Westinghouse Non-Proprietary Class 3

WCAP-8964-A
Addendum 1-A, Revision 1-A

June 2006

Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis (Departure from Nucleate Boiling Mechanistic Propagation Methodology)

WCAP-8964-A
Addendum 1-A, Revision 1-A

Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis (Departure from Nucleate Boiling Mechanistic Propagation Methodology)

Original: July 2003
Revision 1: February 2005
Approved: June 2006

Prepared by:
Scott Sidener
Karen Keiser
Jay Akers
*** William Slagle**

*** Electronically Approved Records Are Authenticated in the Electronic Document Management System**

Westinghouse Electric Company
4350 Northern Pike
Monroeville, PA 15146-2886

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Table of Content

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Section A

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001
September 8, 2005

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

SUBJECT: FINAL SAFETY EVALUATION FOR TOPICAL REPORT WCAP-8963-P-A. ADDENDUM 1, REVISION 1, "SAFETY ANALYSIS FOR THE REVISED FUEL ROD INTERNAL PRESSURE DESIGN BASIS" (TAC NO. MC0327)

Dear Mr. Gresham:

By letter dated August 5,2003, as supplemented by letters dated August 23,2004, and February 1, 2005, Westinghouse Electric Company (Westinghouse) submitted topical report (TR) WCAP-8963-P-A, Addendum 1, Revision 0 and Revision 1 to WCAP-8963-P-A, Addendum 1, entitled, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis," to the U.S. Nuclear Regulatory Commission (NRC). By letter dated June 10,2005, an NRC draft safety evaluation (SE) regarding our approval of WCAP-8963-P-A, Addendum 1, Revision 0 and Revision 1 to WCAP-8963-P-A, Addendum 1, was provided for your review and comments. By letter dated June 29,2005, Westinghouse commented on the draft SE. The staff's disposition of Westinghouse's comments on the draft SE are attached to the final SE enclosed with this letter.

The NRC staff has found that WCAP-8963-P-A, Addendum 1, Revision 1 to WCAP-8983-P-A, Addendum 1, 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 final SE. The final 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 accepted proprietary and non-proprietary versions of this TR within three months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed final SE after the title page. Also, they must contain historical review information, including NRC requests for additional information and your responses. The accepted versions shall include a "-A" (designating accepted) following the TR identification symbol.

The document transmitted herewith contains proprietary information. When separated from the proprietary SE, this document is decontrolled.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, Westinghouse and/or licensees referencing it will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

Sincerely,

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

Project No. 700

Enclosures: 1. Final Non-Proprietary SE
2. Final Proprietary SE

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

FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-8963-P-A, ADDENDUM 1, REVISION 1

"SAFETY ANALYSIS FOR THE REVISED FUEL ROD

INTERNAL PRESSURE DESIGN BASIS

WESTINGHOUSE ELECTRIC COMPANY

1.0 INTRODUCTION

In letters dated August 5,2003 (Agencywide Document Access Management System (ADAMS) Accession No. ML032340667), August 23,2004 (ADAMS Accession No. ML042400343), and February 1,2005 (ADAMS Accession No. ML050350323), Westinghouse Electric Company (Westinghouse) submitted to the U.S. Nuclear Regulatory Commission (NRC) a licensing topical report WCAP-8963-P-A, Addendum 1, Revision 0 and Revision 1 to WCAP-8963-P-A, Addendum 1, entitled, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis," for review and approval. The previously approved WCAP-8963-P-A describes the approach currently employed by Westinghouse to evaluate the possibility of departure from nucleate boiling (DNB) propagation for various fuel rod designs. The approach is based on a statistical probability of a fuel rod simultaneously experiencing DNB and a high internal pressure greater than the system pressure.

According to the Standard Review Plan, Section 4.2, fuel rods predicted to be in DNB are assumed to fail. DNB is not allowed during normal operation or anticipated operational occurrences (AOOs). For postulated accidents, the consequences of the radiological dose take into account the total number of fuel rods violating the DNB limit. The DNB propagation criterion was established in WCAP-8963-P-A, which states that the rod internal pressure will not cause extensive DNB propagation to occur. During a postulated DNB transient, the surface temperature of a fuel rod increases significantly, resulting in a significant increase in the creep rate. If the fuel rod experiences both DNB and high internal pressure conditions, clad ballooning can occur, thereby degrading heat transfer from adjacent fuel rods due to restricted flow. Under such conditions, the adjacent fuel rods are assumed to experience DNB as well and the DNB propagation phenomenon is initiated.

Revision 1 to WCAP-8963-P-A. Addendum 1 describes an alternate approach for assessing DNB propagation which has been previously approved for Combustion Engineering (CE), now an integral part of Westinghouse. This alternative, which is mechanistically based, is described in CEN-372-P-A, entitled, "Fuel Rod Maximum Allowable Gas Pressure." Westinghouse intends to adopt the mechanistic approach without alteration from its previously licensed form

except taking into account the fuel rod geometric differences. The DNB propagation criterion remains unchanged in Revision 1 to WCAP-8963-P-A, Addendum 1. The revised approach will be applicable for the currently licensed Westinghouse cladding products.

2.0 . REGULATORY EVALUATION

The fuel system consists of an array 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 AOOs, (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 NRC staff's acceptance criteria are based on the NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants." Section 4.2, "Fuel System Design," These criteria include three parts: (1) design bases that describe specified acceptable fuel design limits (SAFDLs) as depicted in General Design Criterion 10 to Appendix A of Title 10 of the Code of *Federal Regulations* Part 50, (2) design evaluation that demonstrates that the design bases are met, and (3) testing, inspection, and surveillance plans that show that there are adequate monitoring and surveillance of irradiated fuel. The design bases include (1) fuel system damage, (2) fuel rod failure, and (3) fuel coolability. DNB is identified as a failure mechanism and part of the SAFDLs.

