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

Our ref: LTR-NRC-02-55

November 13, 2002

Subject: Fuel Criterion Evaluation Process (FCEP) Notification of the RFA-2 Design, Revision 1, (Proprietary)

Dear Mr. Wermiel:

Enclosed are copies of the Proprietary and Non-Proprietary versions of the Fuel Criterion Evaluation Process (FCEP) Notification of the RFA-2 Design, Revision 1. This submittal serves as Westinghouse notification to the NRC, as required by the SER on Westinghouse Fuel Criteria Evaluation Process (FCEP), that the NRC-approved process in WCAP-12488-A is being used for the validation of the WRB-1, WRB-2 and WRB-2M DNB correlation applicability to the Robust Fuel Assembly 2 (RFA-2) mid-grid/IFM grid design modifications.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-02-1573 with Proprietary Information Notice and Copyright Notice.

2. One (1) copy of Affidavit, AW-02-1573.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR 9.17(a)(4). Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the expressed prior written approval of Westinghouse.

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Correspondence with respect to any Application for Withholding should reference AW-02-1573 and should be addressed to H. A. Sepp, Manager of Regulatory and Licensing Engineering, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

Copy to:
R. Caruso, NRR
S. L. Wu, NRR
U. Shoop, NRR
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Our ref: AW-02-1573

November 13, 2002

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: Fuel Criterion Evaluation Process (FCEP) Notification of the RFA-2 Design, Revision 1, (Proprietary)

Reference: Letter from H. A. Sepp to J. S. Wermiel, LTR-NRC-02-55, dated November 13, 2002

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-02-1573 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-02-1573 and should be addressed to the undersigned.

Very truly yours,

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

AW-02-1573

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Henry A. Sepp, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse") and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

MARGARET L. GONANO
COMMONWEALTH
OF
PENNSYLVANIA
NOTARY PUBLIC

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

Sworn to and subscribed
before me this 13th day
of November, 2002.

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 Manager, Regulatory and Licensing Engineering, in Nuclear Services, of the Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse") and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Electric Company.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Electric Company in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked "Fuel Criterion Evaluation Process (FCEP) Notification of the RFA-2 Design, Revision 1, (Proprietary)," November 13, 2002, for submittal to the Commission, being transmitted by Westinghouse Electric Company (W) letter (LTR-NRC-02-55) and Application for Withholding Proprietary Information from Public Disclosure, Henry A. Sepp, Westinghouse, Manager Regulatory and Licensing Engineering 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 to provide notification to the NRC staff of the implementation of the Robust Fuel Assembly 2 (RFA-2) design modifications under the Fuel Criterion Evaluation Process (FCEP) and correlation applicability.

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

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

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to continue to implement corrective actions to ensure the highest quality of fuel in order to meet the customer needs.

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

The documents transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies for the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.790 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection not withstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond these necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

Fuel Criterion Evaluation Process (FCEP)
Notification of the RFA-2 Design
Revision 1

November 2002

Fuel Criterion Evaluation Process (FCEP)
Notification of the RFA-2 Design

Revision 1:

Revision 1 to this FCEP notification is to provide clarification as to the applicability of DNB correlations to the RFA-2 design. All changes associated with Revision 1 are in italics with revision bars. In Revision 0, the changes to the MV5H mid-grids and MIFMs associated with the RFA-2 design were shown to have no effect on the DNB performance of the mid-grids and IFMs. Thus, WRB-1 and WRB-2 are applicable to 17x17 RFA-2 fuel with or without IFMs for both 12 foot and 14 foot cores with a 1.17 DNBR correlation limit. Subsequent to the original RFA-2 notification, an additional evaluation of the CHF data has determined that WRB-2M is also applicable to the 17x17 RFA-2 fuel with or without IFMs for both the 12 foot and 14 foot cores with a 1.14 DNBR correlation limit[5]. All DNBR correlation limits specified herein are based on a 95/95 criterion basis.

