Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Direct tel: (412) 374-5093
e-mail: harperzs@westinghouse.com

LTR-NRC-22-7

February 28, 2022

Subject: Fuel Criterion Evaluation Process (FCEP) Notification of the 17x17 OFA PRIME Fuel Product Implementation (Proprietary/Non-Proprietary)

Enclosed are the proprietary and non-proprietary versions of the report, "Fuel Criterion Evaluation Process (FCEP) Notification of the 17x17 OFA PRIME Fuel Product Implementation."

This submittal contains proprietary information of Westinghouse Electric Company LLC ("Westinghouse"). In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Nuclear Regulatory Commission's ("Commission's") regulations, we are enclosing with this submittal an Affidavit. 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 the proprietary aspects of this submittal or the Westinghouse Affidavit should reference AW-22-008 and should be addressed to Zachary S. Harper, Manager, Licensing Engineering, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 1, Cranberry Township, PA 16066.

Zachary S. Harper, Manager
Licensing Engineering

cc: Ekaterina Lenning
Dennis Morey

Enclosures:

(1) Affidavit, AW-22-008
(2) Fuel Criterion Evaluation Process (FCEP) Notification of the 17x17 OFA PRIME Fuel Product Implementation (Proprietary)
(3) Fuel Criterion Evaluation Process (FCEP) Notification of the 17x17 OFA PRIME Fuel Product Implementation (Non-Proprietary)

Commonwealth of Pennsylvania:
County of Butler:

(1) I, Zachary Harper, Manager, Licensing Engineering, have been specifically delegated and authorized to apply for withholding and execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse).

(2) I am requesting the proprietary portions of LTR-NRC-22-7 Enclosure2 be withheld from public disclosure under 10 CFR 2.390.

(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 10 CFR 2.390, 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 and is not customarily disclosed to the public.

(ii) The information sought to be withheld is being transmitted to the Commission in confidence and, to Westinghouse's knowledge, is not available in public sources.

(iii) Westinghouse notes that a showing of substantial harm is no longer an applicable criterion for analyzing whether a document should be withheld from public disclosure. Nevertheless, 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.

(5) Westinghouse has policies in place to identify proprietary information. 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.

(6) The attached documents are bracketed and marked to indicate the bases for withholding. The justification for withholding 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 (5)(a) through (f) of this Affidavit.

I declare that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief. I declare under penalty of perjury that the foregoing is true and correct.

Executed on: 2/25/2022

Signed electronically by
Zachary Harper

Enclosure 3

Fuel Criterion Evaluation Process (FCEP) Notification of the 17x17 OFA PRIME Fuel Product Implementation

(Non-Proprietary)

(17 pages including this cover page)

February 2022

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

Fuel Criterion Evaluation Process (FCEP)
Notification of the 17x17 OFA PRIME Fuel Product Implementation

1.0 Background

In its continued efforts to pursue innovative solutions for its customers, Westinghouse has developed several advanced fuel assembly features to improve fuel performance, enhance fuel reliability, provide additional margin for uprates, improve operability and provide enhanced fuel cycle economics. These features, which include **Low Tin ZIRLO™ (LTZ)** grids, **[ ]**^{a,c} of the bottom nozzle, and reinforced guide thimble tubes, were initially implemented in the Next Generation Fuel (NGF) assembly design for Westinghouse Pressurized Water Reactors (PWRs) as documented in WCAP-16498-P-A (Reference 1), which was reviewed and approved by the NRC. These features, with some minor enhancements as described herein, are part of the new **PRIME™** fuel product and are now available for plants with the 17x17 VANTAGE+ with Debris Mitigation Features a.k.a. the Optimized Fuel Assembly (17x17 OFA) design.

The **PRIME** Program fuel advanced features improve the fuel reliability, dimensional stability and corrosion resistance of the 17x17 OFA fuel design. The17 OFA **PRIME** fuel product includes the following features:

A. **LTZ grid strap material** – This material offers improved corrosion resistance and is compatible with **Optimized ZIRLO™** fuel rods. All inner and outer straps are changing from **ZIRLO®** to **LTZ** material and apply to grids with both "balanced" and "unbalanced" vane patterns for the 17 OFA **PRIME** fuel product. There is no change to the top and bottom Alloy 718 grids.

