Comments by Dale Lancaster on the

Comparison of Pressurized Water Reactor Depletion Code Validation Approaches

The first comment is that the report is very needed to flush out the understanding on this issue. Although the following comments may sound critical, the work done by the NRC to produce this document is greatly appreciated.

1. Page 2 first paragraph. The basis of the Kopp 5% is not documented. It is not wise to create a justification at this point. From my conversations with people who were around at the time of the Kopp memo, it was important that there was good agreement between the fuel management tools and measurements but the 5% came from reactivity balances (boron letdown curves and startup soluble boron measurements). A 5% error in the power distribution or soluble boron prediction does not imply 5% agreement in depletion reactivity. Larry Kopp would not have been so loose as to suggest that a 5% agreement on figures of merit implies a 5% depletion uncertainty.
2. Page 2 third paragraph. Again, this paragraph suggests the 5% comes from agreement of 5% with a "certain measured values." The only measured parameter that would apply to the depletion reactivity is the change in boron concentration with burnup. Again, Larry was not using 5% from some generic good agreement point of view. Kopp did not use the relative assembly power agreement. That is strictly the EPRI approach and converting that agreement to a reactivity is a new development done for the EPRI project. (It is correct that Westinghouse developed a method of fuel management optimization using power distributions/reactivity but this had never been applied to criticality prior to the EPRI work I proposed.)
3. Direct Difference Section, Second Paragraph. Where does the 95/50 come from? On Page 38 of NUREG/CR-7108 it specifically says the analysis of the tolerance limit was 95/95. The only other analysis I know of was the analysis for Indian Point and it too was 95/95.
4. EPRI Reactivity Benchmarks first paragraph 4th line. The measured data was mainly used to infer a bias not an uncertainty. It is clear from the report that uncertainty in this bias is difficult.
5. EPRI Reactivity Benchmarks first paragraph 7th line. The 11 benchmarks are produced in the benchmark report. The utilization report demonstrates how to use these 11 benchmarks in criticality validation.
6. EPRI Reactivity Benchmarks second paragraph. It is true that the uncertainty at hot full power was estimated. However, there is a fundamental disagreement with the NRC on whether we should have 95/95 uncertainty on the next measurement of the depletion bias or 95/95 uncertainty in the mean bias. Both the tolerance band and confidence band are given on the figures. The problem is we know the bands are not correct since the data is highly correlated. EPRI chose an uncertainty that was considerably higher than the calculated confidence band to cover this correlation. Recent work addresses this better. The foot note talks about similar problems with the chemical assays but the big difference is the amount of measurements. There are greater than 10 times as many measurements with the EPRI data.

DESIGNATED AS ORIGINAL

BRIAN BENNEY

7. EPRI Reactivity Benchmarks third paragraph. Table 5.2 is the bias between SCALE and the benchmarks not CASMO 5. CASMO 5 varies from the benchmarks as shown on Table 7.1 of the EPRI benchmark report.
8. EPRI Reactivity Benchmarks third paragraph. NUREG/CR-7108 and the Utilization report address both bias and uncertainty. Yes the **bias** from the two reports are similar but the source of the uncertainty is the set of experiments which are very different so it is not expected that the uncertainty would be similar.
9. EPRI Reactivity Benchmarks fourth paragraph. Although both the EPRI and NUREG approaches are dependent on measured data, the EPRI approach utilizes 1816 measurements rather than 100 thus reducing the uncertainty in the mean.
10. Most of the rest of the report goes into statistics that I am not prepared to discuss without better understanding, however, I am surprised that the report is disagreeing with the NUREG/CR-7108 assessment of the 95/95 limit from the direct difference approach. Do the authors of NUREG/CR-7108 agree with this new statistical analysis? I have used the statistical approach given in NUREG/CR-6698 and get similar results as the current NUREG/CR-7108. Is the NUREG/CR-6698 approach inappropriate for this analysis? Does this mean it is inappropriate for the fresh fuel criticals validation?
11. This report accepts the analysis of the chemical assays used in NUREG/CR-7108 without modification. It is now known that the TMI data is poor (email from Ian Gauld, 5/23/2016). Also the HB Robertson sample that is high is due to inappropriate analysis. Prior to final conclusions it seems that the chemical assay analysis needs independent review and updated with the chemical assays added since NUREG/CR-7108. An independent analysis was performed for the Indian Point Unit 2 LAR and can be found on ADAMS with ML14329A195.
12. Conclusion 2nd paragraph. The USM approach uses large burnup bins, 0-15, 15-40, and 40 to 60 GWd/T. In these large bins it is assumed that the multiplicative bias is a constant. However, it is known that the form of the bias is not a simple multiple on the isotopic content. For example, the bias for U-235 should be zero at zero burnup than an additive bias should be proportional to the change in content from the initial condition. U-238 has the same problem. For isotopes such as Pu-239 which have no initial content, the multiplicative bias is appropriate at low burnups. However, at high burnups Pu-239 content equilibrates. As this equilibration happens the functional form of the bias changes. The USM approach cannot pick this up with the large burnup bins. The direct difference approach utilizes the actual burnup of each point. Further, there is a dependence between isotopes for a sample. That is Pu-240 content depends on the Pu-239 content and so forth. The direct difference approach includes this dependence but the USM approach assumes that the content of each isotope is independent. This actually makes the direct difference approach more sound.
13. Conclusion last paragraph. It is a poor choice of words to describe two methods which result is clear quantities for the depletion uncertainty as "qualitative." Both methods rely on some estimation. In the case of the Kopp memo the basis for the estimation is not documented. In the case of the EPRI approach the estimations are presented with rationale. All approaches, including those based on the chemical assays, require approximations. It is best to be specific about the acceptability of particular approximations to aid in the decisions resolving the depletion uncertainty.