From: Kimberly Gruss
To: Machiels, Albert
Date: 08/12/2002 10:07AM
Subject: RE: ISG 11

Hi Albert-

Thanks for your comments. I will take a look at the paper that you attached. Please note that any email message that I receive are publically available documents.

I look forward to discussing your comments in more detail at the upcoming NEI/NRC meeting on the ISG.

Kim

>>> "Machiels, Albert" <AMACHIEL@epri.com> 08/07/2002 7:47:42 PM >>>

Hello! Kim!

Thank you for the copy of ISG-11, Rev. 2. As you can guess, I have more than just a passing interest in this document. I realize that you did not specifically ask for my reactions. But anyway, here they are.

First of all, Rev. 2 provides specific guidance for storage, but delays the resolution for transportation (Rev. 3?). I will discuss storage and transportation separately.

Storage

I truly believe that this Revision is a giant step forward compared to the guidance contained in Rev. 1.

What I like about the revision:

1. It is applicable to all fuel that is currently licensed by the NRC for commercial plant operations. What is acceptable to be used in-reactor for power operation is acceptable for the purpose of this ISG. The present revision eliminates the disconnect between the NRC regulations (Parts 50 and 72), which was a sore point with the licensees.

2. It eliminates the restrictions with regard to cladding oxide thickness limitations and spalling. Therefore, the need for canning when cladding oxide thickness are determined to be over 70 to 80 micrometers is eliminated. With Rev. 1, avoiding canning of the assemblies would have required reliance on analytical tools to predict cladding oxide thickness, or actual measurement campaigns (practicality and $$$). Therefore, implementing canning would probably have been the most direct and practical implementation path with Rev. 1.

3. I does not specify a maximum hoop stress, which would have resulting in over-constraining the problem.

4. It does not specify a creep strain limit (such as 1%), which does not have a true physical meaning.

5. The maximum cladding temperature of 400°C is reasonable; it provides

some flexibility to the applicant in terms of optimizing cooling time versus initial storage temperature versus maximum cladding temperature experienced during the fuel drying procedure.

6. It does not require performing detailed calculations of cladding hoop stress and creep deformation (strain). Revision 2 is simple and practical, and appears devoid of requiring an abundance of calculations with regard to temperature history, stress history, creep evaluation, etc. Instead, it specifies a reasonable upper temperature limit, and this provides an acceptable envelope for the prevention of excessive damage to the fuel, with little need to dwell into the details.

7. It retains a high temperature limit (570°C) for hypothetical accidents involving fires [and off-normal thermal transients? See (2) below].

Some additional feedback:

1. A couple of utility individuals I talked to did not understand the technical basis for the limitation on thermal cycling. One of them thought it had to do with fatigue! There is a bit of education to do here. I obviously noticed that you went for the most conservative delta in temperature for thermal cycling (65°C). I had proposed a slightly higher delta (~100°C). This is the area that is likely to result in the highest level of questions or feedback from the users.

2. In the very last paragraph on page 2 in the Appendix, a clarification may be needed. The paragraph states on line 1 "Regarding accidents involving a fire or off-normal thermal transients, ..." In the next sentence, "off-normal thermal transients or accidents" is again stated; however, at the end of that sentence, the 570°C is specifically mentioned for "an accident involving a fire." The question that arises is whether this sentence should be read as the 570°C limit applies to only "accidents involving a fire", or to "accidents involving a fire or off-normal transient", as the reading of the entire paragraph would appear to imply.

3. I am not sure why there is such an explicit reference to the " ... evaluations of fuel rod structural integrity, such as the buckling analysis, ..." As discussed previously, this does not appear (to me) to have any useful purpose. I will refer again to ISG-3 that states, most appropriately in my opinion: "The accident analysis chapters should be rewritten to require that the staff evaluate all credible accidents and focus the review on those accidents with potential consequences resulting in the failure of the confinement boundary." [Also, for your information, three years ago, EPRI provided some brief comments on ISG-12 "Buckling of Irradiated Fuel Under Drop Conditions". The EPRI comments are attached below. They were transmitted to NRC by NEI in a letter, from Lynnette Hendricks to Bill Brach, dated June 30 1999].

Transportation

This remains to be nailed down. On Thursday, July 31, I was part of a short discussion (over the phone) involving Wayne Hodges, Lynnette Hendricks, and myself. Wayne indicated that a consensus with regard to transportation did not yet exist, and that some additional work remains to be done. The one item that seemed to be on Wayne's mind was §71.55 "General requirements for fissile material packages". It was my impression that Wayne was comfortable with the ability of the transportation package to meet the containment and shielding regulations embodied in §71.51, as they apply to hypothetical accident condition (§71.73). Wayne referred specifically to §71.55(e). The latter reads:

(e) A package used for the shipment of fissile material must be so designed and constructed and its contents so limited that under the tests specified in §71.73 ("Hypothetical accident conditions"), the package would be subcritical. For this determination, it must be assumed that:

(1) The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package and the chemical and physical form of the contents;

(2) Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents; and

(3) There is full reflection by water on all sides, as close as is consistent with the damaged condition of the package.

So, the question would appear to be: After the package has incurred all the abuse stipulated in §71.73, does it still maintain subcriticality?