3.0 TECHNICAL EVALUATION

3.1 Mechanistic Approach

The current approach of Westinghouse's DNB propagation, as described in WCAP-8963-P-A, conservatively assumes that a fuel rod, coupled with conditions of higher internal pressure than the system pressure and DNB, would instantaneously balloon and contact the four neighboring rods. If any of the four neighboring rods have higher internal pressure than the system pressure, the rod is also assumed to go into DNB and balloon. The propagation is assumed to continue in this manner until a condition exists where the last rod to balloon no longer contacts a rod that exceeds the system pressure.

In CEN-372-P-A, a mechanistic DNB propagation approach was developed and accepted for licensing applications. The approach involves two pertinent parameters: (1) fuel rod internal pressure higher than the coolant system pressure. and (2) a critical strain. The approach assumes that the DNB propagation mechanism is initiated when a fuel rod with high internal pressure balloons to a strain larger than the critical strain during a DNB transient. The large strain results in a severe flow channel blockage, causes the temperature to rise in the adjacent rods, and subsequently causes ballooning of the high internal pressure adjacent rods. Thus, the ONB propagation would continue until any ballooned rods do not exceed the critical strain.

There are several conservative assumptions built into the approved mechanistic approach such as; (1) DNB propagation can occur simultaneously for the four adjacent rods, (2) the rod pressure remains constant even after cladding swelling, and (3) the critical strain is less than the strain that would cause 50 percent rod-to-rod gap closure. Although developed using standard CE fuel designs, Westinghouse states that the critical strain is applicable to the

Westinghouse fuel designs due to the similarity between CE and Westinghouse fuel-designed geometries and physical parameters. Westinghouse provided geometric parameters which encompass both Westinghouse and CE fuel designs.

The NRC staff reviewed the geometric parameters and conservative assumptions in the mechanistic approach. Based on the conservatism of the approach, the NRC staff concludes that the mechanistic approach in CEN-372-P-A is acceptable for use in WCAP-8963-P-A, Addendum 1, Revision 1.

3.2 Westinghouse Fuel Design Applications

In general, the most limiting transients would be those of the longest duration, highest heat flux, lowest flow, highest rod internal pressure, and lowest DNB ratio, Westinghouse selected five transient cases including rod ejection, rod withdrawal, and three locked rotor cases to examine the adequacy of the mechanistic approach. These five cases, though not necessarily limiting, represent severe transient conditions for current Westinghouse fuel designs. Conservative inputs were generated using approved codes and methods including VIPRE-01. The results show that for the most severe transient studied, the largest strain is still below the critical strain indicating no DNB propagation. In addition, the results of these cases are consistent with the previous CE study which demonstrated that no DNB propagation occurs for the mechanistic approach.

The NRC staff reviewed the cases and results. Based on the conservative inputs and approved codes, the NRC staff concludes that the mechanistic approach is adequate for DNB propagation analysis in WCAP-8963-P-A, Addendum 1, Revision 1.

3.3 Cladding Burst

The current WCAP-8963-P-A, Addendum 1, Revision 1 does not analyze the cladding burst phenomenon. The NRC staff raised concerns that cladding burst could occur prior to reaching the critical strain, which will affect the DNB propagation analysis. To address the NRC staff concern, Westinghouse provided additional information which [

]. Any deviation from the current or existing approach in WCAP-8963-P-A, Addendum 1, Revision 1 constitutes a new issue and requires review by the NRC staff. Thus, the NRC staff concludes that the cladding burst concern is adequately resolved for WCAP-8963-P-A, Addendum 1, Revision 1.

4.0 LIMITATIONS AND CONDITIONS

1. [

]

2. Any deviation from the current or existing approach in WCAP-8963-P-A, Addendum 1, Revision 1 constitutes a new issue and requires review by the NRC staff.

5.0 CONCLUSION

The NRC staff has reviewed the Westinghouse submittal of the proposed mechanistic approach for DNB propagation analysis. Based on the NRC staff evaluation, the proposed mechanistic

approach for DNB propagation analysis in WCAP-8983-P-A, Addendum 1, Revision 1 is approved for the currently licensed Westinghouse cladding products.

Principal Contributor: Shi-Liang Wu, NRR

Date: September 8, 2005

Westinghouse Comments on
WCAP-8963-P-AAddendum 1, Revision 1 DRAFT SE

Sections	Westinghouse Comment	Staff's Response	Disposition
Various	Material is considered proprietary.	Agree	Marked as proprietary and provided a non-proprietary version.
Various	Correction for Clarity.	Agree	Changed

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Section B

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Our ref: LTR-NRC-03-45

August 5,2003

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

Subject: Submittal of WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval (Proprietary/Non-proprietary)

Dear Mr. Wermiel:

Enclosed are copies of WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, " Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation *Methodology)," submitted* to NRC for Review and Approval *(Proprietary/Non-proprietary).* It is requested that the above topical be approved by February 2004, in support of several licensees that are interested in implementing the revised methodology in their spring/fall 2004 reload analyses. It is also requested that the NRC provide an estimate on the man-power resources required for the review.

This addendum to WCAP-8963-P-A describes an alternate approach for assessing DNB propagation which has been previously licensed by CE for its fuel designs. This alternative, which is mechanistically based, is described in topical report CEN-372-P-A, "Fuel Rod Maximum Allowable Gas Pressure" and revalidated in CENPD-404-P-A, "Implementation of ZIRLO™ Cladding Material in CE Nuclear Power Fuel Assembly Designs" for its applicability to ZIRLO™ cladding material. Westinghouse intends to adopt the mechanistic approach without change from its licensed form. Westinghouse has demonstrated, herein, that the previously licensed mechanistic approach is applicable to Westinghouse specific fuel design features which are principally geometric differences in fuel dimensions. As with the CE licensed application, this approach applies to both Zircaloy-4 and ZIRLO™ fuel designs.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-03-1684 with Proprietary Information Notice and Copyright Notice.

