August 5, 2015

Mr. Richard W. Boyle, Acting Director
Division of Engineering and Research
Office of Hazardous Materials Safety
U.S. Department of Transportation
1200 New Jersey Ave., S.E.
Washington, D.C. 20590

SUBJECT: REVALIDATION OF THE ARGENTINE CERTIFICATE OF APPROVAL NO. RA-009-B(U)F-96, REVISION 2, FOR THE MODEL NO. MG1 PACKAGE

Dear Mr. Boyle:

This is in response to your letter dated March 26, 2014, requesting our assistance in evaluating the Model No. MG1 package, authorized by the Argentine Certificate of Approval No. RA-009-B(U)F-96, Revision 2.

On December 11, 2014, April 9 and June 9, 2015, you provided the responses to two requests for additional information (RAI) letters dated August 6, 2014, and March 17, 2015, respectively.

Based upon our review, the statements and representations contained in the safety analysis report for the Model No. MG1 package, as supplemented, and for the reasons stated in the enclosed safety evaluation report, we recommend revalidation of the Argentine Certificate of Approval No. RA-009-B(U)F-96, Revision 2, with the following conditions:

(1) MTR fuel assembly grids, as described in Drawing Nos. 0767-1600-3BMPQ-204-1B and 0767-1600-3CFPQ-205-1A, are allowed for transport. Transport of control rod elements in any other assembly grid, as depicted in Drawing No. 0908-GU01-3ASIN-026-A, is not authorized.

(2) The package can only be lifted using the external hoisting eyes in accordance with step 2 of Section 6.1 of the Operations and Shipment Manual (Document No. CDAD-1001-3MSGC-005-E, Revision E).

(3) The tie-down configuration, shown in Figure 5 of the Operations and Shipment Manual (Document No. CDAD-1001-3MSGC-005-E, Revision E), is the only approved method to secure the package for transport.

If you have any questions regarding this matter, please contact Pierre Saverot of my staff at (301) 415-7505.

Sincerely,

/RA/

Mark Lombard, Director
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-3086
TAC No. L24907

Enclosure: Safety Evaluation Report

If you have any questions regarding this matter, please contact Pierre Saverot of my staff at (301) 415-7505.

Sincerely,

/RA/

Mark Lombard, Director
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-3086
TAC No. L24907

Enclosure: Safety Evaluation Report

This closes TAC No. 24907

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SAFETY EVALUATION REPORT
Model No. MG1
Argentine Certificate of Approval No RA-009-B(U)F-96, Revision 2
Docket No. 71-3086

By letter dated February March 26, 2014, the U.S. Department of Transportation (DOT) requested the Nuclear Regulatory Commission (NRC) staff's assistance in evaluating the Model No. MG1 package, as authorized by the Argentine Certificate of Approval No. RA-009-B(U)F-96, Revision 2, to provide a recommendation concerning the revalidation of the certificate for import and export use.

On December 11, 2014, April 9 and June 9, 2015, DOT provided the responses to two requests for additional information (RAI) letters dated August 6, 2014, and March 17, 2015, respectively.

The staff evaluated the Model No. MG1 package against the standards in the International Atomic Energy Agency (IAEA), "Regulations for the Safe Transport of Radioactive Material," Safety Standards Series No. TS-R-1, 2009 edition.

Based upon the statements and representations contained in the application and supplemental information received on December 11, 2014, April 9 and June 9, 2015, the staff recommends revalidation of the Argentine Certificate of Approval No. RA-009-B(U)F-96, Revision 2, with the following conditions:

Condition No. 1: MTR fuel assembly grids, as described in Drawing Nos. 0767-1600-3BMPQ-204-1B and 0767-1600-3CFPQ-205-1A, are authorized for transport. Transport of control rod elements in any other assembly grid, as depicted in Drawing No. 0908-GU01-3ASIN-026-A, is not authorized.

Condition No. 2: The package can only be lifted using the external hoisting eyes in accordance with step 2 of Section 6.1 of the Operations and Shipment Manual (Document No. CDAD-1001-3MSGC-005-E, Revision E).

Condition No. 3: The tie-down configuration, shown in Figure 5 of the Operations and Shipment Manual (Document No. CDAD-1001-3MSGC-005-E, Revision E), is the only approved method to secure the package for transport.

