-Lag installations are acceptable. Instead, they are one of the elements of defense-in-depth features. It was not IP's intent to imply that the administrative controls and physical design at CPS are significantly superior to those at other nuclear power plants, or that the administrative controls would prevent all fires from occurring.

The description of the administrative controls in the safety evaluations is intended to demonstrate two main points, namely control of ignition sources and control of transient combustibles.

The control of ignition sources at CPS reduces the potential for a fire occurring by restricting the use and type of transient ignition sources in the plant. CPS procedurally requires the posting of a continuous firewatch while hot work is being performed. A review of fire event reports for nuclear power plants shows that most fires are detected by plant personnel and that many fires associated with transient ignition sources are extinguished by personnel when the fire is discovered. The posting of the continuous firewatch greatly reduces the chance that a fire will go undetected and increases the likelihood that any fire that does occur will be effectively suppressed.

Additionally, CPS limits and controls the amounts and types of combustibles allowed inside the plant. Limiting the amounts and types of combustibles allowed inside the plant limits the size and consequences of any fire involving such combustibles.

The safety evaluations conclude that the most severe credible fire in each affected fire zone will not prevent achieving and maintaining safe shutdown.

NRC COMMENT

3.2 <u>Fire Modeling</u>

> The staff believes that the uncertainties associated with the use of fire modeling, due to the lack of experimental validation of the models for typical nuclear power plant compartments, and the lack of adequate data on the fire performance of components susceptible to fire damage typically present in a plant, make it unreasonable to conclude, based solely on the results of a fire model, that there is no credible risk of damage to redundant safe shutdown components at CPS. The staff specified the technical information to be addressed in engineering evaluations

used to demonstrate that existing fire barriers are adequate to ensure safe shutdown capability in the letter to the licensee dated September 19, 1994. The licensee's evaluation does not fully address the specified variables and attributes to be included in a fire hazard analysis.

IP RESPONSE

3.2 Fire Modeling

Fire modeling, discussed in the 50.59 safety evaluation, shows that safe shutdown can be achieved and maintained in the event of a most severe, credible fire.

Fire modeling was used to assess the exposure to the Thermo-Lag installations of interest. The purpose of the fire modeling was to quantitatively account for many of those attributes and variables which are important in a fire hazards analysis as outlined in the September 19, 1994 NRC letter to IP. In IP's judgment, the use of quantitative fire modeling tools, recently developed by EPRI, represents an improvement in accounting for those attributes and variables over previous traditional qualitative methods.

The fire modeling method used at CPS has been compared favorably with fire test results. Recognizing there are uncertainties associated with application of the method, IP has consistently applied the method in a conservative manner. Examples of conservatism are as follows:

- Materials involved in a fire are assumed to burn at their maximum heat release rate (HRR) until all material is consumed.
- Transient fires are assumed to potentially occur at all locations where transients may exist, thus addressing the "worst possible" location for a fire to occur.
- The modeling was performed without taking quantitative credit for any manual or automatic suppression.

Fire Modeling Method

Fire modeling was used to determine location dependent fire exposure temperatures at installed Thermo-Lag locations.

The modeling method used was that described in the Draft Report for EPRI Project 3385-01, "Fire PRA (FPRA) Methodology Implementation Guide", and also in the Final Report for EPRI Project 3385-05, "Methods for Evaluation of Cable Wrap Fire Barrier Performance". The method is based on the fire modeling equations described in FIVE (EPRI Test Report TR-100370, "Fire-Induced Vulnerability Evaluation"), Section 10.4, and in EPRI TR-100443, "Methods of Quantitative Fire Hazard Analysis" by F.W. Mowrer, which is available from the Society of Fire Protection Engineers.

Comparison with Test Data

The modeling method used at CPS utilized the FIVE plume/ceiling jet/hot gas layer correlations to determine pre-flashover temperatures within the fire compartment. These correlations have shown good agreement with experimental data. Comparisons have been made between temperatures measured in full scale compartment fire tests and those determined analytically using the FIVE equations. The compartment fire tests were performed by Factory Mutual and Sandia National Laboratories in large smooth ceiling enclosures as documented in NUREG/CR-4681, "Enclosure Environment Characterization Testing for the Base Line Validation of Computer Fire Simulation Codes". Measured temperatures in the plume and in the ceiling jet for different sized fires and varying ventilation rates were shown to agree well with calculated temperatures. The comparisons are documented in Mowrer's report.

Adaptation of Fire Modeling Method for Power Plants

To ensure that the application of the FIVE fire modeling method to power plant compartments provided defensible results, EPRI accomplished the following:

- Enhanced the FIVE fire modeling method to better define the burning characteristics of power plant compartment fires, and
- Evaluated the method for application in compartments with irregular shapes, intervening pipes, strong airflow and similar features which distinguish a power plant compartment from a simple rectangular compartment with no obstructions and smooth ceilings/walls/floors.

The EPRI fire modeling method used at CPS included enhancements to better define the burning characteristics of a power plant compartment fire. These enhancements are based on conservative interpretation of actual fire test data and provide the capability of calculating fire growth/propagation in addition to providing improved definition of the burning characteristics of actual nuclear power plant combustible materials.

The EPRI fire modeling method used at CPS is based on the FIVE fire modeling which has been shown to provide good correlation with actual compartment fire test data for relatively large empty compartments with smooth ceilings/walls. Application of the FIVE fire modeling is conservative when applied to typical power plant enclosures as cited below:

- The test rooms were empty, whereas power plant compartments typically are congested with pipes, cable trays, HVAC ducts, etc. Intervening objects will typically break up the plume or ceiling jet, entraining cool air. Where obstructions can create pockets which trap hot plume or ceiling jet gases, the method recognizes these locations and treats them accordingly.

- The method incorporates the effects of irregularly shaped rooms and rooms with large (equipment) obstructions. A conservative location factor is applied where fires are located near walls or other large objects. The effect of the location factor is to increase the plume and ceiling jet temperatures to account for reradiation and geometry effects.
- The effects of forced ventilation are accounted for in the EPRI method. Evaluation of actual cable burn fire tests, where ventilation rates were varied, indicate no significant increase in heat release rate as a result of forced ventilation and indicate a significant decrease in plume temperatures from higher ventilation. Distortion of the plume by strong airflow (i.e., from a close HVAC vent) was found to be up to 10°F vertically under very high airflow. At CPS, forced ventilation was considered and determined to have no impact on the fire scenarios.

The EPRI fire modeling method employs a combination of field inspection and engineering calculations to evaluate all credible ignition sources and determine which can develop into a fire scenario.

Engineering calculations are employed before the field inspection to calculate zones of influence for typical ignition sources. These zones of influence are used during the inspections to quantitatively determine which ignition sources can develop into fire scenarios.

Detailed physical dimensions are obtained from walkdowns at Clinton Power Station for the identified fire scenarios. This geometry serves as input to the fire model.

Material burning characteristics are also input to the model. The selected burning characteristics are representative of the combustible materials at CPS. Material burning characteristics are taken from test data described in the following documents:

1) Nowlen, S., "Quantitative Data on the Fire Behavior of Combustible Materials Found in Nuclear Power Plants: A Literature Review," NUREG/CR-4679, Sandia National Laboratories, Albuquerque, NM, February, 1987.

2) Lee, B., "Heat Release Rate Characteristics of Some Combustible Fuel Sources in Nuclear Power Plants," NBSIR 85-3195, U.S. Department of Commerce, National Bureau of Standards, Gaithersburg, MD, July, 1985.

3) Nowlen, S., "Heat and Mass Release for Some Transient Fuel Source Fires: A Test Report," NUREG/CR-4680, Sandia National Laboratories, Albuquerque, NM, October, 1986.

4) Chavez, J., "An Experimental Investigation of Internally Ignited Fires in Nuclear Power Plant Control Cabinets: Part 1: Cabinet Effects Tests," NUREG/CR-4527/1 OF 2, Sandia National Laboratories, Albuquerque, NM, April, 1987.

5) "Fire-Induced Vulnerability Evaluation (FIVE)," EPRI TR-100370, Electric Power Research Institute, Palo Alto, CA, April, 1992.

6) Nowlen, S., "A Summary of Nuclear Power Plant Fire Safety Research at Sandia National Laboratories, 1975-1987," NUREG/CR-5384, Sandia National Laboratories, Albuquerque, NM, December, 1989.

7) Test Report for Project 13780-95568 from Omega Point Laboratories, "Evaluation of the Ignition, Heat Release & Flame Spread Properties of Thermo-Lag".

NRC COMMENT

3.3 Separation Criteria

The separation criteria specified in Section III.G of Appendix R to 10 CFR Part 50, was based on industry fire experience and experimental data. Specific details on the origin of the separation criteria was provided by the staff in NUREG-0050, "Recommendations Related to Browns Ferry Fire," dated February 1976, and in the final rulemaking (45 FR 76602) regarding the fire protection program for operating nuclear power plants. The licensee's evaluations, that concluded that fire damage to both redundant trains is not credible due to the location of cable trays, did not consider this information. An adequate technical basis for the licensee's conclusion that the location of the cable trays will prevent damage to cables of redundant divisions has not been provided.

IP RESPONSE

3.3 Separation Criteria

IP did take into consideration the regulatory criteria and guidance related to the separation of redundant divisions. The safety evaluations identified the deviations from NRC's separation criteria. IP's safety evaluations explain the plant-specific conditions at each Thermo-Lag installation. The safety evaluation statement that, "it is not credible to postulate damage to both the redundant divisions of safe shutdown cable tray due to the location of cable tray stacks," is based on the distance between the safe shutdown cables and credible ignition sources. IP did not rely solely on the location of the cable trays to conclude that the trays will not be damaged by a fire. Instead, IP also identified the fire hazard in each fire zone in question. Based upon the location of the cable trays and the

most severe, credible fixed and transient fire hazards in each fire zone identified by fire modeling, IP determined that a fire would not adversely impact the ability to achieve and maintain safe shutdown. For these fire zones, it is unnecessary to provide the separation specified in Appendix R, because the plant-specific fires are less severe than the generic fires used as the basis for Appendix R. Descriptions of the cable tray locations and ignition sources are provided below.

Fire Zone A-1a

Fire Zone A-1a is a relatively large and open fire zone with a floor area of 2964 square feet and a height of 28.33 feet. The Thermo-Lag wrapped cable trays are routed horizontally below the ceiling. They are separated by a 1-foot thick cantilevered concrete slab from the redundant divisional cable trays which run below the slab. The lowest of the cable trays located below the slab is 14.5 feet above the floor level. The fire zone contains very few fixed sources of ignition. The most severe, credible fixed fire hazards in this fire zone are the fan motors; however, no electric motor is located directly beneath the divisional cable trays. The most severe, credible transient fire source in this fire zone is miscellaneous maintenance waste. An evaluation of the fire zone showed that the fixed and the transient fires are not capable of preventing safe shutdown of the plant.

Fire Zone CB-1e

Fire Zone CB-1e is a relatively large and open fire zone. The total floor area is 18,072 square feet. About a third of the floor area is at the 737 foot elevation with a ceiling height of 24 feet. The remaining floor is on the mezzanine level at 751 foot elevation with a ceiling height of 10 feet. The lowest wrapped cable tray is 18.5 feet above the 737 foot elevation and 7.5 feet above the 751 foot elevation. The most severe, credible fixed fire hazards in this fire zone are the fan motors, electric panels and a humidification boiler. The most severe, credible transient fire hazard at the 737 foot elevation is a canvas cart filled with protective clothing. The most severe, credible transient fire hazard at the 751 foot elevation is miscellaneous maintenance waste. An evaluation of this showed that the fixed and the transient fires are not capable of preventing safe shutdown of the plant.

