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Perry Nuclear Power Plant
Docket No. 50-440
Final Response to Request for Additional Information Regarding Perry Nuclear Power Plant Individual Plant Examination of External Events (TAC No. M83659)

Ladies and Gentleman:

In a letter received April 20, 1998, the NRC issued a Request for Additional Information (RAI) concerning the Individual Plant Examination of External Events for Severe Accident Vulnerabilities (IPEEE) for the Perry Nuclear Power Plant (PNPP). The RAI is related to the seismic and fire analyses of the PNPP IPEEE.

The PNPP staff responded to the IPEEE RAI questions in a letter dated June 18, 1998 (PY-CEI/NRR-2297L). In this letter, Questions 3 and 7 of the RAI, related to the IPEEE fire analysis, were considered generic and as such, the responses were delayed in anticipation of an industry response to be drafted by the Electric Power Research Institute (EPRI). The anticipated EPRI response has since been received and the two outstanding questions are now submitted.

Attachment 1 contains the responses to fire analysis Questions 3 and 7 of the RAI received April 20, 1998.

If you have questions or require additional information, please contact Mr. Gregory A. Dunn, Manager - Regulatory Affairs, at (440) 280-5305.

Very truly yours,

for John K. Wood

Attachment

cc: NRC Project Manager
NRC Resident Inspector
NRC Region III

A011

I, Robert W. Schrauder, hereby affirm that (1) I am General Manager, Perry Nuclear Power Plant Department of the FirstEnergy Nuclear Operating Company, (2) I am duly authorized to execute and file this certification as the duly authorized agent for The Cleveland Electric Illuminating Company, Toledo Edison Company, Ohio Edison Company, and Pennsylvania Power Company, and (3) the statements set forth herein are true and correct to the best of my knowledge, information and belief.

Robert W. Schrauder

Subscribed to and affirmed before me, the 18th day of December, 2000

LINDA J. BOSIACKI
Notary Public, State of Ohio
My Commission Expires April 23, 200
(Recorded in Lake County)

Fire Question 3

NUREG-1407, Section 4.2 and Appendix C, and GL 88-20, Supplement 4 request that documentation be submitted with the IPEEE submittal with regard to the Fire Risk Scoping Study (FRSS) issues, including the basis and assumptions used to address these issues, and a discussion of the findings and conclusions. NUREG-1407 also requests that evaluation results and potential improvements be specifically highlighted. Control system interactions involving a combination of fire-induced failures and high probability random equipment failures were identified in the FRSS as potential contributors to fire risk.

The issue of control systems interactions is associated primarily with the potential that a fire in the plant (e.g., the main control room [MCR]) might lead to potential control systems vulnerabilities. Given a fire in the plant, the likely sources of control systems interactions could happen between the control room, the remote shutdown panel, and shutdown systems. Specific areas that have been identified as requiring attention in the resolution of this issue include:

(a) Electrical independence of the remote shutdown control systems: The primary concern of control systems interactions occurs at plants that do not provide independent remote shutdown control systems. The electrical independence of the remote shutdown panel and the evaluation of the level of indication and control of remote shutdown control and monitoring circuits need to be assessed.

(b) Loss of control equipment or power before transfer: The potential for loss of control power for certain control circuits as a result of hot shorts and/or blown fuses before transferring control from the MCR to remote shutdown locations needs to be assessed.

(c) Spurious actuation of components leading to component damage, loss-of-coolant accident (LOCA), or interfacing systems LOCA: The spurious actuation of one of more safety-related to safe-shutdown-related components as a result of fire-induced cable faults, hot shorts, or component failures leading to component damage, LOCA, or interfacing systems LOCA, prior to taking control from the remote shutdown panel, needs to be assessed. This assessment also needs to include the spurious starting and running of pumps as well as the spurious repositioning of valves.

(d) Total loss of system function: The potential for total loss of system function as a result of fire-induced redundant component failures or electrical distribution system (power source) failure needs to be addressed.

Please describe how your procedures provide for transfer of control to the remote station(s). Provide an evaluation of whether loss of control power due to hot shorts and/or blown fuses could occur prior to transferring control to the remote shutdown location and identify the risk contribution of these types of failures (if these failures are screened, please provide the basis for the screening). Finally, provide an evaluation of whether spurious actuation of components as a result of fire-induced cable faults, hot shorts, or component failures could lead to component damage, a LOCA, or an interfacing systems LOCA prior to taking

control from the remote shutdown panel (considering both spurious starting and running of pumps as well as the spurious repositioning of valves).