1.0 GENERAL INFORMATION

1.1 Packaging

The Model No. MG1 package is a modified version of the model GURI 100 package. The six existing GURI-100 packages were modified with a new outer lid and protective skirt (Report No. 0767-1600-3ICPQ-015-10) for transportation of MTR fuel elements. These six packages were re-certified as MG-1 packages while two new MG-1 packages were also manufactured under the revised MG-1 design.

The MG1 package is constituted by a central tube, made of 304L stainless steel, with covers on both ends to form a cylindrical jacket. The inner jacket is 2 mm thick while the outer jacket is 6 mm thick. The 30 mm space between the two jackets is filled with a thermal ceramic layer of fireproof insulation blanket, known as HP1260 “Kaowool Blanket.” The two bolted covers (top and bottom) are fitted with fins on the outside and have an elastomeric protection on the inside.

The inner cavity is 1960 mm long with a 250 mm diameter, while the package itself is 2898 mm long with a 912 mm diameter. The weight of the packaging is 668 kg. The outer shell, made of a 3 mm-thick steel, is connected to the containment system by fins which are welded to both the central tube and the axial structural tubes.

1.2 Contents

The authorized contents are fresh MTR-type fuel elements.

The total payload of the MTR-type fuel assemblies is 14.542 kg of uranium with a maximum enrichment of 19.75% ^{235}U (2,910 g ^{235}U).

The gross weight of the loaded package is 774.2 kg for MTR fuel contents. The Criticality Safety Index (CSI) is zero.

2.0 STRUCTURAL EVALUATION

2.1 Structural Evaluation

The staff reviewed the MG-1 package structural performance using IAEA TS-R-1, 2009 edition for a Type B(U)F-96 package. Paragraph 650 of TS-R-1 requires that all Type (B) packages meet the general requirements specified in paragraphs 606-616, as well as the requirements specified in paragraphs 634-647. Because the MG-1 package can be shipped via air, it must also meet the additional requirements of paragraphs 617-619.

The applicant used a combination of hand calculations and ANSYS finite element software for analysis of the package. Additionally, the applicant used a full size model with a surrogate fuel to demonstrate the package performance for the tests required in Section VII of TS-R-1.

A grid supports the fuel assemblies inside the containment and a guide prevents the rotation of the support grid. The primary containment is connected to a 3 mm thick outer shell by means of six 3 mm circumferential disks. These disks are welded to the primary containment and to eight axial reinforcement pipes. Eight blades, connecting the primary containment to the outer sleeve (see Drawing No. 076716003AFPQ01310), are welded to each disk.

The package has four lifting and tie-down lugs and four shoes. The inner and outer lids are attached with 16-8 mm hex head screws. The package is lifted by means of four lugs attached to the outer sleeve with 2 mm filet welds. These lugs are also used to secure the package for transport.

The package is supported by four feet that are attached to the outer sleeve by 2 mm flare-bevel welds. The feet fit into fixing devices that are also used to secure the package for transport.

2.1.1 Compliance with paragraphs 606-616

Based on the dimensions and the weight of the package, as described by the applicant in the SAR, the staff determines that the package can be easily transported and is designed such that it can be properly secured for transport and, therefore, meets the requirements of TS-R-1, paragraph 606.

The applicant evaluates the lifting lugs by assuming a hoisting failure in which only one lug is holding the package, as shown in Figure 9 of the SAR. The staff requested the applicant to demonstrate the acceptance of the hoisting/tie-down lugs. The applicant responded with a stress analysis (Document Number: 0908-GU01-3BSIN-054, Revision C) that considered a dynamic load factor of 1.2 and assumed a package weight of 9480 N. Using the ANSYS finite element analysis software, the applicant determined the average stress in the one eyebolt to be 330 MPa. While this exceeds the yield stress of the material (172 MPa), the staff finds this acceptable, because the average stress did not exceed the failure stress (483 MPa). Paragraph 607 of TS-R-1 states that, "The design shall be such that any lifting attachments on the package will not fail when used in the intended manner…" The applicant's analysis considered only one lifting lug which does not represent the intended manner of lifting. If all four are used, the average stress in each lug will be reduced by at least a factor of four because the ANSYS analysis indicated that the maximum average stress occurred at a point in which the lug is bent due to the off angle application of the load as a result of using only one lug. This means that the average stress in each lifting lug will be at most 82.5 MPa which is well below the yield stress of the material; therefore, the staff finds that the package meets the lifting requirements of TS-R-1 paragraph 607. Furthermore, the staff finds that, if failure of the attachments were to occur and cause a failure of the outer sleeve at the point of attachment, this would not impair the package from meeting other requirements of TS-R-1, because the primary containment will still be intact and the thermal evaluation does not consider the outer sleeve; therefore, the package meets the failure requirement of TS-R-1, paragraph 607.

