FRAMATOME ANP

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FRAMATOME ANP, Inc.

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Document Control Desk
ATTN: Chief, Planning, Program and Management Support Branch
U.S. Nuclear Regulatory Commission
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Partial Response to RAI on BAW-10238(P), Revision 1, "MOX Fuel Design Report."

Ref.: 1. Letter, Drew G. Holland (NRC) to James F. Mallay (Framatome ANP), "Request for Additional Information (RAI) – Topical BAW-10238(P), Revison 1, 'MOX Fuel Design Report'," (TAC NO. MB7550), October 8, 2003.

Ref.: 2. Letter, James F. Mallay (Framatome ANP), to Document Control Desk (NRC), "Partial Response to RAI on BAW-10238(P), Revision 1, 'MOX Fuel Design Report'," NRC:03:072, October 27, 2003.

Ref.: 3. Letter, James F. Mallay (Framatome ANP), to Document Control Desk (NRC), "Partial Response to RAI on BAW-10238(P), Revision 1, 'MOX Fuel Design Report'," NRC:03:080, November 24, 2003.

Ref.: 4. Letter, James F. Mallay (Framatome ANP), to Document Control Desk (NRC), "Partial Response to RAI on BAW-10238(P), Revision 1, 'MOX Fuel Design Report'," NRC:03:082, December 5, 2003.

This letter responds to several of the questions contained in the RAI of Reference 1. Specifically, responses to questions 3, 15, 18, 19, 20, 21, 22, 23 and 24 are provided in two attachments – one proprietary and one non-proprietary. The remaining responses to reference 1 are expected to be submitted to the NRC by December 19, 2003.

References 2, 3 and 4 provided responses to many of the other questions in the RAI.

Framatome ANP considers some of the information contained in Attachment 1 to be proprietary. The affidavit provided with the original submittal of the topical report satisfies the requirements of 10 CFR 2.790(b) to support the withholding of this information from public disclosure.

Very truly yours,

James F. Mallay, Director
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Enclosures

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Attachment 1
Responses to RAI on Topical Report
BAW-10238(P), MOX Fuel Design Report

In all responses, "BAW-10238" means *MOX Fuel Design Report*, BAW-10238(P), Revision 1, May 2003.

Question 3: *Page 1-2 states that the fuel rod contains MOX pellets based on the rod design and pellet specification used for European MOX fuel. Please provide these European specifications and explain how compliance with specifications is being ensured.*

Response 3: The proprietary European specifications are attached.

MOX fuel assemblies to be irradiated in the U.S. will be built to U.S. specifications. Compliance with U.S. specifications will be ensured by inspection requirements that are included in the specifications. The U.S. specification requires measurements at least as frequently as the European specification.

Pellets for lead assemblies and for batch assemblies will be fabricated in different facilities. Therefore, they are discussed separately below.

The existing European pellet specification contains inspection requirements that state how frequently each inspection must be made. For example, it states how many measurements must be made of uranium isotopic composition, plutonium isotopic composition, impurity content, etc. The measurement frequency is based on experience and has been sufficient to ensure the satisfactory irradiation performance of European MOX fuel.

Pellets for lead assemblies will be produced in Europe on an existing MOX pellet fabrication line by experienced personnel. Therefore, European experience in MOX pellet fabrication is directly applicable. In particular, requirements on measurement frequency that were sufficient to ensure the satisfactory irradiation performance of European MOX fuel pellets will also be sufficient to ensure the satisfactory performance of pellets for the U.S. lead assemblies. In addition, the European pellet manufacturing facility will be subjected to a formal qualification process.

Pellets for batch assemblies will be produced in the U.S. at the MFFF. It is expected that the European requirements on measurement frequency will be applicable at the MFFF, and the appropriate frequency will be confirmed as part of the MFFF startup and qualification process.

The difference between LEU and MOX fuel pellets does not affect any other aspect of fuel assembly manufacturing. Therefore, experience with LEU fuel assembly manufacturing is directly applicable to MOX. Requirements on inspection frequency for MOX fuel rods are the same as those for LEU fuel rods.

