123 Main Street
White Plains, New York 10601
914 681.6950
914 287.3309 (Fax)

New York Power Authority

James Knubel
Senior Vice President and
Chief Nuclear Officer

September 30, 1998
IPN-98-104

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Subject: **Indian Point 3 Nuclear Power Plant**
Docket No. 50-286
Response to Request for Additional Information
Regarding Response to Generic Letter 88-20, Supplement 4:
Individual Plant Evaluation For External Events (TAC No. M83632)

References:

1. NRC letter, George F. Wunder to James Knubel, "Request for Additional Information Regarding Response to Generic Letter 88-20, Supplement 4, 'Reactor Vessel Structural Integrity' – Indian Point Unit 3 (TAC No. M83632)," dated June 3, 1998.

2. NYPA letter to NRC (IPN-97-132), "Individual Plant Examination of External Events (IPEEE)," dated September 26, 1997.

3. EPRI TR-105928, "Fire PRA Implementation Guide," Final Report, December 1995.

This letter provides a response to the NRC's request for additional information (Reference 1) regarding the Indian Point 3 response to Generic Letter 88-20, Supplement 4 (Reference 2). The NRC's questions followed by the Authority's responses are contained in Attachment I.

Several of the staff's questions are associated with the EPRI "Fire PRA Implementation Guide" (Reference 3), which the Authority used in the preparation of the Indian Point 3 IPEEE. NEI and EPRI are working with the nuclear power industry to answer the NRC's questions on the implementation guide. The Authority will monitor the resolution of those questions with the NRC, NEI, EPRI and the industry. If necessary, the Indian Point 3 IPEEE will be revised to reflect the final resolution of the questions. If significant changes to the IPEEE are required, a report detailing the changes and a summary of the results will be prepared and submitted to the NRC.

Attachment II summarizes the commitments contained by this letter. If you have any questions, please contact Ms. C. D. Faison.

Very truly yours,

J. Knubel
Senior Vice President and
Chief Nuclear Officer

Attachments: As stated

cc: Regional Administrator
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Resident Inspector's Office
Indian Point Unit 3
U.S. Nuclear Regulatory Commission
P.O. Box 337
Buchanan, NY 10511

Mr. George F. Wunder, Project Manager
Project Directorate I-1
Division of Reactor Projects I/II
U.S. Nuclear Regulatory Commission
Mail Stop 14B2
Washington, DC 20555

ATTACHMENT I TO IPN-98-104

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING GENERIC LETTER 88-20, SUPPLEMENT 4: REACTOR VESSEL STRUCTURAL INTEGRITY

NEW YORK POWER AUTHORITY
INDIAN POINT 3 NUCLEAR POWER PLANT
DOCKET NO. 50-286
DPR-64

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING THE INDIAN POINT 3 IPEEE SUBMITTAL

Question 1:

In areas where credit was taken for fire suppression success, such as the cable spreading room, the reliability of fire suppression systems is critical. The automatic suppression failure analysis used reliability values from the FIVE methodology. These data are acceptable for systems that have been designed, installed, and maintained in accordance with appropriate industry standards, such as those published by National Fire Protection Association (NFPA).

Please verify that automatic fire suppression systems at Indian Point 3 meet NFPA standards. Alternatively, provide an assessment of the fire areas surviving screening based on the reliability of existing plant suppression systems and, to the extent possible, using demonstrated plant reliability experience with these systems.

Response:

The IP3 fire protection system was designed, in part, to "enable [the] system to equal or exceed the standards of the National Fire Protection Association." In 1994, the Authority conducted walkdowns to identify and document the level of conformance to NFPA codes of fire protection systems and features at IP3. On 1/31/95, letter IPN-95-009 (NFPA Code Compliance Walkdown Project Summary) was sent to the NRC describing the results of these walkdowns. Although minor deviations were identified, none affected the ability of systems covered by the Technical Specifications to perform their design functions. Therefore, use of the generic reliability values from the FIVE methodology was judged to be acceptable in the IP3 fire analysis.