In addition to the acceptance of the lifting/tie-down lugs, the staff requested the applicant to demonstrate the acceptance of the 50 mm holes in the external sleeve that can be used to lift the package, as shown in Figure 11 of the SAR. The applicant responded that the holes were used only for validation tests, to hoist the package for drop tests and that they have no function during transport and will not be used to hoist in the manipulations. The applicant stated that the correct form of manipulation of the package is indicated in Section 6.1 of Document Number CDAD-1001-3MSGC-005, Revision E. With the condition that the package can be lifted only by the four lifting lugs attached to top of the package and that any holes in the outer sleeve be "rendered incapable of being used during transport," the staff finds that the package meets the requirements of TS-R-1, paragraph 608.

Based on the description of the package in the SAR, the staff finds that the package meets the requirements of TS-R-1 paragraphs 609, 610, and 611, because (i) there are no protruding features that may require decontamination, (ii) the outer layer of the package will prevent the collection of water, and (iii) there are no features added to the package that could reduce its safety.

The applicant states that the internal and external covers are attached using elastic safety Grover type rings. The staff considered NUREG-6007, "Stress Analysis of Closure Bolts for Shipping Casks," which states that the vibration load on bolts is normally not significant unless a resonance condition exists or excessive prying/bending action is present. Based on the description of the closure systems in the SAR, the staff concludes that there will be no prying or

bending action on the bolts as a result of transportation vibration. Additionally, Chapter 7 of NUREG-6007 states, “A desirable engineering practice concerning closure bolts is the use of anti-vibration-loosening devises or other methods to maintain a steady operating preload.” Based on the use anti-vibration-loosening devices and a preload of 9.8 N-m torque, the staff finds that the package meets the vibration requirements of TS-R-1, paragraph 612.

Based on the description of the package, there are no valves; therefore, the staff finds the package meets the requirements of TS-R-1, paragraph 614. Additionally, the staff finds that the design of the package considers all ambient temperatures and pressures and, therefore, meets the requirements of TS-R-1, paragraph 615.

The staff finds that the package meets the general structural requirements for all packages specified in paragraphs 606-616 of TS-R-1.

2.1.2 Compliance with Paragraphs 617-619

The applicant determines the maximum normal operating pressure to be 370 kPa, assuming an internal temperature of 500°C. Based on this internal pressure, the applicant determines the maximum stress in the internal sleeve to be 22.6 MPa which is stated to be much lower than the yield stress of 196 MPa. Additionally, the applicant determines the maximum stress in the closure bolts for the internal cover to be 22.6 MPa, which is also stated to be much lower than the yield stress of 588 MPa for the bolt material. For air transport, TS-R-1 requires the analysis for an internal pressure which produces a pressure differential of not less than the maximum normal operating pressure plus 95 kPa. The applicant did not conduct this analysis; however, the staff notes that adding the additional 95 kPa to the internal pressure of 370 kPa increases the stress in the internal sleeve and the closure bolt by a factor of 1.27. Even with this increase, the stress in both the internal sleeve and especially the closure bolts is much less than the yield stress of the material. The staff concludes that package is capable of withstanding, without leakage, this applied pressure and meets the requirements of TS-R-1, paragraph 619.

The staff finds that the applicant demonstrates that the package meets the additional structural requirements for packages transported by air specified in paragraphs 617-619.

2.1.3 Compliance with paragraphs 634-647

As described by the applicant, the package is 912 mm in diameter and 2898 mm long; therefore, the staff finds that the package meets the requirements of TS-R-1, paragraph 634.

