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EPRI High Burnup Used Fuel Confirmatory Demonstration Project [The "High Burnup Demo"]

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Outline

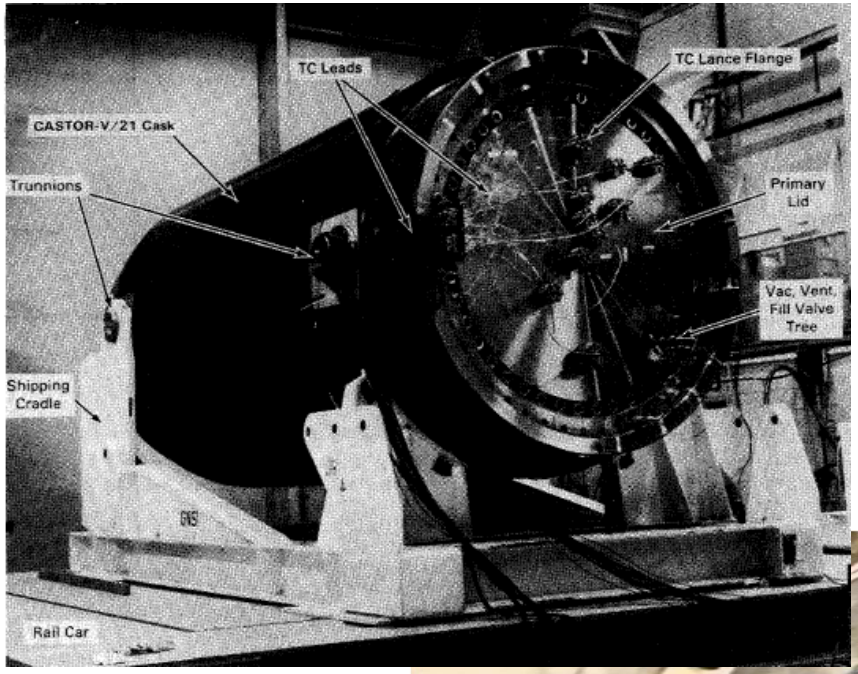
- Purpose of the high burnup demo
- Low burnup confirmatory data collection work
- Initial engagement
- DOE Request for Proposal
- EPRI Team proposal
- Future plans

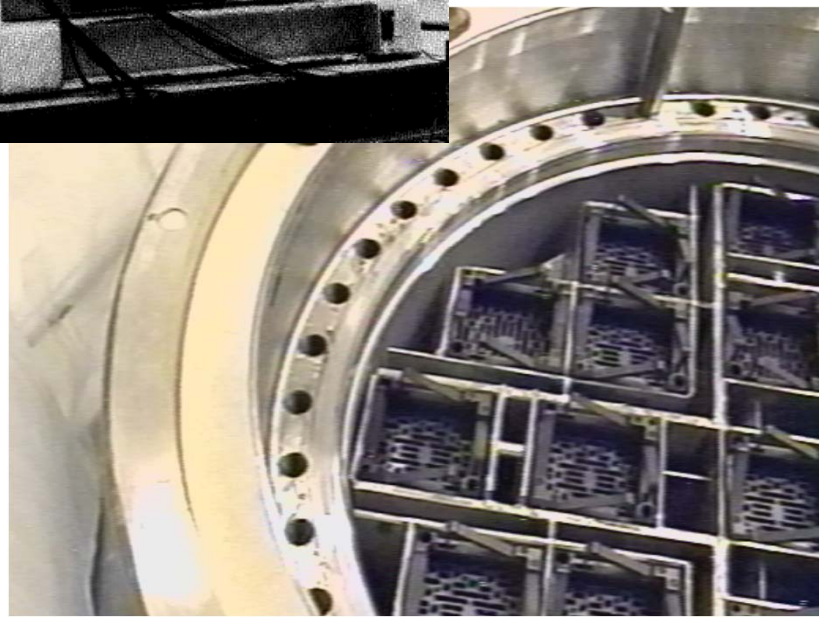
Full-Scale Used Fuel Dry Storage Demonstrations – A Brief History

- Several data collection “demos” using low burnup fuel from mid 1980s through early 1990s
  - CASTOR V/21 (1985)
  - MC 10
  - TN-24P
  - VSC-17
- Demo data collection
  - Internal gas composition and pressure
  - Internal and external temperatures
  - External dose rates