Question 2a:

Fire severity factors were used in the analysis of many unscreened fire compartments in the fire assessment. Severity factors were used in scenarios where fire suppression was credited. Since the potential for a large fire is dependent upon fire suppression, there appears to be a significant possibility that the use of a fire severity factor when fire suppression is modeled accounts for suppression efforts twice.

a) *For the scenarios where both fire suppression and severity factors were credited, please explain why crediting both does not constitute redundant credit for suppression.*

Response:

The use of fire severity factors is described in the Fire PRA Implementation Guide (EPRI-TR-105928, December 1995). These factors were introduced to compensate for the fact that an examination of fires at U.S. nuclear power plants shows that not all incipient fires become fully developed, whereas fire modeling techniques assume the presence of a fully developed fire with peak heat release rates at inception. The fire severity factors in the Fire PRA Implementation Guide estimate the fraction of incipient fixed-ignition fires that become fully developed. While these factors may account for early fire detection by plant personnel, they do not take credit for fixed fire suppression systems. Thus the use of fire severity factors is not redundant to the taking of credit for fire suppression systems.

Question 2b:

b) *Please provide an analysis of fire zone 73a, the upper cable penetration area, which was screened at 9E-7 per year, just under the screening criterion of 1E-6 per year, while the analysis also included a severity factor in the screening CDF estimate.*

Response:

The IP3 fire analysis was performed in accordance with the Fire PRA Implementation Guide (EPRI-TR-105928). Therefore, prior to fire modeling, fire compartments were screened if fire-induced damage to all safe shutdown equipment in the compartment is not risk-significant (i.e., if the contribution to the core damage frequency is $< 1.0 \times 10^{-6}$/yr). While this preliminary quantitative screening of fire compartments is based primarily on the product of the compartment ignition frequency and the compartment conditional core damage probability (CCDP), Step 4.2 of the EPRI Fire PRA Implementation Guide also allows credit to be taken for full-zone automatic suppression, manual suppression of transient fires, and severity factors for fixed-ignition sources. This step was utilized in the IP3 fire analysis.

Question 3:

From the submittal it cannot be inferred that the licensee has considered hot shorts as a failure mode for control or instrumentation cables in control room fire scenarios. Hot shorts in control cables can simulate the closing of control switches leading, for example, to the repositioning of valves, spurious operation of motors and pumps, or the shutdown of operating equipment. These types of faults might lead, for example, to a LOCA, diversion of flow within various plant systems (IN 92-18), deadheading and failure of important pumps, premature or undesirable switching of pump suction sources, undesirable equipment operations, or unrecoverable damage to motor-operated valves. For main control room (MCR) abandonment scenarios, such spurious operations and actions may not be indicated at the remote shutdown panel(s), may not be directly recoverable from remote shutdown locations, or may lead to the loss of remote shutdown capability (e.g., through loss of remote shutdown panel power sources). In instrumentation circuits, hot shorts may cause misleading plant readings potentially leading to inappropriate control actions or generation of actuation signals for emergency safeguard features.

Discuss to what extent these issues have been considered in the IPEEE analysis of the Indian Point 3 control room. If they have not been considered, please provide an assessment of how inclusion of potential hot shorts would impact the quantification of fire risk scenarios in the IPEEE. Include in the response, the issues raised in IN 92-18, which addresses potential MOV damage from hot shorts.

Response:

Fire-induced failures of control and instrumentation cables are discussed in Section 4.3 of the IPEEE report. Notwithstanding the differing consequences and probabilities of fire-induced open circuit failures, short circuits to ground and hot shorts, the highly conservative approach taken in the IP3 IPEEE fire analysis assumed that if equipment could fail as a result of fire damage to cable, failure would occur on fire damage regardless of the failure mechanism (i.e., regardless of whether damage entailed an open-circuit failure, a short circuit to ground or a hot short). Furthermore, a fire in a control room cabinet or panel was assumed to fail all control circuits in that panel or cabinet.

As the application of these conservative assumptions is tied closely to the use of IPE models, deterministic screening was also applied to ensure that hot-shorts that might give rise to spurious actuations not included in the IPE models were considered. This screening is summarized in Table 1.

Given the conservative handling of the consequences of fire-induced cable damage and the conclusions drawn from the fire analysis, little mention was made in the IPEEE report of the specific role played by hot shorts. This role will therefore now be described by discussions of five items:

- LOCAs
- ISLOCAs

- Fire induced instrument and human error
- Spurious failures that might compromise alternate safe shutdown
- Mechanical damage to valves as a result of spurious operation that might compromise containment isolation, create pathways for containment bypass or compromise safe shutdown of the plant.

