SCE&G
A SCANA COMPANY

September 24, 1998
RC-98-0170

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

Attention: Mr. L. M. Padovan

Gentlemen:

Subject: VIRGIL C. SUMMER NUCLEAR STATION
DOCKET NO. 50/395
OPERATING LICENSE NO. NPF-12
REQUEST FOR ADDITIONAL INFORMATION REGARDING
IPEEE REPORT GENERIC LETTER 88-20

Reference: Gary J. Taylor letter to Document Control Desk, August 21, 1998
L. Mark Padovan letter to Gary J. Taylor, April 9, 1998
Gary J. Taylor letter to Document Control Desk, June 30, 1995

Gary J. Taylor
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The NRC letter of April 9, 1998 issued a request for additional information (RAI) regarding the Virgil C. Summer Nuclear Station (VCSNS) IPEEE Report submitted June 30, 1995 and requested that the additional information be provided by September 1, 1998. The RAI pertains to the IPEEE seismic and fire analyses. There were no RAIs in the high winds, floods, and other external events areas.

South Carolina Electric and Gas Company (SCE&G) submitted the RAI on the Seismic IPEEE attached to the Gary J. Taylor letter of August 21, 1998. The August 21, 1998 letter also documents your approval to submit the Fire IPEEE RAI responses in two phases. A partial submittal of the available responses on September 25, 1998 followed by a final submittal of the Fire IPEEE RAI by January 5, 1999.

This partial submittal includes additional information on 10 of the 15 Fire IPEEE RAI questions. This submittal includes answers to questions 8, 9, 11 and 12, as well as information concerning questions 1, 3, 4, 10, 14 and 15.

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This partial submittal includes additional information on 10 of the 15 Fire IPEEE RAI questions. This submittal includes answers to questions 8, 9, 11 and 12, as well as information concerning questions 1, 3, 4, 10, 14 and 15.

In response to Generic Letter 88-20, Supplement 4, submitted by the referenced June 30, 1995 letter, SCE&G performed an examination of potential fire-induced vulnerabilities at VCSNS using the EPRI Fire-Induced Vulnerability Evaluation (FIVE) methodology. At the time, the industry recognized, that due to the screening nature of FIVE, the analysis would provide very conservative results. It appears from the RAI that the NRC is trying to derive an absolute core damage frequency (CDF) value for fire-induced risk at VCSNS based on this screening analysis. Therefore, SCE&G is preparing an addendum to the 1995 FIVE submittal to reduce the conservatism, as well as provide the quantitative details requested by the RAI.

VCSNS continues to participate in an industry effort to address the 15 NRC Generic Fire-IPEEE Questions submitted to NEI. Several of the VCSNS RAIs address technical issues similar or identical to these Generic Questions. Once the industry-wide effort is complete, SCE&G intends to utilize its findings to support the VCSNS response to these RAIs. This intent is indicated in the text of the attached responses to the applicable individual RAIs.

I declare that these statements and matters set forth herein are true and correct to the best of my knowledge, information and belief.

Should you have questions, please call Mr. Jim Turkett at (803) 345-4047 or Mr. Tyndall Estes at (803) 345-4703.

Very truly yours,

Gary J. Taylor

JT/GJT
Attachments

c: See Page 3

c: Without Attachment II
J. L. Skolds
W. F. Conway
R. R. Mahan (w/o Attachments)
R. J. White
L. A. Reyes
L. M. Padovan
NRC Resident Inspector
M. K. Batavia
Paulette Ledbetter
J. B. Knotts, Jr.
RTS (LTR 880020)
File (815.14)
DMS (RC-98-0170)

STATE OF SOUTH CAROLINA :
: TO WIT :
COUNTY OF FAIRFIELD :

I hereby certify that on the 24th day of September 1998, before me, the subscriber, a Notary Public of the State of South Carolina personally appeared Gary J. Taylor, being duly sworn, and states that he is Vice President, Nuclear Operations of the South Carolina Electric & Gas Company, a corporation of the State of South Carolina, that he provides the foregoing response for the purposes therein set forth, that the statements made are true and correct to the best of his knowledge, information, and belief, and that he was authorized to provide the response on behalf of said Corporation.

WITNESS my Hand and Notarial Seal

Michael J. Zaccone
Notary Public

My Commission Expires

My Commission Expires July 13, 2005
Date

RESPONSES TO USNRC REQUEST FOR ADDITIONAL INFORMATION PERTAINING TO V. C. SUMMER NUCLEAR STATION FIRE IPEEE

1. The sum of the fire-induced core damage frequencies (CDFs) for VCSNS after the "Post-FIVE Analysis" is 4.1E-4 per year. The fire CDF estimate remains high in comparison to other pressurized water reactor plant IPEEE submittals the NRC has reviewed to date. However, you have identified no fire-related vulnerabilities, and implemented no plant improvements to reduce fire risk. You provided a qualitative discussion of conservatisms in your analysis.

1.a. Please define plant "vulnerability" that you used in assessing the results of the IPEEE fire analysis.

1.b. Describe how you determined that there are no cost-effective plant modifications that you could make to reduce fire risk at VCSNS.

<u>RESPONSE:</u>

1.a. In June 95, in response to Generic Letter 88-20 Supplement 4, VCSNS performed an evaluation of potential fire-induced vulnerabilities at VC Summer using the FIVE methodology. At the time, the industry recognized that due to the screening nature of FIVE, the evaluation provides very conservative results. The quoted core-damage frequency (CDF) values for individual scenarios are adequate to identify the relative safety significance of various fire scenarios, but are too conservative to be used as an absolute value or summed as an indication of the absolute overall CDF for fire-initiated scenarios at VCSNS. It is also inappropriate to use these results for comparison to other plants without understanding the underlying factors. NEI 91-04 (formally NUMARC 91-04), Revision 1, dated 12/94, "Severe Accident Issue Closure Guidelines" states that for fire compartments which were not considered to be insignificant "The resulting figure of merit is used to compare the core damage frequencies in Table 1, although ***it should not be considered an estimate of core damage in contexts outside of this application."*** (emphasis added)

The search for vulnerabilities in the 1995 Fire Induced Vulnerability Evaluation was a continuous process that included area walkdowns. Areas that did not screen at less than 1.0E-06 were reviewed in an attempt to identify unique features that could be addressed through procedure or hardware changes. The primary reason that areas failed to screen was found to be conservative modeling assumptions. Further quantitative analysis was not considered warranted as no plant vulnerabilities were identified during the qualitative evaluation as documented in Section 4 of the 1995 Fire Induced Vulnerability Evaluation.

It appears from the RAI that the NRC is trying to derive an absolute CDF value for fire-induced risk at VCSNS based on this screening evaluation. This was neither our intent in performing the Fire Induced Vulnerability Evaluation nor the intent of Generic Letter 88-20, Supplement 4 as we understood it. To avoid the inappropriate use of the 1995 results as an indication of fire risk at VCSNS and to provide a study that is more representative of the VCSNS fire protection design and practice, VCSNS is preparing an addendum to the 1995 FIVE submittal. This addendum will reduce the conservatism as well as provide the quantitative details requested in the RAI. NEI 91-04 will be used as general guidance in the review for unique features that can be addressed through procedure changes or hardware changes. Numeric results are only part of the input to determine if changes are desirable.

The real value of a risk analysis is the knowledge gained during the process, and not a measurement against a fixed CDF threshold.

1.b. The VCSNS evaluation did not identify a justifiable administrative and/or hardware modification, considering the screening nature of FIVE and conservatisms in those results. However, since the completion of the 1995 VCSNS Fire Induced Vulnerability Evaluation, VCSNS has taken steps aimed at reducing the plant fire risk.

- MRF-20951 replaces the existing fire detection system with a Simplex System that supports addressable fire detection devices located throughout the plant site. There are eight new local control panels (Model 4100), one new Main CPU (Model 2120) with a color graphic display monitor located in the Control Room and in the Fire Protection Officer's Office with a dot matrix printer located in the Control Room that records all 2120 response messages.

- MRF-34498 (Spring 1996) replaced the TSI Thermolag 330 wrap by using an approved Rockbestos Firezone R cable, or by enclosing certain circuits within a one hour fire rated gypsum. This eliminated the TSI cable wrap from the plant. The only cable tray wrap at VC Summer used to meet the BTP APCSB 9.5-1, Appendix A and 10CFR50, Appendix R requirements is [illegible] Kaowool triple wrap. For additional information, please refer to Response 11.a.

