Waste Confidence Generic Environmental Impact Statement Comments

Docket ID No. NRC–2012–0246

1. **How can the NRC GEIS have confidence in extended storage when the NRC and the Department of Energy (DOE) have not completed their research on extended storage and transportation?** The NRC does not have the research data (let alone the solutions) to validate the draft Generic EIS conclusions. The DOE has identified 94 critical technical data gaps in knowledge of spent nuclear fuel (SNF) storage and transportation.[1] NRC and DOE extended storage and transportation research should be completed before the NRC completes their EIS.

2. **How can the NRC GEIS have confidence in extended storage of high burnup (>45 GWd/MTU) spent nuclear fuel (SNF) when the NRC states they have insufficient data to support dry cask licensing for more than an initial 20 years for high burnup SNF?** See Division of Spent Fuel Storage and Transportation Interim Staff Guidance-24, Revision 0, *The Use of a Demonstration Program as Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years*[2]

3. **How can the NRC GEIS have confidence in extended storage of SNF when their own Interim Staff Guidance 11, rev 3, *Cladding Considerations for the Transportation and Storage of Spent Fuel* excludes approval of transportation casks for high burnup SNF** (except on a case by case basis)?[3] The fuel is over twice as radioactive as lower burnup fuel and is hotter, requiring up to a minimum 20 years cooling in spent fuel pools.[4] The fuel is proving unstable in storage and there are no current solutions to these problems. The NRC GEIS[5] quotes one study (Pages B-13 and B-23) regarding the problems of fuel cladding embrittlement with high burnup SNF, yet ignores the potential consequences of this – shattering of the embrittled fragile fuel cladding, which could release radiation into the environment. (See Attachment A for details).

4. **How can the NRC GEIS have confidence in extended storage of SNF when the independent U.S. Nuclear Waste Technical Review Board (NWTRB) December 2010 report, "Evaluation of Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel,"[6]** states "Argonne scientists reported high burn-up fuels may result in fuel rods becoming more brittle over time." And "…insufficient information is available on high burnup fuels to allow reliable predictions of degradation processes during extended dry storage." The NRTWB report also states:

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[1] DOE Review *of Used Nuclear Fuel Storage and Transportation Technical Gap Analyses*, 7/31/2012 http://1.usa.gov/1bQr5xO

[2] Division of Spent Fuel Storage and Transportation Interim Staff Guidance-24, Revision 0, *The Use of a Demonstration Program as Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years* http://pbadupws.nrc.gov/docs/ML1305/ML13056A516.pdf;
Status of NRC Research on High Burnup Fuel Issues (Slide 7) Dr. Robert E. Einziger http://1.usa.gov/15E8gX5 Hear 3/13/2013 Conference session on Storage and Transportation of High Burnup Fuel. Dr. Einziger's presentation starts at minute 39:50. http://www.nrc.gov/public-involve/conference-symposia/ric/past/2013/docs/audio/w24.mp3.

[3] NRC Interim Staff Guidance 11, rev 3, *Cladding Considerations for the Transportation and Storage of Spent Fuel* http://www.nrc.gov/reading-rm/doc-collections/isg/isg-11R3.pdf

[4] Appendix A to CoC No.1029, Technical Specifications for the Advanced Nuhoms® System (Table 2.12) http://pbadupws.nrc.gov/docs/ML0515/ML051520131.pdf

[5] NRC *Draft Waste Confidence Generic Environmental Impact Statement NUREG-2157*, September 2013 http://pbadupws.nrc.gov/docs/ML1322/ML13224A106.pdf http://www.nrc.gov/waste/spent-fuel-storage/wcd/pub-involve.html

[6] U.S. Nuclear Waste Technical Review Board (NWTRB) *Evaluation of Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel*, December 2010 http://bit.ly/1jfI1Sn

> *Only limited references were found on the inspection and characterization of fuel in dry storage, and they all were performed on low-burnup fuel after only 15 years or less of dry storage. Insufficient information is available on high-burnup fuels to allow reliable predictions of degradation processes during extended dry storage, and no information was found on inspections conducted on high-burnup fuels to confirm the predictions that have been made. The introduction of new cladding materials for use with high-burnup fuels has been studied primarily with respect to their reactor performance, and little information is available on the degradation of these materials that will occur during extended dry storage.*

5. **Why did the NRC GEIS choose to ignore information about how the level of burnup negatively impacts extended storage in both dry casks and spent fuel pools?** Most of the cases made in the GEIS are for lower burnup fuel. Information for high burnup fuel is consistently ignored or downplayed. Here is one example. See Attachment A for details on this example and other examples.
   In the paragraph starting on Line 22 of Page B-8, the GEIS cherry picks a paragraph of a 1998 IAEA report[7] and concludes

   > *"the database for zirconium alloys supports a judgment of satisfactory wet storage in the time frame of 50 to 100 years or more*."