Response to Fire Question 3

Off-Normal Instruction (ONI)-C61 [Reference 4] dictates the actions that are to be taken when the control room is to be evacuated. Prior to evacuating the control room, Reactor Protection System (RPS) Manual SCRAM pushbuttons are to be armed and depressed followed by the Reactor Mode Switch being placed in the SHUTDOWN position. After the Reactor Mode Switch has been placed in SHUTDOWN, as many as possible of the following items are to be performed before evacuating the control room:

1. Verify all control rods inserted and thermal power decreasing.
2. Trip the main turbine by depressing the TURBINE TRIP pushbutton.
3. Place the Division 3 diesel generator DIESEL CONTROL TRANSFER switch to LOCAL.

From the appropriate Remote Shutdown Panel the operators are instructed to:

1. Insert a SCRAM if not completed in the control room.
2. Verify ALL RODS IN and that thermal power is decreasing if not verified prior to evacuating the control room.
3. Trip the turbine if not tripped from the control room.
4. Confirm station loads automatically shifted from the Auxiliary Transformer to the Startup Transformer. If station loads fail to shift, the operators are instructed to open the 13.8 kV buses, L11 and L12 and the normal supply breakers, L1102 and L1202 and enter ONI-R22-2, "Loss of a Non-essential 13.8 kV or 4.16 kV bus" [Reference 5].
5. Enter Integrated Operating Instruction (IOI)-11, "Shutdown from Outside Control Room" [Reference 6].

If the control room was evacuated due to a fire, Attachment 21 of IOI-11 lists the steps necessary for control room isolation. These steps include instructions for transferring switches to emergency, opening disconnects, and taking local control of equipment and manually positioning valves.

It has been documented within the corrective action process [Reference 7] that several valves were potentially vulnerable to failing their safe shutdown function in the event of a control room fire. This is a generic industry issue identified within NRC Information Notice 92-18, "Potential For Loss Of Remote Shutdown Capability During A Control Room Fire." The response to the hot short issue was addressed by first identifying the affected valves. The source of this information was taken from Table 3.5-1 and Table 3.12-2 of the Safe Shutdown Capabilities Report (SSCR) [Reference 8]. These tables identify valves required to support Appendix R safe shutdown from the Remote Shutdown Panel and from Motor Control Centers, or locally via manual actions due to a fire in the control room or any other area. It was noted that the valve torque/limit switch could be bypassed by a fire in the control room resulting in the valve going to the stalled condition. For these valves, the stall thrusts were determined. Comparison of these values was made to the existing weak link analyses. If stall thrusts were less than the existing weak link calculations, no further review

was required. For stall thrusts exceeding the valves' existing weak link limits, a more rigorous analysis was performed. Eight valves did not pass the analytical requirements. Therefore, a commitment was made to the NRC to modify the circuitry for these eight valves. Subsequently, the circuitry for 22 marginal valves was also modified. Since valve thrusts remain within weak link limits, there is no concern with respect to initiating a LOCA from valve pressure boundary failure. The modifications resulted in the wiring of the torque switch to functionally be as shown below:

The completed wiring modifications for the 30 valves adequately address the hot shorts concern. With the modifications, a hot short from a fire in the control room would not render the valve torque switches inoperable.

Most fuses relating to safe shutdown equipment are not located in the control room. In fact, none of the fuses for Motor Operated Valves (MOVs) are in the control room. For a fire in the control room, Method A is relied upon for shutdown [Reference 8]. A review of all components required for Method A was performed to determine the ability to safely shutdown the plant given a fire in the control room. The review verified that:

- All necessary components either can be electrically isolated from the control room, or there is sufficient time to operate the component manually.
- No spurious failure will prohibit safe shutdown.

Safe shutdown components that are electrically isolated from the control room are not dependent upon the operation of fuses in the control room. For the few Method A safe shutdown components that have fuses located in the control room, a second set of remotely located fuses exist. If a control room fuse were to blow before control is transferred to the remote shutdown location, the duplicate fuse logic would ensure operability of the shutdown equipment from the remote panel.

The Safe Shutdown Analysis addresses the potential for spurious actuation of safe shutdown components. For each safe shutdown system, two component lists were developed. One was the list of "Safe Shutdown Components" and the other list, "Potential Spurious Actuation", contains all components whose spurious operation would degrade system performance. The second list includes valves forming high/low pressure interface boundaries. With the exception of high/low pressure interfaces two valves in a branch line were analyzed to show that a single spurious signal would not cause both valves to operate. Where spurious operation could impact safe shutdown, components are protected in accordance with 10CFR50 Appendix R, Section III.G.2. Compliance or deviations to Section III.G are summarized in the SSCR [Reference 8], Table 3.12-1. For high/low pressure interfaces, multiple hot shorts from a single fire were assumed. The operation of high/low pressure interface isolation valves was shown to be protected or the circuits separated.

