Enclosure 3

Set 1 of Responses to the Second Round of Requests for Additional Information on Westinghouse Topical Report WCAP 18446-P/NP, "Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs"

(Non-Proprietary)

(40 pages including this cover page)

December 2022

Westinghouse Electric Company
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Cranberry Township, PA 16066

Request for Additional Information (RAI) 1.2:

In response to RAI 1 (Ref. 5), Westinghouse stated that fuel thermal conductivity in the loss-of-coolant accident (LOCA) analysis is implemented **[**
]^{a,c} However, the NRC staff's review of the **FULL SPECTRUM™** Loss-of-Coolant Accident (**FSLOCA™**) methodology described in WCAP-16996-P-A/WCAP-16996-NP-A, Volumes I, II, and III, Revision 1 (Ref. 1), and associated RAI questions 36-38 did not identify a clear discussion of the **[** **]**^{a,c} basis of the fuel thermal conductivity modeling approach and justification for its acceptability. Therefore, please describe this aspect of the modeling approach for fuel thermal conductivity and justify its acceptability for the extended burnup range proposed in WCAP-18446-P/WCAP-18446-NP, Revision 0.

Response to RAI 1.2:

The use of the **[** **]** ^{a,c} in the determination of the fuel pellet thermal conductivity for each fuel rod during the LOCA transient calculation is not explicitly discussed within WCAP-16996-P-A, Revision 1 [1-1]. However, it can be inferred since the **[**
] ^{a,c}

The fuel pellet thermal conductivity influences a LOCA transient primarily in two distinct ways. First, the thermal conductivity affects the fuel pellet average temperature during normal operation, which is a boundary condition at the start of the LOCA transient. The fuel pellet temperature has a strong influence on the initial stored energy in the core at the time of the break, which drives the cladding heatup during the blowdown phase for larger break sizes. Second, the pellet thermal conductivity can influence the rate of heat release from the fuel pellet to the cladding during a LOCA. This **[**
] ^{a,c}

Both of these considerations are addressed in turn.

Initial Fuel Pellet Temperature

Assessment of the fuel average temperature initialization within the WCOBRA/TRAC-TF2 code as part of the **FULL SPECTRUM LOCA** (**FSLOCA**) evaluation model (EM) was performed in the response to RAI #37 (refer to LTR-NRC-14-17 [1-2]) with related discussion provided in the response to RAI #20 on the incremental burnup submittal (LTR-NRC-22-4 [1-3]).

Figures RAI37-1 through RAI37-4 of LTR-NRC-14-17 show initial pellet average temperature profiles in WCOBRA/TRAC-TF2 after calibrating to the PAD5 data, compared with PAD5 predictions assuming the same axial power distribution and rod average burnup.

The PAD5 prediction **[**

] ^{a,c}

Energy Release from Fuel Pellet

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] ^{a,c}

Reference(s)

1-1) WCAP-16996-P-A, Revision 1, Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology)," November 2016.

1-2) LTR-NRC-14-17, Revision 0, "Submittal of Westinghouse Responses to 'WCAP-16996-P, 'Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology)' Request for Additional Information – RAIs 36-39' (Proprietary/Non-Proprietary), Project 700, TAC No. ME5244," March 2014.

1-3) LTR-NRC-22-4, Revision 0, "Submittal of Set 1 of Responses to Requests for Additional Information on Westinghouse Topical Report WCAP-18446-P/NP, 'Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs.' (Proprietary/Non-Proprietary)," February 2022.

Request for Additional Information (RAI) 11.2:

The response to RAI 11 (Ref. 6) indicates that updated data is plotted in Figures 11-1 and 11-2. However, these figures do not appear to be part of the RAI response. Please provide these plots.

Response to RAI 11.2:

Since the response to RAI #11 was issued (LTR-NRC-22-22 [11-1]), Westinghouse has completed LOCA burst testing **[**

]^{a,c} All of the

characterizations from the response to RAI #11 remain appropriate with the supplemental information provided in this response.