Fire Zone CB-1f

Fire Zone CB-1f is a very large and open fire zone with a floor area of 18,462 square feet and ceiling height of 17.5 feet. The two Thermo-Lag installations protecting the Division 2 safe shutdown cables in this fire zone are at the north and the south ends of the fire zone. In the north side, the Thermo-Lag wrapped cable trays are routed up from the floor to the ceiling and then routed below the ceiling. In the south side, the Thermo-Lag wrapped cable trays are floor-to-ceiling cable tray enclosures. The most severe, credible

fixed fire hazards in this fire zone are the three component cooling water pumps at the north end. The most severe, credible transient fire hazard in this fire zone is a canvas cart filled with protective clothing. An evaluation of this fire zone showed that the fixed and the transient fires are not capable of preventing safe shutdown of the plant.

Fire Zone C-2

Fire Zone C-2 is the entire Containment Building. The Thermo-Lag wrapped cable trays are located on the south side fire zone, below the floor grating at 828.25 foot elevation. The floor below the cable trays is also a grating floor at 803.25 foot elevation. This location is essentially open from the slab at 793.5 foot elevation to the domed ceiling of the containment at 927 foot elevation. In order for a hot gas layer to damage the Thermo-Lag wrapped cable trays, the volume under the containment dome would have to be filled with high temperature gases; this is not credible, given the relatively few fire hazards and low combustible loading in the containment.

NRC COMMENT

3.4 Barrier Worth

The determination that the existing Thermo-Lag will protect the required circuit until extinguishment can be achieved by the plant fire brigade has not been technically justified. The licensee has determined that the 1 hour Thermo-Lag barriers at CPS have a fire endurance rating of 28 or 46 minutes and the 3-hour Thermo-Lag barriers have a fire endurance rating of 85 minutes, based on the "NEI Application Guide for Evaluation of Thermo-Lag Barriers" and tests conducted by Sandia National Laboratories for the NRC. The staff position on the use of generic test data to qualify plant specific applications was provided to IP in a letter dated December 28, 1994. The staff also stated that based on its inspections of Thermo-Lag barriers and industry experience finding installation defects during destructive examinations, that some installation parameters cannot be verified by walkdowns or a review of installation records and procedures. In its response, dated March 28, 1995, the licensee stated that it does not intend to conduct any further verification of the installation parameters. To conclude that the 1- and 3-hour Thermo-Lag fire barriers installed at Clinton have a fire endurance rating of 28/46 and 85 minutes respectively, the licensee must have valid and verifiable information on each of the important material properties and installation parameters. Hose stream testing of Thermo-Lag barriers was not addressed in the licensee's evaluations.

IP RESPONSE

3.4 Barrier Worth

Fire Brigade Response

IP's response to NRC comment 3.5 provides the IP position with regard to fire brigade response.

Mechanical Properties

Mechanical properties such as tensile strength, compressive strength, shear strength, and flexural strength are related to the fire barrier seismic considerations and not to fire barrier performance. The Thermo-Lag fire barriers at CPS are not seismically qualified; however, like for piping insulation, the dead weight of the material was accounted for in the evaluation of the structural adequacy of the raceway hangers during a seismic event. The fire barriers are installed with stress skin, steel bands and tie wires in a configuration which makes gross failure of Thermo-Lag fire barriers during a seismic event unlikely. For these reasons, IP does not consider it necessary to conduct any further examinations or tests to verify Thermo-Lag mechanical properties.

Installation Parameters

IP is not taking credit for Thermo-Lag as a one-hour or three-hour barrier. However fire endurance tests and the NEI application guide demonstrate that Thermo-Lag does have some ability to protect against fire.

Given the defense-in-depth nature of IP's safety evaluations, minor variations in the quality of procured and installed Thermo-Lag (with associated effects on fire rating) would not invalidate IP's conclusion that the plant can be safely shut down. Nevertheless, as stated in IP's response to NRC comments 1.0 and 2.0 previously in this attachment, there is adequate confidence that the as-installed Thermo-Lag at CPS conforms with its specifications.

For those installation parameters applicable to the evaluation of the barrier worth which could not be verified by walkdowns or a review of installation records and procedure, conservative assumptions were made in the fire endurance calculations. Using the NEI Fire Endurance Application Guide, IP determined that the CPS Thermo-Lag would provide the 28, 46 or 85 minute protection referred to in the NRC comment.

Hose Stream Test

The NRC letter to NEI dated April 7, 1994, stated that the purpose of the hose stream test is to evaluate the structural integrity of the fire barrier and its ability to protect the enclosed raceway from damage caused by in-plant firefighting and falling external objects during a fire. All of the NEI tests used as the basis for determining barrier worth of the CPS Thermo-Lag installations did include the impact, cooling, and erosion effects of a hose stream applied immediately following removal of the assembly from the test furnace. In all cases the hose stream was directed, for a minimum period of 5 minutes, perpendicularly to the assembly through a 1-1/2" fog nozzle at a distance of 5 feet from the exposed face, with a nozzle pressure of 75 psig, a spray angle of 30°, and a minimum flowrate of 75 gpm.

From review of NEI Test Reports 2-7 and 2-10, for much of the test assembly lengths there were no openings in the barrier, either before or after the hose stream application. In the cases where an opening was created in the barrier during the fire test, it was always at the radial bend or on the bottom of the box or tray, locations not prone to damage of cables due to the presence of the bottom or siderails of the cable tray. It is noted that all cable trays wrapped in Thermo-Lag at CPS have solid steel sides and bottoms. These NEI tests did not identify any cases where the hose stream application created an opening in a barrier that did not already have an opening from the fire test.

The previous discussion on hose stream testing of Thermo-Lag barriers is not specifically addressed in the CPS safety evaluations, but is included in the detailed fire barrier worth calculations referenced within the safety evaluations.

NRC COMMENT

3.5 Fire Brigade

The assumption that the fire brigade responds within 12 minutes and is able to extinguish a fire within 28 minutes has not been justified by the licensee. Response times of the brigade recorded during fire drills may not be representative of the actual time for the fire brigade to achieve fire extinguishment. Industry experience, as documented in Licensee Event Reports, has demonstrated that actual time to achieve extinguishment of reportable fires significantly exceeds the recorded response times during drills.

IP RESPONSE

3.5 Fire Brigade

The assumption that the fire brigade responds within 12 minutes and is able to extinguish the fire within 28 minutes is relevant to the safety evaluations for Thermo-Lag installed in fire zones CB-1e and A-1a.

Fire Extinguishment

The fire brigade response times discussed in the safety evaluations are based on actual CPS fire drill experience. IP agrees that there exists no direct correlation between response times and fire extinguishment times. In fire zones A-1a and CB-1e, however, fire extinguishment would be prompt because they are relatively open and frequently traversed areas, and are protected by wet pipe sprinkler systems. Consequently, fire extinguishment is expected to occur promptly in the incipient or early stages of combustion.

The extinguishment times identified in the Licensing Event Reports are not necessarily relevant. The term "extinguishment time" is subjective. The fire brigade leader or the shift supervisor is designated to control fire events and may not declare the fire "out" or "extinguished" until termination of the emergency. This evolution may include salvage and overhaul operations and potentially reflash watch.

Fire Zone A-1a

A-1a is a relatively open fire zone that provides access to the Emergency Core Cooling System (ECCS) pump rooms at the 707 foot elevation of the Auxiliary Building. This corridor is 2964 square feet by 28.33 feet high, contains very few ignition sources, and is easily accessed from the main (737 foot elevation) floor of the Auxiliary Building by two stairwells (one of which is enclosed by fire rated walls). Fire zone A-1a contains two manual hose stations each with 75 foot hoses and three portable extinguishers. The enclosed stairwell to A-1a is approximately 40 feet at the same elevation from the nearest fire brigade cage and approximately 50 feet from an additional hose station with a 75 foot hose. The open stairwell is approximately 130 feet at the same elevation from the same fire brigade cage and approximately 30 feet from an additional hose station with a 75 foot hose.

Over 90% of the calculated combustible loading in fire zone A-1a consists of IEEE-383 qualified cable and Thermo-Lag. Self ignition of the IEEE-383 qualified cables within cable trays or the Thermo-Lag is not possible due to the lack of an ignition hazard. As documented in the safety evaluation, the remaining ignition hazards in fire zone A-1a

cannot ignite the Thermo-Lag or cables in cable trays due to their location at the floor. If the cable and Thermo-Lag fire loads are excluded, the remaining combustibles represent a fire severity of less than 6 minutes. Therefore, the response of the fire brigade to a postulated fire is not a crucial fire protection element in fire zone A-1a.

Fire Zone CB-1e

CB-1e is a relatively open fire zone that provides access to the three diesel-generator rooms and the personnel elevators at the main floor (737 foot elevation) of the Control Building. The total floor area of fire zone CB-1e is 18,072 square feet, with approximately one-third of the floor area at the 737 foot elevation with a ceiling height of 24 feet; the remainder of the floor area is at an open mezzanine (which can be accessed by two open stairwells) at the 751 foot elevation with a ceiling height of 10 feet. Fire zone CB-1e contains four manual hose stations (one with a 50 foot hose, two with 75 foot hoses, and one with a 100 foot hose) and three portable extinguishers at the lower elevation. Fire zone CB-1e also contains three manual hose stations each with 100 foot hoses and four portable extinguishers at the mezzanine level. The west doors to fire zone CB-1e are approximately 200 feet at the same elevation from one fire brigade cage and the east doors to fire zone CB-1e are approximately 80 feet at the same elevation from another fire brigade cage.

Over 84% of the calculated fire loading in fire zone CB-1e consists of IEEE-383 qualified cable and Thermo-Lag. Self ignition of the IEEE-383 qualified cables within cable trays or the Thermo-Lag is not possible due to the lack of an ignition hazard. As documented in the safety evaluation, the remaining ignition hazards in fire zone CB-1e cannot ignite the Thermo-Lag or cables in cable trays due to their location at the floor. If the cable and Thermo-Lag fire loads are excluded, the remaining combustibles represent a fire severity of less than 5 minutes. Therefore the response of the fire brigade to a postulated fire is not a crucial element for fire protection in fire zone CB-1e.

In conclusion, the estimated fire barrier worth of Thermo-Lag in fire zones A-1a and CB-1e provide the CPS fire brigade adequate time for extinguishing the fire. This is a component of the CPS defense-in-depth.

NRC COMMENT

3.6 <u>Cable Damageability</u>

The assumptions used by the licensee that IEEE 383 cables have a failure temperature of 700°F and an ignition temperature greater than 900°F is not technically supported. The temperature threshold for cable damage of IEEE-383 qualified cables reported by Sandia National Laboratory in NUREG/CR-5546

ranged from 617°F to 689°F. Sandia also concluded that the temperature threshold for piloted ignition is less than the temperature threshold reported for cable damage.

IP RESPONSE

3.6 Cable Damageability

The cable failure temperature of 700°F and ignition temperature of 932°F were used in the evaluations as approximate limits in fire modeling scenarios. The 700°F was used as a threshold below which even unwrapped cable would be undamaged (assuming the Thermo-Lag wrap did not exist). The intent was to demonstrate that the cables would not be damaged by the postulated fire by a substantial margin.

The 932°F was used as an approximate threshold below which unwrapped cable (an intervening combustible in this case) would not ignite and propagate a fire.

A review of NUREG\CR-5546 identified the following information:

- The temperature threshold of cable thermal damage for the tested varieties of IEEE-383 qualified cables ranged from a low of 617°F to 626°F to a high of 689°F to 698° F (Table 5.1, page 31 of NUREG\CR-5546).

- The temperature threshold of cable thermal damage for EPR/Hypalon cable was 689° F to 698°F for unaged cables and 653°F to 662°F for aged cables. Test exposures of 80 minutes identified no cable failures at 689°F for unaged cables or 653°F for aged cables (Table 5.1, page 31 of NUREG\CR-5546).

As was noted in the 50.59 safety evaluations (for example, see page 13 of the fire zone A-1a safety evaluation), CPS uses the damage temperature for EPR/Hypalon insulated cable since all of the safety related cable in the fire zones under evaluation is of this type.

The thermal aging of the test specimens in NUREG\CR-5546 was performed to simulate a 40 year life at an ambient temperature of 140°F. This temperature is significantly higher than the 104°F maximum design basis temperature in any of the fire zones for which fire modeling was performed (S&L HVAC Design Criteria DC-VA-CP-01, Rev. 3). Additionally, the actual temperatures in the analyzed fire zones are significantly lower than the maximum design temperature.