- VCSNS revised a number of Fire Protection Procedures: Control of Transient Combustibles; Duties of a Fire Watch; Burn Permit; Handling and Storage of Flammable Liquids and Gases; Barrier Control; Shift Inspector; and Conduct of Fire Drills.

2. **Section 4.0 of your submittal provides "vulnerability evaluations" based on a qualitative discussion of the sources of conservatism in the unscreened fire areas/compartments analysis. The discussions included cited conservatisms which are derived primarily from three elements. One element was equipment duty factors. However, duty factors are inherently included in the experience-based fire event data used in the study. A second element was giving some credit to suppression and detection. You based these credits on assessing damage times versus detection/suppression times. However, suppression has also been inherently credited through the severity factors used in the post-FIVE analysis (see related discussions in RAI items 7 and 8). The third element was the availability of alternate equipment to provide the backup system function. You should use appropriate plant models to support your assessment. The models should include the credited equipment, appropriate human reliability analyses to ensure that required operator actions are appropriately accounted for, and cable tracing to ensure independence from the postulated fire.**

   2.a. **Please provide a revised quantitative assessment of the CDF contribution taking into consideration the above three factors for each of the unscreened areas/compartments identified in Table 11 of your submittal. Include a quantitative treatment of perceived major conservatisms using available fire risk analysis tools.**

   2.b. **Based on the results, please reassess the potential that these scenarios might represent fire vulnerabilities, and identify potential measures to reduce fire risk at VCSNS.**

RESPONSE:

An addendum is being prepared to the 1995 Fire Induced Vulnerability Evaluation that will provide the revised quantitative assessment and vulnerability assessment. The addendum will take into consideration the appropriateness of the above three elements.

3. **The VCSNS Fire Emergency Procedures cited in the IPEEE study specify establishing power to the emergency bus from its respective diesel generator (A or B train) and tripping offsite power. In particular, page 52 of the submittal states that the VCSNS Fire Emergency Procedures (FEP-1.0, FEP-2.0, FEP-3.0, and FEP-4.0) direct the operators to isolate the offsite power source to the emergency bus(s) that is (are) supplying power to the designated safe shutdown train(s). After initiating safe shutdown, offsite power can be reestablished to selected emergency loads.**

   3.a. **Please provide a copy of the above cited procedures (FEP-1.0 - 4.0).**

   3.b. **Assess the impact on the CDF values reported in Table 11 of not isolating offsite power from the emergency bus when required by the plant Fire Emergency Procedures.**

RESPONSE:

3.a. A copy of the latest VCSNS Fire Emergency Procedures (FEPs) are included with this submittal as Attachment II.

FEP-1.0	Fire Emergency Procedure Selection
FEP-2.0	'A' Train Plant Shutdown to Hot Standby Due to Fire
FEP-2.1	'A' Train Shutdown from Hot Standby to Cold Shutdown Due to Fire
FEP-3.0	'B' Train Plant Shutdown to Hot Standby Due to Fire
FEP-3.1	'B' Train Shutdown from Hot Standby to Cold Shutdown Due to Fire
FEP-4.0	Control Room Evacuation Due to Fire
FEP-4.1	Plant Shutdown from Hot Standby to Cold Shutdown Due to Fire in Control Building

3.b. An addendum is being prepared to the 1995 Fire Induced Vulnerability Evaluation that will impact the results as presented in Table 11 of the June 1995 submittal. The following provides a qualitative discussion in response to Question 3.

Before examining the effect of isolating offsite power, it is important to understand the operator's response to a severe fire at VCSNS. When necessary, the Fire Emergency Procedures (FEPs) are always entered at FEP-1.0, "Fire Emergency Procedure Selection" to determine the correct procedure to use, and any amplifying information needed for fires in specific zones. The FEPs are not entered unless the fire is of such a nature (due to magnitude, location, or equipment involved) that there is concern about the ability to safely control the plant using the normal operating procedures. Once the decision to enter the FEPs is made, FEP-1.0 provides three basic choices depending on the location of the fire:

1. Shutdown the plant using "A" Train, FEP-2.0, "A TRAIN PLANT SHUTDOWN TO HOT STANDBY DUE TO FIRE"

2. Shutdown the plant using "B" Train, FEP-3.0, "B TRAIN PLANT SHUTDOWN TO HOT STANDBY DUE TO FIRE"

3. Evacuate the Control Room and shutdown the plant from the Control Room Evacuation Panel (CREP) using "B" Train, FEP-4.0, " CONTROL ROOM EVACUATION DUE TO FIRE"

There are only 6 fire zones (CB-4, CB-6, CB-15, CB-17.1, CB-17.2, CB-17.3) that require evacuation of the control room due to fire. The remaining zones constitute <u>96%</u> of the fire zones and are split between "A" or "B" train shutdown from <u>within the control room</u>.

For a shutdown from ***within the control room***, the sequence followed by the operator to re-align the ESF buses as follows:

- The non-shutdown ESF bus is de-energized to prevent spurious operation from cable damage:

    1. The Intermediate Building Auxiliary Operator (IBAO) verifies the DG output breaker is open, removes the breaker control power, and inhibits the non-shutdown DG by placing the engine controls in the maintenance position. (Local actions)

    2. The Balance of Plant (BOP) operator opens the normal and alternate offsite power breakers to the non-shutdown bus from the main control board (MCB) after notification from the IBAO that the DG is disabled.

- The shutdown DG is started, and the shutdown ESF bus is aligned to onsite power:

  1. The BOP operator starts the DG from the MCB using the emergency start push-button.

  2. The BOP operator verifies normal voltage and frequency response before continuing. At this point, if the DG failed to start or if the DG was known to be unavailable due to maintenance, it is expected that the operator would leave the shutdown bus aligned to offsite power while initiating efforts to restore the shutdown DG to functional status. This sequence of actions is very important since a large part of the shutdown DG unavailability is due to maintenance and failure to start. Under either of these situations, offsite power would not be disconnected. The only remaining failure mode of the DG would be failure to run.

  3. The BOP operator then opens the normal and alternate offsite power breakers to the shutdown bus from the main control board (MCB) causing the bus to be de-energized which actuates the ESF Load Sequencer (ESFLS), and provides the permissive to close the DG breaker.

  4. The BOP operator then verifies the DG breaker closes to re-energize the shutdown bus. This should occur within 3-4 seconds since the DG is already at rated speed and voltage.

  5. Finally, the BOP operator verifies that the critical loads sequenced by the ESFLS have started.

For a shutdown ***outside of the control room***, the sequence followed by the operator to re-align the ESF buses is different due to the additional local actions and the assumption that the ESFLS may not function:

- The "A" train ESF bus is de-energized to prevent spurious operation from cable damage:

  1. The BOP operator locally opens and disables the normal and alternate offsite power breakers, and the DG supply breaker to the "A" train vital bus. This de-energizes "A" train.

2. The IBAO inhibits the "A" DG by tripping the engine, if necessary, and placing the engine controls in the maintenance position. (Local actions)

- The "B" train ESF bus is aligned to onsite power:

1. The IBAO prepares the "B" DG for starting by placing the engine controls in the local position. (Local actions)

   The nuclear reactor operator at the controls (NROATC) locally strips the loads from the 7.2 KV "B" bus by placing local/remote switches in local and placing the start/stop switches to the desired positions. Other operators assist by stripping 480 v loads at different locations.

   When the BOP operator notifies the NROATC that the "B" DG is ready for start, the NROATC opens and disables the normal and alternate offsite power breakers. The "B" bus will remain de-energized for 15-20 seconds allowing for undervoltage relay actuation and DG acceleration to rated speed and frequency. The NROATC remains at the switchgear to confirm DG breaker closure and manually start loads as directed after reporting to the control room supervisor at the control room evacuation panel. At this point, if the DG failed to start the NROATC would have to re-close a normal or alternate offsite power breaker to get power back. If the DG was known to be unavailable due to maintenance, the operator would leave the shutdown bus aligned to offsite power while initiating efforts to restore the shutdown DG to functional status.