Original CASTOR V/21 Demo: *Low* Burnup (BU) Cladding (1984-2002)

- Surry fuel up to 35GWd/MTU
- Demo initiated in 1984
  - [EPRI NP-4887, 1985]
- Re-opened after 14 years
  - [EPRI 1002882, 2002]
- *Demo conducted at DOE TAN facility*





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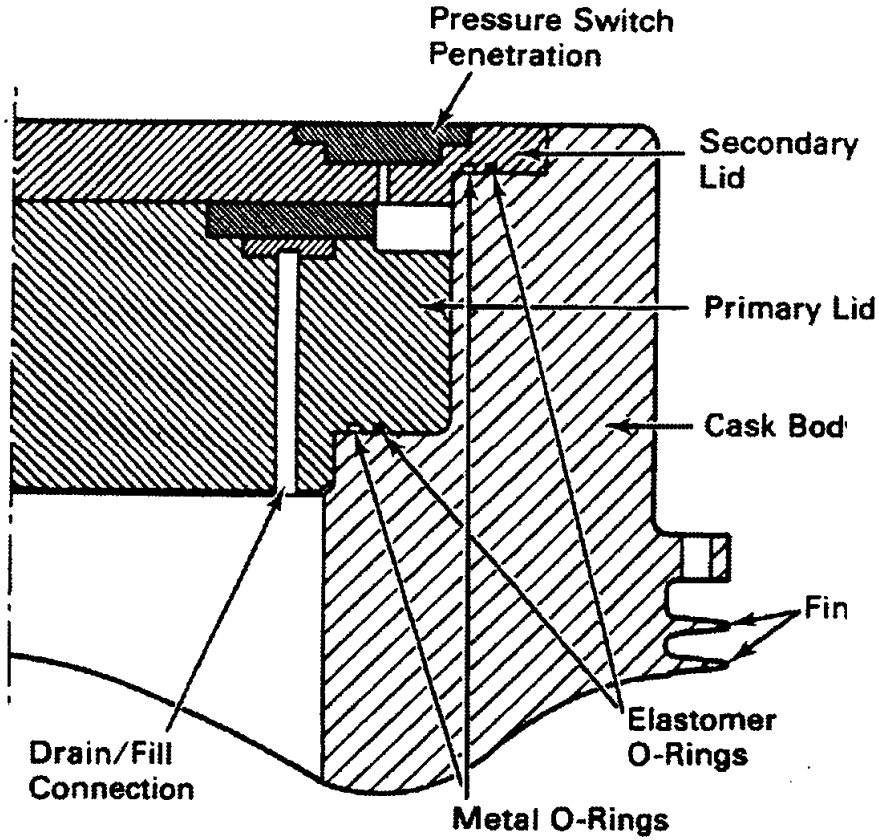
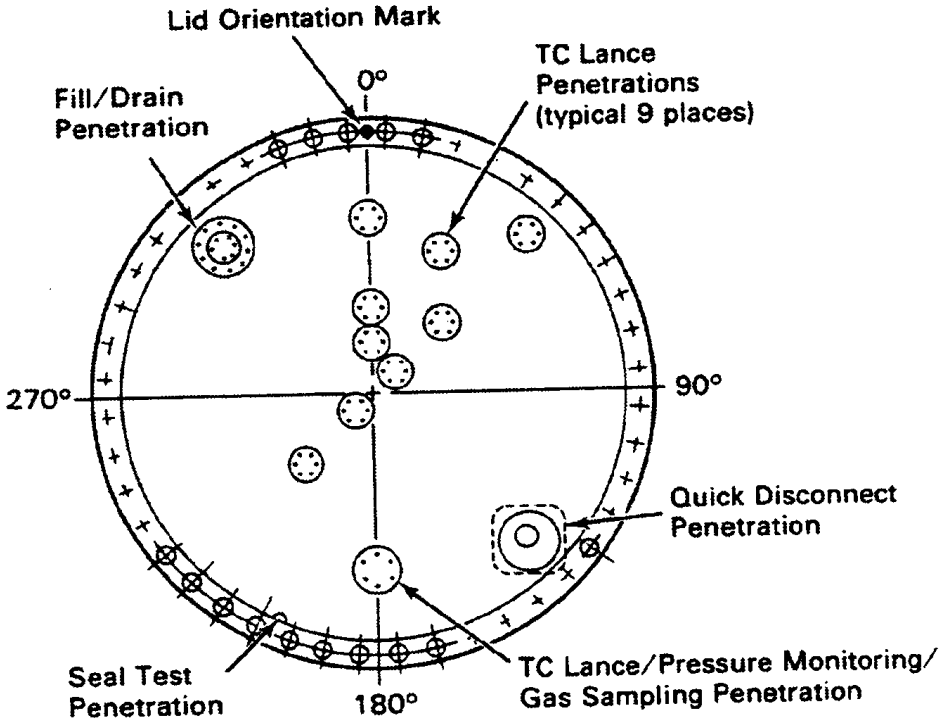
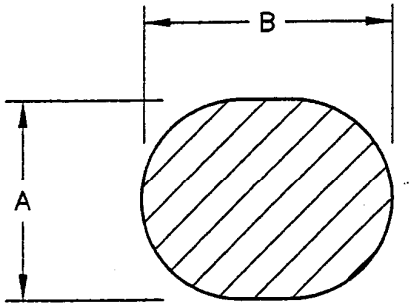
Modification to CASTOR V/21 Primary Lid