B. **PRIME Bottom Nozzle** – The **PRIME** Bottom Nozzle includes the Lowered Side Skirt from the Advanced Debris Filter Bottom Nozzle (ADFBN, Reference 2) and the Low Pressure Drop Feature of the 17x17 NGF design. The **PRIME** Bottom Nozzle improves fuel performance with respect to leaking fuel rods due to debris-induced fretting by improving debris capture. Additionally, **[ ]**$^{a.c}$ feature results in a decreased resistance and hence, higher flow through the fuel assembly. The **PRIME** Bottom Nozzle is equipped with a lower side skirt and the 17x17 NGF flow plate **[ ]**$^{a.c}$

C. **[ ]**$^{a.c}$ **Dashpot Tube** – The **[ ]**$^{a.c}$ Dashpot Tube stiffens the dashpot region of the fuel assembly to minimize the potential for incomplete rod insertion. The17 OFA **PRIME** fuel product includes **[ ]**$^{a.c}$ on all guide thimble locations to create a structurally stiffer/stronger fuel assembly design.

1.1 Description of the Change

PRIME Low Tin ZIRLO Grids

Current Design

The current 17x17 OFA mid grids design function includes supporting the fuel rods to ensure that they are maintained in a uniform and symmetric geometry as well as ensuring that adequate mixing of the reactor coolant occurs as enabled by the mixing vanes located at the top of the inner straps of the mid grid. The mid grids (and Intermediate Flow Mixing (IFM) grids) employ a vertical spring design as shown in the mid grid assembly presented in Figure 1. The mid grids (and IFM grids) utilize a **ZIRLO** material which has adequate strength against grid crush, has acceptable corrosion resistance and a lower thermal neutron cross-section, as compared to older Alloy 718 grid designs, which resulted in a significant improvement in the neutron economy. There are two different versions of the 17x17 OFA mid grid and IFM designs which include "balanced" and "unbalanced" vane pattern designs. The newer "balanced" vane pattern reduces/eliminates fuel vibration concerns related to fuel assembly self-excitation (Reference 3). This 17x17 OFA mid grid design has had good performance with respect to concerns such as grid-to-rod fretting and also has good thermal margins.

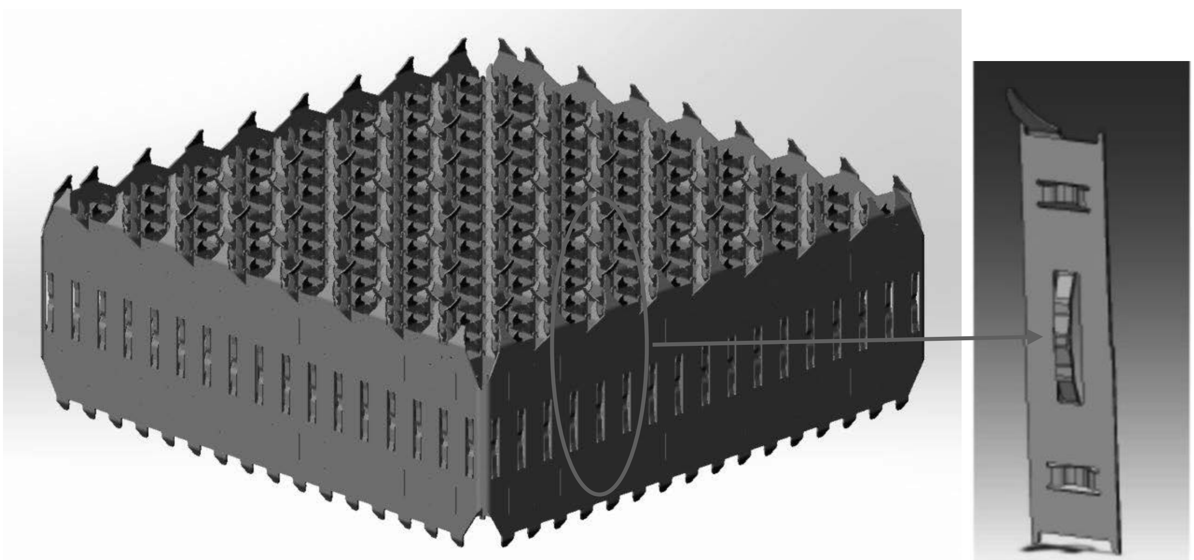

Figure 1: 17x17 OFA Mid Grid Assembly (Vertical Spring Design)