The fire Probabilistic Risk Assessment (PRA) includes the potential for the total loss of a system function even if control is successfully transferred to the remote shutdown panel.

This potential is quantified in the event trees by assigning realistic failure probabilities to all system functions required to mitigate a fire.

In light of the above discussion, loss of control power due to hot shorts and/or blown fuses could occur prior to transferring control to the remote shutdown location. In such an event, modifications have been implemented to prevent degradation of the valve or actuator that would have resulted in the loss of safe shutdown capability. These modifications reduce the potential for the loss of remote shutdown capability due to hot shorts caused by a control room fire and make it possible to control equipment necessary to safely shut down the plant from the remote shutdown panels. Likewise, spurious actuation of components as a result of fire-induced cable faults, hot shorts or valve failures are not likely to lead to a LOCA or interfacing system LOCA.

Fire Question 7

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 R.1 (*see actual RAI for the figure*) 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 [R1].

Based on evidence provided by a 1982 paper by Cooper et al. [R2], 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 misinterpretation of the results. Reference [R2], 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 [R2] 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 Perry IPEEE fire study discusses heat loss factors only in conjunction with the detailed analysis of electrical cabinets in one fire compartment (1CC3a). No hot gas layer (HGL)

temperature is estimated and HGL effects are apparently not considered important based on test data and referenced information that could not be verified. HGL effects were apparently also considered in other detailed compartment analyses.

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 and provide the resulting change in scenario contribution to core damage frequency.

Response to Fire Question 7

The values used for the heat loss factors in the Individual Plant Examination of External Events for Severe Accident Vulnerabilities (IPEEE) [Reference 9] fire study are justifiable. The Fire-Induced Vulnerability Evaluation (FIVE) methodology was used to quantitatively screen fire compartments at Perry. FIVE consists of three phases:

- Phase I, Fire Area Screening – Evaluate fire compartments within fire areas using Fire Compartment Interaction Analysis (FCIA).
- Phase II, Critical Fire Compartment Screening – Fire vulnerability frequencies computed.
- Phase III, Plant walkdown/verification and documentation – Potential vulnerabilities are re-evaluated with FIVE or an alternative PRA evaluation.

There are three screening steps in Phase I:

1. No shutdown equipment in the fire area.
2. Fire in compartment would not cause demand for safe shutdown equipment.
3. FCIA screening criteria satisfied.

Likewise, there are three screening steps in Phase II:

1. Fire ignition frequency (Fi) less than 1.0E-06.
2. Probability for redundant/alternate system unavailability (P2) x Fi less than 1.0E-06.
3. Probability for critical combustible loading damage (Pccl) x P2 x Fi less than 1.0E-06.

Generally for each screening step except Step 3 of Phase II, all circuits and components within a compartment are assumed to fail given a fire. However, in the case of compartment Control Complex Building (CC2/1 - Health Physics Area) credit was taken for Appendix R separation to limit the damage in accordance with the FIVE approach. In any event, the heat loss factor was not a consideration during these steps of the screening process. Most fire compartments were screened through Phase II, Step 2, however a number of compartments still remained [Table 4-3 of IPEEE (Reference 9)]. A refined analysis of the ignition frequencies reduced the number of unscreened compartments to nine. A detailed fire analysis [Reference 3] was performed on the following six unscreened compartments:

1. 1CC-3a, Unit 1, Division 2, Control Complex Building, Switchgear Room,

2. 1CC-3c, Unit 1 Division 1, Control Complex Building, Switchgear Room,
3. CC2/4, East Control Complex Building, Elevation 599',
4. IB-2, Intermediate Building, Elevation 599',
5. 1TB, Unit 1, Turbine Building, and
6. 1CC-5a, Unit 1, Control Complex Building, Control Room.

A detailed analysis was not performed for the other three unscreened areas. These three areas are:

1. 1TPC/1, Unit 1, Turbine Power Complex, Switchgear Room,
2. CC1, Unit 1, Control Complex Building, Elevation 599', and
3. FH3, Fuel Handling Building, Elevation 620'.

Each detailed analysis evaluated the following four general types of fire damage phenomena:

1. Damage to an elevated target located in the fire plume directly above a fire source;
2. Damage to an elevated target located within the ceiling jet, but outside the plume;
3. Damage to a target located in the hot gas layer, but outside the plume and ceiling jet; and
4. Damage to a target located next to the fire source, exposed to direct thermal radiation.