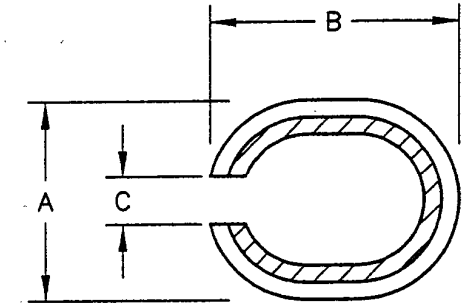


CASTOR V/21 Cask Re-Opening Observations and Data Collection (1999-2001)

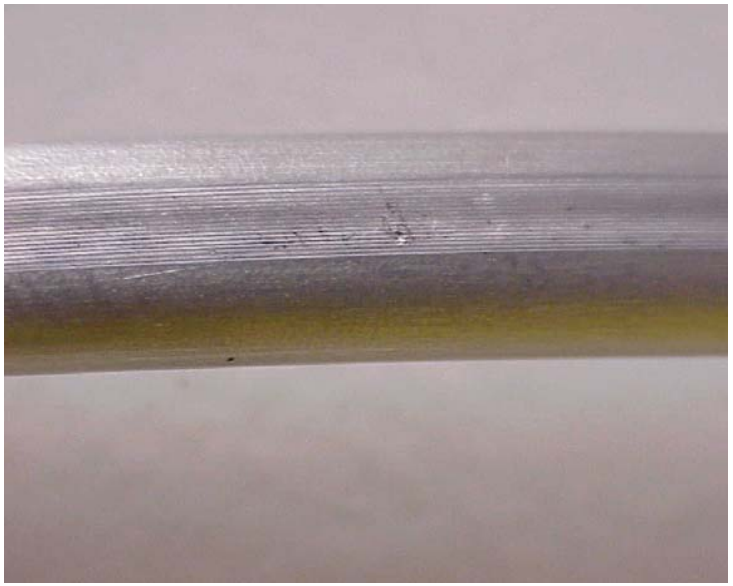
O-Ring Condition after 14 Years: Still Elastic



LOC.	DIMENSION A MEAS.	DIMENSION B MEAS.
2"	0.336"	0.427"
4"	0.338"	0.422"
6"	0.337"	0.423"
8"	0.340"	0.421"
10"	0.340"	0.421"
12"	0.338"	0.421"
14"	0.342"	0.420"
16"	0.340"	0.420"
AVERAGE:	0.339"	0.422"
σ:	0.002"	0.002"