If we assume that the fuel either remains intact, or is extremely damaged, it is generally accepted that the probability of creating a configuration involving some debris more reactive than the intact configuration is vanishingly small. In addition, in performing criticality calculations, an administrative margin of 0.05 for the effective multiplication coefficient is taken into account. The origin for this margin, according to Don Carlson who used to be on the NMSS staff, was for protection against unanalyzed configurations. My interpretation of Don's statement is that since there is always a remote possibility that the material might reconfigure itself into a more reactive configuration, this would be prevented by this administrative margin. Therefore, we have a "belt and suspender" approach: a 5% hit on the effective multiplication factor to protect against the improbable coupled with reconfiguration highly likely to result in a less reactive configuration.

The reason I am going into so much detail is that I am looking for technical areas in which a contribution could be made in this area as well. With regard to establishing a framework for continuing working on Questions B.4 and B.6, I would simply refer to my letter to you dated July 19.

Since there is talk of a meeting (at least in the planning stage) (1) to advertise ISG-11 and provide a forum for questions and clarifications, and (2) possibly, for closing open items between SFPO and NEI (scope/schedule of responses to RAI Questions B.4 and B.6), I hope that this long e-mail provides a few things we should think about ahead of the proposed meeting.

Obviously, I would be delighted to know any reactions you may have, either by e-mail, or over the phone (650-855-2054) to the contents of this e-mail. We all do really appreciate your hard work.

Best regards,

Albert.

-----Original Message-----
From: Kimberly Gruss [mailto:KAG1@nrc.gov]
Sent: Tuesday, August 06, 2002 10:32 AM
To: apn@nei.org
Cc: Joe@anatech.com; amachiel@epri.com; lxh@nei.org
Subject: RE: ISG 11

ISG11, Rev 2 ... Hot off the press...

>>> "NELSON, Alan" <apn@nei.org> 07/29/2002 3:00:59 PM >>>
great

-----Original Message-----
From: Kimberly Gruss [mailto:KAG1@nrc.gov]
Sent: Monday, July 29, 2002 2:56 PM
To: apn@nei.org; M. Wayne Hodges; Robert Temps
Cc: lxh@nei.org
Subject: Re: ISG 11

Alan-
The ISG will most likely be issued on 7/31. I will talk to Wayne about scheduling a meeting.
Kim

>>> "NELSON, Alan" <apn@nei.org> 07/29/2002 1:38:31 PM >>>
Wayne:

We have all worked extremely hard to bring high burnup to it's current resolution.
NEI and EPRI would like the hold a 1/2 day high burn up workshop with SFPO once the ISG has been published.
I know that the industry is quite anxious and will be willing to discuss implementation first hand.

Let's discuss at your connivance.

I assume that you will be publishing ISG 11 tomorrow as planned.
Could you please forward an electronic copy to me and Lynnette when it is available.

Thanks
Alan

Alan Nelson
Nuclear Energy Institute
<mailto:apn@nei.org> apn@nei.org
(202) 739 8110

Fuel Rod Buckling - ISG-12

Background

The buckling analysis contained in LLNL Report UCID-21246 has been rejected by the NRC staff on the grounds that it is over-simplified. To make the point, IGS-12 contains Euler buckling calculations that differ from LLNL's calculations by adding the mass of the fuel, thereby calculating a new buckling load that is about six times smaller. The ISG, however, admits that Euler buckling analysis approach can lead to unrealistically small buckling loads, and recommends that a dynamic buckling analysis would be acceptable, if the cladding stress is demonstrated to remain below yield. The ISG also calls for modifying NUREG-1536 to "clearly reflect analytical approach to fuel rod buckling analysis".

Industry Response

Comments on ISG-12

The fuel-rod buckling issue is one of the few safety issues that can be resolved generically. Although the industry is in general agreement with the ISG's recommendations, the following points need to be made:

(1): The buckling problem has been addressed in two previous studies: an EPRI study, EPRI-NP-7419, dated July 1991, and a DOE study, SAND90-2406 • TTC-1019 • UC-820, dated November 1992. These two studies came after the LLNL report. However, ISG-12 reads as if no work, other than UCID-21246, has been done on the subject.

(2): From basic principles, the Euler-buckling analysis of a dynamic event is not a valid approach. This can be easily demonstrated by examining the frequency domains of the two interacting deformation modes of the fuel rod under end drop, namely, the axial and the flexural modes. For these two modes to interact in time to cause buckling, the time duration of the impact load has to be at least as long as the period of the flexural mode. Simple calculations will show that the fundamental flexural period of a single span, considering fuel mass and cladding-only moment of inertia, is 120 ms. This is roughly 10 times higher than the impulse duration of an end drop. This is confirmed by the EPRI and Sandia studies referenced above. It is clear from the above, that the impact event is over, long before the flexural mode has time to be activated, and the occurrence of buckling post rebound would not be technically feasible.

(3): The EPRI study referenced above shows, in a dynamic analysis of an end-drop event, that the cladding stresses remain below yield for a g-loading of 300 g's. The analysis conditions are consistent with the requirements stated in the ISG. The DOE study, however, goes beyond the elastic response, and shows that a 15x15 PWR assembly and a 7x7 BWR bundle may sustain strains at the lowest mid-span of 2% and 0.25%

respectively for 9-m regulatory drop. The 2% strain (0.8% elastic + 1.2% plastic) is well within the cladding capacity. The report calculates failure probabilities for these rods of 10^{-7} and 10^{-13} respectively.