These issues will be addressed in turn.

LOCAs. Spurious signals induced by hot shorts may cause LOCAs. Only one scenario is of concern at IP3: the inadvertent opening of power-operated relief valves (PORVs). This scenario was examined in Section 4.7.4 of the IPEEE report. The PORVs protect the reactor coolant system from overpressure and, in conjunction with the high head safety injection system, remove heat from and depressurize the reactor coolant system during transients in which secondary cooling is lost. The PORVs discharge from the pressurizer upper head to the pressurizer relief tank. In considering the impact of hot shorts and spurious signals on the PORVs, the failure of concern is their inadvertent opening or failure to reclose. (A stuck-open PORV resembles a small-break LOCA in that the reactor coolant system depressurizes.) The contribution to the core damage frequency made by control room fires that cause the opening of the PORVs is occasioned by damage to control cabinets FBF and FCF. This contribution was calculated to be ~ 5×10^{-10}/year or ~ 0.014 % of the total contribution of control room fires. This calculation reflects the facts that hot shorts occur in only a small fraction of fire-induced cable damage incidents and that operators are aware of the potential for inadvertent PORV opening. Procedures are in place to address such an event. If control room evacuation has not been called for, the operators would follow an alarm response procedure relating to a stuck-open PORV (ARP-3). Furthermore, ONOP-FP-30 and the EOPs direct the operators to close or isolate the PORVs should control room indications of PORV status be unavailable. Finally, it should be noted that if control room evacuation is not required, a stuck-open PORV could be mitigated using the ECCS. For fires requiring control room evacuation, procedure ONOP-FP-1A requires that the PORVs be de-energized by opening the circuit breakers in dc distribution panel 31 and 32.

From these quantitative analyses, we can conclude that hot short induced LOCAs do not pose a significant risk of core damage at IP3.

ISLOCAs. Spurious signals are a potential cause of interfacing system loss of coolant accidents (ISLOCAs). These accidents are caused by the failure of low-pressure piping or other components subsequent to their exposure to high-pressure reactor coolant. As a result, both unmitigated LOCAs inside containment and containment bypass (with subsequent containment bypass) are possible. Potential ISLOCAs are described in detail in Section 3.1.4.5 of the IPE report. In some cases, the ISLOCA might be initiated by the hot-short induced opening of an MOV or AOV. However, as each of these ISLOCA scenarios requires that two or more check valves would also have to fail (or MOV circuit breakers would have to be closed in violation of Technical Specifications), it can be qualitatively concluded that hot-short induced ISLOCAs pose no significant risk at

IP3. This conclusion was confirmed by quantitative modeling in the fire analysis summarized in Section 4.8.1 of the IPEEE report.

Fire-Induced Instrument and Human Error. Instrumentation that monitors vital plant parameters and provides input signals to the reactor protection or engineered safety feature actuation systems, is supplied with power from 118-Vac instrument power buses. In general, these systems function on a "de-energize to operate" principle. Accordingly, for fire-induced cable failures involving a short circuit to ground or open-circuit failure, these instrument systems can be regarded as being fail-safe. In contrast, should a hot short occur, the automatic actuation of these safeguard systems will be degraded. However, given the redundant logic and signals employed in these systems, a complete loss of system function is most unlikely.

Hot shorts on instrument or power cables may also impair the ability of operators to monitor plant status or cause them to take inappropriate actions. However, IP3 operators are well aware of the possibility of hot shorts, the spurious operation of valves and motors, and false instrumentation readouts (e.g., ONOP-FP-30, Rev. 2). This possibility is mitigated by instrumentation that provides functional redundancy. In particular, in addition to control room instrumentation, local instrument panels are available for plant shutdown. This latter instrumentation measures the following parameters:

Parameter(s)	Panel Location
Pressurizer level and pressure	PAB and AFW pump building
Steam generator level and pressure	AFW pump building
AFW pump suction and discharge pressure	AFW pump building
CST and RWST levels	At tanks
RCS temperature	AFW pump building
CCW flow to RCPs	Piping penetration area
RCP seal injection flow	PAB/piping penetration area

Furthermore, as noted in Section 4.9.1 of the IPEEE report, remote shutdown circuits are provided with a parallel fused path should a (control room) fire induce short circuits. The transfer switches used to bypass or de-energize cables routed to the control room are found at the local panels. Power for the control of alternate safe shut down equipment is from a dedicated 125-Vdc power panel and is routed so as not to be affected by control building fires.