2. The IBAO returns to the "B" DG within 30 minutes of the start of the event to check the DG. If the DG is not running, he coordinates with the NROATC to emergency start the DG locally, and locally close the DG output breaker.

The VCSNS Fire Emergency Procedures provide systematic control of off-site and on-site emergency power. Transfer between off-site and on-site power employs a dead bus transfer methodology that improves the reliability of safe shutdown power. The improved reliability is achieved by eliminating the procedure steps of paralleling on-site and off-site electrical power supplies during a live bus transfer. Additionally, the VCSNS Fire Emergency Procedures accommodate DG unavailability due to maintenance or failure to start. Therefore VCSNS Fire Emergency Procedures reduce CDF by remaining on off-site power when the DG is not available.

4. FEP-4.0 deals with fires requiring main control room (MCR) evacuation at VCSNS. The IPEEE discussion of MCR evacuation events (page 71 of the submittal) indicated that "it (FEP-4.0) assumes a loss of offsite power and no load sequencer actions." It is unclear what this statement implies in the context of the IPEEE analysis. In particular, we need to know what was assumed in the IPEEE analysis regarding the plant state at the time of a forced MCR evacuation. Operator actions are required to recover the emergency loads in the event of a "loss of offsite power with no load sequencer action." Failure to recover the emergency loads properly could lead to isolating both normal and emergency alternating current (AC) power for some period of time.

   As a further note, page 54 of the submittal states that the load sequencer is located in the relay room (fire area CB-6). Accordingly, fires in this area have the potential to fail the load sequencer. This fire area is also identified on page 71 as one of the areas in which an "uncontrolled fire" would force MCR evacuation. Thus, assuming loss of the sequencer function for such fires would be appropriate. For other fire areas/compartments, it is unclear whether or not loss of the sequencer has been, or should be, assumed in the IPEEE analysis.

   4.a. For each area/compartment in which fires might lead to MCR evacuation at VCSNS, please provide (1) the assessment details with regard to the assumed state of the plant at the time of MCR evacuation, and (2) the operator actions required to shutdown the plant from the control room evacuation panel.

   4.b. Also detail the human reliability analysis (HRA) for these scenarios including the operator action event trees, a description of the SAIC HRA methodology as applied to these scenarios, and the input values and their bases as applied to these HRA models.

   4.c. Provide an assessment of the impact on fire compartment CDF if you assume that all AC power is lost in the relevant MCR evacuation scenarios, if the potential for sequencer failure (due to either fire-induced failures or random failures) has not been included.

RESPONSE:

4.a. The following paragraphs discuss the assumed state of the plant at the time of evacuation and the actions needed following evacuation.

Control room evacuation is required for uncontrolled fires that occur in six fire zones within the control building: Lower Cable Spreading Room (CB-4), Relay Room (CB-6), Upper Cable Spreading Room (CB-15), and Control Complex (CB-17.1, CB-17.2, and CB-17.3). The criterion for evacuation and use of FEP-4.0 is that a fire in one of these zones raises concern about the ability to safely shutdown the plant.

When implementing FEP-4.0 for control room evacuation, the initial key actions are to manually trip the reactor, isolate the pressurizer and steam PORVs, and isolate primary and secondary system water inventory relying on passive cooling. This would re-establish system integrity if the assumed spurious fire induced valve operations occurred. After a brief period of passive cooling, the operators then manually re-establish the Appendix R analyzed train of equipment for active cooling to hot shutdown. These actions are described in more detail as follows.

In FEP-4.0, prior to evacuation of the control room, the operators manually trip the reactor, turbine and reactor coolant pumps, and take actions to establish manual control at the control room evacuation panel (CREP), and at local stations within the plant. The key actions to establish local control are to open the disconnect switches located inside the Main Control Board and select "Local" on the B Train Fire Switches and CREP switches. The disconnect switches are used both to protect the plant from spurious actions related to hot shorts in the DC circuits and to establish RCS and SG integrity. If the disconnect switches in the control room are not accessible due to the fire, then the same functions can be performed using additional disconnect switches in the termination cabinets located at CB 448 as described in FEP-4.0. The "Local" switches isolate the control circuits from the six fire zones noted above.

The primary and secondary system isolation described above is maintained for a brief period during which AC breakers are opened to strip loads from selected safety buses. Normal buses for BOP equipment remain connected. These actions protect the plant from new fire induced spurious actions and allow the operators to sequence loads on the diesel generator. Core cooling is sustained during this brief period of isolation by using SG safeties to relieve steam if the secondary pressure relief point is reached.

Intermediate actions called for in FEP-4.0 are to manually energize bus 1DB using the B diesel generator and load the required ESF equipment. Additional actions support maintaining primary and secondary inventory by controlling emergency feedwater, seal injection, and charging flow. The manual loading is required because the sequencer and its wiring, located in these six fire zones, are assumed lost due to the fire.

The load sequencer is assumed to fail in all MCR evacuation scenarios. For fires in all other zones the sequencer is assumed to be subject to the random failures consistent with the IPE model. The steps in FEP-4.0 provide for manual DG start up and manual loading without support from the sequencer. These steps accommodate any sequencer actuation prior to entering FEP-4.0 and prevent subsequent sequencer action. Control, coordination and monitoring activities are carried out at the CREP. Coordination of the loading sequence involves sequencing of activities built into the procedures, the use of plant communication systems to report on status of plant actions, and instructions from the control room supervisor.

Longer-term actions are to maintain support systems such as service water and building cooling. As described in FEP-4.0 the hot shutdown conditions can be maintained for an indefinite period by replenishing the CST. Operators initiate the transition to cold shutdown using FEP-4.1 based on their judgement and on verification that all the needed equipment is available.

4.b. and 4.c The HRA models are being revised in the 1998 VCSNS Fire Induced Vulnerability Evaluation Addendum to more accurately reflect the use of the FEPs, since the initial study used conservatively assigned values for train unavailability where operator actions were implicitly included rather than explicitly modeled. Preliminary results of the addendum project indicate that the probability estimates for the conditional probability of core damage are bounded by the assessed values for P2 used in the results of Table 11 page 93 of the June 1995 VCSNS Fire Induced Vulnerability Evaluation submittal. The 1998 VCSNS Fire Induced Vulnerability Evaluation Addendum will provide the basis for evaluating the impact on the CDF, and therefore VCSNS is deferring a complete response to this question until the final response to this RAI.

5. Offsite power restoration failures was credited in the "Post-FIVE" analysis for fires in the MCR (pages 58 and 80). Table 12 of the 1995 VCSNS Fire Induced Vulnerability Evaluation submittal indicates that three panels (6116, 6118, and 6225) associated with offsite power are located in the MCR. It is unclear whether or not the offsite power restoration failure probability (OSPREC) shown in the event tree on page 79 of the submittal includes the potential that fire-induced failures in one (or more) of these panels might prevent restoring offsite power.

Please provide a detailed assessment of the potential for restoring offsite power if any or all of the above listed panels are subject to fire damage. Also provide the basis for the assumed OSPREC value for MCR fire scenarios at VCSNS. Reassess the CDF contribution for the relevant fire scenarios in which fire damage might occur, if the potential for restoration might be impacted, and this potential was not included in the original analysis.

RESPONSE:

Restoration of offsite power appears to have been credited in error for offsite power panels 6116, 6118 and 6225 in the MCR. The 1998 VCSNS Fire Induced Vulnerability Evaluation Addendum, currently being prepared, includes a complete reevaluation of the control room CDF contributions for all panels, and specifically addresses fires in the offsite power panels. The addendum is being prepared in accordance with the guidance provided for control room analysis in the EPRI Fire PRA Implementation Guide [Ref.[1]]. We acknowledge that Generic Questions are being raised by the NRC related to this methodology. Our final response to this RAI will reflect the conclusion of the on-going industry effort towards the resolution of the fire IPEEE Questions.

The reevaluation includes a complete revision of the control room event trees, including redefining the events to reflect detailed human reliability analysis of the fire emergency procedures more accurately. The OSPREC event no longer exists in the revised event trees. The basis for the events in the revised event trees will be provided, along with the revised CDF, in the final response to this RAI.

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1 W. J. Parkinson, et. al., *Fire PRA Implementation Guide*, TR-105928, Electric Power Research Institute, Palo Alto, CA, Final Report, December 1995.

