GNF/NRC Meeting on Data Needs to Support SNF Storage and Transportation

Structural and Materials Section
Spent Fuel Project Office
NMSS
USNRC

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Purpose of Meeting

- NRC SFPO to Describe Current Materials Issues Related to Storage and Transportation of SNF
- GNF to Brief NRC SFPO Personnel on their Programs that might shed light on NRC Issues (Proprietary)

GNF information

- GNF information is proprietary and will not be discussed with any applicant
  - NRC may direct applicants to Vendors

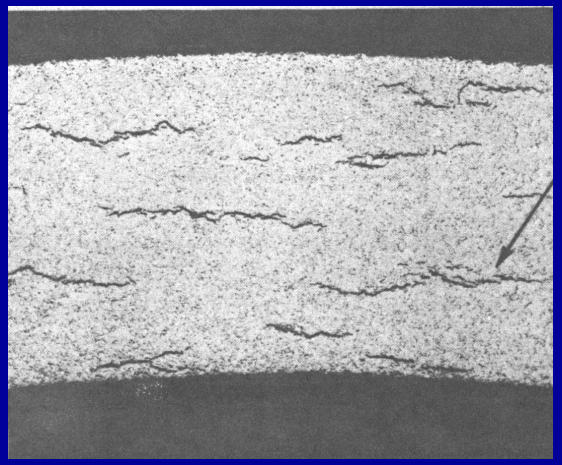
NRC Regulations/GOALS

- Subcriticality under all situations
- Confine Nuclear Material
- Maintain exterior dose rates below regulatory levels
- Maintain temperature of the fuel at a level that minimizes unacceptable cladding degradation
- Maintain structural Integrity

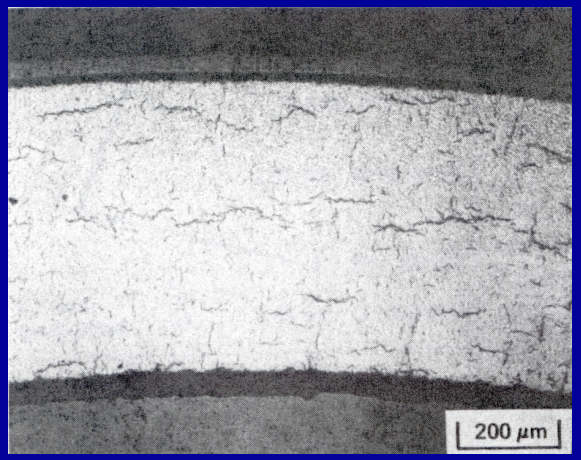
Degradation During Storage

- Thermal Creep (not an issue for LBF)
- Hydride Reorientation
  - Critical stress for reorientation
  - Hoop Stress in cladding
  - Extent of reorientation
  - Reorientation affect on mechanical properties
    - **Axial tensile strength,**
    - **ductility**

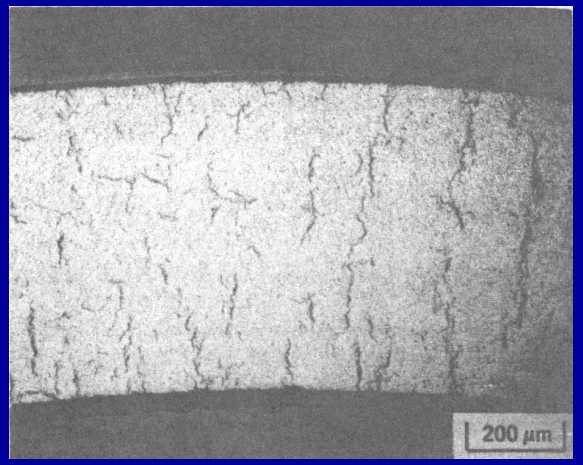
Low Hoop Stress f(Temp, H conc, etc.) **High Hoop Stress**