These factors support a lower degree of thermal aging than was analyzed in NUREG\CR-5546 with a correspondingly higher cable damage temperature. One final point regarding the importance of aging is provided by the following quote from NUREG\CR-5546: "The thermal damage threshold changes observed in these tests are not considered of a sufficient magnitude to significantly alter risk estimates for scenarios involving cable thermal damage".

In any case, the results of the fire modeling calculations performed for the evaluated fire zones did not depend on the use of 700°F, and the conclusions in those calculations would not be affected by the use of the low cable damage temperature of 653°F (at which no cable failures occurred).

The temperature specified in the 50.59 safety evaluations for piloted ignition of IEEE-383 qualified cable was 932°F. This is an approximate value specified in the Fire Induced Vulnerability Evaluation (FIVE) methodology. This value was provided as background information and did not have any impact on the analyses for the following reasons:

° In fire zone A-1, a no piloted ignition scenarios were identified. Additionally, the highest temperature calculated at cable locations was 157°F. This temperature is far below the temperatures tested in NUREG\CR-5546 in which cable damage/ignition occurred. Correspondingly, the specified cable ignition temperature is immaterial in fire zone A-1a.

° In fire zone CB-1e, the only cable ignition scenario involves electrical cabinet 0AP87E. In this scenario the electrical cable was assumed to ignite at the same time that the fire occurred in the ignition source. No analysis was performed to determine if the affected cables would actually reach the 932°F ignition temperature. No other piloted ignition scenarios were identified in this fire zone. Correspondingly, the cable ignition temperature is immaterial in fire zone CB-1e.

° In fire zone CB-1f, the only potential cable ignition fire scenario involve an electrical cabinet ignition source that ignites the vertical drop cables entering the top of the cabinet. In these scenarios the cables entering the top of the panel were assumed to ignite without any analysis to determine the actual temperature of the cable. Correspondingly, the specified cable ignition temperature is immaterial in these fire scenarios.

Fire scenarios were identified in which Thermo-Lag installations had the potential to be ignited from either fixed or transient ignition sources. The cables inside of the burning Thermo-Lag were, however, assumed to be failed which makes the actual failure temperature of the cables immaterial for these scenarios. The heat content of

the cables located inside the Thermo-Lag installations was examined for impact on the formation of a damaging hot gas layer. Based on the size of the fire zone and the heat content from this scenario (15.2 millic . BTUs), no potential for the formation of a damaging hot gas layer exists. Correspondingly, the cable ignition temperature is immaterial for these scenarios.

NRC COMMENT

3.7 Fire Initiating Event Frequency

The assumptions used by the licensee in calculating the fire initiating event frequencies used in the probabilistic risk assessment are not technically supported. No technical basis is provided for excluding cables, junction boxes and pumps of 5 horsepower or less as potential ignition sources.

IP RESPONSE

3.7 Fire Initiating Event Frequency

Cables were excluded as ignition sources at CPS due to the use of IEEE-383 qualified cable as field cable in the fire zones of interest. The basis is that the Fire Events Database (FEDB), NSAC-178L, did not identify any cases where IEEE-383 qualified cable self-ignited. Work documented in NUREG/CR-5384 "A Summary of Nuclear Power Plant Fire Safety Researches at Sandia National Laboratories 1975-1987", also supports this point. On page 35 of the document, Nowlen observed that #12 AWG, IEEE-383 qualified cables required 100 to 130 amperes of current to induce open flaming which persisted for 40 to 240 seconds before self-extinguishing. This degree of cable loading is more than five times the allowable currents in cable at CPS, given the electrical design (fuses, circuit breakers, application of IEEE Standards, etc.) of the plant.

Junction boxes were not included as ignition sources because of the solid metal, unvented construction of these enclosures. This metal, unvented construction prevents a fire from propagating outside of the junction box.

The exclusion of motors smaller than five horsepower, unless in close proximity to other equipment, was based on a review of the FEDB and the very low HRR for this size of motor. The FEDB did not identify any cases where five horsepower or smaller motors self-ignited. If self-ignition is postulated to occur, the heat release rate would be low as a result of the fact that these motors are not oil lubricated and contain a very small amount of combustible material. An examination of the fire zones for which fire modeling was performed identified only zone A-1a as containing any motors of this size. These motors are floor drain pump motors located in fire zone A-1a, which are offset laterally

approximately 30 feet and vertically 17.67 feet from the nearest Thermo-Lag installation. Using the heat release rate recommended in the FPRA for electric motors, the temperature reached at the nearest affected Thermo-Lag installation from self-ignition of these motors would be only 119°F. This temperature is so small that it has no impact regardless of which cable damage or ignition temperature is selected. Correspondingly, exclusion of small motors has no material effect on any of the 50.59 safety evaluations.

NRC COMMENT

3.8 Probabilistic Risk Assessment

The licensee's use of a probabilistic risk assessment to determine the benefit provided by the installed fire barrier to protect equipment required to achieve and maintain safe shutdown is not technically justified. The assessment assumes that fire damage causes a failure of all components regardless of fire barrier protection and the effect on core damage protection, containment isolation, containment heat removal and hydrogen control. The staff's position regarding the limiting safety consequences, required shutdown functions, performance goals, and equipment generally necessary for shutdown, are specified in Generic Letter 81-12, "Fire Protection Rule," dated February 20, 1981. If the Thermo-Lag installed in a fire area is not required to meet NRC requirements, the licensee should revise its analysis accordingly.

IP RESPONSE

3.8 Probabilistic Risk Assessment

The most important point regarding the use of probabilistic risk assessment (PRA) in the evaluation of Thermo-Lag is that PRA results were used to identify the installations which should be modified and not used as the sole basis to accept Thermo-Lag installations. PRA was used to identify the Thermo-Lag installations that provided identifiable benefit in preventing core damage or in protecting containment isolation, containment combustible gas control or containment heat removal functions. The installations that the PRA analysis identified as providing some benefit were all selected for modification to bring them into conformance with Illinois Power's commitment to 10 CFR 50 Appendix R. The installations for which the PRA analysis did not identify any safety benefit were all subjected to deterministic analyses to evaluate the plant's ability to achieve and maintain safe shutdown.

NRC COMMENT

3.9 Operator Actions

Reliance solely on operator actions and the plants emergency response organization to ensure plant safety in the event that both divisions of redundant safe shutdown equipment is disabled is not in accordance with the defense-in-depth concept specified by the NRC for fire protection programs. The objectives of the fire protection program are: (1) prevent fires from starting, (2) rapidly detect, control and extinguish fires that do occur, and (3) provide protection for structures, systems, and components important to safety so that a fire that is not promptly extinguished will not prevent the safe shutdown of the plant. In order to meet the third objective, one train of systems necessary to achieve and maintain safe shutdown conditions must be free of fire damage. The staff concludes that although operator training and the activation of the plants emergency response organization are important elements of the program to ensure plant safety, these elements are not unique to CPS, and are not considered adequate by themselves to meet this requirement.

IP RESPONSE

3.9 Operator Actions

IP did not rely solely upon operator actions as the basis for concluding that a fire would not adversely affect the ability of CPS to achieve and maintain safe shutdown. Instead, this factor was one of a number of factors that provide defense-in-depth for protection of safe shutdown capability. Operator actions, together with other factors discussed in the 50.59 safety evaluation, provides reasonable assurance that safe shutdown can be achieved and maintained in the event of a fire. The discussions of operator actions were intended to show that the expected operator actions in the evaluated fire zones make it very unlikely that consequences of the fire would result in adverse impact on the health and safety of the public.

The safety evaluations point out that, after analyzing the worst possible loss of safe shutdown equipment at CPS due to a fire in the affected fire zones, scenarios representing these worst case casualties were presented to operating crews in the CPS simulator. In the manner of licensed operator examination, the crew had no prior knowledge of what the event would be, and was allowed only minimum shift manning. In each scenario presented, the crew was able to achieve and maintain hot shutdown of the power plant. In every scenario, the Shift Supervisor did activate the Emergency Response Organization (ERO) promptly and assume Command Authority of the ERO.

Scenarios such as Anticipated Transient Without Scram (ATWS), large Loss of Coolant Accidents (LOCAs), and Station Black Out (SBO) are the basis of the NRC's licensed operator qualification program. The demonstration of the crews' ability to mitigate highly complex, multiple-failure scenarios successfully is regarded as an accurate assessment of the safety level of the plant itself. The most severe fires postulated for Thermo-Lag wrapped areas were not as severe as some other scenarios that have been used for examination during losses of power that go beyond the SBO at CPS.

The most important factor in the ability of CPS to withstand severe damage to Division 1 and Division 2 safety related cables is the existence of the Division 3 High Pressure Core Spray (HPCS) system. The Division 3 diesel generator and the associated systems allow CPS operators to achieve and maintain hot shutdown with a total loss of core cooling and heat removal capability from Divisions 1 and 2 and a loss of all Non-division 3 power. Few commercial nuclear plants have an equivalent to the HPCS system, making CPS somewhat unique in plant survivability due to events affecting multiple divisions of safety related equipment.

It should be pointed out that these simulator scenarios were conservative in that they postulated a concurrent Loss of Offsite Power (LOOP). An evaluation of the electrical circuits within the fire zones was not conducted to determine whether or not fires in the fire zones in question would lead to a LOOP. The availability of offsite power would likely provide more flexibility to the operator in the mitigation of the postulated fire.

During all significant plant transients, the actions of licensed operators are one line of defense. Activation of the plant's ERO will provide any necessary assistance in addition to the operating crew. In no event will a postulated worst case fire leave a crew without the ability to achieve and maintain hot shutdown due to operator training, existing procedures, and the Division 3 HPCS system.

NRC COMMENT

3.10 <u>Fire Zone A-1a</u>

Several conclusions stated by the licensee in the detailed justification for the deviation in this area are not technically supported. For example, the licensee stated that since the cable trays are all located a minimum of 14 feet above the floor and there are no vertical floor to ceiling cable runs, it is not credible to postulate cable damage due to a fire originating at the floor. This conclusion is not correct. It appears that the analysis only considers flame impingement as a credible initiator of cable damage, the licensee has not considered the rapid rise in temperatures in the plume generated by a floor level fire, the high temperatures

expected in the ceiling jet and descending hot gas layer and the radiant energy transfer from these sources to the target cables, as sufficient to damage the cables. No basis has been provided to exclude these sources as potential initiators of cable damage.

The licensee also concluded that a hot gas layer cannot be formed due to the unvented construction of electrical panels, use of conduit for cables not in trays, large distances between ignition sources and targets, and the use of IEEE-383 qualified cable. These considerations have little effect on the potential for the formation of a hot gas layer. Typical factors that affect the formation of the hot gas layer are the heat release rate of the fuel, fuel surface area, the compartment geometry and the compartment ventilation. Provide an analysis that considers all relevant factors in the formation of a hot gas layer.

IP RESPONSE

3.10 Fire Zone A-1a

A description of the fire phenomena considered and the methodology used in the CPS safety evaluations, is included in the following section. This methodology was used in all of the modeled fire zones (CB-1e, CB-1f, and A-1a).

Fire Modeling Methodology

The objective of fire modeling is to determine the effects of a fire on cables or equipment located within a fire zone. The impact of a fire on a particular piece of equipment or cable is a function of the ignition source, cable/equipment characteristics and fire zone geometry. Fire modeling is performed on an ignition source-by-source basis and has two subdivisions: fixed (in-situ) sources and transient sources. Fixed ignition sources are those sources that are either installed such that they are immobile (for example, a pump) or by procedure or practice are always located in the same place within a fire zone. Transient ignition sources are defined as sources that have the potential to be located essentially anywhere within a fire zone.

Equipment is selected for evaluation as a fixed ignition source based on criteria contained in the Fire-Induced Vulnerability Evaluation (FIVE) methodology guide. Equipment that does not meet the selection criteria may be included for evaluation as an ignition source if it is in close proximity to an important piece of equipment or associated cable.

