## Gallagher, Carol

(1)

10/24/2017
82FR49233

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| **From:** | Donna Gilmore <donnagilmore@gmail.com> |
| **Sent:** | Tuesday, December 26, 2017 5:55 PM |
| **To:** | Wise, John; Gallagher, Carol |
| **Cc:** | Marvin Resnikoff; Diane D: Arrigo |
| **Subject:** | [External_Sender] Comments for Docket ID NRC-2016-0238 NUREG/CR 2214 Managing Aging Processes In Storage (MAPS Report) and NUREG/CR 7198 Rev 1 Transport (no seismic) |

Please include these as comments to Docket ID NRC-2016-0238 NUREG/CR 2214 Managing Aging Processes In Storage (MAPS Report).

Please extend the review time for NUREG/CR-2214 to January 31, 2018. It's become clear that the documents used as evidence for NUREG/CR 2214 also need to be reviewed. This will require more time.

Overall, I find a lack of evidence for conclusions in NUREG/CR 2214. NUREG/CR 2214 makes statements the NRC has lack of evidence that there are various problems and within certain timeframes. However, the fact the NRC is approving use of inferior thin-wall canisters that are welded shut and that cannot and have not been inspected (inside or out) for cracks or other degradation, and cannot be monitored, repaired or maintained to PREVENT leaks is the root of the problem. Until you address this root problem, you are putting our communities at risk for major radioactive releases, with no adequate plans in place to prevent or stop these releases. Cherry picking data and making assumptions due to inability to inspect canisters and their contents should be unacceptable to anyone who that cares about the future of this country. The problem is now. These canisters are reaching the age of no return. Please include information in this presentation as part of my comments. These issues have not been adequately addressed, but are critical for managing aging processes in storage.

> Coast to Coast Spent Fuel Dry Storage Problems and Recommendations, Erica Gray, NRC REG CON 2015, November 18, 2015
> https://www.nrc.gov/public-involve/conference-symposia/dsfm/2015/dsfm-2015-erica-gray.pdf

I reviewed NUREG/CR 7198 (and Rev 1 which replaces the original) referenced in NUREG/CR 2214. It does not provide sufficient evidence that it can be used as confirmatory research to justify approval of the storage (or transport) of high burnup fuel or the safety of cladding. Neither NUREG mentions it is applicable to seismic loading, nor that it is applicable to all fuels and claddings. Where is the other evidence to support high burnup cladding will not fail?

Also, NUREG/CR 7198 was done assuming undamaged fuel pellets. As you likely know, the uranium pellets can change their grain structure from high burnup fuel and other causes. Is there another study that addresses damaged fuel pellets? At the end of this email I included two reports that indicate more problems, not less.

NUREG/CR 7198 mentions the cladding failures were at the pellet to pellet boundary, which is an indicator it relied on undamaged and intact fuel pellets for structural support. Therefore, if the cladding is dependent on the fuel pellets, that is an unresolved technology gap, so is insufficient to use as confirmatory information without the data on other than intact fuel pellets.

Uranium structure can change with higher burnup fuels. NUREG/CR 7198 use of HB Robinson for irradiated fuel is not typical high burnup fuel, likely due to the relatively low linear power compared to others. Therefore, it is not a conservative evaluation of high burnup fuel or fuel cladding.

**SUNSI Review Complete**
**Template = ADM – 013**
**E-RIDS= ADM-03**
**Add=** J. Wise (JPW1)

*Characterization of High-Burnup PWR and BWR Rods*, Hanchung Tsai (htsai@anl.gov), Mike Billone (Billone@anl.gov), Argonne National Laboratory, Nuclear Safety Research Conference 2002, October 28-30, 2002
https://www.nrc.gov/docs/ML0230/ML023050234.pdf

Slide 4
Limerick and H. B. Robinson Rod Characterization
Fission Gas Release

- H. B. Robinson rods: 1.4 – 2.5%
    - o Probably due to the relatively low linear power: ˜ 8 kW/ft BOL decreasing to 3-4 kW/ft EOL
- Limerick rods: 5 – 17%
    - o Relatively high release attributable possibly to fuel microstructure

The below Oak Ridge slides show some other variables. For example, in the heated samples (heated from the outside in) a bonding of the pellets to the cladding occurred. See other items in red. More unknowns rather than sufficient data.

