Definition of high burnup fuel (HBF)

Gilmore: What was the technical basis for changing the definition of high burnup fuel from >40 GWd/MTU to >45 GWd/MTU in NUREG-1536, *Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility*? Please provide technical references in your response.

NRC:
The demarcation point between high and low burnup is not a sharp cut off in terms of material properties, but rather a gradual change over a range of burnups (Ref. 1, Sections 4.1.2, and 4.1.3). The definition of high burnup fuel has evolved over time with our understanding of the effects of increased fuel irradiation times in reactor cores, and it continues to be defined differently for different purposes (e.g., in-core operations versus dry storage). For example, 45 GWd/MTU is not considered a particularly high burnup in reactor operation, as average fuel discharge burnups are above this value. Also, other regulatory institutions have set the definition of high burnup fuel at different values. For example, IAEA Specific Safety Guide SSG-15, "Storage of Spent Nuclear Fuel," (Ref. 2) defines high burnup fuel as that having a burnup higher than 55 GWd/MTU.

NRC currently defines high burnup fuel in dry storage and transportation at greater than 45 GWd/MTU, as discussed in Spent Fuel Project Office Interim Staff Guidance – 11, Revision 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel," (ISG–11, Rev. 3) (Ref. 3) and has required applicants to provide additional fuel data or conservative safety analyses for fuel above this value. In the 1990s, when average discharge burnups for spent fuel were less than 30 GWd/MTU, (Ref. 4) high burnup fuel was defined at a lower value than today, since average discharge burnups are now greater than 45 GWd/MTU. At the time NUREG-1536 (Ref. 5) was originally published in January 1997, cladding data for burnups up to 40 GWd/MTU was available. Applicants and licensees wishing to store and transport fuel beyond 40 GWd/MTU needed to supply additional data or analyses.

More recent studies show the magnitude and rate of increase of characteristics affected by burnup will vary based on the way fuel is irradiated. When plotted against burnup, all of these parameters generally start to reach a transition zone when the burnup of the fuel reaches 40 – 45 GWd/MTU; however, the changes in the fuel cladding properties themselves between 40 and 45 GWd/MTU are not significant (Ref. 1). Therefore, NRC has concluded that data available for 40 GWd/MTU is applicable for burnups up to 45 GWd/MTU for dry storage and transportation.

Stop approval of HBF use

Gilmore: Please provide technical references to support your claim that there is no safety basis to discontinue approving high burnup fuel. Also, your discussion above doesn't address high burnup storage or transportation, only how the fuel reacts in the reactor. Why would you approve operating in a reactor when you don't have a safe storage or transport solution? The technical references we provided address those issues.

NRC: The references supporting NRC's conclusions are identified in ISG-11, Rev. 3. If fuel is burned in the reactor to a higher burnup then currently allowed in a particular cask design, the applicant would have: 1) to store the fuel in a different system, or 2) to request an amendment to the cask license supported by evidence that the higher burnup fuel can meet all safety regulations in that cask possibly by cooling the fuel for a longer time in the storage pool.

The NRC concludes that the recommendations in ISG-11, Rev. 3, support the continued safe storage of high burnup fuel. NRC has reviewed contrary conclusions submitted by several outside groups, but found them to be unsubstantiated. NRC has found no valid data to contradict the position in ISG-11, Rev. 3, that high burnup fuel can be safely stored.

Following publication of ISG-11, Rev. 3, subsequent work at Argonne National Laboratory (ANL) (Ref. 6), and the Central Research Institute of Electric Power Industry (CRIEPI) of Japan (Refs. 7 and 8) raised the possibility of hydride reorientation under very limited transportation circumstances. Applicants must therefore address whether hydride reorientation could impact rod behavior during a transportation accident. The licensee may address this by conservatively assuming severe reconfiguration of fuel assemblies in its shielding, thermal, and criticality safety analyses. For transportation, ISG-11, Rev. 3 is no longer the prevailing reference for hydride reorientation issues. The issue of hydride reorientation does not, however, call into question ISG-11, Rev. 3, data on storage of high burnup fuel because spent fuel in storage would not be subject to the same forces as in transportation.