Spurious Failures That Compromise Alternate Safe Shutdown. Control room fires may require use of alternate safe shut down. At IP3, this function is provided by a charging pump, a component cooling water pump, a back-up service water pump, a train of essential process monitoring instrumentation and the turbine-driven AFW pump. This equipment is supported by buses, distribution panels, transformers, instrumentation power cabinets fed from the Appendix R diesel generator, power transfer switches and local instrumentation panels.

Spurious operation of alternate safe shutdown system components as a result of control room fires has been examined in detail and is addressed in ONOP-FP-30 (Control

Building Fires) and ONOP-FP-1A (Safe Shutdown from Outside Control Room). All problem areas were resolved.

Mechanical Valve Damage. The potential for hot shorts resulting in mechanical failures of valves was described in NRC Information Notice (IN) 92-18. This has been reviewed in detail by IP3 and the potential problem of fire-induced rotor locks in MOVs relied upon in the Appendix R Safe Shut Down procedures has been addressed and problem areas resolved.

Hot shorts that might compromise containment isolation or create pathways for containment bypass were specifically addressed in the fire analysis. In discussing containment isolation in Section 4.8.2 of the IP3 IPEEE report, it was concluded that fires that might give rise to hot shorts and thus to containment isolation valves operating or remaining open would not impede access to these valves or prevent operator action to close them. Since fire-induced accidents are unlikely to lead to early reactor vessel failure, many hours would be available to take corrective action and close containment isolation valves should fire-induced cable damage require local valve closure.

Similarly, in discussing containment bypass in Section 4.8.1 of the IP3 IPEEE report, the creation of containment bypass paths as the result of hot-short induced valve opening was addressed. Because of the conservative approach taken in the fire analysis and the fact that no significant bypass events were identified, we can conclude that neither hot-shorts nor any other fire-induced cable failures were a significant cause of containment bypass. In discussing containment bypassing, Section 4.8.1 of the IPEEE stated that "fire-induced mechanical failures (of containment isolation valves) are not credible." This sentence should have stated "fire-induced mechanical failures are not significant causes of a loss of containment isolation."

TABLE 1
DETERMINISTIC EVALUATION OF HOT SHORTS IN THE CONTROL ROOM

In the IP3 IPEEE control room analysis, a deterministic screening evaluation of hot shorts was performed to identify any single critical component which might give rise to a control circuit hot short.

Initial Assumptions and Criteria:

1. Hot shorts were considered singly. Multiple simultaneous hot shorts were deemed most unlikely.
2. If the component was accessible, hot shorts could be corrected with local action, given enough time. The component would then still be unavailable, but would not have other impacts.
3. The component that suffers a hot short is unavailable to perform as desired (as if the component endures an open-circuit or short circuit to ground).
4. Intermittent hot shorts were not considered credible – i.e., intermittently on- off. If the component hot-shorted, it was assumed to stay in the actuated state.
5. Only hot shorts in control cables were considered. Except for DC-powered valves, these are not power cables. A hot short in the control cable can be negated by removing the power from the component and, for a valve, returning it manually to its normal position. It was assumed there was local capability to remove power from a pump at the breaker.
6. Once the control room is evacuated, and the operators have stationed themselves at the remote control stations, all further control room fire damage is assumed isolated from the plant and of no consequence.
7. Hot shorts in instrumentation were not considered.

Using these assumptions and criteria, the following conclusions were drawn from a deterministic screen of all components in the control room:

1. Hot shorts in non-PRA systems are not important.
2. Hot-shorts in main feedwater and BOP systems are not important, because little credit is given them in the first place and because BOP equipment can be completely, and easily, isolated from the reactor system by isolation valves.
3. Hot shorts in PRA systems that are operable from outside the control room can be disabled from the circuits provided outside the control room. The possibility that the component might be damaged by the time the operator acts at the remote control station was not considered—IP3 has resolved all issues associated with IN 92-18.
4. SW valves would be accessible and can be restored.
5. CCW main header valves would be accessible and can be restored. If smaller valves to a particular load (such as an ECCS pump) were not accessible, the valve could stay open and not cause any harm. Valve closure (by a hot short) was considered in the PRA.
6. AFW valves, except those in containment, would be accessible. AFW valves in containment could stay open and control would be excercised using redundant valves in the AFW system.

