Response to Request for Additional Information RE: Westinghouse Electric Company WCAP-16260-P/WCAP-16260-NP, Revision 2, "The Spatially Corrected Inverse Count Rate (SCICR) Method for Subcritical Reactivity Measurement" Topical Report (EPID L-2017-TOP-0064)

(Non-Proprietary)

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RAI #1:

The Standard Technical Specification (STS) BASES identify five distinct tests required for startup physics testing. ***[***

] $^{a,\,c}$ *Please describe how the SCICR method addresses testing for critical boron concentration with control rods inserted. Alternatively, discuss whether this testing parameter is not considered within the scope of SCICR, or provide a justification as to why such testing is unnecessary.*

RAI #1 Response:

Reference 4 in the STS BASES document (NUREG-1431, Revision 4) is the 1985 revision of ANSI/ANS-19.6.1, "Reload Startup Physics Tests for Pressurized Water Reactors". Therefore, the reload PHYSICS TESTS requirements noted in the STS BASES document are from the 1985 version of the ANS Standard. The above noted requirement was deleted from the standard in the next revision (1997) as it is only used to confirm the reactivity computer performance for Rod Swap or Sequential Dilution LPPT programs. It is not necessary for more advanced LPPT programs, which began with LPPT via the DRWM technique and continues now with SPT.

The current revision of ANSI/ANS-19.6.1 is 2011. The SPT program, as outlined in Table 3-1 of this topical report, meets the requirements of ANSI/ANS-19.6.1-2011, which now requires validation of key core characteristics as opposed to specific PHYSICS TESTS requirements in earlier revisions.

RAI #2:

In the TR's **[ ]**$^{a, c}$ *Westinghouse states that the factor includes a* **[ ]**$^{a, c}$ *function, which "can be calculated* **[ ]**$^{a, c}$ *as described in WCAP-13360-P-A, "Westinghouse Dynamic Rod Worth Measurement Technique."*[1] **[**

]$^{a, c}$

RAI #2a:

Explain how the spatial **[ ]**$^{a, c}$ *is determined in greater detail, including discussion that describes what ensures that the* **[ ]**$^{a, c}$ *function does not inadvertently introduce calculational error or bias, or if such potential exists, how it is accounted for in the overall SCICR methodology.*

RAI #2a Response:

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]$^{a, c}$ Core design will define the fission rate distribution for any given condition, and using the **[ ]**$^{a, c}$ function, the detector response can be predicted.

The presumption in RAI #2 is correct; the content in the DRWM technique topical report **[ ]**$^{a, c}$ is the information that the SCICR topical report is referring to **[ ]**$^{a, c}$ More specifically, calculation of the SCICR methodology **[ ]**$^{a, c}$ is performed similarly to calculation of the DRWM methodology **[ ]**$^{a, c}$ functions **[ ]**$^{a, c}$ Note that this portion of the SCICR methodology has not changed between Revisions 1 and 2. **[**

]$^{a, c}$

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[1] Agencywide Document Accession and Management System (ADAMS) Accession No. **[ ]**$^{a, c}$ (Proprietary)

1. **[**

] ^{a,c}

[

] ^{a,c}

Calculation errors will be highlighted by comparing measured and predicted ICRR. **[** **]** ^{a,c} the SCICR methodology measurements are not sensitive to changes in the **[** **]** ^{a,c} function since the measurement and prediction are independent. The most-relevant detectability study is the neutron source change study presented in Section 5.2.2.2. Ultimately, errors in the **[** **]** ^{a,c} function are guarded against by applying the results evaluation criteria presented in Section 5.3 to the ICRR M−P results.

RAI #2b:

Provide, as an illustrative example, a description of how the **[** **]** ^{a,c} *was calculated for use in one of the demonstrations provided in Chapter 4.*

RAI #2b Response:

The following example is for the Plant D demonstration:

First, the **[** **]** ^{a,c} factors were calculated per the process described in the response to RAI #2.a to account for the **[** **]** ^{a,c} material and dimensional geometry specific to Plant D **[** **]** ^{a,c} The **[** **]** ^{a,c} factors are presented in Figures 2-1 and 2-2, respectively.