*CIRFT Testing of High Burnup Used Nuclear Fuel from PWR and BWRs* (slides) J.-A. Wang, H. Wang, H. Jiang, Y. Yan, B. Bevard, Oak Ridge National Laboratory, 2016 Nuclear Waste Technical Review Board (NWTRB), February 17, 2016
http://www.nwtrb.gov/docs/default-source/meetings/2016/february/bevard.pdf?sfvrsn=8

**Slide 11**

**HBR SNF S-N data indicates a hydrogen content dependency**

Hydrogen was estimated from oxide thickness; detailed hydrogen measurements are needed to further quantify any hydrogen-dependent failure mechanism

**Slide 17**

**Annealed SNF CIRFT testing is needed to allow an accurate comparison between HBU CIRFT data and HR CIRFT data**

The hydride reorientation (HR) sample preparation has the potential to introduce a material bias into test results due to the followings:

• **Induces a thermal annealing effect in the clad tubing structure**;

• Heat source of HR samples is initiated from the clad outer surface (~400C), which may reduce clad compressive radial stress and generate a thermal gradient from clad to fuel

• In-situ pressurization of 3,500 psi pressure may reduce the radiation induced clad crimping effect (of 2,450 psi coolant pressure) and counter/decrease the radial **compressive residual stress that occurs during clad irradiation;**

• Combined effects of thermal annealing & clad pressurization could permanently change clad geometry (i.e. enlarge the clad inner wall radius) and reduce the pellet support to the clad.

**Slide 18**

**Initial observations from CIRFT testing include: [why only talking about HBR (HB Robinson fuel)]?**

- The fuel provides strength (flexural rigidity) to the fuel/clad system

- When the clad is fatigued to failure, failure occurs primarily at the pellet-pellet interface

- The fuel pellets retain their shape (dishing and chamfering is evident) and do not become fragmented – very little residue is released from rods that are broken into two pieces

- Considering the complexity and non-uniformity of the HBU fuel cladding system, it was significant to find that the strain to failure data for the SNF was characterized by a curve expected of standard uniform materials

- It was significant to find that the HBU HBR exhibited an endurance limit, if an endurance limit is defined by survival of $>10(^7)$ cycles

- At low loads, the PWR HBR fuel did not fail after >10M cycles

**Slide 19**

**Other observations from the CIRFT testing:**

- Pellet-clad-interaction includes P-C bonding efficiency

- Hydrogen concentration does affect SNF system strength

- The SNF system has significant stress concentrations and residual stress distributions

- It appears that transient shock accumulated damage may reduce the SNF fatigue lifetime

- In addition to the fatigue strength data, fracture toughness data of the SNF system is also essential to assist in the SNF vibration reliability study, especially in a high-rate loading arena

Here are the two reports I reference regarding damaged fuel issues. Were these considered in NUREG/CR 2214?

Impact of High Burnup Uranium Oxide and Mixed Uranium– Plutonium Oxide Water Reactor Fuel on Spent

Fuel Management, IAEA Nuclear Energy Series, No. NF-T-3.8, VIENNA, 2011 http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1490_web.pdf

Page 36

The grain size changes within high burnup fuel as you proceed from the central portion to the outer rim of the fuel. The major portion of high burnup fuel will have a grain size similar to (unchanged from) the as-fabricated grain size of approximately 10 μm typical of commercial fuel. The central portion of the fuel may have some grain growth (up to a factor of 2).[9] The rim portion of high burnup fuel will have much higher burnups than the pellet average and forms restructured fine sub-grains at pellet average burnups > 40 GWd/t U. The sub-grain sizes are generally between 0.1 μm to 0.3 μm [39.49–51]. As the burnup of the rim increases the original as-fabricated grain boundaries begins to disappear as the sub-grain structure becomes dominant. This restructured rim is not present in the older fuel where rod or bundle burnups did not exceed 33 GWd/t U.

