Fourth Set of Responses to the Second Round of NRC's Request for Additional Information by the Office of Nuclear Reactor Regulation for Topical Report (TR) WCAP-16747-P, "POLCA-T: System Analysis Code with Three-Dimensional Core Model" (TAC No. MD5258) (Non-Proprietary)

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POLCA-T Supplemental Stability RAI 6-33S1

The staff requested the stability phenomena identification and ranking table (PIRT) to assist the staff in reviewing the relevant capabilities of POLCA-T that are required to perform stability evaluations. The staff requires additional information regarding the stability PIRT provided in response to RAI 6-33.

Part 1- Initial Condition Rankings

Under the subcategory of "Initial Conditions" the PIRT specifies the following phenomena as ranked low: [[ ]]. This appears to be inconsistent with the rank of [[ ]] under the subcategory of "Calculation of Fuel Rod Heat Transfer."

The staff considers the [[ ]] as a highly important parameter in the stability evaluation because it affects the coupling between the neutronic power and the response of the fluid. The initial conditions specified for the [[ ]] appear to impact the fuel rod heat transfer characteristics. For instance, during irradiation as fission gas escapes the pellet the conductivity of the fill gas decreases, thus increasing the total fuel rod heat resistance. This effect, it would seem to the staff, would be captured through initial conditions specifying the [[ ]]. For these phenomena provide a more detailed rationale for the low ranking.

If a ranking is "low" because the results are not sensitive to the analysis input conditions, please quantitatively justify the rationale.

Westinghouse Response

[ ]^{a,c} are ranked low for stability analysis because the results are not sensitive to these parameters.

The sensitivity of the calculated decay ratio (DR) and fuel thermal time constant to [ ]^{a,c} has been studied, see also the response to Stability RAI 6-37:

[ ]^{a,c}

A similar study was also made concerning the [ ]^{a,c}:

[ ]^{a,c}

An assumption of [ ]^{a,c} was made to simplify the evaluation of the [ ]^{a,c} in this study. Even though this definition does not directly apply for a dynamic heat transfer response, it sufficiently characterizes the heat transfer in a fuel rod.

The results show that the influence of [ ]^{a,c} are small compared to [ ]^{a,c} among other properties, for stability analysis.

<u>Method of calculating the equilibrium heat transfer time constant:</u>

The equilibrium thermal time constant was calculated for an average powered [ ]^{a,c} as described in the equations contained in the response to RAI 6-37.

Part 2 - Input Assumptions Affecting Heat Resistance

Based on the PIRT ranking the staff is not certain if the aforementioned phenomena are treated in the W standard production stability analysis methodology. Please refer to POLCA-T audit open item 8 (referenced in RAI 4-11) in terms of the oxide thickness. Please provide similar information for the fill gas parameters.

Westinghouse Response

Gas pressure and gas composition and their impact on fuel rod thermal resistance are treated in the Westinghouse standard production stability analysis.

The fuel rod gas pressure in each axial segment of a fuel rod is calculated dynamically (for each time step) from the gas gap volume, temperatures of the rod structures and gas composition.

Gas composition (number of moles) is calculated taking into account the initial fill gas (He) and the fraction of fission gases released from the pellet. The gas gap volume is calculated taking into account the pellet and cladding displacement.

The cladding oxide layer thickness [
]^{a,c}.

However, [
]^{a,c}.

Part 3 - Regional Mode Oscillations and Bypass Boiling

The staff notes the [[ ]] was a highly ranked PIRT for regional mode instability analyses. The staff notes that if POLCA-T is run with a [[ ]] that POLCA-T [[ ]] the capability to model transient changes in [[ ]] during regional mode oscillations. Because the total reactor power and pressure drop remain constant during stable regional oscillations, treating [[ ]] results in no net change in the [[ ]]. However, for regional oscillations the local heat deposited in the [[ ]]. In order to capture the effect of [[ ]] during regional mode oscillations the [[ ]] must be treated with [[ ]] (one on each side of the harmonic symmetry plane). Please clarify how this highly ranked phenomenon is captured in the POLCA-T simulations.

The staff understands that POLCA-T has the capability to model the [[ ]] as well as sub-dividing the [[ ]] into several isolated regions. This degree of modeling resolution is not likely to be necessary in all cases. Please provide a detailed description of the process by which the potentiality of [[ ]] is assessed. This process description should consider those reactor conditions typical of decay ratio analysis such as low flow points in the operating domain and conditions of natural circulation. Please also describe the process or methodology by which the [[ ]] several parallel channels. This description should address how hot channel peaking factors and the regional mode flux harmonic shape are used to determine where greater resolution is required for [[ ]].

Westinghouse Response

Voiding in bypass is expected to influence power and flow oscillations. Voiding in bypass may occur at very low recirculation flow (some tripped recirculation pumps or at natural circulation conditions) due to excessive direct heating.

A possible local boiling may not be captured by a single bypass channel model. POLCA-T has capability to model multiple bypass channels. The number of core bypass channels in simulation of regional mode oscillations is decided on a case-by-case basis to be able to capture voiding but also to avoid getting into unnecessary large core bypass models.