6. **Licensees have misinterpreted and inappropriately extrapolated test results for the control cabinet heat release rate (HRR) in the Electric Power Research Institute (EPRI) Fire PRA Implementation Guide. The Guide uses cabinet HRRs as low as 65 Btu/sec. In contrast, experimental work has developed HRRs ranging from 23 to 1171 Btu/sec. Licensees should use a HRR in the mid-range of the currently available experimental data (e.g., 550 Btu/sec) for the analysis, considering the range of HRRs that could be applicable to different control cabinet fires, and to ensure that cabinet fire areas are not prematurely screened out of the analysis.**

   6.a. **Please discuss the HRRs used in the VCSNS IPEEE assessment of control cabinet fires.**

   6.b. **Discuss changes in the IPEEE fire assessment results, if you assumed that the HRR from a cabinet fire is increased to 550 Btu/sec.**

RESPONSE:

VCSNS is a participant in an industry effort to address the 15 Generic Fire-IPEEE Questions that NRC submitted to NEI by letter in December 1997. This is the same technical area contained in Generic Question 12. Several of the questions transmitted to VCSNS in this RAI address technical areas similar or identical to the Generic Questions being addressed industry-wide. Once the industry-wide effort is complete, VCSNS intends to utilize its findings to support a VCSNS-specific response to this RAI.

7. **The fire analysis in the VCSNS MCR appears to have included "double counting" in applying certain reduction factors. In particular, you applied a "fire severity factor" of 0.05 to account for the fraction of fire events that result in a fully developed fire. At the same time, you applied a non-suppression probability of 3.4E-3 to account for the suppression of a panel fire prior to MCR evacuation. These factors account for the same phenomena, namely, interruption of the fire prior to extended fire involvement. Hence, using one factor or the other might be considered appropriate with proper justification, but using both factors simultaneously in a fire risk analysis is generally inappropriate.**

   Further, the non-suppression probability of 3.4E-3 is based on the availability of optimally placed smoke detectors in each of the potential fire source panels. The IPEEE submittal described the smoke detectors present in the "main control board." However, there is no discussion of smoke detectors located in other panels. All MCR panels represent potential fire sources that might lead to MCR evacuation.

   7.a. Please select and justify applying the non-suppression probability based on the physical configurations of each panel considered as a potential MCR fire source, and

   7.b. Reassess the fire CDF estimates for the MCR assuming that either the non-suppression or severity factor applies, but not both.

RESPONSE:

7.a. VCSNS is a participant in an industry effort to address the 15 Generic Fire-IPEEE Questions that NRC submitted to NEI by letter in December, 1997. Applying the non-suppression probability for cabinets without smoke detectors is the same technical area contained in Generic Question 4. Several of the questions transmitted to VCSNS in this RAI address technical areas similar or identical to the Generic Questions being addressed industry-wide. Once the industry-wide effort is complete, VCSNS intends to utilize its findings to support a VCSNS-specific response to this RAI.

At VCSNS, smoke detectors are provided in the control room, inside the main control board and HVAC control board for the control room area (control room, associated rooms, and technical support center, elevation 463' - 0").

7.b. Severity factors appear to have been credited in error in some MCR event tree sequences. The 1998 VCSNS Fire Induced Vulnerability Evaluation Addendum will include a complete reevaluation of the control room CDF contributions. We acknowledge that Generic Questions are being raised by the NRC related to this methodology. Our final response to this RAI will reflect the conclusion of the on-going industry effort towards the resolution of the fire IPEEE Questions. The reevaluation includes a complete revision of the control room event trees, crediting either severity factors or non-suppression, but not both.

8. Page 51 of the IPEEE submittal indicates that you developed severity factors for various fire sources and scenarios in the Post-FIVE analysis. However, it appears from the discussions on page 67 that you applied both severity factors and automatic/manual non-suppression factors to at least some fire scenarios. As discussed in RAI number 7, applying both a severity factor as developed in the submittal and independent credit for other suppression efforts represents "double counting." It is also unclear for individual fire areas/compartments how the IPEEE has applied these factors in going from the FIVE results of Table 3 to the Post-FIVE results in Table 11.

For each area/compartment considered in Table 11 of the IPEEE submittal, please provide a detailed breakdown of the contributing factors that comprise the estimated CDF. Identify the following:

- **original fire frequency from the FIVE analysis**
- **modified Post-Five fire frequency (Post-FIVE Step 1 results)**
- **applied severity factor(s) (the Post-FIVE Step 2 results)**
- **credit taken for detection and suppression**
- **conditional core damage probability**

For those areas/compartments where the total fire-induced CDF is the sum of more than one individual scenario, provide the information for each contributing scenario.

RESPONSE:

As requested, the following provides the detail for the results of the analysis submitted in the June 1995 VCSNS Fire Induced Vulnerability Evaluation. It is important to point out that these results are being revised in the 1998 Fire Induced Vulnerability Evaluation Addendum.

Table RAI 8-1 presents a detailed breakdown of the scenarios analyzed using FIVE (and not subsequently reanalyzed in the Post-Five analysis). The core damage frequency (CDF) for scenarios analyzed using FIVE was quantified using Equation 1.

$$F3 = F1 \times P2 \times [\, P_f + P_{fst} \times p \times u \times y/2 \times \ln(1/y) \,] \qquad (1)$$

where: F1 is the compartment fire frequency from the FIVE analysis

P2	is the conditional core damage probability
Pf	is the probability of suppression unavailability when exposed to a fixed combustible fire source
Pfst	is the probability of suppression unavailability when exposed to a transient combustible fire source
p	is the probability of transient combustibles being exposed
u	is the probability that transient combustibles are located in the range of the target components (i.e., an area ratio).
$y/2 \times \ln(1/y)$	represents the frequency of having the critical combustible loading present in the compartment in violation of plant policy (not credited in this analysis, i.e.,= 1.0)

A detailed breakdown of the zones subjected to Post-FIVE analysis is provided in Table RAI 8-2. The CDF for Post-FIVE scenarios was quantified using Equation 2.

$$CDF = \sum_i (F1_i \times P2_i \times Pas_i \times Pms_i \times p_i \times u_i \times SF_i) \qquad (2)$$

where:

F1	is the modified post-FIVE fire frequency
P2	is the conditional core damage probability
Pas	is the probability of automatic suppression unavailability (not credited in this analysis, i.e., =1.0)
Pms	is the probability of manual suppression unavailability (credited for transient ignition sources only)
p	is the probability of transient combustibles being exposed
u	is the probability that transient combustibles are located in the range of the target components (i.e., an area ratio).
SF	is a severity factor (credited for fixed ignition sources only)

The VCSNS submittal evaluated 3 zones to credit the ability to recover offsite power when available. A detailed breakdown of the scenarios analyzed crediting recovery of offsite power is provided in Table RAI 8-3. The CDF for these scenarios was quantified using Equation 3a (diesel generator rooms), 3b (control room fires in critical cabinets) and/or 3c (control room fires outside critical cabinets).

$$CDF = \sum_i (F1_i \times SF_i \times EDG_i \times OSPREC_i \times P2CON_i \times Pccl_i) \quad (3a)$$

$$CDF = \sum_i (F1_i \times SF_i \times SUP_i \times EDG_i \times OSPREC_i \times P2CON_i) \quad (3b)$$

$$CDF = \sum_i (F1_i \times SUP_i \times EDG_i \times OSPREC_i \times P2CON_i) \quad (3c)$$

where:	F1	is the modified post-FIVE fire frequency
	SF	is a severity factor
	SUP	is the probability that suppression will preclude Control Room evacuation
	EDG	is the unavailability of the redundant diesel generator train
	OSPREC	is the probability that operators will fail to restore off-site power to the redundant train bus in the event the redundant diesel generator fails
	P2CON	is the unavailability of the redundant train equipment given that its associated emergency bus is energized
	Pccl	is the probability of manual suppression unavailability

Tables RAI 8-1, RAI 8-2 and RAI 8-3 provide detailed breakdowns for all compartments considered in Table 11 of the 1995 submittal, except TB-1. TB-1 was subjected to a qualitative evaluation, discussed in Section 3.6 of the June 1995 VCSNS Fire Induced Vulnerability Evaluation submittal report.