Stop approval of HBF dry cask storage

Gilmore: Please provide technical references to support your claim it is safe to store high burnup fuel in dry cask storage. Studies on lower burnup fuel do not address high burnup fuel. The “backgrounder on high burnup spent fuel” you recommended also does not have technical references.

NRC: ISG-11, Rev. 3, provides the technical basis with references to support the continued safe storage of high burnup fuel. While ISG-11, Rev. 3, is based on short term laboratory data, including high burnup fuel, its conclusions for low burnup fuel were confirmed when a cask at Idaho National Laboratory was opened and the fuel was examined (Ref. 9). Less than 0.1% creep strain was measured, and no radial hydrides were observed. The results of that examination were easily extrapolated to show at much longer storage times that no failure of low burnup fuel was expected. Because the creep mechanism is self-limiting, this conclusion would be valid for high burnup fuel at least through an initial 20-year storage period. As dry storage renewal applications are received, this conclusion is reevaluated, using the most recent available cladding data.

Make solving high burn up fuel storage problems one of its highest priorities

Gilmore: The fact millions of dollars are being spent for this study, means you don’t have the data to support it safe now. The technical references we provided show problems with cladding integrity. Please provide technical references that show otherwise.

NRC:
The NRC is conducting significant high burnup fuel research in two areas. One is in the area of Extended Storage and Transportation (EST) (Ref. 10), to identify what issues might appear in periods of extended storage and determine regulatory solutions before they occur. The second area is conducting analyses to confirm the safety basis in initial and renewal applications are valid. This research should not be interpreted as NRC thinking there is a problem, but rather that NRC wants information to confirm that conclusions from previous short-duration research, indicating there would be no long-term issues, are still valid. Research of this type includes the

vibration testing at Oak Ridge National Laboratory, mechanical properties testing at Argonne National Laboratory, extreme temperature seals testing at the National Institute of Standards and Technology, and other programs.

The industry testing programs are also providing confirmatory data to allow the utilities and cask vendors to make their safety cases in initial and renewal applications without relying on overly conservative assumptions. For example, NRC research has determined that when the transportation of high burnup fuel occurs, there may be concerns at low temperatures in some specific and rare cases. NRC identified the issue, and now DOE and the nuclear industry are obtaining data to respond to that issue in licensing applications. Similarly, NRC is coordinating with DOE on their cask demonstration program (Ref. 11), which is being conducted to confirm the accuracy of high burnup fuel evaluations over long storage periods.

Develop adequate strategies to detect and mitigate unexpected degradation.

Gilmore: In your above description, I don't see anything that addresses an actual mitigation plan – only an evaluation of conditions that might lead to a need for one. The NRC and DOE have already identified 94 technical data gaps, such as stress corrosion cracking of stainless steel storage canisters in a marine environment, and numerous fuel cladding issues. It appears you have enough known areas to develop actual mitigation strategies. If it's not possible to develop them at this time, then what safety basis is there for continuing to approve production of nuclear waste?

NRC: The gaps that you mentioned were identified for conditions that may exist in the EST time frame (i.e., 120 years or more). These are gaps in understanding the probability that the issues would actually occur, not gaps in how they can be approached or mitigated.

Currently, there are no actual mitigation plans for the EST timeframe, as the NRC is not certain if or when mitigation plans will be necessary. Any mitigation plans established at this point would be based on current technology, which might be outmoded when it actually needs to be applied. When NRC research determines whether and when the gap issue will actually occur, then mitigative actions and plans would be warranted. Until that time, as mentioned in the NRC response, license renewals will continue to require either a time-limited aging analysis or an aging management plan (AMP) for all components of the system that have the potential to degrade in a way that can affect safety. An AMP consists of 10 parts (Ref. 12) that include identification of the degradation mechanism, and physical signs of the degradation occurring. The AMP describes the methods to be used to detect the degradation, the frequency of inspection, and the criteria for when mitigative or corrective action is necessary. In general, the detailed steps of the corrective or mitigative plan would be best established when the degradation has been identified (e.g., through inspection or operating experience of similar systems) and characterized.