[ ]a, b, c

Figure 2-1: Plant D [ ]$^{a, c}$ Factors (Quarter-core Excerpt, Four Nodes per Fuel Assembly)

[ ]$^{a, b, c}$

Figure 2-2: Plant D [ ]$^{a, c}$ Factors

The **[** **]**$^{a, c}$ factors were then input to the nuclear design code along with the **[** **]**$^{a, c}$ inputs (e.g., secondary source composition and location, spontaneous fission source composition), linkage to the design model, and the desired state point configurations. The **[** **]**$^{a, c}$ value at each state point is calculated according to Equation 2-6 as part of the code execution.

RAI #2c:

The TR notes that, [ ]$^{a, c}$, W [ ]$^{a, c}$ is fixed.” Explain whether this means that W is calculated specifically:

- i *for each plant where SCICR is applied,*
- ii *on a cycle-specific basis, or*
- iii *generically for each plant type in which SCICR is applied.*

RAI #2c Response:

W is calculated for each plant where SCICR is applied. **[ ]**$^{a, c}$

RAI #2d:

Regardless of the approach taken for Item 2.c, above, provide a justification that the approach provides a valid spatial [ ]$^{a, c}$ in all cases it is applied.

RAI #2d Response:

[ ]$^{a, c}$ differences exist across plants within a given plant type, so it would not be appropriate to calculate *W* generically by plant type. However, over 20 combined years of applying the DRWM and SCICR methods has shown that **[ ]**$^{a, c}$ changes are 1) not routine, and 2) planned well enough in advance of the impacted outage and subsequent cycle startup. This successful experience provides justification to calculate *W* on a plant-specific basis, and not on a cycle-specific basis.

RAI #3:

[***]*** $^{a, c}$ *Westinghouse notes that the presence of an extraneous source is typically omitted from routine core design calculations, but that its presence can be included in order to determine this factor. Provide additional information about the modeling of the extraneous source for this purpose:*

RAI #3a:

Provide a brief summary that explains whether the NRC staff review for the nuclear design codes currently in use (e.g., PHOENIX-P/ANC)[2] *specifically considered modeling subcritical conditions and the presence of an extraneous source.*

RAI #3a Response:

For the NRC-approved nuclear design codes currently in use, the extraneous sources are not considered in the determination of core characteristics. Fundamentally, this is because:

- In a critical reactor, the flux distribution is driven by the reactivity distribution in the core. The extraneous source contribution is orders of magnitude lower than the fission source contribution, and is therefore not significant to the nuclear design calculations. **[** **]** $^{a, c}$
- Inclusion of the sources adds an extra dimension to the calculation, which is unnecessarily complex for typical core design purposes.

In a subcritical array, the extraneous source and fission neutron populations are more similar in magnitude. **[** **]** $^{a, c}$ thus, the extraneous source is considered only when applying the SCICR methodology.

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[2] WCAP-11596-P-A, ADAMS Accession No. **[** **]** $^{a, c}$ (Proprietary)

RAI #3b:

Explain whether any code changes or software modifications were required, subsequent to NRC approval, either to provide a capability to model extraneous sources, or to facilitate, more generally, the use of the nuclear design codes to support the SCICR methods.

RAI #3b Response:

Updates were required to the relevant nuclear design codes to include the capability to perform the fixed extraneous source calculations **[**

] $^{a, c}$ However, the code updates did not change the associated licensed methodologies (e.g., PHOENIX-P/ANC), which was evaluated and documented as part of the overall software validation process (see response to RAI #3c for further details). The code updates were originally performed in 2005 (following approval of Revision 0 of this topical report) per Westinghouse Quality Program requirements. Details of the quality assurance methods are provided in the response to RAI #3c.

