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January 29, 2001

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit Nos. 1 & 2; Docket Nos. 50-317 & 50-318
Response to Request for Additional Information Concerning the Individual Plant Examination of External Events Submittal (TAC Nos. M83603 and M83604)

REFERENCE: (a) Letter from C. H. Cruse (BGE) to NRC Document Control Desk, dated August 31, 1998, same subject

Calvert Cliffs responded to questions concerning our submittal of the Calvert Cliffs Nuclear Power Plant Individual Plant Examination of External Events Summary Report. Our response to three of those questions was incomplete pending Electric Power Research Institute's (EPRIs) response to questions concerning their Fire Probabilistic Risk Assessment Implementation Guide, which was used for our analysis. We have completed a re-analysis based on the EPRI guidelines and our revised response to Questions 2, 3, and 6 from Reference (a) is attached. This information completes our responses to the Reference (a). No additional information requests are currently outstanding.

Should you have questions regarding this matter, we will be pleased to discuss them with you.

Very truly yours,

CHC/PSF/bjd

Attachment: (1) Responses to Generic Issues Referenced in the Request For Additional Information on IPEEE Submittal

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ATTACHMENT (1)

RESPONSES TO GENERIC ISSUES REFERENCED IN THE REQUEST FOR ADDITIONAL INFORMATION ON IPEEE SUBMITTAL

RESPONSES TO GENERIC ISSUES REFERENCED IN THE REQUEST FOR ADDITIONAL INFORMATION ON IPEEE SUBMITTAL

Calvert Cliffs Nuclear Power Plant, Inc. (CCNPP) deferred final resolution of three 1998 Request for Additional Information (RAI) items to the forthcoming Electric Power Research Institute (EPRI) response to generic issues identified in the "Review of the EPRI Implementation Guide" dated August 1997 by Energy Research, Inc. In March 2000, EPRI responded to the generic issues in the Final Report, "Guidance for Development of Response to Generic Request for Additional Information on Individual Plant Examination for External Events (IPEEE)," SU-105928.

This submittal provides full response to Fire RAI items 2, 3, and 6. Note that the 1998 submittal Fire answers 2 and 6 already provided substantive information whereas the item 3 response was entirely deferred pending the generic resolution.

RAI Question 2:

The analysis of the main Control Room (MCR) has assumed a conditional probability of MCR abandonment given a fire of 3.4E-3 based on a suppression model taken from the EPRI Fire Probabilistic Risk Assessment [PRA] Implementation Guide (FPRAIG). However, this abandonment model only applies to situations that include an optimally placed smoke detector within the initiating panel. The use of the 3.4E-3 conditional abandonment probability has not been adequately justified and should include specific consideration of the test conditions as compared to the configuration at Calvert Cliffs. Further, the analysis has independently applied two separate severity factors; namely, a 6/9 reduction for manually suppressed fires versus the total number of MCR fires, and a 1/3 reduction for severe versus minor fires. All three of these factors inherently consider the same phenomena; namely, the likelihood that a fire would be suppressed before Control Room abandonment would be required. Hence, independent application of all three factors appears to represent "double counting' for the likelihood of suppression.

Based on the above discussion, please reassess the conditional probability of Control Room abandonment, given a fire, that includes specific consideration of the fire detection features provided at Calvert Cliffs. Also, reassess the core damage frequency (CDF) contribution due to MCR fires assuming that only one factor is applied to a given sequence (i.e., either apply a single severity factor or a single non-suppression probability to the analysis but not both).

Additional CCNPP Response:

3.4 RAI Question 4 – Control Room Evacuation Scenarios makes three recommendations:

> If severity factors were multiplied by non-suppression probabilities for the MCR scenarios, one or the other needs to be removed (i.e., set to 1.0) and MCR scenarios re-evaluated.
>
> If the Control Room fire frequency was not apportioned to other areas, this only needs to be stated...
>
> Finally, an analysis of the remote shutdown capability is required if one was not performed...

Calvert Cliffs Fire Probabilistic Risk Assessment (CCFPRA) Control Room modeling does not explicitly apply severity factors in conjunction with non-suppression probabilities. As explained (previously), the evacuation likelihood is apportioned to any fire, severe or minor, that would require suppression. Fire severity determines the extent of functional damage, thus, severe fires result in multiple functional impacts. Note that a panel fire is assumed to fail all the functions associated with the panel. In instances where multiple panel groupings are damaged, due to either configuration or propagation, all the functions of all the effected panels are failed. Since we model only those fires resulting in multiple functional impacts (a single functional impact would be subsumed in the normal component failure) the evacuation split fraction value is adjusted to achieve the 3.4×10^{-3} abandonment value based on the aggregate severe fire frequency. This is a conservative treatment because a panel ignition that forces Control Room evacuation will have concomitant multiple equipment failures that would not exist in the non-severe ignition scenario. In addition, the EPRI technical basis for *Question 4* supports use of the 3.4×10^{-3} abandonment value.

Regarding the second recommendation, the CCFPRA Control Room fire frequency was not apportioned to any area other than the Control Room.