Fire modeling of fixed ignition sources is performed in a stepwise fashion. The modeling methodology is drawn from the Fire Induced Vulnerability Evaluation (FIVE) and Fire Risk Analysis Implementation (Fire PRA) methodologies developed by the EPRI. The

detailed steps involved in modeling are provided below. Not all steps of the fire modeling were necessary to identify and evaluate the effect of each ignition source on other cables and equipment. In most cases, the conclusion that the ignition source causes no adverse impact was reached upon completion of the deterministic steps 1 through 10.

1. Determine the physical characteristics of the fire zone. This requires floor area, ceiling height, room volume, maximum fire zone ambient temperature, and identification of any features that could affect the analysis. This information is obtained from plant design documents and HVAC calculations.

2. Identify all fixed ignition sources in the fire zone. This information is collected from plant databases and verified by walkdown of the zone. During the course of the walkdown, any material storage locations are also identified. These locations are treated as fixed ignition sources.

3. Select an appropriate heat loss factor. The heat loss factor accounts for heat absorbed into the fire zone floor, ceiling and walls. A figure of 0.70 is utilized in modeling based on guidance in the FIVE. This heat loss factor is very conservative in that Sandia testing found a factor of 0.85 to be more realistic. Additionally, longer duration (greater than 5 minutes) scenarios, such as the formation of a damaging hot gas layer, have been experimentally determined to have heat loss factors in the range of 0.94 to 0.98.

4. Determine target damage and ignition temperatures. For Thermo-Lag, an ignition temperature of 1000°F is used based on guidance in the Thermo-Lag Combustibility Evaluation Methodology Plant Screening Guide.

5. Determine target damage radiant heat fluxes. For IEEE-383 qualified cable, a heat flux of 1.0 BTU/s/ft^2 is used based on guidance in the FIVE manual. For Thermo-Lag, an ignition heat flux of 2.2 BTU/s/ft^2 is used based on guidance in the Thermo-Lag Combustibility Evaluation Methodology Plant Screening Guide.

6. Identify heat release rates (HRRs) for the different categories of fixed ignition sources located within the fire zone. The FPRA manual provides HRRs for most of the standard equipment categories. In cases where HRRs are not explicitly stated, expert judgment is obtained from Science Applications International Corporation (SAIC), the consultant that developed the FPRA manual for EPRI. For fixed ignition sources containing oil the HRR is calculated from the amount of oil contained in the source and the potential surface area of the oil spill.

7. Assign a location factor for each fixed ignition source in the fire zone. The location factor accounts for the higher plume temperatures found for fires near walls and in corners.

8. Calculate in-plume damage heights and radiant damage ranges for each fixed ignition source located in the fire zone. This calculation uses equations contained in the FIVE manual.

9. Determine targets for each fixed ignition source. This step utilizes the damage heights and ranges calculated in step 8. Any piece of equipment, cable, conduit or tray within the damage heights and ranges were noted. Targets that are outside of the radiant damage range and are not located in the plume are evaluated for potential damage from the ceiling jet. Fixed ignition sources without any potential targets are excluded from further analysis other than the loss of the fixed ignition source itself and impact of forming a damaging hot gas layer (HGL).

   If a target is found to be within the ignition range of a fixed ignition source, the target is in turn treated as an ignition source and additional targets are identified. This models the propagation of a fire from a source to a series of combustible targets. Additionally, the heat content of the ignited target must be considered to determine if the formation of a damaging HGL is possible.

10. Determine the set of cables and equipment associated with each target set. This step identifies all cables contained within the trays and conduits of each target set that are associated with equipment included in the CPS PRA model. Target sets that do not contain any modeled cables or equipment are eliminated from further analysis other than for formation of a damaging HGL.

11. Determine the basic events (human or equipment failures) in the CPS PRA model that are associated with each cable or piece of modeled equipment in a format that allows quantification of the PRA model. As part of this step, each target set equipment list is reviewed and appropriate PRA model initiators are included in the input deck.

12. Calculate ignition frequency for each fixed ignition source with a target set containing modeled equipment or cables. The frequency is calculated from the Fire Events Database (NSAC-178L).

13. Quantify the PRA model for each target set input deck. Quantification of the PRA model for a particular target set generates a conditional core damage probability (CCDP) that results from the loss of the target set.

14. Determine the significance of each ignition source - target set combination. The product of the ignition frequency and the CCDP for each combination is calculated and compared to the significance threshold of 10^{-7}. The value for the significance threshold is taken from the FPRA manual. Ignition source - target combinations below the significance threshold are deemed to pose an acceptably low level of risk.

Modeling of transient ignition sources and combustibles is similar to fixed ignition sources with some additional steps to account for the uncertainty in location and amount of the combustibles. These additional steps are as follows:

15. Determine what transient combustibles are likely to be present or traverse the fire zone. This evaluation used preventive maintenance and equipment history data, physical layout of the zone and adjacent fire zones as well as the CPS fire load calculation. Due to the potential for large HRRs from oil fires, special emphasis was placed on identifying oil lubricated components as well as any such equipment that was likely to be reached by traversing the fire zone under analysis. The type of container in which oil is transported is also of importance. Oil transported in sealed 55 gallon drums or NFPA-approved containers are assumed to be not exposed to potential ignition sources. If oil is not transported in these types of containers, the frequency with which oil would be present in the fire zone must be calculated.

16. Determine the transient combustible ignition frequency for the subject fire zone. This number is based on the types of transient ignition sources that are not prohibited in the fire zone.

17. Select an appropriate transient fuel package based on what types of transient materials are likely to be present in the fire zone. The fuel packages and their associated HRRs are selected from Sandia National Laboratory (SNL) testing.

18. Determine target sets based on specific floor locations. Target sets are identified that could be damaged by a fire involving the transient fuel package.

19. Calculate area ratios for each floor location - target set combination. The area that a transient fuel package fire could be located within and damage each target set is measured. These areas are then divided by the total fire zone floor area to the ratio that represents the probability of the transient fuel package being located in the area affecting a particular target set given that it is in the fire zone of interest. These area ratios are used to modify the transient combustible ignition frequency for each target set.

Following the completion of step 19, the transient target sets are evaluated using the same techniques as for fixed ignition sources. As was the case with fixed ignition sources, the significance level for the ignition frequency, CCDP products is 10^{-7}. The final step in the analysis is to sum all of the CCDP and ignition frequency products for both fixed and transient ignition sources.

Fire Zone A-1a

Fire modeling calculations were performed at CPS to support the fire zone A-1a safety evaluation. These calculations did consider the effects of in-plume, ceiling jet and radiant heating exposure to wrapped cables. The salient points of these calculations are summarized in the following paragraphs.

The lowest of the Thermo-Lag wrapped Division 2 cable trays in fire zone A-1a is at elevation 729.5 feet (sheet 2 of enclosure 1 of the original safety evaluation). This makes the minimum height of any wrapped cable tray above the floor in fire zone A-1a to be 22 feet. Below this tray is a 1-foot thick concrete slab. Below the slab are three unwrapped Division 1 cable trays. The lowest unwrapped tray is 14.5 feet above the floor. Wet pipe suppression systems are provided both above and below the concrete slab. All cable trays in this fire zone have solid steel bottoms.

No oil lubricated components are located in this fire zone. Oil is transferred through fire zone A-1a to other fire zones in sealed NFPA-approved containers. The use of such containers prevents lubricating oil traversing this fire zone from being exposed to an ignition source. Transient combustible control procedures at CPS prohibit lubricating oil from being left unattended when not sealed in approved containers. These factors eliminate the potential for a large, oil pool type fire from occurring in fire zone A-1a.

The largest ignition sources in fire zone A-1a are electric motor fires and miscellaneous maintenance waste with a HRR of 138 BTU/s. The 138 BTU/s HRR is based on Sandia testing for a fuel packet of maintenance refuse.

The impact of the electrical motor fire was first examined by determining the location of the electric motor in relation to the Thermo-Lag wrapped cables. No electric motor is located directly beneath the wrapped trays. Therefore, flame impingement is not a concern.

The impact of the ceiling jet generated by an electric motor fire was also examined in the fire modeling analysis. First, the nearest electric motor to a wrapped cable tray was identified. The vertical distance between this ignition source and the ceiling is 13.83 feet. The vertical distance from the highest wrapped cable tray to the ceiling is 2.88 feet. Per the FIVE methodology, the ceiling jet sublayer extends downward from the ceiling a

distance equal to 15% of the distance from the ceiling to the virtual surface of the fire. In this case, the ceiling jet sublayer extends downward from the ceiling only 2.07 feet. Since the highest of the wrapped cable trays is below this level, no potential exists for the ceiling jet generated by an electric motor fire to affect any of the Thermo-Lag wrapped cables.

The impact of radiant energy effects resulting from an electric motor fire was also examined. Using calculations and the recommended radiant energy damage flux for qualified cable contained in the FIVE methodology, the maximum range at which an electric motor fire could cause damage was determined. This distance, 1.4 feet, is much smaller than the proximity of the nearest electric motor to the wrapped cable trays. Therefore, no potential exists for damage to cables in wrapped cable trays from radiant energy effects generated by electric motor fires in fire zone A-1a.

One other aspect of electrical motor fires in this fire zone is the potential ignition of the Thermo-Lag fire break section from an adjacent area cooler fan motor. This cooler is at approximately the same elevation as the fire break and is offset laterally from the edge of the cooler by 1.75 feet. This relative orientation of the fire break to the cooler prevents any interaction from plume or ceiling jet effects from a cooler electric fan motor fire. The area cooler contains tw electric fan motors. These motors are offset from the vertical sides of the cooler approximately 9 inches and are completely inside the metal casing of the cooler. The side of the cooler adjacent to the fire break does not contain any penetrations. This solid metal side provides an effective shield against radiant energy affecting the fire break. Even without this solid side, the range at which an electric motor fire can ignite the Thermo-Lag fire break is only 1 foot. Correspondingly, no potential impact on the Thermo-Lag fire break exists from an electrical fan motor fire in fire zone A-1a.

The effect of a maintenance waste fire on wrapped cable trays was examined by postulating a transient waste fire directly beneath a wrapped cable tray. No credit was taken for the concrete slab that shields the Thermo-Lag wrapped trays from fires at lower elevations. The elevation of the lowest Thermo-Lag wrapped cable tray is 22 feet above the floor. Using the FIVE in-plume correlation and a HRR of 138 BTU/s, a temperature of 157°F was calculated at the wrapped tray. This resulting temperature is far below the potential damage temperature for cables or the 1000°F Thermo-Lag ignition temperature.

Potential damage to the wrapped cables from the ceiling jet was also examined since the top two wrapped cable trays would be enveloped by the ceiling jet sublayer. The only situation where the ceiling jet could exceed the temperature of the plume would be to postulate a maintenance waste fire close to enough to a wall or corner where the effective heat release rate is higher due to the confining effects of those structural features. The temperature rise in the ceiling jet resulting from a fire in the nearest corner to a wrapped cable tray was found to reach 187°F. This temperature rise is too small to damage either cables or Thermo-Lag.

Fire zone A-1a has a floor area of 2964 square feet and a ceiling height of 28.33 feet. It is connected by a stairway opening (with dimensions of 10.83 feet by 7.42 feet) in the ceiling to fire zone A-1b which has a floor area of 5650 square feet and a ceiling height of 23.08 feet. A wet pipe fire suppression system is provided throughout fire zone A-1a. Because of the large size of the stairwell opening, formation of a damaging HGL in fire zone A-1a requires that the layer first descend through fire zone A-1b. Based on the heat added to the fire zone from the transient waste fire, it is estimated that the temperature of the HGL would only reach 171°F. This temperature is far below the cable or Thermo-Lag damage temperature. The temperature rise from an electric motor fire would be even smaller due to the lower heat content of the motor relative to the transient waste.

