

**Westinghouse Non-Proprietary Class 3**

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

**May 2005**

# **Extended Burnup Evaluation of Westinghouse Fuel, Revision to Design Criteria**



# **Extended Burnup Evaluation of Westinghouse Fuel, Revision to Design Criteria**

**May 2005**

**Prepared by:**

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**\*Official Record Electronically Approved in EDMS**

**Westinghouse Electric Company LLC  
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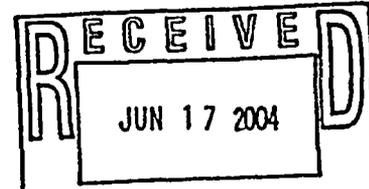
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**Section A**



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

June 10, 2004



Mr. James A. Gresham, Manager  
Regulatory and Licensing Engineering  
Westinghouse Electric Company  
P.O. Box 355  
Pittsburgh, PA 15230-0355

**SUBJECT: FINAL SAFETY EVALUATION FOR REVISION 1 TO WCAP-10125-P-A,  
ADDENDUM 1-A, "EXTENDED BURNUP EVALUATION OF WESTINGHOUSE  
FUEL, REVISION TO DESIGN CRITERIA" (TAC NO. MC1646)**

Dear Mr. Gresham:

On December 8, 2003, Westinghouse Electric Company (Westinghouse) submitted Revision 1 to Topical Report (TR) WCAP-10125-P-A, Addendum 1-A, "Extended Burnup Evaluation of Westinghouse Fuel, Revision to Design Criteria," to the staff for review. On May 20, 2004, an NRC draft safety evaluation (SE) regarding our approval of Revision 1 to TR WCAP-10125-P-A, Addendum 1-A, was provided for your review and comments. By telephone conference on June 2, 2004, Mr. Rob Sisk of your staff provided Westinghouse's acceptance of the draft SE without comments.

The staff has found that Revision 1 to TR WCAP-10125-P-A, Addendum 1-A, is acceptable for referencing in licensing applications for Westinghouse-designed pressurized water reactors to the extent specified and under the limitations delineated in the TR and in the enclosed SE. The SE defines the basis for acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that Westinghouse publish an accepted version of this TR, including a non-proprietary version, within three months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed SE between the title page and the abstract. It must be well indexed such that information is readily located. Also, it must contain in appendices historical review information, such as questions and accepted responses, draft SE comments, and original report pages that were replaced. The accepted version shall include a "-A" (designating accepted) following the report identification symbol.

J. Gresham

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If the NRC's criteria or regulations change so that its conclusions in this letter, that the TR is acceptable, are invalidated, Westinghouse and/or the licensees referencing the TR will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the TR without revision of the respective documentation.

Sincerely,

Handwritten signature of Herbert N. Berkow in cursive script.

Herbert N. Berkow, Director /RA/  
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, Manager  
Owners Group Program Management Office  
Westinghouse Electric Company  
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

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

"EXTENDED BURNUP EVALUATION OF WESTINGHOUSE FUEL,

REVISION TO DESIGN CRITERIA"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION

On December 8, 2003, Westinghouse Electric Company (Westinghouse) submitted to the NRC Revision 1 to Topical Report (TR) WCAP-10125-P-A, Addendum 1-A, "Extended Burnup Evaluation of Westinghouse Fuel, Revision to Design Criteria," for review and approval. WCAP-10125-P-A is an approved TR that describes analytical methodologies that include the design bases, limits, and criteria for Westinghouse fuel in high burnup licensing applications. WCAP-10125-P-A, Addendum 1-A, is an approved addendum that revises the fuel cladding stress criterion to be consistent with industry practice.

Revision 1 to Addendum 1-A intends to apply the same revised fuel cladding stress criterion to another approved TR, WCAP-12488-A, "Westinghouse Fuel Criteria Evaluation Process." This TR describes a process and criteria intended to apply to changes or improvements in existing fuel designs that will not require NRC review and prior approval when these criteria are satisfied. Revision 1 to Addendum 1-A will clarify the fuel cladding stress criterion in WCAP-12488-A to maintain a set of fuel rod design criteria consistent with industry practice.

2.0 REGULATORY EVALUATION

The fuel system consists of arrays of fuel rods including fuel pellets and tubular cladding, spacer grids, end plates, and reactivity control rods. The objectives of the fuel system safety review are to provide assurance that: (1) the fuel system is not damaged as a result of normal operation and anticipated operational occurrences; (2) fuel system damage is never so severe as to prevent control rod insertion when it is required; (3) the number of fuel rod failures is not underestimated for postulated accidents; and (4) coolability is always maintained.

