LSNReviews

From: Tripp, Christopher
Sent: Tuesday, January 12, 2010 11:20 AM
To: Sippel, Timothy; Whaley, Sheena
Subject: DOE's RAI
Attachments: Thoughts on DOEs RAI 1-7-10.doc

Jack asked me to review their RAI response and work with you on it. I'm not an expert on BWR burnup credit, but here are my comments on what they sent in. Please let me know if there's anything I can do to assist, though if it involves a lot of effort we should re-TAR it.

I'm wondering also what we're trying to do, as I thought we'd decided that we'd finished the review and were going to do license conditions/tech specs/etc. SO can yo utell me how this fits in?

Thanks,
Chris

Thoughts on DOE's RAI Dated January 7, 2010

I have not reviewed the issues discussed herein in detail, nor have time to do so. So these just represent my initial impressions, based on my limited knowledge of Tim's and Oleg's review.

General Comment: The RAIs basically are saying there isn't enough data to support DOE's taking full burnup credit (in one case, for specific nuclides; in the other, for BWRs). Resolving this issue would seem to require one of three things: (1) new data, (2) more margin, or (3) new analysis showing that the current margin is sufficient. There is no new data available, and DOE is not adding any margin, so the only option is new analysis. However, the documents that were submitted along with the RAI response all appear to be older documents, usually several years old. So it does not appear at first glance that the responses have provided any significant new information that would change the underlying fact that the available data is insufficient.

RAIs 25 & 26

The basic response to our saying there isn't enough data to take credit for the 5 nuclides (^{95}Mo, ^{99}Tc, ^{101}Ru, ^{103}Rh, and ^{109}Ag) is that they have lots of margin. They claim the Δk_{ISO} of 0.0249 is very large, and that the added 5% burnup penalty is very conservative, for example. However, the penalties are assigned because of a lack of experimental data, so they can't be taken credit for as being conservative. For example, part of the reason for the large Δk_{ISO} is because there is a lot of variability in the available data and the fact that it tests not normal. It is as large as it is out of necessity, not because they're trying to be conservative.

Part of the problem with the response is that the analysis lumps together all 29 nuclides, and does not directly address the lack of data to support the 5 metal nuclides. There is a lot of data for many of the 29 principal isotopes, so lumping all the nuclides together makes the situation appear less serious than it is. Examples:

Figure 1 shows the spread in biases for individual state points compared to the penalty Δk_{ISO}. This is meant to show that Δk_{ISO} is bounding, as of course it must be. So what? If you look at the figure closely, the spread in data is on the order of ~2% (one sigma, estimated by eyeball). The largest spread covers a range in Δk_{eff} from roughly -0.025 to roughly 0.06, or a spread of ~8.5%. The value of Δk_{ISO} of 0.0249 is hardly large compared to this, and in fact, a couple of the data points (out of roughly 100) appear to be just on the line, so there's maybe only a 98% confidence that a future calculation below the "licensing basis" will be subcritical.

Figure 2 shows that the value of Δk_{ISO} is larger than the reactivity effect of burnup credit, over the range up to 50 GWd/MTU. This of course is good, but hardly demonstrates the adequacy of coverage of the 5 metal nuclides, because these burnup curves are calculated using the entire set of 29 principal isotopes.

The only specific discussion of the 5 individual nuclides is the first paragraph on page 2 of the response. The discussion of sensitivities to changes in the macroscopic cross section is not convincing. The numbers quotes for $(\delta k/k)/(\delta n/n)$ are dimensionless; they give the percent change in k_{eff} corresponding to a 1% change in the macroscopic cross section. They cannot be directly compared to the uncertainty in k_{eff}, because they are sensitivities, not k_{eff} values. To be converted to k_{eff} values, they must be multiplied by the percent uncertainty in the cross section.

Consider the differential sensitivity of ^{103}Rh, which is 8.24×10^{-3}. This is about ¼ as large as the overall k_{eff} uncertainty, 3.16×10^{-2}. This is not a large difference, and, if the uncertainty in the ^{103}Rh macroscopic cross section—which is a function both of uncertainty in the microscopic cross section and the calculated number density— is more than a few percent, it may not be bounding. Also, the overall uncertainty must encompass the uncertainty in all the nuclides, when the uncertainties in the individual nuclides are combined.

Summary: The statistical calculation of k_{eff} and its uncertainties and margins is a mathematical exercise, one that does not take into account the differing physics of individual nuclides. Also, the statistical quantities are calculated on the basis of all 29 principal isotopes. The question of whether the validation covers any particular nuclide is a completely separate one.

RAI 36

NOTE: I am a lot less knowledgeable when it comes to BWR burnup credit.

The response is based on reports with the term "code-to-code comparison" in the title. NRC's historic position has been not to allow validation based on code-to-code comparison. If DOE's justification for BWR is based in part on code-to-code comparison, care should be taken to ensure that the codes are independent to extent possible (different nuclear data sets, different cross section treatments, etc.). Complete independence will probably not be possible since the codes must all model the same underlying physics phenomena.

The answer to the claim that the BWR RCA data is insufficient is that it was lumped together with PWR RCA data. As with RAI 25&26, statistics derived by lumping the data together does little to justify extension of the area of applicability to regions where there is little data available. The basic disagreement seems to be over whether the existing RCA data is sufficient.

Figure 1 shows that burnup credit is only taken for initial enrichments above 4.5wt%. (Below this, they must assume fresh fuel.) It does appear that there is considerable margin above about 4wt%, but there doesn't appear to be any inventory above 4.5wt%. Perhaps the limited amount of BWR burnup credit needed could be part of the justification for acceptability, but this raises the question of whether they even need BWR burnup credit.