The noted ceiling jet results were described here to emphasize that credible fires in this fire zone cannot cause damage to the wrapped cables. In actuality, even if the jet had damaged the wrapped cables it would not have affected the unwrapped Division 1 cables in this fire zone due to their lower elevation. This factor makes ceiling jet concerns in this fire zone immaterial.

Damage distances from radiant energy effects were also calculated for a maintenance waste fire. These distances are 2.1 feet for exposed cable damage and 1.4 feet for Thermo-Lag ignition. Since the nearest wrapped cable tray is 22 feet from the postulated fire, no potential impact to wrapped cables or Thermo-Lag exists in this fire zone.

The features noted in NRC's comment are of importance in this fire zone since they affect the parameters discussed in the safety evaluation. The unvented construction of the electrical panels in this fire zone means that fires will not propagate outside of the panels themselves. This restricts the fuel surface area and the HRR. Use of conduit means that the cables inside will not ignite from an exposure fire. Again, this restricts the fuel surface area of the fire and the HRR. The large distances between ignition sources and targets describes the inability of combustible targets. Failure to propagate to other combustible targets restricts the fuel surface area and the HRR. The use of IEEE-383 qualified cable makes it more difficult to ignite than unqualified cable. Reducing the potential for cable ignition also reduces the potential for fire propagation and, by extension, reduces the fuel surface area and HRR. As stated earlier, no credible oil pool type fire scenarios exist in this fire zone. This leaves the previously mentioned electric motor fires and maintenance waste fires as the only credible fire sources in this fire zone.

NRC COMMENT

3.11 <u>Fire Zone C-2</u>

In this fire zone the licensee has improperly applied the guidance contained in Appendix A to the Branch Technical Position Section F.10. Section F.10 relates to the separation of diesel fuel oil storage buildings from buildings containing

safety related equipment. Fire zone C-2 is the containment building outside of the drywell. This section of the BTP is not applicable to this Thermo-Lag configuration. The separation criteria for fire areas inside containment outside of the drywell is specified in Section III.G.2 of Appendix R to 10 CFR 50. Provide an analysis that properly applies the criteria contained in Appendix R.

The licensee has improperly classified the Thermo-Lag in this fire zone as a noncombustible material. In Information Notice 95-27, "NRC Review of Nuclear Energy Institute, Thermo-Lag 330-1 Combustibility Evaluation Methodology Plant Screening Guide," May 31, 1995, the staff informed industry that the NEI methodology for evaluating Thermo-Lag combustibility does not provide a level of safety equivalent to that specified by existing NRC requirements and that the NRC staff would not accept the use of the NEI guide to justify the use of Thermo-Lag where noncombustible materials are specified by existing NRC fire protection requirements or to assess the combustibility of Thermo-Lag materials. The methodology used by IP in their safety evaluation is similar to the NEI guidance. In addition Information Notice 92-82, "Results of Thermo-Lag 330-1 Combustibility Testing," the staff provided the results of combustibility testing performed by the National Institute of Standards and Technology, which determined that Thermo-Lag 330-1 is a combustible material.

IP COMMENT

3.11 Fire Zone C-2

Reference to NRC Requirements

When IP referenced Section F.10 of Appendix A to Branch Technical Position APCSB 9.5-1, it was only to make a comparison between the two means of providing physical separation (fire barrier and by spatial distance). IP agrees with the NRC comment that the appropriate reference is the 10 CFR 50 Appendix R, Section III.G. 2.d requirement applicable to non-inerted containments. That section requires "Separation of cables and equipment and associated non-safety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustibles or fire hazards." IP's justifications for accepting the Thermo-Lag in fire zone C-2 provided in Block 2 of the safety evaluation, however, would still bc the same.

Thermo-Lag Combustibility

As stated in the NRC letter, IP used the methodology developed by the NEI to determine the combustibility of Thermo-Lag in fire zone C-2. Subsequent to IP's safety evaluation accepting the Thermo-Lag in fire zone C-2, the NRC issued IEIN 95-27 which disagreed with the NEI methodology.

IP concurs that, in using the definition in ASTM E-136, Thermo-Lag would be a combustible material. Because this test method relies solely on comparison of pre-test and post-test mass in the solid state, it is biased against products such as Thermo-Lag, which is by design a subliming material. While IP concurs that Thermo-Lag can be categorized as a combustible material when subjected to a controlled test environment from ASTM E-136, these conditions are not present in any of the Thermo-Lag installations at CPS. Rather:

° The CPS installations are remote from fixed ignition sources such that direct flame impingement from any other in-situ fire hazards is not possible;

° In cases where the Thermo-Lag is located close to the floor, the floor is marked with a warning which explicitly prohibits both storage of combustible material around them and unprotected hot-work in those locations, such that damage from any transient fire hazards is very unlikely;

° The CPS installations are located within very large rooms which have only a small fraction of the combustibles (including cables and the Thermo-Lag itself) necessary to ignite Thermo-Lag, both in terms of ignition temperature and heat flux. Additionally, these rooms have naturally open paths (stairwells to above elevations or louvers to the outside) which minimize, if not prevent, formation of a potential damaging hot gas layer in these rooms.

Therefore, IP concludes that while Thermo-Lag may be categorized as a combustible material by ASTM E-136, its use to firestop or enclose intervening combustibles (cable trays) at CPS is acceptable in view of the lack of credible Thermo-Lag ignition sources.

Plant Specific Conditions

IP's safety evaluation of the Thermo-Lag installation in fire zone C-2 takes into account the large spatial distances from potential ignition sources, the horizontal configuration of the Thermo-Lag, the steel grating floors 13 feet below the bottom of the Thermo-Lag fire barrier and 8 feet above the top of the Thermo-Lag fire barrier, the substantial containment dome volume, the low fire load within the containment and the high ignition temperature of Thermo-Lag. The cable trays wrapped by Thermo-Lag are solid bottom, covered trays; therefore the cables are not exposed. The cables are IEEE-383 qualified; therefore the potential for a substantial electrical fire and for fire propagation is minimal. Additionally, CPS procedure 1019.04, "Control of Tools, Equipment, and Materials Used in Performing Work in the Containment/Drywell or Near Open Pools," places administrative controls on the introduction of materials into the containment. These

factors were the bases for the conclusion that there is no potential for a heat flux of sufficient energy to ignite the Thermo-Lag in this fire area. While IP agrees that Thermo-Lag 330-1 material is combustible given certain conditions, the Thermo-Lag installation in fire zone C-2 is acceptable given the plant-specific conditions discussed above.

NRC COMMENT

3.12 Fire Zone CB-1e

Conclusions stated by the licensee in the detailed justification for the deviation in this area are not technically supported. For example, the licensee stated that cable trays are all located high in this fire zone, therefore it is not credible to postulate cable damage from a fire at the floor level. This conclusion is not correct. It appears that the analysis only considers flame impingement as a credible initiator of cable damage, the licensee has not considered the rapid rise in temperatures in the plume generated by a floor level fire, the high temperatures expected in the descending hot gas layer and the radiant energy transfer from these sources to the target cables, as sufficient to damage the cables. No basis has been provided to exclude these sources as potential initiators of cable damage. Provide the technical basis for excluding these sources for cable damage.

The licensee also concluded that a hot gas layer cannot be formed due to the use of conduit for cables not in trays, large distances between ignition sources and targets, and the use of IEEE-383 qualified cable. These considerations have little if any effect on the potential for the formation of a hot gas layer. The factors that affect the formation of the hot gas layer are the heat release rate of the fuel, fuel surface area, the compartment geometry and the compartment ventilation. Provide an analysis that considers all relevant factors in the formation of a hot gas layer.

IP RESPONSE

3.12 Fire Zone CB-1e

Fire modeling calculations were performed at CPS to support the fire zone CB-1f safety evaluation. These calculations did consider the effects of in-plume, ceiling jet and radiant heating exposure to wrapped cables. A description of the modeling process is included in the response to question 3.10. The salient points of the modeling analysis are summarized in the following paragraphs.

No oil lubricated components are located in this fire zone. Oil is transferred through fire zone CB-1e to other fire zones in sealed NFPA-approved containers. The use of such containers prevents lubricating oil traversing this fire zone from being exposed to an

ignition source. Transient combustible control procedures at CPS prohibit lubricating oil from being left unattended when not sealed in approved containers. These factors eliminate the potential for a large, oil pool type fire from occurring in fire zone CB-1e.

The largest credible ignition sources in fire zone CB-1e were electric fan motor fires, electric panel fires, humidification boiler fires and transient ignition sources. The HHRs for the electric motor and electric panel fires are specified in the FPRA implementation guide. The HHR for the humidification boiler was not specified in any source. In this analysis, the boiler HHR was assumed to be 65 BTU/s, the same value as electric motor and panel fires. This value was selected because the boiler fires would be electrical in nature and would have characteristics similar to electric motor and panel fires. The transient combustible fuel packages selected for fire zone CB-1e were miscellaneous maintenance waste with a HRR of 138 BTU/s and a protective clothing cart with a HRR of 333 BTU/s. The HRRs for the transient fuel packages wer ken from the results of Sandia testing.

The impact of an electrical motor fire was first examined by determining the location of the electric fan motor in relation to the Thermo-Lag wrapped cables. No electric fan motors are located directly beneath the wrapped trays. Therefore, no impact from direct flame impingement or from the fire plume other than heat up of the HGL was determined to be possible.

The impact of the ceiling jet generated by an electric motor fire was also examined in the fire modeling analysis. First, the nearest electric motor to a wrapped cable tray was identified. The vertical distance between this ignition source and the ceiling is 2.08 feet. The vertical distance from the highest wrapped cable tray to the ceiling is 1.88 feet. Per the FIVE methodology, the ceiling jet sublayer extends downward from the ceiling a distance equal to 15% of the distance from the ceiling to the virtual surface of the fire. In this case, the ceiling jet sublayer extends downward from the ceiling only 0.31 feet. Since this tray is the highest of the wrapped cable trays, no potential exists for the ceiling jet generated by an electric motor fire to affect any of the Thermo-Lag wrapped cables.

The impact of radiant energy effects resulting from an electric motor fire was also examined. Using calculations and the recommended radiant energy damage flux for qualified cable contained in the FIVE methodology, the maximum range at which an electric fan motor fire could cause damage was determined. This distance, 1.4 feet, is smaller than the distance (2.58 feet) from the nearest electric fan motor to a wrapped cable tray. Therefore, no potential exists for damage to cables in wrapped cable trays from radiant energy effects generated by electric fan motor fires in fire zone CB-1e.

The impact of a fire in 0VL13B (humidification boiler) was first examined by determining the location of it in relation to the Thermo-Lag wrapped cables. No wrapped cables are located directly over 0VL13B. Therefore, no impact from direct flame impingement or from the fire plume other than heat up of the HGL is possible.

The impact of the ceiling jet generated by a fire was also examined in the fire modeling analysis. First, the nearest wrapped cable tray was identified. The vertical distance between 0VL13B and the ceiling is 5.08 feet. The vertical distance to the ceiling from the wrapped cable tray nearest to 0VL13B is 1.83 feet. Per the FIVE methodology, the ceiling jet sublayer extends downward from the ceiling a distance equal to 15% of the distance from the ceiling to the virtual surface of the fire. In this case, the ceiling jet sublayer extends downward from the ceiling only 0.77 feet. Since this tray is the highest of the wrapped cable trays, no potential exists for the ceiling jet generated by a fire in 0VL13B to affect any of the Thermo-Lag wrapped cables.

The impact of radiant energy effects resulting from a fire in 0VL13B was also examined. Using calculations and the recommended radiant energy damage flux for qualified cable contained in the FIVE methodology, the maximum range at which a fire could cause damage was determined. This distance, 1.4 feet, is much smaller than the distance (12.25 feet) from 0VL13B to a wrapped cable tray. Therefore, no potential exists for damage to cables in wrapped cable trays from radiant energy effects generated by a humidification boiler fire in fire zone CB-1e.

