SAFETY EVALUATION REPORT
Docket No. 71-3034
Model No. TN-BGC1
French Package Design Certificate No. F/313/B(U)F-96
Revision Jbb

SUMMARY

The Department of Transportation (DOT) requested the Nuclear Regulatory Commission staff's recommendation concerning the revalidation of the Model No. TN-BGC1 package, French Package Design Certificate No. F/313/B(U)F-96, for transport of non-pyrophoric powders. The package is currently licensed under International Atomic Energy Agency (IAEA) *Regulations for Safe Transport of Radioactive Material*, TS-R-1, Rev. 2009, by the French Competent authority. The package is suitable for sea, road, and air transport.

On June 12, 2009, staff recommended revalidation of the Model No. TN-BGC1 package, as described in French Certificate of Approval No. F/313/B(U)F-96, Rev. No. Iak, with the condition that uranium metallic powder and uranium tetrafluoride be prohibited under Content No. 11 as allowable contents. The justification for prohibiting uranium metallic powder was insufficient controls on leak tightness and pressure to eliminate the potential for a pyrophoric reaction. On March 25, 2015, as supplemented March 24, May 18, May 20, and May 21, 2015, DOT requested NRC staff's assistance in evaluating the Model No. TN-BGC1 package as described in French Certificate of Approval No. F/313/B(U)F-96, Rev. No. Jbb. DOT requested that the review be limited to determining if the prohibition of shipping uranium powder under Content No. 11 could be relaxed to allow the shipment of non-pyrophoric uranium powder. Based on the statements and representations in the application, as supplemented, staff recommends revalidation of the French Package Design Certificate No. F/313/B(U)F-96, for use in the United States, with the following conditions:

(1) For Content No. 11, the maximum fissile mass is not to exceed 5 kilograms U-235 per package. The mass of water and the equivalent mass of other hydrogenous materials must not exceed 2000 grams per package. The guaranteed containment diameter must not exceed 120 mm;

(2) Uranium metallic powder is prohibited under Content No. 11 if it can ignite within five (5) minutes after coming in contact with air when tested according to section 33.3.1.4 Test N.2 of the UN Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria; and

(3) For Content No. 26, the maximum number of TRIGA fuel elements per package is not to exceed 5 standard elements or 23 thin elements, where standard and thin elements are defined in F/313/B(U)F-96 26ak, Appendix 26, Content No. 26. The total mass of cardboard must not exceed 1200 grams, the moisture content of the wood components must not exceed 10 percent, and the total water content (including moisture content of

the wood and water equivalent in the form of cardboard) must not exceed 2900 grams per package. No other hydrogenous packaging materials are permitted within the package containment vessel.

1.0 GENERAL INFORMATION

The application requested approval to ship uranium molybdenum powder enriched to less than 20 percent uranium-235 (^{235}U) by weight having a ceramic coating under Content No. 11. Previous versions of French Certificate of Approval No. F/313/B(U)F-96 described Content No. 11 in broad terms and identified that the minimum mass of material allowed for shipment was 7 kilograms of uranium. However, French Certificate of Approval No. F/313/B(U)F-96, Rev. No. Jbb created sub-content categories for Content No. 11 with each sub-content category having better defined characteristics and a variety of maximum mass limits. The application specifically classified the powder as Content No. 11d which allows a maximum of 7 kilograms of uranium. Consequently, based on a review of the statements and representations in the application the staff concludes the contents have been adequately described and evaluated to meet the International Atomic Energy Agency (IAEA) requirements of TS-R-1, Rev. 2009, provided compliance with the conditions below is assured.

2.0 MATERIALS

The material to be shipped is Uranium-Molybdenum (UMo) metallic powder with a ceramic coating enriched to less than 20% by weight in the isotope ^{235}U. The material will be shipped under Content No. 11d. The application states that the shipper shall test the UMo as specified in Section 124 of Title 49 *Code of Federal Regulation* Part 173 to United Nations Manual of Tests and Criteria 33.3.1 and justify that the material is non-pyrophoric (ML15111A460). Test results submitted in support of the application substantiated the non-pyrophoric behavior of the material (ML15138A309 and MI15142A386). The staff finds that the submitted testing documents discussed above provide reasonable assurance that the coated UMo is non-pyrophoric and that the contents meet the IAEA requirements of paragraph 506 in TS-R-1, Rev. 2009, provided compliance with the conditions below is assured.

3.0 CRITICALITY

For ground transport of fissile materials, the provisions of paragraphs 650 to 671, 673 to 679, 681, and 682 in IAEA TS-R-1 apply. Paragraphs 681 and 682 specify, in part, that an array of packages must be subcritical under conditions consistent with the Type B package tests, assuming reflection by at least 20 cm of water. For air transport of fissile materials, the provisions of paragraphs 650 to 671, 673 to 679, and 680 in IAEA TS-R-1 apply. Paragraph 680 specifies, in part, that the package shall be subcritical under conditions consistent with the Type C package tests as specified in paragraph 734, assuming reflection by at least 20 cm of water.