   However, in the same paragraph of that 1998 IAEA report (Summary, Page 1), the GEIS chose to exclude this caution about high burnup fuel and details about Zircaloy cladding corrosion.

   > *However, it is necessary to place into perspective the advancing corrosion that has occurred on Zircaloy clad uranium metal fuel from the Hanford N Reactor. The otherwise durable Zircaloy was mechanically damaged during reactor discharge, exposing uranium metal, that is vulnerable to aqueous corrosion in the temperature range encountered in wet storage environments. An additional issue involves advancing corrosion and hydriding of zirconium alloy cladding subject to extended burnup. Diminished low* temperature ductility imposes the need for additional care in spent fuel handling operations to avoid any mechanical impact that may cause cladding fracture.

In addition, see attached document "*High Burnup Nuclear Fuel: No short-term storage or transport solutions*", SanOnofreSafety.org.

More information is available at http://sanonofresafety.org/nuclear-waste/

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[7] IAEA-TECDOC-1012 Durability of spent nuclear fuels and facility components in wet storage, April 1998 http://www-pub.iaea.org/MTCD/Publications/PDF/te_1012_prn.pdf

ATTACHMENT A

EXAMPLE 1. The NRC's *September 2013 Draft Generic Environmental Impact Statement (GEIS) report (NUREG-2157)*[8] references an Argonne Lab and NRC report.[9] This Argonne/NRC report indicates the NRC has insufficient information to assume safe storage of high burnup fuel even short-term. However, the NRC GEIS cherry picks information from this report and concludes otherwise, by this misleading statement on GEIS page B-13: *"…but the NRC is not aware of information that would require it to conclude that high-burnup fuel would need to be repackaged during the short-term timeframe defined in the draft GEIS*." Here is GEIS Page B-13

GEIS Page B-13:

For example, the NRC is aware of concerns regarding potential detrimental effects of hydride reorientation on cladding behavior (e.g., reduced ductility). Reduced ductility, which makes the cladding more brittle, increases the difficulty of keeping spent fuel assemblies intact during handling and transportation. Research performed in Japan and the United States (Billone et al. 2013) indicated that: (1) hydrides could reorient at a significantly lower stress than previously believed and (2) high-burnup fuel could exhibit a higher ductile-to-brittle transition temperature due to the presence of radial hydrides. This phenomenon could influence the approach used for repackaging spent fuel **but the NRC is not aware of information that would require it to conclude that high-burnup fuel would need to be repackaged during the short-term timeframe defined in the draft GEIS.** Should spent fuel cladding be more brittle, greater care could be required during handling operations, regardless of when repackaging would occur, to limit the potential for damage to spent fuel assemblies that could affect easy retrievability of the spent fuel and complicate repackaging operations.

Based on available information and operational experience, degradation of the spent fuel should be minimal over the short-term storage timeframe if conditions inside the canister are appropriately maintained (e.g., consistent with the technical specifications for storage). Thus, it is expected that only routine maintenance will be needed over the short-term storage timeframe. Repackaging of spent fuel may be needed if storage continues beyond the short-term storage timeframe. In the draft GEIS, the NRC conservatively assumes that the dry casks would need to be replaced if storage continues beyond the short-term storage timeframe. The NRC assumes replacement of dry casks after 100 years of service life, even though studies and experience to date do not preclude a longer service life. Accidents associated with repackaging spent fuel are evaluated in Section 4.18 and the environmental impacts are SMALL because the accident consequences would not exceed the NRC accident dose standard contained in 10 CFR 72.106. The NRC is not aware of any additional studies that would cause it to question the technical feasibility of continued safe storage of spent fuel in dry casks for the timeframes considered in the draft GEIS. The NRC continues to evaluate aging management programs and to monitor dry cask storage so that it can update its service life assumptions as necessary and consider any circumstances that might require repackaging spent fuel earlier than anticipated.

