September 21, 2004

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

SUBJECT: FINAL SAFETY EVALUATION FOR TOPICAL REPORT WCAP-16182-P, "WESTINGHOUSE BWR CONTROL ROD CR 99 LICENSING REPORT" (TAC NO. MC1644)

Dear Mr. Gresham:

On December 16, 2003, the Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-16182-P, "Westinghouse BWR Control Rod CR 99 Licensing Report," to the staff for review. On August 30, 2004, an NRC draft safety evaluation (SE) regarding our approval of the TR was provided for your review and comments. By e-mail dated September 10, 2004, Westinghouse stated that they had no comments on the draft SE.

The staff has found that WCAP-16182-P is acceptable for referencing in licensing applications for General Electric designed boiling water reactors to the extent specified and under the limitations delineated in the TR and in the enclosed SE. The SE defines the basis for acceptance of the TR.

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

In accordance with the guidance provided on the NRC website, we request that Westinghouse publish 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 SE between the title page and the abstract. It must be well indexed such that information is readily located. Also, it must contain historical review information, such as questions and accepted responses, draft SE comments, and original TR pages that were replaced. The accepted version 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

Enclosure: Safety Evaluation

cc w/encl:

Mr. Gordon Bischoff, Manager
Owners Group Program Management Office
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

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Enclosure: Safety Evaluation

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*** SE dated 8/24/04.**

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-16182-P, "WESTINGHOUSE BWR CONTROL ROD

CR 99 LICENSING REPORT"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION

By letter dated December 16, 2003 (Reference 1), the Westinghouse Electric Company LLC (Westinghouse), submitted Topical Report (TR) WCAP-16182-P, "Westinghouse BWR Control Rod CR 99 Licensing Report," to the NRC staff for review and approval. By letter dated May 19, 2004 (Reference 2), Westinghouse responded to a staff request for additional information (RAI).

The purpose of the TR is to present for licensing approval an improved boiling water reactor (BWR) control rod design (i.e., CR 99) along with a set of the design requirements used by Westinghouse to develop and evaluate BWR control rod designs for domestic use in BWRs in the United States.

The basic Westinghouse CR 99 control rod design has been in use for over 30 years in BWR reactors of all vendors. Currently, Westinghouse BWR control rod designs have been reviewed and approved for use in the domestic BWR designs supplied by the vendor General Electric (GE). Specifically, the Westinghouse CR 82 design has been approved for use in the D-Lattice (Reference 3), C-Lattice (Reference 4) and S-Lattice (Reference 5) BWRs. The improved CR 99 design is the same as the approved CR 82 design with the following changes:

- An improved neutron absorber material is used to replace the B_4C compacted powder and hafnium rodlets used in the CR 82 design.

- AISI 316L stainless steel material is used in the blade wings to replace the AISI 304L stainless steel used in the CR 82 design.

The TR gives a technical description of the Westinghouse CR 99 control rod design and provides the justification for the use of the CR 99 control rods in GE-designed BWRs. In addition, the TR also provided for staff review the formal design bases used by Westinghouse for the development and qualification of the CR 99 design. This set of design bases consists of general design requirements and a set of quantifiable and measurable acceptance criteria to ensure that the design requirements are met. These criteria address the materials, mechanical, physics, and operational performance requirements. The conformance methods used to verify that the CR 99 control rod design met these criteria are also identified. Westinghouse further states that this process will be used for the foreseeable future to make control rod design improvements, which will involve incremental changes from the basic design.

2.0 REGULATORY EVALUATION

The NRC's regulatory requirements for nuclear power plants are set forth in Title 10 of the *Code of Federal Regulations,* Part 50 (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities." Appendix A of 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants," provides the criteria to be met in licensing applications.

General Design Criterion (GDC) 27, "Combined Reactivity Control Systems," requires that the reactivity control system be designed with appropriate margin, and in conjunction with the emergency core cooling system, to be capable of controlling reactivity and cooling the core under post-accident conditions. GDC 28, "Reactivity Limits," requires that the control rod reactivity be maintained consistent with the plant safety analysis throughout its lifetime to provide sufficient control to shut down the core.

NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP), Section 4.2, "Fuel System Design," defines the basis for the acceptance criteria for staff reviews. These criteria ensure compliance with GDC 27 and 28.