The staff requested the applicant to describe the feature that will be incorporated into the outside of the package that will provide evidence the package has not been opened. The applicant responded that a metallic safety seal with identification number is fitted to the outside of the package for immediate verification that the package has not been opened during shipment in accordance with paragraph 7 of Section 6.2.6 of Document Number CDAD-1001-#MSGC-005, “Operations and Shipment Manual.” The staff reviewed this document and finds that the package meets the requirements of TS-R-1, paragraph 635.

The applicant states that the package can be shipped via land, sea, or air. Because of discrepancies between the SAR and the Shipping Procedures, the staff requested the applicant to provide a full static analysis of the tie-down configuration and clearly indicate the configuration that is to be used for transport.

In Document No. 0908-GU01-3BSIN-054, Revision C, the applicant analyzes the package for the following simultaneously applied accelerations to the center of gravity of the package:

- 10 g axial acceleration
- 5 g lateral acceleration
- 2 g vertical acceleration

The applicant reports a maximum stress of 234 MPa in the weld that attaches the tie-down lugs to the container which is below the allowable stress of 241 MPa. The applicant reports that the stresses on the interior weld of the legs approach the maximum allowable, with one portion exceeding the allowed value of 241 MPa. The applicant attributes this to the geometric discontinuity that results from the way in which the joint was modeled, and states that the weld seam is very likely to reduce this discontinuity by making a smoother transition in the connection than that of the model.

The staff reviewed the ANSYS model results and finds that the maximum stress at the interior weld location is acceptable, because the average stress in the entire weld is below the allowable stress. As the material at this location yields, the rest of the weld will assume more load and will not cause the connection to fail. With the condition that the tie-down configuration, shown in Figure 5 of the Operations and Shipment Manual (Document No. CDAD-1001-3MSGC-005-E, Revision E), is the only approved method to secure the package for transport, the staff finds that under normal and accident conditions of transport, the forces in the tie-down attachments will not impair the structural performance of the package and that the package meets the requirements of TS-R-1, paragraph 636.

The applicant states that the internal sleeve and the internal lid comprise the containment boundary. Based on the description of the package by the applicant, and the evaluation of the package for air transport, the staff finds that the package cannot be opened unintentionally or by a pressure that may arise in the package and meets the requirements of TS-R-1, paragraph 639.

Based on the applicant's description of the package, the staff concludes that the containment system does not form a separate unit of the package, per se; however, it is capable of being securely closed by a positive fastening device which is independent of any other part of the packaging in that the internal lid is bolted to the internal sleeve and serves no other purpose. In either case, the staff finds that the package meets the requirement of TS-R-1, paragraph 641.

The applicant demonstrates that the package can withstand, without leakage, an additional increase in the differential pressure produced by the maximum operating pressure of 95 kPa (paragraph 619). A reduction in ambient pressure to 60 kPa represents an increase in the differential pressure of 41 kPa (101 kPa – 60 kPa = 41 kPa) which is less than 95 kPa; therefore, the staff concludes that the package meets the requirements of TS-R-1, paragraph 643.

Based on the description of the package, there are no valves; therefore, the staff finds the package meets the requirements of TS-R-1, paragraph 644.

Based on the description of the package, there is no separate radiation shield. The internal and external lids are bolted to the internal and external sleeves respectively to form internal and external compartments. These are attached by fins as described earlier in the SER. Based on paragraph 645.1 in TS-G-1.1 that states, "The requirement of para. 645 is primarily intended to

ensure that the radiation shield is constantly maintained…," the staff finds the package meets the requirement of TS-R-1, paragraph 645.

The applicant asserts that, based on the description of the package and the material of construction, the water spray test of paragraph 721 will not modify the initial conditions of the free drop, stacking, and penetration tests, in accordance with paragraph 719. Additionally, the applicant states that damage caused by the penetration and freefall tests of paragraphs 722 and 724, respectively, can be disregarded, based on the performance of the package under accident conditions.

For the stacking test, the applicant states that failure of the internal fins reinforcements will cause the package to lose its effectiveness. Based on the weight of five packages and the yield stress of the material, the applicant states that the cross sectional area of the fin reinforcement is more than three times the cross sectional area required to preclude failure.

