Creedon, Meghan

From: Butler, Ralph [ButlerRa@missouri.edu]
Sent: Friday, January 07, 2011 2:23 PM
To: Adams, Alexander; 'Daune.Hardesty@nrc.gov'; Tran, Linh
Cc: Fruits, John L.; Foyto, Leslie P.; McKibben, J. Charles; Ernst, John P.; Rathke, Donna J.; Stout, Margee P.
Subject: Teleconference Memo
Attachments: NRC Memo LSSS 1-7-2011.docx

Al Adams,

Attached is a memo summarizing the content of teleconferences conducted on January 4 and January 5, 2011 between NRC staff and MURR staff.

Ralph A. Butler
Director, MURR

Date: January 6, 2011
To: Alexander Adams, Jr., NRC
From: Ralph A. Butler, MURR Director

Re: Teleconferences Regarding Potential Error in Calculation

This memo summarizes the content of two teleconferences held on January 4 and January 5, 2011 between staff from the NRC, Washington Safety Management Solutions and MURR. Please note that this memo is solely for convenience and is not intended to serve in any way as legal notification.

The topic of the teleconferences was the discovery of a potential error in a calculation contained in the MURR Safety Limit Analysis dating back to 1973. This potential error could require a revision to the MURR Safety Limits and a Limiting Safety System Setting. For clarity, at no time did MURR exceed or have the potential to exceed the MURR Safety Limits.

- Discovery of potential error:
  - Dr. Earl Feldman, Argonne National Laboratory (ANL), during December 2010 while helping with relicensing Request for Additional Information (RAI) 16.1 regarding the 10 mil reduction in coolant channel question, felt that he had identified a potential error in the 1973 NUS Corporation Safety Limit Analysis. The analysis had used a different heated diameter definition than the one given by Bernath.
    - Bernath's D_i = heated perimeter divided by π = 1.12936 inches
    - NUS's D_{heated} = 4 times flow area divided by the heated perimeter = 0.1755 inches

- Initial response to the discovery of the potential error:
  - Correcting to the Bernath heated diameter definition with three (3) of the four (4) LSSS variables at their corresponding limits (i.e., pressurizer pressure at 75 psia, total core flow rate at 3200 gpm, and core inlet temperature at 155 °F) the Safety Limit for power was recalculated using the NUS methodology, which includes the current Hazards Summary Report's extremely conservative peaking factors. The recalculated power is reduced from 14.892 MW to 12.376 MW (our LSSS for power is 12.5 MW).

  - A Standing Order was issued which instructed the operators to manually scram the reactor should core inlet temperature reach 136 °F. This would remain in effect until such time as the exact discrepancy could be verified.

- <u>During our phone conversation on January 4, 2011:</u>
  - We reported the above discovery and our initial response. With the newly developed Safety Limit curves based on the above and reducing the core inlet temperature LSSS from 155 °F to 142 °F, MURR has a safety limit of 14.942 MW with the other three (3) LSSS variables set at their limits. This provides a 2.44 MW margin between the 12.5 MW LSSS and the safety limit. This margin is actually greater than the previous NUS calculated Safety Limit of 14.89 MW.

Note: As described in the August 31, 2010 submittal to RAI 4.17 regarding our Safety Limits, the peaking factors used are extremely conservative because they are a combination of unrealistic or impossible peaking factors determined by three different two-dimensional diffusion code models, which was the only code method available in the early 1970's.

- Additional analysis:
  - While ANL was closed during holiday break, our analysis was sent by email to Dr. Feldman for his review when he returned to work on January 4, 2011. He completed his review by the end of the day on the 4th. During his review, he identified the following error in our calculations: the azimuthal hot stripe to hot plate peaking factor of 1.07 had been multiplied to two different component peaking factors that are then combined to calculate the overall peaking factor. This resulted in an effective hot strip peaking factor of 1.145 instead of the actual factor of 1.07.

  - Correcting this error and using the actual 1.07 hot stripe factor, the MURR Safety Limits were recalculated. It was determined that based on the new limits the only change required was reducing the core inlet temperature LSSS from 155 °F to 153 °F. The actual scram set points are set more conservatively than the LSSSs and the current core inlet temperature scram set point is 148 °F, so no adjustment is required to meet this proposed revision to the LSSS. It only requires reducing the actual Safety Limit table values and curves.

- <u>During our phone conversation on January 5, 2011</u>
  - MURR reported this correction in a conference call on January 5, 2011. With the new Safety Limit curves, in conjunction with reducing the core inlet temperature LSSS from 155 °F to 153 °F, MURR has a new Safety Limit of 14.955 MW with all four (4) LSSS variables at their limits. This provides a 2.45 MW margin between the 12.5 MW LSSS and the Safety Limit (actual high power scram is set at 119% of 10 MW, or 11.9 MW). This new Safety Limit with the other three (3) variables at the LSSS is actually greater than the previous NUS calculated Safety Limit of 14.89 MW.

  - Based on this analysis, MURR feels that the current scram set point of 148 °F provides a sufficient margin for safety and does not need to be adjusted to meet a reduction in the new core inlet temperature LSSS of 153 °F. A Reactor Operations standing order has been issued that administratively implements the new reduced Safety Limit curves and LSSS for core inlet temperature until such a time when an Amendment can be submitted.

  - MURR staff stated that we would be submitting a report as required by the MURR Technical Specifications.

- **<u>Basis for the New Safety Limits</u>**
  - Since 2006, MURR has been actively collaborating with the ANL/RERTR group on the conversion from HEU to LEU fuel. During this time, the team has benchmarked the MURR HEU fuel and reactor core design performance.

- We now have more accurate peaking factors that can be used in determining appropriate Safety Limits:
  - The ANL/RERTR group and MURR have completed HEU benchmarking work using REBUS/DIF3D, MCNP, and PLTEMP to support the LEU conversion analysis.
  - We have excellent agreement for our current 775 gram U-235 fuel element operating in both the earlier 1971 reflector arrangement and the current "2008" reflector arrangement.
  - We have benchmarked the MURR mixed core burnup fuel cycle and determined the peaking factors. Our worst case peaking is in a mixed core with a fresh fuel element running adjacent to one in its last week of operation before reaching the 150 MWD burnup limit.
  - *Combining the new MURR/ANL Feasibility Analysis peaking factors with the corrected Bernath/BOLERO/Waters & Croft methodology for safety limits, a new set of Safety Limits were developed that meet the current criteria.*

- New Safety Limit tables and graphs have been calculated using the ANL worst case HEU mixed core peaking factors combined with the MURR Safety Limit engineering peaking factors, with an additional 1.04 peaking factor on both the hot spot heat flux and coolant channel enthalpy rise.

To conclude, with all LSSS variables at their worst case SCRAM set points and the reactor operating at that point, there would have been 1.24 MW margin between the combined SCRAM set points and the safety limit.