A few minor differences will be noted between the results provided here and the results reported in Table 11 of the June 1995 submittal report. These differences are the result of minor computational errors in the original analysis that were found and corrected during preparation of this response. None of the errors were significant to the results or conclusions of the analysis.

Both severity factors and automatic/manual non-suppression factors were applied to only three compartments: DG-1.2 (Train A Diesel Generator Room), DG-2.2 (Train B Diesel Generator Room) and CB-17.1 (Control Room). These three rooms are currently undergoing reanalysis.

Table RAI 8-1
Detailed Breakdown of Table 11 Scenarios Analyzed Using FIVE

Fire Compartment	F1	P2	Pf	Pfst	p	u	F3
AB-1.2	2.90E-04	1.82E-01	0	1	0.05	2.36E-01	6.23E-07
AB-1.3	2.90E-04	1.49E-01	0	1	0.05	7.42E-02	1.60E-07
CB-15	2.12E-03	1.82E-01	0	1	0.05	5.63E-02	1.08E-06
CB-18	2.90E-04	1.82E-01	0	1	0.05	2.40E-01	6.32E-07
FH-1.4	2.90E-04	1.49E-01	0	1	0.05	8.61E-03	1.86E-08
IB-12	2.90E-04	1.49E-01	0	1	0.05	2.21E-01	4.76E-07
IB-21.2	2.90E-04	1.82E-01	0	1	0.05	2.33E-01	6.15E-07
IB-24	2.90E-04	1.82E-01	0	1	0.05	1.80E-01	4.74E-07

Table RAI 8-2
Detailed Breakdown of Table 11 Scenarios Using Post-FIVE Analysis

Fire Compart-ment	Unscreened Ignition Source	F1	P2	Pas	Pms	p	u	SF	Scenario CDF	Total Compartment CDF
AB-1.10	Transients (welding)	2.562E-04	1.82E-01	1	0.15	1	6.42E-03	na	4.488E-08	7.751E-08
	Transients (other)	4.298E-05	1.82E-01	1	0.65	1	6.42E-03	na	3.263E-08	
AB-1.5	Transients (welding)	2.480E-04	1.49E-01	1	0.15	1	5.64E-02	1	3.126E-07	5.346E-06
	Transients (other)	4.160E-05	1.49E-01	1	0.65	1	5.64E-02	1	2.272E-07	
	Pumps - oil	3.226E-05	1.49E-01	1	1	na	na	1	4.806E-06	
AB-1.7	Transients (welding)	2.480E-04	1.82E-01	1	0.15	1	5.00E-02	1	3.385E-07	6.455E-06
	Transients (other)	4.160E-05	1.82E-01	1	0.65	1	5.00E-02	1	2.461E-07	
	Pumps - oil	3.226E-05	1.82E-01	1	1	na	na	1	5.871E-06	
AB-1.29	Xfmr	7.745E-05	1.49E-01	1	1	na	na	0.5	5.770E-06	7.662E-06
	Transients (welding)	2.480E-04	1.49E-01	1	0.15	1	1.98E-01	1	1.095E-06	
	Transients (other)	4.160E-05	1.49E-01	1	0.65	1	1.98E-01	1	7.962E-07	
CB-1	Elec. Cab (panels)	3.158E-04	1.49E-01	1	1	na	na	0.05	2.352E-06	9.528E-06
	Transients (welding)	2.480E-04	1.49E-01	1	0.15	1	3.50E-01	1	1.940E-06	
	Transients (other)	4.160E-05	1.49E-01	1	0.65	1	3.50E-01	1	1.410E-06	
	Ven. Subsys.	2.568E-04	1.49E-01	1	1	na	na	0.1	3.826E-06	
CB-6	Xfmr	3.098E-04	1.82E-01	1	1	na	na	0.5	2.820E-05	3.404E-05
	Transients (welding)	2.480E-04	1.82E-01	1	0.15	1	5.00E-01	1	3.384E-06	
	Transients (other)	4.160E-05	1.82E-01	1	0.65	1	5.00E-01	1	2.460E-06	

Table RAI 8-2
Detailed Breakdown of Table 11 Scenarios Using Post-FIVE Analysis

Fire Compart-ment	Unscreened Ignition Source	F1	P2	Pas	Pms	p	u	SF	Scenario CDF	Total Compartment CDF
IB-14	Elec. Cab (panels)	1.263E-05	1.82E-01	1	1	na	na	0.05	1.150E-07	6.399E-07
	Transients (welding)	2.480E-04	1.82E-01	1	0.15	1	4.49E-02	1	3.040E-07	
	Transients (other)	4.160E-05	1.82E-01	1	0.65	1	4.49E-02	1	2.210E-07	
IB-20	Xfmr	1.549E-04	1.82E-01	1	1	na	na	0.5	1.410E-05	1.809E-05
	Transients (welding)	2.480E-04	1.82E-01	1	0.15	1	3.42E-01	1	2.315E-06	
	Transients (other)	4.160E-05	1.82E-01	1	0.65	1	3.42E-01	1	1.683E-06	
IB-21.1	Xfmr	7.745E-05	1.82E-01	1	1	na	na	0.5	7.048E-06	9.097E-06
	Transients (welding)	2.480E-04	1.82E-01	1	0.15	1	1.75E-01	1	1.186E-06	
	Transients (other)	4.160E-05	1.82E-01	1	0.65	1	1.75E-01	1	8.624E-07	
IB-22.1	Transients (welding)	2.480E-04	1.49E-01	1	0.15	1	6.67E-02	1	3.695E-07	1.910E-06
	Transients (other)	4.160E-05	1.49E-01	1	0.65	1	6.67E-02	1	2.686E-07	
	Ven. Subsys.	8.533E-05	1.49E-01	1	1	na	na	0.1	1.271E-06	
IB-22.2	Xfmr	1.937E-04	1.49E-01	1	1	na	na	0.5	1.443E-05	1.823E-05
	Transients (welding)	2.480E-04	1.49E-01	1	0.15	1	3.97E-01	1	2.202E-06	
	Transients (other)	4.160E-05	1.49E-01	1	0.65	1	3.97E-01	1	1.601E-06	
IB-23	Transients (welding)	2.480E-04	1.82E-01	1	0.15	1	5.50E-02	1	3.724E-07	6.514E-06
	Transients (other)	4.160E-05	1.82E-01	1	0.65	1	5.50E-02	1	2.707E-07	
	Pumps - oil	3.226E-05	1.82E-01	1	1	na	na	1	5.871E-06	

Table RAI 8-2
Detailed Breakdown of Table 11 Scenarios Using Post-FIVE Analysis

Fire Compartment	Unscreened Ignition Source	F1	P2	Pas	Pms	p	u	SF	Scenario CDF	Total Compartment CDF
IB-25.1.1	Transients (welding)	2.480E-04	1.82E-01	1	1	0.1	1.97E-02	1	8.889E-08	1.038E-07
	Transients (other)	4.160E-05	1.82E-01	1	1	0.1	1.97E-02	1	1.491E-08	
IB-25.1.2	Pumps - oil	2.581E-04	1.49E-01	1	1	na	na	1	3.846E-05	3.846E-05
IB-25.1.3	Pumps - oil	1.935E-04	1.82E-01	1	1	na	na	1	3.522E-05	3.522E-05
IB-25.1.4	Transients (welding)	2.480E-04	1.82E-01	1	1	0.1	1.09E-04	1	4.936E-10	5.764E-10
	Transients (other)	4.160E-05	1.82E-01	1	1	0.1	1.09E-04	1	8.280E-11	
IB-25.1.5	Transients (welding)	2.480E-04	1.82E-01	1	1	0.1	1.84E-02	1	8.320E-08	9.716E-08
	Transients (other)	4.160E-05	1.82E-01	1	1	0.1	1.84E-02	1	1.396E-08	
IB-25.2	Transients (welding)	4.960E-04	1.82E-01	1	0.15	1	9.09E-02	1	1.231E-06	3.440E-05
	Transients (other)	5.200E-05	1.82E-01	1	0.65	1	9.09E-02	1	5.592E-07	
	Pumps - motor	1.469E-04	1.82E-01	1	1	na	na	1	2.674E-05	
	Pumps - oil	3.226E-05	1.82E-01	1	1	na	na	1	5.871E-06	
IB-3	Elec. Cab	6.316E-05	1.82E-01	1	1	na	na	0.05	5.748E-07	4.942E-05
	Batt. Charger	5.000E-04	1.82E-01	1	1	na	na	0.5	4.550E-05	
	Transients (welding)	2.480E-04	1.82E-01	1	0.15	1	2.86E-01	1	1.934E-06	
	Transients (other)	4.160E-05	1.82E-01	1	0.65	1	2.86E-01	1	1.406E-06	