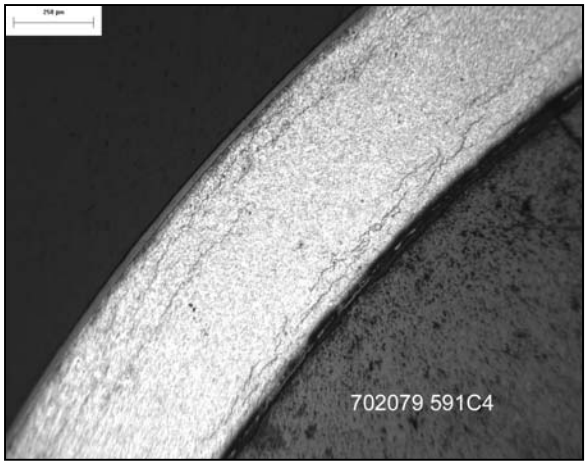


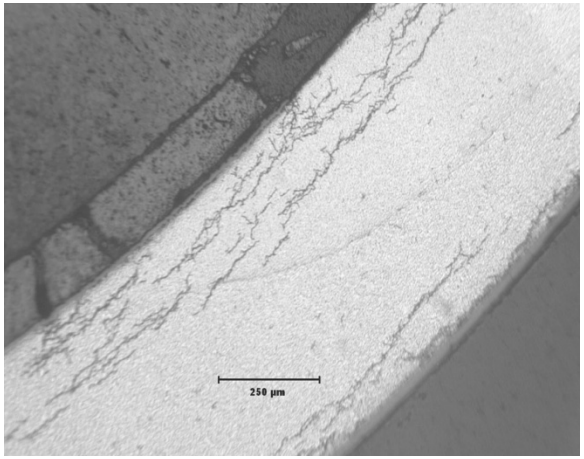
LOC.	DIMENSION A MEAS.	DIMENSION B MEAS.	DIMENSION C MEAS.
2"	0.355"	0.445"	0.085"
4"	0.352"	0.445"	0.080"
6"	0.354"	0.446"	0.065"
8"	0.353"	0.450	0.081"
10"	0.355"	0.452"	0.086"
12"	0.353"	0.454"	0.095"
14"	0.353"	0.456"	0.088"
16"	0.354"	0.450"	0.074"
18"	0.354"	0.454"	0.073"
AVERAGE:	0.354"	0.450"	0.081"
σ:	0.001"	0.004"	0.009"



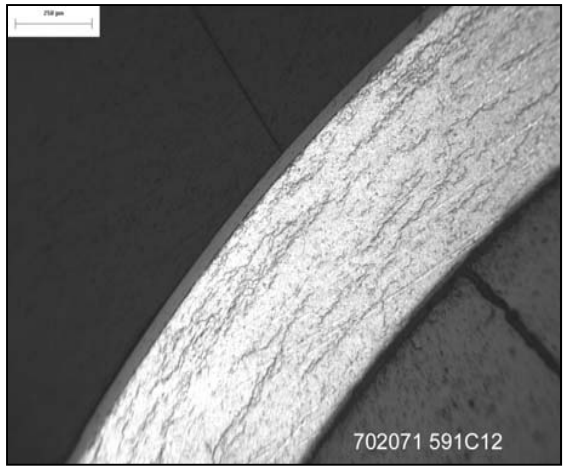
Cask Bottom Cover Plate Bolt Corrosion

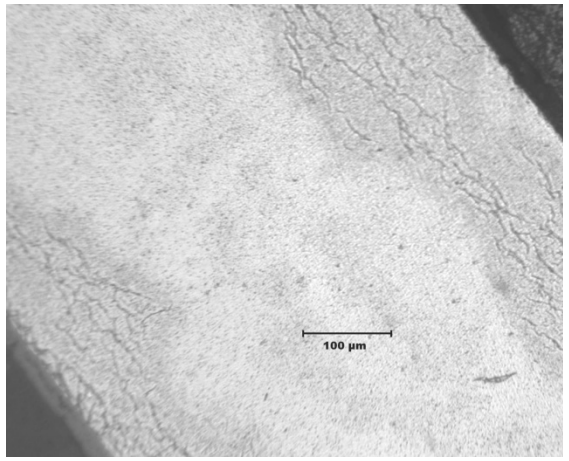
CASTOR V/21 *Low* BU Cladding: Morphology of Hydrides Mostly Circumferential





