Template NMSS-010

February 29, 2000

MEMORANDUM TO: Susan F. Shankman, Deputy Director
Licensing and Inspection Directorate
Spent Fuel Project Office, NMSS

FROM: Marissa Bailey, Project Manager
Licensing Section /s/
Spent Fuel Project Office, NMSS

SUBJECT: SUMMARY OF JANUARY 31, 2000, MEETING WITH HOLTEC INTERNATIONAL

On January 31, 2000, the Spent Fuel Project Office (SFPO) staff met with representatives from the Holtec International to discuss Holtec's proposed method for determining the maximum permissible rod cladding temperature of high burnup spent fuel. An attendance list is included as Attachment 1. The meeting was noticed on January 18, 2000.

Meeting Discussion

The meeting discussion centered on the attached meeting handout (Attachment 2).

Holtec stated that the ability to place high burnup spent fuel in dry storage is an urgent industry issue. In the coming years, more than 40% of the spent fuel inventory in many reactor spent fuel pools will have burnups between 45 and 60 GWD/MTU. Thus, establishing a reasonable method for ensuring the integrity of high burnup fuel during dry storage is important. To this end, Holtec is proposing a method for determining the maximum permissible rod cladding temperature for high burnup spent fuel at different post core decay times. Holtec's method uses existing creep data for low and medium burnup fuel. The method uses an accepted failure model for creep failure of pressurized cladding to establish the permissible cladding temperature. Holtec claims that its method establishes a permissible cladding temperature limit that is reasonably, rather than overly, conservative.

The specifics of Holtec's proposed method were discussed during the proprietary portion of the meeting. The staff pointed out that Holtec's method seems similar to those proposed by other applicants.

No regulatory decisions were requested or made during the meeting.

Docket Nos. 72-1008, 72-1014

Attachments: 1. Attendance List
2. Holtec Meeting Handouts

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Dockets	NRC File Center	PUBLIC	NMSS R/F	SFPO R/F	SGagner, OPA
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G:\BAILEY\01-31-00 Holtec meeting summary.wpd

OFC	SFPO MGB	E	SFPO	E	SFPO	N		
NAME	MBailey:		VLTharpe		CRChappell			
DATE	2/28/00		2/27		2/29/00			

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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Meeting between Nuclear Regulatory Commission
and Holtec International

January 31, 2000

ATTENDEES

Name	Organization
Marissa Bailey	NRC/NMSS/SFPO
Kim Gruss	NRC/NMSS/SFPO
Jack Guttmann	NRC/NMSS/SFPO
Wayne Hodges	NRC/NMSS/SFPO
Eric Leeds	NRC/NMSS/SFPO
Ralph Meyer	NRC/RES
Harold Scott	NRC/RES
Sud Basu	NRC/RES
Farouk Eltawila	NRC/RES
Kris Singh	Holtec International
Bernard Gilligan	Holtec International
Indresh Rampall	Holtec international
Lynnette Hendricks	Nuclear Energy Institute
Mike Neal	NUSIS
Steve Schulin	The Ibex Group

Attachment 1

A Method to Determine the Maximum Permissible Rod Cladding Temperature for High Burnup SNF at Different Post Core Decay Times (PCDTs)

By
Dr. K.P. Singh
Dr. I. Rampall
Mr. B. Gilligan
Holtec International
555 Lincoln Drive West
Marlton, NJ 08053

