From: Donna Gilmore <dgilmore@cox.net>
Sent: Monday, May 18, 2015 5:44 PM
To: Akhavannik, Huda
Cc: CHAIRMAN Resource; Shane, Raeann; Marvin Lewis; Marvin Resnikoff; Arjun Makhijani; Mary Olson; Rick Morgal; Jeff Steinmetz; Ace Hoffman - SONGS; Diane D'Arrigo; Joseph Street; Marni Magda; David Lochbaum - Union of Concerned Scientists; Frank N. von Hipple; Arnie Gundersen; Mary Beth Brangan; Peter Lam; Per Peterson; John Geesman; Kevin Barker - CEC; Michal Freedhoff; Hira Ahluwalia
Subject: Comment for 5/18/2015 High Burnup Fuel meeting

NEI's statement in today's (5/8/2015) HBF meeting that high burnup fuel will be the same as lower burnup fuel is not supported by data. Also, when I pressed for data, NEI admitted their claim that "high burnup is better" based on how it acts in the reactor, not in dry storage. Until the public has data to support NEI's statements, they cannot be believed.

I appreciate that the NRC technical staff were able to make some very good comments and clarifications in this meeting. It's an indicator we need more reliance on NRC technical staff and less delegation to the nuclear industry and utilities.

The San Onofre thin steel canisters have been loaded with spent fuel starting in 2003. Based on technical data, much of which was provided in NRC meetings on stress corrosion cracking, it is clear these canisters may have through wall cracks within 8 years. Especially since we have similar environmental conditions to the Koeberg South Africa plant that had a similar component with a through-wall crack of 0.6" -- greater than the thickness of most U.S. canisters (0.5" to 0.625"). Both plants have a higher risk environment for chloride-induced stress corrosion cracking (CISCC): on-shore winds, ocean surf and frequent year-round fog. And after learning that a Diablo Canyon canister has a low enough temperature (85 degrees or less) and highly corrosive magnesium chloride salts after only two years of loading, it could even happen sooner.
https://sanonofresafety.files.wordpress.com/2011/11/diablocanyonscc-2014-10-23.pdf

Please advise what the difference in impact will be with a through-wall canister crack with and without failed cladding. Please include this in your RIS and NUREG-1927 Rev 1. Dr. Singh, Holtec CEO, stated even a microscopic crack will release millions of curies of radiation and it's not practical to repair these canisters.
https://www.youtube.com/watch?v=euaFZt0YPi4&feature=youtu.be

Given the fact even one of these canisters contains more radiation than that released at Chernobyl, this is of major concern to California.

I was not allowed to make an additional public comment during today's meeting, so I am writing the following comment instead. Please include this in meeting minutes. NEI's comment that the Fukushima casks were similar to the U.S. dry storage system is not true. Fukushima used thick steel casks stored in concrete reinforced buildings. They did not use thin steel canisters. It was also low burnup fuel with fewer fuel assemblies per cask and lower heat loads. Also, Japan limits drying temperature to 275 degrees C (instead of the U.S. 400 degrees C for HBF), which

as stated in this meeting, is a major factor for potential cladding embrittlement. See below links for supporting documents.
https://sanonofresafety.files.wordpress.com/2013/06/fukushimacaskspecifications2010.jpg

https://www.iaea.org/OurWork/ST/NE/NEFW/Technical-Areas/NFC/documents/spent-fuel/TM-45455/Agenda-10-JAPAN_of_Dry_Cask_Inspection_at_Fukushima_2013_7.pdf

https://sanonofresafety.files.wordpress.com/2013/06/caskstoragebeforefukushimadisaster.jpg

http://energy.gov/sites/prod/files/Gap%20Comparison%20Rev%200.pdf
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Except for Japan, which considers the thermal profiles it currently has as adequate, there is consensus that more thermal modeling is needed. Regulations in Japan limit peak cladding temperature to only 275°C, much lower than the 400 °C peak cladding temperature limit in the United States.