Description of Change

The new grids are essentially identical to the existing **ZIRLO** grids, except that the grid material is **LTZ**. This material change applies to grids with both "balanced" and "unbalanced" vane patterns. The **LTZ** material tends to reduce the corrosion rate, which can provide an incremental benefit for grid growth. For other grid properties, the **LTZ** grid functions in the same manner as traditional **ZIRLO** grids with respect

to the primary functions of the grid, such as, fuel rod support and flow mixing, etc. **[** **]**^{a,c} This conclusion applies to both the **LTZ** mid grids and to the **LTZ** IFM grids. All applicable design and safety criteria remain satisfied.

PRIME Bottom Nozzle

Current Design

The current 17x17 Standardized Debris Filter Bottom Nozzle (SDFBN) is a square structure that serves as the bottom structural element of the fuel assembly and directs the coolant flow distribution to the fuel assembly bundle region. The SDFBN is fabricated from wrought Type 304L stainless steel and consists of a perforated adapter plate and four angle legs with bearing plates. Side skirts act to help support the bottom nozzle legs to preclude the legs from bending, primarily during fuel handling activities. The legs and side skirts form a plenum for the inlet coolant flow to the fuel assembly. The adapter plate helps to direct flow into the fuel bundle region and prevents accidental downward ejection of the fuel rods from the fuel assembly. The bottom nozzle is fastened to the fuel assembly guide tubes by thimble screws that penetrate through the nozzle and mate with an inside fitting in each of the 24 guide tubes per fuel assembly. Each thimble screw is retained in position by a locking cup that is expanded into the detents (lobes) on the bottom side of the bottom nozzle adapter plate.

The SDFBN flow hole pattern includes a large number of small holes **[** **]**^{a,c} which help reduce the possibility of debris entering the active region of the fuel assembly. Coolant flow through the fuel assembly is directed from the plenum in the bottom nozzle upward through the flow holes in the adapter plate to the channels between the fuel rods. The flow holes in the plate are positioned between the rows of the fuel rods and **[** **]**^{a,c} Axial loads (holddown) imposed on the fuel assembly and the weight of the fuel assembly are transmitted through the bottom nozzle to the lower core plate. Indexing and positioning of the fuel assembly is controlled by alignment holes in two diagonally opposite bearing plates that mate with locating pins in the lower core plate. Any lateral loads on the fuel assembly are transmitted to the lower core plate through the locating pins.

The side skirt is a reinforcing skirt around the perimeter of the bottom nozzle which enhances reliability during postulated adverse handling conditions during refueling. The SDFBN side skirt leaves an opening **[** **]**^{a,c} which is a potential path for debris to migrate into the channel between fuel assemblies and could potentially lead to debris reaching the fuel bundle region. Debris traveling between fuel assemblies has the potential to cause fuel leakers, especially on the peripheral fuel rods of the fuel assembly. The SDFBN is shown in Figure 2.