Background:

In 1998, Westinghouse notified the NRC of the introduction of the Robust Fuel Assembly (RFA) and of the applicability of WRB-1 and WRB-2 DNB correlations to the 17x17 modified LPD mid-grid[1] and modified IFM grid[2] used on this design. The RFA design was introduced for both 12 foot and 14 foot cores. The original RFA mid-grid was a modified V5H mid-grid that restored DNB margins and eliminated fuel assembly vibration. Additionally, grid to fuel rod fretting that was observed in the V5H fuel assembly design was significantly reduced. The RFA-2 grid is a modification to RFA to further improve its resistance to fuel rod fretting wear. The modifications [

] [a, c] (refer to Figure 1). The objective of the modification was to improve fretting wear, but not significantly affect any other thermal-hydraulic or mechanical performance features of the RFA design. Fretting wear tests, conducted in the VIPER loop, have shown that significant wear margin has been achieved. The RFA-2 design primarily achieves its improved fretting wear resistance by [

] [a, c]. The RFA-2 design has the same mixing vane shape and pattern as the original RFA mid-grid. The following sections will address the design categories and associated parameters in the Westinghouse Fuel Criteria Evaluation Process (FCEP), WCAP-12488-A[3], to show that the RFA-2 design changes have an insignificant impact on these parameters.

Design Categories:

A. Fuel Damage and Fuel Rod Failure Criteria

a. Clad Stress
b. Clad Strain
c. Clad Fatigue
d. Clad Oxidation
e. Zircaloy Clad Hydrogen Pick-up
f. Fuel Rod Axial Growth
g. Clad Flattening
h. Rod Internal Pressure
i. Fuel Clad Fretting Wear
j. Fuel Rod Clad Rupture (Burst)
k. Fuel Pellet Overheating
l. Non-LOCA Fuel Clad Temperature
m. LOCA Fuel Clad Temperature
n. Departure from Nucleate Boiling (DNB)
o. Thermal-Hydrodynamic Stability

B. Fuel Coolability

a. Fuel Assembly Hold-Down Force
b. Clad Embrittlement During Locked Rotor/Shaft Break Accident
c. Clad Ballooning and Flow Blockage
d. Violent Expulsion of Fuel (Rod Ejection)
e. Fuel Assembly Structural Response to Seismic/LOCA Loads

C. Nuclear Design

a. Shutdown Margin
b. Fuel Storage Sub-criticality
c. Stability
d. Reactivity Feedback Coefficients
e. Power Distribution
f. Maximum Controlled Reactivity Insertion Rate

Evaluation:

Each of the parameters under each category listed above have been examined and those impacted by the design change to the RFA-2 mid-grid will be addressed in the following sections.

Category A:

Fuel Damage and Fuel Rod Failure Criteria

Parameters "a-h", "j", and "k" in this category are not impacted by the RFA-2 design change since the fuel rod was not altered. Parameters "i", "l", "m", "n" and "o" are discussed below.

Table 1 compares key characteristics of the RFA-2 design to the original RFA design. The changes in [ ]^{a,c}. There is no significant change in the [ ]^{a,c} of the ZIRLO™ grid. The slightly higher [ ]^{a,c} for the Zr-4 grid is due to a difference in the [ ]^{a,c}, to address differences in [ ]^{a,c}.

[
] [a, c]. However, this effect is judged to be negligible in view of the very small change in [ ] [a, c] involved.

LOCA and Non-LOCA Fuel Clad Temperature

Tests were performed in both the FACTS and the VIPER loops to confirm that the flow resistance of the RFA-2 mid-grid was not different from the original RFA mid-grid. An evaluation of the data showed that the measured loss coefficient was the same as the RFA design value.

[ ] [a, c] are both inputs to the LOCA safety analysis. The impact of the changes identified in Table 1 on the LOCA Fuel Clad Temperature (Item m) were assessed and found to be negligible. Impacts on Non-LOCA Fuel Clad Temperature (Item l) and all other safety analysis parameters were found to be unaffected by these changes. This was confirmed by Westinghouse in an Integrated 10 CFR 50.59 evaluation[(4)].