Several updates are made to WCAP-18446-P [11-3]. Figure 4.4-10 of WCAP-18446-P is updated with Figure 11-1, Figure 4.4-11 of WCAP-18446-P is updated with Figure 11-3, and Figure 4.4-12 is updated with Figure 11-2. The discussion in Section 4.4.3.2 of WCAP-18446-P is entirely replaced. A new Table 4.4-2 is added to WCAP-18446-P. Some updates are made to the reference list. All of these updates are provided below.

a,c

Figure 11-1: Updated Burst Temperature Criterion for the Incremental Burnup Cladding Rupture Calculations

a,c

Figure 11-2: Comparison of Updated Burst Temperature Criterion to the FRAPTRAN Model

a,c

Figure 11-3: Comparison of Updated Burst Temperature Criterion to the [ ]^{a,c} from Table 4.4-1 of WCAP-18446-P

4.4.3.2 Cladding Rupture Models

These models are discussed in Section 8.4.1 of (Kobelak et al., 2016). The existing model for the cladding rupture temperature as a function of the engineering hoop stress in the WCOBRA/TRAC-TF2 code for ZIRLO and Optimized ZIRLO cladding is presented in Figure 8-19 of (Kobelak et al., 2016). The data presented in the figure, from which the model was developed, are for **[**

]^{a,c}

The impact of irradiation on cladding and its attendant impact on LOCA behavior is described in (OECD, 2009). As discussed in Section 3.2.1 therein, hydrogen uptake into the cladding is expected to embrittle the cladding, which in turn could degrade the burst temperature. Therefore, since the cladding rupture model was developed from as-fabricated cladding, it is necessary to assess the model against hydrided / irradiated cladding as previously discussed in Section 4.4.3.1.

A compilation of various cladding burst data is presented as Table 4.4-1 herein. The burst testing database presented in Table 4.4-1 includes samples that were **[**

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]^{a,c}

Table 4.4-2 Supplemental Cladding Rupture Data at High Internal Pressure

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The following reference is added to Section 4.9:

Geelhood, K. J., et al., May 2016, “FRAPTRAN-2.0: A Computer Code for the Transient Analysis of Oxide Fuel Rods,” PNNL-19400, Volume I, Revision 2.

The following reference is removed from Section 4.9:

[ ]^{a,c}

Reference(s)

11-1) LTR-NRC-22-22, Revision 0, “Submittal of Set 3 of Responses and Clarifications to Requests for Additional Information on Westinghouse Topical Report WCAP-18446-P/NP, ‘Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs’ (Proprietary/Non-Proprietary),” June 2022.

11-2) PNNL-19400, Volume 1, Revision 2, "FRAPTRAN-2.0: A Computer Code for the Transient Analysis of Oxide Fuel Rods," May 2016.

11-3) WCAP-18446-P, Revision 0, "Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs," December 2020.

Request for Additional Information (RAI) 16.2:

In response to RAI 16 (Ref. 4), Westinghouse stated that if the small-break LOCA (SBLOCA) peak cladding temperature exceeds the large-break LOCA (LBLOCA) peak cladding temperature, then cladding rupture calculations would also be performed for the SBLOCA. The NRC staff requests further clarification concerning the terminology being used by Westinghouse in this response. TR WCAP-18446-P/WCAP-18446-NP, Revision 0, refers in various places (e.g., last paragraph in Section 4.7.3.1) to three regions of the LOCA spectrum: LBLOCA, intermediate-break LOCA (IBLOCA), and SBLOCA. However, the response to RAI 16 refers only to SBLOCA and LBLOCA, omitting discussion of the IBLOCA. While the base **FSLOCA** methodology applies a two-region model, the NRC staff's review of WCAP-16996-P-A/WCAP-16996-NP-A, Volumes I, II, and III, Revision 1, identified that the Region I and Region II terminology used therein does not appear to correspond, directly and uniformly, to the SBLOCA and LBLOCA events, respectively (i.e., with the IBLOCA range corresponding to the interstitial region between Regions I and II). For instance, the executive summary of WCAP-16996-P-A/ WCAP-16996-NP-A, Volumes I, II, and III, Revision 1 (Ref. 1), states that:

> *Region-I provides coverage of what typically are defined as Small Break LOCA scenarios and stretch into Intermediate Break LOCA. Region-II starts from Intermediate Break size and include what typically are defined Large Break LOCA scenarios.*

Therefore, please clarify the correspondence of the three-region categorization of the LOCA break spectrum (i.e., SBLOCA, IBLOCA, and LBLOCA) to the two-region categorization of **FSLOCA** (i.e., Region I and Region II) and confirm whether the RAI-16 response's usage of the terms SBLOCA and LBLOCA is intended to be fully equivalent to the **FSLOCA** methodology's Region I and Region II, respectively, as defined in WCAP-16996-P-A/ WCAP-16996-NP-A, Volumes I, II, and III, Revision 1.