2. One (1) copy of Affidavit, AW-03-1684.

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.

Correspondence with respect to this Application for Withholding should reference AW-03-1684 and should be addressed to H. A. Sepp, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

John S. Galembush, Acting Manager
Regulatory Compliance and Plant Licensing

Enclosure

Copy to:
F. Akstulewicz, NRR
B. Benney, NRR
U. Shoop, NRR
S. L. Wu, NRR

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

Our ref: AW-03-1684

August 5, 2003

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: Submittal of WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval (Proprietary/Non-proprietary)

Reference: Letter from J. S. Galembush to J. S. Wermiel, LTR-NRC-03-45, dated August 5, 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-03-1684 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-03-1684 and should be addressed to H. A. Sepp, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

John S. Galembush, Acting Manager
Regulatory Compliance and Plant Licensing

AW-03-1684

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 Compliance and Plant Licensing

Sworn to and subscribed
before me this 5th day
of August, 2003.

Notary Public

Notarial Seal
Sharon L. Fiori, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires January 29, 2007
Member, Pennsylvania Association Of Notaries

SHARON L. FIORI
COMMONWEALTH
OF
PENNSYLVANIA
NOTARY PUBLIC

(1) I am Acting Manager, Regulatory Compliance and Plant Licensing, 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-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, 'Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)'," for NRC Review and Approval (Proprietary/Non-proprietary), August 5, 2003, for submittal to the Commission, being transmitted by Westinghouse Electric Company (W) letter (LTR-NRC-03-45) and Application for Withholding Proprietary Information from Public Disclosure, John S. Galembush, Westinghouse, Acting Manager Regulatory Compliance and Plant Licensing 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 that associated with a request for NRC review and approval.

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

(a) Obtain generic NRC licensed approval for the Mechanistic DNB Propagation Methodology for Westinghouse fuel designs.

(b) This change to the Mechanistic DNB Propagation Methodology will promote convergence between Westinghouse business units.

Further this information has substantial commercial value as follows:

(a) Westinghouse can use its methodology capability to further enhance their licensing position over their competitors.

(b) Assist customers to obtain license changes.

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

Section C

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U.S. Nuclear Regulatory Commission
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Direct tel: (412) 374-4643
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e-mail: greshaja@westinghouse.com

Attention: J. S. Wermiel, Chief
Reactor Systems Branch

Our ref: LTR-NRC-04-50

August 23,2004

Subject: Page Change Submittal to WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval **(Proprietary/Non-proprietary)**

Dear Mr. Wermiel:

Enclosed are three page changes to WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval.

In August 2003, Westinghouse submitted Addendum 1 to WCAP-8963-P-A which addressed adopting, without change, the mechanistic approach to DNB propagation for Westinghouse NSSS fuel designs that had been reviewed and approved by the NRC in CEN-372-P-A for CE-NSSS fuel designs.

As part of the demonstration that the mechanistic approach was applicable to Westinghouse NSSS fuel designs with the same limit that had been approved for the CE-NSSS fuel designs, the topical included a discussion on "burst".

Based on a discussion with the NRC staff, Westinghouse is proposing to modify the existing topical to clarify its position. Therefore, Westinghouse is providing the attached three page changes. If these changes are acceptable to the NRC staff, they will be included in the final approved version of the topical report. Note: the proposed changes are marked by revision bars in the margins.

Also enclosed is:

1. One (1) copy of the Application for Withholding, AW-04-1884 (Nonproprietary) with Proprietary Information Notice.

2. One (1) copy of Affidavit (Nonproprietary).

This submittal contains proprietary information of Westinghouse Electric Company, LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding from Public Disclosure and an affidavit. The affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

LTR-NRC-04-50
August 23,2004

Correspondence with respect to the affidavit or Application for Withholding should reference AW-04-1884 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O.Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very p l y yours,

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Enclosures
cc: W. Macon
F. Akstulewicz, NRR
S. Wu, NRR
E. Peyton

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Attention: J. S. Wermiel, Chief
Reactor Systems Branch

Our ref: AW-04-1884

August 23,2004

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: Page Change Submittal to WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval (Proprietary)

Reference: Letter from J. A. Gresham (Westinghouse) to J. S. Wermiel (NRC), "Page Change Submittal to WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval (Proprietary/Non-proprietary)," dated August 23,2004

The Application for Withholding is submitted by Westinghouse Electric Company LLC (Westinghouse), pursuant to the provisions of Paragraph (b) (1) of Section 2.390 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 2.390, Affidavit AW-04-1884 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 2.390 of the Commission's regulations.

Correspondence with respect to this Application for Withholding or the accompanying affidavit should reference AW-04-1884 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Enclosures

cc: W. Macon
F. Akstulewicz, NRR
S. Wu, NRR
E. Peyton

AW-04-1884

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared J. A. Gresham, 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 (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:

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Sworn to and subscribed
before me this 23rd day
of ____, 2004

Sharon L. Fiori
Notary Public

Notarial Seal
Sharon L. Fiori, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires January 29, 2007
Member, Pennsylvania Association Of Notaries

(1) I am Manager, Regulatory Compliance and Plant Licensing, in Nuclear Services, Westinghouse Electric Company LLC (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 rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 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 Westinghouse 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 2.390 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 that 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 2.390, 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 in "Page Change Submittal to WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval (Proprietary/Non-proprietary)," dated August 23, 2004, for submittal to the Commission, being transmitted by Westinghouse letter (LTR-NRC-04-50) and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse Electric Company is that associated with a request for NRC review and approval.

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

(a) Obtain generic NRC licensed approval for the Mechanistic DNB Propagation Methodology for Westinghouse fuel designs.

