Historical Nuclear Fuel Burnup Limit Increases

Historical Nuclear Fuel Technology Evolution

- Stainless steel was used in early nuclear fuel designs
- Transition to Zircaloy-2/Zircaloy-4 in the 1960s, most of the transition completed by mid 1970s
  - Improved Zircaloy-4 introduced in the 1980s for better corrosion performance
- Advanced zirconium based alloys, such as ZIRLOTH and M5® introduced in the 1990s
- Burnup limit increase pursued in the early 1980s from 33 GWd/MTU to 50+ GWd/MTU
  - Better performance from Zircaloys
  - Fuel design changes with better thermal and mechanical performance

Fuel Vendor Activities to Increase Burnup Limit from 33

- Major fuel vendors submitted topical report to increase the burnup limit from 33 to 50+ GWd/MTU
  - B&W topical report, https://www.nrc.gov/docs/ML2021/ML20215F563.pdf
  - Combustion Engineering, https://www.nrc.gov/docs/ML2005/ML20055A015.pdf
  - Westinghouse, https://www.nrc.gov/docs/ML2014/ML20140A616.pdf
  - The topical report in combination with the respective NRC Safety Evaluation Reports on the topicals can provide insight on key concerns and regulatory environment at the time
- DOE spent fuel characterization can provide additional information on the fuel design
  - DOE/Rw=0184, https://curie.pnnl.gov/system/files/documents/not%20yet%20assigned/DOE-RW-0184-Vol3-Appendix%202A%20-%20HQX.19880405.0024.pdf?utm_source=chatgpt.com

Activities to Increase Burnup Limit to 62

- NRC sponsored generic environmental evaluation to support 62 GWd/MTU burnup increase in the early 2000s
  - Provide framework for fuel vendors to draft their specific topical reports
  - NUREG/CR-6703, https://www.nrc.gov/docs/ML0103/ML010310298.pdf
  - Regulatory guide 1.183, https://www.nrc.gov/docs/ml0037/ml003716792.pdf
- Select fuel vendor topical report (not exhaustive list, other methods may be updated to support the new limit)
  - WCAP-12478, https://www.nrc.gov/docs/ML0105/ML010570235.pdf
  - WCAP-17642. https://www.nrc.gov/docs/ML1330/ML13308A426.pdf
  - BAW-10227P (M5 Cladding/structural materials), https://www.nrc.gov/docs/ML0036/ML003686365.pdf
- No major fuel performance issues identified (except GTRF)

Framatome Fuel Introduction

- Framatome acquired B&W in the early 1990s
  - Continued use of B&W fuel designs
  - Introduction of M5 early 2000s in the US
- High burnup beyond 62 GWd/MTU
  - Topical report submitted to the US NRC in 2024,ANP-10358NP https://www.nrc.gov/docs/ML2433/ML24331A087.pdf
  - “Framatome will use the GAIA fuel design topical report (Reference 14) to provide the structure (including fuel design criteria) to evaluate the GAIA 17x17 design and the HTP 14x14, 15x15 and 16x16 designs for specific plants”

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