November 26, 1997

Ms. Irene Johnson, Acting Manager
Nuclear Regulatory Services
Commonwealth Edison Company
Executive Towers West III
1400 Opus Place, Suite 500
Downers Grove, IL 60515

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION ON QUAD CITIES IPEEE SUBMITTAL (TAC NOS. M83665 AND M83666)

Dear Ms. Johnson:

Based on our ongoing review of the Quad Cities Individual Plant Examination of External Events (IPEEE) submittal, we have developed the enclosed requests for additional information (RAIs). The RAIs are related to the seismic, fire, and high winds, floods, and transportation and nearby facility accidents (HFOs) analyses in the IPEEE. We have learned from the meeting held at the NRC on August 20, 1997, that Commonwealth Edison Company (ComEd) intends to update its fire IPEEE to include the plant-specific improvements proposed for reducing the identified fire risks. Therefore, some of the fire RAIs, derived from the submitted IPEEE, may no longer be applicable to the improved plant conditions; nevertheless, they are provided herewith to help ComEd focus on the staff's concerns and address them, when appropriate, in its update of the fire IPEEE.

We request that you provide your response within 60 days in conformance with our review schedule. If you have any questions concerning our review, please contact me at (301) 415-3016.

Sincerely,

Orig. signed by

Robert M. Pulsifer, Project Manager
Project Directorate III-2
Division of Reactor Projects - III/IV
Office of Nuclear Reactor Regulation

Docket Nos. 50-254, 50-265

Enclosure: RAIs

cc w/encl: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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cc w/encl: See next page

cc:

Michael I. Miller, Esquire
Sidley and Austin
One First National Plaza
Chicago, Illinois 60603

Plant Manager
Quad Cities Nuclear Power Station
22710 206th Avenue North
Cordova, Illinois 61242

U.S. Nuclear Regulatory Commission
Quad Cities Resident Inspectors Office
22712 206th Avenue North
Cordova, Illinois 61242

Chairman
Rock Island County Board
of Supervisors
1504 3rd Avenue
Rock Island County Office Bldg.
Rock Island, Illinois 61201

Illinois Department of Nuclear Safety
Office of Nuclear Facility Safety
1035 Outer Park Drive
Springfield, Illinois 62704

Regional Administrator
U.S. NRC, Region III
801 Warrenville Road
Lisle, Illinois 60532-4351

William D. Leach
Manager - Nuclear
MidAmerican Energy Company
907 Walnut Street
P.O. Box 657
Des Moines, Iowa 50303

Vice President - Law and
Regulatory Affairs
MidAmerican Energy Company
One RiverCenter Place
106 East Second Street
P.O. Box 4350
Davenport, Iowa 52808

Document Control Desk-Licensing
Commonwealth Edison Company
1400 Opus Place, Suite 400
Downers Grove, Illinois 60515

Site Vice President
Quad Cities Nuclear Power Station
22710 206th Avenue North
Cordova, Illinois 61242

QUAD CITIES
Request for Additional Information

Seismic

1. The reported plant HCLPF [high confidence in low probability of failure] capacity of 0.09g, which credits plant improvements and resolution of Unresolved Safety Issue (USI) A-46 concerns, is a very low value. Please describe in detail the actions that are being taken to ensure that the plant has adequate seismic margin (i.e., that there is high confidence that the plant will have a high probability of surviving an earthquake greater than the SSE [safe-shutdown earthquake] level). (In this regard, please clearly describe any completed or planned resolution actions pertaining to USI A-46 and/or IPEEE, additional to those already mentioned in the submittal, that may have an effect on the plant seismic margin.)

2. The identified backup shutdown path does not employ systems that are substantially independent of those relied upon for the primary shutdown path, and hence, the primary and backup success paths collectively have minimal diversity/redundancy. According to seismic margin assessment (SMA) procedures, diverse and independent systems should be employed to the extent possible in alternate success paths. Please provide a complete, detailed justification for use of the current success paths, including consideration of the potential and effects of correlated equipment failures (e.g., failures of ADS [automatic depressurization system] valves). If necessary, enhance the IPEEE equipment list to include redundant equipment that reflect diverse and independent means for achieving safe shutdown, and report the findings pertaining to the SMA evaluation of these additional components.

3. The submittal does not provide a description of unit differences and does not identify which success path components (a) belong to Unit 1, (b) belong to Unit 2, and (c) are shared among Units 1 and 2. Please identify and describe in detail any differences among the plant units. Please confirm (and justify) whether or not the reported plant HCLPF capacity and other seismic IPEEE results apply equally to Units 1 and 2.

4. NUREG-1407 ("Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities") requests that screening criteria be applied with respect to non-seismic failures and human actions. Provide a list of all operator actions that are required to ensure integrity of the chosen success paths. For each human action, indicate the time after the earthquake that the operator action is required and its location.