Presentation to The USNRC

January 31, 2000

HOLTEC
INTERNATIONAL

Facts

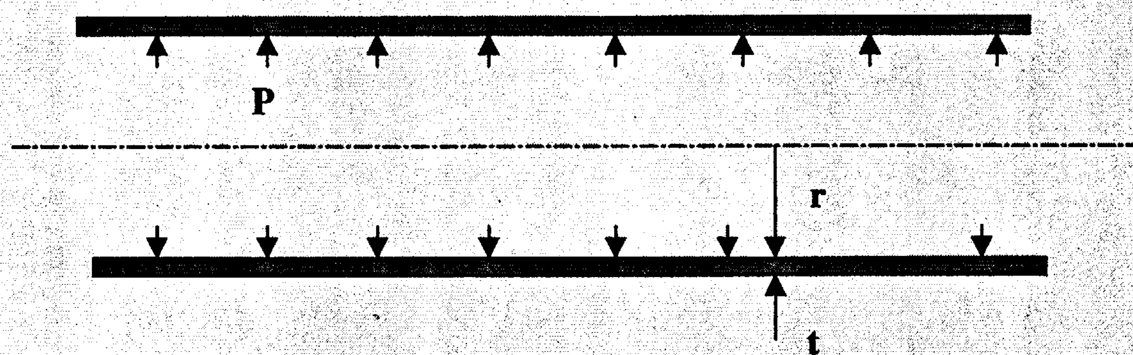
- To stay alive, nuclear plants will continue to move towards higher initial enrichments and longer operating cycles
- High burnup fuel (45 to 65 GWD/MTU) will be discharged in abundance in the coming years

  Example: Over 40% of Sequoyah's SNF will be high burnup. V.C. Summer's last discharge included SNF with up to 58 GWD/MTU burnup!

Facts (continued)

To permit non-operating reactors to decommission on a more reasonable schedule, it is necessary that the permissible cladding temperature for high burnup fuel be reasonably conservative; not unduly conservative.

The Fundamental Degradation Mode for Fuel Cladding is Increasing Hoop Strain with Time (Creep)



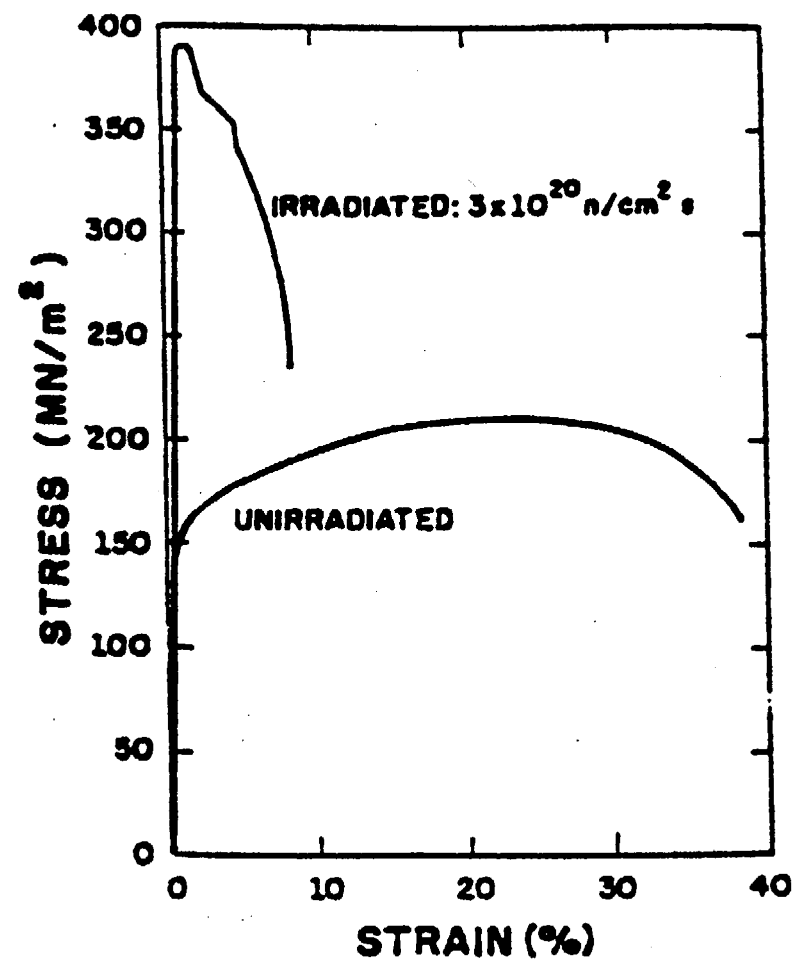
Hoop Stress (σ) = P r/t

Rate of Creep = f (σ,T)