(b) This change to the Mechanistic DNB Propagation Methodology will promote convergence between Westinghouse business units.

Further this information has substantial commercial value as follows:

(a) Westinghouse can use its methodology capability to further enhance their licensing position over their competitors.

(b) Assist customers to obtain license changes.

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.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 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 2.390(b)(1).

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Section D

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e-mail: greshaja@westinghouse.com

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

Our ref LTR-NRC-05-6

February 1,2005

Subject: Response to NRC Questions on WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval (Proprietary/Non-Proprietary)

Dear Mr. Wermiel:

Enclosed is the response to NRC's questions on WCAP-8963-P-A, Addendum 1 / WCAP-8964-A, Addendum 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval.

In August 2003, Westinghouse submitted Addendum 1 to WCAP-8963-P-A which addressed adopting, without change, the mechanistic approach to DNB propagation for Westinghouse NSSS fuel designs that had been reviewed and approved by the NRC in CEN-372-P-A for CE-NSSS fuel designs.

As part of the demonstration that the mechanistic approach was applicable to Westinghouse NSSS fuel designs with the same limit that had been approved for the CE-NSSS fuel designs, the topical included a discussion on "burst".

Based on a continued discussions with the NRC staff, Westinghouse is proposing to modify the existing topical to clarify its position. Therefore, Westinghouse is providing revision 1 to the previously submitted topical.

This submittal contains proprietary information of Westinghouse Electric Company, LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, the previously submitted Application for Withholding from Public Disclosure and affidavit (AW-03-1684) remain in effect. The affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to this affidavit or Application for Withholding should reference AW-03-1684 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

T. Rodack, Director
Quality & Licensing Programs

Enclosures

cc: B. Benney, NRR
F. Akstulewicz, NRR
S. Wu, NRR

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 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 2.390(b)(1).

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WCAP-8963-P-A, Addendum 1, Revision 1/
WCAP-8964-A, Addendum 1, Revision 1
"Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis, (Departure from Nucleate Boiling Mechanistic Propagation Methodology)," for NRC Review and Approval

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Abstract

WCAP-8964-A, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis" (Reference 1), defines the approach currently employed by Westinghouse Electric Company LLC (Westinghouse) to assess Departure from Nucleate Boiling (DNB) Propagation for its various fuel rod designs. The approach described therein is statistically based. This addendum promotes the best practices of all other Westinghouse business segments and is part of the overall Westinghouse integration process. This addendum to WCAP-8964-A describes an alternate approach for assessing DNB propagation which has been previously licensed by CE for its fuel designs. This alternative, which is mechanistically based, is described in topical report CEN-372-P-A, "Fuel Rod Maximum Allowable Gas Pressure" (Reference 3) and revalidated in CENPD-404-P-A, "Implementation of ZIRLO™ Cladding Material in CE Nuclear Power Fuel Assembly Designs" (Reference 5) for its applicability to ZIRLO™ cladding material. Westinghouse intends to adopt the mechanistic approach without change from its licensed form. Westinghouse has demonstrated, herein, that the previously licensed mechanistic approach is applicable to Westinghouse specific fuel design features which are principally geometric differences in fuel dimensions. As with the CE licensed application, this approach applies to both Zircaloy-4 and ZIRLO™ fuel designs. (ZIRLO™ as stated herein refers to the current licensed ZIRLO™ and Optimized ZIRLO™ as justified in WCAP-12610-P-A/CENPD-404-P-A, Addendum 1, Reference 7).

This addendum justifies the applicability of the previously licensed mechanistic DNB propagation approach to Westinghouse fuel designs including the range of applicability and the acceptance criteria values relevant to Westinghouse fuel designs. Typical example analyses of the mechanistic approach applied to Westinghouse designs are also provided.

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Acronyms

CE	Combustion Engineering
DNB	Departure from Nucleate Boiling
DNBR	Departure from Nucleate Boiling Ratio
GAD or Gd	Gadolinia
IFBA	Integrated Fuel Burnable Absorber
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RIP	Rod Internal Pressure
SAFDL	Specified Acceptable Fuel Design Limit
SRP	Standard Review Plan (NUREG-0800)
Westinghouse	Westinghouse Electric Company LLC

Definitions

Condition I: **Normal Operation**. Condition I occurrences are those that are expected to occur frequently or regularly in the course of power operation, refueling, maintenance, or maneuvering of the plant. As such, Condition I occurrences are accommodated with margin between any plant parameter and the value of that parameter which would require either automatic or manual protective action. Since Condition I events occur frequently, they must be considered from the point of view of their effect on the consequences of fault conditions (Conditions II, III, and IV). In this regard, analysis of each fault condition described is generally based on a conservative set of initial conditions corresponding to adverse conditions which can occur during Condition I operation.

Condition II: **Faults of Moderate Frequency**. These faults, at worst, result in the reactor trip with the plant being capable of returning to operation. By definition, these faults (or events) do not propagate to cause a more serious fault, i.e., Condition III or IV events. In addition, Condition II events are not expected to result in fuel rod failures, reactor coolant system failures, or secondary system overpressurization.

Condition III: **Infrequent Faults**. Condition III events are faults which may occur infrequently during the life of the plant. They may result in the failure of only a small fraction of the fuel rods. The release of radioactivity will not be sufficient to interrupt or restrict public use of those areas beyond the exclusion area boundary, in accordance with the guidelines of 10 CFR 100. A Condition III event alone will not generate a Condition IV event or result in a consequential loss of function of the reactor coolant system or containment barriers.

Condition IV: **Limiting Faults**. Condition IV events are faults which are not expected to take place but are postulated because their consequences would include the potential of the release of significant amounts of radioactive material. They are the most drastic faults which must be designed against and they represent limiting design cases. Condition IV faults are not to cause a fission product release to the environment resulting in doses in excess of guideline values of 10 CFR 100. A single Condition IV event is not to cause a consequential loss of required functions of systems needed to cope with the fault, including those of the ECCS and the containment.

