Addendum 1 to WCAP-10125-NP-A

Revisions to Design Criteria

December 2002

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Introduction

The purpose of this submittal is to update certain fuel licensing criteria that are applied to Westinghouse fuel. The criteria to be updated pre-date NUREG-0800[1]. The update promotes convergence with the practices of all other Westinghouse business segments and is consistent with current industry guidelines.

Parameter:	Fuel Cladding transient Strain
Current Criteria:	The transient strain will be less than 1% and fuel centerline melt will not occur.
Proposed Criteria:	No change.

Parameter:	Fuel Cladding Transient Stress
Current Criteria:	The transient stress will be less than [ ] ^{a,c}.
Replace With:	Cladding stresses will be consistent with ASME Code Section III requirements.

The following sections give the bases for justifying the changes to the fuel cladding stress design criterion.

Updated Fuel Rod Cladding Stress Criterion

A review was performed of the fuel rod design criteria presented in References 2, 3 and 4. Those criteria were correlated with the design criteria presented in NUREG-0800[1] and in the robust fuel program technical requirements document[5]. Based on this review it was determined that the following changes were needed in the criteria.

- Remove cladding transient stress criterion, and
- Replace with cladding stress criterion based on ASME pressure vessel criteria.

A detailed description and justification for the proposed removal of the transient stress criterion and substitution of static stress criterion are given below.

<u>Transient Stress:</u> The design limit for the fuel rod cladding stress under normal operation and AOOs is that the volume averaged effective stress, considering interference due to uniform cylindrical pellet-to-cladding contact is less than the [

] a,c.

This limit was designed to protect the cladding during pellet-cladding interaction (PCI). This is one of four criteria which were imposed to protect the cladding from PCI during Condition I and II operation. These four criteria are:

- Transient Stress [ ] a,c,
- Transient Strain < 1%,
- No Centerline Fuel Melt, and
- Cladding Total Strain < 1%

The remaining three criteria which protect the cladding from PCI are detailed below.

<u>Transient Strain:</u> The design limit for the fuel rod cladding transient strain during AOOs is that the total tensile strain due to uniform cylindrical pellet thermal expansion during the transient is less than 1% of the pre-transient value.

The transient strain is the change in total strain from the start to the peak of the transient.

$$\varepsilon_{trans} = \varepsilon_{tot\_at\_trans\_peak} - \varepsilon_{tot\_at\_start}$$

<u>Total Strain:</u> The design limit for the fuel rod cladding total strain during normal steady state operation is that the total strain of the cladding shall not exceed 1%. The total strain consists of both plastic and elastic components and is determined in PAD[6] at any time step by:

[ ] a, c

No Centerline Fuel Melt: The design limit for fuel temperature analysis during Condition I and II is that there is at least a 95% probability that the peak kW/ft fuel rods will not exceed the UO_2 melting temperature.

These three criteria are sufficient to protect the cladding from PCI. The transient stress criterion is redundant and does not represent industry practice. The criterion to be substituted is based on current industry practice and is described below.

Fuel Rod Cladding Stress: Maximum cladding stress intensities excluding PCI induced stress will be evaluated using ASME pressure vessel guidelines(7). Cladding corrosion is accounted for as a loss of load carrying material. Stresses are combined to calculate a maximum stress intensity which is then compared to criteria based on the ASME code.

Criteria: Sm = the minimum of:

1/3 σ_{ult} minimum specified at room temperature
1/3 σ_{ult} value at temperature
2/3 σ_y minimum specified at room temperature
2/3 σ_y value at temperature

Su = the minimum of:

σ_{ult} minimum specified at room temperature
σ_{ult} value at temperature

where: σ_y is the 0.2% offset yield strength
σ_{ult} is the ultimate tensile strength

Stress Intensity Limits		
Loading Conditions	**Description**	**Limit**
Pm	Primary Membrane	Sm
Pm + Pb	Primary Membrane + Bending	1.5Sm
Pm + Pb + Pl	Primary Membrane + Bending + Local	1.5Sm
Pm + Pb + Pl + Q	Primary Membrane + Bending + Local + Secondary	3.0Sm
Pm	Faulted Conditions - Primary Membrane	Minimum of 0.7Su or 1.6 Sm
Pm + Pb Pm + Pb + Pl	Faulted Conditions - Primary Membrane + Bending	Minimum of 1.05Su or 2.4 Sm

The stresses to be considered due to and the stress category are listed:

Stress Due to	Stress Category
Differential Pressure	Primary Membrane
Ovality	Primary Bending
Flow induced vibration	Primary Bending
Fuel Assembly Bow	Primary Bending
Fuel Rod Bow	Primary Bending
Spacer grid contact force	Primary Local
Thermal differential across the cladding	Secondary

Conclusions

The current criteria applied to Westinghouse fuel pre-date NUREG-0800[1] and do not conform completely to NUREG-0800[1], to industry guidelines[5], and to those criteria in use at other Westinghouse business units. The proposed updated criteria are provided in order to conform to both NUREG-0800[1] and to current industry guidelines[5]. These updated criteria are sufficient to preclude fuel damage and will also promote convergence between practices of all Westinghouse business segments.

References

1. U. S. NRC, "USNRC Standard Review Plan, Section 4.2, Fuel System Design," NUREG-0800, July 1981.

2. Davidson, S. L. (Ed.), et al., "VANTAGE + Fuel Assembly Reference Core Report," WCAP-12610-P-A, April 1995, pg. 12.

3. Davidson, S. L. (Ed.), et al., "Westinghouse Fuel Criteria Evaluation Process," WCAP-12488-A (Proprietary), WCAP-14204-A (Non-proprietary), October 1994.

4. Davidson, S. L. (Ed.), et al., "Extended Burnup Evaluation of Westinghouse Fuel," WCAP-10125-P-A, December 1985.

5. EPRI, "Robust Fuel Program Technical Requirements for Nuclear Fuel Performance," TR-110689, November 1999.

6. Foster, J. P. and Sidener, S., "Westinghouse Improved Performance Analysis and Design Model (PAD 4.0)," WCAP-15063-P-A, Revision 1 with Errata, July, 2000.

7. ASME Pressure Vessel Code, Section III, Article NG-3000, 1998.