Damaged Spent Nuclear Fuel at U.S. DOE Facilities, Experience and Lessons Learned, by INL, Nov 2005 INL/EXT-05-00760,

https://inldigitallibrary.inl.gov/sites/sti/sti/3396549.pdf

Page 4 & 5:
The uranium metal SNF [Spend Nuclear Fuel] within the DOE inventory contains many elements whose cladding was breached during reactor discharge, subsequent handling, or storage. Initial cladding failures varied from minor cracks to severed fuel elements. The reaction of exposed uranium metal with water produces uranium dioxide and hydrogen. This reaction is not a result of chemical impurity of the basin water. It is a chemical reaction of the water with the uranium metal. Uranium hydride forms from the available hydrogen, particularly where there is a limited amount of oxygen (see Reference 3). The lower densities of the uranium oxide and uranium hydride products relative to the uranium metal cause swelling of the material within the cladding and subsequent additional cladding damage. Additional water reaction then occurs with the newly exposed uranium metal. **Each cycle of fuel-water reaction results in fission product releases and contamination of water in the canister or the storage pool**. Examples of uranium metal SNF element damage after extended water storage are shown in Figure 3. In extreme cases, the uranium metal has also been known to completely oxidize and form a mud-like mixture with the water.

The generation of high surface area uranium metal SNF fragments and uranium hydride necessitates additional measures during SNF drying, dry storage, and transportation because of the **pyrophoric nature of these materials when exposed to air**. As a result, degraded uranium metal fuels are stored and transported in inerted canisters after removal from the basin and drying. Radiolysis of water within the SNF-water corrosion products must also be addressed for long-term storage because of the **ability of the resultant gases to**

**overpressurize containers, embrittle welds on containers, and reach flammable concentrations.**

Thanks,
Donna Gilmore

On 11/21/2017 12:24 PM, Wise, John wrote:

Donna,
Thank you for bringing this question forward. On page 3-89 (Section 3.6.1.1), the NRC referred to the confirmatory research at Oak Ridge National Laboratory to verify the staff's expectation of the structural integrity of the high burnup fuel cladding under normal, off-normal, and accident conditions of storage (which includes seismic loading). The results of that research have since been published: NUREG-CR 7198, Revision 1 (ML17292B057).

I'm sure we'll have a chance to discuss this further at the public meeting, but I'll suggest that you submit a formal comment as described in the Federal Register notice to ensure that the NRC staff evaluates the need to more fully describe the technical basis for the integrity of the high burnup cladding.

Regards,
John

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**From:** Donna Gilmore [mailto:donnagilmore@gmail.com]
**Sent:** Monday, November 20, 2017 4:08 PM
**To:** Wise, John <John.Wise@nrc.gov>
**Cc:** Marvin Lewis <marvin.lewis1938@gmail.com>; Ace Hoffman <rhoffman@animatedsoftware.com>; Ray Lutz <raylutz@citizensoversight.org>
**Subject:** [External_Sender] NRC Meeting: NUREG-2214 Managing Aging Processesln Storage (MAPS Report)

John,
Would you please provide the technical references used to substantiate the below statement in NUREG-2214. If I'm understanding this correctly and after reviewing other information, it's claiming cladding embrittlement is only a problem in something as severe as a transport accident, such as with a 30 foot drop, or when retrieving fuel assemblies. Is there a seismic analysis that was done that addresses cladding embrittlement in dry storage in a high risk earthquake zone such as San Onofre?

Page 3.6
**Although hydride reorientation and hydride-induced embrittlement of high-burnup cladding is credible, these mechanisms are only expected to potentially compromise intended functions under pinch-type loads. Such loads are not expected to be present during storage.*

https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2214/

Thanks,

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