Finally, the CCFPRA incorporates post-abandonment operator actions including those at the Auxiliary Safe Shutdown Panel and other key locations. Other elements of this analysis, Auxiliary Safe Shutdown specific equipment and functions, were discussed in CCNPP Fire RAI Item 1.

In summary, we feel the CCFPRA is presently consistent with the Generic Response.

RAI Question 3:

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. In Fire-Induced Vulnerability Evaluation (FIVE), the heat loss factor is modeled as being inversely related to the amount of heat required to cause a given temperature rise. Thus, for example, 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 1 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 1 Om x 5m x 4m compartment with a forced ventilation rate of 1130 cfm; 2) the FIVE-recommended damage temperature for qualified cable is 700F for qualified cable and 450F 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 [3.1].

<Figure Not Shown>

Figure 1 Sensitivity of the hot gas layer temperature predictions to the assumed heat loss factor

Based on evidence provided by a 1982 paper by Cooper et al. [3-2], the EPRI Fire PRA Implementation 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 [3.2], which documents the results of multicompartment 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 [3.2] 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 EPRI Fire PRA Implementation Guide.

The Calvert Cliffs IPEEE fire study uses a heat loss factor of 0.85 based on information in the FPRAIG. Hot gas layer (HGL) effects were apparently considered in detailed compartment analyses. For each scenario where the hot gas layer temperature was calculated, please verify 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 and provide the resulting change in scenario contribution to core damage frequency.

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

3.2 L. Y. Cooper, M. Harkleroad, J. Quintiere, W. Rinkinen, 'An Experimental Study of Upper Hot Layer Stratification in Full-Scale Multiroom Fire Scenarios,' ASME Journal of Heat Transfer, 104, 741-749, November 1982.

Additional CCNPP Response:

In *3.2 RAI Question 2 – Heat Loss Factor* EPRI makes the following recommendation for the use of 0.70 Heat Loss Factor (HLF):

> Generally results in conservative HGL temperatures throughout the fire event and under any conditions. May yield overly conservative temperatures especially for extended duration events (i.e., longer than brigade response time).
>
> > Appropriate for approximating HGL temperatures during the early portion of fast growing floor-based fires (i.e. oil spills prior to brigade response).

And regarding use of 0.85 HLF states:

> Generally results in conservative HGL temperatures when the HGL volume is calculated assuming that the virtual fire surface is at least 0.40H (where H is the ceiling height). May be unconservative for events involving rapidly developing floor-based fires.
>
> > Appropriate for fire initiated by electrical cabinets including those involving cable trays (virtual surface at cabinet top).
> >
> > Appropriate for overhead cable tray fires where the HGL is based on the volume above the burning tray (HGL volume = 0.60 * room volume or less).

(Guidance concerning use of 0.94 HLF is omitted. The only HLF value used in the original CCFPRA was 0.85.)

We examined workbooks for all fire modeled areas and changed the HLF value from 0.85 to 0.70 for each plume worksheet with exception of the Intake Structure. Since most plume worksheets are used to calculate a damage screening distance, the Height of Target above Fire Source is set to the least value that ensures: 1) the Estimated Critical Q_{tot} is less than the Actual Critical Q_{tot}, and 2) Critical Temperature Rise minus Plume Temperature Rise is a positive value. Components and targets in each area were then re-analyzed for damage using the new screening values.

In most cases, the new 0.70 HLF screening value caused no change in impact. Several reasons for this are explained below.

⇒ The maintenance refuse fire is an ignition source common to all areas. We model this as a 100 BTU per second fire with a virtual surface three feet above the floor. Listed below are some representative areas and their screening values (in decimal feet) using each HLF.

Fire Location →	Center		Wall		Corner	
Room Area ↓ HLF →	0.85	0.70	0.85	0.70	0.85	0.70
A318 or A312 (purge fan room)	5.0	5.9	6.6	7.7	8.6	10.2
A317 (switchgear room)	4.6	4.7	6.1	6.2	8.0	8.1
A419 (truck bay)	4.5	4.6	5.9	6.0	7.8	7.9
A306 (cable spreading room)	4.5	4.6	5.9	6.0	7.8	7.9
A227 (piping penetration room)			6.0	6.3		
A225 (fan room)	4.5	4.7	6.0	6.2	7.9	8.1
A228 (component cooling water pump room)			6.7	8.3		
A226 (service water pump room)	4.5	4.6	6.0	6.1	7.9	8.0

Note: An empty box indicates that there is no screening value developed as there are no targets of concern at the fire location.

As seen above, the change in HLF typically produced only small changes in the screening distance. Only in the smaller volume rooms does the use of 0.70 HLF produce a significant change in screening distance, and of these rooms, targets of concern were already damaged or exceed the new screening distance.

