FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

WCAP-16498-P/WCAP-16498-NP, "17X17 NEXT GENERATION FUEL (17X17 NGF)

REFERENCE CORE REPORT"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION AND BACKGROUND

By letter dated April 3, 2008 (Reference 1), the Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-16498-P/WCAP-16498-NP, "17X17 Next Generation Fuel (17X17 NGF) Reference Core Report," to the U.S. Nuclear Regulatory Commission (NRC) for review and approval. The 17x17 NGF fuel design is an evolutionary design of NRC approved 17x17 fuel designs in general and the 17x17 Robust Fuel Assembly (RFA) design in particular. Thus, most of the design features of the 17x17 NGF fuel are identical to those of the NRC accepted 17x17 RFA fuel. To assure that the Nuclear Steam Supply System (NSSS) conditions applied in the previous approvals of 17x17 fuel do not invalidate or change the analysis methodology for 17x17 NGF fuel, a scoping analysis was performed of the NSSS conditions of the various 17x17 fueled plants. This TR presents generic information with regard to the performance of the improved fuel design features associated with the transition from 17x17 RFA to 17x17 NGF fuel. The key feature in that transition is associated with the design of the grids. The mixing vane design has been modified to improve heat transfer performance during normal operation. Furthermore, the number of Intermediate Flow Mixing (IFM) grids has been increased from three to five so as to provide additional turbulent mixing in the upper spans of the fuel assembly, and, thereby, allow more thermal margin in the design and in the support of plant uprates.

2.0 REGULATORY EVALUATION

Topical Report WCAP-16498-P/WCAP-16498-NP presents the 17X17 NGF design evaluation that provides, through demonstrated conformance to the guidance given in the Section 4.2, Revision 2, "Fuel System Design" of NUREG-0800, "Standard Review Plan [(SRP)] for the Review of Safety Analysis Reports for Nuclear Power Plants," (Reference 2), assurance that:

(a) The fuel system is not damaged as a result of normal operation and anticipated operational occurrences.

(b) Fuel system damage is never so severe as to prevent control rod insertion when it is required.

(c) The number of fuel rod failures is not underestimated for postulated accidents.

(d) Coolability is always maintained.

These objectives implement General Design Criteria 10, 27, and 35. All fuel damage criteria relevant to these requirements are described in SRP 4.2; those stated in terms that involve the departure from nucleate boiling ratio (DNBR) or the critical power ratio (CPR) limits, that are relevant specific thermal-hydraulic criteria, are given in the Section 4.4, Revision 2, "Thermal and Hydraulic Design" of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP 4.4) (Reference 3). The specific coolability requirements for the loss-of-coolant accident (LOCA) and for the dose analysis in postulated accidents are given respectively by 10 CFR 50.46 and 10 CFR Part 100.

3.0 TECHNICAL EVALUATION

The 17x17 NGF fuel assembly is designed as a follow-on to the 17x17 RFA design. The key differences in the two designs are given in the following table.[1]

Key Differences of 17x17 RFA and 17x17 NGF Fuel Design		
	RFA	**NGF**
Fuel Assembly		
Weight, lbs.	**[ ]**	**[ ]**
Grids		
Mid-grids	Five grids, modified horizontal dimple, diagonal spring, and modified V5H vane	Five grids, wide horizontal dimple, new "I-spring", and modified RFA vane
Mid-grid Height, in.	**[ ]**	**[ ]**
IFM – Grids	Three	Five
IFM – Grid Height, in.	**[ ]**	**[ ]**
Nozzle		
Top Nozzle	Machine and/or cast, reconstitutable	Cast, reconstitutable, integral spring pad
Top Nozzle Weight, lbs.	**[ ]**	**[ ]**
Bottom Nozzle	Debris filter	Debris filter with improved ΔP
Guide Thimble		
Guide Thimble Dashpot Design	Swaged	Tube-in-tube
Joints and Connections		
Top-Grid Joint	One Bulge to guide thimble	Two Bulges to guide thimble
Restraint Bulge	Zero	Two
Fuel Rod		
Clad Material	ZIRLO™	Optimized ZIRLO™
Axial Blankets	**[ ]**	**[ ]**

[1] Note: All dimensions are in inches and are listed as reference values as would be done in a plant's Final Safety Evaluation Report.

The 17x17 NGF fuel assembly is designed to be mechanically compatible with the 17x17 RFA design for operation with mixed fuel cores. Moreover, most of the new features of the 17x17 NGF design, relative to the 17x17 RFA design, have a licensing pedigree as indicated by the references in the table.

Therefore, given that most of the 17x17 NGF design is identical to that of previously NRC approved 17x17 fuel designs, TR WCAP-16498-P/WCAP-16498-NP presents the 17x17 NGF design evaluation in line with the structure of the SRP 4.2 (Reference 2) supplemented with the appropriate references to any materials already approved by the NRC. As such, the evaluation is organized along functional lines: Mechanical Design, Nuclear Design, Thermal and Hydraulic Design, Accident Analysis, Reactor Vessel and Internals Evaluation, and Radiological Assessment.