As part of the FIVE methodology, calculation worksheets where provided for computing the potential fire hazard associated with the above scenarios. Worksheet 1 was used for the first damage phenomena. Worksheet 2 was used for the next two damage phenomena and Worksheet 3 was used to evaluate the fourth damage phenomena. Effects of the above phenomena may be compounded (e.g., a target placed in the plume of a fire may receive a sub-critical heat flux from the plume as well as a sub-critical heat flux from a hot gas layer, but the combined heat flux is critical). In such cases multiple analyses were evaluated to assess the ultimate potential for damage. Completed worksheets for the fire analysis are contained in Appendix B of the Perry Detailed Fire Analysis [Reference 3].

Six main groups of ignition sources were evaluated in the detailed fire analysis. The sources are:

1. Large electrical cabinets,
2. Large pumps and compressors,
3. Junction boxes,
4. Miscellaneous small fixed sources,
5. Transient sources, and
6. Welding sources.

Heat loss factors or mass burnout fractions as they were sometimes referred to in the Perry detailed fire analysis were only included in the evaluation of the large electrical cabinets. The detailed fire analysis typically used a value of 0.7 for the mass burnout fraction. A value of 0.7 generally results in conservative hot gas layer temperatures throughout the fire event.

Overly conservative temperatures may result for extended duration events when manual suppression is not successful. When 0.7 was used for the heat loss factor, the source of the fire was assumed to be at the elevation of the cabinets. By holding the level of the fire to the elevation of the cabinets, the hot gas layer volume is reduced, increasing the calculated hot gas layer temperatures.

There are two exceptions to the use of a 0.7 heat loss factor. The exceptions are highlighted on the appropriate worksheets in Appendix B of the Perry Detailed Fire Analysis [Reference 3]. Both deal with the potential for damage to Temperature Sensitive Electrical Equipment (TSEE) located near the floor elevation. In one case a fire in a compartment with 4.16 kV switchgear and a 480 V bus was evaluated. The other exception was for the assessment of a compartment with an MCC fire. Both of these cases used a value of 0.8 for the heat loss factor. In the cases where a value of 0.8 was used for the heat loss factor, the hot gas layer was assumed to descend within a few feet of the floor. This is consistent with the assumption that the hot gas layer descended below the source. If the hot gas layer did not descend below the source, the TSEE would not be subject to damage. A heat loss factor of 0.7 was used to evaluate the other fire damage phenomena associated with 4.16 kV swithgears, 480 V buses and MCCs.

The detailed analysis resulted in two previously unscreened compartments becoming screened. These two compartments are East Control Complex Building (CC2/4), Elevation 599' 0" and Intermediate Building (IB-2), Elevation 599' 0". The status of the fire compartments that did not initially screen are summarized in Table 4-10 of the IPEEE [Reference 9].

The above discussion indicates that the heat loss factors used in the Perry Fire IPEEE are conservative, if not overly conservative in that higher temperatures may be predicted for extended duration events. In the two cases where 0.8 was used for the heat loss factor, the intent was to provide a greater heat load to the increased surface area of the hot gas layer. Increasing the hot gas layer increased the probability that damage would occur to equipment near the compartment fire boundary.

References

1. "SFPE Handbook of Fire Protection Engineering," 2nd Edition, P.J. DiNenne, et al, eds., National Fire Protection Association, 1995, pp. 3-140.
2. L.Y. Cooper, M. Harkleroad, J. Quintiere, W. Rinkinen, "An Experimental Study of Upper Hot Layer Stratification in Full-Scale Multiroom Fire Scenarios," Journal of Heat Transfer, v. 104, 741-9 (November 1982).
3. Project No. 9Y46/FIRE-03B, "Detailed Fire Analysis for Perry Nuclear Power Plant", Revision 0, August 23, 1996 and 9Y46/FIRE-03C, "Control Room Detailed Fire Analysis for Perry Nuclear Power Plant", Revision 0, August 23, 1996.
4. Off-Normal Instruction, ONI-C61, "Evacuation of the Control Room"
5. Off-Normal Instruction, ONI-R22-2, "Loss of a Non-essential 13.8 kV or 4.16 kV bus"
6. Integrated Operating Instruction, IOI-11, "Shutdown from Outside Control Room"

7. Potential Issue Form (Corrective Action Program), PIF No. 96-2458, Potential for a loss of remote shutdown capability during a control room fire.
8. Appendix R Evaluation: Safe Shutdown Capability Report, Perry Nuclear Power Plant, Revision 1, October 1990.
9. Perry Nuclear Power Plant Individual Plant Examination – External Events for Severe Accident Vulnerabilities submitted on November 6, 1995.
10. Project No. 9Y46/FIRE-03A, "Refined F2 and FIVE F3 Evaluations for Perry Nuclear Power Plant", Revision 0, August 23, 1996.