PROPRIETARY INFORMATION

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-8963-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.

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,

/RA/
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

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Owners Group Program Management Office
Westinghouse Electric Company
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Pittsburgh, PA 15230-0355

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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 DNB 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-8963-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-A Addendum 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