Indicate also the human error probabilities, accounting for seismic effects on operator actions. Provide a list of the random failures (and their failure rates) having the most significant potential to compromise integrity of the success paths. Indicate the screening criteria applied to rates of random failures and operator errors, and report the results of your screening evaluation.

5. The assessment of seismic failure of fire suppression systems examined only the potential for adverse interactions with safety equipment; however, it did not examine this issue from the viewpoint of loss of fire suppression capability. For example, in the examination of seismically induced fires, a poorly anchored day tank storing diesel fuel oil for the diesel-driven fire pump was assessed and judged not to be a concern from the viewpoint of a seismically induced fire; however, this component was not identified as a concern from the viewpoint of seismically induced loss of fire-water capability.

   In regard to the potential for seismically induced loss of capability of fire suppression systems, examples of relevant items found in past studies include (but are not limited to):

   - Unanchored CO_2 tanks or bottles
   - Sprinkler standoffs penetrating suspended ceilings
   - Fire pumps unanchored or on vibration isolation mounts
   - Unrestrained batteries/rack for diesel-driven fire pumps
   - Block wall interactions with fire pumps or batteries
   - Use of cast iron fire mains to provide fire water to fire pumps

   NUREG-1407 suggests a walkdown as a means of identifying any such items. Please identify a complete list of instances where weaknesses in fire suppression equipment exist at the plant, as encountered by plant walkdowns, and report your approach for resolution of these weaknesses. Provide guidelines given to walkdown personnel for evaluating these issues (if they exist).

6. Even for plants characterized as rock sites, there may still exist some soil-founded or buried components (e.g., piping and tanks) or soil structures (including onsite or offsite canals, dams, or embankments) that can affect plant response. Please identify any such components, evaluate their importance to plant safety, evaluate the potential and effects of soil response/failure (including soil settlements/deformations, soil stresses, etc.) on their capacities, and report your related analyses and findings.

7. For the following outliers identified in the seismic IPEEE and assessed as having a capacity below the review level earthquake (RLE) (see the table in Section 3.1.5 of the IPEEE submittal for a complete list of such equipment), please provide capacity calculations (including HCLPF calculations), completed

screening evaluation work sheets (SEWSs), walkdown notes/checklists, and photographs:

- Cable trays - cable tunnels (LAR 004); surrounding hydraulic control units (HCUs) (LAR 012);cable spreading room (LAR 002); reactor, turbine, and service buildings (LAR 011); and turbine building (LAR 008)
- Racks 2201-32 and 2202-32
- Switchgear 23-1, 13-1, 14-1, 24-1, 18, 19, 28, 29, 23, 13, 14, and 24
- Silencers 1-6667, 2-6667, ½-6667
- Chargers 2-8350 and 2-8300-1A
- Cubicle coolers ½, 1, 2-5749, and 1,2-5746A,B, -5747, -5748A,B
- MCCs 1B, 2A, 2B, 18-1A, 18-1A-1, 18-1A-1 PNL, 18-1B, 18-3, 19-1, 19-1-1, 19-1-1 PNL, 19-4, 28-1A, 28-1A-1, 28-1B, 28-3, 29-1, 29-1-1, 29-1-1 PNL, 29-4, and Transformer MCCs 28-1A-1 TR and 29-1-1 TR
- Panels 901-50 and 901/902-27
- Damper 2-9472-32
- Switch PE-1

Please provide similar information for masonry block walls adjacent to the following equipment (see Table 3-1 of the IPEEE submittal): SWGR 24-1, SWGR 13-1, SWGR 14-1, and 2252-87. (Note that the calculations for these block walls are all apparently provided in Reference 93C2806.03-C-003.)

(Note: Where multiple components of a given class are listed above, and the walkdown findings and calculations for all such components are essentially identical, relevant information need only be provided for one representative component of the class.)

8. Section 6.3.3 of NUREG-1407 states that "USI A-45 ... should be specifically addressed as part of the seismic IPEEE." Please report your approach and findings pertaining to the resolution of USI A-45.

9. Discuss the ability of the primary and backup success paths to respond to medium and large loss-of-coolant accidents (LOCAs) resulting from stuck-open safety-relief valves.

10. Please provide a list of the comments made by peer reviewers of the seismic IPEEE and indicate how each review comment was resolved.

Fire

1. Please provide the basis for dismissing fire-induced initiators other than general transients and loss of offsite power.

2. Was the timing of fire-induced damage considered when allowing credit for automatic suppression of the fire? If not, please provide a re-evaluation of fire scenarios where automatic suppression was credited, considering the timing of actuation, suppression, and fire damage.

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 the 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 A.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 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 degrees Fahrenheit for qualified cable and 450 degrees Fahrenheit 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 [1].