RAI #3c:

If code changes were required, provide a summary of the quality assurance methods used to establish that the codes have an adequate predictive capability to model the extraneous sources. Include specific information that demonstrates such modeling capabilities are adequate.

RAI #3c Response:

The code updates were based on the prototype software programs used to generate the results presented in Revision 0 of this topical report, which demonstrated that the extraneous source modelling capabilities were adequate and compliant with the Safety Evaluation requirements issued for Revision 0 of this topical report.

Consistent with all computer software developed by Westinghouse Fuel Engineering & Safety Analysis, the code updates were completed per the Computer Software Development and Maintenance Procedure, **[**

] $^{a, c}$ More specifically, the software was designed according to a software requirements document, which was input to a code validation package. The validation package included all code and system test plans and the subsequent results. In this case, the results of the calculations using the updated code version were essentially the same (within the margin of error of the method) as those obtained using the previous code version.

The validation package also included compliance evaluation and documentation for NRC-licensed codes/methodologies. In this case, the code changes were in compliance with, and did not result in a deviation from, the previously licensed methodologies. Finally, the revised software was released via formal letter, which included a reference to the completed software validation procedure and user documentation (i.e., updated user manual for nuclear designers).

RAI #4:

Reviewing **[** **]**$^{a, c}$ *in Section 3.1 of WCAP-16260-P/WCAP-16260-NP, Revision 2, it is suggested that the state points that a core progresses through during an approach to criticality are known ahead of time and* **[**

]$^{a, c}$ *Describe whether a plant could proceed through SCICR testing with deviations in the planned approach that may not be reflected in the calculations* **[**

]$^{a, c}$

RAI #4 Response:

[

]$^{a, c}$

$$\left[\qquad\qquad\qquad \right]^{a, c}$$

Both **[**

]$^{a, c}$ Each state point in the predicted data set is defined by **[**

]$^{a, c}$ A sample data set is provided in Table 7-3 in the response to RAI #7 that follows. It is possible for a plant to proceed through SCICR testing with minor deviations from **[**

]$^{a, c}$

If the actual bank position is different from the predicted bank position, **[**

]$^{a, c}$ If the actual boron concentration or temperature is different from the predicted value, **[**

]$^{a, c}$

[

]$^{a, c}$

RAI #5:

Chapter 4 of WCAP-16260-P/WCAP-16260-NP, Revision 2, provides details and results of several subcritical physics testing (SPT) applications. The discussion for some of the tests notes that the initial results are normalized. ***[***

] $^{a, c}$ *Without further qualification, this statement implies that the measured inverse count rate ratios may be somehow adjusted,* ***[*** ***]*** $^{a, c}$ *Explain why the normalization is appropriate and necessary, and describe how it is performed. Confirm that the normalization is precluded from introducing, or is unlikely to introduce, a* ***[*** ***]*** $^{a, c}$ *effect* ***[***

] $^{a, c}$

RAI #5 Response:

In the stated context, normalization refers to assignment of the reference ICRR state point, particularly the reference excore detector count rate. **[**

] $^{a, c}$

[

] $^{a, c}$

- For ICRR monitoring, the normalization occurs at the initial state point configuration (generally with the lowest measured count rate), which enables observation of changes from the reference condition. A common example is ICRR monitoring during rod withdrawal starting at ARI. Following rod withdrawal, **[**

  ] $^{a, c}$

- [

]$^{a, c}$

RAI #6:

The comparison of measured-to-predicted ICRR data ***[***

] $^{a, c}$ *requires an assumption that the predicted values contain zero or negligible error. However, it is understood that there are various sources of uncertainty associated with these predicted values, which could be introduced either by the core design modeling,* ***[***

] $^{a, c}$ *used to determine the predicted detector responses. The uncertainties have the potential to introduce error in the predicted ICRR values. Provide an estimate of the analytic uncertainty associated with the predicted ICRR data and demonstrate that this uncertainty is sufficiently small as to be neglected.*