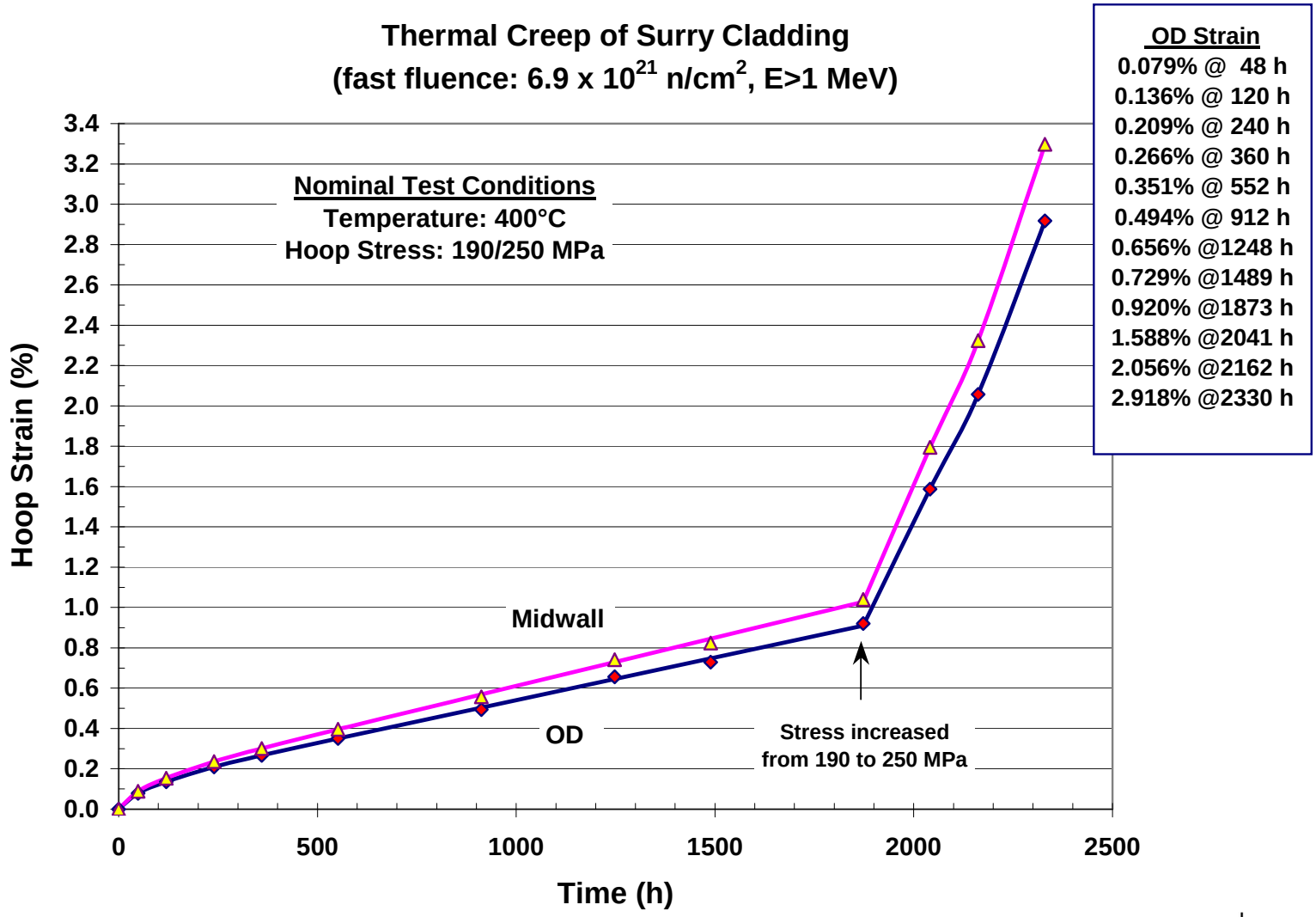
Mid plane





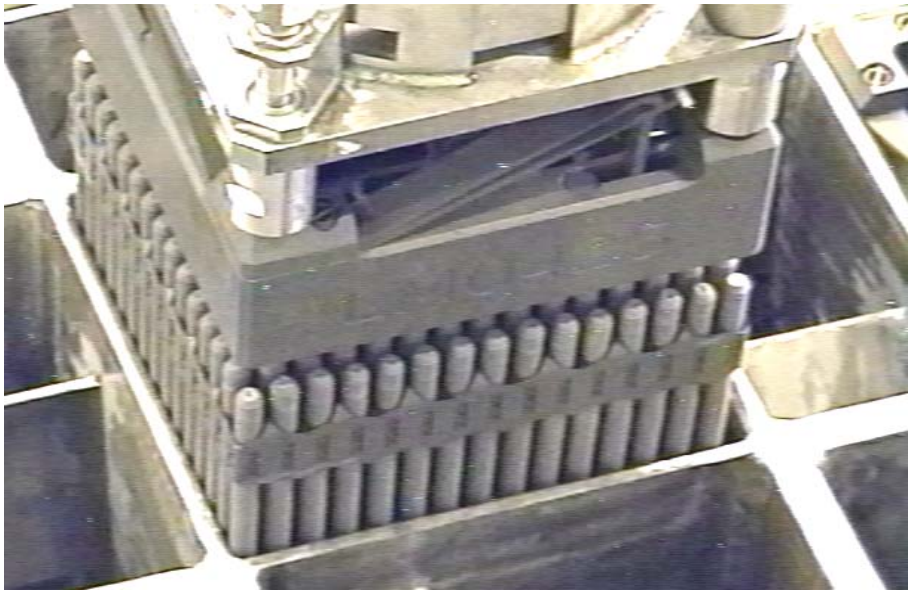
0.5m above mid plane

CASTOR V/21 *Low* BU Cladding: Significant "Creep Life" Remains



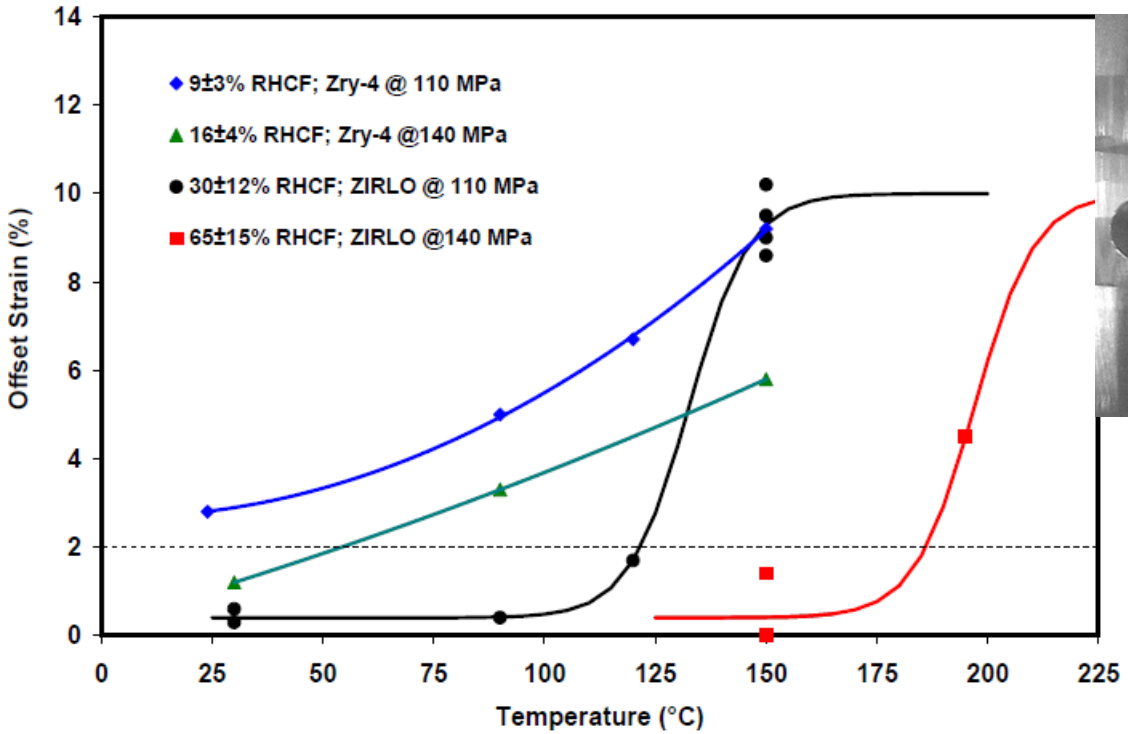
CASTOR V/21 *Low* BU Demo Final Results: No Evidence of Degradation After 14 Years