   Based on evidence provided by a 1982 paper by Cooper et al. [2], the *EPRI [Electric Power Research Institute] Fire PRA Implementation Guide* recommends a heat loss factor of 0.94 for fires with durations greater than 5 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 [2], 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 [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*.

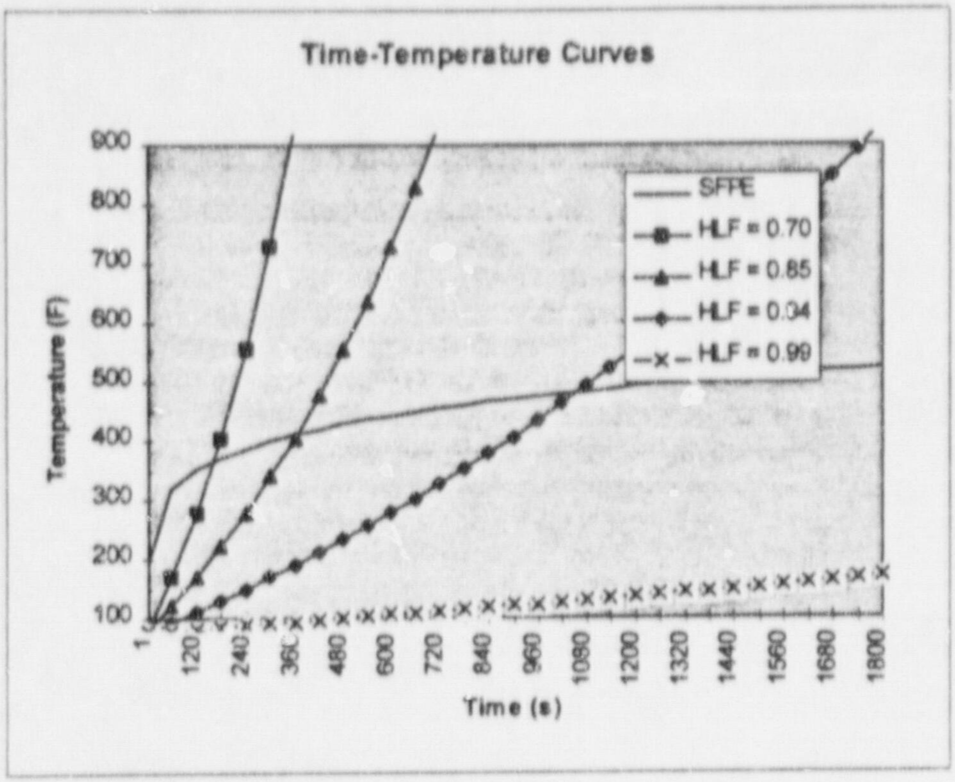

Figure A.1 Sensitivity of the hot gas layer temperature predictions to the assumed heat loss factor

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.

4. In computing the extent of fire propagation and equipment damage for a given scenario, it is important that experimental results not be used out of context. Inappropriate use of experimental results (e.g., employing propagation times specific to a particular cable tray separation to fires involving cable trays with lesser separation) can lead to improper assessments of scenario importance. In one case [3], rather than performing fire model calculation and using the results, experimental data from a test performed to model cable tray fire propagation in the absence of an exposure fire was used to model cable response to an exposure fire, which led to over an order of magnitude reduction in predicted fire-induced core damage frequency.

For each fire scenario in which experimental data were used to estimate the rate and extent of fire propagation, please: (a) indicate if FIVE (or similar) calculations were performed for the scenario and provide the results (equipment damaged) of these calculations; (b) indicate which experimental results were used and how they were utilized in the analysis; and, (c) justify the applicability of these experimental results to the scenario being analyzed. The discussion on results applicability should compare the geometries, ignition sources, fuel type and loadings, ventilation characteristics, and compartment characteristics of the experimental setup(s) with those of the scenario of interest.

5. Fires in the main control room (MCR) are potentially risk-significant because they can cause I&C [instrumentation and control] failures (e.g., loss of signals or spurious signals) for multiple redundant divisions, and because they can force control room abandonment. Although data from two experiments concerning the timing of smoke-induced, forced control room abandonment is available [4], the data must be carefully interpreted, and the analysis must properly consider the differences in configuration between the experiments and the actual control room being evaluated for fire risk. In particular, the experimental configuration included placement of smoke detectors inside the cabinet in which the fire originated, as well as an open cabinet door for that cabinet. In one case, failure to account for these configuration differences led to more than an order of magnitude underestimate in the conditional probability of forced control room fire abandonment [3]. In addition, another study raises questions about control room habitability due to room air temperature concerns [5].

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

6. The EPRI Fire PRA Implementation Guide methodology for evaluating the effectiveness of suppression efforts treats manual recovery of automatic suppression systems as being independent of subsequent manual efforts to suppress the fire. This assumption is optimistic, as the fire conditions (e.g., heat, smoke) that lead to the failure of recovery efforts can also influence the effectiveness of later suppression efforts. Such an approach, therefore, can overlook plant-specific vulnerabilities.

