May 14, 2001

Mr. T. A. Coleman, Vice President
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Framatome ANP
3315 Old Forest Road
P. O. Box 10935
Lynchburg, Virginia 24506-0935

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION - CHAPTER 13 OF FRAMATOME TOPICAL REPORT BAW-10231P (TAC NO. MA9783)

Dear Mr. Coleman:

By letter dated July 31, 2000, Framatome requested a review of Topical Report BAW-10231P, "COPERNIC Fuel Rod Design Code." The staff has determined that additional information for Chapter 13, MOX Applications, is required in order to complete our review.

The enclosed questions have been discussed with your staff. As discussed with your staff, by June 30, 2001, please respond to the urania-related questions and provide a schedule for responding to the MOX-related questions. If you have any questions concerning our review, please contact me at (301) 415-1321.

Sincerely,

/RA/

Stewart Bailey, Project Manager, Section 2
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 693

Enclosure: Request for Additional Information

cc w/encl: See next page

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REQUEST FOR ADDITIONAL INFORMATION

TOPICAL REPORT BAW-10231P, CHAPTER 13

"COPERNIC FUEL ROD DESIGN CODE"

MOX APPLICATIONS

The questions provided below address COPERNIC evaluations related to normal operation. A second round of questions related to mixed oxide (MOX) fuel application to transient and accident analyses will be issued separately.

1. It is recoginized that weapons grade plutonium will be used for MOX for commercial application in the U.S. However, the isotopic plutonium ratios are significantly different between reactor grade (reprocessed LWR fuel) plutonium and weapons grade plutonium. Please provide the plutonium ratios for reactor grade and weapons grade plutonium and; also, the tabular values of pellet radial power profiles to be used for weapons grade plutonium and how these values were determined. If the reactor grade and weapons grade MOX radial profiles are proposed to be similar, provide the calculational results for both MOX types that demonstrate this conclusion.

2. Please provide the specifications (including nominal values) of oxygen-to-metal (O/M) ratio, PuO_2 particle size, and grain size specified for the U.S. commercial application.

3. For the experimental thermal MOX data, what were the O/M ratios used for code verification?

4. For the MOX fission gas release data, please provide the nominal and range of PuO_2 particle size for the different experimental rods used for code verification?

5. The conductivity equation for unirradiated MOX (Eq. 4-44) defines the term, y, as Pu content in weight-percent, but it appears that this may be weight fraction. Please verify which unit is intended. If the Pu content is in weight fraction, the correction for Pu conductivity is small for 100 wt% $PuO_{2,}$ which appears to be too low (see questions 6 and 8 below).

6. The Halden Reactor Project correction for unirradiated MOX is an 8 percent reduction in the urania thermal conductivity (at all temperatures) when the Pu concentration is equal to or below 12 wt%. This is significantly higher than the value used in COPERNIC. Also, the COPERNIC model for urania and MOX pellet thermal conductivity at high burnups and nominal stoichiometry (x = 0.02) is significantly higher in the range from 500 to 1500 K than similar burnup-dependent models, such as those proposed by ORNL/Kurchatov (Popov, 2000), Halden (Wiesenack, 2000, HPR-589) and Baron (Baron 1998). Please justify the higher thermal conductivity values used by COPERNIC for unirradiated and high burnup MOX (see question 8 below).

7. Recent high-temperature data on unirradiated urania fuel pellet thermal conductivity (Ronchi et al., 1999) has indicated that the conductivity in the range from 2000 to 3000 K is significantly lower than the COPERNIC equations for urania and, by implication, for LWR MOX also. Most of the current conductivity models (including COPERNIC) are based on very old data at high temperature from which there was considerable scatter. The more recent data appears to have less scatter and better experimental techniques to minimize the scatter due to heat loss and other effects. Please justify the higher estimates of COPERNIC conductivity in this high temperature range because the discrepancy affects the LHGR margin to center fuel melting.

8. The integral MOX experiments provided, where centerline temperatures are measured, to verify the COPERNIC integral thermal predictions of MOX fuel rods are limited to very low burnup levels, i.e., less than 5 GWd/MTU. Please provide COPERNIC predictions of at least three of the following Halden MOX instrumented assemblies, IFA-597.4/.5/.6, IFA-606, IFA-610, and IFA-648.1, that achieved burnups of approximately 24 GWd/MTM to 57 GWd/MTM, or suggest other Halden MOX instrumented assemblies. Please justify the reasons for eliminating some of the data and/or assemblies for COPERNIC comparisons and the reasons for selecting others (this should be discussed with the NRC reviewer prior to issuing a response to the request for additional information). Also, rod pressures due to fission gas release were measured for two experimental Halden MOX fuel rods in IFA-597.4/.5/.6. COPERNIC predictions of rod pressure are also needed, where appropriate.

9. What are the gas production values (xenon, krypton and helium) used in COPERNIC for MOX. Justify their application to weapons grade Pu. Also, how are the release fractions for helium determined in the rod pressure analysis, LOCA analyses, and other analyses where it is important?

10. Has Framatome (or other parties) examined the interface between MOX fuel and the cladding at high burnups to determine if there are any chemical reactions (such as Zr-oxide formation or other reactions) between the fuel and cladding?

REFERENCES

Baron, D., 1998. "About the Modeling of the Fuel Thermal Conductivity Degradation at High Burnup, Accounting for Recovery Processes with Temperature" paper 2.5 in *Proceedings of the NEA Seminar on Thermal Performance of High-Burnup LWR Fuel,* Cadarache, France, 3-6 March 1998.

Popov, S.G., et al., 2000. *Thermophysical Properties of MOX and UO_2 Fuels including the Effects of Irradiation,* ORNL/TM-2000/351, Oak Ridge National Laboratory, Oak Ridge, TN.

Ronchi, C., M. Shiendlin, M. Musella, and G.J. Hyland, 1999. "Thermal Conductivity of Uranium Dioxide up to 2900 K from Simultaneous Measurement of the Heat Capacity and Thermal Diffusivity," *Journal of Applied Physics*, Vol. 85 no. 2, pages 776 to 789.

W. Wiesenack and T. Tverberg, 2000. "Thermal Performance of High Burnup Fuel - In-Pile Temperature Data And Analysis," in *Proceedings of the ANS International Topical Meeting on Light Water Reactor Fuel Performance, Park City, Utah, April 2000,* pages 730 to 737. (As-modified for MOX by HWR-589)