Response to RAI 16.2:

While the cladding rupture calculations must utilize the WCOBRA/TRAC-TF2 code, which is licensed as part of the **FULL SPECTRUM LOCA** (**FSLOCA**) methodology (WCAP-16996-P-A, Revision 1 [16-1]), other evaluation models may form the basis for the LOCA analyses of record for a specific plant. Therefore, the terms SBLOCA and LBLOCA were used to more generally cover the suite of potential LOCA evaluation models which could comprise the licensing basis LOCA analyses for different plants.

Westinghouse confirms that the usage of SBLOCA and LBLOCA identified in this RAI is intended to be fully equivalent to the usage of Region I and Region II (respectively) when referring to the **FSLOCA** methodology.

The text identified for addition to Section 4.7.1 of the topical report at the end of the response to RAI #16 is modified as follows:

Based on this discussion, if the [

]^{a,c}

Reference(s)

16-1) WCAP-16996-P-A, Revision 1, "Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (**FULL SPECTRUM LOCA** Methodology)," November 2017.

Request for Additional Information (RAI) 19.2:

In RAI 19 (Ref. 6), the NRC staff requested that Westinghouse justify its proposed uncertainty treatments for the statistical approach for assuring that fuel rods in the extended burnup region do not rupture during a postulated LOCA. Please provide additional justification concerning the following topics that the NRC staff did not consider to be fully addressed in Westinghouse's response to RAI 19:

a. Westinghouse's response discusses sampling of the entire range of time-in-cycle, irrespective of whether any rods in the core reside in the extended burnup range or are otherwise susceptible to fuel dispersal at the sampled time-in-cycle. Including samples from times-in-cycle that are not relevant to the potential for fuel dispersal in the statistical analysis would appear to result in the calculation of statistical tolerance limits that would not be representative for the portion of the fuel cycle during which fuel dispersal could occur. Please justify the acceptability of the proposed approach or propose an alternative approach that would address the concern associated with the representativeness of the tolerance limits determined by Westinghouse. If Westinghouse proposes an alternative sampling approach, please address how the alternative approach would affect the sampling of burnup-dependent parameters (e.g., linear heat rates, rod bow, core axial power shapes – see Table 29.4.1-1 of WCAP-16996-P-A/WCAP-16996-NP-A, Volumes I, II, and III, Revision 1 (Ref. 1), peaking factor uncertainties, etc.).

b. Westinghouse's assumption of non-dispersal for any fuel rod sampled below a rod-average burnup of 62 GWd/MTU does not appear consistent with the conclusion in the Research Information Letter (RIL) by the NRC Office of Nuclear Regulatory Research RIL 2021-13 (Ref. 8) that fuel dispersal may occur at local burnups exceeding 55 GWd/MTU. Hence, the sampling approach described in the response to RAI 19 does not appear capable of providing an accurate statistical characterization of the actual propensity for fuel dispersal. Please adequately justify the proposed approach or propose an alternative approach that would resolve the concern associated with the statistical characterization of fuel dispersal on fuel rods below 62 GWd/MTU rod-average burnup. If Westinghouse proposes an alternative sampling approach, please address how the alternative approach would affect the sampling of burnup-dependent parameters (e.g., linear heat rates, rod bow, core axial power shapes – see Table 29.4.1-1 of WCAP-16996-P-A/WCAP-16996-NP-A, Volumes I, II, and III, Revision 1 (Ref. 1), peaking factor uncertainties, etc.).

c. The response to RAI 19.b states "current peaking factor uncertainties utilized in the **FSLOCA**™ evaluation model (EM)… are based on a statistical analysis of predicted to measured differences at many different burnups throughout the cycle for many different plants, and thus are applicable to all burnups." This statement is broad in scope, implying the uncertainties derived from a database of limited burnup range are applicable to not only the incremental burnup range under consideration in the present review, but also beyond. Effectively, the uncertainties are said to be applicable beyond the range of data used to derive them and validate the associated methodology. Without an assessment of the associated database for potential trending in uncertainties with increasing burnup or additional forms of validation (e.g., additional experimental data, benchmarking against higher order methods, etc.) the veracity of this statement cannot be ascertained. The response to RAI 19.b does not appear to provide such an assessment. Therefore, please (1) justify the peaking factor uncertainties derived for the **FSLOCA** EM remain applicable to the incremental burnup range under consideration or (2) propose alternative peaking factor uncertainties that expressly apply to the burnup range to be analyzed according to the methodology in WCAP-18446-P/WCAP-18446-NP, Revision 0.

