

Westinghouse Non-Proprietary Class 3

WCAP-10125-NP-A  
Addendum 1-A

May 2003

# Addendum 1 to WCAP-10125-NP-A Revisions to Design Criteria



Westinghouse Non-Proprietary Class 3

WCAP-10125-NP-A, Addendum 1-A

**Addendum 1 to WCAP-10125-NP-A**  
**Revisions to Design Criteria**

**Original: December 2002**

**Approved: May 2003**

**Prepared by:**  
**William H. Slagle**

© 2003 Westinghouse Electric Company LLC  
All Rights Reserved

**Table of Content**

<b>Section</b>	<b>Description</b>
<b>A</b>	<b>Letter from H. N. Berkow (NRC) to H. A. Sepp (Westinghouse), "Safety Evaluation of Addendum 1 to Topical Report (TR) WCAP-10125-P-A, 'Extended Burnup Evaluation of Westinghouse Fuel,' (TAC No. MB7484)," April 14, 2003.</b>
<b>B</b>	<b>Letter from H. A. Sepp (Westinghouse) to J. S. Wermiel (NRC), "Submittal of WCAP-10125-P-A, Addendum 1/WCAP-10125-NP-A, Addendum 1 of Extended Burnup Evaluation of Westinghouse Fuel, "Revision to Design Criteria," (Proprietary/Non-Proprietary)</b>

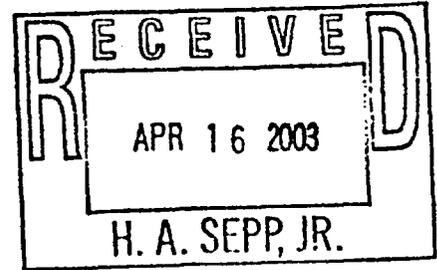
**Section A**



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

April 14, 2003

Mr. Henry A. Sepp, Jr.  
Manager of Regulatory and Licensing Engineering  
Westinghouse Electric Company  
P.O. Box 355  
Pittsburgh, PA 15230-0355



SUBJECT: SAFETY EVALUATION OF ADDENDUM 1 TO TOPICAL REPORT (TR)  
WCAP-10125-P-A, "EXTENDED BURNUP EVALUATION OF WESTINGHOUSE  
FUEL" (TAC NO. MB7484)

Dear Mr. Sepp:

On December 5, 2002, Westinghouse Electric Company submitted Addendum 1 to TR WCAP-10125-P-A, "Extended Burnup Evaluation of Westinghouse Fuel," for NRC staff review and approval. WCAP-10125-P-A is an approved TR that describes analytical methodologies including the design bases, limits, and criteria for Westinghouse fuel in high burnup licensing applications.

The addendum proposes a revision to the fuel cladding stress criterion to be consistent with current industry guidelines. Specifically, it replaces the transient stress criterion of fuel rod analysis with a new cladding stress criterion based on the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III requirements. The NRC staff has completed its review of the subject Addendum 1 to TR WCAP-10125-P-A. The addendum is acceptable for referencing in licensing applications to the extent specified and under the limitations delineated in the report and in the associated NRC safety evaluation (SE). The enclosed SE defines the basis for acceptance of the TR.

Pursuant to 10 CFR 2.790, we have determined that the enclosed SE does not contain proprietary information. However, we will delay placing the SE in the public document room for a period of ten working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects only. If you believe that any information in the enclosure is proprietary, please identify such information line by line and define the basis pursuant to the criteria of 10 CFR 2.790.

We do not intend to repeat our review of the matters described in the subject report and found acceptable, when the report appears as a reference in license applications, except to ensure that the material presented applies to the specific plant involved. Our acceptance applies only to matters approved in the report.

In accordance with the guidance provided on the NRC website, we request that Westinghouse publish an accepted version within three months of receipt of this letter. The accepted version shall incorporate (1) this letter and the enclosed SE between the title page and the abstract, (2) all requests for additional information from the staff and all associated responses, and (3) a "-A" (designating "accepted") following the report identification symbol.