Based on the materials of construction, the staff finds that the water spray test will have no impact on the performance of the package for the other tests. Additionally, based on the performance of the package under accident conditions (evaluated later in this SER), and the analysis of the package for stacking, the staff finds that the package will not lose its effectiveness, in compliance with TS-R-1, paragraph 646, after being subjected to the tests of paragraphs 710–724. Because the package is not designed for liquid radioactive material or gases, the staff finds that the requirements of TS-R-1, paragraphs 647–649 are not applicable.

The staff finds that the package meets the structural requirements as specified in paragraphs 633-641 and 643-649.

2.1.4 Compliance with Paragraph 727

For the mechanical tests specified in paragraph 727, the applicant determined the combination and sequence that leads to the maximum damage for the thermal test is the 9 m drop (727a) followed by the punch test (727b). The applicant used a full scale model with a surrogate fuel that was equal in weight and dimensions to the actual fuel. Following the sequence mechanical tests specified in paragraph 727, the applicant reports that the only significant damage is the failure of the bolts on the external cover which allows the external cover to detach. The applicant determined that this is acceptable because (i) there was no damage to the internal tube or the internal cover (primary containment), (ii) the thermal screen remains in place and (iii) only the internal tube is considered for the thermal test of paragraph 728. Based on the applicant's description of the full size scale model after the drops test, the staff finds that protection for the package will remain effective after being subjected to the tests of paragraph 727.

Staff recommends the following conditions to be included for the revalidation of Certificate of Approval, RA/0099/B(U)F-96, Revision 2, for transport of MTR fuel elements, to ensure that the integrity of the package is maintained during lifting operation and transport:

(1) The package can only be lifted using the external hoisting eyes in accordance with step 2 of Section 6.1 of the Operations and Shipment Manual (Document No. CDAD-1001-3MSGC-005-E, Revision E).

(2) The tie-down configuration shown in Figure 5 of the Operations and Shipment Manual (Document No. CDAD-1001-3MSGC-005-E, Revision E) is the only approved method to

secure the package for transport. Contrary to step 10 of Section 6.3.1, the officer in charge cannot approve a configuration different than that shown in Figure 5 of the Operations and Shipment Manual.

2.2 Materials Evaluation

A materials review of the MG-1 package was conducted to ensure compliance with the safety requirements of paragraphs 613, 615, 618, 638, 642, 651-656, 664 and 676 of IAEA TS-R-1, 2009 Edition. The evaluation included verifying materials compatibility, ability of the materials to perform without degradation, any potential generation of gases or corrosive atmospheres from radiolysis, and ability of the materials to meet the temperature requirements.

The staff requested legible drawings with clear descriptions of the materials of construction, including any design standards used. Many of the drawings provided in the original application did not provide legible dimensions and often only included text in Spanish. The drawings did not reference the materials of construction, nor was a bill of materials provided to cross-check with the drawings. The staff obtained large-scale drawings and verified the package materials and their ability to meet TSR-1 (2009) requirements. The package does not contain any welds between Aluminum AA-6061 and steel (SST AISI 304L, ASTM 516) components.

The staff asked for clarification that chrysotile asbestos was not included in the package design, since several documents referred to the first material as a thermal insulator. The applicant clarified that all six GURI-100 packages were modified to replace the chrysontile asbestos with the new insulator Kaowool HP 1260, and no other insulation material would be used (Report No. 0908-GU01-3BSIN-001-C).

The staff further asked for clarification of the grade of ASTM 516 used in Parts 3 and 6 (lid flanges) of Drawing No. 0767-1600-3AFPQ-013-10, “MTR Fuel Container Body.” The ductile-to-brittle transition temperature (DBTT) of the 516 steel can vary significantly depending on its grade and heat treatment. The applicant clarified that the flanges are manufactured using ASTM 516 Grade 70 steel (DBTT -46°C in accordance with ASME B&PVC Code 2013, Section II Part A). The staff also asked clarification if a single fuel assembly grid would be used for both MTR and bar-type fuel elements, since the certificate from the Argentine Competent Authority states that different types of holding grids are fitted inside the cylinder, as appropriate to the type of contents to be transported. The applicant clarified that holding grid for shipment of control elements is not included in the certificate, and did not submit any revised drawings.