7. SI and charging system valves could remain open with no undesired effects. These are not ISLOCA valves and the flow is controlled by pumps.
8. RHR valves could remain open with no undesired effects. While the train may be inoperable, it would not create any undesired flow paths or cause flow diversion.
9. The charging pumps will not be dead-headed.

Question 4:

The EPRI fire PRA Implementation Guide assumes that all enclosed ignition sources cannot lead to fire propagation or other damage (page 4-18 of [1]). The Guide also assumes that fire spread to adjacent cabinets cannot occur if the cabinets are separated by a double wall with an air gap or if the cabinet in which the fire originates has an open top (see Appendix H of [1]). These can be optimistic assumptions for high-voltage cabinets since an explosive breakdown of the electrical conductors may breach the integrity of the cabinet and allow fire to spread to combustibles located above the cabinet. For example, switchgear fires at Yankee-Rowe in 1984 and Oconee Unit 1 in 1989 both resulted in fire damage outside the cubicles. In the absence of high energy components, arbitrarily crediting electrical cabinets with the ability to contain fire and damage may still be optimistic. Recent reports from the Technical Research Center (VTT) of Finland (Refs. [7] and [8]) have demonstrated that cabinet warping under heat loads may also allow fire to breach cabinet boundaries.

While citing the EPRI Fire PRA Implementation Guide as a reference, the submittal does not discuss the treatment of electrical cabinets outside of the control room in this regard.

- *Please provide a discussion of the treatment of fire propagation from electrical cabinets in the Indian Point 3 Study.*
- *If the assumptions described above were made, please provide an assessment of the effects, and contribution to the fire CDF, of the failure of such cabinets to contain fires and damage.*

Response:

The Indian Point 3 IPEEE fire analysis adequately addressed the concerns expressed in this question.

- The IP3 analysis interpreted the guidance of the Fire PRA Implementation Guide with respect to screening enclosed ignition sources very conservatively. A fully enclosed cabinet was taken to mean a cabinet with solid metal sides and top (and bottom, if the cabinet was wall-mounted), tight-fitting doors and no ventilation openings. Thus, fully enclosed cabinets are primarily lighting panels, fire protection panels and similar small wall-mounted panels. At IP3, fully enclosed cabinets do not include cabinets similar to those involved in the 6.9-kV switchgear Yankee Rowe[1] and 480-V switchgear Oconee[2] fires, or the control and relay panel cabinets of the type simulated in tests by the Technical Research Center (VTT)[3,4] of Finland as, at IP3, these cabinets are vented, and therefore do not meet the screening criterion for enclosed ignition sources.

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1 "480 Volt Bus 4-1 Failure", Yankee Nuclear Power Station, LER Number 84-013-00, NRC Public Documents Room Accession Number 8409100062, 08/31/84.

2 "Fire in 1TA Switchgear Due to Unknown Cause", Oconee Nuclear Station Unit 1, LER Number 89-002-00, NRC Public Documents Room Accession Number 8902140434, 02/02/89.

3 Mangs, Johan, and Keski-Rahkonen, Olavi, "Full scale fire experiments on electronic cabinets," Technical Research Center of Finland (Valtion Teknillinen Tutkimuskeskus, VTT), VTT publication 186, Espoo, Finland, 1994 (ISBN 951-38-4924-5; ISSN 1235-0621; UDC 614.84:699.81:621.3.05).

- All unscreened cabinets were subjected to an analysis which explicitly addressed both damage and propagation to cables above the cabinet. The analysis used the fire modeling techniques provided in FIVE[5] assuming a 65-Btu/s heat release rate for vertical cabinets with qualified cable. The virtual surface of the fire was conservatively located at the top of the highest ventilation opening, usually the top of the cabinet. This heat release rate, when placed at the top of the cabinet, is believed to be in accord with the photographic evidence of cabinet fires presented by VTT.

- The IP3 analysis typically resulted in a prediction that at least one (and sometimes more) cable trays above the cabinet could be ignited by the cabinet fire. The effect of the ensuing cable tray fire was also taken into account when assessing early damage in the zone of influence of the fire–damage to trays higher up in the stack was predicted based on the combined heat release rates of the cabinet fire and the tray fire, and was assumed to occur immediately. The models generally predicted more severe damage (i.e., damage to all but the very highest trays in the stack) than was reported to have resulted in the Oconee and Yankee Rowe events.