Question 15: *In section 6.1.8, what was the calculated fuel rod EOL pressure and what was the margin between the calculated value and the limit?*

Response 15: Framatome ANP calculated the fuel rod internal pressure for the limiting fuel rod of the lead assemblies using the methodology described in Reference Q15.1, along with additional conservatisms on the assumed power history, plutonium content, and number of transients. At the end of the third cycle of irradiation, the calculated bounding internal pressure was [ ] psia.

The approximate nature of the previous result is not significant because the limiting time in life was predicted to be the end of the second cycle of operation, as the lower power of the third cycle results in lower internal pressures. At the end of the second cycle, the calculated bounding internal pressure was [ ] psia.

As indicated in Reference Q15.2, the fuel rod internal pressure is limited to the pressure which is required to achieve cladding liftoff, or [ ] psi above system pressure, whichever is smaller. The margin to the applicable limit, [ ] psi above system pressure, was [ ] psi for this conservative calculation. If the actual anticipated power history, plutonium content, and minimum number of required transients were used, additional margin would be obtained.

Q15.1 BAW-10231P Chapter 13, *COPERNIC Fuel Rod Design Computer Code: Chapter 13 – MOX Applications*, July 2000.

Q15.2 BAW-10183P-A, *Fuel Rod Gas Pressure Criterion (FRGPC)*, July 1995.

Question 18: *Section 7.2.3 refers to extended cycle designs, please define extended cycle designs.*

Response 18: "Extended cycle design" means that the design was for irradiation cycles using an 18-month schedule.

Question 19: *The end of section 7.2.3 discusses current MOX fuel experience in German reactors. However, it only discusses the loading of fuel assemblies and projected burnups. Please provide any results and data obtained from these experience sets.*

Response 19: The most severe irradiation conditions were those at Philippsburg 2. Figure Q19.1 shows oxide thicknesses as a function of rod average burnup for the following fuel:

- two MOX assemblies with M5® cladding that were irradiated in Philippsburg 2, A/C 1488 (gold) and A/C 1393 (green)
- LEU assemblies with M5® cladding that were irradiated in Philippsburg 2 (red)
- LEU assemblies with M5® cladding that were irradiated in other reactors (blue)

Fuel assemblies A/C 1488 and A/C 1393 reached assembly-average burnups of [ ] MWd/MThm, respectively. The results for the MOX fuel assemblies fall within the range expected from experience with LEU.

Oxide thicknesses are measured by inserting a probe from the side of the fuel assembly. As the probe passes over each fuel rod, multiple oxide thickness measurements are taken. The measurements for each rod are averaged. The process is repeated, with the probe being inserted at various elevations. Because of the repeated insertions, each fuel rod will have multiple average oxide thickness measurements. The largest of these averages is recorded as the oxide thickness for that rod. BAW-10238 describes such results as the "maximum average azimuthal value" of the oxide thickness.

Figure Q19.1. Comparison of Fuel Rod Oxidation for MOX and LEU Fuels

Question 20: *In section 7.2.5.1, hot cell examinations of MOX fuel from French reactors is outlined. Please provide a listing of all hot cell examinations performed and the results obtained from them. Also, please define similarly as it relates to the waterside corrosion and rod dimensional effects behavior of MOX versus LEU fuel.*

Response 20: Table 3-3 of Reference Q20.1 lists the MOX hot cell examinations that provided information for the Framatome ANP database. The programs are T158, PRIMO, 7404, 7415, 7416, 7417, 7418, and 74CA. Six fuel rods are not associated with a named program. Results from hot cell examinations are given in Tables 5-2, 6-2, and 9-2 of Reference Q20.1. In addition to the database, Table 5-4 of Reference Q20.1 provides results on transient fission gas releases. These measurements were taken in the PRIMO, 7118, and 7131 programs.