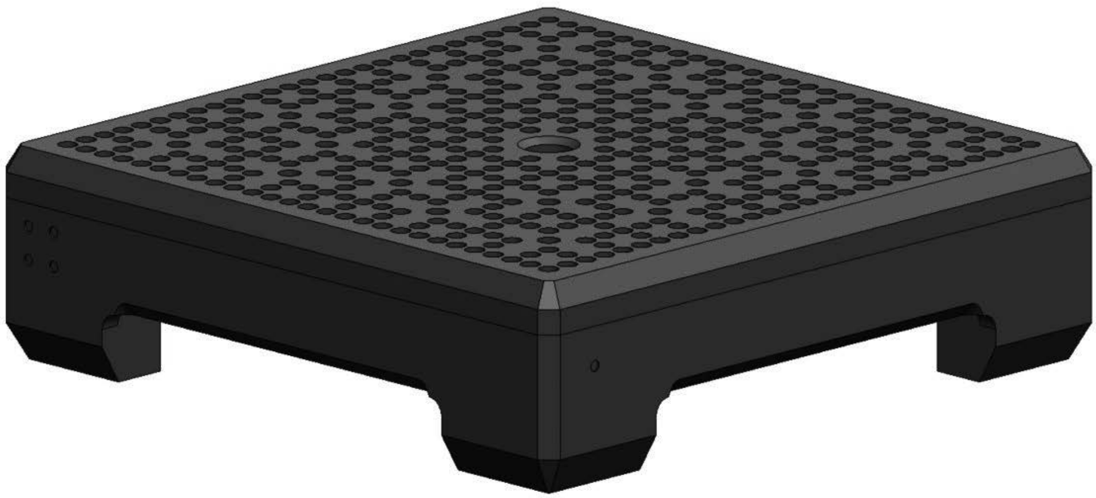

Figure 2: Standardized Debris Filter Bottom Nozzle (3D View)

Description of Change

The17 OFA **PRIME** fuel uses the **PRIME** Bottom Nozzle with low pressure drop flow holes and ADFBN side skirts. The 17x17 ADFBN design is currently being used successfully in operating plants. The **PRIME** Bottom Nozzle has a Next Generation Fuel (NGF) style **[** **]**a,c as compared to the current SDFBN design shown above. In addition, a second key feature of the **PRIME** Bottom Nozzle design is that the side skirts are lowered for improved debris mitigation as they were for the ADFBN design (Reference 2). Each of these two features are discussed herein and have been previously incorporated into existing bottom nozzle designs, such as for the NGF bottom nozzle design which has **[** **]**a,c and the 17x17 ADFBN design which lowered the side skirts to improve debris mitigation.

The 17x17 SDFBN design has **[** **]**[a,c] The introduction of the NGF style flow hole feature, **[** **]**[a,c] as compared to the 17x17 SDFBN design. As a result of this **[** **]**[a,c] there is a transition core effect which is addressed as part of the standard Westinghouse reload process. Figure 3 **[** **]**[a,c] for the current 17x17 SDFBN and 17 OFA **PRIME** Bottom Nozzle flow holes.

a,c

Figure 3: 17 OFA PRIME Bottom Nozzle and SDFBN Flow Holes

As shown in Figure 2, the SDFBN skirt has an opening that is **[** **]**[a,c] This opening could provide a path for debris to migrate into the open channel/gap between fuel assemblies and into the fuel bundle region which could potentially cause debris-induced fretting leakers on the peripheral fuel rods of the fuel assembly.

As a result of this limitation in the design of the 17x17 SDFBN bottom nozzle, the **PRIME** Bottom Nozzle design lowers the side skirts so that they are only **[** **]**[a,c] For the **PRIME** design, as shown in Figure 4 and Figure 5, **[** **]**[a,c]

In addition, **[**

][a,c] These flow holes allow for **[**

][a,c] The size and number of these side skirt flow holes were selected to ensure that the reactor vessel design bypass flow was unaffected.

The pocket on the lowered skirt was designed to accommodate potential interfacing features on the lower core plate. Specifically, **[**

][a,c]

In order to minimize difficulties in inserting, torquing, and crimping the four thimble screws **[**

][a,c]

a,c

Figure 4: Bottom View of 17 OFA PRIME Bottom Nozzle

a,c

Figure 5: Side View of 17 OFA PRIME Bottom Nozzle

<u>Reinforced Dashpot</u>

Current Design

The current guide thimble tube design for the 17x17 OFA fuel design includes a swaged dashpot design for the lower portion of the guide thimble tube as shown in the left side of Figure 6. This swaged dashpot design is established such that approximately 85% of the active fuel region is above the dashpot entrance. This ensures that the control rods following a reactor trip signal rapidly fall into the fuel assemblies shutting the reactor down. Once the control rods reach the dashpot region, the control rods slow down due to the small diameter associated with the dashpot region which acts as a damper. Typically, four small holes are provided just above the dashpot region in the side of the guide thimble tube area to minimize the hydraulic dashpot action until the control rods are close to being fully inserted into the core.