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[8] NRC *Draft Waste Confidence Generic Environmental Impact Statement NUREG-2157*, September 2013 http://pbadupws.nrc.gov/docs/ML1322/ML13224A106.pdf

[9] GEIS Page B-23 Reference: Billone, M.C., T.A. Burtseva, and R.E. Einziger. 1 2013. "Ductile-to-Brittle Transition Temperature for High-Burnup Cladding Alloys Exposed to Simulated Drying-Storage Conditions." Nuclear Engineering Division, Argonne National Laboratory, NRC Division of Spent Fuel Storage and Transportation, Journal of Nuclear Materials 433(1–3):431–448. http://www.sciencedirect.com/science/article/pii/S0022311512005181
Executive Summary of above study: http://pbadupws.nrc.gov/docs/ML1218/ML12181A238.pdf

EXAMPLE 2. In the paragraph starting on Line 22 of GEIS Page B-8 Appendix B, the GEIS cherry picks a paragraph of a 1998 IAEA report[10] and concludes "*the database for zirconium alloys supports a judgment of satisfactory wet storage in the time frame of 50 to 100 years or more*." However, in the same paragraph of that 1998 IAEA report (page one of the Summary), the GEIS chose to exclude this caution about high burnup fuel and the details about Zircaloy corrosion:

> **However, it is necessary to place into perspective the advancing corrosion that has occurred on Zircaloy clad uranium metal fuel from the Hanford N Reactor.** The otherwise durable Zircaloy was mechanically damaged during reactor discharge, exposing uranium metal, that is vulnerable to aqueous corrosion in the temperature range encountered in wet storage environments. **An additional issue involves advancing corrosion and hydriding of zirconium alloy cladding subject to extended burnup**. Diminished low temperature ductility imposes the need for additional care in spent fuel handling operations to avoid any mechanical impact that may cause cladding fracture.

EXAMPLE 3. In that same 1998 IAEA report (page 3), additional warnings about higher burnup fuel are described, yet these are not mentioned in the GEIS.

> **RADIATION EFFECTS**
>
> Radiation effects in FSPs arise from gamma radiation from irradiated fuel assemblies or from cobalt-60 or radiocesium sources. The gamma fluxes have little effect on the properties of metals in the FSPs. However, gamma fields have had significant effects in some wet storage facilities that include components with materials that are subject to radiolytic decomposition, notably, neutron absorbers that include organic materials, and rack configurations that trap water that subsequently forms gas pressures from radiolyic decomposition. On the other hand, gamma radiation fields have not seemed to promote substantial increases in corrosion of the metals in wet storage conditions.
>
> There are materials issues from residual effects of reactor irradiations on fuel and cladding. Metallic uranium develops porosity when irradiated to moderate to high burnups. The porous uranium is prone to accelerated corrosion and associated hydriding if exposed to aqueous media, liquid or vapour. Neutron irradiation does not appear to significantly affect uniform corrosion of aluminium and zirconium alloys when subsequently exposed to wet storage conditions. However, losses of ductility have been observed in cladding from high burnup fuels clad with zirconium alloys, interpreted to include effects from irradiation-induced and hydrogen-induced embrittlement. The SSs are susceptible to irradiation-assisted phenomena at grain boundaries (IASCC) that can result in intergranular attack in water at reactor operating thermal regimes. There have not been sufficient systematic studies of irradiated SSs under aqueous storage conditions to isolate specific effects of neutron irradiation on stainless steel corrosion in storage. Stainless steel cladding from LWR service did not show evidence of intergranular attack under wet storage conditions, but SSs exposed in LMRs and OCRs have been subject to intergranular corrosion effects in wet storage that could be due to thermal or radiation effects, or a combination.

EXAMPLE 4: In the same 1998 IAEA report (page 5), additional warnings about high burnup fuel:

> 7. A major consideration in the corrosion of fuel cladding is the potential impact when the fuel is transferred to interim dry storage or to permanent disposal. The concern is not only for diminished cladding integrity but also for water inventories associated with corrosion products. The water is a potential source of future corrosion, pressure buildup due to radiolytic generation of gases, and a source of hydrogen/oxygen mixtures. Observations that crud layers tend to soak loose after a few years of wet storage also has implications when the fuel is shipped, transferred to dry storage, or to a repository. High hydrogen contents of high burnup fuel clad with zirconium alloys suggests care to avoid impacts during fuel handling.

