ENCLOSURE 2

MFN 16-039

Response to Round 4 Requests for Additional Information 101 and 102

Non-Proprietary Information – Class I (Public)

IMPORTANT NOTICE

This is a non-proprietary version of Enclosure 1, from which the proprietary information has been removed. Portions of the enclosure that have been removed are indicated by an open and closed bracket as shown here [[ ]].

RAI 101

In its review, the NRC staff has identified several issues with the description of the decay heat modeling approach provided in the TRACG-LOCA Licensing Topical Report (LTR). Please address the following:

- Describe the historical source of the decay heat model and explain how it has been adapted for use within TRACG-LOCA. Provide plots (or reference such plots within the LTR) comparing decay heat as a function of time between the current and prior models to illustrate the evolution.
- Explain how the decay heat is perturbed in the statistical analysis. Include examples reflective of production safety analysis, including a description of attributes important to characterizing the decay heat as applied to various limiting and average channel groupings.
- Correct in-text inconsistencies in the LTR, particularly on Pages 2-8 and 5-33.
- NEDE-30996P-A, as referenced in the LTR Table 2.5-1, has no Appendix B. Please explain.

RAI 101 Response

The reference to Appendix B of NEDE-30996P-A in LTR Table 2.5-1 is a typographical error. The correct reference is Appendix B of NEDE-23785-1-PA, Volume 3. This reference describes a generic decay heat curve based on the American Nuclear Society (ANS) 1979 standard for use with SAFER. In subsequent plots, this nominal decay heat curve is referred to as the "SAFER LTR" curve.

As discussed in Section 9.3 of NEDE-32176P, the 1979 and 1994 ANS standards are implemented in TRACG in a simplified manner. The source of these models in TRACG is the DECAY computer program (referred to as "DECAY01P" in subsequent plots). The DECAY program was developed in response to NRC Information Notice (IN) 96-39, which pointed out the inconsistent calculation of decay heat within the domestic nuclear power industry. Thus, the DECAY code was developed to faithfully replicate the ANS 1979 and 1994 decay heat standards. The simplifications employed relative to DECAY, for implementation in TRACG, are either of little consequence, or result in a conservatively high decay heat.

The major simplification to fit in the TRACG framework is that [[

]]. This is a noticeable conservatism for decay heat driven transients such as a Loss-of-Coolant Accident (LOCA). The conservatism is demonstrated by comparing the DECAY01P nominal, TRACG04P nominal, and SAFER LTR nominal ANS 1979 decay heat for a 10 GWD/ST exposure case. Note in Figure R101-1 and R101-2 that the TRACG04P nominal is increasingly greater than the DECAY01P nominal and SAFER LTR nominal after about [[ ]] seconds of shutdown time. To confirm that this simplification is the source of the conservatism, the DECAY01P nominal values are adjusted by [[

]] ("DECAY01P ADJUSTED"). The "DECAY01P ADJUSTED" points are visually identical to the TRACG04P nominal curve.

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For the LOCA application, TRACG initializes the decay heat model [[

]]. For a constant irradiation time, the decay heat can be lower for a larger exposure, although the effect is very small for the first 20,000 seconds. However, since a [[

]].

For the LOCA application, the decay heat uncertainty is calculated as specified by the 1979 ANS standard. In particular, the standard specifies that uncertainties be determined for energy per fission, fission product decay power, and reactor power. Since the reactor power uncertainty is included in the initial total thermal power, it is not included in the decay heat uncertainty. The uncertainty in the energy per fission is 0.25%. The uncertainties in the fission product decay power are as specified by the ANS standard. For the same demonstration case, the TRACG04P +2σ and DECAY01P +2σ total shutdown power, as a fraction of initial, are compared in Figure R101-3.

For a given LOCA transient statistical trial, a particular decay heat uncertainty, in terms of number of standard deviations from the nominal is specified via input (the particular value is sampled from a specified probability distribution function). The same number of standard deviations is then applied [[ ]] in that trial. [[

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Table R101-1 indicates decay power fractions, as a function of exposure, for both the initial condition, and at 3,000 seconds after a large break LOCA. These values are for a typical nominal case (no decay heat uncertainty), and for a large positive and negative uncertainty relative to nominal. In general, the long term decay heat is higher for higher exposure.