In addition to providing access for the control rods, another important design function of the guide thimble tubes is that they serve as the structural members of the fuel assembly skeleton. The fuel assembly skeleton includes the bottom nozzle, the guide thimble tubes, the instrument tube, the mid and IFM grids and the top nozzle which are all connected together during the manufacturing process. As the dashpot region of the guide thimble tubes have a smaller diameter, **[**

]$^{a.c}$

Description of Change

To improve the design of the guide thimble tubes, a **[** **]**$^{a.c}$ has been developed which increases the stiffness of the 17x17 OFA fuel assembly design. The **[** **]**$^{a.c}$ is retrofitted into the current 17x17 OFA design as shown on the right side of Figure 6.

a.c

Figure 6: Swaged Dashpot and Swaged Dashpot with [ ]^{a,c}

[ ][a,c] Thus, criteria such as the control rod drop time remain unaffected by this new [ ][a,c] dashpot design. A comparison of the current guide thimble and dashpot design and the new [ ][a,c] dashpot design are presented in Table 1.

Table 1: Guide Thimble/Dashpot and Joint Design Comparison

a,c

[ ]

[ ][a,c] and thereby stiffens the dashpot region of the fuel assembly as shown in Figure 6. The joints and connections of the bottom grid, protective grid and bottom nozzle remain identical to the swaged guide thimble design.

2.0 Design Categories

The design functions of the **PRIME** fuel assemblies, within the context of 10 CFR 50.59 and NEI-96-07, are to serve as the primary fission product barrier, to allow full control rod insertion within the credited rod drop time, and to maintain a coolable geometry. The fuel rod matrix and cladding provide the primary fission product barrier. The fuel assembly skeleton is primarily responsible for

maintaining a coolable geometry. The grids support the fuel rods and ensure that proper lateral spacing is maintained as well as providing mixing of the reactor coolant via the inner strap mixing vanes. The top nozzle and guide tubes allow for control rod insertion and the bottom nozzle serves as the bottom structural element of the fuel assembly and directs the coolant flow distribution to the fuel assembly bundle region.

The grids serve several of the following desgn functions:

1. The grids provide both lateral and vertical support for the fuel rods. This support system allows for differential thermal expansion, creep and growth of the fuel rods, while maintaining sufficient spring contact force to prevent flow-induced vibration damage.

2. The grids maintain proper fuel rod spacing and thus set the fuel rod pitch and the flow channel configuration for the fuel assembly by means of grid dimples and springs which position each fuel rod in its grid cell. The grid design retains sufficient structural integrity such that fuel performance is maintained during normal operational loading conditions and under specific accident conditions.

3. The grid assemblies are part of the overall fuel assembly skeleton structure and they provide the lateral structure that ties the guide thimble tubes and the instrument tube together to form the skeleton structure between the top and bottom nozzles.

4. The grid assemblies by their presence in the flow stream, induce coolant turbulence in the channels between the fuel rods and improve the mixing and heat transfer to the reactor coolant from the fuel rods. The mid grids and the IFM grids have mixing vanes on the top of the inner straps which add a swirling action to the turbulence to further increase the mixing in some areas of the core typically where DNB can be limiting.

5. The grids provide lateral support for the rod control cluster assembly (RCCA) guide thimble tubes so that they will be sufficiently straight such that insertion of the RCCAs is not impeded under normal or accident conditions.

The bottom nozzle serves the following design functions:

1. The bottom nozzle legs and side skirts form a plenum which directs the reactor coolant flow distribution upward through the flow holes in the adapter plate to the channels between the fuel rods in the fuel assembly.

2. The adapter plate of the bottom nozzle prevents the downward ejection of the fuel rods from the fuel assembly.

3. Axial holddown loads imposed on the fuel assembly and the weight of the fuel assembly are transmitted through the bottom nozzle to the lower core plate.

4. The bottom nozzle reduces the possibility of debris passing into the fuel rod bundle region of the fuel assembly which could cause debris-induced fretting failures.

5. The bottom nozzle positions the fuel assembly on the lower core plate by two diagonally opposite alignment holes which mate with pins in the lower core plate. This allows any lateral loads on the fuel assembly to be transmitted to the lower core plate through the lower core plate pins.