1.0 Introduction

The purpose of this submittal is to obtain generic approval for an alternative approach for evaluating Departure from Nucleate Boiling (DNB) propagation in Westinghouse Electric Company LLC (Westinghouse) fuel designs.

WCAP-8964-A, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis" (Reference 1), defines the approach currently employed by Westinghouse to assess DNB propagation for its various fuel rod designs. The approach described therein is statistically based. This addendum promotes the best practices of all other Westinghouse business segments and is part of the overall Westinghouse integration process. This addendum to WCAP-8964-A describes an alternate approach for assessing DNB propagation which has been previously licensed by CE for its fuel designs. This alternative, which is mechanistically based, is described in topical report CEN-372-P-A, "Fuel Rod Maximum Allowable Gas Pressure" (Reference 3) and revalidated in CENPD-404-P-A, "Implementation of ZIRLO™ Cladding Material in CE Nuclear Power Fuel Assembly Designs" (Reference 5) for its applicability to ZIRLO™ cladding material. Westinghouse intends to adopt the mechanistic approach without alteration from its previously licensed form, except where necessary to account for Westinghouse specific fuel design features which are principally geometric differences in fuel dimensions. As with the CE licensed application, this approach is applicable to both Zircaloy-4 and ZIRLO™ fuel designs. (ZIRLO™ as stated herein refers to the current licensed ZIRLO™ and Optimized ZIRLO™ as justified in WCAP-12610-P-A/ CENPD-404-P-A, Addendum 1, Reference 7).

The current accepted practice is to assume that rods predicted to be in DNB fail. Consequently, if DNB is predicted to occur, fuel failure is assumed and the consequences of the radiological dose are considered. DNB is not allowed during normal operation or anticipated operational occurrences (i.e., Condition I and II events). During normal operation there is a potential for some portion of the fuel rods to achieve internal gas pressures that are in excess of the external RCS pressure. During a postulated DNB transient, the surface temperature of a fuel rod may increase significantly, resulting in a potentially significant increase in creep rate. If the fuel rod experiences both DNB and high internal pressure conditions, the potential exists for clad ballooning to occur, thereby degrading heat transfer from adjacent fuel rods. Under such conditions, the adjacent fuel rods are assumed to experience DNB as well and the DNB propagation phenomenon is initiated.

This addendum justifies the applicability of the previously licensed mechanistic DNB propagation approach to Westinghouse fuel designs including the range of applicability and the acceptance criteria values relevant to Westinghouse fuel designs. Example analyses of the mechanistic approach applied to Westinghouse designs are also provided. These examples are based on typical FSAR transients using severe and excessively conservative input (i.e., beyond design basis compared to typical FSAR input) and

a conservative fuel temperature calculation to provide a basis for direct comparison of DNB propagation timing.

1.1 Assumptions and Range of Applicability

The assumptions and range of applicability of this mechanistic DNB propagation approach to Westinghouse designs are as follows:

- Applicable for any transient conditions falling within the licensed range of applicability of the cladding high temperature creep and burst models,

- Applicable for Westinghouse and CE rod and lattice geometries ranging from rod diameters of [ ]^{a,b,c}, and rod pitches from [ ]^{a,b,c},

- Applicable to calculated cladding ballooning strains up to [ ]^{a,c},

- Applicable to current licensed codes and methods, and

- Applicable to all Westinghouse licensed clad material and fuel designs.

2.0 Current Criterion

The DNB propagation criterion has been established in WCAP-8964-A to address the NRC criterion in the Standard Review Plan (SRP) Section 4.2.II.A.1.(f),

> "Fuel and burnable poison rod internal gas pressures should remain below the nominal system pressure during normal operation unless otherwise justified."

In WCAP-8964-A, a pressure design criterion has been justified and accepted by the NRC under which the fuel rod internal pressure is permitted to exceed system pressure. The pressure design criterion that has been established states that RIP will not cause extensive DNB propagation to occur. This criterion will not change based on the alternate approach to analyze DNB propagation.

3.0 Current Approach

The current approach in WCAP-8964-A, used for analyzing the potential for DNB propagation, is based on a statistical convolution of probabilities of a fuel rod simultaneously experiencing DNB and an elevated internal pressure greater than system pressure. Specifically, the analysis assumes that if [

] [a,c], during a Condition III or IV transient. If [

] [a,c], thus, propagating the DNB process.

4.0 Mechanistic Approach

A mechanistic DNB propagation methodology has been previously developed and licensed (References 3 and 5). The mechanistic high temperature creep and rupture correlations described in Section 5.1 are used to determine total accumulated strain during a DNB transient. If the strain exceeds the strain criterion defined in Section 5.2, DNB propagation to the adjacent fuel rods is assumed to occur.

Incremental cladding high temperature creep strain is calculated using [

] [a,c]. The time-dependent DNB transient local properties are obtained from the appropriate licensed transient analysis methodology for any given plant. These inputs include time, heat flux, quality, mass flow, system pressure, rod internal pressure, and fuel rod initial geometry.

The input heat flux, rod internal pressure and flow conditions are utilized to calculate the local cladding temperature and differential cladding stress. The temperature and stress are then input to the high temperature creep model. The calculated [

] [a,c] of the DNB transient. The resultant output is the [ ] [a,c] strain incurred by the rod.

To evaluate the potential for DNB propagation against the design criteria, the plant's limiting Condition III and IV transients are used. The transients inputs are generated using NRC licensed codes and methods. In general, the most limiting transients would be ones which occur for the longest duration, highest heat flux, lowest flow, highest rod internal pressure, lowest system pressure, and lowest DNBR, or some combination thereof.