Response to RAI 19.2:

Part A

It was noted in the response to RAI #19 (LTR-NRC-22-22 [19-1]) that for analyses performed using the **FULL SPECTRUM**™ LOCA (**FSLOCA**™) evaluation model (EM) (WCAP-16996-P-A, Revision 1 [19-2]), because the **[**

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]^{a,c}

This revised approach does not impact the descriptions of sampling burnup-dependent parameters from the response to RAI #19, which remain applicable. Additional information regarding the peaking factor uncertainties is provided in Part C of this response.

Part B

The focus of the LOCA calculations performed under the incremental burnup extension is [

]^{a,c}

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[1] See the response to RAI #26 (LTR-NRC-22-15 [19-3]) and RAI #26.2 for additional insights regarding fuel rods that remain within current burnup limits.

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]^{a,c} This revised approach discussed in response to Part A of this RAI does not impact the descriptions of sampling burnup-dependent parameters from the response to RAI #19, which remain applicable. Additional information regarding the peaking factor uncertainties is provided in Part C of this response.

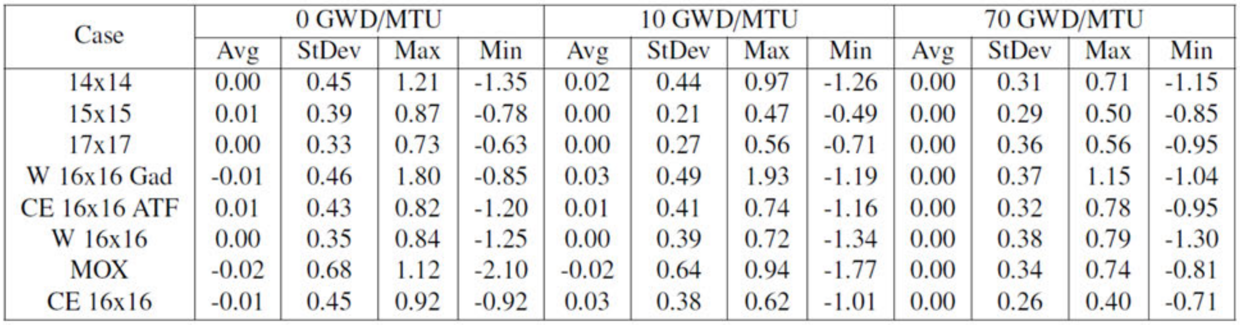
Refer to the response to RAI #26 (LTR-NRC-22-22) for a characterization of the percentage of rods susceptible to fine fragmentation (for both modern plant operation and under the incremental burnup extension).

Part C

The current Westinghouse approved power distribution uncertainties for safety analysis and for core monitoring were originally developed in WCAP-7308-P-A [19-4]. These uncertainties were confirmed for subsequent method improvements in WCAP-11596-P-A (PHOENIX/ANC) [19-5], WCAP-16045-P-A (PARAGON1) [19-6], and WCAP-18443-P-A (PARAGON2) [19-7]. The basis for concluding that these uncertainties will remain valid for fuel rod burnups up to **[** **]**^{a,c} is:

1. The qualification of PARAGON2 in WCAP-18443-P-A [19-7] did include comparisons of PARAGON2 to Monte Carlo (SERPENT2) for burnups up to 70 GWD/MTU. These comparisons showed no significant increase in uncertainty in the pin power distribution between 30 and 70 GWD/MTU. WCAP-18443-P-A [19-7] has presented comparisons that demonstrate that there is no significant difference between the predicted power distributions between PARAGON1 and PARAGON2.