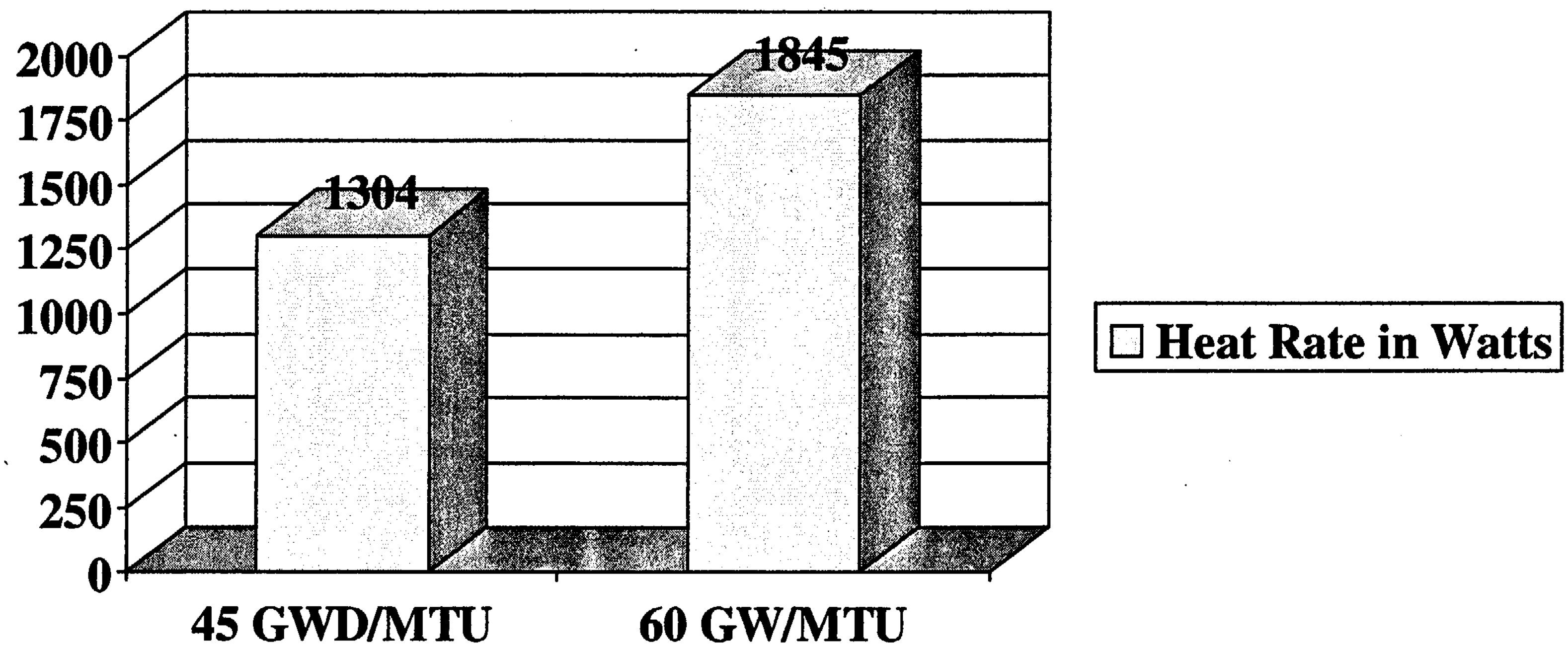
Characteristics of High Burnup SNF

i.	Greater Decay Heat Load at Equivalent PCDT
ii.	Less Peaked Decay Heat Distribution
iii.	Greater Neutron Flux
iv.	Greater Yield Strength
v.	Reduced Strain-to-Failure
vi.	Reduced rate of Creep Deformation