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[10] IAEA-TECDOC-1012 Durability of spent nuclear fuels and facility components in wet storage, April 1998 http://www-pub.iaea.org/MTCD/Publications/PDF/te_1012_prn.pdf

EXAMPLE 5: High burnup fuel usage in U.S. reactors generally started about 15 years ago. GEIS Page B-8 Appendix B (below) mainly uses documents prior to that to support its position on the integrity of spent fuel and cladding in spent fuel pools. It does not state anywhere here that this "justification" doesn't apply to high burnup fuel.

B.3.1.1 Integrity of Spent Fuel and Cladding in Spent Fuel Pools

In **198**4, the NRC provided information supporting the low degradation rates of spent fuel in spent fuel pools based on national and international storage experience, which at that time totaled 18 years of experience with zirconium-clad fuel[2] and 12 years of experience with stainless-steel-clad fuel (49 FR 34658). Examples of the cited information are:

1. In "Behavior of Spent Nuclear Fuel in Water Pool Storage," Johnson (**1977)** reported on corrosion studies of irradiated fuel at 20 reactor pools in the United States, finding no detectable degradation of zirconium cladding.

2. At the American Nuclear Society's Executive Conference on Spent Fuel Policy and its Implications, presented in Buford, Georgia, April 2 to 5, **1978**, Johnson, Jr. (1978) presented "Utility Spent Fuel Storage Experience," which reported that no degradation has been observed in commercial power reactor fuel stored in onsite pools in the United States and that extrapolation of corrosion data suggests that less than a tenth of a percent of the thickness of the zirconium clad would be corroded after 100 years.

3. In "The Long-Term Storage of Irradiated CANDU Fuel Under Water," Walker (**1979**) concluded that "50 to 100 years under water should not significantly affect their [spent fuel bundles] integrity."

Almost 30 years of additional experience has been gained since the publication of the first Waste Confidence rulemaking in **1984**, during which time the technical basis for very slow degradation rates of spent fuel in spent fuel pools has continued to grow. Examples of this additional experience include the following:

1. In "Durability of Spent Nuclear Fuels and Facility Components in Wet Storage," the IAEA (**1998**) summarized the durability of materials in wet storage, stating: "The zirconium alloys represent a class of materials that is highly resistant to degradation in wet storage, including some experience in aggressive waters. The only adverse experience involves Zircaloy clad metallic uranium where mechanical damage to the cladding was a prominent factor during reactor discharge, exposing the uranium metal fuel to aqueous corrosion. Otherwise, the database for the zirconium alloys supports a judgment of satisfactory wet storage in the time frame of 50 to 100 years or more."

2. In "Spent Fuel Performance Assessment and Research: Final Report of a Co-Ordinated Research Project on Spent Fuel Performance Assessment and Research (SPAR) **1997–2001**," the IAEA (2003b), while discussing spent fuel storage experience reported on a detailed review of the degradation mechanisms of spent fuel cladding under wet storage and stated that "wet storage of spent fuel only appears to be limited by adverse pool chemistry or the deterioration of the fuel storage pool structure."

[2] In 1984, only two commercial light water reactor nuclear power plants used stainless-steel-clad fuel, whereas most used zirconium-clad fuel (49 FR 34658).

High Burnup Nuclear Fuel

No short-term storage or transport solutions
Docket ID No. NRC-2012-0246

The Nuclear Regulatory Commission (NRC) states they have no safe short-term storage or transportation solutions for high burnup[1,2] spent nuclear fuel:

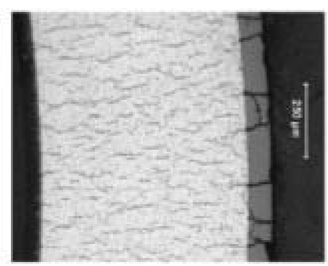
- Insufficient data to approve high burnup dry cask storage for over 20 years,[3] and
- No approved transportation casks to safely move high burnup spent nuclear fuel offsite. *Exceptions approved on a case-by-case basis*.[4]

San Onofre[5] and Diablo Canyon[6] nuclear power plants both use high burnup fuel as do other U.S. nuclear power plants.[7] The NRC approved high burnup fuel about 15 years ago.[8]

High burnup fuel stays in the reactor longer, thus increasing industry profits, but makes us less safe. The NRC defines "high burnup" as fuel that has burned over 45 gigawatt-days per metric ton of uranium (>45 GWd/MTU). However, according to a June 15th, 2013 Department of Energy (DOE) report, experimental data suggests fuel with burnup as low as 30 GWd/MTU shows signs of premature failure.[9]

The NRC has not approved short-term storage and transportation because numerous scientific reports have shown these high burnup fuel problems:

- **Unstable and unpredictable in storage**
  - The protective Zirconium metal cladding around the low enriched (up to 5% U-235) uranium fuel is becoming brittle, making it fragile and subject to shattering. If the radiation breaches the cladding, it can also breach the steel canister and cement cask, release radiation into the environment.
  - High burnup fuel reacts with the Zirconium cladding resulting in hydrides, adding the risk of a hydrogen explosion.