Based on its review of the materials and representation provided by the applicant, the staff has reasonable assurance that transport of MTR fuel elements in the MG-1 package meets the materials performance requirements of TS-R-1.

The staff recommends revalidation of Certificate of Approval, RA/0099/B(U)F-96, Revision 2, from the Argentine Competent Authority, for transport of MTR fuel elements, with the following condition:

MTR fuel assembly grids, described in Drawings Nos. 0767-1600-3BMPQ-204-1B and 0767-1600-3CFPQ-205-1A, are allowed for transport. Transport of control rod elements in any other assembly grid, as depicted in Drawing No. 0908-GU01-3ASIN-026-A, is not authorized.

3.0 THERMAL EVALUATION

The staff reviewed the MG1 package to verify that the thermal performance of the package has been adequately evaluated for the thermal tests specified in Safety Standards No. TS-R-1 ("Regulations for the Safe Transport of Radioactive Material"), 2009 Edition.

The thermal tests, specified in paragraph 728 of TS-R-1, require the package to be exposed to a thermal environment which provides a heat flux at least equivalent to that of a hydrocarbon fuel–air fire in sufficiently quiescent ambient conditions to give a minimum average flame emissivity coefficient of 0.9 and an average temperature of at least 800°C, fully engulfing the specimen, with a surface absorptivity coefficient of 0.8 or that value which the package may be demonstrated to possess if exposed to the fire specified, starting from a steady state ambient temperature of 38°C.

In order to demonstrate compliance with IAEA TS-R-1 requirements, the applicant performed a thermal analysis of the MG1 package, as described in the application. The applicant stated that it is very difficult to evaluate the heat transfer from the outer enclosure to the central tube; so, it assumed the outer wall of the central tube is maintained at 800°C for half an hour.

The applicant estimated the maximum temperatures reached by the aluminum alloy (which the grid and fuel elements are made of) by using an analytical solution of the heat conduction equation for concentric cylinders. The applicant calculated a maximum temperature of 451°C, which is lower than the meltdown failure temperature at grain boundaries of 590°C, as identified in the application.

The staff reviewed the applicant's analysis and assumptions to determine the adequacy of the analytical approach and also to determine the conservatisms in the calculations. Additionally, the staff performed confirmatory analyses using a general purpose heat transfer code, based on the model described in the application.

Based on the review of the applicant's analysis and results and staff's confirmatory analysis, the staff determined that the applicant's approach is acceptable and the results are conservative.

Based on the described model and the thermal evaluation results, the staff finds the MG1 package thermal evaluation during hypothetical accident conditions fire conditions? acceptable because it demonstrates compliance with applicable IAEA regulations for the safe transport of radioactive material.

Based on review of the statements and representations in the application, the staff concludes that the thermal performance of the MG1 shipping container has been adequately analyzed to determine compliance with the IAEA TS-R-1 safety standards.

4.0 CONTAINMENT EVALUATION

The staff reviewed the MG1 package to verify that the containment performance of the package has been adequately evaluated for tests specified in International Atomic Energy Agency (IAEA) Safety Standards No. TS-R-1 ("Regulations for the Safe Transport of Radioactive Material"), 2009 Edition.

The primary containment of the MG1 package consists of a central tube, thermal insulation, and two cylindrical steel sleeves. The radioactive contents (described in the application) are loaded

in the inner cylindrical sleeve. The central tube is fitted with an elastomer protection on the internal face.

The applicant performed the applicable tests described in TS-R-1 to demonstrate containment of the radioactive contents is not challenged. Based on the results of these tests, the applicant concluded that under both normal and accident conditions, the integrity of the radioactive contents and primary containment (central tube) is demonstrated to comply with the limits for loss of radioactive material contents under normal transport conditions and accident conditions.

The staff reviewed the application to determine that a description of the containment system has been provided and that applicable tests were performed to demonstrate containment of the radioactive material is assured under normal and accident conditions.

The staff also reviewed the application to determine acceptable limits for loss of radioactive material have been identified and comply with both normal and accident conditions. The staff determined these limits were adequately identified in TS-R-1 regulations and adequately complied with during the applicable tests.