The guide thimble tubes, including the dashpot region, serve the following design functions:

1. The guide thimble tubes, including the dashpot region, transmit the vertical loads between the top and bottom nozzles, position the fuel rod support grids vertically, react to the loads from the fuel rods that are applied to the grids, and provide some of the lateral load capability for the overall fuel assembly. The guide thimble tubes are the structural members of the fuel assembly skeleton, which consists of the top and bottom nozzles, the grids, and the guide thimble tubes and instrument tube.

2. The guide thimble tubes provide defined channels in the core lattice which are used for movable or replaceable components, such as RCCAs, burnable poison rods, thimble plugs and neutron sources.

3. The dashpot region of the guide thimble tubes helps to slow the RCCAs down following a reactor trip signal and help ensure that the RCCA and control rod drive mechanism do not impact the fuel assembly at the top nozzle location.

The design functions related to structural support after fuel assembly insertion into the core are assured by meeting defined limits on stresses and deformations caused by various loads, including normal and abnormal loads caused by Condition I and II events (normal and upset loads) and abnormal loads caused by Condition III and IV events (emergency and faulted loads).

The following discussion addresses the design categories and associated parameters in the NRC-approved Westinghouse Fuel Criteria Evaluation Process (FCEP), WCAP-12488-A (Reference 4) and Addendum 1-A, Revision 1 to WCAP-12488-A (Reference 5), to demonstrate that the17 OFA **PRIME** fuel product has no adverse impact on these design requirements.

A. <u>Fuel Damage and Fuel Rod Failure Criteria</u>

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

As discussed in Revision 1 to Addendum 1-A to WCAP-12488-A , criterion "e" for structural components was replaced with the following criterion:

> "The Zircaloy-4 and **ZIRLO** structural component stresses will be consistent with ASME Code Section III requirements after accounting for thinning due to corrosion."

The Hydrogen Pickup criterion presented in Reference 4 still applies to the fuel cladding. The change in the criterion for the structural components is based on the following:

- The ductility of unirradiated Zircaloy-4 and **ZIRLO** does not abruptly decrease above hydrogen concentrations of 600 ppm. There is a gradual decrease in ductility with increases in hydrogen concentrations up to 2000 ppm. At operating temperatures, significant ductility still exists for hydrogen concentrations up to 2000 ppm.
- The ductility of irradiated Zircaloy-4 and **ZIRLO** is primarily affected by irradiation.
- While hydrides contribute to the embrittlement of irradiated Zircaloy-4 and **ZIRLO** the absolute magnitude is small in comparison to irradiation effects to hydrogen concentrations **[ ]**^{a,c}
- Hydrogen content has little effect on the tensile strength of irradiated Zircaloy-4 and **ZIRLO** at either room, or operating temperatures.
- The yield strength of irradiated recrystallized Zircaloy-4 and **ZIRLO** at operating temperatures is about four times the value for unirradiated material and the value is about double at room temperatures.

In the Addendum 1 SER, the NRC approved the criteria change as follows.

> The NRC staff concluded that it is acceptable "….to replace the hydrogen pickup limit criterion for fuel assembly structural components, excluding cladding, with a new criterion based on the stress level consistent with the ASME Code Section III requirements after taking into account thinning due to corrosion. Based on the available tests and adequate analyses, the staff approves the proposed new criterion for structural components of fuel assemblies in Revision 1 to Addendum 1-A of WCAP-12488-A."

B. <u>Fuel Coolability Criteria</u>

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

C. <u>Nuclear Design Criteria</u>

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

3.0 Evaluation

Each of the criteria listed above have been examined for the design changes associated with the17 OFA **PRIME** fuel product as compared to the current 17x17 OFA fuel design as discussed in the following

sections. This evaluation considers all three of the new fuel features, including the **PRIME** Bottom Nozzle, the **LTZ** grids and the **[ ]**^{a,c}

Category A Fuel Damage and Fuel Rod Failure Criteria

Criterion "a" Clad Stress **[ ]**^{a,c} for clad stress evaluated using the ASME Stress criterion (PAD5 Analyses, Reference 6). Sufficient margin exists in the analysis to accommodate **[ ]**^{a,c} Criteria "b" through "h", are not impacted by 17 OFA **PRIME** fuel product changes for either transition cores or full core loadings as there are no changes specifically being made to the fuel rod design associated with the 17 OFA **PRIME** fuel product.