H. Sepp

Should our criteria or regulations change so that our conclusions as to the acceptability of the report are invalidated, Westinghouse and/or the applicants referencing the TR will be expected to revise and resubmit their respective documentation, or submit justification for the continued applicability of the TR without revision of their respective documentation.

Sincerely,



Herbert N. Berkow, Director  
Project Directorate IV  
Division of Licensing Project Management  
Office of Nuclear Reactor Regulation

Project No. 700

Enclosure: Safety Evaluation

cc w/encl:  
Mr. Gordon Bischoff, Project Manager  
Westinghouse Owners Group  
Westinghouse Electric Company Mail  
Stop ECE 5-16  
P.O. Box 355  
Pittsburgh, PA 15230-0355



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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-10125-P-A, ADDENDUM 1,

"EXTENDED BURNUP EVALUATION OF WESTINGHOUSE FUEL"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION

On December 5, 2002, Westinghouse Electric Company submitted Addendum 1 to Topical Report (TR) WCAP-10125-P-A, "Extended Burnup Evaluation of Westinghouse Fuel," for NRC staff review and approval. WCAP-10125-P-A is an approved TR that describes analytical methodologies including the design bases, limits, and criteria for Westinghouse fuel in high burnup licensing applications. Addendum 1 proposes a revision to the fuel cladding stress criterion to be consistent with current industry guidelines.

2.0 REGULATORY EVALUATION

Title 10 of the *Code of Federal Regulations (10 CFR)* Part 50, Appendix A, General Design Criterion (GDC) 10 states, "The reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences." This review provides assurance that the requirements of GDC 10 are properly implemented in the proposal.

Fuel rods constantly experience thermal and mechanical loads during steady-state and transient reactor operating conditions. The cladding strain produced from those loads can be divided into two components: steady-state and transient strains. The total strain is the sum of the steady-state and transient strains. However, cladding stress is either steady-state stress or transient stress depending on the cladding loading conditions. To protect fuel rods against pellet-cladding interaction (PCI), which is a severe transient condition that could lead to multiple fuel failures, Standard Review Plan (SRP) Section 4.2 establishes two limiting criteria: (1) the total strain shall not exceed 1 percent, and (2) fuel melting should be avoided.

3.0 TECHNICAL EVALUATION

Westinghouse has established four design criteria to protect against PCI in WCAP-10125-P-A. These four criteria are: (1) transient strain must be less than 1 percent, (2) total strain must be less than 1 percent, (3) fuel centerline melting must not occur, and (4) transient stress must be less than a proprietary value. Westinghouse stated that the first three criteria meet the intent of the SRP recommendations, and the fourth criterion is redundant and does not represent current

industry guidelines. Westinghouse therefore proposed to replace the fourth criterion of transient stress with a cladding stress limit based on the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code), Section III criteria.

SRP Section 4.2 indicates that stress limits are acceptable if they are obtained using methods based on the ASME Code, Section III criteria. Section III describes various stress state criteria and limits, and is widely accepted in the nuclear industry. The Westinghouse proposal for a fuel rod cladding stress limit based on the ASME Code, Section III is consistent with the SRP Section 4.2 recommendations. Based on the use of the acceptable ASME Code, Section III methods, the staff approves the Westinghouse proposal to revise the fuel rod cladding stress limit.

#### 4.0 CONCLUSION

The staff has reviewed Addendum 1 to WCAP-10125-P-A that would replace the transient stress criterion of fuel rod analysis with a new cladding stress criterion based on the ASME Code, Section III requirements. Because it is consistent with the SRP Section 4.2 and ASME Code, Section III requirements, the staff approves the proposed cladding stress criterion in Addendum 1 to WCAP-10125-P-A.