   It is important that all relevant factors be considered in an evaluation of the effectiveness of fire suppression. These factors include (a) the delay between ignition and detector/suppression system actuation (which is specific to the configuration being analyzed), (b) the time-to-damage for the critical component(s) (which is specific to the fuel type and loading as well as to the configuration being modeled), (c) the response time of the fire brigade (which is plant-specific and fire-location-specific), (d) the time required by the fire brigade to diagnose that automatic suppression has failed and to take manual action to recover the automatic suppression system, and (e) PSFs [performance shaping factors] affecting fire brigade actions. These PSFs could include factors such as perseverance (persistent efforts made to recover a failed automatic suppression system), smoke obscuration, and impaired communications [3].

Finally, it should be noted that the Nuclear Regulatory Commission (NRC) staff's evaluation of the FIVE methodology [6] specifically stated that licensees need to assess the effectiveness of manual fire-fighting teams by using plant-specific data from fire brigade training to determine the response time of the fire fighters.

Please identify those scenarios for which credit is taken for both manual recovery of automatic suppression systems and manual suppression of the fires (if manual recovery efforts are unsuccessful), and please indicate the plant equipment that may be affected by the fires. In the analysis of these scenarios, how are dependencies between manual actions treated? Please justify the treatment, considering the expected fire environment, the recovery actions required, and the manual fire suppression actions required.

7. The EPRI Fire PRA Implementation Guide assumes that all enclosed ignition sources cannot lead to fire propagation or other damage (page 4`-18 of [1]). This can be an optimistic assumption for oil-filled transformers and high-voltage cabinets. 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 (page H-3 of [1]). This can also be an optimistic assumption for high-voltage cabinets since an explosive breakdown of the electrical conductors may breach the integrity of the cabinet and allow fire to spread to combustibles located above the cabinet. For example, switchgear fires at Yankee-Rowe in 1984 and Oconee Unit 1 in 1989 both resulted in fire damage outside the cubicles.

   Please provide the basis for the assumption and a discussion on how the specific enclosures were analyzed to ascertain that the assumption is applicable to them.

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

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

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

9. In general, the fire risk associated with a given compartment is composed of contributions from fixed and transient ignition sources. Neglect of either contribution can lead to an underestimate of the compartment's risk and, in some cases, to improper screening of fire scenarios. The *EPRI Fire PRA Implementation Guide* allows the screening of transient ignition sources in compartments where all fixed ignition sources have been screened out. Based on this approach, a cable spreading room or a cable shaft that does not contain any items other than IEEE 383 qualified control and instrumentation cables, and access to the compartment is strictly controlled, can be screened out. If such compartments contain the cables for all redundant trains of important plant safety systems, a major vulnerability may be overlooked, without sufficient analysis of potential accident sequences and needed recovery actions.

   In compartments where all fixed ignitions sources have been screened out, has the possibility of transient combustible fires been considered? For each compartment where transient fires have not been considered, please provide the justification for this conclusion and provide a discussion on compartment inventory in terms of system trains and associated components (i.e, cables and other equipment). Please explain whether or not the conditional core damage probabilities, given damage to all cables and equipment in these compartments, are significant (i.e., cables from redundant trains are present). If the conditional core damage probability for a compartment is considered significant, please provide justification for assigning a very low likelihood of occurrence to transient fuel fires for the compartment.

10. Please provide a list of multi-compartment fire scenarios that were screened out based upon a lack of hot gas layer formation.

High Winds, Floods, and Others

1. Please provide the analysis concerning the probable maximum precipitation (GI-103), as requested in NUREG-1407.

References for Fire RAIs

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

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.

3. J. Lambright, et al., "A Review of Fire PRA Requantification Studies Reported in NSAC/181," prepared for the United States Nuclear Regulatory Commission, April 1994.

4. J. Chavez, et al., "An Experimental Investigation of Internally Ignited Fires in Nuclear Power Plant Cabinets, Part II-Room Effects Tests," NURFG/CR-4527/V2, October 1988.

5. J. Usher and J. Boccio, "Fire Environment Determination in the LaSalle Nuclear Power Plant Control Room," NUREG/CR-5037, prepared for the United States Nuclear Regulatory Commission, October 1987.

6. A. Thadani, "NRC Staff Evaluation Report on Revised NUMARC/EPRI Fire Vulnerability Evaluation (FIVE) Methodology," U.S. Nuclear Regulatory Commission, August 21, 1991 (letter to W. Rasin, NUMARC, with enclosure, "Staff Evaluation of the Fire Vulnerability Evaluation (FIVE) Methodology for Use in the IPEEE").