Subject: Re: Discussion on ballooning and rupture models
From: Ralph Meyer <rmeyer@goeaston.net>
Date: 10/12/2016 11:55 AM
To: "Bales, Michelle" <Michelle.Bales@nrc.gov>
CC: "Scott, Harold" <Harold.Scott@nrc.gov>, "Lee, Richard" <Richard.Lee@nrc.gov>

Michelle,

I'm glad to see that you are taking the discussion of a review seriously, but I need to make it clear that I am not advocating the models in NUREG-0630. Although I think the data on which NUREG-0630 is based are still totally relevant, I believe the models in NUREG-0630 are outdated.

There are three models of interest: (1) rupture conditions; (2) ballooning strains; and (3) assembly flow blockage. All might be different for the newer alloys, but my main concern is with the ballooning strains. If you focus on the data points in Fig. 8 of NUREG-0630, you will see two peaks and a valley. The peaks will shift to the left or right for modern high-burnup fuel because of increased fission gas pressure and alloy phase differences. The peaks might go up or down a little because of rupture properties of newer alloys. You might be able to get an indication of these trends from separate-effect tests.

Nevertheless, the overwhelming message from Fig. 8 is that the rupture process is stochastic (we all understand why). It no longer seems appropriate to try to mechanistically model Fig. 8 with a conservative bound because new alloys and high burnup have added two more "dimensions" of variability (left and right, and up and down in Fig. 8).

Now that the licensing limit is so strongly dependent on the ballooning strains, I think you have to shift from inappropriate mechanistic modeling to statistical modeling and agree on some characteristic of the data distribution for the model (e.g., median, mean, one sigma, 95%). Although it seems harsh to reject all current mechanistically based models and require new statistically based models, it's really not that much of a big deal. Because of alloy and burnup effects, I'm guessing that you just make a temperature-independent representation of Fig. 8 – scaled up or down a little for alloy effects and add any new data points you can find – and then turn it over to a statistician. Couple days work.

Regarding the five points of your discussion outline:

I don't think we need to discuss the first two because models similar to those in NUREG-0630 no longer seem appropriate.

I have no problem in the third point with covering uncertainties with conservatisms in other parts of the general model as long as you don't sell the pig twice.

I disagree with the fourth point. There should be a sense of urgency about this because these models were used to generate the results on which Paul's safety evaluation (2/10/12) was based. If

these models are inadequate, then you should not conclude that this safety assessment confirms the safe operation of the U.S. commercial nuclear fleet.

The fifth point seems like a good idea and I don't think I would have anything to add.

I think we are making progress with these emails, but we can still have a phone call if it's desirable. Putting this off for a couple weeks is good for me because it will give me a chance to hook up some headphones I have ordered to my telephone. Maybe then I can follow a phone conversation better.

Ralph

On 10/11/2016 5:37 PM, Bales, Michelle wrote:

> Ralph,
>
> We can accommodate your request for moving forward with a combination of emails and phone calls.
>
> Attached is a copy of the one-pager that has been coordinated with a few other staff in NRR and RES. It was prepared last week and it doesn't address some of the additional points you raised in the email below. However, it will give you a better idea of the type of information we thought we'd discuss.
>
> I suggest that we set up a call with the folks in NRR and RES that have been discussing your technical concerns where you will have an opportunity to ask any questions that come up from reading the one pager. You can also expand on the points you raise below. I will forward your email to them in preparation for the call.
>
> A few of us have some conflicts over the next two weeks, so I would like to ask about your availability in early November. What would be the best time and day to reach you?
>
> - Michelle Bales
>
> Senior Reactor Systems Engineer
> Office of Nuclear Regulatory Research
> U.S. Nuclear Regulatory Commission
> Phone: 301-415-1783
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> ---
>
> **From:** Ralph Meyer [mailto:rmeyer@goeaston.net]
> **Sent:** Saturday, October 08, 2016 1:26 PM
> **To:** Bales, Michelle <Michelle.Bales@nrc.gov>
> **Cc:** Scott, Harold <Harold.Scott@nrc.gov>; Lee, Richard <Richard.Lee@nrc.gov>
> **Subject:** [External_Sender] Re: Discussion on ballooning and rupture models
>
> Michelle,
>
> Thanks for answering by email. I can't believe how bad my hearing has become, and it affects almost everything I do now. Nevertheless, I can talk on the telephone, but I have to concentrate so much on figuring out what is being said to me that it's a distraction. We can probably make progress using a combination of emails and phone calls, but frankly I don't think I have much to add that's not explained in my letter.

Let me try to address your 4 bullets:

Bullet #1

I don't know what your have in mind regarding 2009, but I personally am not familiar with any B&R testing since 1980 that fits the stringent requirement for internal heating. This data requirement was paramount following the sausage-balloon results of Ed Hindle in the UK which nearly shut down the industry. We dismissed those results on the basis of non-prototypicality, and then proceeded to evaluate more prototypical results in NUREG-0630. This report was issued in draft form for comment and was heavily reviewed by ACRS before being issued as a final report.

B&R tests with internal heaters are extremely expensive and I doubt that much more has been done since the big-budget days of the 1970s. Maybe Patrick has looked into this.

Likewise I am unfamiliar with B&R models. I think most or all industry models try to be mechanistic, and I believe that such an approach cannot work. The B&R process is stochastic for the several reasons we are all familiar with; therefore, only a statistical approach would be suitable. I doubt this has ever been done, but it should not be difficult.

Bullet #2

I'm sure that all the vendors mention NUREG-0630 in reference to their models, but I have no information on the vendors' models. Not long after NUREG-0630 was issued, Lester Rubenstein (associate division director) personally negotiated deals with all the vendors. The vendor models were never reviewed by the Reactor Fuels Section, and not long thereafter the Reactor Fuel Section was disbanded (Powers to R-III, Tokar to NMSS, Voglewede to ADM, and I went to RES). If the models were reviewed at all, it was done by Landry or other T-H people.

Bullet #3

My concern is simply that I don't think the vendor B&R models have ever been reviewed critically, and now that they will probably be controlling they should be critically reviewed.

Bullet #4

I think the only reasonable resolution of this issue is to require the industry to prepare new statistical models and submit them for NRC review. If a vendor is already using a statistical model, then you, who have the fuels background, should review it again in light of its new found importance.

Hope this helps. Let's continue.

Ralph

On 10/7/2016 4:33 PM, Bales, Michelle wrote:

> Dear Ralph,
>
> I'm writing regarding your petition on the subject of ballooning and rupture models. I presume you've received a letter from NRR already and you probably noticed that it stated, "The staff will engage with you to better understand your technical concerns." The format of the engagement is flexible, and our initial thought was to have a group of the technical staff have

a conference call with you. The objectives of the call would be to:

- Provide information about activity on the subject of ballooning and rupture models that has occurred since 2009.
- Describe in a general way how NUREG-0630 is being used by vendors today.
- Seek feedback on whether we have fully understood your technical concern.
- Present actions related to ballooning and rupture models that are being considered.

Harold mentioned to me that a conference call may not be the easiest thing, because it may be difficult to hear. I have been working with Harold, Paul Clifford, and a few other staff in NRR and RES to outline some thoughts for the call on a one-pager. We could send that one-pager to you ahead of the call so you'd have something in front of you during the call in case it became difficult to hear. What are your preferences for our interaction? Please let us know and we will make our plans to accommodate your preferences.

Best Regards,

- Michelle Bales

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