Summary of % pin power differences (PARAGON2-SERPENT2)/PARAGON2



Case	0 GWD/MTU				10 GWD/MTU				70 GWD/MTU			
	Avg	StDev	Max	Min	Avg	StDev	Max	Min	Avg	StDev	Max	Min
14x14	0.00	0.45	1.21	-1.35	0.02	0.44	0.97	-1.26	0.00	0.31	0.71	-1.15
15x15	0.01	0.39	0.87	-0.78	0.00	0.21	0.47	-0.49	0.00	0.29	0.50	-0.85
17x17	0.00	0.33	0.73	-0.63	0.00	0.27	0.56	-0.71	0.00	0.36	0.56	-0.95
W 16x16 Gad	-0.01	0.46	1.80	-0.85	0.03	0.49	1.93	-1.19	0.00	0.37	1.15	-1.04
CE 16x16 ATF	0.01	0.43	0.82	-1.20	0.01	0.41	0.74	-1.16	0.00	0.32	0.78	-0.95
W 16x16	0.00	0.35	0.84	-1.25	0.00	0.39	0.72	-1.34	0.00	0.38	0.79	-1.30
MOX	-0.02	0.68	1.12	-2.10	-0.02	0.64	0.94	-1.77	0.00	0.34	0.74	-0.81
CE 16x16	-0.01	0.45	0.92	-0.92	0.03	0.38	0.62	-1.01	0.00	0.26	0.40	-0.71

From "PARAGON2 Depletion Validation Using SERPENT2 Monte Carlo Code", presented at M&C 2017 - International Conference on Mathematics & Computational Methods Applied to Nuclear Science & Engineering, Jeju, Korea, April 16-20, 2017, on USB (2017)

2. Comparisons were reported in WCAP-16045-P-A (PARAGON1) [19-6] and WCAP-18443-P-A [19-7] of isotopic measurements of several high burnup (> 70 GWD/MTU) fuel rods. The results indicate good agreement for these high burnup rods.

3. Application of the Incremental Burnup Methodology will allow fuel assemblies on the core periphery to have some low power rods with burnup up to **[** **]**^{a,c}. The plant assembly power benchmarks that were used in the above topicals to confirm the core power distribution uncertainty did include measured- prediction power errors for those assemblies on the core periphery that included incore detectors. While the peripheral assembly samples represent only a small fraction of the total samples (since there are relatively few peripheral assemblies that contain incore detectors), subsequent analyses of core power distribution measured vs prediction differences have indicated that there is no significant difference in assembly power errors between peripheral and non-peripheral fuel assemblies after incore power tilts have been accounted for.

4. The application of the Incremental Burnup Methodology will not result in a significant change to the core loading pattern or fuel assembly configuration. Core loading strategy will remain consistent for interior assemblies with only minor changes to assembly burnups on the core periphery. The only anticipated change will be a relatively small increase in the rod average burnup for some rods in assemblies on the core periphery. Thus, there is no expectation that the accuracy of the core power distribution prediction will be significantly degraded.

Reference(s)

19-1) LTR-NRC-22-22, Revision 0, “Submittal of Set 3 of Responses to Requests for Additional Information on Westinghouse Topical Report WCAP-18446-P/NP, ‘Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs.’ (Proprietary/Non-Proprietary),” June 2022.

19-2) WCAP-16996-P-A, Revision 1, “Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology),” November 2016.

19-3) LTR-NRC-22-15, Revision 0, “Submittal of Set 2 of Responses to Requests for Additional Information on Westinghouse Topical Report WCAP-18446-P/NP, ‘Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs.’ (Proprietary/Non-Proprietary),” April 2022.

19-4) WCAP-7308-P-A, Revision 0, “Evaluation of Nuclear Hot Channel Factor Uncertainties,” June 1988

19-5) WCAP-11596-P-A, Revision 0, “Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores,” June 1988.

19-6) WCAP-16045-P-A, Revision 0, “Qualification of the Two-Dimensional Transport Code PARAGON,” August 2004.

19-7) WCAP-18443-P-A, Revision 0, “Qualification of the Two-Dimensional Transport Code PARAGON2,” July 2021.

Request for Additional Information (RAI) 23.2:

Figures 23-1 through 23-3 in the response to RAI 23 (Ref. 4) provide comparisons of the neutron correction factor versus decay time for **[** **]**^{a,c} In general, these plots demonstrate the **[** **]**^{a,c} neutron correction factor is conservative **[** **]**^{a,c} for the plotted decay time range of 16 minutes (1,000 seconds). However, the NRC staff did note a trend of decreasing conservativeness towards the end of the plotted decay time range. Bearing this in mind, the NRC staff also noted the response to RAI 16 indicates the maximum cladding temperatures for SBLOCA may not always be less than for LBLOCA. When considering that SBLOCA events can evolve across time frames longer than the 16-minute decay time range assessed in the response to RAI-23, a possibility exists the neutron correction factor may not remain conservative for all times at which maximum cladding temperatures for SBLOCA may occur. Please provide justification that the neutron capture correction factor remains conservative or acceptable for the time frames at which maximum cladding temperatures for SBLOCA may occur.