Because nearly all degradation mechanisms are temperature-dependent, thermal profile histories are needed to predict SSC performance. Therefore, temperature data are needed for all SSCs from the time the fuel is loaded into the cask, dried, through the storage period, and during subsequent transportation. The NRC issued guidance on temperature limits based on the need to maintain the integrity of the cladding (NRC 2010b). Therefore, when making approximations for modeling, most modelers have used conservative ones to ensure cladding does not exceed those limits. However, because some degradation processes only occur as the dry cask storage system (DCSS) cools below a threshold temperature, more realistic thermal calculations are needed. Similarly, conservatively high temperatures would over-predict various degradation rates.

The following data conflicts with NEI's claims that there is no difference to cladding based on burnup. As promised, I'm sending you links for the documents I referenced in today's meeting. I recommend the NRC reference the following studies in the RIS and NUREG-1927 Rev 1. If the NRC disagrees with this, please advise.

If NEI continues to provide the public and others with misinformation, it is even more important for the NRC to reference data studies that counter NEI "misinformation". The NEI referenced the Billone study (Report #1 below) as if it is the only study that made the case for high burnup cladding embrittlement, which, of course, is not the case. The second and third documents below provide data based on actual irradiated fuel rods from reactors.

This chart is referenced as Figure 20 in the NWTRB report #2 below and as Figure 2-2 in the EPRI report #3 below.
https://sanonofresafety.files.wordpress.com/2013/06/higherburnupcladdingfailurechart1.jpg

Report #1

Ductile-to-Brittle Transition Temperature for High-Burnup Zircaloy-4 and ZIRLO™ Cladding Alloys Exposed to Simulated Drying-Storage Conditions M.C. Billone, T.A. Burtseva, and Y. Yan Argonne National Laboratory September 28, 2012.

http://pbadupws.nrc.gov/docs/ML1218/ML12181A238.pdf

"...the trend of the data generated in the current work clearly indicates that ***failure criteria for high-burnup cladding need to include the embrittling effects of radial-hydrides for drying-storage conditions*** *that are likely to result in significant radial-hydride precipitation...A strong correlation was found between the extent of radial hydride formation across the cladding wall and the extent of wall cracking during RCT [ring-compression test] loading."*

Report #2
U. S. Nuclear Waste Technical Review Board (NWTRB) fuel cladding failure chart (Figure 20 on page 56) and December 2010 report
https://sanonofresafety.files.wordpress.com/2013/06/usnwtrb-evaloftechbasisforextendeddrystorageandtransportofusednuclearfuel2010-dec-eds_rpt.pdf
A second consequence of in-reactor corrosion, particularly in PWRs, is partial absorption of the corrosion-product hydrogen into the Zircaloy metal (hydrogen pickup) that can lead to hydrogen embrittlement (loss of cladding ductility) of the cladding. When the concentration of hydrogen in solution in the Zircaloy matrix exceeds the solubility limit, the excess hydrogen precipitates as hydrides. Cladding is manufactured with a texture to ensure that hydrides precipitate generally in a circumferential direction upon reactor cool down (lower photograph in Figure 19). Hydride precipitation can be evenly distributed or dominate in certain areas.(67) Both cladding hydrogen content and effective wall-thickness are correlated to the amount of oxidation that occurs on the outer surface of the cladding. Plotting more than 4,400 measurements from commercial fuel-rods taken from reactors around the world, Figure 20 shows the maximum outer-surface oxide-layer thickness data in low-Sn Zircaloy-4 cladding plotted as a function of burnup (68)

Report #3
Spent Fuel Transportation Applications—Assessment of Cladding Performance EPRI 1015048 Final Report, December 2007
http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001015048&Mode=download
Page 2-2 Oxide Thickness and Hydrogen Content
Cladding hydrogen content and effective wall thickness are correlated to the cladding outersurface zirconium oxide. The maximum outer-surface oxide layer thickness data, as a function of fuel rod average burnup, are shown in Figure 2-2 for UO2 fuel rods with low-tin Zircaloy-4 cladding material irradiated to burnup levels greater than 60 GWd/MTU. Figure 2-2 contains more than 4,400 measurements from commercial fuel rods irradiated in reactors worldwide [14]. See Figure 2-2 Cladding Outer Surface Oxide Layer Thickness versus Rod Average Burnup

The NEI claimed the newer cladding are improved. This Billone study shows the newer claddings M5 and ZIRLO are actually worse than the older cladding for storage. See links to the study and the slides below. The NRC should use this data and other cladding storage data when evaluating whether to approve higher burnups and newer cladding alloys in reactors. At a recent NRC meeting regarding approving a new cladding material for a reactor, when I mentioned that these newer claddings may have performance problems in storage, the response was that the NRC person was aware of this study, but unless Mark Lombard (NRC Director of Spent Fuel Management Division) tells them it's a problem, they don't plan on including this data in their evaluation.