Microscopic View of Fuel Clad Hydrides

- **Hotter and over twice as radioactive**
  - Requires up to a minimum cooling of 20 years in spent fuel pools (instead of 5 years for lower burnup fuel).[10] Fuel cladding temperature must be 400° C (752° F) or less before moving fuel assemblies to dry storage.[11]
  - Requires over double the storage space (of lower burnup fuel) in a permanent geological repository and there are no geological repository designs for high burnup fuel. [12]

The NRC has known for decades of high burnup fuel problems,[13] yet continues to approve use of this fuel. In some cases, it has approved burnup levels up to 75 GWd/MTU.[14]

High Burnup Nuclear Fuel

No short-term storage or transport solutions
Docket ID No. NRC-2012-0246

The independent U.S. Nuclear Waste Technical Review Board December 2010 report, "*Evaluation of Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel,*"[15] states ***"Argonne scientists reported high burn-up fuels may result in fuel rods becoming more brittle over time*.**" And "***…insufficient information is available on high burnup fuels to allow reliable predictions of degradation processes during extended dry storage.***" It also states

> *Only limited references were found on the inspection and characterization of fuel in dry storage, and they all were performed on low-burnup fuel after only 15 years or less of dry storage. Insufficient information is available on high-burnup fuels to allow reliable predictions of degradation processes during extended dry storage, and no information was found on inspections conducted on high-burnup fuels to confirm the predictions that have been made. The introduction of new cladding materials for use with high-burnup fuels has been studied primarily with respect to their reactor performance, and little information is available on the degradation of these materials that will occur during extended dry storage.*

There is no technology to monitor conditions inside dry casks.[16] According to Argonne scientists, this requires sensors with (1) the ability to endure temperatures above 200 degrees C, (2) the ability to endure radiation levels higher than 1000 rads per hour, (3) a means of "harvesting" the energy inside the container, and (4) batteries that will power the sensors for more than 10 years, and (5), a way to wirelessly transmit the sensor data out of the cask.

Statistics from the Nuclear Energy Institute (NEI):

- High burnup fuel has been stored in dry casks in the U.S. since 2003
- Approximately 200 loaded-casks contain high burn-up fuel
- Most fuel in pools for future loading is high burn-up.[17]

RECOMMENDATIONS

The NRC should stop approving high burnup fuel. The NRC should not approve the Waste Confidence Generic Environmental Impact Statement, since they do not have sufficient data on extended storage of high burnup to have confidence this waste can be safely stored or transported.

The DOE and NRC should take a leadership role in finding both short and long term storage and transport solution for high burnup spent fuel, and not depend on the nuclear industry to put safety over profits. This should take priority over research for new reactors and nuclear waste reprocessing. Congress should provide adequate funding to find a solution that puts safety above industry profits.

High Burnup Nuclear Fuel

No short-term storage or transport solutions

Docket ID No. NRC-2012-0246

REFERENCES

[1] Low enriched uranium (up to 5% U-235) fuel that has burned over 45 gigawatt-days per metric ton of uranium is high burnup (>45 GWd/MTU). Spent fuel assemblies with average burnups exceeding 45 GWd/MTU are only approved for transport on a case-by-case basis. NRC Spent Fuel Project Office Interim Staff Guidance - 11, Revision 3, Cladding Considerations for the Transportation and Storage of Spent Fuel, Nov 17, 2003 http://www.nrc.gov/reading-rm/doc-collections/isg/isg-11R3.pdf