RAI #6 Response:

Physics tests (subcritical, low power, or at power) are directed toward the confirmation of consistency of core behavior with design predictions prior to established power operations. Therefore, the measurements are compared to the predictions with a set tolerance (review or acceptance criteria) that demonstrates acceptable variances. Measurements and predictions of various core parameters are determined using vastly different methodologies. For instance, the prediction of a bank worth is made from an eigenvalue change in a code; whereas the measurement may be from RCS dilution, rod exchange, or dynamically as in the DRWM technique. These must agree within established tolerances to confirm that the prediction is valid for the constructed core. Disagreement between measurement and prediction initiates further actions (dependent on what is observed) to confirm or refute the deviation and to establish remedial steps.

[

] $^{a, c}$

RAI #7:

A complete understanding of the process **[**

]$^{a, c}$ *requires synthesis of material described in Sections 1.6, 2.3, 3.1, and 3.2.2 of the TR. An example of the process is necessary to ensure that a complete understanding can be obtained from the material referenced above, and to ensure that the calculation* **[** **]**$^{a, c}$ *represents a valid implementation of the spatial correction theory described in Chapter 2 of the TR. For one of the demonstrations addressed in Chapter 4, provide a step-by-step description of the calculational procedure employed* **[** **]**$^{a, c}$ *Describe the computer codes used, explain how many reactivity changes were modeled, explain the extent to which the predicted detector responses changed, describe whether the measured detector responses required any adjustment or renormalization, and explain whether other regression parameters changed* **[**

]$^{a, c}$

RAI #7 Response:

The following example is for **[** **]**$^{a, c}$ Plant D demonstration. **[**

]$^{a, c}$ Table 7-1 and Figure 7-1 contain the data **[**

]$^{a, c}$

See Table 7-3 for the predictions that support this example. **[**

]$^{a, c}$

[

] ***a, c***

[

] ***a, c*** The full ***M*** vs. ***P*** data following application of the PCCF is presented in Table 7-2 and Figure 7-2.

[

] ***a, c***

Table 7-1: Plant D Measured and Predicted Data

[ ] ***a, c***

a, b, c

[ ] *a, b, c*

Figure 7-1: Plant D Measured vs. Predicted Detector Count Rate
[ ] *a, c*

Table 7-2: Plant D Measured and Predicted Data

[ ] a, c

[ ] a, b, c

[ ] *a, b, c*

Figure 7-2: Plant D Measured vs. Predicted Detector Count Rate

[ ] ***a, c***

Table 7-3: Plant D Nuclear Design Constants

[ ] $^{a, c}$

a, b, c

RAI #8:

The basis for acceptability of SCICR includes detailed comparisons of the proposed testing to prior testing methods for 4-loop Westinghouse plants. Additional demonstrations of the testing methods for 2- and 3-loop Westinghouse plants, and for a Combustion Engineering (CE) 217-fuel assembly plant are provided, ***[***

] $^{a, c}$

Consider a revised limitation that applies a more general set of evaluation and data retention requirements for first-use implementation. ***[***

] $^{a, c}$

RAI #8 Response:

For Revisions 0 and 1 of WCAP-16260-P-A/WCAP-16260-NP, the "experience base" for SCICR was limited to **[**

] $^{a, c}$

[

] $^{a, c}$

As stated previously, the foundation of the SPT application is **[**

] ***a, c***

[

] ***a, c***

A significant improvement in the SPT application is **[**

] ***a, c*** The probability of a core anomaly or a core design error is independent of the plant design and the possibility of masking dependent on plant type is no longer a concern. Therefore, it is not necessary to **[**

] ***a, c***

Although not explicitly asked, it may be beneficial to address why Appendix C requires conduct of the side-by-side comparison and basic detectability study while future applications on the 2-Loop, 3-Loop, and CE-217 plant types do not. **[**

] ***a, c***