Response to RAI 23.2:

The decay heat and kinetics package submitted in WCAP-18446-P [23-1] was based on underlying nuclear physics data from the PARAGON code (WCAP-16045-P-A [23-2]), and use of Equation 11 from the American Nuclear Society ANSI/ANS 5.1-1979 standard [23-3] to account for the neutron capture correction (up to decay times of 10,000 seconds). Since the time of submittal, Westinghouse has received NRC approval of the PARAGON2 code (WCAP-18443-P-A [23-4]), which is approved well beyond the burnup level requested in the incremental burnup extension. Furthermore, as observed in the request, the neutron capture correction indeed becomes slightly non-conservative when **[** **]**^{a,c} as discussed in the response to RAI #23. Therefore, several changes are made in response to this RAI.

First, the nuclear physics data utilized in the WCOBRA/TRAC-TF2 (also referred to as TF2) kinetics and decay heat model (Section 4.6.1 of WCAP-18446-P) are updated from the PARAGON code to the PARAGON2 code. Figures 23-1 through 23-14 herein present the data from PARAGON2 that is equivalent to the PARAGON data presented in Figures 4.6-1 through 4.6-14 of WCAP-18446-P. It is observed that the **[**

]^{a,c}

Second, the neutron capture correction for up to 10,000 seconds after shutdown is calculated in WCOBRA/TRAC-TF2 using Equation 11 from the American Nuclear Society ANSI/ANS 5.1-1979 standard as follows:

$$G(t) = 1.0 + (3.24 * 10^{-6} + 5.23 * 10^{-10} t) * T^{0.4} \psi$$

Where:

G(t) = Neutron Capture Correction, dimensionless
t = Time after Shutdown (also referred to as the Cooling Time), seconds
T = Total Operating Time, seconds
ψ = Fissions per Initial Fissile Atom, dimensionless

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[**]a,c**

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]^{a,c}

The text in Section 4.6.1 of WCAP-18446-P is updated as follows:

It was noted in RAI #23 to (Kobelak et al., 2016) that in the WCOBRA/TRAC-TF2 modeling of various important physical parameters related to fuel burnup, the burnup range presented was limited to **[** **]^{a,c}** assembly average burnup. This resulted in Limitation and Condition #5 on the **FSLOCA** EM. Westinghouse indicated that the adequacy of the fitting parameters to the physics calculations presented in these figures would be revisited if seeking approval to rod average burnups beyond **[** **]^{a,c}**

The supporting physics data utilized in the WCOBRA/TRAC-TF2 are updated to be valid for rod average burnups up to **[** **]^{a,c}** The updated physics data are based on the PARAGON2 code (Ouisloumen et al., 2021), which is NRC-approved to 100 MWd/MTU burnup (well beyond the incrementally increased fuel rod average burnup limit)~~ALPHA/PARAGON (Slagle et al., 2004) with cross-section library version ENDF/B-VI~~. The nuclear physics data was coded directly into the WCOBRA/TRAC-TF2 code rather than curve fitting the data as was done previously. The information presented in Figures 9-1 through 9-3 and Figures 9-5 through 9-15 of (Kobelak et al., 2016) is presented in Figures 4.6-1 through 4.6-14 herein for the updated physics data up to a burnup of **[** **]^{a,c}**

The text in Section 4.6.2 of WCAP-18446-P is updated as follows:

There are three conditions related to the use of Equation 11 from (ANS, 1979) to calculate the neutron capture correction. The first is that the equation is only valid for shutdown times up to 10,000 seconds. After 10,000 seconds, Table 10 of (ANS, 1979) lists maximum values which can be used. The WCOBRA/TRAC-TF2 code **[**

]^{a,c}

The second condition is a maximum operating time of 4 years; however, this limitation could be exceeded for various nuclear designs (e.g., for fuel assemblies which are operated through three 18-month cycles). **[**

]^{a,c}

The third condition is that the number of fissions per initial fissile atom is less than 3.0. **[**

]^{a,c}

In conclusion, it was determined that the existing WCOBRA/TRAC-TF2 neutron capture correction is valid for analysis of higher burnup fuel.