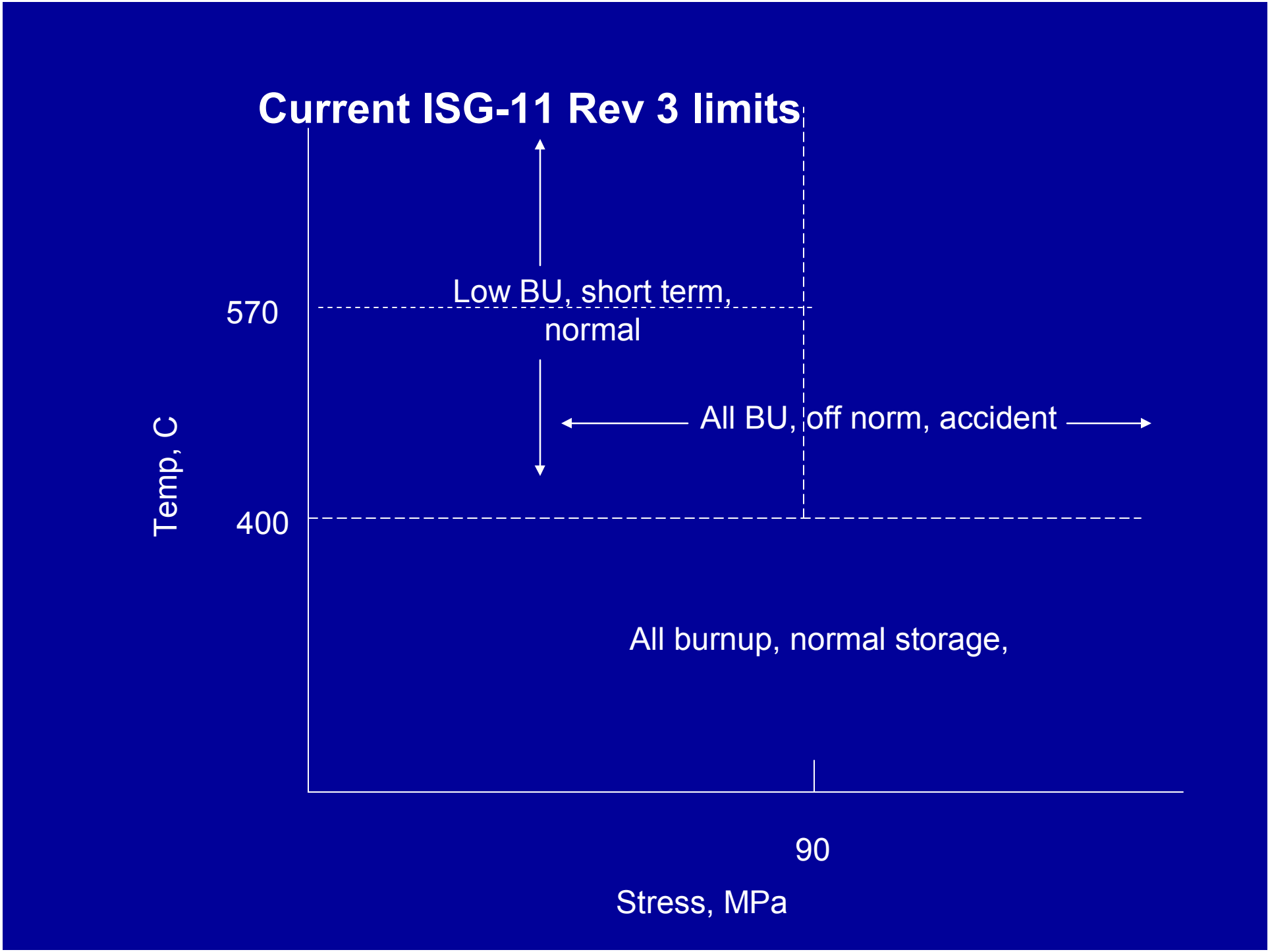
Circumferential Hydrides in Irradiated Zircaloy Cladding



Mixed Hydrides In Irradiated Zircaloy Cladding



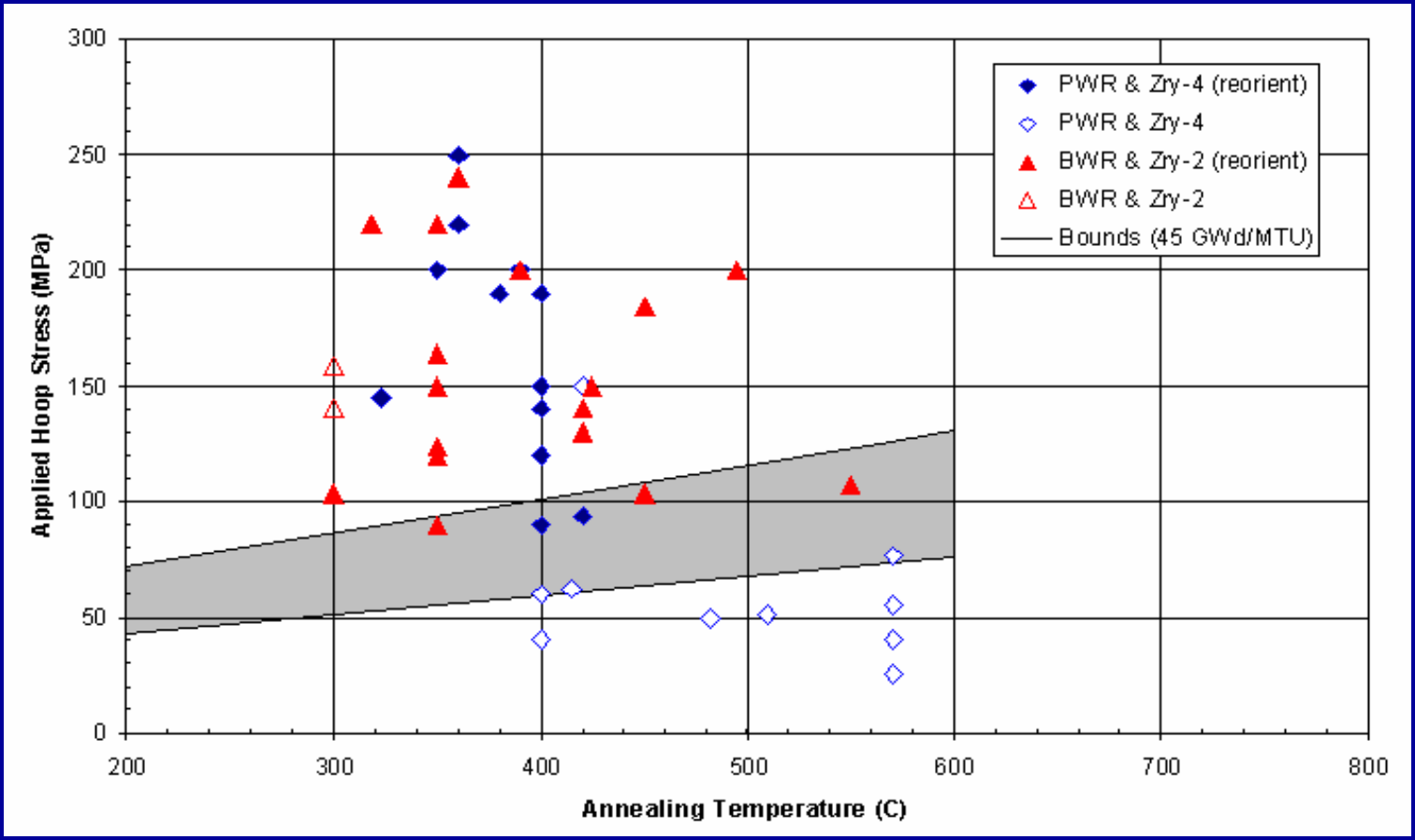
Radial Hydrides In Irradiated Zircaloy Cladding