Table RAI 8-2
Detailed Breakdown of Table 11 Scenarios Using Post-FIVE Analysis

Fire Compart-ment	Unscreened Ignition Source	F1	P2	Pas	Pms	p	u	SF	Scenario CDF	Total Compartment CDF
IB-9	Transients (welding)	2.480E-04	1.49E-01	1	0.15	1	1.28E-01	1	7.122E-07	2.793E-05
	Transients (other)	4.160E-05	1.49E-01	1	0.65	1	1.28E-01	1	5.177E-07	
	Pumps - motor	1.469E-04	1.49E-01	1	1	na	na	1	2.189E-05	
	Pumps - oil	3.226E-05	1.49E-01	1	1	na	na	1	4.806E-06	
SWPH-1	Elec. Cab (panels)	2.667E-05	1.82E-01	1	1	na	na	0.05	2.427E-07	8.154E-06
	Xfmr	7.745E-05	1.82E-01	1	1	na	na	0.5	7.048E-06	
	Transients (welding)	2.480E-04	1.82E-01	1	0.15	1	7.22E-03	1	4.888E-08	
	Transients (other)	4.160E-05	1.82E-01	1	0.65	1	7.22E-03	1	3.553E-08	
	Ven. Subsys.	4.279E-05	1.82E-01	1	1	na	na	0.1	7.788E-07	
SWPH-2	Elec. Cab (panels)	5.538E-05	1.49E-01	1	1	na	na	0.05	4.126E-07	4.126E-07
SWPH-3	Elec. Cab (panels)	2.571E-05	1.49E-01	1	1	na	na	0.05	1.916E-07	5.963E-06
	Xfmr	7.747E-05	1.49E-01	1	1	na	na	0.5	5.771E-06	
SWPH-5.1/5.2	Pumps - oil	2.469E-05	1.82E-01	1	1	na	na	1	4.493E-06	5.012E-06
	Ven. Subsys.	2.853E-05	1.82E-01	1	1	na	na	0.1	5.192E-07	

Table RAI 8-3
Detailed Breakdown of Scenarios Analyzed Crediting Off-Site Power

Fire Compartment	Scenario	F1	SF	SUP	EDG	OSPREC	P2CON	Pccl	CDF	Total
DG-1.1/1.2	EDG A-1	2.60E-02	0.1	na	9.14E-01	1.00E+00	0.1	0.15	3.56E-05	3.93E-05
	EDG A-2	2.60E-02	0.1	na	8.61E-02	9.91E-01	0.1	0.15	3.33E-06	
	EDG A-3	2.60E-02	0.1	na	8.61E-02	9.04E-03	1	0.15	3.04E-07	
DG-2.1/2.2	EDG B-1	2.60E-02	0.1	na	9.14E-01	1.00E+00	0.0689	0.15	2.46E-05	2.72E-05
	EDG B-2	2.60E-02	0.1	na	8.61E-02	9.91E-01	0.0689	0.15	2.29E-06	
	EDG B-3	2.60E-02	0.1	na	8.61E-02	9.04E-03	1	0.15	3.04E-07	
CB-17.1	INCR-1	2.65E-03	0.05	9.97E-01	9.91E-01	1	2.42E-02	na	3.17E-06	5.38E-06
	INCR-2	2.65E-03	0.05	9.97E-01	9.10E-03	9.91E-01	2.42E-02	na	2.88E-08	
	INCR-3	2.65E-03	0.05	9.97E-01	9.10E-03	9.04E-03	1	na	1.09E-08	
	INCR-4	2.65E-03	0.05	3.40E-03	8.61E-02	0.87	0.1	na	3.37E-09	
	INCR-5	2.65E-03	0.05	3.40E-03	8.61E-02	0.13	1	na	5.04E-09	
	EXCR-1	6.21E-03	na	3.40E-03	9.14E-01	1	0.1	na	1.93E-06	
	EXCR-2	6.21E-03	na	3.40E-03	8.61E-02	1.30E-01	1	na	2.36E-07	

9. The automatic suppression system failure analysis used reliability values from the FIVE methodology. This data is 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 VCSNS meet applicable NFPA standards.

RESPONSE:

The Fire Protection System at VCSNS has been designed to satisfy the guidelines in the National Fire Protection Association (NFPA) Standards 1973, the requirements of the American Nuclear Insurers (ANI) 1976, and the Factory Mutual (FM) Loss Prevention Guidelines 1973. In addition, the system complies with Occupational Safety and Health Act (OSHA) regulations 1972 and the Southern Standard Building Code 1973. Fire Protection devices, where possible, are listed or approved by the Underwriters Laboratories (UL) or FM. Design and installation of the systems was performed by engineers and vendors cognizant of NFPA Code requirements.

Beginning in June 1990, a NFPA Code Compliance assessment [Ref. [2]] was conducted through Licensing commitments/documents, detail design documentation reviews and field inspections of selected installed fire protection systems. As documented in the referenced report, the automatic fire suppression systems at VCSNS do meet applicable NFPA standards.

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2 VCSNS Fire Protection System NFPA Code Review (1/23/91, Rev. 0).

10. The heat loss factor (HLF) is defined as the fraction of energy released by a fire that is transferred to the enclosure boundaries. This is a key parameter for predicting component damage, as it determines the amount of heat available to the hot gas layer (HGL). A larger HLF 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. If the value assumed for the HLF is unrealistically high, fire scenarios can be improperly screened out. Figure 1 provides a representative example of how HGL temperature predictions can change assuming different HLFs. Please note that: (1) the curves are computed for a 1000 kW fire in a 10 meter x 5 meter x 4 meter compartment with a forced ventilation rate of 1130 cubic feet per meter; (2) the FIVE-recommended damage temperature for qualified cable is 700°F for qualified cable and 450°F for unqualified cable; and, (3) the Society for Fire Protection Engineers (SFPE) curve in the figure is generated from a correlation provided in the SFPE Handbook (Ref. [3]).

Based on evidence provided by an old American Society of Mechanical Engineers (ASME) research paper by Cooper et al. (Ref. 4), the EPRI Fire PRA Implementation Guide recommends a HLF 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 research results. Cooper's paper (Ref. [4]) which documents the research results of multi-compartment fire experiments, indicates that the higher HLFs are associated with the movement of the HGL from the burning compartment to adjacent, cooler compartments. Earlier in the experiments, where the HGL is limited to the burning compartment, Cooper reports much lower HLFs (on the order of 0.51 to 0.74). These lower HLFs are more HGL predictions are very sensitive to the assumed value of the HLF; and (b) large HLFs cannot be justified for single-room scenarios based on the information referenced in the EPRI Fire PRA Implementation Guide. In the VCSNS submittal, you assumed the HLF to be 0.7 for 94% of the compartments. However, the submittal states that, for 6% of the compartments, the HLF was relaxed to 0.85.

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[3] P. J. DiNenno, et al, eds., "SFPE Handbook of Fire Protection Engineering," 2nd Edition, National Fire Protection Association, P. 3-140, 1995.

[4] L. Y. Cooper, et al, "An Experimental Study of Upper Hot Layer Stratification in Full-Scale Multi Room Fire Scenarios," ASME Journal of Heat Transfer, 104, 741-749, November 1982.

10.a. Please identify those areas where you used a HLF of 0.85 in the IPEEE analysis.

10.b. For each of these fire areas, either:

(1) justify the value used and discuss its effect on identifying fire vulnerabilities, or

(2) repeat the fire risk analysis using a more justifiable value and provide the resulting change in scenario contribution to CDF.

