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

February 18, 2010

Mr. Paul A. Harden
Site Vice President
FirstEnergy Nuclear Operating Company
Beaver Valley Power Station
Mail Stop A-BV-SEB1
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Shippingport, PA 15077

SUBJECT: BEAVER VALLEY POWER STATION, UNIT NOS. 1 AND 2 – REQUEST FOR ADDITIONAL INFORMATION RE: SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED WATER REACTORS" (TAC NOS. MC4665 AND MC4666)

Dear Mr. Harden:

By letters dated December 20, 2007, February 14, 2008, August 28, 2008, October 29, 2008, March 12, 2009, April 30, 2009, and June 30, 2009, FirstEnergy Nuclear Operating Company (licensee) submitted supplemental responses to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," for the Beaver Valley Power Station, Unit Nos. 1 and 2 (BVPS-1 and 2).

The Nuclear Regulatory Commission staff has reviewed the licensee's submittals and determined that additional information is needed to conclude that there is reasonable assurance that GL 2004-02 has been satisfactorily addressed for BVPS-1 and 2. Please respond to the enclosed request for additional information (RAI) by the date that will be established after a subsequent public meeting to discuss these items.

If you have any questions or concerns regarding this issue, please contact me at (301) 415-1016.

Sincerely,

Nadiyah S. Morgan, Project Manager
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-334 and 50-412

Enclosure:
RAI

cc w/encl: Distribution via Listserv

REQUEST FOR ADDITONAL INFORMATION

REGARDING SUPPLEMENTAL RESPONSES TO GENERIC LETTER 2004-02

FIRSTENERGY NUCLEAR OPERATING COMPANY

FIRSTENERGY NUCLEAR GENERATION CORP.

OHIO EDISON COMPANY

THE TOLEDO EDISON COMPANY

BEAVER VALLEY POWER STATION, UNIT NOS. 1 AND 2

DOCKET NOS. 50-334 AND 50-412

By letters dated December 20, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML073620201), February 14, 2008 (ADAMS Accession No. ML080510246), August 28, 2008 (ADAMS Accession No. ML082480045), October 29, 2008 (ADAMS Accession No. ML083080094), March 12, 2009 (ADAMS Accession No. ML090750618), April 30, 2009 (ADAMS Accession No. ML091250180), and June 30, 2009 (ADAMS Accession No. ML091830390), FirstEnergy Nuclear Operating Company (licensee) submitted supplemental responses to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," for the Beaver Valley Power Station, Unit Nos. 1 and 2 (BVPS-1 and 2). To complete its review, the Nuclear Regulatory Commission (NRC) staff requests the following additional information:

Break selection

1. Please confirm that limiting break locations as defined in responses to date remain limiting after new evaluations based on planned replacement of problem insulation. Describe any differences in the break selection process from that previously used and verify that the new process maximizes each remaining debris source and the potential for debris combinations that could result in the most challenging head loss for the strainer.

Debris Generation/Zone of Influence (ZOI)

2. In Reference 1, it is stated that additional Temp-Mat insulating material had been discovered on the reactor coolant system (RCS) piping at the BVPS-1 reactor vessel nozzles. Please provide details on how the revised strainer performance evaluations reflect this material or whether and how its impact has been otherwise mitigated.

3. Please provide additional details and assumptions on the alternate ZOI calculated for the Microtherm insulation installed on the RCS for BVPS-2, to describe how the ZOI was adjusted for the confined space within the reactor annulus. In Reference 1, it is stated that the alternate ZOI was calculated using the Boiling Water Reactor Owners Group Utility Resolution Guidance method 3 for restrained breaks and was adjusted for the confined volume in the reactor annulus. Please provide details on the installation of the piping, insulation, and other structures or components that could affect the calculation, including how the axial and radial offsets were determined for the piping, the location of the insulation relative to the piping, pipe wall thickness, postulated break locations, whether longitudinal pipe breaks were considered, the destruction pressure used for the evaluation, etc. Please discuss whether a pancake-shaped jet as described in ANSI/ANS-58-2-1988 was evaluated, justify that a spherical ZOI is appropriate for the postulated restrained break, or describe how the jet was evaluated to behave within the confines of the reactor annulus. Provide information that describes how the amount of Microtherm debris would change with respect to the size of the ZOI. A non-conservative treatment of Microtherm would likely result in non-conservative head loss inputs. The Microtherm head loss is the bounding case for BVPS-2.