Figures 2 and 3 of Reference Q20.2 show the similarity of the MOX and LEU fuel as regards waterside corrosion and rod dimensional effects. At burnups below 29000 MWd/MThm, it is difficult to distinguish the fuel rod growth of MOX and LEU fuel. At burnups above 29000 MWd/MThm, MOX fuel rods appear to grow slightly less than LEU fuel rods, but no statistical significance is claimed for the difference. Likewise, it is difficult to distinguish between the oxide thicknesses of LEU and MOX fuels, though the oxide thickness appears to be slightly smaller for MOX fuel with burnups near 50000 MWd/MThm. Again, no statistical significance is claimed for the difference.

Q20.1 BAW-10231P-A, *COPERNIC Fuel Rod Design Computer Code*, June 2002.

Q20.2 P. Blanpain et al., "Recent Results from the In Reactor MOX Fuel Performance in France and Improvement Programme," *ANS Fuel Performance Meeting*, March 2-6, 1997, Portland, Oregon.

Question 21: *Section 7.2.5.1 provides the poolside oxide thickness measurement for the MOX German fuel. Please provide the oxide thickness measurement for the similar burnup LEU German fuel.*

Response 21: Figure Q19.1 reports oxide thickness measurements for German fuel, both LEU and MOX.

Question 22: *Please provide the data used to support the discussion of section 7.2.5.2.*

Response 22: Rod puncture and axial growth data for MOX fuel irradiated at Gravelines 4 and Dampierre 2 are provided in Tables Q22.1 and Q22.2, respectively. The data are from PIE programs 74CA and 7418. "GR4" or "DA2" in the rod number indicates that a rod was irradiated at Gravelines 4 or Dampierre 2, respectively.

Table Q22.1. Rod Puncture Data for MOX Fuel from Gravelines 4 and Dampierre 2

Rod Number	Fast Fluence (n/cm^2)	Burnup (MWd/MThm)	FGR (%)		Free Volume (cm^3)		Internal Pressure (100 kPa)	
			Calc	Meas	Calc	Meas	Calc	Meas

Note: Calc = calculated value; Meas = measured value; N/M = not measured

Table Q22.2. Axial Growth Data for MOX Fuel from Gravelines 4 and Dampierre 2

Rod Number	Fast Fluence (n/cm^2)	Burnup (MWd/MThm)	Fuel Rod Growth (%)		Fuel Stack Growth (%)	
			Calc	Meas	Calc	Meas

Note: Calc = calculated value; Meas = measured value; N/M = not measured

Question 23: *Section 7.2.5.4 discusses short segment ramp tests from which fission gas release measurements were obtained. Please provide the data that supports this discussion.*

Response 23: The ramp test data are reported in Table 5-4 of Reference Q23.1. The table includes results for both MOX and other fuel types.

Q23.1 BAW-10231P-A, *COPERNIC Fuel Rod Design Computer Code*, June 2002.

Question 24: *Why would the LTAs only be confirmatory and not required, including the hot cell examinations, prior to batch loading given that SRP 4.2 explicitly states that any time a fuel change is made LTAs should be used and tested prior to batch loading?*

Response 24: The question appears to reflect differences in nomenclature. Duke Power and Framatome ANP recognize that a lead assembly program is required for MOX fuel. In June 1999, shortly after beginning work on the MOX Fuel Project, Duke Power and Framatome ANP met with the NRC staff and described the lead assembly program that was planned to support the batch use of MOX fuel. All submittals to the NRC have been consistent with that position.

The lead assemblies are required to confirm the acceptability of the Mark-BW/MOX1 fuel assembly for future batch implementation. Acceptability for batch operation will be demonstrated by successful operation and by meeting specified acceptance criteria during non-destructive ("poolside") post-irradiation examinations after the second cycle of operation.

Duke and Framatome ANP have identified no specific data from the lead assembly program that are needed to develop performance models for MOX fuel. The lead assembly data will be used to confirm that the fuel performance models are applicable to the planned use of weapons grade MOX fuel in United States reactors. Because no specific data are required to develop new models, Duke and Framatome ANP consider the MOX fuel lead assembly program to be confirmatory in nature.