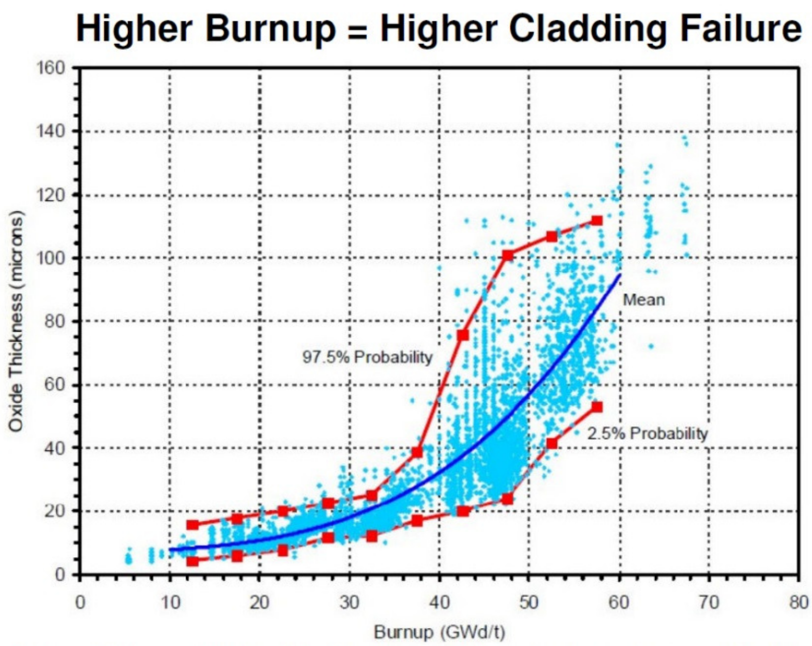
High Burnup Nuclear Fuel – Unstable in Storage and Transport

High burnup fuel is unstable in both storage and transport. High burnup fuel (HBF) is fuel that has burned about twice as long in a nuclear reactor as lower burnup fuel. This increased burnup, although profitable to the nuclear industry, causes the highly radioactive fuel to become over twice as hot, both thermally and radioactively.

Consequences of High Burnup Fuel

- **Damaged fuel assemblies and baskets**: HBF can continue to degrade during both short and long term dry storage, resulting in damaged fuel cladding, damaged uranium fuel pellets, and damaged aluminum alloy fuel assembly baskets. HBF creates oxides and hydrides in these materials.
- **Explosions and Criticality**: If HBF is exposed to 5% air in dry storage, it can result in hydrogen gas explosions from the metal hydrides. If damaged fuel rods in dry storage are exposed to unborated water they will go critical.
- **Brittle Fuel Rods:** Radial cracks form in HBF cladding, causing the fuel rods to become brittle, where it can shatter like glass, especially in transport. And there is no seismic earthquake evaluation of HBF rods.

Higher Burnup = Higher Cladding Failure
Plots of more than 4,400 measurements from commercial fuel-rods from reactors around the world show both medium burnup fuel (>35 GigaWatt days per ton) and high burnup fuel (>45 GWd/t) increase oxide thickness, making fuel cladding subject to damage and hydrides.

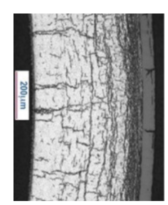


Higher oxide thickness results in higher cladding failure. Argonne scientists reported high burn-up fuels may result in fuel rods becoming more brittle over time. "… insufficient information is available on high burnup fuels to allow reliable predictions of degradation processes during extended dry storage." U.S. Nuclear Waste Technical Review Board *Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel*, December 2010, Burnup Chart Page 56

The NRC should treat HBF as damaged fuel and should stop approving use of HBF.

Instead, they make the problem worse by allowing unsafe storage and transport of high burnup fuel.

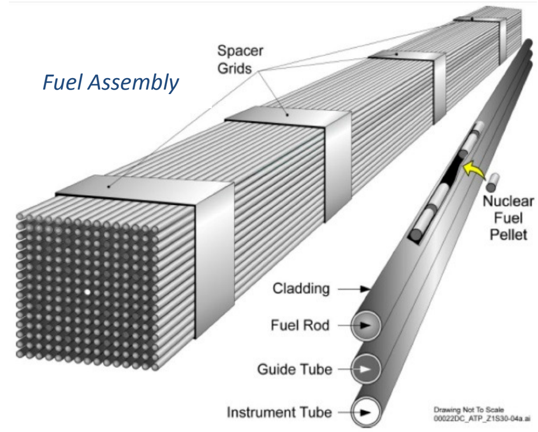
- **The NRC continues to approve higher and higher burnups.** They redefined HBF from >35 GWd/t to >45 GWd/t.
- **The NRC approves thin-wall (mostly ½" thick) stainless steel welded dry storage canisters**. These canisters cannot be inspected (inside or out). They cannot be maintained to prevent cracks, leaks, explosions or criticalities.
- **The NRC refuses to treat high burnup fuel as damaged fuel.** The NRC requires each damaged fuel assembly to be placed in unsealed damaged fuel cans before loading into storage containers. These damaged fuel cans do not fully replace the function of the sealed fuel rods. Other countries used tubes or quivers that seal each rod, replacing the defense in depth lost by damage fuel rods.
- **The NRC approves high burnup fuel transport**. The NRC is still studying whether train vibrations will cause cladding to fail. NRC regulations require intact containment (*10 CFR § 71.85 Packaging and Transportation of Radioactive Materials).*
- **The NRC ignores risk of aluminum fuel assembly basket failure.** Japan banned use of aluminum alloy fuel baskets. They may not last 60 years, even with lower burnup fuels.