Principal Contributor: S. Wu

Date: April 14, 2003

**Section B**



Westinghouse Electric Company  
Nuclear Services  
P.O. Box 355  
Pittsburgh, Pennsylvania 15230-0355  
USA

U.S. Nuclear Regulatory Commission  
ATTN: Document Control Desk  
Washington, DC 20555

Direct tel: 412/374-5282  
Direct fax: 412/374-4011  
e-mail: [Sepp1ha@westinghouse.com](mailto:Sepp1ha@westinghouse.com)

Attention: J. S. Wermiel, Chief  
Reactor Systems Branch  
Division of Systems Safety and Analysis

Our ref: LTR-NRC-02-62

December 5, 2002

Subject: Submittal of WCAP-10125-P-A, Addendum 1/WCAP-10125-NP-A, Addendum 1 of Extended Burnup Evaluation of Westinghouse Fuel, "Revision to Design Criteria," (Proprietary / Non-proprietary)

Dear Mr. Wermiel:

Enclosed are copies of the Proprietary and Non-Proprietary versions of Addendum 1 to WCAP-10125-P-A/WCAP-10125-NP-A, "Extended Burnup Evaluation of Westinghouse Fuel," being submitted for review and approval. This addendum was previously submitted by Westinghouse as Addendum 2 to WCAP-12488-A, but was withdrawn based on the NRC's comment that it was more appropriate to be an addendum to WCAP-10125-P-A.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-02-1589 with Proprietary Information Notice and Copyright Notice.
2. One (1) copy of Affidavit, AW-02-1589.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR 9.17(a)(4). Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the expressed prior written approval of Westinghouse.

Correspondence with respect to any Application for Withholding should reference AW-02-1589 and should be addressed to H. A. Sepp, Manager of Regulatory and Licensing Engineering, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,



John S. Galembush, Acting Manager  
Regulatory and Licensing Engineering

Copy to:

S. L. Wu, NRR  
R. Caruso, NRR  
U. Shoop, NRR  
G. Shukla, NRR



Westinghouse Electric Company  
Nuclear Services  
P.O. Box 355  
Pittsburgh, Pennsylvania 15230-0355  
USA

U.S. Nuclear Regulatory Commission  
ATTN: Document Control Desk  
Washington, DC 20555

Direct tel: 412/374-5282  
Direct fax: 412/374-4011  
e-mail: Sepp1ha@westinghouse.com

Attention: J. S. Wermiel, Chief  
Reactor Systems Branch  
Division of Systems Safety and Analysis

Our ref: AW-02-1589

December 5, 2002

APPLICATION FOR WITHHOLDING PROPRIETARY  
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Submittal of WCAP-10125-P-A, Addendum 1/WCAP-10125-NP-A, Addendum 1 of Extended Burnup Evaluation of Westinghouse Fuel, "Revision to Design Criteria," (Proprietary / Non-proprietary)

Reference: Letter from H. A. Sepp to J. S. Wermiel, LTR-NRC-02-62, dated December 5, 2002

Dear Mr. Wermiel:

The application for withholding is submitted by Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse"), pursuant to the provisions of paragraph (b)(1) of Section 2.790 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.790, Affidavit AW-02-1589 accompanies this application for withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-02-1589 and should be addressed to H. A. Sepp, Manager of Regulatory and Licensing Engineering, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,



John S. Galembush, Acting Manager  
Regulatory and Licensing Engineering

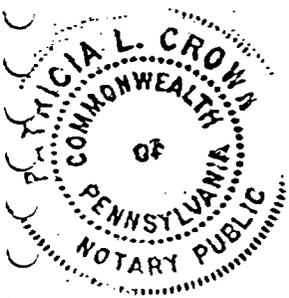
AFFIDAVIT

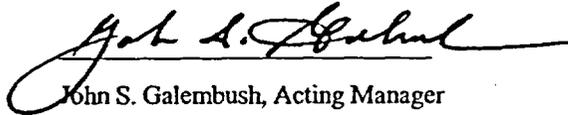
COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared John S. Galembush, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse") and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

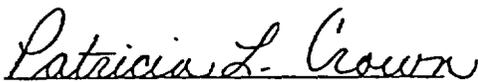




John S. Galembush, Acting Manager  
Regulatory and Licensing Engineering

Sworn to and subscribed  
before me this 5th day  
of December, 2002.

