

## **Preliminary NRC Questions Presented for 71-9319, MAP-12 and MAP-13 Cr-Coated Fuel Rods Application**

**1.**

### **FS1-0038397 MAP PWR Fuel Shipping Package – USA/9319/B(U)F-96**

The changes associated with the Cr Coated fuel are clear.

Section 2.11 Table 2-4 contains a comparison of the Cr-coated M5 vs uncoated M5 Cladding. The changes in mechanical properties appear to be minor, but this is a summary and not actual testing data.....

Framatome Response:

The test data available for the Cr-coated cladding is now provided as an appendix to the SAR, Section 2.12.3.

**2.**

### **FS1-0040260 Mechanical Inputs to Licensing for ATF Fuel Shipments in MAP Series Containers**

This contains the same information Section 2.11 Table 2-4 in FS1-0038397 MAP PWR Fuel Shipping Package – USA/9319/B(U)F-96, so it really is not helpful. The details of the testing appear to be in the following 2 references:

[3] FS1-0036308-1.0, Cr-coated M5 cladding Input data for US LTR justification.

[4] FS1-0039626-1.0, Fabrication of GAIA Fuel Assemblies with Chrome Coated Fuel Rods **I request that these be made available for review.** In particular, we would like to see if there is any evaluation of the fracture resistance of the coated cladding. The method used to apply the coating can be a factor in fracture and fatigue resistance.

Framatome Response:

Information regarding the fracture resistance of the Cr-coated cladding is now provided in reference [3] and is provided as an appendix to the SAR, Section 2.12.2.

Reference [4] was provided informally to the NRC. Reference [4] has been removed from this document (FS1-0040260) since the discussion concerning fabrication slip loads has been removed. The justification for this change is that any potential changes or variation to the slip load has no change to the results of the lifted rod impact evaluation. By removing the discussion of the slip load it simplified this part of the evaluation.

**3.**

### **Nuclear Engineering and Technology, “AREVA NP’s enhanced accident-tolerant fuel developments: Focus on Cr-coated M5 cladding”**

This described the coating process as physical vapor deposition which is likely to have little impact on fracture resistance so that information was useful.

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The data presented in the paper was geared more towards in-reactor performance. While interesting, it was not necessarily useful for evaluating the effects of Cr Coating on the cladding for transportation. Consequently, the references identified above are still needed.

Framatome Response:

The justification for the Nuclear Engineering and Technology reference was to provide a publicly available source for information regarding the eutectic temperature of the Cr-coated cladding. This reference remains in FS1-0040260.

The other identified references have been provided to the NRC reviewers. As discussed in question 2 above, one of the references has been removed and the other is provided as an appendices to the SAR in Sections 2.12.2 and 2.12.3.

### 4.

Other comments on sections that were not changed in this amendment request:

There are a couple of the statements on materials that are questionable but do not meet the threshold of a safety issue that need to be addressed in this review.

Section 3.2.2 includes a statement that Aluminum 6061-T6 has an operating temperature of 400F.

For Al 6061, the allowable stress decreases with increasing temperature for all tempers including T4, T451, T6, and T651. Aging at higher temperature or holding at higher temperature after aging at 320 degrees Fahrenheit (°F) (160 degrees Celsius (°C)) will coarsen the magnesium sulfide precipitates and correspondingly reduce the strength of the alloy (Farrell, 1995). Note that ASME Section II, Part D, Table 1B requires that time dependent properties be used for precipitation-hardened Al 6061 at temperatures at or above 350 °F (177 °C).

Farrell, K., "Assessment of Aluminum Structural Materials for Service within the ANS Reflector Vessel," ORNL/TM-13049, August 1995.

Assessment: Although the statement in Section 3.2.2. is not accurate and needs to be corrected, it is a moot point because Table 3-1 shows that the temperature of the aluminum components does not likely reach a temperature where the mechanical properties are affected. In addition, it takes time at elevated temperatures to affect the mechanical properties. The Al 6061 components are not going to be exposed to elevated temperatures for a significant period of time even in a HAC fire.

Framatome Response:

Framatome agrees with the comment and assessment but recommends that this comment be incorporated in the next amendment. The MAP-13 packages are currently being

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fabricated and other non-safety related changes are expected to be made in the next few months.

### 5.

Section 2.2.1.6 contains the following statement: *The closure pins are also fabricated from ASTM A564, Type 630, Condition H900, precipitation hardened stainless steel. Per Section 5 of NUREG/CR-1815, bolts are not considered as fracture-critical components because multiple load paths exist and bolting systems are generally redundant, as is the case with the MAP package. Therefore, brittle fracture is not a failure mode of concern.*

First, staff cannot read the drawings in the compressed file (I understand you were struggling with a file size limitation). As such, I cannot tell if these components are redundant as described.