DNB

As noted above, the hydraulic loss coefficient of the RFA-2 mid-grid were measured in tests, and found to be the same as the original RFA mid-grid. Since the pressure drop and variation in resistance across the grid in the RFA-2 assembly is the same as in the RFA assembly, there are no differences in pressure, local mass velocity, and local quality.

There are no changes to the mixing vane in the RFA-2 mid-grid or the IFM. Grid parameters affecting DNB such as [
] [a, c] are not affected.

Because more of the strap material is used as a [
] [a, c], increases for the RFA-2. [

] [a, c]. The following paragraphs describe an assessment of the DNB performance of the RFA-2 design.

A freon (refrigerant R-11) heat transfer test loop was recently installed and made operational at the Development Laboratory in Columbia, S.C. The tests used [ ] [a, c] with V5H, RFA, and RFA-2 mid-grids, and no IFMs. The test method was to first establish steady pressure, flow, and inlet temperature at a heat flux below that expected to produce DNB. The bundle power was then increased until one rod experienced a temperature excursion and exceeded an elevated temperature, typically

450 °F. The objective of the test program was to test each bundle at the same inlet conditions, then compare the bundle power at DNB. It was anticipated that the freon tests would identify differences in DNB performance roughly equivalent to the water DNB tests for V5H and RFA. Based on prior water DNB tests, a difference of about [ ]^{a,c} in bundle power at DNB between the V5H tests and the RFA tests was expected.

The bundle powers at DNB (in kW) for each test bundle were fit with response curves as functions of bundle pressures (psia), flows (lb/min), and inlet temperatures (°F). The regression curves were then compared. Figure 2 compares the bundle power for RFA and RFA-2 with that of V5H, using the above regression curves for a range of bundle conditions. According to the correlations, RFA and RFA-2 assemblies have higher predicted DNB heat flux than V5H over the range of conditions.

[

]^{a,c}.

[

]^{a,c}. The test series was targeted at [ ]^{a,c} tests, with test conditions matched to previous tests run with the RFA grids. Tests with IFMs were performed because previous experience showed the [ ]^{a,c} was with this configuration.

[

]^{a,c}.

[

]^{a,c}.

Thus, it is concluded that the RFA-2 does not degrade DNB performance relative to RFA. Therefore, DNB correlations applicable to RFA (with or without IFMs), *i.e., WRB-1, WRB-2 and WRB-2M,* are also |

applicable to the RFA-2 design (with or without IFMs). This conclusion applies to either Zr-4* or ZIRLO™ assemblies.

Thermal-Hydrodynamic Stability

Since the pressure drop of the RFA-2 mid-grid is the same as the RFA, the assembly loss coefficient is also the same, such that thermal hydraulic stability characteristics are not changed.

Fuel Rod Clad Fretting Wear

Full-scale tests were performed in the VIPER (Vibration Investigation and Pressure-drop Experimental Research) loop. All rods were examined for wear marks, and the wear depth was measured. Two separate tests were performed. The test results showed that the wear depth would be less than the allowable [ ]^{a,c} of wall thickness criterion [ ]^{a,c} after three eighteen month cycles. Tests were also performed on two RFA-2 assemblies (one with and the other without IFMs) at test conditions identical to previous VIPER tests with V5H, RFA, and OFA assemblies. The wear performance of the RFA-2 assembly can be compared directly with the V5H, RFA, and OFA assembly, as shown in Figure 3. It can be seen that the RFA-2 assembly with IFMs performs as well or better than the RFA and OFA under identical test conditions, and is significantly better than the V5H assembly. Since the OFA assembly has performed well in the field, these results provide confidence that the RFA-2 design will also perform well.

In addition to the VIPER testing, some information has been obtained from PIE inspections that indicates the RFA design is performing significantly better than expected. RFA assemblies show substantially less wear after two cycles than V5H assemblies that operated in the same core under similar conditions at Wolf Creek. With the VIPER test results, this suggests that the RFA-2 fretting performance will also be acceptable in-core.