Notarial Seal  
Patricia L. Crown, Notary Public  
Monroeville Boro, Allegheny County  
My Commission Expires Feb. 7, 2005  
Member, Pennsylvania Association of Notaries



Notary Public

- (1) I am Acting Manager, Regulatory and Licensing Engineering, in the Nuclear Services, of the Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse") and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Electric Company.
- (2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.
- (3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Electric Company in designating information as a trade secret, privileged or as confidential commercial or financial information.
- (4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.
  - (i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.
  - (ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

- (a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.
- (b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.
- (c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

- (d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.
- (e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.
- (f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

- (a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.
  - (b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.
  - (c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.
  - (d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.
  - (e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.
  - (f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.
- (iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.790, it is to be received in confidence by the Commission.
  - (iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

- (v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked "Submittal of WCAP-10125-P-A, Addendum 1/WCAP-10125-NP-A, Addendum 1 of Extended Burnup Evaluation of Westinghouse Fuel, "Revision to Design Criteria," (Proprietary/Non-proprietary), December 5, 2002, for submittal to the Commission, being transmitted by Westinghouse Electric Company (W) letter (LTR-NRC-02-62) and Application for Withholding Proprietary Information from Public Disclosure, Henry A. Sepp, Westinghouse, Manager Regulatory and Licensing Engineering to the attention of J. S. Wermiel, Chief, Reactor Systems Branch, Division of Systems Safety and Analysis. The proprietary information as submitted by Westinghouse Electric Company is Addendum 1 to WCAP-10125-P-A/WCAP-10125-NP-A which provides revisions to certain design criteria. This addendum was previously submitted by Westinghouse as Addendum 2 to WCAP-12488-A, but was withdrawn based on the NRC's comment that it was more appropriate to be an addendum to WCAP-10125-P-A.

This information is part of that which will enable Westinghouse to:

- (a) The proposed criteria replace indirect performance correlations with direct performance correlations that are more readily measured and provide direct feedback to design.
- (b) The revised criteria conform to both NUREG-0800 and to current industry guidelines.
- (c) These updated criteria will promote convergence between Westinghouse business units.

Further this information has substantial commercial value as follows:

- (a) Westinghouse can continue to ensure the highest quality of fuel since the proposed criteria is more readily measurable and thus provides direct feedback to fuel designs.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing the enclosed improved core thermal performance methodology.

Further the deponent sayeth not.

**Proprietary Information Notice**

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC. In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.790(b)(1).

**Copyright Notice**

The documents transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies for the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.790 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond these necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

WCAP-10125-NP-A, Addendum 1

**Addendum 1 to WCAP-10125-NP-A**  
**Revisions to Design Criteria**

**December 2002**

© 2002 Westinghouse Electric Company  
All Rights Reserved

**Addendum 1 to WCAP-10125-NP-A  
Revisions to Design Criteria**

**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<sup>(1)</sup>. 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 [ ] <sup>2</sup>.  
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<sup>(1)</sup> and in the robust fuel program technical requirements document<sup>(5)</sup>. 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.

**Transient Stress:** 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 [

] <sup>a, c</sup>.

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 [ ] <sup>a, c</sup>,
- 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.

**Transient Strain:** 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.

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

**Total Strain:** 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<sup>(6)</sup> at any time step by:

$$\left[ \right]^{a, c}$$

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<sub>2</sub> 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<sup>(7)</sup>. 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:  $S_m$  = the minimum of:  
            $1/3 s_{ult}$  minimum specified at room temperature  
            $1/3 s_{ult}$  value at temperature  
            $2/3 s_y$  minimum specified at room temperature  
            $2/3 s_y$  value at temperature  
 $S_u$  = the minimum of:  
            $s_{ult}$  minimum specified at room temperature  
            $s_{ult}$  value at temperature

where:  $s_y$  is the 0.2% offset yield strength  
 $s_{ult}$  is the ultimate tensile strength

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

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

<b>Stress Due to</b>	<b>Stress Category</b>
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<sup>(1)</sup> and do not conform completely to NUREG-0800<sup>(1)</sup>, to industry guidelines<sup>(5)</sup>, 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<sup>(1)</sup> and to current industry guidelines<sup>(5)</sup>. 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-NP-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.