Also, staff questions the application of NUREG/CR-1815 here.

Also, Sunder et al., 1967 showed that the impact strength of H925 aged 17-4 PH SS is very low at -40F. 9 ft-lb for H925 at -40 (Table X). H900 will be as low or lower than H925.

It is not clear for staff what the definition of Brittle fracture is in this case, but 9 ft-lb for a steel is brittle.

Slunder, C.J., A.F. Hoenie, and A.M. Hall, "Thermal and Mechanical Treatments for Precipitation-Hardenable Stainless Steels and their Effect on Mechanical Properties." NASA Technical Memorandum (TM) X-53578 Huntsville AL: NASA George C. Marshall Space Flight Center, February 20, 1967.

Assessment: Staff does not like Framatome technical bases but staff does not think this is an issue that we need to raise in this review. If staff was reviewing the original application, we might have asked for this to be addressed (perhaps in Chapter 8). Nevertheless, staff would like to see a better version of the drawings.

With respect to the closure pins fabricated from **ASTM A564, Type 630, Condition H900**, you cited Section 5 of NUREG/CR-1815 which states the following:

*Bolts are generally not considered as fracture critical components because multiple load paths exist and because bolted systems are designed to be redundant. In other words, failure of one or more bolts can be tolerated since failure normally does not lead to penetration or rupture of the container. However, in cases where a particular bolt is determined to be a fracture critical component, the toughness requirements for that bolt should be specified at the same category level as other components of the system.*

It is not clear to me whether the closure pins are considered to be a fracture critical component. Can you elaborate?

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NUREG/CR-6007 Section 6.2 specifically address material toughness requirements for bolts and states: *To assure that the bolt material has the required ductility, the material must meet the ASME Subsection NB requirements for bolting material testing and examination*

ASME NB-2128 Bolting Material states: *(a) Material for bolts and studs shall conform to the requirements of one of the specifications listed in Section II, Part D, Subpart 1, Table 4. Material for nuts shall conform to SA-194 or to the requirements of one of the specifications for nuts or bolting listed in Section II, Part D, Subpart 1, Table 4.*

Section II, Part D, Subpart 1, Table 4 identifies allowable materials for bolts. The **H900 condition for ASTM A564, Type 630 is not included in this table!**

ASTM A564, Type 630 in the H1100 condition is included. ASTM A564, Type 630 in the H1100 condition does not suffer from the low fracture resistance at low temperatures.

Framatome Response:

Clear drawings were provided to the NRC reviewers.

There are 44 closure pins on the MAP-12 and 48 for the MAP-13 packaging. These closure pins are not considered a fracture critical component due to multiple failures needed for radioactive material to be released. The nuclear safety category for these closure pins is defined as a Category B item in accordance with NUREG/CR-6407.

Framatome agrees with the comment and recommends that this comment be incorporated in the next amendment. The MAP-13 packages are currently being fabricated and other non-safety related changes are expected to be made in the next few months.

### **6.**

Table 3-1 (results from previous application with no chromium coated along the cladding) shows that the neutron moderator may have a HAC temperature (< 500 F) close to the limit (500 F). With such a small margin, what is your justification that the use of chromium coating will not increase that limit?

1) Where did you include the thermal properties (e.g., density, thermal conductivity, specific heat) of the cladding and chromium coating to ensure there is no significant HAC temperature change caused by a change of the thermal conductance between the cladding and the chromium coating.?

2) We need References [3] and [5] to verify the information that you provided on the Cr-coating heat capacity and eutectic reaction.

Framatome Response:

Information regarding the HAC temperature and the neutron moderator is now in FS1-0040260 which is provided as an appendix to the SAR, Section 2.12.2. The specific heat,

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density, and thermal conductivity is shown to have an insignificant change and therefore no change to the results of the neutron moderator since the heat input is from the outside.

- 1) The thermal properties are now included in FS1-0040260 which is provided as an appendix to the SAR, Section 2.12.2.
- 2) References have been provided to the reviewers.

### **7.**

Provide justification that the lifted rod condition is bounded by the seated rod configuration.

Framatome Response:

Information to justify the lifted rod condition is now in FS1-0040260 which is provided as an appendix to the SAR, Section 2.12.2.

Reference [4], FS1-0039626, Fabrication of GAIA Fuel Assemblies with Chrome Coated Fuel Rods was provided informally to the NRC. Reference [4] has been removed from FS1-0040260 since the discussion concerning fabrication slip loads has been removed. The justification for this change is that any potential changes or variation to the slip load has no change to the results of the lifted rod impact evaluation. By removing the discussion of the slip load it simplified this part of the evaluation.