For Condition I and II events, DNB propagation is precluded by meeting the DNB design limits. Condition I and Condition II events are limited to a steady state and transient strain value. The Condition I and Condition II strain limits are significantly less than the allowable clad strain specified herein for a Condition III or Condition IV transient. In conclusion, only Condition III and IV events need to be analyzed.

5.0 Application to Westinghouse Fuel Designs

The application of the mechanistic DNB propagation approach to Westinghouse designs is nearly identical to that licensed for CE designs in References 3 and 5. The only differences exist in supplying the transient inputs and application of the appropriate cladding creep models.

[

] [a,c] be supplied from a plant specific licensed methodology. There is no feedback from the output of this analysis into any other design calculations or safety analyses, unless it is shown that the limits cannot be met in which case, additional radiological analyses may be required.

The Westinghouse specific high temperature creep model for ZIRLO™ has already been used in this approach in CE designs (Reference 5). Therefore, the only difference in creep models would apply to Zr-4. Both CE and Westinghouse have licensed similar high-temperature creep models for Zr-4 (References 1 and 3), therefore, when using this approach on Westinghouse designs with Zr-4, the appropriate licensed creep model (Reference 10) will be used.

The following sections summarize the application of the mechanistic approach to Westinghouse fuel designs.

5.1 High Temperature Creep Models

For the example discussion, the details of the high temperature creep behavior of ZIRLO™ cladding are included below. However, the application of this approach may be used with any cladding material given that the appropriate licensed high temperature creep model is used.

The high temperature creep behavior of ZIRLO™, used in mechanistic DNB propagation evaluations is based on the licensed model for Westinghouse in Reference 6 and is based on the licensed model for CE in Reference 3. The following describes the details and implementation of the model.

High temperature creep strains have been modeled as a function of [

] [a,c].

Strain rate is given by

$$\frac{de}{dt} = A' \exp(-\frac{Q}{RT})S^n = AS^n \tag{5.1}$$

where:

S = hoop stress, MPa
e = true strain, in/in
t = time, seconds
T = temperature, K

and

$$A = A' \exp(\frac{-Q}{RT}) \tag{5.2}$$

$$A = A(S, T) \tag{5.3}$$

$$n = n(S, T) \tag{5.4}$$

The coefficients are obtained directly from Reference 6.

The accumulated true strain e is obtained from the numerical integration of Equation 5.1 and can be converted into engineering strain by the relationship:

$$e = \ln(1 + \varepsilon) \tag{5.5}$$

or

$$\varepsilon = \exp(e) - 1 \tag{5.6}$$

where:

ε = engineering strain, in/in

Since large deformations occur, the effect of an increasing diameter and a decreasing wall thickness is included. Dimensional changes for large deformations are given by:

$$D = D_o(1 + \varepsilon) \tag{5.7}$$

$$w = \frac{w_o}{(1 + \varepsilon)} \tag{5.8}$$

and the stress is given by

$$S = \Delta P \frac{D}{2w} \tag{5.9}$$

where:

ΔP = pressure difference across wall, MPa
D_o = initial tube diameter, inches
w_o = initial wall thickness, inches
D = deformed diameter, inches
w = deformed wall thickness, inches

An additional empirical correction to the calculated strain increment during a given time increment is required [

] [a, c]. The correction is provided in terms of the engineering strain.

The engineering strain increment is adjusted to an effective engineering strain increment by the following equation.

[ ] [a, c] (5.10)

where:

[ ] [a, c]

5.2 Strain Criterion versus Channel Blockage

The amount of channel blockage is limited to prevent degradation of the cooling of adjacent fuel rods as described in Reference 3. The strain criterion for channel blockage is primarily based on geometric effects in terms of fuel rod gap closure. Reference 3 provides an NRC approved criterion of [ ] [a, c] fuel rod diametral strain or less. It is assumed that DNB propagation will not occur if the fuel rod diametral strain is less than or equal to [ ] [a, c].

The above [ ] [a, c] strain has been developed using standard CE geometries. Westinghouse designed lattices have very similar geometries to those used in Reference 3. Table 5.2.1 summarizes the fuel rod diametral strain at a [ ] [a, c] gap reduction and the % gap reduction at the [ ] [a, c] strain criterion for typical Westinghouse and CE fuel design lattices.

Table 5.2.1
Comparison of Fuel Rod Strains at % Gap Reduction
and % Gap Reduction at % Strain for Typical Westinghouse and CE Fuel

a, b, c

[

]

It can be seen from Table 5.2.1 that the [ ] [a, c] criterion bounds the strain at [ ] [a, c] gap reduction for all Westinghouse and CE fuel geometries. There is no effect on DNB as long as gap reductions are less than [ ] [a, c] based on DNB tests defined in References 3 and 4. The maximum % gap reduction at the [ ] [a, c] strain limit for the Westinghouse fuel geometries [ ] [a, c] to the maximum value of the CE fuel geometries [ ] [a, c]. Therefore, the application of the CE licensed [ ] [a, c] strain criterion is applicable to Westinghouse designs and will be used in the DNB propagation methodology for all designs.

5.3 Discussion of Conservatism for DNB Propagation

The analysis of DNB propagation is extremely conservative. Reference 3 provides a detailed discussion of the propagation model conservatisms. However, the primary conservatisms are listed below:

1. The DNB rod ballooning is conservatively assumed to occur symmetrically. [

] [a, c].

2. [

] [a,c].

3. [
] [a,c].

4. DNB transients are modeled conservatively assuming the hot rod in DNB when the plant DNB Ratio (DNBR) limit is violated. The DNBR limit is determined based on test data so that there is at least a 95 percent probability at a 95 percent confidence level that DNB will not occur on the hot rod.

5. During the DNB transient, it is conservatively assumed that film boiling heat transfer occurs if the DNBR is below the DNBR limit.