Table R101-1 Typical [[ ]] Decay Power Fractions

[[ ]] Type	Exposure (GWD/MT)	Fraction of Initial Thermal Power due to Decay Heat At Time 0 / At 3,000 seconds		
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Figure R101-1 TRACG04P Decay Heat Comparison to DECAY01P and SAFER LTR (0 – 10,000 seconds)

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Figure R101-2 TRACG04P Decay Heat Comparison to DECAY01P and SAFER LTR (0 – 1,000 seconds)

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Figure R101-3 TRACG04P Decay Heat Comparison to DECAY01P with + 2 Sigma Uncertainty (0 – 1,000 seconds)

LTR Impact

Note: These changes are relative to the LTR version after implementing the changes for previous RAI responses. For example, the decay heat figure in the original LTR was Figure 5.1-18, corresponding to 15 GWD/MT. This figure was changed in the response to RAI-54 to correspond to 11 GWD/MT, and is now Figure 5.1-17, due to other changes.

1. Table 2.5-1; 3.2.2 Fission Heat, 3.2.3 Decay of Actinides, 3.2.4 Fission Product Decay Heat
   a. Replace the third row, 2nd column (GEH Process) with:

      The heat generation from radioactive decay of fission products is calculated in accordance with the 1979 ANS standard. [[

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   b. Change the reference in the third row, 3rd column (Evaluation) from [25] to [21].
2. Replace the text of Section 5.1.3.31 C25 – Decay Heat (H) with:

   TRACG calculates the decay heat as a function of time in a way that conservatively approximates the American National Standards Institute (ANSI)/ANS-5.1-1979 standard entitled "American National Standard for Decay Heat Power in Light Water Reactors" [59]. In this standard, values are provided for decay heat power from fissioning of the major fissionable nuclides present in light water reactors (LWRs) (i.e., U235 and Pu239 (thermal) and U238 (fast)) and methods are prescribed for evaluating the total fission product decay heat power from the data given for these specific fuel nuclides. By way of this methodology, the decay heat curve becomes a function of the fuel design, depletion environment and power history. Thus, in theory, each point in the reactor has a unique decay heat curve. Fortunately, the variations in decay heat due to the above effects are small and curves can be defined [[ ]] with little loss in accuracy. The details of the derivation as well as the calculation of the uncertainties are described in References [59] and [38]. TRACG implementation details are provided in Section 9.3 of Reference [1]. For the purpose of illustration, the nominal decay heat curve and the $\pm 1\sigma$ curves are shown in Figure 5.1-17 for an exposure of 11 GWd/MTU. [[

   ]], as determined from the uncertainty specified as part of the ANS decay heat standard.
3. Change the Figure 5.1-17 caption to: "Decay Heat Uncertainty at an Exposure of 11 GWD/MTU".

RAI 102

During the course of the NRC staff review, GEH has revised its approach to addressing initial conditions, particularly the modeling of initial bundle power distribution. The relevant request for additional information responses and revised LTR text do not provide a sufficiently complete description as to enable the NRC staff to determine that the revised modeling approach (including adjustments to the level of detail of modeling for the core, to the approach for including a variety of limiting bundle characteristics, and to accounting for variability in the core spray distribution) provides an acceptable, best-estimate representation of "relevant factors such as the actual total power, actual peaking factors, and actual fuel conditions," as recommended in Regulatory Position 3.1 of Regulatory Guide 1.157. Please provide a description of the minimum number of hot CHAN components required for use in production TRACG-LOCA safety analysis, and explain why additional hot CHAN components would be included. Provide examples and relevant core operating limit curves to illustrate the analytic method.

RAI 102 Response

The revision to Licensing Topical Report (LTR) Section 6.2.5 as part of the RAI-73 response was [[

]] This RAI response provides clarification of applied bundle power distributions and how they relate to Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) limits that ensure that acceptance criteria are met.

In the response to RAI-73, GE Hitachi Nuclear Energy (GEH) provided the details of hot CHAN types modeled in the TRACG LOCA application. The summary table provided in the RAI-73 response for [[

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Figure R102-1 Minimum Hot Channel Modeling Approach for a Typical Jet Pump Plant Application

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Figure R102-2 Minimum Hot Channel Modeling Approach for a Non-Jet Pump Plant Application

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Figure R102-3 Typical Hot Channel Modeling Approach for a Non-Jet Pump Plant Application

LTR Impact

None.