Electrical panel 0AP87E (motor control center for the laboratory humidification boiler) contained the only vented electrical cubicles located in fire zone CB-1e. A fire in this panel has the potential to ignite the cables entering the top of the cabinet. Cables enter the cabinet top from a 1 foot wide riser. This riser has a vertical length of 7.75 feet before entering a 90° turn with a 2.67 feet radius. These dimensions result in a potential burn length of 11.9 feet of 1 foot wide tray as the fire propagates vertically up the cable.

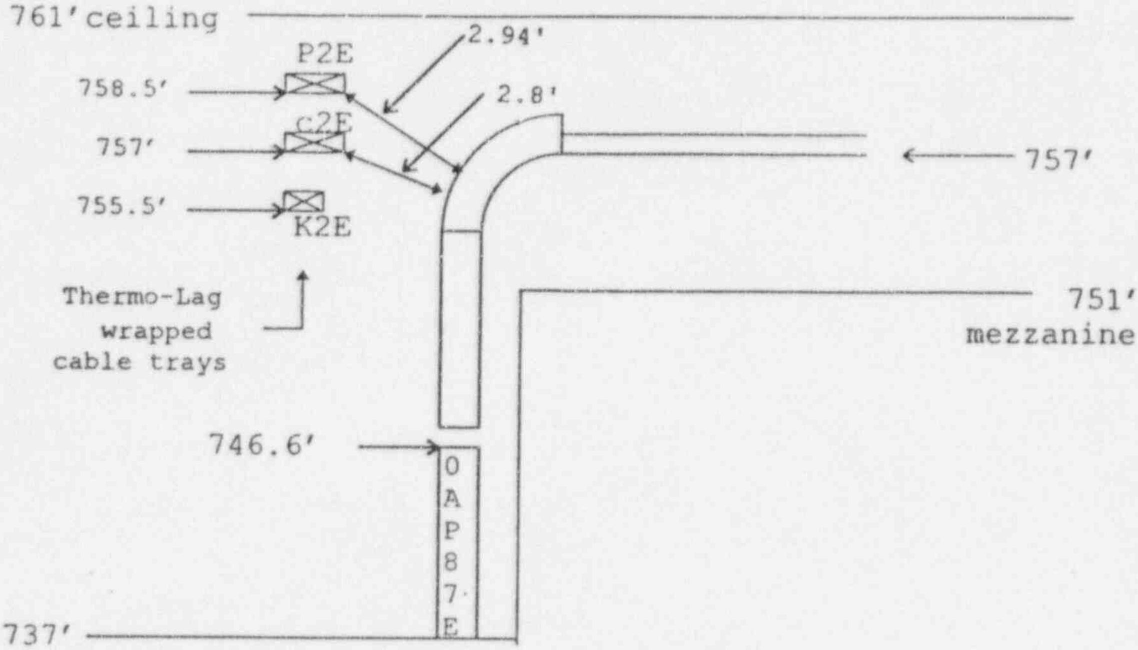
The impact of a fire in 0AP87E was first examined by determining the location of 0AP87E in relation to the Thermo-Lag wrapped cables. No wrapped cables are located directly over the panel. Therefore, no impact from direct flame impingement or from the fire plume, other than heat up of the HGL, was possible. Figure 1 displays the potential fire scenario involving 0AP87E.

The impact of the ceiling jet generated by a fire in 0AP87E was also examined in the fire modeling analysis. The modeling of this fire scenario requires some judgment since the location of the fire moves until the fire is extinguished. The cable initially ignites at the top of 0AP87E (746.58 feet). The highest wrapped target near the cable riser is 2 feet below the ceiling and offset laterally approximately 3 feet from the riser.

In this scenario, the highest wrapped tray is initially partially within the ceiling jet sublayer. As the surface of the fire continues vertically, the tray quickly (within the first 1.08 feet of cable) fails to meet the 15% criteria for being affected by the ceiling jet sublayer. This movement of the fire surface is the major source of uncertainty in analyzing this scenario.

Figure 1

Fire Scenario Originating in 0AP87E,
Cross-Section of Fire Zone CB-1e



For those portions of the highest wrapped tray that are below the ceiling jet, no potential for damage to the tray from the jet exists. In this regard, the temperature of the ceiling jet at the highest point on the riser where the 15% criteria is met is only 193.9°F, well below any temperature where damage to electrical cables or Thermo-Lag could occur.

Due to the uncertainty regarding the fire surface, this scenario was conservatively examined as if the highest wrapped cable tray remained fully within the ceiling jet, regardless of the 15% ceiling jet criterion. The surface of the fire was conservatively treated as the highest point on the riser that burning is occurring. The initial surface of the fire was chosen as the top of the electrical cabinet with an initial HRR of 65 BTU/s.

The riser entering 0AP87E contains IEEE-383 qualified cables. This rating requires, among other cable attributes, that flame will not propagate up a vertical cable faster than 6 feet per 20 minutes. This propagation rate limits the rate of HRR increase to 0.209 BTU/s^2 and the propagation rate of the fire surface to 0.005 foot/s. Using these values and the FIVE correlations for temperature outside of the plume, a calculation was performed to determine the temperature of the ceiling jet as a function of time after ignition. This calculation assumed that the fuel in 0AP87E and in the cable in the riser would not be exhausted during the fire and that the HRR of 0AP87E and the cable segments would remain at the maximum rate throughout the fire.

The calculation found that the ceiling jet did not reach 1000°F at the same lateral offset as the highest wrapped tray until 38.1 minutes had passed. This time starts from the point that ignition of the cable in the riser occurs. In reality, the fire would burn inside 0AP87E for a significant length of time prior to ignition of the cables. During this period, the combustion products released from the cabinet fire would activate the ionization detection located in this fire zone long before active flaming in the cables occurs. This time delay is more than adequate for manual fire suppression to be effective in suppressing such a fire. Additionally, fire zone CB-1e has an automatic wet pipe suppression system with coverage in the area of 0AP87E. The sprinkler heads on this system open at 165°F and one of the sprinkler heads is located within the plume from the riser fire and is less than 3 feet above the riser. The location of the sprinkler head assures rapid response and high effectiveness of the wet pipe suppression system.

Even in the event that the cables in highest wrapped cable trays are damaged, the extent of this damage would be limited. Only Division 2 cables have any potential to be affected by fire originating in 0AP87E. This limited damage means that the Division 1 and 3 equipment would all still be available for safe shutdown.

The impact of radiant energy effects resulting from a fire originating in 0AP87E was also examined. The riser entering the top of 0AP87E has a solid steel cover in the side facing the wrapped cable tray for the entire vertical section. The point where the riser curves 90° and becomes a horizontal tray does not have the cover on the side facing the wrapped trays. The radius of the transition curve between the riser and the tray is 2.67 feet. This translates to a potential burn length of 4.19 feet of 1 foot riser/tray. The HRR of a fire involving this amount of cable is 175.4 BTU/s. The ignition radiant heat flux for Thermo-Lag is 2.2 BTU/s/ft^2. Based on this HRR and ignition heat flux, the distance at which Thermo-Lag could be ignited is 1.6 feet. The nearest wrapped cable tray is 2.8 feet from the riser/tray interface. This dimension is based on conservatively modeling the riser as square instead of curved at the transition point to the tray. Correspondingly, no potential for damage to the wrapped trays exists from fires originating from 0AP87E.

Potential damage to Thermo-Lag wrapped cables from transient combustible was also considered in the fire modeling analysis. The transient combustible fuel package used for analysis on the 737 foot elevation was a canvas cart filled with protective clothing with a HRR of 333 BTU/s. This selection was made since the fuel package had the highest of the recommended HRRs for transient combustibles in the FIVE manual. Evaluation of transient combustibles on the 751 foot elevation of this fire zone used a transient combustible fuel package of miscellaneous maintenance waste with a HRR of 138 BTU/s as specified in Sandia tests. The bag of maintenance waste from the Sandia tests was selected since these wastes were similar to what would be expected to be found on the 751 foot elevation (the only access to this level is by stairs which would make it extremely difficult to bring a cart to this area).

To determine the impact of a transient fire on Thermo-Lag wrapped cable trays, the transient combustibles were modeled as being directly beneath the lowest Thermo-Lag installation on both the 737 and 751 foot elevations in fire zone CB-1e. This modeling envelopes out-of-plume and radiant heating damage scenarios since the in-plume scenarios result in higher temperatures than other scenario types for a particular fire.

The lowest Thermo-Lag installation over the 737 foot elevation is 18 feet above the surface of a postulated canvas cart fire. The cart was modeled as being next to a wall in order to have the highest possible effective HRR. With an ambient temperature of 104°F, the temperature reached at the lowest wrapped tray was calculated to be 420°F. This value is well below the ignition temperature for Thermo-Lag or the cable damage temperature. Correspondingly, no potential for Thermo-Lag or cable damage exists from a transient fire on the 737 foot elevation.

The lowest Thermo-Lag installation over the 751 foot elevation is 7.5 feet above the surface of a maintenance waste fire. With an ambient temperature of 104°F, the temperature reached at the lowest wrapped tray is 420°F. This value is well below the 1000°F ignition temperature for Thermo-Lag and the cable damage temperature. Correspondingly, no potential for Thermo-Lag ignition or cable damage exists from a transient fire on the 751 foot elevation.

The potential for hot gas layer formation was also examined in fire zone CB-1e. This fire zone is connected by ceiling openings to fire zones CB-1f, CB-1g and CB-1i. The largest potential fire in this fire zone is the scenario involving 0AP87E. The amount of heat generated from this fire scenario is 1.55 million BTUs. Based on this heat value and the size of CB-1e and communicating fire zones, the HGL temperature is estimated to be only 136°F. This temperature is too small to cause damage to either the cables or Thermo-Lag.

NRC COMMENT

3.13 Fire Zone CB-1f

In this fire zone the licensee concluded that based on fire modeling there is no credible risk to safe shutdown equipment from either fixed or transient combustibles. The staff believes that the uncertainties associated with the use of fire modeling, due to the lack of experimental validation of the models for typical nuclear power plant compartments, and the lack of adequate data on the fire performance of components susceptible to fire damage typically present in a plant, make it unreasonable to conclude, based solely on the results of a fire model, that there is no credible risk of damage to redundant safe shutdown components from fixed and transient combustibles. Provide the detailed validation and verification of the fire model used in this analysis.

The licensee has concluded that based on the NEI Application Guide for Thermo-Lag Fire Barrier Systems that the Thermo-Lag installed in this area has a fire endurance of 85 minutes. Provide the detailed analysis that the Thermo-Lag barriers installed in this are qualified to an equivalent fire rating of 85 minutes including hose stream testing.