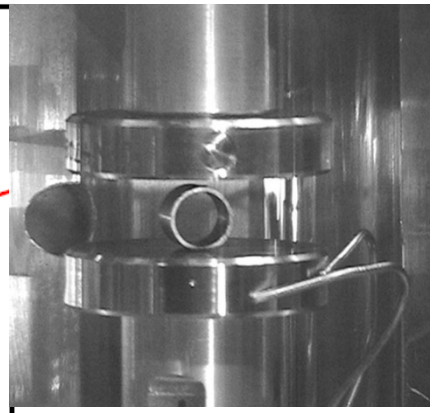
- No radiation or temperature ‘hot spots’
- No leakers
- No visual evidence of O-ring degradation
- All assemblies came out easily
- No visual evidence of additional assembly/cladding degradation or bowing
- No visual evidence of additional internal basket degradation
- Little to no detachment of crud

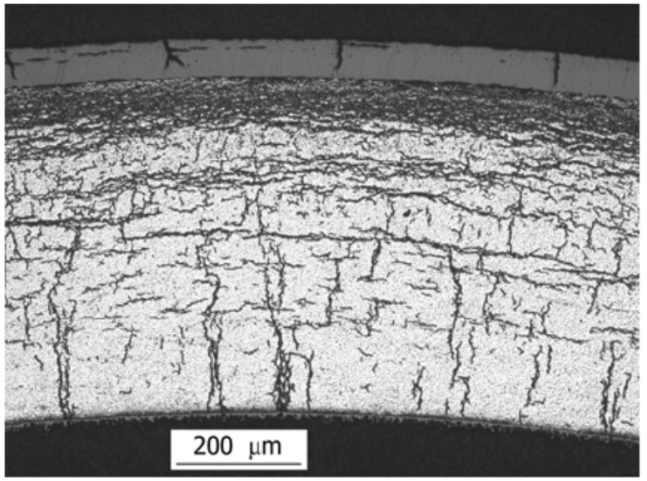


Fast Forward:
Industry Shift to Use of High Burnup Fuel

NRC Concern: *High* BU Cladding Performance During Extended Storage (followed by transportation)







Used fuel cladding cross-section showing hydride embrittlement

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Gap: Full Scale *High* Burnup Demonstration

- Repeat earlier low BU demo using high BU fuel
- Will high BU cladding become so brittle it cannot be moved?
- DOE prefers *assembly* retrievability

- Need for data for high BU license extensions in the USA:
  - ***Now: Prairie Island, Calvert Cliffs***
  - ***Mid to late 2020's: several more***

Full-scale, High Burnup Confirmatory Data Collection ("high burnup demo") Plans

Confidence in understanding longer-term behavior of dry storage system requires

- Model development and benchmarking data
- "Separate effects testing"
- Confirmatory testing under "prototypic" conditions
  - Full scale
  - Representative dry storage conditions
    - Drying process and inerting
    - Thermal evolution
    - Geometry
  - Prefer multiple high BU fuel types (if possible)

High Burnup Demo Objectives

- Confirmatory data to support
  - Thermal models
  - Behavior of cask internal components (fuel, cladding, assembly hardware, baskets, neutron absorber)
- Avoid rewetting the fuel after initial loading

High Burnup Demo Activities

Industry desire to keep this short

- Obtain “t=0” data from sister rods
  - Profilometry
  - Cladding properties (hydrogen content and initial orientation, mechanical, internal gas content)
- Modify existing cask with a special lid that includes
  - Thermocouples
  - Gas sampling
- Load cask and emplace modified lid
- ***Data collection through lid begins immediately***
  - Capture temperature and gas evolution during drying
  - Continue temperature measurements and periodic gas sampling
- After X years (TBD), re-open, remove rods, visually inspect for degradation
  - Rods for destructive exams to compare to “t=0”
  - Option to perform exams on internals

2003: EPRI Study on Alternative High BU Demo Options [EPRI 1007872] (costs in $ millions)

Activity	Option A: Augment Existing Exam Program	Option B: Utility ISFSI Followed by Laboratory Examination	Option C: Laboratory Storage and Examination
Estimated program duration [yr]	*5*	*12*	*12*
Program management	1	4	4
Demonstration storage system	0	~5	~7
Pool-side NDE	>0	>0.2	>0.2
Shipping to laboratory	0.3	0.3	0.3 to >1
Dry storage demonstration period with periodic monitoring and surveillance	0	1.5	1.5
Post-storage fuel rod examination	3	4 to 7	4 to 7
Post-test disposal and cleanup	1	1	>1
TOTAL	~5	~15 to 20	~18 to 21