The NRC staff's Requests for Additional Information (RAIs) that addressed a one-to-one comparison between methodologies, computer codes, and specific performance characteristics as they relate to the fuel performance analysis of the NRC approved 17x17 RFA fuel design and the 17x17 NGF fuel design in the context of the same reference core (Reference 4). In addition, the calculation notes for fuel rod design, thermal-hydraulic design, and core design were made available at request for audit purposes.

Based on the generic information presented by Westinghouse in TR WCAP-16498-P/ WCAP-16498-NP in regard to the design evaluation of the 17x17 NGF fuel design, and the response to the NRC staff's RAIs, the following performance characteristics are confirmed by the NRC (Reference 5).

3.1 Mechanical Design

- The 17x17 NGF fuel assembly design is mechanically compatible with the 17x17 RFA design.
- The design bases for fuel assembly structural components are satisfied.
- The design bases and limits for the 17x17 NGF fuel assembly and fuel rod performance are satisfied for lead rod average burnups of 62,000 MWD/MTU.
- The grid impact force for seismic and LOCA events was determined to be within the allowable limits as determined by grid crush tests.
- Hydraulic flow testing of the 17x17 NGF fuel assembly with the 17x17 RFA fuel design confirms that fuel rod wear is within the Westinghouse established guidelines and provides additional margin relative to current 17x17 designs.

3.2 Nuclear Design

- Standard nuclear design analytical models and methods accurately describe the neutronic behavior of the 17x17 NGF fuel design.
- The 17x17 NGF nuclear design bases are satisfied.
- Safety limit characteristics of the 17x17 RFA fuel design apply to the 17x17NGF fuel design with no loss of margin to those limits.

3.3 Thermal and Hydraulic Design

- With the implementation of the five IFM grids, the thermal margins are increased.

- A new departure from nucleate boiling (DNB) correlation WNG-1 has been developed through testing of the 17x17 NGF fuel assembly. The application of this correlation to meet the DNB design basis of SRP 4.2 and SRP 4.4 (Reference 2, Reference 3), that there will be at least a 95 percent probability at a 95 percent confidence level that DNB will not occur on the limiting fuel rods during Conditions I and II events for the 17x17 NGF fuel, is based on the NRC-approved TR WCAP-16766-P-A/WCAP-16766-NP-A (Reference 8).
- Hydraulic flow tests of the 17x17 NGF fuel assembly indicate a **[ ]** increase in the core pressure drop compared to 17x17 RFA fuel.
- No rod bow DNBR penalty is required in the IFM-grid spans as the additional grids in the 17x17 NGF fuel assembly eliminate rod bow issues.

3.4 Accident Analyses and Evaluations

- For the non-LOCA accidents, the currently-approved methods and computer codes used in the Final Safety Analysis Report non-LOCA Chapter 15 analyses are applicable for 17x17 NGF fueled core accident evaluations for demonstrating that acceptance criteria are met.
- For the LOCA analyses, the currently-approved realistic Large Break LOCA and deterministic Small Break LOCA methods are applicable for 17x17 NGF fueled core accident evaluations for demonstrating that acceptance criteria are met.

3.5 Reactor Vessel and Internals Evaluation

3.5.1 Reactor Internals System Thermal-Hydraulic Performance

- The thermal-hydraulic analysis methodology used by Westinghouse of the reactor internals in pressurized water reactors implementing changes in fuel remains valid for Westinghouse PWRs implementing 17x17 NGF fuel.

3.5.2 Reactor internals System Structural Response to Seismic and LOCA Conditions

- The Westinghouse finite element modeling associated with LOCA and seismic analyses of the reactor vessel, reactor internals, and fuel remains valid in the analysis of a Westinghouse PWR implementing the 17x17 NGF fuel design. (Reference 7)

3.5.3 Reactor Control Cluster Assembly (RCCA) Scram Performance

- The Westinghouse RCCA scram time methodology remains valid for use in the analysis of Westinghouse PWRs implementing the 17x17 NGF fuel design. RCCA scram time evaluations have been performed for several plants with 17x17 NGF fuel and indicate a slight increase in the scram time. Thus, plant-specific RCCA scram time analysis will be done by Westinghouse to confirm that the RCCA scram time limit is not violated.

3.5.4 Reactor Internal Components Structural Performance

- With a change in fuel design there is a possibility of increased gamma heating on the internal components surrounding the core. The model and methodology used by Westinghouse in analyzing increased gamma heating on the reactor internal components is unaffected by the 17x17 NGF design.

3.5.5 Reactor Internal Components Interface with the Fuel

- The Westinghouse methodology used in evaluating the impact of the introduction of 17x17 NGF fuel does not have an effect on the interface between the fuel and the reactor internal components.