Report #4
Ductile-to-Brittle Transition Temperatures for High-Burnup PWR Cladding Alloys Mike Billone and Yung Liu Argonne National Laboratory U.S. NWTRB Winter Meeting November 20, 2013, DOE Slide Presentation

- https://sanonofresafety.files.wordpress.com/2014/02/billone2013-09-30embrittlementdbtthighbrnup-pwrfuelclad-alloys.pdf
- http://www.nwtrb.gov/meetings/2013/nov/billone.pdfSlide 6 Cladding Mechanical Properties and Failure Limits
  -
    -
    - Available for HBU Zircaloy-4 (Zry-4) with circumferential hydrides
    - Available for Zry-2 but data needed at high fast fluence (i.e., HBU)
    - **Data needs**
      - Tensile properties of **HBU M5® and ZIRLO™** cladding alloys
      - Failure limits for **all cladding alloys** following drying and storage
        - Radial hydrides can embrittle cladding in elastic deformation regime
  - **Slide 12 Summary of Results**
    - **Susceptibility to Radial-Hydride Precipitation**
      - Low for HBU Zry-4 cladding
      - **Moderate for HBU ZIRLO™**
      - **High for HBU M5®**
    - **Susceptibility to Radial-Hydride-Induced Embrittlement**
      - Low for HBU Zry-4
      - **Moderate for HBU M5®**
      - **High for HBU ZIRLO™**

Report #5 NEI's claims become even more proposterous considering the information in this DOE document. I've provided just one example below, showing how the fuel structure and other factors change due to high burnup.
USED FUEL DISPOSITION CAMPAIGN, Review Of Used Nuclear Fuel Storage and Transportation Technical Gap Analyses, 28 July 31, 2012

http://energy.gov/sites/prod/files/2013/06/f1/FY12%20Review%20of%20Used%20Nuclear%20Fuel%20Storage%20and%20Transportation%20Technical%20Gap%20Analysis.pdf

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As a general rule, the quantity of fission gases, such as xenon and krypton, released from the fuel pellet increases with increasing burnup. In reality, the duty cycle, which is a combination of parameters such as the operating power level, temperature, and other factors, has a larger direct effect than burnup. Actinides such as plutonium, americium, and curium are also generated in the fuel by neutron capture reactions. The quantity of both fission products and higher actinides increases roughly linearly with burnup.

Another major change occurs when the local pellet burnup reaches about 40 GWd/MTU. At this burnup, the fuel undergoes a microstructure change with the formation of the high burnup structure (HBS) or pellet rim (Lassman et al. 1995). Typical LWR fuel pellets have grain sizes between 7 µm and 14 µm, whereas the HBS forms subgrains on the order of 0.1 µm to 0.2 µm and a fine network of small (~1 µm) fission gas bubbles. The HBS is highly porous, yet it still does not release a significant portion of the fission gases, which remain trapped in the high pressure bubbles within the fuel matrix.

Also, would you please sent the ML number for the NEI slides, since they were not available to the public during the meeting.
Thanks for the following ML# for the NRC 5/18 slide presentation. It was extremely helpful to have this to follow along on the phone call.
http://pbadupws.nrc.gov/docs/ML1513/ML15138A021.pdf

Thank you,
Donna Gilmore
SanOnofreSafety.org
949-204-7794

On 5/18/2015 8:54 AM, Akhavannik, Huda wrote:

Yes, I will provide the ML No. for my slides at the start of the meeting so everyone can follow along on the phone. I did not get NEI's slides.

-----Original Message-----
From: Donna Gilmore [mailto:dgilmore@cox.net]
Sent: Monday, May 18, 2015 11:50 AM
To: Akhavannik, Huda
Subject: today's HBF meeting

Are there slides for today's HBF meeting?