REQUEST FOR ADDITIONAL INFORMATION

RELATED TO TOPICAL REPORT ANP-10346P, REVISION 0,

"ATWS-I ANALYSIS METHODOLOGY FOR BWRs USING RAMONA5-FA"

FRAMATOME INC.

(EPID: L-2017-TOP-0067)

BACKGROUND

The specific regulatory requirements associated with anticipated transient without scram (ATWS) events are contained in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50.62, "Requirements for reduction of risk from anticipated transients without scram (ATWS) events for light-water-cooled nuclear power plants," and 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," as well as General Design Criteria (GDC) 12, "Suppression of Reactor Power Oscillations," 14, "Reactor Coolant Pressure Boundary," 16, "Containment Design," 35, "Emergency Core Cooling," 38, "Containment Heat Removal," and 50, "Containment Design Basis," which are contained in Appendix A to 10 CFR 50.

Of those requirements, GDCs 12 and 35 are the most relevant, in that the intent of the ATWS with-instability (ATWS-I) analyses is to demonstrate that: (1) power oscillations that arise due to instability in the core are adequately mitigated by appropriate operator actions and/or automatic system responses, and (2) adequate cooling of the fuel is maintained, such that the maximum cladding temperature does not reach thresholds where significant fuel/cladding damage or metal-water reactions are expected to occur. The NRC guidance related to the boiling water reactor (BWR) ATWS-I event is presented in Standard Review Plan Section 15.8. During review of Topical Report (TR), ANP-10346P, Revision 0, "ATWS-I Analysis Methodology for BWRs Using RAMONA5-FA," the NRC staff identified some information that would be necessary to establish adequate technical bases to make a safety determination based on the above regulatory requirements. In particular, this information directly affects the calculation of the three figures of merit (FoMs) that the demonstration of regulatory compliance are based on—the oscillation inception (i.e., how much time operators have to act), limit cycle amplitude (i.e., worst case oscillation), and post-dryout (i.e., peak cladding temperature (PCT)).

REQUEST FOR ADDITIONAL INFORMATION (RAI) QUESTIONS

The Framatome 3-dimensional core physics simulator code, MICROBURN-B2, is used to produce data transfer files which pass condensed versions of relevant information for use in the RAMONA5-FA neutron kinetics solution. **[**

] Therefore, the NRC staff requests the following information:

RAI-1

What **[** **]** information is passed from MICROBURN-B2 to the RAMONA5-FA ATWS-I calculation? What process and/or criteria, if any, are used to ensure that **[**

]?

The RAMONA5-FA code incorporates several models to capture specific phenomena of interest for the ATWS-I event. These models are typically constructed from empirical correlations developed based on a combination of theoretical principles and experimental data analysis. In order for the models to capture the phenomena of interest throughout the ranges of interest for key analysis parameters, the appropriate dependencies must be accurately captured in the models. To do so, the models must consider all relevant parameters, and the empirical correlations must be based on an appropriate analysis of the available data (including any gaps or limitations). Therefore, the NRC staff requests the following information:

RAI-2

The NRC staff has the following questions regarding the fitting of model parameters to measured data:

a. For models such as the dryout-rewet model and gap conductance model which contain multiple fitting parameters, how were values for these parameters inferred in cases where direct experimental validation for each parameter is not possible or not available?

b. For the gap conductance model, the TR states that "**[**
]". Describe this approach in additional detail, including how this adjustment was performed and how these values compare to similar values used in other Framatome methodologies.

RAI-3

Justify the **[** **]** used in the TR methodology. Include data for the **[**
], where available.

RAI-4

Since the **[** **]** was not part of the KATHY dryout-rewet experimental validation, justify that the models are a reasonable and accurate representation of **[** **]** during ATWS-I.

RAI-5

The **[**

] How is the model ensured to give reasonable and accurate behavior under such conditions during ATWS-I?

Once all of the models and coupling equations were combined into an unified analysis methodology within RAMONA5-FA to calculate the thermal hydraulic and neutron kinetics response during an ATWS-I event, Framatome validated the overall methodology by comparing calculational results to independent benchmarks. By demonstrating that RAMONA5-FA can independently reproduce key parameters for applicable benchmarks, reasonable assurance is provided that RAMONA5-FA will reproduce the same parameters for a postulated ATWS-I event. The key comparison results are presented in the TR, but some additional detail is needed to confirm that the benchmarks, and information used in the benchmarking calculations, are applicable to the intended use of RAMONA5-FA. Therefore, the NRC staff requests the following information:

RAI-6

The NRC staff has the following questions regarding the linear stability benchmarks provided in the TR:

a. Provide a table showing the following operating conditions and calculated conditions for each linear stability benchmark case: core power, core flow rate, core inlet subcooling, axial peaking factor, peak axial power location, and radial peaking factor.

b. What fuel type(s) were present in the core for each of the linear stability benchmarks? Were all data and specifications available for these fuel types? What data and specifications required by RAMONA5-FA ATWS-I were not available, if any?

c. What neutronic and thermal hydraulic data were used from each plant in these benchmarks?