Below is attached a description of Westinghouse regional stability analysis process with POLCA-T. The regional mode simulation in case the reactor is highly susceptible to global (core wide) oscillations is also discussed in response to RAI 6-29.

a,c

a,c

NRC RAI 7-26

The fuel cladding damage criterion of 170 cal/gm in Section A.2.4 is only applicable to fuel rods that are below system pressure, please revise the LTR to specify an acceptance criterion of 150 cal/gm for fuel rods with internal rod pressures that exceed the system pressure. Please refer to SRP 4.2 Appendix B of revision 3 of NUREG-0800. Provide a description of the aspects of the POLCA-T method that will ensure that uncertainty in the calculated internal rod pressure is conservatively accounted for when determining the number of damaged fuel rods.

Westinghouse Response

Westinghouse will use the interim criteria in standard review plan (SRP) 4.2 Appendix B of NUREG-0800 Rev. 3 for new plant applications as required by the SRP. Once final criteria have been issued by the NRC, Westinghouse will evaluate the new criteria as required. The LTR will be revised with respect to the acceptance criteria for new plants where the internal rod pressure exceeds the system pressure.

The number of moles of gas in each fuel rod gas gap is calculated from fission gas release correlations and the initial number of moles of Helium with which the rods are filled. This fission gas release fraction is used to determine the moles of fission gas initially present in the fuel rod gas gap. [

]^{a,c}. In this way, the pressure in the fuel rod is conservatively calculated when the number of damaged fuel rods is determined.

NRC RAI 11-13S1 (Supplement 1)

Based on the figure provided in response to RAI 11-13, the burst stress model in POLCA-T appears [[ ]] in the high temperature range (alpha-beta and beta phases). On this basis the staff cannot conclude that POLCA-T [[ ]] the incidence of cladding rupture.

Westinghouse Response

[ ]^{a,c}

NRC RAI 11-13S1 (1)

Please confirm that the cladding rupture model is fully consistent with the cladding rupture model approved by the staff in WCAP-15682-P-A.

Westinghouse Response

We have reviewed the cladding rupture model with the model in WCAP-15682-P-A /CENDP-293-P-A and can confirm that is fully consistent.

NRC RAI 11-13S1 (2)

The staff notes several differences that are likely due to typographical errors in WCAP-16747P. Please confirm Equation (14-87), (14-97), (14-102) are analogous to Equations (5.6-24), (5.6-10), and (5.6-15) of CENPD-293-P-A. Please correct any inconsistencies. Please confirm that the POLCA-T burst stress plotted in the RAI response is consistent with the correct model.

Westinghouse Response

[ ]^{a,c}

[ ]a,c

We can confirm that the plot in the RAI response is consistent with the corrected equations.

NRC RAI 11-13S1 (3)

CENPD-293-P-A contains a plot in Figure 7-22 of a comparison of the cladding rupture model to the measured data provided in NUREG-0630. Please provide a similar confirmation for the POLCA-T cladding rupture model to ensure consistency with the data.

Westinghouse Response

A confirmatory plot as in Figure 7-22 of CENDP-293-P-A is provided in Figure 1 below:

[ ]a, b, c

A second confirmatory plot as in Figure 7-23 of CENDP-293-P-A is provided in Figure 2 below:

[ ] a, b, c

NRC RAI 11-13S1 (4)

If POLCA-T [[ ]] please describe how this phenomenon is conservatively treated in licensing analysis. Specifically address the core coolability criteria for ABWR CRDA (see SRP 4.2 Appendix B Item C-3).

Westinghouse Response

The rod-to-rod contact causing increased heat transfer between the pellet and the cladding is taken into account in POLCA-T.

NRC RAI 11-13S1 (5)

It does not appear that the POLCA-T [[ ]] incorporates the same bias in CHACHA-3D to ensure that [[ ]]. Please include the bias.

Westinghouse Response

[

]a,c

NRC RAI 11-13S1 (6)

Please also provide descriptive details of how Equation 14-85 is implemented. The double layer burst stress modifier depends on the double layer thickness and total oxygen concentration. How does POLCA-T determine these parameters? Is the total oxygen uptake a static or dynamic variable? It is not clear from WCAP-16747P. An analogous section of CENPD-293-P-A refers to Section 4.5.6.4 which does not appear to exist within that LTR.

Westinghouse Response

Equation 14-85 is used in the same way as described in CENDP-293-P-A including the integration in time, with a local time step with treatment as in CENDP-293-P-A. The total oxygen uptake, oxide layer and oxygen stabilized layer are integrated in time, evaluated after each time step (equation 14-108) to obtain the required data for thickness of the double layer, $\delta_{x\alpha}$, and the total oxygen uptake G_{tot}. The total oxygen uptake is a dynamic variable.

NRC RAI 11-13S1 (7)

The cladding rupture model appears to be best estimate in nature. How are its uncertainties captured in accident analyses?

Westinghouse Response

[

]a,c