The staff acceptance criteria are based on NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP), Section 4.2, "Fuel System Design." These criteria include three parts: (1) design bases that describe specified acceptable fuel design limits (SAFDLs) that implement Criterion 10, "Reactor design," as specified in Title 10 of the *Code of Federal Regulations*, Part 50 (10 CFR Part 50), Appendix A, "General Design Criteria for Nuclear Power Plants;" (2) design evaluations that demonstrate that the design bases are met; and (3) testing, inspection, and surveillance plans that show

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there is adequate monitoring and surveillance of irradiated fuel. The design bases include: (1) fuel system damage; (2) fuel rod failure; and, (3) fuel coolability. The fuel rod cladding stress and strain limits are part of the SAFDLs.

### 3.0 TECHNICAL EVALUATION

Fuel rods are constantly under thermal and mechanical loads during steady-state and transient operating conditions in reactors. The cladding strain produced from these loads can be divided into two components: steady-state and transient strains. The total strain is the sum of 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, SRP Section 4.2 establishes two limiting criteria: (1) the transient-induced strain should not exceed 1 percent, and (2) fuel melting should be avoided.

Westinghouse has established four design criteria in WCAP-10125-P-A to protect against PCI. These four criteria are: (1) steady-state strain must be less than 1 percent; (2) transient 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 met the intent of the SRP requirements, but the fourth criterion was redundant and did not represent current industry practice. Westinghouse therefore proposed to replace the fourth criterion of transient stress with a stress limit based on the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code).

SRP Section 4.2 states that stress limits obtained by methods similar to those given in Section III of the ASME Code are acceptable. ASME Code 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 criteria is consistent with SRP Section 4.2.

Since WCAP-12488-A references WCAP-10125-P-A and shares the same cladding stress limit, the staff concludes that the revised fuel rod cladding stress limit of WCAP-10125-P-A is also applicable to WCAP-12488-A.

### 4.0 CONCLUSION

The staff has reviewed the Westinghouse submittal to replace the transient stress limit of fuel rod analysis with a revised cladding stress limit based on the ASME Code Section III criteria. Because it is consistent with SRP Section 4.2 and the ASME Code, the staff concludes that the revised fuel rod cladding stress limit of Revision 1 to WCAP-10125-P-A, Addendum 1-A, is acceptable.

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The staff further concludes that the revised fuel rod cladding stress limit of Revision 1 to WCAP-10125-P-A, Addendum 1-A, is also applicable to WCAP-12488-A. The staff requires that Westinghouse administratively update the section on clad stress in WCAP-12488-A to reflect the revision that will supersede the current limit. There is no requirement for Westinghouse to submit an updated WCAP-12488-A to the staff; however, Westinghouse should submit a letter informing the staff of the update.

Principal Contributor: S. Wu

Date: June 10, 2004

**Section B**



Westinghouse Electric Company  
Nuclear Services  
P.O. Box 355  
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USA

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

Direct tel: 412/374-5036  
Direct fax: 412/374-4011  
e-mail: galem1js@westinghouse.com

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

Our ref: LTR-NRC-03-72

December 8, 2003

Subject: Submittal of Revision 1 to WCAP-10125-P-A, Addendum 1-A/Revision 1 to WCAP-10125-NP-A, Addendum 1-A 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 Revision 1 to WCAP-10125-P-A, Addendum 1-A/Revision 1 to WCAP-10125-NP-A, Addendum 1-A, "Extended Burnup Evaluation of Westinghouse Fuel, Revision to Design Criteria," is being submitted for review and approval. The revision to the addendum is necessitated due to Addendum 2 of WCAP-12488-A being withdrawn. Clarifications were needed in order to maintain a consistent set of fuel rod design criteria. Approval is requested by March 2004 to support utility operations.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-03-1722 with Proprietary Information Notice and Copyright Notice.
2. One (1) copy of Affidavit, AW-03-1722.

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.

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LTR-NRC-03-72  
December 8, 2003

Correspondence with respect to this Application for Withholding should reference AW-03-1722 and should be addressed to J. S. Galembush, Acting Manager Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,



H. A. Sepp, Manager  
Regulatory Compliance and Plant Licensing

Copy to:  
F. M. Akstulewicz/NRR  
B. J. Benney/NRR  
E. S. Peyton/NRR  
S. L. Wu/NRR  
U. Shoop/NRR



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

Our ref: AW-03-1722

December 8, 2003

APPLICATION FOR WITHHOLDING PROPRIETARY  
INFORMATION FROM PUBLIC DISCLOSURE

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

Reference: Letter from H. A. Sepp to J. S. Wermiel, LTR-NRC-03-72, dated December 8, 2003

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-03-1722 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-03-1722 and should be addressed to J. S. Galembush, Acting Manager Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

Handwritten signature of H. A. Sepp in black ink.