Additional tests were performed to confirm that a [ ]^{a,c} was not present in the RFA-2 design. In addition, the potential for [ ]^{a,c} of the RFA-2 [ ]^{a,c} were evaluated in the VISTA (Vibration Investigation of Small-scale Test Assemblies) Loop. Flow velocities below and above expected values, associated with in-core operation, were used. There was no resonant vibration over the normal core operation flow velocities.

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* The Zircaloy-4 RFA or RFA-2 designs are for international licensees that have not yet transitioned to ZIRLO™ clad fuel rods or ZIRLO™ structures. All U. S. licensees using the RFA or planning to use the RFA-2 design will have the ZIRLO™ design.

Category B:

Fuel Coolability

Parameters "a-d" in this category are not impacted by the RFA-2 mid-grid design since the fuel rod and component pressure drops are unchanged. Due to the changes in the [ ] [a, c], the mid-grid impact strength and stiffness may be affected. The fuel assembly lift force is not impacted based on the pressure drop tests performed in VIPER and FACTS.

The fuel assembly [ ] [a, c] are not effected by the mid-grid design change. Even a detailed model would indicate an insignificant difference, but the simplified models, used in the grid impact load analysis and the systems analysis, would be identical to the RFA model. The mid-grids impact strength and stiffness for the RFA-2 mid-grid was determined by dynamic testing. The factor used to determine its acceptability for seismic/LOCA considerations is $P/\sqrt{K}$ (seismic factor). Testing shows that the RFA-2 design is essentially identical to the RFA design in this area.

Category C:

Nuclear Design

None of the parameters in this category are affected by the RFA-2 mid-grid design changes. The fuel rod design is identical to RFA, as are the grid locations, masses and pressure drop.

Conclusion:

It is concluded that the design changes made to the RFA-2 design will have no effect on the performance of the mid-grid in the design categories listed above. The RFA-2 design changes may therefore be implemented under the Fuel Criteria Evaluation Process, which requires NRC notification; however, no NRC review is deemed necessary.

References:

1. Letter from H. A. Sepp (Westinghouse) to Document Control Desk (NRC), "Notification of FCEP Application for WRB-1 and WRB-2 Applicability to the 17x17 Modified LPD Grid Design for Robust Fuel Assembly Application," NSD-NRC-98-5618, March 25, 1998.

2. Letter from H. A. Sepp (Westinghouse) to Document Control Desk (NRC), "Fuel Criteria Evaluation Process Notification for the 17x17 Robust Fuel Assembly with IFM Grid Design," NSD-NRC-98-5796, October 13, 1998.

3. Davidson, S. L., (Ed.), et al., "Westinghouse Fuel Criteria Evaluation Process," WCAP-12488-A, October 1994.

4. "Transmittal of EVAL-01-066: GENERIC-Implementation of Robust Fuel assembly-2 (RFA-2) Design Changes," LTR-ESI-01-154, August 31, 2001.

5. *Smith, L. D., Lloyd, M. W., Sung, Y. X. and Leech, W. J., "Modified WRB-2 Correlation, WRB-2M, for Predicting Critical Heat Flux in 17x17 Rod Bundles with Modified LPD Mixing Vane Grids," WCAP-15025-P-A, April 1999.*

Table 1
RFA-2 Fuel Assembly Design

The following information is for the RFA-2 fuel assembly design (Same as RFA except for Zr-4 or ZIRLO™ RFA-2 mid-grid) for use in 17x17, 0 374 rod designs, with and without IFMs

General Fuel Assembly Information a, b, c

TABLE 1
RFA-2 Fuel Assembly Design (continued)

Grid Information a, b, c

TABLE 1
RFA-2 Fuel Assembly Design (continued)

Mid Grid Elevation	a, b, c

Table 2
Comparison of Hot Rod Average Heat Flux, RFA-2 Data versus RFA

a, b, c

[ ]

TABLE 3
Water DNB Test Matrix

[ ]^{a,c}

[ ]^{a,b,c}

Figure 1
RFA-2 Mid-grid Design
Compared with RFA and V5H

a, b, c

Figure 2
RFA and RFA-2 Freon Loop Bundle Power at DNB
Versus V5H at Same Test Conditions

a, b, c

Figure 3
VIPER Test Results

a, b, c