Absent a comprehensive safety analysis, not approve 32 assembly casks for HBF, such as the NUHOMS® 32PTH2 cask system

Gilmore: We have made comments to this proposed rule. (See Diane Curran comments on behalf of a large number of environment groups and individuals, including those living in the San Onofre area). The NRC had years to review these specifications. Approving this and allowing only 30 days review is not reasonable. Also, putting 32 fuel assemblies in space designed for 24 fuel assemblies significantly increases our risk, even if just one canister fails. The NUHOMS 32PTH2 even required a separate definition of "damaged fuel" from any definition ever used in the past, including for the NUHOMS 32PTH1, which this canister is based on. Even the NRC questioned this in their (RAI) review process. The 32PTH2 eliminates failed fuel cans, so doesn't meet NRC and DOE fuel assembly retrievability requirements. This cask is also being approved for transport, which is precedent setting, in spite of the current Spent Fuel Project Office Interim Staff Guidance 11, Revision 3, that does not allow it, due to the issues with high burnup fuel.

NRC:

The NRC will be responding to the comments you raised on the rule in that rulemaking process. Generally, the size and design of a cask is not determined by the physical space available to hold a particular number of assemblies. Rather, the design of the cask determines the physical limitations on the contents so that the cask system will meet all safety requirements. If more assemblies are put in the system, it still must be shown that all safety functions are maintained. The risk is determined not only by the contents in the system, but also by the behavior of the system. Additionally, ISG-11, Rev. 3, is review guidance to the NRC staff addressing one methodology that an applicant can use to show that all the safety functions are met. It does not establish requirements, nor does it forbid the transport of high burnup fuel.

Require all HBF assemblies be containerized in damaged fuel cans for dry Storage

Gilmore: As stated above (i.e., "… based on testing in the laboratory and modeling, the NRC staff has determined that high burnup fuel can be safely stored. The NRC staff has not seen any data from either domestic or international sources that contradict this position. While NRC regulations allow canning (i.e., placing the fuel in a container) as a means of addressing grossly damaged fuel in storage to contain the fuel in a known volume in the cask, available information indicates high burnup fuel integrity will be maintained during storage without canning. Therefore, there is no safety basis to require canning of all high burnup fuel.", please provide technical references to support this.

NRC: The conclusions in ISG-11, Rev. 3, and references identified within it support the continued storage of high burnup fuel. NRC has reviewed contrary conclusions submitted by several outside groups, but found them to be unsubstantiated. NRC has reviewed domestic and international research on high burnup fuel cladding properties, and found no valid data to contradict the position in ISG-11, Rev. 3, that high burnup fuel can be safely stored. Notwithstanding this position, NRC is requiring that applicants provide data to confirm that the conclusions of ISG-11, Rev. 3, remain valid for their specific cask designs and approved contents prior to issuing the licenses for continued storage of high burnup fuel beyond the initial license term of 20 years.

Reject NUREG-2125 Spent Fuel Transportation Risk Assessment as inadequate as it does not address HBF

Gilmore: NUREG-2125 (Page 139) states: "A detailed examination of the effect of the higher burnup levels is **outside the scope** of this document." It then speculates on "**expected** changes." Speculation is not substantiation. Please provide technical substantiation.

NRC: This scope of this NUREG (Ref. 13) was to evaluate the authorized contents of actual casks. None of the packages evaluated in this study were licensed to transport high burnup fuel, as such a transportation package had not yet been approved at the start of the study. Regardless, the inclusion of high burnup fuel in a spent fuel transportation package would not invalidate the results of the study, as discussed in Section 6.3 of the report. Since the study assumes the maximum external radiation dose rates allowed under the regulations for incident-free transport, the risk magnitude for incident-free transport will not change. Higher burnup fuel will have to be cooled long enough before it is transported to meet the cask's heat and external dose rate limits. The study demonstrated that, in hypothetical accidents severe enough to cause the transportation package containment to fail, the acceleration level is high enough to fail the cladding of all of the fuel, regardless of the burnup.

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