H. A. Sepp, Manager  
Regulatory Compliance and Plant Licensing

AW-03-1722

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

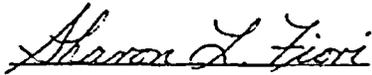
COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared H. A. Sepp, 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:

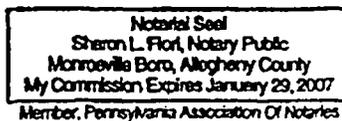


H.A. Sepp, Manager  
Regulatory Compliance and Plant Licensing

Sworn to and subscribed  
before me this 8th day  
of December, 2003.



Notary Public



- (1) I am Manager, Regulatory Compliance and Plant Licensing, in 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 Revision 1 to WCAP-10125-P-A, Addendum 1-A/Revision 1 to WCAP-10125-NP-A, Addendum 1-A of Extended Burnup Evaluation of Westinghouse Fuel, Revision to Design Criteria," (Proprietary/Non-Proprietary), December 8, 2003 for submittal to the Commission, being transmitted by Westinghouse Electric Company letter (LTR-NRC-03-72) and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk, Attention Mr. J. S. Wermiel, Chief, Reactor Systems Branch, Division of Systems Safety and Analysis. The proprietary information as submitted by Westinghouse Electric Company is "Revision 1 to WCAP-10125-P-A, Addendum 1-A" which provides a revision to certain design criteria. The revision to the addendum has been necessitated in part due to Addendum 2 of WCAP-12488-A being withdrawn. Clarifications are needed in order to maintain a consistent set of fuel rod design criteria.

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.

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AW-03-1722

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.

Westinghouse Non-Proprietary Class 3

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

**Revision 1 to WCAP-10125-NP-A, Addendum 1-A  
Extended Burnup Evaluation of Westinghouse Fuel,  
Revision to Design Criteria**

**December 2003**

Westinghouse Electric Company LLC  
4350 Northern Pike  
Monroeville, PA 15146  
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### 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>(2)</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 the static stress criterion are given below.

**Transient Stress:** The design limit for the fuel rod cladding stress under Condition I and II modes of operation is that the volume averaged effective stress [  $\sigma_{eff}$  ]<sup>(3)</sup> considering interference due to uniform cylindrical pellet-to-cladding contact (caused by pellet thermal expansion and swelling, uniform clad creep, and fuel rod/coolant system pressure differences) is less than the [  $\sigma_{ASME}$  ] with consideration of temperature and irradiation effects. The yield strength is calculated [  $\sigma_{ASME}$  ]<sup>(4)</sup>.

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

- Transient Clad Stress [  $\sigma_{eff}$  ]<sup>(3)</sup>,
- Transient Clad Strain < 1%<sup>(4)</sup>,
- No Centerline Fuel Melt<sup>(4)</sup>, and
- Steady State Clad Strain < 1%<sup>(4)</sup>

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

stress limit substitution is also acceptable in the Fuel Criteria Evaluation Process<sup>(3)</sup>. The substitution of the transient stress criterion is on a forward fit basis and is intended to be used in conjunction with previously licensed topical reports, such as References 2, 3, 4, and 6.

**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:  
 $1/3 \sigma_{ult}$  minimum specified at room temperature  
 $1/3 \sigma_{ult}$  value at temperature  
 $2/3 \sigma_y$  minimum specified at room temperature  
 $2/3 \sigma_y$  value at temperature

$S_u$  = the minimum of:  
 $\sigma_{ult}$  minimum specified at room temperature  
 $\sigma_{ult}$  value at temperature

where:  $\sigma_y$  is the 0.2% offset yield strength  
 $\sigma_{ult}$  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	Faulted Conditions - Primary Membrane + Bending	Minimum of $1.05S_u$ or $2.4 S_m$
Pm + Pb + Pl		

The stresses to be considered 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<sup>(1)</sup> and do not conform completely to NUREG-0800<sup>(1)</sup>, to industry guidelines<sup>(2)</sup>, and to those criteria in use at other Westinghouse business units. The proposed updated criterion is provided in order to conform to both NUREG-0800<sup>(1)</sup> and to current industry guidelines<sup>(2)</sup>. This updated criterion, in conjunction with the current transient and steady-state clad strain and no centerline fuel melt criteria is 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.