3.0 TECHNICAL EVALUATION

The staff's technical review of the CR 99 control rod design was based on Section 4.2 of the SRP. The review primarily considered the changes from the currently approved CR 82 design:

- An improved neutron absorber material to replace the B_4C powder and hafnium rodlets used in the CR 82 design.

- Use of AISI 316L stainless steel material in the blade wings to replace the AISI 304L stainless steel used in the CR 82 design.

The following sections address the review topics in the order that they are presented in WCAP-16182-P.

3.1 Design Requirements - Section 4

WCAP-16182-P presents the six general design requirements to be used for Westinghouse BWR control rods for use in GE-designed BWRs. Table 4-1 of the TR lists a matrix of the design requirements versus the applicable criteria used for the CR 99 evaluation. In response to the staff's RAI, Westinghouse provided a discussion of the relationship between these design requirements and applicable criteria both to the applicable SRP Section 4.2 review criteria and to the applicable 10 CFR Part 50 Appendix A GDCs. The RAI response also provided a pointer to the specific TR sections that disposition each requirement and criteria.

Specifically, SRP Section 4.2, Part I, "Areas of Review," requires the review to cover specific areas:

A. Design Bases
B. Description and Design Drawings
C. Design Evaluations
D. Testing, Inspection, and Surveillance Plans

Additionally, Appendix A of the SRP requires review of control rod insertability following a safe shutdown earthquake (SSE).

SRP Section 4.2, Part II, "Acceptance Criteria," specifies the review acceptance criteria for each review area.

The staff reviewed the CR 99 design requirements relative to the approved CR 82 design requirements and finds that they are essentially equal, although the methods used to demonstrate that the requirements are met are not the same. The staff also reviewed the TR with respect to completeness of the CR 99 design requirements in meeting the SRP criteria and finds that all applicable requirements are addressed either in specific sections of the TR or in the response to the staff's RAI.

The following subsections summarize the review areas and staff conclusions.

3.1.1 Design Bases

The staff reviewed the CR 99 design bases with respect to meeting the specified SRP criteria:

- Compliance with GDC 27 and 28
- Stress, strain and loading limits
- Cumulative number of strain fatigue cycles
- Dimensional changes regarding control rods
- Control rod reactivity must be maintained

Based on its review of the TR and the RAI responses, the staff has determined that the Westinghouse CR 99 control rod design bases meets the applicable criteria of the SRP and the requirements of the specified GDCs.

3.1.2 Description and Design Drawings

Outline drawings of the CR 99 design for D, C, and S-Lattice cores were provided in the RAI response. The staff finds that these meet the SRP criteria.

3.1.3 Design Evaluation

The staff reviewed the CR 99 design evaluation with respect to:

Prototype Testing - Control Rod Structural and Performance Test

Based on its review of the TR and the RAI responses, the staff has determined that the Westinghouse CR 99 control rod design evaluation meets the applicable criteria of the SRP.

3.1.4 Testing, Inspection, and Surveillance Plans

The staff reviewed the CR 99 testing, inspection and surveillance plans with respect to:

> Surveillance of control rods containing B_4C should be performed to ensure against reactivity loss.

Based on its review of the TR and the RAI responses, the staff has determined that the Westinghouse CR 99 design testing, inspection and surveillance plans meet the applicable criteria of the SRP.

3.1.5 SRP Appendix A

The staff reviewed the criteria of SRP Appendix A with respect to the CR 99 capability:

> Control rod insertability must be assured following an SSE

Based on its review of the TR and the RAI responses, the staff has determined that the Westinghouse CR 99 control rod design meets the applicable criteria of the SRP sections and the requirements of the specified GDCs.

3.2 Materials Evaluation - Section 5

Extensive control rod operating experience, supplemented by the inspections referenced in WCAP-16182-P, have shown an increased potential for control rod blade cracking for rods used in high duty locations in modern high capacity factor, extended operating cycle cores. High duty locations are typically found in control cell core reload core designs where individual control rods are deeply inserted for a significant fraction of the operating cycle. These control rods receive high doses of both thermal and fast neutrons in a short amount of time. The fast neutron dose is not measured by current core monitoring systems, but it is well known that fast neutron irradiation makes stainless steel more susceptible to irradiation assisted stress corrosion cracking.

The CR 99 use of an improved high density neutron absorber material, which is less sensitive to both powder densification and absorber swelling due to neutron absorption reactions, minimizes the possibility of absorber swelling causing contact with the surrounding stainless steel and contributing to stress. The CR 99 use of AISI 316L stainless steel, with its better resistance to fast neutron IASCC, also reduces the potential for control blade cracking.