The application sought approval to ship a metallic UMo alloy powder coated with a zinc-nitride ceramic. The application identified that the uranium, 91% by weight for the coated particles, will be enriched to less than 20% ^{235}U. The application referenced a criticality safety evaluation submitted on November 19, 2013 (ML13345A106). This criticality evaluation was generated using the APOLLO and MORET criticality codes. Using these criticality codes, the TN BGC-1 package was modeled with 15 kilograms of 100% enriched ^{235}U solid uranium-bearing

materials, Content No. 11, with varying amounts of water in a TN-90 container under both normal conditions of transport and hypothetical accident conditions. Under hypothetical accident conditions, the package is assumed to retain the geometric shape and dimensions. The application models damage to the package under hypothetical accident conditions as a loss of 15 mm of the 48 mm neutron poison resin layer and the outer cage. The application shows these packages remain subcritical under both normal conditions of transport and hypothetical accident conditions. The application also evaluated an array of 5N damaged packages, where N=50, and found it to be subcritical. Therefore the Criticality Safety Index is determined as 1.0 for this package in accordance with TS-R-1, paragraphs 681-683. For air transport, only a single package needs to be evaluated at both normal conditions of transport and hypothetical accident conditions. The application evaluated the packages with a maximum fissile load of 15 kilograms of uranium, assumed to be 100% ^{235}U. The hydrogenous packaging materials are estimated to be 2000 g of water plus 2500 g of carbon. Other material considered in the analysis included the stainless steel shells and aluminum spacers. The application assumed the borated resin, which is a neutron absorber, was present.

Staff performed an independent analysis using SCALE 6.1 for ground and air transport packages. The staff criticality models assumed the borated resin was not present in the package and all non-metal space was modeled as full-density water. Staff assumed a maximum fissile mass of 5 kg for material that would qualify to be shipped as Content No. 11, specifically Content No. 11d. Both heterogeneous and homogeneous systems were analyzed at both 100% and 20% enriched in ^{235}U. The analyses supporting the application only investigated package geometry with a diameter of 100 mm. This does not correspond to the application's stated intention to qualify the material under Content No. 11d, which has a containment diameter guaranteed to be less than 120 mm. Staff's analyses instead assumed maximum containment diameter to be 120 mm. The application provided documents stating weight percentages of the powder components. From these documents, staff observed that the ZnN ceramic coating replaces uranium compared to the uncoated material composition. Staff conservatively assumed the fissile material consisted of uncoated powder, with weight fractions of 93% and 7% for uranium and molybdenum, respectively. This assumption maximizes fissile material in the model.

Staff modeled both homogeneous and heterogeneous systems. Staff varied fissile geometry to determine maximum reactivity. These selections ranged from water-reflected spheres of solid UMo at theoretical maximum density to cylinders of homogenized UMo-water mixtures with increasing volume until the internal cavity was filled. Staff repeated this analysis for a water-reflected array of 288 packages in two layers of 144 packages in a hexagonal array. The space between the packages was modeled as void, and per paragraph 681 of TS-R-1 for N=50, the number of packages analyzed conservatively exceeds five times N with neutron poison resin removed. For the array analysis, staff utilized a reflective boundary condition on the bottom face of the array, effectively inverting the bottom layer. This arrangement conservatively minimizes the vertical separation between the fissile mass in each layer. In all cases, staff's analyses showed that, when enriched to 20% ^{235}U, the results are bounded by prior staff analyses of a system enriched to 100% ^{235}U.

The staff finds that the package meets the IAEA requirements of paragraph 680 in TS-R-1, Rev. 9, provided compliance with the conditions prescribed below is assured.

CONDITIONS

The NRC recommends revalidation of French Competent Authority Certificate F/313/B(U)F-96, for use in the United States with the following conditions:

(1) For Content No. 11, the maximum fissile mass is not to exceed 5 kilograms U-235 per package. The mass of water and the equivalent mass of other hydrogenous materials must not exceed 2000 grams per package. The guaranteed containment diameter must not exceed 120 mm;

(4) Uranium metallic powder is prohibited under Content No. 11 if it can ignite within five (5) minutes after coming in contact with air when tested according to section 33.3.1.4 Test N.2 of the UN Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria; and

(2) For Content No. 26, the maximum number of TRIGA fuel elements per package is not to exceed 5 standard elements or 23 thin elements, where standard and thin elements are defined in F/313/B(U)F-96 26ak, Appendix 26, Content No. 26. The total mass of cardboard must not exceed 1200 grams, the moisture content of the wood components must not exceed 10 percent, and the total water content (including moisture content of the wood and water equivalent in the form of cardboard) must not exceed 2900 grams per package. No other hydrogenous packaging materials are permitted within the package containment vessel.

CONCLUSIONS

Based on the statements and representations contained in the application, as supplemented, the staff concludes the Model No. TN-BGC1 package design, with the above stated conditions meets the IAEA requirements of TS-R-1, Rev. 2009. Therefore, the staff recommends revalidation of French Competent Authority Certificate F/313/B(U)F-96, for use in the United States with these conditions.

Issued with letter to R. Boyle, Department of Transportation, on June 30, 2015.