- The IP3 analysis addresses fires within cubicles in a very conservative manner: it assumed that a fire in one cubicle would result in the loss of function of the entire cabinet (e.g., a fire in one switchgear cubicle was assumed to result in damage to the entire switchgear).

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4 Mangs, Johan, and Keski-Rahkonen, Olavi, "Full scale fire experiments on electronic cabinets II," Technical Research Center of Finland (Valtion Teknillinen Tutkimuskeskus, VTT), VTT publication 269, Espoo, Finland, 1996 (ISBN 951-38-4927-9; ISSN 1235-0621; UDC 614.842:621.3.04:53.083).

5 *Fire-Induced Vulnerability Evaluation (FIVE) Methodology*, EPRI TR-100370, April 1992.

Question 5:

The Indian Point 3 submittal refers to the EPRI Fire PRA Implementation Guide (the Guide) for guidance in the fire analysis. The heat loss factors recommended in the Guide lead to optimistically low damage estimates. The Indian Point 3 submittal does not provide the value used in its analysis for this parameter.

The heat loss factor is defined as the fraction of energy released by a fire that is transferred to the enclosure boundaries. This is a key parameter in the prediction of component damage, as it determines the amount of heat available to the hot gas layer. A larger heat loss factor means that a larger amount of heat (due to a more severe fire, a longer burning time, or both) is needed to cause a given temperature rise. It can be seen that if the value assumed for the heat loss factor is unrealistically high, fire scenarios can be improperly screened out. Figure A provides a representative example of how hot gas layer temperature predictions can change assuming different heat loss factors. Note that: 1) the curves are computed for a 1000 kW fire in a 10m x 5m x 4m compartment with a forced ventilation rate of 1130 cfm; 2) the FIVE-recommended damage temperature for qualified cable is 700°F for qualified cable and 450°F for unqualified cable; and 3) the SFPE curve in the figure is generated from a correlation provided in the Society for Fire Protection Engineers Handbook [2].

Based on evidence provided by a 1982 paper by Cooper et al. [3], the Guide recommends a heat loss factor of 0.94 for fires with durations greater than five minutes and 0.85 for "exposure fires away from a wall and quickly developing hot gas layers." However, as a general statement, this appears to be a misinterpretation of the results. Reference [3], which documents the results of multi-compartment fire experiments, states that the higher heat loss factors are associated with the movement of the hot gas layer from the burning compartment to adjacent, cooler compartments. Earlier in the experiments, where the hot gas layer is limited to the burning compartment, Reference [3] reports much lower heat loss factors (on the order of 0.51 to 0.74). These lower heat loss factors are more appropriate when analyzing a single compartment fire. In summary, (a) hot gas layer predictions are very sensitive to the assumed value of the heat loss factor; and (b) large heat loss factors cannot be justified for single-room scenarios based on the information referenced in the Guide. The EPRI Fire PRA Implementation Guide asks the analyst to indicate a heat loss factor on the walkdown worksheet.

The submittal does not indicate the heat loss factor used in the analysis. For each scenario where the hot gas layer temperature was calculated, please specify the heat loss factor value used in the analysis. In light of the preceding discussion, please either: a) justify the value used and discuss its effect on the identification of fire vulnerabilities, or b) repeat the analysis using a more justifiable value, such as the 0.7 value recommended in FIVE, and provide the resulting change in scenario contribution to core damage frequency.

Response:

The heat loss factor used in the calculation of critical hot gas layer temperatures was 0.85. This value is consistent with the methodology published in the EPRI Fire PRA Implementation Guide (EPRI-TR-105928, December 1995). The Guide recommends using a value of at least 0.94 for times ≥ 5 minutes (i.e., slowly developing hot gas layers) where the whole compartment is filled by the hot gas layer and smaller values (0.85) for "exposure fire scenarios away from a wall and quickly developing hot gas layers (e.g., large flammable liquid pool fires)".

The issue of appropriate heat loss factors will be addressed further in the NEI response to the generic RAI on the EPRI Fire PRA Implementation Guide.