[2] Division of Spent Fuel Storage and Transportation Interim Staff Guidance-24, Revision 0, *The Use of a Demonstration Program as Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years* http://pbadupws.nrc.gov/docs/ML1305/ML13056A516.pdf;
NRC Dr. Robert E. Einziger: *insufficient data to support licensing dry casks for >20 years*, (slide 7) *Status of NRC Research on High Burnup Fuel Issues,* March 13, 2013 Regulatory Information Conference session on *W24-Storage and Transportation of High Burnup Fuel.* Dr. Einziger is Senior Materials Scientist, NRC Division of Spent Fuel Storage & Transportation http://1.usa.gov/15E8gX5,
Audio of Dr. Einziger's presentation starts at minute 39:50: http://www.nrc.gov/public-involve/conference-symposia/ric/past/2013/docs/audio/w24.mp3

[3] Ibid

[4] NRC Spent Fuel Project Office Interim Staff Guidance - 11, Revision 3, Cladding Considerations for the Transportation and Storage of Spent Fuel, Nov 17, 2003 http://www.nrc.gov/reading-rm/doc-collections/isg/isg-11R3.pdf

[5] NRC Inspection Report: San Onofre Independent Spent Fuel Storage Installation (ISFSI), May 20, 2011. Attachment 2 LOADED CASKS AT THE SONGS ISFSI (last 3 pages of document). http://pbadupws.nrc.gov/docs/ML1114/ML111430612.pdf

[6] NRC Inspection Report: Diablo Canyon Independent Spent Fuel Storage Installation (ISFSI), May 20, 2013. Attachment 2 LOADED CASKS AT THE DIABLO CANYON POWER PLANT ISFSI (last 2 pages of document) http://pbadupws.nrc.gov/docs/ML1314/ML13140A430.pdf

[7] DOE Inventory and Description of Commercial Reactor Fuels within the United States, March 31, 2011 (Table 7) http://sti.srs.gov/fulltext/SRNL-STI-2011-00228.pdf

[8] GAO-12-797 SPENT NUCLEAR FUEL: Accumulating Quantities at Commercial Reactors Present Storage and Other Challenges, August 2012 http://www.gao.gov/assets/600/593745.pdf

[9] DOE FCRD-NFST-2013-000132, Rev. 1; Fuel Cycle Research & Development-Nuclear Fuel Storage and Transportation-2013-000132, Rev. 1, June 15, 2013 http://www.hsdl.org/?abstract&did=739345

[10] No. 1029 Technical Specifications for Advanced NUHOMS® System Operating Controls and Limits, Appendix A Table 2-12 (page 2-16) http://pbadupws.nrc.gov/docs/ML0515/ML051520131.pdf

[11] NRC Spent Fuel Project Office Interim Staff Guidance - 11, Revision 3, Cladding Considerations for the Transportation and Storage of Spent Fuel, Nov 17, 2003 http://www.nrc.gov/reading-rm/doc-collections/isg/isg-11R3.pdf

[12] RWMA Marvin Resnikoff, PhD: *The Hazards of Generation III Reactor Fuel Wastes* May 2010 http://bit.ly/19dVRsY

[13] NRC Agency Program Plan for High-Burnup Fuel, To NRC Commissioners, July 6, 1998 http://bit.ly/19R1i2L

[14] Catawba Nuclear Station, Environmental Assessment & Finding of No Significant Impact, Federal Register Vol 75, No. 142, Docket 50-413 & 50-414; NRC-2010-0260, 7/26/10 http://www.gpo.gov/fdsys/pkg/FR-2010-07-26/html/2010-18241.htm

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15 U.S. Nuclear Waste Technical Review Board (NWTRB) *Evaluation of Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel*, December 2010 http://bit.ly/1jfI1Sn

16 Fancy New Lids for Nuclear Waste Casks, As Contents Get Hotter, Jeff McMahon, May 2, 2013 http://www.forbes.com/sites/jeffmcmahon/2013/05/02/fancy-new-lids-for-nuclear-waste-casks-as-contents-get-hotter/?view=pc
Division of Spent Fuel Storage and Transportation Interim Staff Guidance-24, Revision 0, *The Use of a Demonstration Program as Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years* http://pbadupws.nrc.gov/docs/ML1305/ML13056A516.pdf;
Briefer on the DOE's High Burn-Up Used Fuel Demonstration Project,John Kessler EPRI, Power Engineering 10/11/2013 http://www.power-eng.com/articles/npi/print/volume-6/issue-5/departments/nuclear-world/briefer-on-the-doe-s-high-burn-up-used-fuel-demonstration-project.html

17 *Cask Storage of High Burn-up Fuel,* NEI, Marc Nichol 7/25/2012 presentation Slide 3 http://sanonofresafety.files.wordpress.com/2013/06/nei-highburnupslide2012-07-25.pdf