RAI-7

The NRC staff has the following questions regarding the nonlinear stability benchmarks provided in the TR:

a. What fuel type(s) were present in the core for each of the nonlinear stability benchmarks? Were all data and specifications available for these fuel types? What data and specifications required by RAMONA5-FA ATWS-I were not available, if any?

b. What deviations, if any, were made in the boundary conditions or other modeling assumptions for these cases relative to measured data and/or available benchmark specifications?

The TR includes guidance for nodalization of the plant models used in executing the RAMONA5-FA ATWS-I calculations. The nodalization selected in a model is generally a balance between managing the time required to complete a calculation, maintaining calculational stability, and resolving the time/spatial distribution of parameters to a sufficiently fine level for accuracy. In general, the testing performed by Framatome can be expected to ensure that the computational time and stability are acceptable, but the NRC staff needs to verify that the nodalization recommendations are adequate to provide reasonable accuracy in the calculations. Therefore, the NRC staff requests the following information:

RAI-8

Justify that the RAMONA5-FA ATWS-I axial nodalization scheme in the core region provides sufficient numerical fidelity for the ATWS-I calculations, including considerations of numerical diffusion and resolution of the axial void distribution. In particular, prior studies by the NRC staff and contractors have shown that the axial void distribution may need to be captured at a sufficiently high resolution to result in an accurate calculation of the axial power profile, and thus accurate calculation of stability behavior (e.g. decay ratio), in some codes. This effect has been shown to be separate from that of numerical diffusion, so provide a discussion regarding whether the average void fraction for each node is accurate enough to correctly capture the axial power distribution for stability calculations. For example, would an increase in the number of thermal hydraulic nodes lead to a significant change in the locally-averaged void fraction across the coupled neutronic nodes due to the higher resolution of the void fraction distribution, and would this significantly affect the RAMONA5-FA ATWS-I calculations?

RAI-9

Justify that the vessel nodalization used for RAMONA5-FA ATWS-I is sufficient to provide a reasonable and accurate prediction of PCT during ATWS-I events.

RAI-10

Provide an example(s) of the calculated time-dependent behavior of the **[** **]** during large-amplitude oscillations with flow reversal. In the cases presented in the TR, did sufficient flow reversal occur such that **[** **]**? If such a circumstance occurs, justify that the RAMONA5-FA ATWS-I methodology treats this circumstance in a reasonable and/or conservative way, with respect to the ATWS acceptance criteria.

Several inputs to the ATWS-I calculation are described in the TR, with specific recommendations provided. In some cases, the parameters of interest may be determined to be insensitive to specific inputs based on engineering judgment or sensitivity studies. In other cases, the parameters of interest are adjusted to achieve desired results. In all cases, the recommendations must ensure that the results from the ATWS-I calculations are accurate or conservative. In order to verify this, the NRC staff requests the following information:

RAI-11

Provide sensitivity results for one or more linear stability benchmark cases and a simulated ATWS-I event (either a nonlinear benchmark problem or a sample full-core case) by adjusting the gap conductance values. Show time-dependent results for power, PCT, and other relevant results.

RAI-12

The NRC staff has the following questions regarding time step control:

a. What input parameters are provided by RAMONA5-FA ATWS-I to control the timestep size? What are the recommended values for use?

b. What values for these parameters were used for the nonlinear stability benchmarks and the sample problem provided in the TR?

c. Provide a set of sensitivity results for timestep size, similar to the sensitivity study provided for RAI 11.

RAI-13

What spatial distribution is used for the **[** **]**? Justify that the modeling approach for **[**

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RAI-14

Justify that the **[**

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The TR provides a brief procedure that would be used to perform the ATWS-I analysis and determine whether acceptance criteria are met. **[**

] Therefore, the NRC staff requests the following information:

RAI-15

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RAI-16

For the process described in RAI 15, discuss how the various modeling and input assumptions remain appropriate when considering their effect on the time of oscillation onset.