Zircaloy Stress Strain Curve



Comparision of Heat Rates for B&W 15 x 15 SNF at Different Burnups



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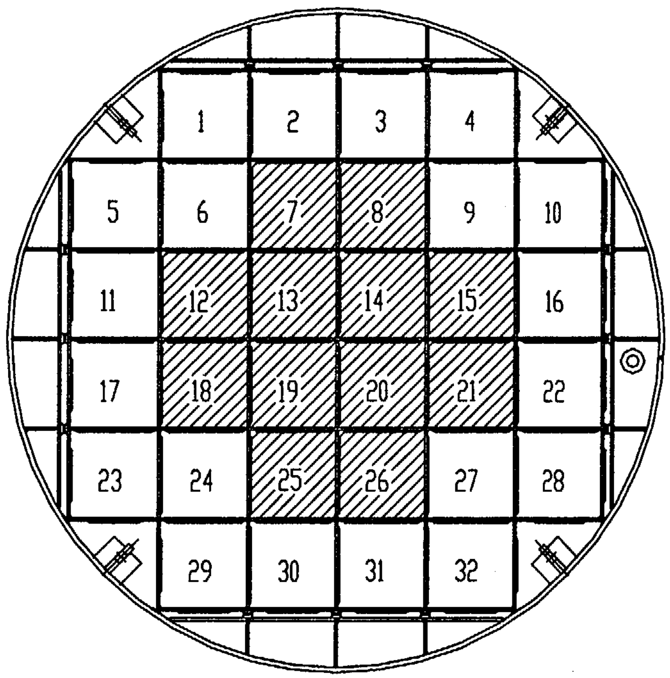
January 31, 2000

Regionalized Storage Necessary to Store and Transport High Burnup SNF

- MPC baskets must use regionalized storage [cold & old fuel on the periphery (Region 2); high burnup & new SNF in the interior (Region 1)]
- RS needed in storage to provide enhanced shielding in the MPC.
- RS needed in transport to meet 10CFR Part 71 Dose Limits (Shielded Configurations)

Regionalized Storage (RS)

Facts



Regionalized Storage in an MPC-32

- RS will reduce dose emitted by the storage cask & transfer cask
- RS is essential to storing and transporting SNF

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Regionalized Storage Facts (continued)

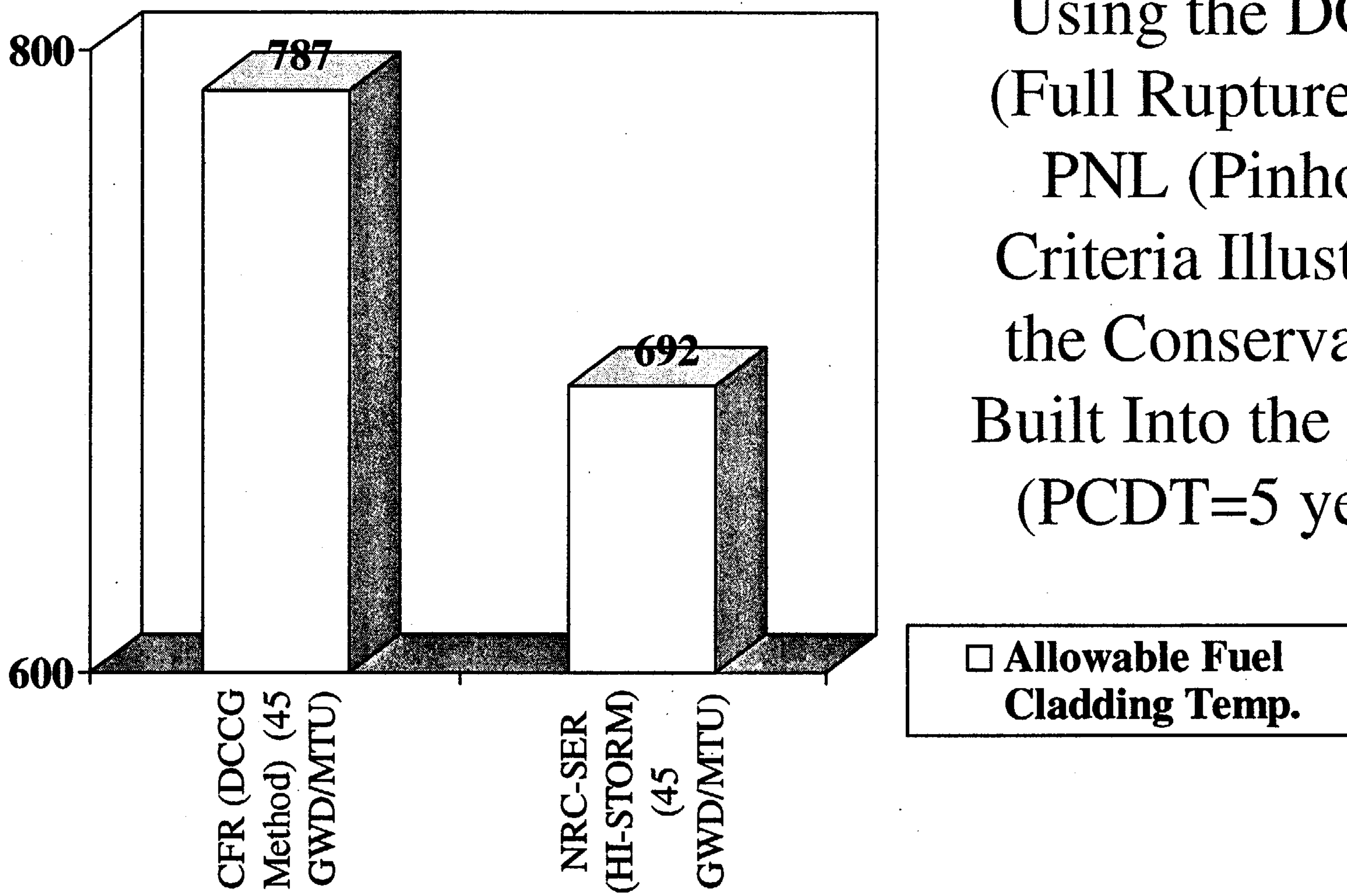
- Realizing that the highest temperature in MPC occurs near the central region, the high burnup fuel will experience the highest temperatures in the fuel basket.