Question 6:

In the EPRI Fire PRA Implementation Guide, test results for the control cabinet heat release rate have been misinterpreted and have been inappropriately extrapolated. Cabinet heat release rates as low as 65 Btu/sec are used in the Guide. In contrast, experimental work has developed heat release rates ranging from 23 to 1171 Btu/sec.

Considering the range of heat release rates that could be applicable to different control cabinet fires, and to ensure that cabinet fire areas are not prematurely screened out of the analysis, a heat release rate in the mid-range of the currently available experimental data (e.g., 550 Btu/see) should be used for the analysis.

Discuss the heat release rates used in your assessment of control cabinet fires. Please provide a discussion of changes in the IPEEE fire assessment results if it is assumed that the heat release from a cabinet fire is increased to 550 Btu/sec.

Response:

Justification for the 65 Btu/sec vertical cabinet heat release rate is contained in Appendix E of the EPRI Fire PRA Implementation Guide. Based on results from the Sandia cabinet fire tests, the Guide recommends a 65 Btu/sec heat release rate for vertical electrical cabinets known to contain only qualified cable. Since all safety-related cable at IP3 have been designed to meet the vertical flame test requirements of IEEE 383, the 65 Btu/sec heat release rate was deemed appropriate.

The issue of appropriate heat release rates will be addressed further in the NEI response to the generic RAI on the EPRI Fire PRA Implementation Guide.

Question 7:

Fires in the main control room (MCR) are potentially risk-significant because they can cause I&C failures (e.g., loss of signals or spurious signals) for multiple redundant divisions, and because they can force control room abandonment. Although data from two experiments concerning the timing of smoke-induced, forced control room abandonment are available [4], the data must be carefully interpreted, and the analysis must properly consider the differences in configuration between the experiments and the actual control room being evaluated for fire risk. In particular, the experimental configuration included placement of smoke detectors inside the cabinet in which the fire originated, as well as an open cabinet door for that cabinet. In one case, failure to account for these configuration differences led to more than an order of magnitude underestimate in the conditional probability of forced control room fire abandonment [5]. In addition, another study raises questions about control room habitability due to room air temperature concerns [6].

The submittal indicates that in-cabinet detectors are present in two major cabinets, the flight and continuous cabinets. The remaining cabinets are also potential fire sources that can lead to the need for control room abandonment; however, detectors in these cabinets are not described in the submittal.

Please provide the detailed assumptions (including any frequency reduction factors and the probability of abandonment) used in analyzing the MCR and justifications for these assumptions. In particular if the probability of abandonment is based on a probability distribution for the time required to suppress the fire, please justify the parametric form of the distribution and specify the data used to quantify the distribution parameters.

Response:

The assumptions pertaining to the IP3 main control room fire analysis are presented in Section 4.7.4.3 of the IPEEE report. In summary:

- The control room will be evacuated if the control room becomes uninhabitable or safe shutdown equipment cannot be operated from within it.
- The time required for a cabinet fire to create uninhabitable conditions is 15 minutes (as determined using the Sandia National Laboratory (SNL) cabinet fire tests).
- Each cabinet contains sufficient cable or combustible loading to generate enough smoke to cause control room evacuation should suppression fail.
- Fire in cabinets that do not contain safe shutdown equipment will be considered as a cause for control room evacuation should fire suppression be unsuccessful.
- Fire in a cabinet (or individual control board in the main control board) was assumed to fail all control circuits in that cabinet and cause a complete function loss for that cabinet.

- Smoke from the control room would not adversely affect operator actions taken at the local control stations.

- Cabinet SHF was the only cabinet in which fires were assumed to result in a loss of offsite power. Fire in SHF will fail all offsite power and all EDG control from the control room.

- Successful manual suppression limits fire damage to the cabinet in which it initiated.

- An ATWS event occurring concurrently with a fire is not considered credible.

- Just prior to control room evacuation, the operators would secure the reactor coolant pumps and main feedwater pumps, close MSIVs, trip the reactor and turbine, and deactivate PORVs.

- Cabinet fires are the only potentially significant fires in the control room because there are no class A flammables, no welding and only limited class B transient combustibles in the control room. Transient fires are assumed incapable of causing cable damage inside a cabinet because of the limited ability of low BTU combustibles to cause cabinet damage and the high probability of rapid suppression.

- Re-entry into the control room after evacuation is not credited.