RESPONSE:

10.a. The areas using a HLF of 0.85 are listed in the following Table RAI 10-1:

Table RAI 10-1
Fire Zones Where Heat Loss Factor of 0.85 Was Used

Fire Area	Fire Compartment	Description
AB-1	AB-1.10	Auxiliary Building
AB-1	AB-1.2	Auxiliary Building
AB-1	AB-1.7	Auxiliary Building
AB-1	AB-1.13	Auxiliary Building
AB-1.29	AB-1.29	Auxiliary Building
CB-1	CB-1	Control Building
CB-6	CB-6	Control Building
CB-16	CB-8/CB-16/CB-19	Control Building
DG-1	DG-1.1/1.2	Diesel Generator Building
DG-2	DG-2.1/2.2	Diesel Generator Building
IB-14	IB-14	Intermediate Building
IB-19	IB-19	Intermediate Building
IB-20	IB-20	Intermediate Building
IB-21	IB-21.1	Intermediate Building
IB-22	IB-22.1	Intermediate Building
IB-22	IB-22.2	Intermediate Building
IB-23	IB-23	Intermediate Building
IB-25	IB-25.1.2	Intermediate Building
IB-25	IB-25.1.3	Intermediate Building
IB-25	IB-25.2	Intermediate Building
IB-3	IB-3	Intermediate Building
IB-8	IB-8	Intermediate Building
IB-9	IB-9	Intermediate Building
SWPH-1	SWPH-1	Service Water Pump House
SWPH-2	SWPH-2	Service Water Pump House
SWPH-3	SWPH-3	Service Water Pump House
SWPH-5	SWPH-5.1/5.2	Service Water Pump House
TB-1	TB-1	Turbine Building

10.b. VCSNS is a participant in an industry effort to address the 15 Generic Fire-IPEEE Questions that NRC submitted to NEI by letter in December 1997. This is the same technical area contained in Generic Question 2. Several of the questions transmitted to VCSNS in this RAI address technical areas similar or identical to the Generic Questions being addressed industry-wide. Once the industry-wide effort is complete, VCSNS intends to utilize its findings to support a VCSNS-specific response to this RAI.

11. The IPEEE submittal discussed the existence of unprotected cable trays and conduits. However, the submittal did not discuss applicable protection requirements and the electrical raceway fire barrier rating used in protecting cable trays and conduits.

11.a. Please identify the types of electrical raceway fire barriers used at VCSNS.

11.b. Identify all fire scenarios in which you take credit for electrical raceway fire barriers, and

11.c. Assess the impact on estimated fire CDF if you do not take credit for these electrical raceway fire barriers.

<u>RESPONSE:</u>

11.a. Per VCSNS Fire Protection Evaluation Report (FPER) (Section 2.2.2.8), there is one type of cable tray wrap in use at VCSNS. Kaowool wrap was used to meet the BTP APCSB 9.5-1, Appendix A requirements. The Kaowool wrap system, as installed on cable trays, conduit, and equipment, provides a 90-minute fire rated barrier as demonstrated by fire tests in accordance with ASTM E-119. Most of the Kaowool is coated with either Flamastic 77 or with a Zetex 800 aluminized cloth to preclude mechanical damage to the wrap system.

VCSNS also protects other electrical raceways by using armor flex cable, installing 1-hour gypsum enclosures (drywall) and 'M'-Board, and placing cable inside rigid conduit as an additional protection method.

11.b. The Electrical Cable Separation Fire Barrier Identification Report (S-200-951, Rev. 41 dated 3/19/98), Section 7, Table 7-4 is a listing of all the fire protected raceways sorted by fire area/zone. These raceways are protected for compliance with 10CFR50 Appendix R as well as other regulatory requirements.

All fire scenarios (Appendix R and other regulatory requirements) for which we credit electrical raceway fire barriers involve the fire areas/zones listed in Table 7-4 and reproduced as the following Table RAI 11-1.

11.c. If no credit is taken for any of the electrical raceway fire barriers listed above, the fire CDF would be increased. If none of these barriers were present, the plant would be in violation of its license, and would also violate acceptable fire protection practices.

Table RAI 11-1

AB-1.4	IB-5	IB-22	RB-1.1
AB-1.9	IB-7.1	IB-22.1	RB-1.1.1
AB-1.10	IB-7.2	IB-23.2	RB-1.2.1
AB-1.18.1	IB-10	IB-24	RB-1.3
AB-1.21.1	IB-11	IB-25.1	RB-1.3.2
	IB-14	IB-25.1.1	
CB-1	IB-15	IB-25.1.2	SWPH-1
CB-1.1	IB-16	IB-25.1.3	SWPH-2
CB-2	IB-17	IB-25.3.2	SWPH-5.1.1
CB-4	IB-18	IB-25.4	SWPH-5.2
CB-5	IB-19	IB-25.6	
CB-10	IB-20	IB-25.6.2	
CB-12	IB-21.1	IB-25.8	
CB-15	IB-21.2	IB-25.9	
CB-18			

12. **Both fire-induced damage and automatic suppression system activation times for some of the critical fire scenarios in the VCSNS IPEEE submittal are so short as to be physically unrealistic. While it can be reasonably assumed that predicted short times to fire damage are conservative, the combined effect of short times for both critical damage and automatic suppression system activation might be overly optimistic. Section 2.5 of the IPEEE indicates that you assumed discharge delay times ranging from 10 to 30 seconds; this may be optimistic. For example, you assumed that pre-action sprinklers have a 10-second delay time. However, systems compliant with NFPA-13 typically have discharge delays in the range of 1 to 3 minutes following detection system activation.**

    Please provide an assessment of the impact on the VCSNS fire CDF using more realistic automatic suppression actuation delay times. One option to achieve this would be to base the assumed timing value on the documented results of actual discharge time observed during the functional acceptance testing. A second acceptable approach would be to uniformly increase the actuation times to 3 minutes.

RESPONSE:

The analysis documented in the 1995 VCSNS Fire Induced Vulnerability Evaluation submittal to the NRC credited automatic suppression for preventing cable/equipment damage in seven fire compartments [AB-1.21.1; CB-7; (CB-8/CB-16/CB-19); CB-9; CB-14; CB-21; and IB-7].

VCSNS performed an assessment to determine the impact of a 3-minute (180 seconds) actuation time on the analysis results. Reevaluating the potential for cable damage in the seven compartments assuming sprinkler actuation at three minutes after the fire starts yielded the following results:

- Two of the seven compartments [CB-7; and (CB-8/CB-16/CB-19)] are unaffected by longer delay times. The times to damage for these two are very long, and suppression still occurs before damage, after increasing the delay time to 180 seconds.
- For the remaining five compartments, the longer delay time means suppression can no longer be credited.
- For four of the five [AB-1.21.1; CB-9; CB-14; and CB-21], the CDFs were very low in the original study, and remain screened after removing credit for automatic suppression.
- One compartment (IB-7) changed from screened to unscreened after removing credit for automatic suppression, however at a very low value (<1.5 E-06).

13. The EPRI Fire PRA Implementation Guide assumes that all enclosed ignition sources cannot lead to fire propagation or other damage. 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. Based on the discussion presented on pages 61 and 62 of the submittal, you applied these assumptions in the VCSNS IPEEE. This resulted in a number of fire sources being screened from the analysis. These assumptions may be optimistic for certain types of electrical fires including oil-filled transformers, high-voltage cabinets, motor control centers, and switchgear. This is because an explosive breakdown of the electrical conductors may breach the integrity of the item/cabinet and allow fire to spread to combustibles located above the item/cabinet. For example, switchgear fires at Yankee-Rowe in 1984 and Oconee Unit 1 in 1989 both resulted in fire damage outside the cubicles.

Please provide the basis for assuming that all enclosed ignition sources cannot lead to fire propagation or other damage at VCSNS. Also discuss how you analyzed each of the specific enclosures to conclude that the assumption applies to them.

RESPONSE:

VCSNS is a participant in an industry effort to address the 15 Generic Fire-IPEEE Questions that NRC submitted to NEI by letter in December, 1997. This is the same technical area contained in Generic Question 11. Several of the questions transmitted to VCSNS in this RAI address technical areas similar or identical to the Generic Questions being addressed industry-wide. Once the industry-wide effort is complete, VCSNS intends to utilize its findings to support a VCSNS-specific response to this RAI.

14. The description of the fire compartment interaction analysis (FCIA) on page 13 of your submittal indicates that you supplemented the FIVE barrier screening criteria with four additional screening criteria. These criteria are not consistent with the NRC-accepted FIVE methodology guidance.