Therefore, it is necessary that the permissible temperature limit for high burnup fuel is not prescribed in an overly conservative manner.

Observations

- The SFPO has selected the more conservative pinhole (PNL) vs. thru-wall rupture (DCCG) as the failure criterion implied by the Code for Federal Regulations.
- The industry can live with this conservative position if it is applied to high burnup fuel without excessively punitive additional conservatisms.
- Just as the SFPO specifies acceptable limits of stress, dose rate, etc., it should also specify acceptable T_{all} for casks.

Histogram of Allowable PWR Fuel Cladding Temp.



Using the DCCG (Full Rupture) and PNL (Pinhole) Criteria Illustrates the Conservatism Built Into the Latter (PCDT=5 years)

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Proposed Method

– Utilizes existing creep data for low and medium burnup fuel in a conservative manner for high burnup fuel.

– Uses the universally accepted failure model for creep failure of pressurized cladding to establish permissible T.

SIEMENS

Comparison of creep strain of unirradiated and irradiated Zry-4 cladding

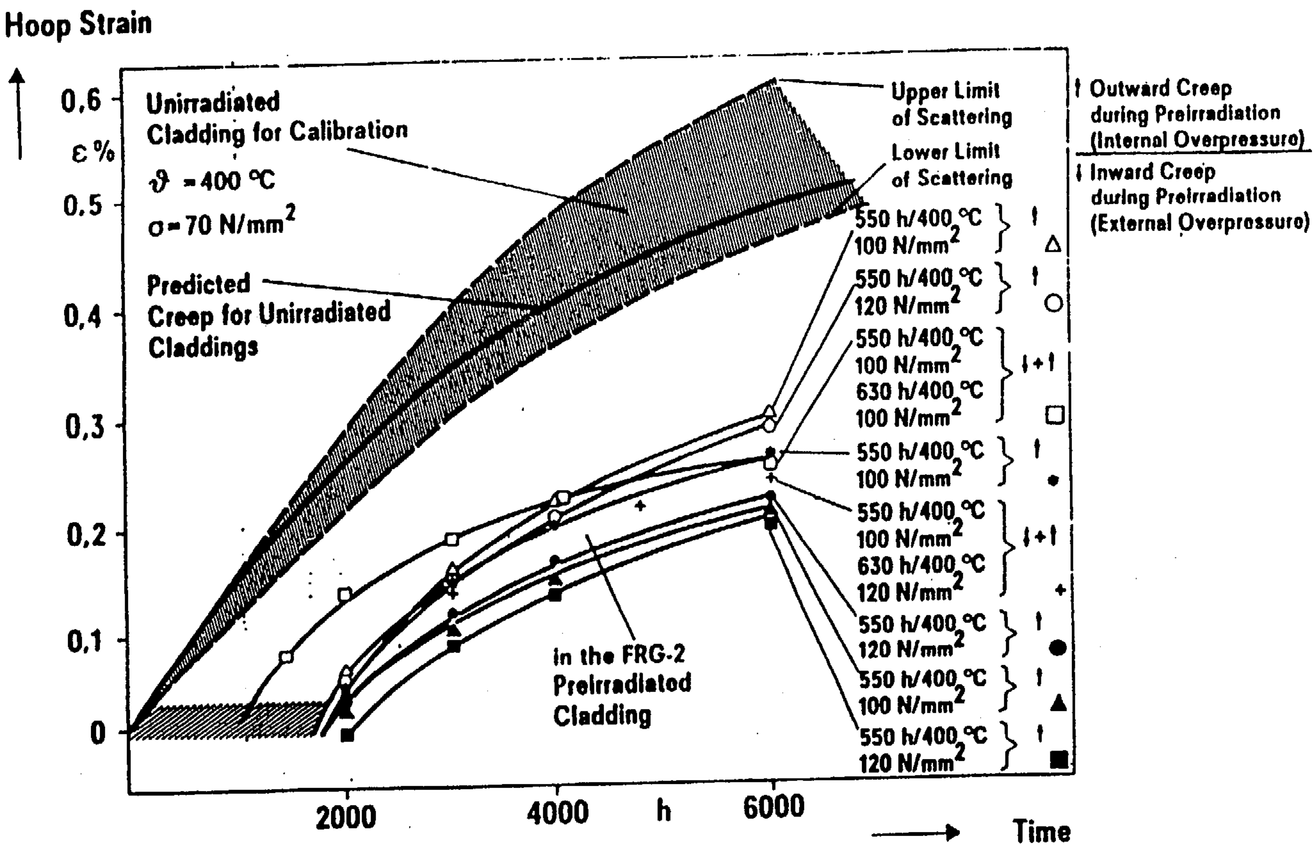

Figure 10

Comparison of creep strain of unirradiated and irradiated Zry-4 cladding

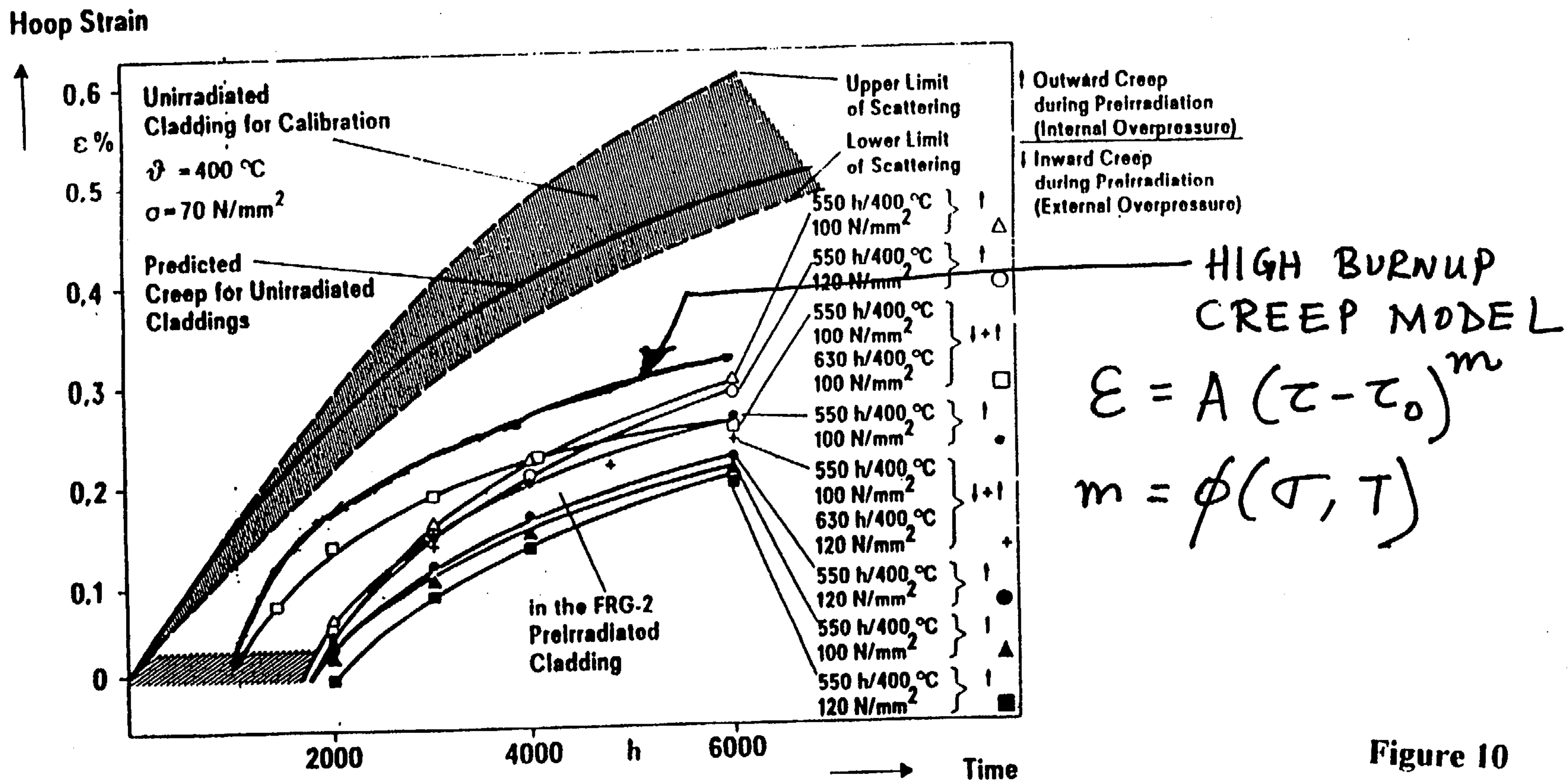

Figure 10

Underlying Concepts

- Creep rate is a function of hoop stress, σ and clad temperature, T.
- The higher the burnup, the lower is the rate of creep.
- The higher the burnup, the smaller is the value of failure strain.
- The accumulated creep, ε, in an irradiated rod can be conservatively defined by the equation

  $\varepsilon = A\,(\tau-\tau_o)^m$; τ is PCDT

  and m is a function of hoop stress and cladding temperature.

Conservative Assumptions

- Assume a limiting value of σ (=150 megapascals) to determine T.
- Assume failure strain at 0.4%.
- Conservatively represent the creep rate of the high burnup rod by the *upper bound creep rate.*