IP RESPONSE

3.13 Fire Zone CB-1f

Fire Modeling

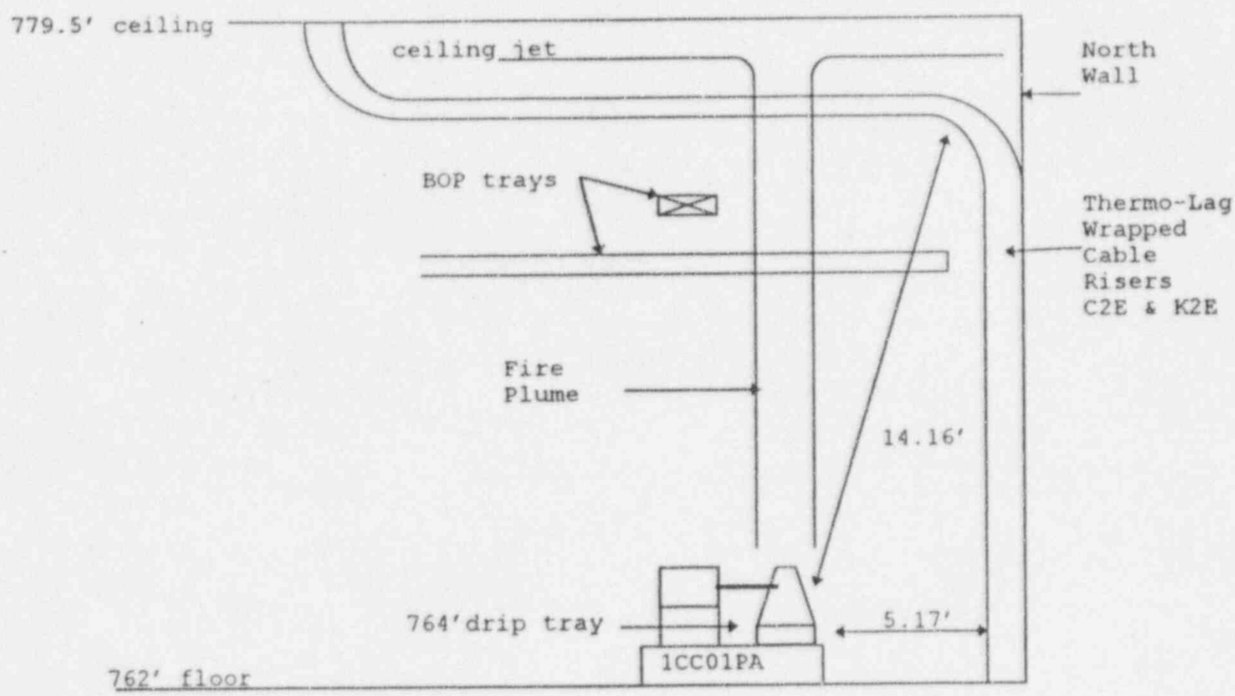
Fire modeling calculations were performed at CPS to support the fire zone CB-1f safety evaluation. These calculations did consider the effects of in-plume, ceiling jet and radiant heating exposure to wrapped cables. A description of the modeling process is included in the response to question 3.10, and a justification for use of fire modeling is included in the response to question 3.2. The salient points of the calculations are summarized in the following paragraphs.

The only oil lubricated items in fire zone CB-1f are the three component cooling water (CC) pumps (1CC01PA, 1CC01PB, and 1CC01PC). Oil is transferred through fire zone CB-1f to other fire zones in sealed NFPA-approved containers. The use of such containers prevents lubricating oil traversing this fire zone from being exposed to an ignition source. Transient combustible control procedures at CPS prohibit lubricating oil from being left unattended when not sealed in approved containers. These factors eliminate any credible potential for an oil pool type fire occurring in fire zone CB-1f from sources other than the three CC pumps.

The CC pumps each have a drip tray located beneath the pump section of the pump-motor installation. These trays are rectangular with dimensions of 2.15 feet by 3.29 feet. Based on these dimensions a HRR of 954 BTU/s was calculated for oil fires originating from the CC pumps.

Figure 2

Fire Scenario Involving CC Pump
Cross-Section of Fire Zone CB-1f



The wrapped horizontal trays make two 90° lateral bends and only pass over one of the CC pumps (1CC01PA) and are a minimum of 12.25 feet above the drip tray. While there are some intervening unwrapped cable trays, the location of these trays and their construction precludes cable ignition from occurring. With a Thermo-Lag ignition temperature of 1000°F and a HRR of 954 BTU/s, the wrapped trays would have to be within 8.7 feet of the surface of the fire for ignition to occur. This separation is also sufficient to prevent damage to the cables even without taking credit for the Thermo-Lag. Correspondingly, no potential impact from plume effects, other than heat up of the HGL, resulting from a CC pump oil fire exists.

The Thermo-Lag installation nearest the CC pumps is a vertical installation surrounding two cable risers and the overhead wrapped horizontal cable trays discussed above. The nearest CC pump drip tray (1CC01PA) is offset 5.17 feet from the vertical Thermo-Lag installation. Due to the proximity of this installation to 1CC01PA, the potential for ceiling jet or radiant energy exposure was examined. Figure 2 displays the fire scenario involving CC pump 1CC01PA and the vertical Thermo-Lag installation.

Two situations were evaluated to determine which has the greatest impact on the vertical Thermo-Lag installation. The first situation was to determine the effect of an oil fire at the point on the riser that was the shortest radial distance from the fire. This case has the largest incident radiant heat flux. The second situation evaluated the effect of a fire at the lowest elevation of the ceiling jet. This case had a heat contribution from both the ceiling jet and radiant heating.

The evaluation of both situations was based on the following information:

- 40% of an oil fire's energy was conservatively assumed to be released as radiant energy. A radiant energy release factor of 20% to 40% is recommended by the FIVE manual.
- The maximum pre-fire ambient temperature in fire zone CB-1f is 104°F per design criteria DC-VA-01-CP, Revision 3.
- Prior to accounting for radiant heat transfer, the riser temperature was assumed to be equivalent to the temperature that would result after equilibrium is reached following the combustion of all oil in pump 1CC01PA. The ambient temperature, based on a pre-fire room temperature of 104°F, was calculated to be 123°F.
- No credit was taken for heat transfer from the riser to the room environment.
- The fire was modeled as a point source located at the nearest point of the pump drip basin to the riser. This distance is 5.17 feet.
- The emissivity of Thermo-Lag was assumed to be 1.0.
- The fire was assumed to burn at the peak HRR until all of the oil contained in the pump was consumed.
- No credit was taken for radiant shielding provided by the pump itself.
- The thermal inertia of Thermo-Lag is 0.0072 $BTU^2/ft^4\ R^2\ s$.
- The incident radiation at the closest point to the fire is 1.137 BTU/ft^2s. Note: since this heat flux is less than the Thermo-Lag ignition heat flux (2.2 $BTU/\ ft^2s$), no potential for Thermo-Lag ignition exists.
- Incident radiation heat flux at the lowest point of the ceiling jet sublayer is 0.152 $BTU/\ ft^2s$. This value was calculated at an axial height of 13.18 feet.
- Pump 1CC01PA contains 2 gallons of oil with a total heat of combustion of 300,000 BTU (from CPS fire load calculation IP-M-0177); this results in a fire duration of 315 seconds.

The evaluation used the following equation to calculate the surface temperature of Thermo-Lag from radiant heating alone:

$$T_s = T_o + 2Q_r \sqrt{t/(k_\rho c\pi)}$$

where

T_s = Thermo-Lag surface temperature at time t.
T_o = Initial Thermo-Lag surface temperature.
Q_r = Radiant heat flux.
t = Duration of fire.
$k_\rho c$ = Thermal inertia.

For the radiant heating only situation, this calculation found that a temperature of 391.4°F would be reached on the surface of the Thermo-Lag at the time the fire burns out. This is the peak temperature that the surface or interior of the riser would reach, which is below the cable damage temperature. Since the Thermo-Lag ignition temperature is 1000°F, no ignition of the Thermo-Lag would occur.

For the ceiling jet and radiant heating situation, this calculation found a temperature increase of 229°F due to the ceiling jet and a temperature rise of 36.1°F due to radiant heating. These temperature increases result in a peak Thermo-Lag surface temperature of 388.1°F, which is below the cable damage temperature. Since the Thermo-Lag ignition temperature is 1000°F, no ignition of the Thermo-Lag would occur.

Other than the noted CC pump, only one other fixed ignition source has the potential to impact the Thermo-Lag installations in this fire zone. Area cooler 0WO07SE is mounted 4.5 feet below the ceiling and offset by approximately 1 foot from the vertical Thermo-Lag installation. This cooler has two small (0.75 hp) electric fan motors located inside a sheet metal housing. The openings for the fans are located a minimum of 0.75 feet from the vertical sides of the cooler housing. While the vertical Thermo-Lag installation and the wrapped cable trays are all outside the damage range for any in-plume, out-of-plume or radiant heating effects from a fire in the cooler fan motors, there is the potential for fire propagation to intervening combustibles. A structural steel member that projects downward from the ceiling and a portion of a conduit are also covered with Thermo-Lag and are in very close proximity to one corner of the area cooler housing. It was assumed that ignition of the Thermo-Lag on the conduit or structural steel could propagate to the vertical Thermo-Lag installation. The consequences of such a spreading fire were determined to be acceptable since even the loss of all wrapped and unwrapped cables within range of this fire would not affect the Division 1 safe shutdown cables from in-plume, out-of-plume or radiant energy effects.

Potential damage to Thermo-Lag wrapped cables from transient combustibles was also considered in the fire modeling analysis. The transient combustible fuel package used for analysis was a canvas cart filled with protective clothing with a HRR of 333 BTU/s. This selection was made since the fuel package had the highest of the recommended HRRs for transient combustibles in the FIVE manual.

To determine the impact of a transient fire on Thermo-Lag wrapped cable trays, the transient combustibles were modeled as either being directly beneath the lowest Thermo-Lag wrapped cable tray or directly adjacent to the vertical Thermo-Lag installations.

The lowest Thermo-Lag wrapped cable tray is 13.75 feet above the surface of a postulated canvas cart fire. By modeling this scenario as an in-plume case, the out-of-plume and radiant heating scenarios are enveloped. With an ambient temperature of 104°F, the maximum temperature reached at the lowest wrapped tray was calculated to be 311°F. This value is well below the 1000°F ignition temperature for Thermo-Lag, and the cable damage temperature. Correspondingly, no potential for damage to Thermo-Lag wrapped cable trays from a transient fire exists in this fire zone.

Both the north and south vertical Thermo-Lag installations have the potential to be ignited by transient combustibles. In order for Thermo-Lag ignition to occur, the canvas cart must be within 2.17 feet of the installation. This distance is the range at which the canvas cart fire, when modeled as a point source, generates a radiant energy flux of 2.2 $BTU/ft^2 s$ at the surface of the Thermo-Lag. As a precaution to prevent a transient fire affecting the vertical Thermo-Lag installations, a transient material exclusion zone was created a minimum of 3.9 feet wide around each vertical installation. This exclusion zone is marked on the floor around each installation.

Nevertheless, it was assumed that ignition of the north Thermo-Lag installation occurred. Ignition of the north Thermo-Lag installation only has the potential to damage Division 2 and balance of plant cables. This would leave the Division 1 safe shutdown method available.

It was also assumed that ignition of the south Thermo-Lag installation occurred. Ignition of the south vertical Thermo-Lag has the potential to damage certain Division 1 and Division 2 safe shutdown cables. Loss of the Division 1 cables that could be affected by such a fire would only result in locking in a Division 1 signal in the RPS 2-of-4 logic for reactor vessel level and pressure. These signals would not prevent any piece of equipment from operating as designed. Correspondingly, the Division 1 and 3 safe shutdown method would still be available following ignition of the south Thermo-Lag installation.

The potential for damaging HGL formation was also examined in fire zone CB-1f. This fire zone is connected by large (over 100 square feet) ceiling openings to fire zones CB-1g and CB-1i. The largest potential fire in this fire zone is the scenario involving the south vertical Thermo-Lag installation. The amount of heat generated from this fire is 15.2 million BTUs. Based on the dimensions of CB-1f and communicating fire zones, the temperature of the HGL would be 394°F. This temperature is below any cable or Thermo-Lag damage temperature. Correspondingly, no potential exists for the formation of a damaging HGL in this fire zone.

Detailed Fire Endurance Analysis

IP's Thermo-Lag fire endurance calculation IP-M-0340 Revision 1 for the two installations in fire zone CB-1f is provided with this transmittal. Hose stream testing is also considered in that calculation.

NRC COMMENT

3.14 Fire Zone D-8

The licensee has concluded that based on the NEI Application Guide for Thermo-Lag Fire Barrier Systems that the Thermo-Lag installed in this area has a fire endurance of 46 minutes. Provide the detailed analysis that the Thermo-Lag barriers installed in this are qualified to an equivalent fire rating of 46 minutes including hose stream testing.

IP RESPONSE

3.14 Fire Zone D-8

IP's Thermo-Lag fire endurance calculation IP-M-0343, Revision 1, for the Thermo-Lag installation in fire zone D-8 is provided with this transmittal. Hose stream testing is also addressed in that calculation.

FOLLOWUP REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING

GENERIC LETTER 92-08

"THERMO-LAG 330-1 FIRE BARRIERS"

CLINTON POWER STATION (CPS)

DOCKET NO. 50-461

The October 4,1995 letter from the NRC states that IP's responses to various RAIs are incomplete. The concern expressed by the NRC appears to center on the issue of performing tests to determine derating factors for cable ampacity values.