The staff's review confirmed that the substitution of the two new materials is the only significant change between the approved CR 82 and the improved CR 99 designs.

Based on its review of the TR and the RAI responses, the staff has determined that the Westinghouse CR 99 control rod design materials evaluation meets the applicable criteria of the SRP.

3.3 Mechanical Evaluation - Section 6

The mechanical criteria to be met are the stress and fatigue limits contained in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III (ASME III), Division 1, Edition 2002.

The staff reviewed the CR 99 design mechanical evaluation with respect to meeting the SRP criteria.

The staff's review confirmed that the mechanical evaluation of the changes from the approved CR 82 design to the improved CR 99 design was adequately conducted and that the appropriate mechanical criteria were met.

3.4 Physics Evaluation - Section 7

The critical attributes for the CR 99 physics evaluation are:

- Total Rod Worth
- Shutdown Margin
- Low Power Range Monitor Detector Signal Change
- Nuclear End-of-Life

The staff reviewed the physics criteria and the methods used for confirmation that the criteria are met for the CR 99 design relative to the approved CR 82 design.

Based on its review of the TR and the RAI responses, the staff has determined that the Westinghouse CR 99 control rod design physics evaluation meets the applicable criteria of the SRP.

3.5 Operational Evaluation - Section 8

The critical attributes for the CR 99 operational evaluation are:

- Nominal wing thickness
- Maximum button thickness
- Maximum wing span
- Maximum velocity limiter diameter (with rollers installed)
- Total weight
- Overall length
- Velocity limiter/coupling design
- Handle design
- Envelope

The staff compared these CR 99 attributes with the values for the approved CR 82 design and finds they are equivalent.

Based on its review of the TR and the RAI responses, the staff has determined that the Westinghouse CR 99 control rod design operational evaluation meets the applicable criteria of the SRP.

4.0 CONCLUSION

The staff has reviewed WCAP-16182-P describing the improved Westinghouse CR 99 control rod design and has compared it to the currently approved CR 82 design. The staff finds that the incremental changes in using the improved neutron absorber and blade wing materials have been adequately evaluated and that the Westinghouse CR 99 design requirements and the resulting evaluations, as outlined in the TR and in the RAI responses, are consistent with the criteria of the SRP and the requirements of the applicable GDCs. Therefore, on the basis of the above review and justification, the staff concludes that the improved Westinghouse CR 99 control rod design is acceptable for use in BWRs in the United States.

The design requirements, criteria, and methodology described in the TR have also been reviewed and determined to be acceptable for use in making minor enhancements to the CR 99 control rod without further NRC review. The NRC staff is to be notified (for information only) of any changes in the materials or numerical limits as described in the TR.

5.0 REFERENCES

1. Letter from B. F. Maurer (Westinghouse) to J. S. Wermiel (NRC), Submittal of WCAP-16182-P/WCAP-16182-NP, "Westinghouse BWR Control Rod CR99 Licensing Report," LTR-NRC-03-69, dated December 16, 2003. (Accession No. ML033530313)

2. Letter from J. A. Gresham (Westinghouse) to NRC, Transmittal of Proprietary Information regarding Responses to RAIs on WCAP-16182-P & NP, "Westinghouse BWR Control Rod CR 99 Licensing Report," LTR-NRC-04-31, dated May 19, 2004. (Accession No. ML041450258)

3. Letter from H. N. Berkow (NRC) to E. Tenerz (ASEA-ATOM), Subject: Acceptance for Referencing of Licensing Topical Report TR UR 85-225, "ASEA-ATOM Control Rods for US BWRs," dated February 20, 1986.

4. Letter from A. C. Thadani (NRC) to E. Tenerz (ASEA-ATOM), Subject: Acceptance as a Reference Document of Supplement 1 to Topical Report TR UR 85-225, "ASEA-ATOM Control Rods for US BWRs," dated May 5, 1988.

5. Letter from A. C. Thadani (NRC) to E. Ternez (ABB ATOM), Subject: Acceptance of Supplement 2 to Topical Report UR-85-225A, "ASEA-ATOM Control Rods for US BWRs as a Reference Document," dated August 8, 1989.

Principal Contributor: E. Kendrick, NRR/DSSA/SRXB-A

Date: September 21, 2004