HBU Fuel Status

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HBU Fuel

- NRC sponsored regulatory research
- Demonstration programs
- EST
- International Programs
- Misconceptions

Where we stand since ISG-11 Issued

- Creep -Europeans are questioning self limiting creep in HBU fuel
- DCCG – a few papers have appeared claiming to see initiating cavity voids in Zircaloy
- Hydride reorientation – Japanese are lowering storage temperature to reduce affect, and many papers showing effect occurs at lower stresses, hydriding affects DBTT.
- DHC – Koreans have proposed alternative theories claiming stress from hydride phase transformation
- Cladding stress – gap closure and German work on fuel swelling questions stress levels
- Mechanisms appear to be alloy dependent

NRC-sponsored HBU Fuel Regulatory Research

- ANL Work
- ORNL Work
- Drying Evaluation
- Temperature distributions inside the cask –
  - High and low temperature distributions may preclude much of the cladding from becoming brittle
  - Evaluate Korean theory of DHC
- Stress levels on the cladding at HBU
  - DHC
  - Low temperature creep

NRC Test Program Objective at ANL

- Determine if cladding has residual ductility after cooling slowly under a decreasing stress commensurate with a decreasing temperature as would be experienced during and after vacuum drying –

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What do we know?

- Early data base contained significant scatter
- No clear cut quantitative measurement of the reorientation.
- Appeared that if stress at temperature was <90 MPa, hydride reorientation did not occur.
- Recent trend (Daum, Chu, Aomi, etc.) is that the critical stress for reorientation appears to be in the 75 to 80 MPa range

ANL Testing Results

- Unirradiated and HBU cladding behave differently
- Different cladding alloys behave differently
- Ductile to brittle transition (DBTT)
  - depends on reorientation stress, hydride content, material
- Protocol established to determine ductile to brittle transition after hydride reorientation.
- Enough data to determine there is a regulatory issue. Insufficient data to support a licensing position.
- Results have had external review and acceptance.
- Will form the basis for guidance on materials properties for HBU cladding. No current intention of proposing a new maximum acceptable cladding temperature

ORNL Studies

- Purpose –
  - Determine effect of fuel pellets on cladding stiffness for HAC analysis,
  - Fatigue behavior of irradiated HBU cladding for normal transport
- Status –
  - Equipment designed and being tested out of cell.
  - Fuel samples available
- Completion of work (to determine if there is a regulatory issue - next spring

View of Purpose of HBU Fuel Demonstration

- Serve the same role that the previous demonstration at Idaho in the late 1990s serves for low burn-up fuel
- Confirm with longer term data that the predictions of fuel behavior based on short term separate effects tests, many on lower burnup fuel, are still valid
- Provide data to benchmark and confirm predictive models
- Provide confidence in the ability to predict performance, and identify any aging effects that could be missed through short-term studies
- Demonstrate that after storage, when the fuel cladding temperature has dropped below the DBTT, that under normal conditions of transport that there is reasonable assurance that the fuel maintains its configuration

Monitoring

- Gives storage performance data from the start of demo
- Monitoring before and after tells if fuel is disrupted during transportation. Monitoring during transport desired but not necessary.
- Monitoring required
  - Temperature –evaluate degradation models
  - Kr – fuel rod failure
  - O_2, N_2 – cask leakage, radiolysis, corrosion
  - H_20 – drying
  - H_2 - flammability
- Optional monitoring
  - Testing of remote monitoring systems if it doesn't delay demo
  - accelerometers

Time Line

- CoCs/licenses for HBU storage for renewal
  - 2012 Prairie Island TN-40HT – No HBU loaded yet
  - Calvert Cliffs-NUHOMS –allowable up to 52 GWd/MTU since 2010
- Storage of HBU fuel
  - Maine Yankee (since 2003) up to 49.5 GWd/MTU
  - Robinson (since 2005) up to 56.9 GWd.MTU
  - Oconee (since 2005) up to 55 GWd/MTU
  - Currently many sites, < 4 years

EST Program, TIN Report
Major Fuel Findings

- Swelling of fuel pellets due to helium in-growth, and fuel rod pressurization due to additional fuel fragmentation, helium release, and fission gas release during accidents
- Thermal calculations
- Effects of residual moisture after normal drying
- Development of in-service monitoring methods for storage systems and components
- Propagation of existing flaws in cladding, Metal fatigue of cladding caused by temperature fluctuations, SCC, and DHC, Low temperature creep and galvanic corrosion of cladding

EST Program, TIN Report

How HBU being addressed in EST Current status

- Information from international programs, other NRC research, foreign research, NEUP, ESCP, DOE and Industry lab work
- Internal RES, NMSS Evaluations
  - Thermal
    - starting independent modeling activities
    - Program plan developed
  - Stress
    - Evaluations and planning
  - Monitoring capabilities
    - Contract with Center to evaluate available methods

International Programs

- IAEA Consultancy -Extending SNF Storage Beyond the Long-term – Mike Waters NRC rep
- IAEA SPAR-III (Spent Fuel Performance Assessment and Research) CRP
  - Evaluating current issues with SNF storage.
  - Fifth in a series.
  - Reps from US, France, Germany, Japan, Switzerland, Hungary, Korea, Argentina, Slovakia, Spain
  - Main issues this cycle are hydride reorientation, fuel characteristics
- IAEA CRP on Demonstration - REE

IAEA CRP on Demonstrating Performance of SNF & Related Storage System Components during very Long Storage

- The overall objective of this CRP is to support and share improvement in the nuclear power community's technical basis for LWR spent fuel management licenses as dry storage durations extend. This will involve developing
  - experimental data on the very long-term performance of spent fuel and related important storage system components;
  - computational and experimental methods to adequately demonstrate very long-term performance;
  - capability to assess the impact of high burn-up fuel on very long-term storage

Misconceptions about High Burnup Fuel

- Data NRC needs and Data applicant needs is the same
- NRC staff believes that HBU fuel will degrade significantly during the initial storage period
- Every site has to unload and inspect some HBU Fuel to get a license extension.
- NRC Staff is treating the cladding as the primary containments boundary
- French transport experience has direct relevance
- HBU fuel will fall apart during normal transportation
- Data is Data, – one piece of data is as good as the next