EPRI Proposal for a High Burnup Used Fuel Confirmatory Data Collection Project

- Modify an existing TN-32 bolted lid cask lid to collect data on:
  - Spatial and temporal temperature distribution inside the cask during loading, drying, and at the end of long-term storage
  - Internal gas pressure and composition (helium, oxygen, hydrogen, fission product gases)
- Remove sister rods to establish rod properties prior to dry storage
- Conduct the demo at North Anna using three types of high burnup fuel: Zircaloy-4, Zirlo, M5
- Monitor the cask temperatures and – if possible – take occasional gas samples for at least ten years
- Move to a site with capability of re-opening the cask dry

The EPRI-Team Demo Option Keeps Startup Time Short

- Avoids up-front transportation to a national lab
- Avoids having to wait for a full-scale hot cell to be funded and constructed
- Multiple, high burnup fuel types already at North Anna
- The TN-32 cask body is already fabricated

EPRI Team was Awarded up to 80% Co-Funding by DOE

- EPRI Team
  - AREVA Federal Services
  - Transnuclear
  - Dominion
  - Subcontractors, such as:
    - Sister rod extraction:
      - AREVA Fuels
      - Westinghouse Fuels
    - Sister rod transportation (competitive bid)
- Contract start date: April 16, 2013 (five-year contract)
- Initial 5-year cost estimate (excluding sister rod examination): $19.8M
  - Will be revised after completion of Final Test Plan

DOE Contract Near-Term Milestones (2013, "Phase 1")

- May: Evaluate existing data gap analyses and recommend complementary modeling, experiments, and small-scale tests
- Early July: Submit a detailed Draft Test Plan to DOE
- Mid July to mid August: Public comment period on the Draft Test Plan
- Late August: Provide revised Test Plan to DOE
- Mid September:
  - DOE provides comments on revised Test Plan
  - Complete Final Test Plan
- Late September: Initiate Test Plan

DOE Contract "Phase 2" Activities through 2018 – Year 2 (notional schedule prior to Final Test Plan)

- Review TN preliminary lid design
- Pre-application review meeting with preliminary lid design and outline of SAR
- Fuel assembly, sister assembly, rod selection
- Second pre-application meeting with NRC
- Final lid design review
- Prepare storage (Part 72) SAR
- Begin design and analysis for transportation (Part 71) SAR
- Procure special cell in the SFP to hold the sister assembly rods for pre-test characterization
- Fuel poolside exams
- Pull rods and place in special cell
- Establish contract to ship rods to a national lab

DOE Contract "Phase 2" Activities – Year 3

- Complete storage SAR preparation
- Submit storage (Part 72) license amendment (LA)
- Respond to NRC Requests for Additional Information (RAIs) for storage
- Continue preparation of transportation (Part 71) SAR
- Procure TN-32 cask body and ship to fabrication shop for instrumented lid
- Procure instrumented lid and all instrumentation. Perform fit-up at fabrication shop
- Meet with DOE and national labs to discuss progress, the hand-off of the rods to the labs, and the labs' rod characterization plans

DOE Contract "Phase 2" Activities – Year 4

- NRC grants storage license
- Review approved License Amendment, Tech Specs and perform necessary site implementation activities
- Continue preparation of transportation (Part 71) SAR
- Ship rods to the national lab
- Rod characterization interactions with DOE and national labs
  - [Rod characterization schedule upon rod transportation cask arrival at the receiving national lab is up to DOE]
- Ship cask and instrumented lid to North Anna
- Perform cask handling/loading dry run

DOE Contract "Phase 2" Activities – Year 5

- Submit transportation (Part 71) LA
- Load cask, dry, move to ISFSI pad
- Take temperature measurements and at least one gas sample
- Respond to NRC RAIs on transportation LA
- Review additional pre-test rod characterization work
- Receive transportation license at the end of Year 5

- TBD:
  - Completion of sister rod pre-characterization
  - Negotiate long-term contract with DOE for the storage period

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