Due to the **[ ]**^{a,c} criterion "i" Fuel Clad Fretting Wear, is potentially affected by the use of **LTZ** grid material. Based on an extensive review of field experience for **LTZ** grids used with **Optimized ZIRLO** fuel cladding, there is good grid-to-rod-fretting performance. Post Irradiation Examinations (PIEs) have been performed and the results showed that there were no wear scars **[ ]**^{a,c} which is the guideline used by Westinghouse to evaluate fretting wear (Reference 3). Furthermore, measurements performed for the grid cells indicated that the grid support feature wear is negligible. Thus, it is concluded that the criterion of fuel clad fretting wear will not be adversely affected.

Small fuel temperature deltas due to the lower pressure drop across the bottom nozzle are negligible and, therefore, do not impact any of the criteria, including criteria "l" and "m". Further, as the fuel rod design is unaffected and there are no changes affecting the ability to remove heat from the fuel rods, the criteria "j" Fuel Rod Rupture (Burst) and "k" Fuel Pellet Overheating are not affected.

While the 17 OFA **PRIME** fuel product has a **[ ]**^{a,c} the RCS flows used to evaluate the DNB design basis remain unchanged, therefore, there is no impact on criterion "n," Departure from Nucleate Boiling. The transition core DNB penalty due to this **[ ]**^{a,c} is addressed in the reload thermal-hydraulic analysis such that the DNB design basis will continue to be met. The criterion "o," Fuel Assembly Holddown Force, was also evaluated and found to be acceptable. Finally, as the thermal-hydraulic related characteristics of the PRIME fuel product are unchanged from the existing 17x17 OFA fuel design, the Thermal-Hydrodynamic Stability (criterion "p") is not impacted.

With respect to the revised criterion in Revision 1 to Addendum 1-A, to WCAP-12488-A, "The Zircaloy-4 and **ZIRLO** structural stresses will be consistent with ASME Code Section III requirements after accounting for thinning due to corrosion." discussed above, the following information is provided.

For Westinghouse structural components, the following applies.

- Zircaloy-4 or **ZIRLO** structural components consist of grids and guide thimble tubes, but the revised criterion only applies to the guide thimble tubes. For the grids, grid crush strength is applied. NUREG 0800, Appendix A defines how to account for grid crush strength, which is determined experimentally.

- For the application to grids, it was concluded that the grid crush test data for unirradiated grids are applicable for seismic and LOCA analysis. This conclusion is based on testing of Zircaloy and

ZIRLO grids with wall thinning values **[** **]**^{a,c} which is the basis for the structural corrosion criteria which limits structural component wastage **[** **]**^{a,c}

- The structural corrosion criteria (which ensures, "…after accounting for thinning due to corrosion…") is checked every cycle by using a structural corrosion model for Zircaloy and **ZIRLO** structural components. The model was developed and licensed in Reference 4. It is also noted that as part of this program the corrosion model was not updated and will be used in a conservative manner (no benefits associated with the improved corrosion resistance of the material).

Furthermore, the NRC review of the **CE16NGF™** topical report (WCAP-16500-P-A, Revision 7) resulted in the justification that the application of Revision 1 of Addendum 1-A of WCAP-12488-A to **LTZ** grids **[** **]**^{a,c} is acceptable.

> "The CE 16x16 NGF spacer grids are similar to Westinghouse grids with respect to the parameters that influence grid strength (material, strap thicknesses, pitch, and straight strap). Therefore, the conclusion from WCAP-12488-A discussed above is also applicable to CE 16x16 NGF spacer grids."

In the Final Safety Evaluation for WCAP-16500-P-A (Reference 7), the NRC states:

> "In response to RAI 8b of Reference 2 regarding irradiation induced spring relaxation on grid crush strength, Westinghouse cited an evaluation within TR WCAP-12488-A and stated that similarities between the CE NGF grid design and Westinghouse design were such that the conclusions were applicable. The NRC staff accepts this justification and finds the grid crush test program acceptable to demonstrate the design basis."