⇒ Two oil ignition sources that we model in detail are the pump/motor journal box and small compressor crankcase. Applicable pumps are high pressure safety injection, low pressure safety injection, containment spray (CS), auxiliary feedwater, and service water. The modeled compressors are saltwater system air compressors. An ignition would involve less than two gallons of oil which we treat as a confined spill that burns for approximately one minute. In these cases, the Peak Fire Intensity is such that any exposed cable (in trays) is damaged by the Plume Temperature Rise and HLF is not a factor. When fire suppression is available, cables of concern that route through conduit are analyzed using the Transient Analysis, Thermally Thick Targets worksheet. The Transient Analysis methodology is based on plume temperatures and not dependent on the critical combustible loading.

⇒ Area A419 is comprised of seven compartments that include passageways. A five gallon transient oil fire under a cable tray stack is the basis for Initiating Events A419F3, 4, 5, and 6. The in-plume worksheets for center location show the cable screening value changes are:

5 Gallon Oil Fire HLF →	0.85	0.70
Cable Damage	18.1	19.6
Cable Ignition	14.8	15.6

The target, a cable tray stack, is protected by fire suppression and analyzed using the Transient Analysis, Thermally Thick Targets worksheet. Thus, when suppression succeeds, trays 13 feet and higher are not damaged. When fire suppression fails the entire stack is damaged (with assumed core damage). Thus, no overall change in impact is noted.

The "Large Truck fire" scenario (A419F7) is deterministically modeled as assumed core damage.

⇒ In the Intake Structure, both the circulating water and saltwater pumps contain larger volumes of oil (as much as 61 gallons). We did not apply the 0.70 HLF to this area as the room is quite large (approximately 400,000 ft^3), has constant forced air ventilation (55,000 m^3/second), and openings in the roof. As described above, Plume Temperature Rise was sufficient to damage overhead targets and, for the larger spills, radiant damage was also a factor. The compartment ΔT is calculated using a Normalized Temperature Rise in Ventilated Space worksheet. The overall rise does not indicate a loss of all room components during the largest postulated oil fire.

⇒ Main turbine or feed pump ignitions involve large volumes of oil. These fires are not amenable to explicit modeling and, as such, their impacts are developed deterministically.

⇒ Lastly, the Control Room fire modeling did not require plume analysis as there are no overhead targets of concern.

The only additional ignition damage appeared in the Cable Spreading Room analysis where two new trays were identified. Tray 1AF29, over open switchboard panel 1C40E (initiating Event A306FM) was within the 0.70 screening distance. However, this tray was previously identified as damaged due to propagation from lower trays in the stack, so no impact changes are required.

The second tray, 2AM15, above the Regulating Transformer for Back up Bus (2X2X07), carries cables associated with 2A Emergency Diesel Generator and 11 CS Pump. Ignition of this transformer is now binned with Initiating Event A302F9. The transformer ignition frequency (3.95×10^{-4}) was added to the existing A302F9 frequency and the loss of 11 CS Pump was included with the functional impacts.

Initiating Event	Fire Scenario	Freq	Ignition Source	Functional Impact	CDF
A302F9 **IPEEE**	C10, C37, T16	2.01E-6	2B EDG Logic Panel, 120 VAC Distribution Panel 22A, Diesel Logic Cabinet (2C69)	GH, HL, H9, QQ	9.02E-11
A302F9 **Present**	C10, C37, C46, T16	3.97E-4	2B EDG Logic Panel, 120 VAC Regulating Transformer for Back up Bus, Distribution Panel 22A, Diesel Logic Cabinet (2C69)	GH, CS, HL, H9, QQ	2.03E-08

Note, the present CDF value is calculated using an in progress revision of the CCFPRA which is built from an updated General Transient Model. In addition, the fire model includes improved cable impact assessments and refinements that better represent the plant design.

There are no other actions required for this item.

RAI Question 6:

The Calvert Cliffs IPEEE assessment has assumed that "fires would not propagate beyond the contents of the cabinet itself" if the cabinet is "enclosed on all four vertical sides as well as the top and bottom" (see, for example, pp. 4-31 and 4-E-1 1). This assumption is consistent with the EPRI Fire PRA Implementation Guide, but can be optimistic for high-voltage cabinets (480V or higher). For high-voltage cabinets 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.

Provide an assessment of the impact on the IPEEE results if it is assumed that fires involving closed electrical panels of 480V or higher might propagate beyond the cabinet of origin.

Additional CCNPP Response:

As explained in our original response to this RAI, none of the known CCNPP motor control center failures caused external damage or penetrated the motor control center (MCC) exterior. Our experience is consistent with the *Question 11* technical basis findings regarding similar events. In *3.11 RAI Question 11 – Screening of Enclosed Ignition Sources*, EPRI states:

> Because of their position in the electrical lineup, most motor control centers will have adequate breaker protection and therefore may be screened if they are unvented. However, analysts should consult plant drawings or knowledgeable plant personnel to ascertain whether exceptions exist.

Experience at CCNPP has shown that the upstream breakers and electrical system coordination provide adequate protection and limit damage following an MCC fault. Also note that all PRA modeled MCCs are fully enclosed.

Concerning other (non-MCC) high-energy switchgear, our analysis is consistent with the *3.11 RAI Question 11* guidance and no further action is required.