As indicated in the CPS ampacity evaluations (which were attached to the safety evaluations for those areas where the Thermo-Lag will be allowed to remain in place), the majority of the cables are very lightly loaded. Those few cables that are not lightly loaded have sufficient margin in their ampacity to accept a sizable ampacity derating (see specific evaluations for loads and ampacities). Therefore, the capability of the cables (to carry their design loads and perform their design functions) was evaluated and found to be adequate and no testing needs to be performed. Consequently, there is no need for revising the design calculations or for establishing new derating factors.

NRC COMMENT

In its submittal of December 16, 1994, the licensee referred to site-specific evaluations. If these evaluations, other than the safety evaluations submitted on March 16, 1995, represent the licensee's final determination of ampacity derating parameters for Thermo-Lag fire barriers, please forward a copy of the subject evaluations for staff review.

IP RESPONSE

The referenced evaluations have already been provided as Enclosure 4 in each subject safety evaluation. For convenience, additional copies are provided with this response as Attachment 5.

NRC COMMENT

Given that there are no unresolved technical issues, the licensee is requested to provide its site-specific schedule and plans for the resolution of the ampacity derating issue for Thermo-Lag fire barriers.

IP RESPONSE

The evaluations of power cables within Thermo-Lag installations demonstrate that there is sufficient margin in all instances. See the evaluations for comparison of actual loads to cable ampacities and the resultant margins. Given that there are no unresolved technical issues, IP considers ampacity derating evaluation complete and therefore has no further schedule or plans.

NRC COMMENT

If a Nuclear Energy Institute (NEI) test program or analysis is expected to be utilized by the licensee, please provide specific program details and incorporate any input by NEI into the licensee's overall schedule.

IP RESPONSE

IP has no plans to use NEI tests or analyses to resolve ampacity derating issues. The existing CPS Thermo-Lag installations have been evaluated and found to be acceptable.

NRC COMMENT

Finally, the staff expects that the licensee will submit in conjunction with the resolution of the fire endurance issues, the test procedures or alternatively, a description of the analytical methodology including typical calculations which will be used to determine the ampacity derating parameters for the Thermo-Lag fire barriers that are installed at the Clinton Power Station.

IP RESPONSE

The methodology in the evaluations compares the actual loads on the installed cables to the nominal design ampacity for that type of cable. This provides the existing ampacity margin in the cables. The cables with the smallest margins were then compared to the cables reported in NRC Information Notice (IEIN) 94-22 by determining the heat intensity of each. As stated in the evaluations, since the heat intensity of the cables with the smallest margin is lower than the heat intensity of the derated cables of IEIN 94-22, all of the cables within the Thermo-Lag are acceptable.

This evaluation process contains additional conservatism for four of the installations due to the fact that, although they have 1/2 inch nominal thick Thermo-Lag, they were compared to the derating values shown in IEIN 94-22 for 1 inch nominal thick installations. Evaluating the cables in this manner demonstrates the conservative manner in which the original cable sizing/selection was done.

For illustrative purposes, the charts on the following page compare the open-tray and wrapped-tray ampacity values of the three cables reported in IEIN 94-22 to the calculated open-tray and 32% derated ampacity values that would be obtained using the methodology of National Electric Manufacturers Association WC-51 and the methodology of CPS calculation 19-G-1. All values are shown as percentages of the IEIN 94-22 open tray test ampacity value for the conductor. The 32% derate factor comes from the site calculated derate for trays wrapped in Thermo-Lag. For actual numbers, see the tables below.

#8 AWG, 1/C

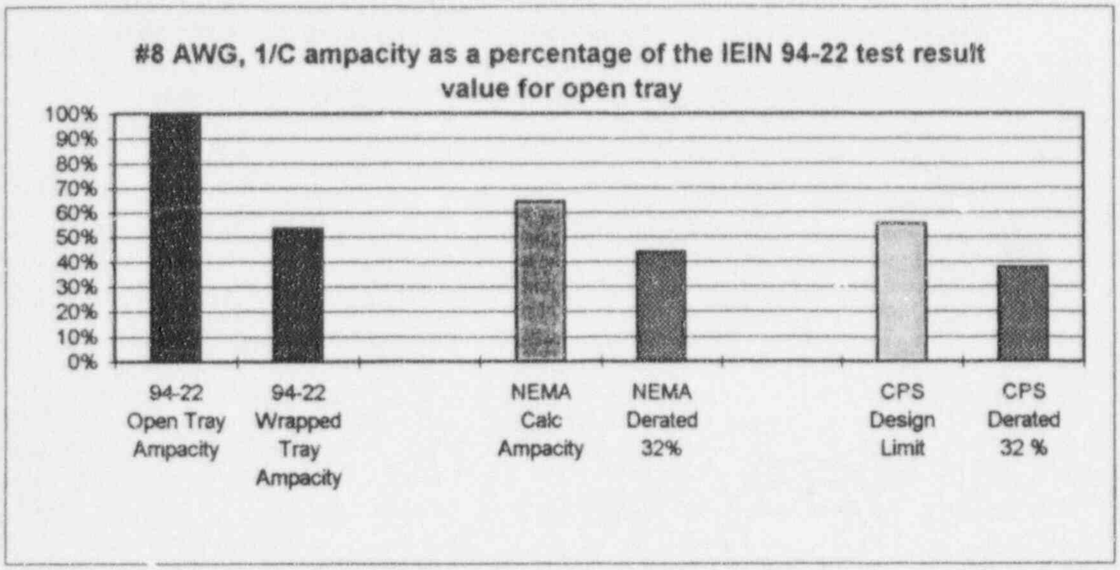
	94-22 Open Tray	94-22 Wrapped Tray	NEMA Calculated Ampacity	NEMA 32% Derated	CPS Design Limit	CPS 32% Derated
Amperes	23.7	12.7	15.3	10.4	13.1	8.9
Percent	100	54	65	44	55	38

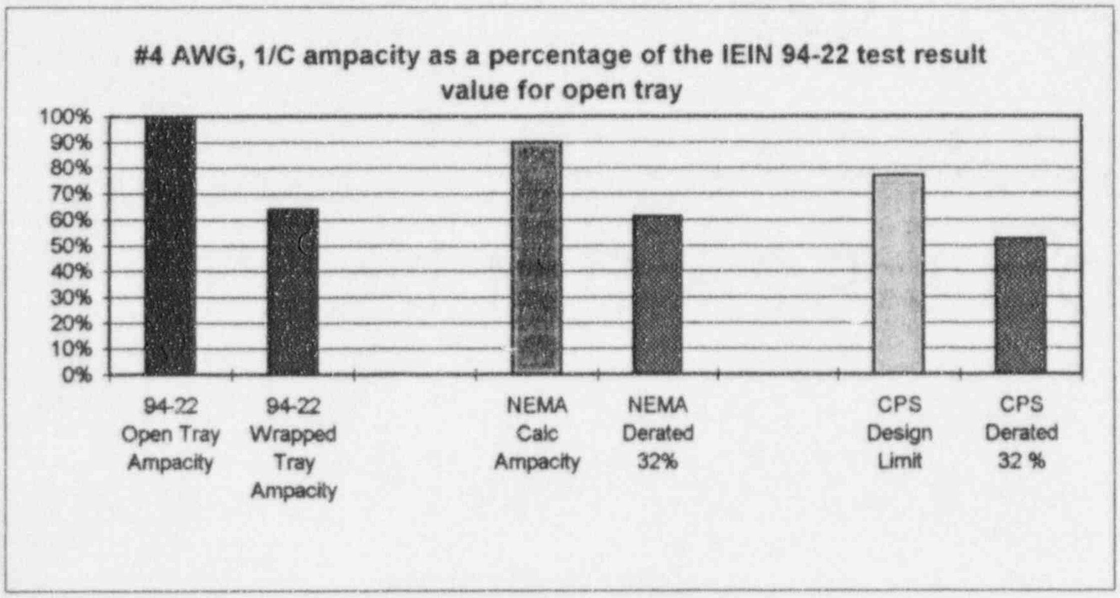
#4 AWG, 1/C

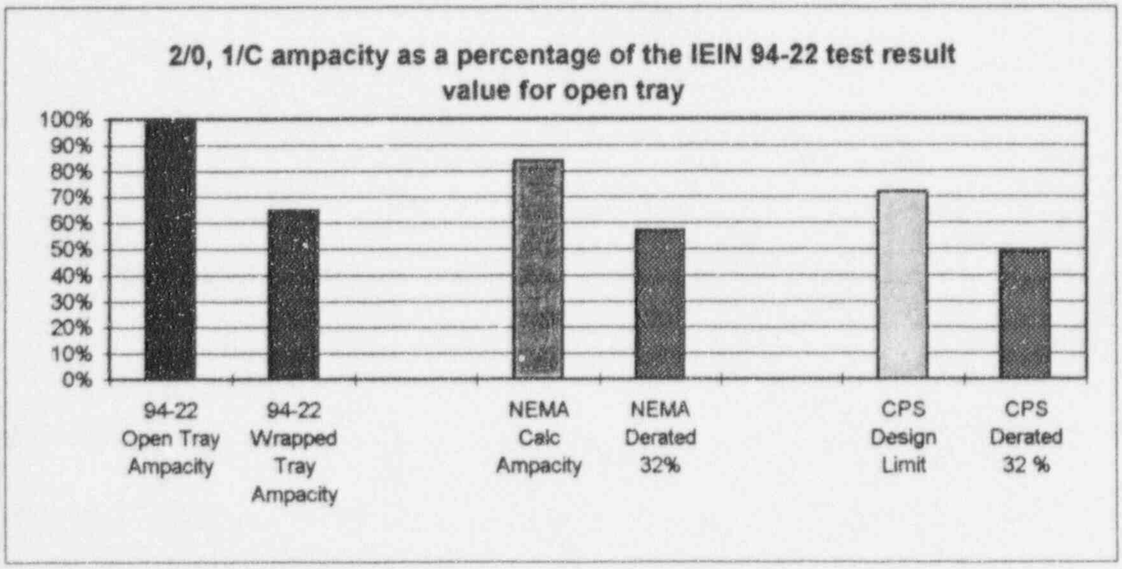
	94-22 Open Tray	94-22 Wrapped Tray	NEMA Calculated Ampacity	NEMA 32% Derated	CPS Design Limit	CPS 32% Derated
Amperes	37.8	24.2	34	23.12	29.1	19.8
Percent	100	64	90	61	77	51

2/0, 1/C

	94-22 Open Tray	94-22 Wrapped Tray	NEMA Calculated Ampacity	NEMA 32% Derated	CPS Design Limit	CPS 32% Derated
Amperes	113.6	73.5	95.3	64.8	81.5	55.4
Percent	100	65	84	57	72	49


#8 AWG, 1/C ampacity as a percentage of the IEIN 94-22 test result value for open tray
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
94-22 Open Tray Ampacity
94-22 Wrapped Tray Ampacity
NEMA Calc Ampacity
NEMA Derated 32%
CPS Design Limit
CPS Derated 32 %


#4 AWG, 1/C ampacity as a percentage of the IEIN 94-22 test result value for open tray
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
94-22 Open Tray Ampacity
94-22 Wrapped Tray Ampacity
NEMA Calc Ampacity
NEMA Derated 32%
CPS Design Limit
CPS Derated 32 %


2/0, 1/C ampacity as a percentage of the IEIN 94-22 test result value for open tray
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
94-22 Open Tray Ampacity
94-22 Wrapped Tray Ampacity
NEMA Calc Ampacity
NEMA Derated 32%
CPS Design Limit
CPS Derated 32 %

As demonstrated by these charts, the derating factor at CPS (32%) is numerically smaller than the test value reported by the NRC in IEIN 94-22 (35%, 36%, and 46%). However, the charts also show that the actual ampacity values that would be allowed at CPS, both before and after derating, are significantly lower than the NRC values for the same cables. CPS's cables have substantial margin due to the utilization of a more conservative methodology.