Damaged fuel rod

- **The NRC assumes no through-wall cracks in thin-wall canisters and no transport accidents with canister leaks.** However, the NRC admits once cracks start in a thin-wall stainless steel canister, they can penetrate the wall in 16 years. The Koeberg nuclear plant in South Africa had a tank the NRC considers comparable to canisters, leak in only 17 years with cracks up to 0.61" long. A 2-year old Diablo Canyon canister has all the conditions for cracking from a marine environment. Other environmental and manufacturing conditions can cause cracks in thin-wall canisters.

References



High Burnup Nuclear Fuel, Pushing the Safety Envelope, Dr. Marvin Resnikoff, Donna Gilmore, January 2014
https://sanonofresafety.files.wordpress.com/2014/01/hbffactsheet01-09-2014.pdf

High Burnup Fuel Fact Sheet, Donna Gilmore, January 2017
https://sanonofresafety.files.wordpress.com/2018/01/highburnupfuelfactsheet2018-01.pdf

GNS IQ Integrated Quiver System *http://www.gns.de/language=en/29870/quiver-iq*

Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel, Nuclear Waste Technical Review Board, December 2017
http://www.nwtrb.gov/docs/default-source/reports/nwtrb-mngmntanddisposal-dec2017-508a.pdf?sfvrsn=12

NRC Safety Evaluation Report, Docket No. 71-9302, Areva Model NUHOMS-MP197HB Package, Certificate of Compliance No. 9302, Rev. No. 7, April 23, 2014 *http://pbadupws.nrc.gov/docs/ML1411/ML14114A132.pdf https://www.nrc.gov/docs/ML1411/ML14114A049.html*

Holtec Response to NRC First Request for Additional Information (RAI) for HI-STORM UMAX Canister Storage System (TAC No. L24664), January 30, 2013 *https://www.nrc.gov/docs/ML1303/ML13032A008.pdf*

Risk of criticality in dry storage if unborated water enters canister, comments for Docket ID NRC-2016-0238, NUREG/CR 2214 Managing Aging Processes in Storage (MAPS), Donna Gilmore, December 26, 2017
https://sanonofresafety.files.wordpress.com/2018/01/criticalitycommentsdocketnrc-2016-0238-nuregcr-2214agingmgmtmaps.pdf

Research and Development Activities Related to the Direct Disposal of Dual Purpose Canisters, William Boyle, U.S. Dept. of Energy, U.S. Nuclear Waste Technical Review Board, April 16, 2013 *http://www.nwtrb.gov/docs/default-source/meetings/2013/april/boyle.pdf*

Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel, Nuclear Waste Technical Review Board, Douglas Rigby, December 2010, PP 55 & 56 *http://www.nwtrb.gov/docs/default-source/reports/eds-final.pdf?sfvrsn=8*

Damaged Spent Nuclear Fuel at U.S. DOE, Facilities, Experience and Lessons Learned, INL/EXT-05-00760, Brett Carlsen, et.al, November 2005, Page 4 & 5 *https://inldigitallibrary.inl.gov/sites/sti/sti/3396549.pdf*

Impact of High Burnup Uranium Oxide and Mixed Uranium– Plutonium Oxide Water Reactor Fuel on Spent Fuel Management, International Atomic Energy Agency, IAEA No. NF-T-3.8, 2011, P. 36 *http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1490_web.pdf*

Comments Docket ID NRC-2015-0241 Draft SFM-Interim Staff Guidance (ISG)-2, Rev. 2, Fuel Retrievability in Spent Fuel Storage Applications, D. Gilmore, November 2015
https://sanonofresafety.files.wordpress.com/2013/06/retrievabilityisg2rev2commentsdocketnrc-2015-0241dgilmore2015-11-20.pdf

Used Nuclear Fuel Storage and Transportation Data Gap Prioritization, Christine Stockman, Sandia Lab (SNL), Brady Hanson (PNNL), Abdelhalim Alsaed (Enviro Nuclear Services), April 28 – May 2, 2013 Slide 25-30, *https://www.osti.gov/scitech/servlets/purl/1078639*

ACRS Recommendations for Improvements to the NRC Staff's Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, ACRSR-1885, Dana A. Powers, April 13, 2000, p. 3 *https://www.nrc.gov/docs/ML0037/ML003704532.pdf*

Explosive Characteristics of Titanium, Zirconium, Thorium, Uranium and their Hydrides, U.S. Dept. of the Interior, Bureau of Mines, Irving Hartmann, et.al., December 1951 *https://sanonofresafety.files.wordpress.com/2014/12/4410914explosivezirconiumdivofmines.pdf*

Comments to NRC proposed rule for regulatory improvements for decommissioning power reactors, Docket NRC-2015-0070, Sierra Club, March 2016 *https://www.nrc.gov/docs/ML1608/ML16082A004.pdf*

Dry Cask Inventory by State, June 2013 *https://sanonofresafety.files.wordpress.com/2015/10/d32-caskinventorybystate2017-05-18.pdf*

U.S. Nuclear Power Reactor Damaged Spent Fuel Assemblies, June 2013
https://sanonofresafety.files.wordpress.com/2011/11/totaldamagedfuelassemblies2013june30.pdf

Letter to DOE from NWTRB, Nuclear Waste Technical Review Board Comments on Post Irradiation Examination Plan for High Burnup Demonstration Project Sister Rods, June 3, 2016 *http://www.nwtrb.gov/docs/default-source/correspondence/rce060316.pdf?sfvrsn=17*