In other words, use the most limiting σ, most limiting failure strain, and a most limiting creep rate curve.

Comparison of the PNL Solution with Proposed Method for the Predicted T_{all}

Case I: σ = 100 Mpa				
		High Burnup Rod Creep Failure Model		
Fuel Age	PNL (°C)	Exp. (°C) (0.4%)	Exp. (°C) (0.2%)	Exp. (°C) (0.1%)
5-Yr	380.7	393.7	378.5	361.6
6-Yr	369.3	390.3	375.3	358.5
7-yr	346.2	386.7	371.8	355.4
10-Yr	341.0	379.7	365.5	349.6
15-Yr	333.2	375.6	361.6	346.1

Comparison of the PNL Solution with Proposed Method for the Predicted T_{all}

Case II: σ = 150 MPa				
		High Burnup Rod Creep Failure Model		
Fuel Age	PNL (°C)	Exp. (°C) (0.4%)	Exp. (°C) (0.2%)	Exp. (°C) (0.1%)
5-Yr	346.9	361.1	345.7	329.0
6-Yr	339.1	357.7	342.6	326.0
7-yr	316.6	354.0	339.2	322.8
10-Yr	311.2	347.1	332.8	316.6
15-Yr	306.0	343.0	329.1	313.3

CONCLUSION

- The PNL data for low burnup at 100 megapascals hoop stress can be conservatively used for high burnup SNF.

- 150 megapascals (σ) will introduce additional (unnecessary!) conservatism.