Identify each of the areas (if any) in Tables 2 and 3 of your IPEEE submittal where you used the additional criteria as the basis for dismissing the potential for fire spread between compartments in the FCIA. For each such set of areas, please provide a detailed assessment including the CDF contributions if these criteria are not applied and the impacted areas are combined for analysis.

RESPONSE:

Table RAI 14-1 provides a list of compartment pairs that were screened based on the four additional screening criteria to FIVE. We still believe that the four additional screening criteria used in the 1995 VCSNS Fire Induced Vulnerability Evaluation submittal are technically justified. Nevertheless, to remain consistent with the FIVE methodology, an assessment of fire spread potential for this set of compartments will be done as part of the 1998 VCSNS Fire Induced Vulnerability Evaluation Addendum.

Table RAI 14-1

Compartment Pairs Screened Using Four Additional FCIA Criteria

Fire Area	Exposing Compartment	Exposed Compartment
AB-1	AB-1.4	AB-1.1
AB-1	AB-1.4	AB-1.5
AB-1	AB-1.4	AB-1.6
AB-1	AB-1.4	AB-1.7
AB-1	AB-1.4	AB-1.8
AB-1	AB-1.4	AB-1.10
AB-1	AB-1.4	AB-1.11
AB-1	AB-1.4	AB-1.12
AB-1	AB-1.4	AB-1.18
AB-1	AB-1.4	AB-1.21
AB-1	AB-1.4	AB-1.30
AB-1	AB-1.11	AB-1.18
AB-1	AB-1.12	AB-1.18
AB-1	AB-1.18.1	AB-1.10
AB-1	AB-1.18.1	AB-1.13
AB-1	AB-1.18.1	AB-1.14
AB-1	AB-1.18.1 (20')	AB-1.18.2 (20')
AB-1	AB-1.18.1	AB-1.20
AB-1	AB-1.18.1	AB-1.21
AB-1	AB-1.18.1	AB-1.22
AB-1	AB-1.18.1	AB-1.23
AB-1	AB-1.18.1	AB-1.24
AB-1	AB-1.18.1	AB-1.26
AB-1	AB-1.18.1	AB-1.27
AB-1	AB-1.18.1	AB-1.30
AB-1	AB-1.18.2	AB-1.10
AB-1	AB-1.18.2	AB-1.11
AB-1	AB-1.18.2	AB-1.12
AB-1	AB-1.18.2	AB-1.15
AB-1	AB-1.18.2	AB-1.16
AB-1	AB-1.18.2 (28')	AB-1.18.1 (28')
AB-1	AB-1.18.2	AB-1.21
AB-1	AB-1.18.2	AB-1.22
AB-1	AB-1.18.2	AB-1.28

Fire Area	Exposing Compartment	Exposed Compartment
AB-1	AB-1.18.2	AB-1.30
AB-1	AB-1.21.1 (25')	AB-1.21.2 (25')
AB-1	AB-1.21.2	AB-1.18
AB-1	AB-1.21.2 (20')	AB-1.21.1 (20')
AB-1	AB-1.21.2	AB-1.22
AB-1	AB-1.21.2	AB-1.23
AB-1	AB-1.21.2	AB-1.24
AB-1	AB-1.21.2	AB-1.25
AB-1	AB-1.21.2	AB-1.26
AB-1	AB-1.21.2	AB-1.28
AB-1	AB-1.21.2	AB-1.30
AB-1	AB-1.21.2	AB-1.31
AB-1	AB-1.22	AB-1.21
AB-1	AB-1.23	AB-1.21
AB-1	AB-1.24	AB-1.21
AB-1	AB-1.25	AB-1.21
AB-1	AB-1.26	AB-1.21
AB-1	AB-1.27	AB-1.21
AB-1	AB-1.30	AB-1.21
AB-1	AB-1.31	AB-1.21
CB-19 *	CB-19 (low loading) *	CB-8.1 (low loading)
* Per Change A to FEP-1.0 (4/23/98) CB-19 zone is now CB-8.5.		
FH-1	FH-1.1 (low loading)	FH-1.3 (low loading)
IB-25	IB-25.1.2	IB-25.6
IB-25	IB-25.1.2	IB-25.7
IB-25	IB-25.4 (no openings)	IB-25.8 (no openings)
IB-25	IB-25.6	IB-25.1
IB-25	IB-25.6	IB-25.5.1
IB-25	IB-25.6	IB-25.5.2
IB-25	IB-25.6	IB-25-7
IB-25	IB-25.6	IB-25.8
MH-2	MH-2.1 (FPER)	MH-2.2 (FPER)
MH-2	MH-2.2 (FPER)	MH-2.1 (FPER)

15. It is important that the human error probabilities (HEPs) used in the analysis properly reflect the potential effects of fire (e.g., smoke, heat, loss of emergency lighting), even if these effects do not directly cause equipment damage in the scenarios being analyzed. The HEPs may be optimistic and result in the improper quantification or screening of scenarios if these effects are not treated. Page 28 of your IPEEE submittal indicates that you included HEPs in the system analysis, but implies that you took the values from the internal events analysis (IPE). HEPs which are conservative with respect to an internal events analysis could be optimistic with respect to a fire risk analysis.

Please clarify whether you took the HEPs directly from the VCSNS IPE analysis, or modified them to reflect the unique aspects of each fire scenario at VCSNS. If the HEPs did not include fire effects (e.g., smoke, heat, loss of lighting), please provide an assessment of the impact on estimated fire-induced CDF if fire effects are included in the formulation of HEPs for each fire scenario.

RESPONSE:

A full response to this question is being deferred until the 1998 VCSNS Fire Induced Vulnerability Evaluation Addendum is completed. The remainder of this response will discuss the HEP approach used in the 1995 VCSNS Fire Induced Vulnerability Evaluation submittal and the approach planned for the addendum.

In the 1995 VCSNS Fire Induced Vulnerability Evaluation, the HRA approach was to implicitly account for HEPs by use of a conservative train level unavailability analysis for initial screening. The pre-fire human errors that leave system components unavailable were explicitly accounted for as in the internal event IPE. This application of pre-fire event HEPs with no adjustment for fire induced stress is an appropriate modeling approach.

The post event operator actions involved in using the Appendix R defined train were not explicitly treated during the screening process, because the V C Summer approach was to identify vulnerabilities on the basis of a qualitative evaluation of a conservative fire zone assessment. There was no attempt to provide detailed HRA assessments in support of the conservative screening analyses; instead the train unavailability was conservatively established. Hence, the key fire zones were evaluated for vulnerabilities on a relative-qualitative basis recognizing that a fire may affect the ability of operators to carry out task(s) identified in the procedures.

HRA models for VC Summer are being developed to more accurately reflect the use of the FEPs during postulated fire events. The 1998 VCSNS Fire Induced Vulnerability Evaluation Addendum directly considers the effect of performance factors on the error potential for actions listed in the FEPs. Comparison of preliminary evaluations in the addendum with the train unavailabilities used in the 1995 VCSNS Fire Induced Vulnerability Evaluation indicates that the initial results were conservative. The main difference in the 1998 VCSNS Fire Induced Vulnerability Evaluation Addendum is a more explicit representation of the key contributors to the conditional probability of core damage as a function of the postulated fire in each zone. The main effect of the "fire related stress factors" is on FEP actions that would be required in the zone where the fire occurs. The FEPs identify contingency actions that can be carried out in other locations for many tasks when such actions cannot be performed in the original location because of dense smoke, or heat at that location.

3.a. VCSNS FIRE EMERGENCY PROCEDURES

FEP-1.0	Fire Emergency Procedure Selection
FEP-2.0	'A' Train Plant Shutdown to Hot Standby Due to Fire
FEP-2.1	'A' Train Shutdown from Hot Standby to Cold Shutdown Due to Fire
FEP-3.0	'B' Train Plant Shutdown to Hot Standby Due to Fire
FEP-3.1	'B' Train Shutdown from Hot Standby to Cold Shutdown Due to Fire
FEP-4.0	Control Room Evacuation Due to Fire
FEP-4.1	Plant Shutdown from Hot Standby to Cold Shutdown Due to Fire in Control Building

May 24, 1989

VIRGIL C. SUMMER NUCLEAR STATION

NUCLEAR OPERATIONS PROCEDURES

FIRE EMERGENCY PROCEDURES

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* Safety Related