3.6 Radiological Assessment

The design changes for the 17x17 NGF fuel do not include changes to the fuel pellets, nor to the enrichment or burnup limits. Thus, there is no direct impact on the core source term and no projected impact on the potential releases of radioactivity from the operating plant under normal operation or under accident conditions.

4.0 LIMITATIONS AND CONDITIONS

Licensees that reference TR WCAP-16498-P/WCAP-16498-NP must ensure compliance with the following conditions and limitations:

1. Where plant-specific analyses are required, these analyses will be documented for that application with appropriate reference to the material in TR WCAP-16498-P/ WCAP-16498-NP.

2. Plant-specific analyses/evaluations will be done for each initial application of the 17x17 NGF fuel assembly design. These analyses/evaluations are to address the transition core effects from the existing 17x17 fuel product to a full core of 17x17 NGF fuel.

3. The transition core DNBR penalty on the 17x17 NGF fuel assembly during the transition from 17x17 fuel is to be evaluated using the current evaluation methodology with the new DNB correlation WNG-1 that has been developed through testing of the 17x17 NGF fuel assembly. The application of this correlation to meet the DNB design basis of SRP 4.2 and SRP 4.4 that there will be at least a 95 percent probability at a 95 percent confidence level, that DNB will not occur on the limiting fuel rods during Conditions I and II events for 17x17 NGF fuel, is based on NRC approved TR WCAP-16766-P-A/ WCAP-16766-NP-A (Reference 6).

4. The Westinghouse RCCA scram time methodology remains valid for use in the analysis of Westinghouse PWRs implementing the 17x17 NGF fuel design. RCCA scram time evaluations have been performed for several plants with 17x17 NGF fuel and indicate a slight increase in the scram time. Thus, plant-specific RCCA scram time analysis will be done by Westinghouse to confirm that the *Technical Specification* RCCA scram time limit is not violated.

5. The reference fuel assembly design, 17x17 NGF, its fuel mechanical design methodology and design criteria, are approved up to a peak rod average burnup of 62 GWd/MTU.

All of the limitations and conditions listed in previous NRC safety evaluations' approvals for methodologies used for 17x17 NGF, including those listed for Optimized ZIRLO™ (Reference 8) will continue to be met.

5.0 CONCLUSION

The NRC staff has reviewed the reference 17x17 NGF fuel design presented by Westinghouse in the TR WCAP-16498-P-P/WCAP-NP and determined that it meets design and regulatory requirements. Plant-specific and cycle-specific evaluations are required to ensure that allowable variances of this fuel assembly design continue to satisfy all criteria.

Based upon its review of TR WCAP-16498-P-P/WCAP-NP, and RAI responses, the NRC staff finds that the Westinghouse 17x17 NGF fuel assembly design, fuel design criteria, and supporting fuel mechanical and reload design methodology is acceptable subject to the conditions and limitations listed in Section 4.0.

6.0 REFERENCES

1. Letter from Gresham, J. A. (Westinghouse) to U.S. Nuclear Regulatory Commission, "Submittal of WCAP-16498-P/ WCAP-16498-NP, '17X17 Next Generation Fuel (17X17 NGF) Reference Core Report'," April 3, 2008 (ADAMS Accession No. ML0810106020).

2. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 4.2, "Fuel System Design", U.S. NRC, March 2007.

3. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 4.4, Revision 2, "Thermal and Hydraulic Design", U.S. NRC, July 1981.

4. Letter from U.S. Nuclear Regulatory Commission to Gresham, J. A. (Westinghouse), "Westinghouse Electric Company Request for Additional Information Re: Topical Report WCAP-16498-P, 'Next Generation Fuel Reference Core Report' (TAC No. MD8540)," July 1, 2009 (ADAMS Accession No. ML091740088).

5. Letter from Gresham, J. A. (Westinghouse) to U.S. Nuclear Regulatory Commission, "Response to the NRC's Request for Additional Information by the Office of Nuclear Reactor Regulation for the Westinghouse Electric Company Topical Report WCAP-16498-P '17x17 Next Generation Fuel Reference Core Report," February 9, 2010 (ADAMS Accession No. ML100480892).

6. Letter from Gresham, J. A. (Westinghouse) to U. S. Nuclear Regulatory Commission, "Submittal of Approved Version of WCAP-16766-P-A/WCAP-16766-NP-A, 'Westinghouse Next Generation Correlation (WNG-1) for Predicting Critical Heat Flux in Rob Bundles with Split Vane Mixing Grids'," March 2, 2010 (ADAMS Accession No. ML100850530).

7. WCAP-9401-P-A, "Verification Testing and Analyses of the 17x17 Optimized Fuel Assembly," September 1981.

8. WCAP-12610-P-A & CENPD-404-P-A, Addendum 1-A (Proprietary)/WCAP-14342-A & CENPD-404-NP-A, Addendum 1-A (Non-Proprietary), "Optimized ZIRLO™," July 10, 2006 (ADAMS Accession No. ML062080563).

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Date: March 16, 2011