4. In Reference 1, it is stated that Benelex 401 is a high-density wood-based material composed of cellulose and lignin fibers. The response stated that the material was evaluated for seismic forces and loss-of-coolant accident (LOCA) pressure loading, but did not specify the assumptions for the evaluation. It was not clear that the evaluation considered all aspects of impingement from a LOCA steam jet. Please provide additional information for the evaluation that determined that the ZOI for Benelex 401 would be limited to 2 diameters (D). Please describe the methodology and assumptions for this evaluation. State whether any testing was performed to determine the appropriate destruction pressure for the material. If testing was conducted provide adequate information to justify that the testing was representative of, or bounded, the conditions that would be expected in the plant at the assumed ZOI. State whether the material is considered to be water soluble. If so, please provide information that justifies that the material would not fail due to the post-LOCA environment and potentially transport to the strainer.

<u>Debris Characteristics</u>

5. In Reference 1, it is stated that only 50% of the calcium silicate within the prescribed 5.45D ZOI was assumed to be destroyed into fines. The other 50% of the calcium silicate within this ZOI was not considered in the analysis (i.e., it was apparently assumed to remain intact following the impact of the LOCA jet). The stated basis for the 50% reduction in calcium silicate was Ontario Power Generation (OPG) testing for which less than 50% of the target calcium silicate was damaged by jet impingement. Please address the following items concerning the assumed calcium silicate debris distribution:

    a. Significant portions of the target insulation in the OPG tests were not exposed to jet forces representative of the calculated ZOI. In other words, the insulation targets used for testing were so long (48 inches) that, due to the small size of the jet nozzle (2.86 inches), a significant portion of the insulation targets was not subjected to destruction pressures prototypical of a complete rupture of RCS piping. In addition, some OPG tests demonstrated the occurrence of insulation damage at distances in excess of that corresponding to a spherical 5.45D. Although a 5.45D ZOI was accepted for calcium silicate based on the OPG testing, the NRC staff's safety evaluation on Nuclear Energy Institute (NEI) 04-07 conservatively recommended that 100% of the calcium silicate within a spherical 5.45D ZOI be assumed to be destroyed into small fines, which compensated for these test setup issues. Thus, it is unclear that assuming a 5.45D ZOI with 50% intact pieces is justified based on the OPG test results.

b. Please identify the jacketing and banding, latching, etc., of the calcium silicate insulation at BVPS-1 and 2 and compare this insulation material to the material that was tested by OPG to support the assumed debris characterization of 50% intact pieces based on the application of the OPG test results. Please also compare the manufacturing process for the calcium silicate at BVPS-1 and 2 with that used for the OPG testing (i.e., hydraulically pressed or molded – see Section 3.3.3 of the NRC's Indian Point Audit Report).

c. The 50% of the calcium silicate considered to be undamaged was not considered for potential erosion and transport to the strainer. However, for some of the OPG tests, the insulation jacketing was removed, even when the base insulation material was not completely removed from the pipe. In light of the removal of the jacketing in a number of tests, please provide justification that erosion of the calcium silicate remaining on pipes need not be considered.

6. Please identify why Benelex is considered to be a particulate insulation in Table 3.c-6 of Reference 1, while page 19 of the same response identifies that this material is constructed from compressed cellulose and lignin fibers.

<u>Head Loss and Vortexing</u>

7. In Reference 1, it is stated that deaeration of the fluid passing through the debris bed could occur, but that the majority of any gases would be absorbed by the fluid prior to reaching the pump suctions. The mechanism for the absorption of the gases was not understood by the NRC staff. It was not clear whether the gases could collect as bubbles in the strainer or piping and eventually transport to the pump suction. It was also not clear that the gases would absorb into the liquid prior to reaching the pump suction. Please provide the assumptions and methodology for the evaluation that predicted the final void fraction at the pump suctions.

8. The NRC staff could not confirm that testing included properly scaled quantities of all debris types. For example, for BVPS-1, Test 6 was stated to bound all breaks. However, Table 3.f.4-3 indicates that only a small amount of Temp-Mat was included in the test. In the transport section, the transport chart for the bounding RCS break appears to indicate that the break would result in more Temp-Mat debris. Another example for BVPS-1 is that the reactor nozzle break test case (Test 2) contains significant Temp-Mat, but the transport charts show that there would be no Temp-Mat debris for this break. For BVPS-2, Case 1A, it appears that the amount of fibrous debris added to the testing was lower than would be required by the transport evaluation.

Please provide the basis for the amount of each debris source added to each test which is considered a design basis test for each strainer.

9. According to Reference 1, for BVPS-1, 0.25 cubic feet (ft^3) of latent fiber is generated and that there would be about 24 pounds (lbs) of latent fiber. Generally, this would be considered to be about 10 ft^3 of fiber. Apparently, a latent fiber density of 94 lb/ft^3 was used to calculate the amount of fiber. It appears that the correct mass of Nukon fiber was added to the head loss testing to represent the latent fibrous debris. Please provide information that specifies the characteristics and amount of latent fibrous debris that was used in head loss testing for BVPS-1. The BVPS-2 evaluation lists a volume of 11.3 ft^3 of latent fiber, an apparently more reasonable value.