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]^{a,c}

[ ]a,c

Where:

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]^{a,c}

Figures 4.6-1 through 4.6-14 of WCAP-18446-P are replaced with Figures 23-1 through 23-14 herein. Figures 23-15 through 23-18 herein are inserted into WCAP-18446-P as Figures 4.6-15 through 4.6-18.

a,c

Figure 23-1: U-235 Fission Fraction (Updated Figure 9-1 from (Kobelak et al., 2016))

a,c

Figure 23-2: Pu-239 Fission Fraction (Updated Figure 9-2 from (Kobelak et al., 2016))

a,c

Figure 23-3: U-238 Fission Fraction (Updated Figure 9-3 from (Kobelak et al., 2016))

a,c

Figure 23-4: $\overline{\beta}$ versus Burnup (Updated Figure 9-5 from (Kobelak et al., 2016))

a,c

Figure 23-5: Prompt Neutron Lifetime (Updated Figure 9-6 from (Kobelak et al., 2016))

a,c

Figure 23-6: Prompt Energy Release (Updated Figure 9-7 from (Kobelak et al., 2016))

a,c

Figure 23-7: Total Energy Release (Updated Figure 9-8 from (Kobelak et al., 2016))

a,c

Figure 23-8: Delayed Group I Lambda (Updated Figure 9-9 from (Kobelak et al., 2016))

a,c

Figure 23-9: Delayed Group II Lambda (Updated Figure 9-10 from (Kobelak et al., 2016))

a,c

Figure 23-10: Delayed Group III Lambda (Updated Figure 9-11 from (Kobelak et al., 2016))

a,c

Figure 23-11: Delayed Group IV Lambda (Updated Figure 9-12 from (Kobelak et al., 2016))

a,c

Figure 23-12: Delayed Group V Lambda (Updated Figure 9-13 from (Kobelak et al., 2016))

a,c

Figure 23-13: Delayed Group VI Lambda (Updated Figure 9-14 from (Kobelak et al., 2016))

a,c

Figure 23-14: U-238 Capture / Fission Ratio as a Function of Initial Enrichment and Burnup (Updated Figure 9-15 from (Kobelak et al., 2016))

a,c

a,c

a,c

a,c

The following reference is added to Section 4.9 of WCAP-18446-P:

Ouisloumen, M., et al., July 2021, “Qualification of the Two-Dimensional Transport Code PARAGON2,” WCAP-18443-P-A.

Reference(s)

23-1) WCAP-18446-P, Revision 0, “Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs,” December 2020.

23-2) WCAP-16045-P-A, Revision 0, “Qualification of the Two-Dimensional Transport Code PARAGON,” August 2004.

23-3) ANSI/ANS 5.1-1979, “Decay Heat in Light Water Reactors,” 1979.

23-4) WCAP-18443-P-A, Revision 0, “Qualification of the Two-Dimensional Transport Code PARAGON2,” July 2021.

23-5) LTR-NRC-22-4, Revision 0, “Submittal of Set 1 of Responses to Requests for Additional Information on Westinghouse Topical Report WCAP-18446-P/NP, ‘Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs.’ (Proprietary/Non-Proprietary),” February 2022.

Request for Additional Information (RAI) 26.2:

In response to RAI-26 (Ref. 5), Westinghouse provided **[**

]^{a,c} While the information provided appears consistent with Westinghouse’s position, the amount of fuel Westinghouse estimated using its methodologies as susceptible to dispersal may exceed expectations associated with previous qualitative assessments. Considerable technical challenges remain to evaluating the impacts of fuel dispersal, and the RAI response ultimately does not constitute a comprehensive, standalone basis for concluding that potential quantities of dispersed fuel following implementation of WCAP-18446-P/WCAP-18446-NP, Revision 0, would be acceptable. As discussed in RIL 2021-13 (Ref. 8), future licensing activities to increase fuel burnup may exacerbate the potential for fuel fragmentation, adding to existing challenges associated with addressing fuel dispersal. Please clarify whether Westinghouse plans to disposition fuel dispersal below 62 GWd/MTU rod-average burnup on a generic basis or defer resolution of this issue to an alternative regulatory process.

Response to RAI 26.2:

Westinghouse has demonstrated in previous RAI responses that the **[**

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Westinghouse does agree that future licensing activities to increase the fuel rod burnup may exacerbate the potential for fuel fragmentation. As such, separate from the incremental burnup extension, Westinghouse plans to address FFRD as part of such future licensing activities (such as licensing a full core burnup increase to higher burnup levels).