6. The strain criterion of [ ] [a,c] is less than allowed by the [ ] [a,c] gap reduction strain (References 3 and 4).

Therefore, while DNB propagation is conservatively assumed, the physical mechanisms involved do not actually support the occurrence of DNB propagation.

5.4 Examples of Mechanistic Approach Applied to Westinghouse Designs

Example analyses have been performed on sample Condition III and IV DNB transients in Westinghouse designs. These examples are based on typical FSAR transients using severe and excessively conservative input (i.e., beyond design basis compared to typical FSAR input) and a conservative fuel temperature calculation to provide a basis for direct comparison of DNB propagation timing.

A total of five typical example designs have been modeled. These 5 cases represent a cross-section of lattice designs. They also represent 2, 3, and 4 loop plants. The 5 cases include postulated locked rotor, rod ejection, and single rod withdrawal transients. It should be noted that due to the duration and limited flow conditions of the Locked Rotor transients, they are considered limiting in terms of induced clad strain. For comparison, the Rod Ejection and Single Rod Withdrawal are modeled. The Single Rod Withdrawal is considered to bound Rod Ejection due to its longer time duration.

The transients associated with those designs are not absolutely limiting, but represent relatively severe conditions for Westinghouse designs. For the example analyses herein, all 5 of the cases have been modeled with a conservatively high assumption of [ ] [a,c].
Typically much lower rod internal pressures are predicted using fuel performance models. In addition to the 5 cases stated, two additional repeats of Case 2 with varying rod internal pressures were made.

The following table gives a brief description of the 5 cases:

Table 5.4.1

Example Cases Analyzed

[ ] a, b, c

The required transient input data has been extracted from a sub-channel thermal-hydraulic code such as VIPRE-01, References 8 and 9. The inputs included: time (s), heat flux (btu/h-ft^2), quality, mass flow (lbm/h-ft^2), and system pressure (psi). The DNBR has been used to select the time steps associated with the transients when the DNBR is below the 95% bounding DNBR limit for each case. The DNBR limits are shown below:

Table 5.4.2
DNBR Limits for Example Cases

[ ] a, c

The sub-set of the total transient when the DNBR limit is violated is what was used to [ ] a, c transient creep strain.

Figures 5.1 through 5.5 show the input DNB transients for cases 1 through 5 respectively. [

]^{a,c}. The result produces an increased final transient strain.

Additional inputs required in the analysis include cladding radius, cladding wall thickness, and hydraulic diameter in inches. These values for the example analysis represented herein are in the table below.

Table 5.4.3
Geometric Parameters for Fuel Designs

[ ]$^{a, b, c}$

a, b, c

Figure 5.1: Case 1 DNB Transient

a, b, c

Figure 5.2: Case 2 DNB Transient

a, b, c

Figure 5.3: Case 3 DNB Transient

a, b, c

Figure 5.4: Case 4 DNB Transient

a, b, c

Figure 5.5: Case 5 DNB Transient

The resultant [ ]^{a,c} strains due to the DNB transients for Cases 1 through 5 are shown below in Table 5.4.4.

Table 5.4.4
Cumulative Strains for Cases 1 through 5

[ ]^{a,c}

It can be seen that none of the example transients induced a strain near the limit of [ ]^{a,c}. Case 1 exhibited an insignificant amount of strain. This was due, in part, to the [ ]^{a,c}. The most severe transient is Case 2. This particular transient is a locked rotor, which [ ]^{a,c}.

Plots of the ballooning strain, cladding temperature, and stress as a function of time for each of the 5 cases are shown in Figures 5.6 through 5.10. [ ]^{a,c}.

[

]^{a,c}.

a, b, c

Figure 5.6: Case 1 Ballooning Strain Results

a, b, c

Figure 5.7: Case 2 Ballooning Strain Results

a, b, c

Figure 5.8: Case 3 Ballooning Strain Results

a, b, c

Figure 5.9: Case 4 Ballooning Strain Results

a, b, c

Figure 5.10: Case 5 Ballooning Strain Results

5.5 Range of Applicability

Westinghouse implementation of the mechanistic approach remains within the range of applicability of the previously licensed approach described in WCAP-8964-A (Reference 1) as well as CEN-372-P-A (Reference 3) and CENPD-404-P-A (Reference 5).

This approach is applicable for any transient conditions falling within the licensed range of applicability of the cladding high temperature models.

This approach is applicable for Westinghouse and CE geometries ranging from rod diameters [ ]$^{a, b, c}$, and rod pitches from [ ]$^{a, b, c}$.

This approach is applicable to calculated cladding ballooning strains up to [ ]$^{a, c}$.

6.0 Conclusion

This evaluation demonstrates that the alternate mechanistic approach can be applied to all Westinghouse fuel designs and this approach does not impact other fuel performance or safety analysis methodologies or evaluations.

7.0 References

1. WCAP-8964-A, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis," August 1978.

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

3. CEN-372-P-A, "Fuel Rod Maximum Allowable Gas Pressure," May 1990.

4. Letter from C. O. Thomas (NRC) to E. P. Rahe (Westinghouse), "Acceptance for Referencing of Licensing Topical Report WCAP-8691 (P)/WCAP-8692 (NP)," December 1982.

5. CENPD-404-P-A, Revision 0, "Implementation of ZIRLO™ Cladding Material in CE Nuclear Power Fuel Assembly Designs," November, 2001.

6. WCAP-12610-P-A, "VANTAGE+ Fuel Assembly Reference Core Report," April 1995.

7. WCAP-12610-P-A/CENPD-404-P-A, Addendum 1, "Addendum 1 to WCAP-12610-P-A and CENPD-404-P-A Optimized ZIRLO™," February 2003.

8. NP-2511-CCM-A, "VIPRE-01: A Thermal-Hydraulic Code for Reactor Cores," Volumes 1-3 (Revision 3, August 1989), Volume 4 (April 1987), Electric Power Research Institute.