10. The flow rates used during BVPS-1 vortex testing were not compared against the maximum potential strainer module flow rates. The maximum flow stated to be used during testing was 600 gallons per minute (gpm) at 1 inch submergence, with a repeated test at zero submergence. The design scaled flow rate was 360 gpm. The design minimum submergence is 2.2 inches. Because the strainer consists of a long train of strainer modules, when the strainer is clean, the module closest to the pump suction will have a significantly higher flow rate than those further from the pump. Please provide the flow rate through the limiting module and verify that this flow rate was considered in the vortex evaluation.

11. The accumulators were credited for strainer submergence for the small-break LOCA. Please provide justification for this assumption or justify that the calculated levels are conservative.

12. It was unclear that the debris preparation for the fibrous material resulted in prototypical fine fiber. In Reference 1, it is stated that the fibrous debris was prepared in a blender. The NRC staff has observed varying debris characteristics for fibrous debris prepared in a blender. In this case, if the fibers are blended for too long a time period, they could become particulate like instead of fibrous. On the other hand, if too much fiber is placed in the blender only a small amount may be affected. Alternately, the NRC staff has observed blended fiber to become compact balls, which is non-prototypical. In general, the NRC staff has stated that fine fiber should represent classes 1 through 3 as defined in NUREG/CR-6808, Table 3-2, with the majority being classes 2 and 3. The supplemental response dated June 30, 2009, stated that the fibers were inspected to ensure that they met the distribution requirements defined in the NUREG, but the NUREG does not define the size distribution. Please provide information that verifies that the fibrous debris used for testing was prototypical of that predicted to reach the strainer by the debris generation and transport evaluation.

13. Reference 1 did not provide information regarding the debris introduction procedures, including the debris introduction locations with respect to the strainer and the potential for agglomeration of debris. Please provide information that shows that the debris was diluted and introduced, such that agglomeration of the debris did not occur and that the debris was allowed to transport to the strainer with the bulk flow in the test tank.

14. The particulate debris load added to the test included paint chips. The paint chips were added prior to the fine fibrous debris. This is not consistent with the March 2008 NRC

staff guidance for head loss testing. Please provide information that justifies that the head loss test results were not affected non-conservatively by the debris addition sequence.

15. The methodology for extrapolation of test results to higher temperatures was not understood by the NRC staff. Please provide the methodology and basis for extrapolation of the head loss test results to higher temperatures. Please state whether flow sweeps were conducted during testing to provide a basis for the extrapolations. Provide the relationship used to perform the extrapolations including the laminar and turbulent terms as appropriate.

16. The flow distribution used for the calculation of the BVPS-1 clean strainer head loss (CSHL) calculation was not provided. Because the strainer is a long train of modules, CSHL will be lower when there is no debris on the strainer. A conservative calculation would assume that the flow is balanced between all modules. For BVPS-2, a conservative assumption of uniform flow through each strainer module was assumed. Please provide the strainer flow distribution assumed for the BVPS-1 CSHL calculation.

17. The height of the loop seal for the quench spray piping that penetrates the BVPS-1 strainer boundary was not provided. It was not stated how this loop seal is maintained full of water during all phases of a postulated LOCA response. Please provide additional details on the configuration of the loop seal and how it is ensured that the seal is maintained full of water throughout the mission time of the strainer.

18. In Reference 1, it is stated that the BVPS-2 strainer is divided into two trains. The purpose for this feature was not provided. Please state the purpose of dividing the BVPS-2 strainer into an A and B train and discuss the effect that dividing the strainer into two trains has on strainer performance.

19. The head loss graph, Figure 3.o.2.17-7 in Reference 1, shows that a flow sweep was conducted prior to the final debris addition and prior to the test reaching a stable value. Please provide the basis for this test sequence. Please provide information that justifies that the flow sweep did not affect the head loss result non-conservatively.

<u>Net Positive Suction Head (NPSH)</u>

20. Please provide the following additional information concerning water hold up volumes in containment:

    a. Please clarify and provide the bases for the assumptions on the water hold up (volumes and quantities) at the time that the limiting minimum water level occurs in containment after the initiation of recirculation.
    b. Please provide the basis for crediting the submerged volumes displaced by hollow components, such as the containment elevator, non-safety-related ductwork, and containment purge vents. Clarify whether these components are leaktight when submerged under post-LOCA conditions, and the difference this makes in the overall evaluation.
    c. Although the NRC staff agrees that the 0.35-inch net level decrease from three hold-up mechanisms not considered by the licensee (see response to item 3.g.10) would

be minor for some of the analyzed scenarios, this level change represents over 15% of the 2.2-inch submergence credited for the limiting small-break LOCA for BVPS-1. Accordingly, please provide a basis for neglecting these hold-up volumes or else include them in the minimum water level calculation.