- If offsite power is not lost as a result of the fire, it is assumed to remain available throughout the event, as operators are not instructed to trip offsite power before leaving the control room.

- A fire in the control room will be suppressed or the control room evacuated before the fire spreads across more than 15 linear ft of the control board.

- The ignition frequency for cabinets was apportioned uniformly, each panel being assigned the same ignition frequency.

- Fire damage in the control room will likely be limited to one cabinet since damaging hot gas layers in the control room are very unlikely as the ceilings in the control room are high and all cables are routed through the floor.

- Fire can propagate from one panel to the next, but damage in the adjacent panels is unlikely to occur until 15 minutes has elapsed should there be partitions between the panels.

In the IP3 IPEEE, a sequence of events was postulated in a fire scenario:

1. A fire is initiated in a single cabinet

2. Fire damages the critical cables before suppression is possible

3. Personnel attempt to suppress the fire

4. If the fire is suppressed within 15 minutes, it does not spread to adjacent cabinets (except in the main control board) and the control room remains habitable. Shutdown is achieved from the control room with the remaining operable equipment.

5. If suppression fails, the control room is evacuated 15 minutes after fire initiation and the fire spreads to adjacent cabinets. Shutdown is performed from outside the control room with remote shutdown capability.

These assumptions make clear the conservative approach taken and the fact that frequency reduction factors were not applied to control room fires.

The control room analysis was performed in accordance with the EPRI Fire PRA Implementation Guide. The probability of abandonment, given a control room fire, was the 3.4×10^{-3} probability developed in the Fire PRA Implementation Guide. This probability was used in the IPEEE as a point estimate. It was derived as a best fit to event times observed in simulator exercises and is in accord with data on actual control room fires. As noted in Section 4.7.4.5 of the IP3 IPEEE report, the probability that operators have to leave the control room is a function of the time available to suppress the fire before smoke reduces visibility at the main control board. The time available to suppress the fire was assessed in Appendix M of the EPRI Fire PRA Implementation Guide. This assessment was based on review of SNL cabinet fire test data on smoke accumulation. The probability of non-suppression as a function of time is also assessed in Appendix M using EPRI's Human Cognitive Reliability (HCR) correlation to interpret the control room fire durations in the EPRI Fire Events Database. The model fits the event times (e.g., fire durations) to a log-normal curve to estimate the probability of inaction for times greater than those observed. Using this method, the probability of non-suppression within 15 minutes is given as 0.0034. Support for this number has been presented in the NEI Response.

Several generic conservatisms in the Fire PRA Implementation Guide were noted in the NEI Response: the selection of evacuation criteria based on optical density rather than observation; the likelihood that the fire will start in a relay or circuit card; and the probability of cable ignition and delays in the ignition of qualified cable. To these conservatisms, we can add several specific to IP3:

- The IP3 control room, with its volume of approximately 60,000 cubic feet, is larger than the SNL test enclosure in which the cabinet fire tests that provide the basis for much of the Fire PRA implementation Guide were conducted. A larger volume tends to ameliorate the impact of fires on control room visibility and room temperature.

- No credit was taken for smoke detectors within control room cabinets. This represents a conservatism as, for cabinets containing smoke detectors, smoke detector actuation may occur quickly, increasing the probability of early detection and reducing uncertainty in the probability of early recovery.

Finally, we would note that if the probability of evacuation is increased three-fold to 0.01, the CDF will increase by 3.2×10^{-6}/yr or 6%.

Furthermore, many of the issues raised in this question have been addressed in detail in the NEI Response to the Generic RAI[6].

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6 NEI Response to Generic Question No. 4

ATTACHMENT II TO IPN-98-104

COMMITMENTS

NEW YORK POWER AUTHORITY
INDIAN POINT 3 NUCLEAR POWER PLANT
DOCKET NO. 50-286
DPR-64

Commitments

Commitment Number	Description	Due Date
IPN-98-104-01	Monitor the resolution of questions regarding EPRI's "Fire PRA Implementation Guide," with the NRC, EPRI and the industry.	Ongoing
IPN-98-104-02	If necessary, revise the Indian Point 3 fire IPEEE to reflect the final resolution of those issues. If significant changes to the fire IPEEE are required, prepare and submit a report to the NRC detailing the changes and summarizing the results.	No more than 120 days after final resolution of issue.