9. WCAP-14565-P-A/WCAP-15306-NP-A, "VIPRE-01 Modeling and Qualification for Pressurized Water Reactor Non-LOCA Thermal-Hydraulic Safety Analysis," October 1999.

10. WCAP-12945-P-A, Volume 1, Revision 2, Sections 1-10, "Code Qualification Document for Best Estimate LOCA Analysis, Volume 1: Models and Correlations," March 1998.

Section E

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

Our ref: LTR-NRC-05-39

June 29.2005

Subject: Response to NRC's Draft Safety Evaluation By the Office Of Nuclear Reactor Regulation Topical Report WCAP-8963-P-A, Addendum 1, Revision 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis" (Proprietary/Non-Proprietary)

Dear Mr. Wermiel:

Enclosed is a proprietary/non-proprietary version of Westinghouse's proprietary review of NRC's Draft Safety Evaluation By the Office Of Nuclear Reactor Regulation Topical Report WCAP-8963-P-A, Addendum 1, Revision 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis."

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-05-2019 with Proprietary Information Notice and Copyright Notice.
2. One (1) copy of Affidavit, AW-05-2019.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR Section 2.390. Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

Correspondence with respect to this affidavit or Application for Withholding should reference AW-05-2019 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinphouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

R. M. Gresham for/

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Enclosures

cc: G. S. Shukla, NRR
B. J. Benney, NRR
F. M. Akstulewicz, NRR
S. L. Wu, NRR
L. M. Feizollahi, NRR

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

Our ref: AW-05-2019

June 29,2005

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-NRC-05-39P-Attachment, "Response to NRC's Draft Safety Evaluation By the Office Of Nuclear Reactor Regulation Topical Report WCAP-8963-P-A, Addendum 1, Revision 1, 'Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis'" (Proprietary)

Reference: Letter from J. A. Gresham to J. S. Wermiel, LTR-NRC-05-39, dated June 29,2005

Dear Mr. Wermiel:

The application for withholding is submitted by Westinghouse Electric Company LLC (Westinghouse) pursuant to the provisions of paragraph (b)(1) of Section 2.390 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 2.390, Affidavit AW-05-2019 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 2.390 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-05-2019 and should be addressed to James A. Gresham, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

R. M. Gresham for/

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Derek. B. Ebeling-Koning, 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 (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:

Derek Ebeling-Koning

Derek B. Ebeling-Koning, Customer 1st Leader
PWR Core Technologies, Nuclear Fuel

Sworn to and subscribed
before me this 29th day
of June, 2005

Margaret L. Gonano

Notary Public

Notarial Seal
Margaret L. Gonano, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Jan. 3, 2006
Member, Pennsylvania Association Of Notaries

(1) I am Customer 1st Leader, PWR Core Technologies, in Nuclear Fuel, Westinghouse Electric Company LLC (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 Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 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 Westinghouse 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 2.390 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 2.390, 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 in LTR-NRC-05-39 P-Attachment, "Response to NRC's Draft Safety Evaluation By the Office Of Nuclear Reactor Regulation Topical Report WCAP-8963-P-A, Addendum 1, Revision 1, 'Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis'", (Proprietary), for submittal to the Commission, being transmitted by Westinghouse letter (LTR-NRC-05-39) and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse Electric Company is to provide notification to the NRC staff of that information included in the NRC's draft safety evaluation which Westinghouse considers proprietary.

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

(a) Assist customers in improving their fuel performance (zero defects).

(b) Promote convergence between Westinghouse business units.

Further this information has substantial commercial value as follows:

(a) Westinghouse can use the methodology to further enhance their licensing position over their competitors.

(b) Assist customers (licensees) to obtain license changes.

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/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 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 2.390(b)(1).

COPYRIGHT NOTICE

WCAP-8964-A
Addendum 1-A, Revision 1-A

LTR-NRC-05-39 P-Attachment
TAC No. MC0327

Response to NRC's Draft Safety Evaluation By the Office Of Nuclear Reactor Regulation Topical Report WCAP-8963-P-A, Addendum 1, Revision 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis"

June 29, 2005

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

Response to NRC's Draft Safety Evaluation By the Office Of Nuclear Reactor Regulation Topical Report WCAP-8963-P-A, Addendum 1, Revision 1, "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis" (TAC No. MC0327)

The following items have been identified as containing information proprietary to Westinghouse contained in the draft safety evaluation from the NRC Office of NRR. Some of the items are suggested changes for clarity. Brackets have been included around the information deemed to be proprietary.

1. Page 1, Lines 34-35: Recommend changing the sentence to read as follows: ". . . be applicable for the currently licensed Westinghouse cladding products ~~including zircaloy-4 and ZIRLO~~."

2. Page 2, Lines 33-35: Correction for clarity: ". . . pressure higher than the coolant system pressure, and (2) a critical strain. ~~The critical strain determines the onset of DNB propagation.~~ The approach ~~depicts~~ *assumes* that the DNB propagation mechanism is initiated when a fuel rod with high internal pressure balloons to a strain larger . . ."

3. Page 2, Line 44: Correction for clarity: ". . . the *strain that would cause* 50 percent ~~strain~~ *rod-to-rod gap closure*. . . ."

4. Page 3, Lines 17-18: Correction for clarity: "The results show that *for* the most severe transient *studied* ~~is the locked rotor accident. However~~, the largest strain is still below . ."

5. Page 3, Lines 28-31: Recommend deleting this paragraph since is adds no real value and can confuse the reader. The pertinent discussion is in the second paragraph of Section 3.3.

6. Page 3, Lines 36-37: Contains information proprietary to Westinghouse. Refer to bracketed information: ". . . concern, Westinghouse provided additional information which [

   ]^{a,c}."

6. Page 3, Line 47: Recommend appending the following text to the end of the sentence on line 47: ". . . approved *for the currently licensed Westinghouse cladding products*."