21. Partial and/or total refueling cavity drain blockage could significantly affect the water hold up assumptions described in the supplemental response. Please provide the following information concerning water drainage from upper containment for BVPS-1 and 2:

    a. The size and quantity of the reactor cavity ventilation openings.
    b. The opening size of the coarse grating over the BVPS-2 reactor cavity ventilation openings.
    c. The opening size of gaps on the side of the shielding below the BVPS-1 permanent reactor cavity seal.
    d. A discussion of the sizes and quantities of debris predicted to transport to the refueling cavity and reactor cavity.
    e. The basis for concluding that blockage of the drainage paths discussed above would not occur following a LOCA, including consideration of the case of a reactor vessel nozzle break potentially leading to significant quantities of debris in the reactor cavity.
    f. A description of whether the potential for partial/total blockage of these drain paths was considered in the dynamic containment water level model incorporated into the MAAP-DBA code.

22. For BVPS-2, please provide additional detail to confirm that the cold leg recirculation NPSH results are bounding with respect to all potential hot leg recirculation flow lineups. Based on the information provided in the supplemental response dated June 30, 2009, and the NRC staff's review of the BVPS-2 Updated Final Safety Analysis Report, the NRC staff accepted that the cold leg recirculation lineup NPSH margin results are limiting with respect to the hot leg recirculation lineup wherein the recirculation spray system (RSS) pumps feed the hot legs via the high-head safety injection/charging pumps. However, it was not clear that the cold leg recirculation lineup was bounding with respect to the configuration in which the RSS pumps recirculate sump fluid through low-head safety injection system piping and into the hot legs. Please clarify whether this latter flow configuration is permissible per emergency operating procedures, and, if so, provide a more detailed basis for concluding that the flows and NPSH margin results for this case are bounded.

23. The supplemental response dated June 30, 2009, describes an internal divider plate installed between the two channels of the BVPS-2 strainer. Please describe the location of the internal divider plate and its function, provide the size of the perforations in the divider plate and its total surface area, and provide the basis for the determination that blockage will not occur at the divider plate based on the sizes and quantities of debris in the flow stream downstream of the strainer surface. Please provide similar information for BVPS-1 if a divider plate internal to the BVPS-1 replacement strainer exists.

24. In its response to Item 3.g.12 in Reference 1, the licensee provided a table showing the post-LOCA distribution of water for various LOCA sizes. It is not clear what break elevations were assumed in the analysis. If a break occurred in the top of the

pressurizer, the entire RCS volume (e.g., including the pressurizer) would be susceptible to refill. Please clarify what break elevations were assumed for the small-break LOCA cases and discuss whether a small-break LOCA at an elevation allowing complete refill of the RCS would be bounded by the assumptions.

25. Table 3.g.1-2 of Reference 1 indicated that the maximum sump flow during safety injection recirculation for BVPS-2 is 13,640 gpm. In response to Item 3.g.6, the licensee stated that emergency operating procedures will be modified to ensure that one of the BVPS-2 RSS pumps supplying the containment spray headers will be shut down when the containment pressure is reduced below a predetermined value to prevent head losses from exceeding the structural limit at low temperatures. Please clarify the following information:

    a. The total sump flow rate before and after the securing of one of the RSS pumps used for spraying containment.
    b. The calculated time and containment pressure when one RSS pump can be terminated.
    c. The calculated time and sump pool temperature when the strainer head loss could exceed its structural limit.

Chemical Effects

The evaluation of the chemical effects was discussed in Reference 1. Although the NRC staff has no additional questions about the current chemical effects evaluation, there are open commitments to address additional Temp-Mat and fibrous insulation in the reactor vessel annulus that is not bounded by the current analyses. If the re-evaluation results in additional chemical and non-chemical debris loading of the strainer, changes should be evaluated to determine if the existing testing and analysis adequately address the revised debris amounts. Please describe your evaluation of the impact of any additional Temp-Mat and fiber.

References:

1. FirstEnergy Nuclear Operating Company Letter L-09-152, "Beaver Valley Power Station, Unit Nos. 1 and 2, Supplemental Response to Generic Letter 2004-02 (TAC Nos. MC4665 and MC4666)," dated June 30, 2009.

February 18, 2010

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Site Vice President
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Sincerely,

/RA/

Nadiyah S. Morgan, Project Manager
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