Current ISG-11 Rev 3 limits
Low BU, short term, normal
570
All BU, off norm, accident
400
Temp, C
All burnup, normal storage,
90
Stress, MPa

Technical Challenges

- Limited data or analysis
- Guidance applies to all cladding types
- Applies to HBF
- No stress limits at temp. below **400EC**
- Never addresses flaws in cladding
- Transportation – case-by-case basis

Data: Reoriented and Circumferential Hydrides



Current availability of data for high-burnup fuel

cladding		Axial strength with radial hydrides	ductility with circumferential hydrides	critical stress	critical radial hydride	ductility with radial hydrides
Zircaloy		No	Yes for PWR	**Research Activity PWR**	No	**Research Activity**
Other Zirconium based alloys		No	limited	**Research Activity M5 ?**	No	No

Stress Driven Damage

- Stress is driving force for hydride reorientation
- Excessive stress
  - Burnable poisons
  - Thermal excursions
  - Cladding wall thinning
  - CRUD
  - Excessive Oxide Spallation

Cladding Leak Detection Transportation and Storage

- Breaches smaller then pinholes and hair-line cracks are not considered damaged
- Assemblies with “gross” breaches must be canned
- Misloadings of damaged fuel
- Methods of leak detection, accuracy, training of operators

Areas of Discussion

- Existence of Proprietary data base on Creep, hydride content, mechanical properties for Zircaloy and other GNF cladding alloys
- New assembly designs that may affect structural analysis
- Methods for examining fuel, damaged, and breaches
- Ongoing or planned experimental programs

Background

Guidance

- Regulatory Requirements stated in 10 CFR 72 (Storage) and 10 CFR 71 (Transportation)
- Standard Review Plans (SRP) developed to guide applicant to prepare SAR to meet Requirements
- Interim Staff Guidance (ISG) developed to clarify SRP

Storage Regulations

72.122h(i) states in part – "The spent fuel cladding must be protected during storage against degradation that leads to gross rupture in the fuel or the fuel must otherwise be confined such that the degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage"

72.236(m) states in part – "… to the extent practicable, consideration should be given to compatibility with removal of the stored spent nuclear fuel to transportation and ultimate disposal by the DOE."

72.122(l) states in part – "Retrievability …allow ready retrieval of spent nuclear fuel for further processing or disposal"

Transportation Regulations

- 71.55(d)(2) - under normal conditions of transport, the geometric form of the packaging contents would not be substantially altered.

- 71.55(e) – states “A package used for the shipment of fissile material must be so designed and constructed and its contents so limited that under the tests specified in para. 71.73 (Hypothetical accident conditions), the package would be subcritical. For this determination, it must be assumed that: (1) the fissile material is in the most reactive credible configuration consistent with the damaged condition of the package and the chemical and physical form of the contents; (2) water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents....."

Transportation Regulations (Con't)

- Normal transport
  - Part71.55(d)2 – "The geometric form of the packaging content will not be substantially altered"
  - One foot side drop
- Accident
  - Part 71.55(e) – with water moderation, there is no credible configuration that will go critical
  - 9 meter axial drop
  - splaying of the fuel rods

(unofficial – repository is expecting to get the vast majority of the fuel in an undamaged condition)

Interim Staff Guidance

- ISG-1 Rev 1 Defines damaged Fuel
- ISG-2 - Defines Retrievability
- ISG-11 Rev 3 – Specifies Storage conditions (temperature, Max rod stress and atmosphere) to minimize unacceptable fuel degradation
- ISG-22 – Loading Operations (under review)
- ISG-15 - Materials Evaluation