Much the same as the **CE16NGF LTZ** grid design, the **PRIME LTZ** grid design continues to be similar to Westinghouse grids with respect to the parameters that influence grid strength (grid material, strap thicknesses, grid inner strap height, pitch, and straight inner and outer straps, in addition to having the same dimple and spring design). This conclusion is based on the fact that the grids (both mid grids and IFM grids) are the same design, except for the grid strap material. In addition, though the **LTZ** grids have **[** **]**^{a,c} when compared to the **ZIRLO** grids, the design basis criteria continue to be satisfied.

Based on the above information for the **LTZ** grids, the grid crush test criteria provides an NRC accepted alternative to the stress criteria presented in Revision 1 of Addendum 1-A of WCAP-12488-A.

Category B Fuel Coolability Criteria

Criteria "a" through "c" are not impacted by the 17 OFA **PRIME** fuel product since the fuel rod and cladding materials are unchanged and transient fuel temperatures are unchanged. Criterion "d" is impacted because of **[** **]**^{a,c} for the 17 OFA **PRIME** fuel product **LTZ** grids.

[

]^{a,c} varies from plant to plant, and with the consideration of homogenous or mixed cores. Plant-specific fuel

seismic/LOCA analyses will be performed to demonstrate that all relevant criteria remain satisfied.

Category C Nuclear Design

No Nuclear Design related criteria are impacted by the17 OFA **PRIME** fuel product since the implementation of the 17 OFA **PRIME** fuel product does not affect the input assumptions, models or methodology that are used in the nuclear design analyses or create conditions more limiting than those enveloped by the current analyses.

4.0 Generic Safety Issue 191 (GSI-191): Assessment of Debris Accumulation on Downstream Effects

The assessment regarding GSI-191 in Reference 1 is also applicable to the bottom nozzle design for the **PRIME** fuel product. The design of the **[ ]**[a,c] for the 17 OFA **PRIME** fuel product is identical to the design approved by the NRC in Reference 1. Additionally, as presented in Reference 2, the side skirt feature will have no adverse impact on the GSI-191 debris testing that has been previously performed and further testing has demonstrated that the debris filtering effectiveness is improved as a result of lowering the side skirts. Thus, it is concluded that long-term core cooling will be achieved with debris in the recirculating coolant such that decay heat will be removed and a coolable core geometry will be maintained with the 17 OFA **PRIME** fuel product.

5.0 Safety Assessment

As part of the development of the 17 OFA **PRIME** fuel product, all of the applicable safety and design criteria were evaluated and were found to be acceptable. The use of **LTZ** material has been approved for fuel grids for both the 17x17 **NGF** and **CE16NGF** designs. The effectiveness of the **PRIME** bottom nozzle design features has been demonstrated by multiple testing programs. The new **[ ]**[a,c] does not affect control rod drop time and **[ ]**[a,c]

6.0 Conclusions

It is concluded that the 17 OFA **PRIME** fuel product will have no adverse effect on the performance of the fuel assembly in the design categories listed in Section 2.0 of this document. All applicable design and safety criteria for the 17 OFA **PRIME** fuel product are met. Therefore, the 17 OFA **PRIME** design can be implemented under the Fuel Criteria Evaluation Process, which calls for NRC notification on an information-only basis.

7.0 References

1. WCAP-16498-P-A, “17x17 Next Generation Fuel (17x17 NGF) Reference Core Report,” May 2011.

2. Westinghouse Letter LTR-NRC-20-43, “Fuel Criterion Evaluation Process (FCEP) Notification of the 17x17 Advanced Debris Filter Bottom Nozzle (ADFBN) Design,” July 27, 2020.

3. Westinghouse Letter LTR-NRC-15-26, “Fuel Criterion Evaluation Process (FCEP) Notification of the 17x17 Optimized Fuel Assembly (OFA) Mid/Intermediate Flow Mixer (IFM) Grid Balanced Vane Design,” March 31, 2015.

4. WCAP-12488-A, “Westinghouse Fuel Criteria Evaluation Process,” October 1984.

5. WCAP-12488-A, Addendum 1-A, Revision 1, “Addendum 1 to WCAP-12488-A Revision to Design Criteria,” January 2002.

6. WCAP-17642-P-A, “Westinghouse Performance Analysis and Design Mode (PAD5),” Revision 1, November 2017.

7. WCAP-16500-P-A, “CE 16x16 Next Generation Fuel Core Reference Report,” August 2007.