Based on review of the statements and representations in the application, the staff concludes that the containment system of the MG1 package has been adequately analyzed to determine compliance with the IAEA safety standards described in TS-R-1.

5.0 SHIELDING EVALUATION

This section is not applicable.

6.0 CRITICALITY EVALUATION

The purpose of this review is to verify that the package design meets the criticality safety requirements of the IAEA Safety Standards (TS-R-1, 2009 Edition), under normal conditions of transport and hypothetical accident conditions.

The contents for this package are MTR-type fuel assemblies. The fuel is U_3Si_2-Al with uranium enriched in U^{235} to 19.75%. Cadmium wires, embedded in the external aluminium supports, are used as burnable poisons, and extend approximately along the active height of the fuel assembly.

The Table below shows the materials that make up the Replacement Research Reactor fuel assemblies, as considered in the criticality analyses that were performed.

Table 2: Fuel assembly material composition					
Material		Mass per FA [g]	Density [g/cm^3]	Element	Weight %
Fuel (U Si - Al)	SI480	3334 (484 g ^{235}U)	6.5108	U	73.72
				Al	20.47
				Si	5.80
	SI380	2957 (383 g ^{235}U)	5.77535	U	65.80
				Al	29.02
				Si	5.18
	SI210	2269 (212 g ^{235}U)	4.43070	U	47.39
				Al	48.87
				Si	3.73
6061 aluminium		4561	2.7	Al	98.92
				Cr	0.2
				Si	0.6
				Cu	0.28

The applicant performed all criticality analyses using the Monte Carlo code, MCNP, Version 4C. The cross sections used for the analysis were based on ENDF/B-VI data. This code system has been validated industry-wide. The applicant complied with paragraph 671 of TS-R-1, which requires subcriticality in normal and hypothetical accident conditions. Subcriticality is based on the applicant's calculation of the effective multiplication factor, k_{eff}.

In accordance with paragraph 681 of TS-R-1, the applicant calculated $k_{eff} + 3\sigma = 0.364$ for an infinite package arrangement under normal conditions of transport. Under hypothetical accident conditions, in accordance with paragraph 682 of TS-R-1, the applicant calculated $k_{eff} + 3\sigma = 0.662$ for an infinite package array. The applicant performed this analysis taking in consideration water entry into the package compartments, with variation in water density, and studying density values ranging from 10^{-7} to 1.0 g/cm^3.

The applicant also considered other scenarios to demonstrate compliance with paragraph 680 (a) of TS-R-1, which is specifically for packages to be transported by air. The applicant assumed having the package and its contents as fully damaged with the fuel assemblies, together with the hydrogenized material inside the package (nylon and asbestos), forming a homogeneous sphere. The homogeneous sphere is in direct contact with the water surrounding it (infinite reflector and a density of 1.0 g/cm^3). No credit was given to the confinement system or other package components. The scenario results in a $k_{eff} + 3\sigma = 0.922$.

The staff performed independent confirmatory evaluations of the MG1 package, for the homogeneous sphere, using the CSAS6 sequence of the SCALE 6.1 code package, with the KENO VI 3-D Monte Carlo code and ENDF/B-VII continuous energy cross-sections. Using assumptions similar to those of the applicant, the staff's confirmatory calculations resulted in a maximum k_{eff} similar to what was reported in the application. Therefore the staff has reasonable confidence in the applicant's calculated values.

From the above analysis and for this application, in accordance with paragraph 683 of TS-R-1, the CSI is equal to 0.

Based on the review of the statements and representations contained in the application, as supplemented, the staff agrees that the MG1 package meets the standards in IAEA Safety Standards Series No. TS-R-1.

7.0 PACKAGE OPERATIONS

The application includes the conditions for use of the packaging, describing the loading of the package in a cell or in a pool, the preparation and inspection prior to shipment, the drying of the cavity, the leaktightness verification prior to transport, the unloading operations, and the decontamination of the package after loading.

The package is prepared for transportation according to INVAP Operations Manual Document No. CDAD-1001-3MSGC-005-E, Revision E.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The application includes instructions for a maintenance program and specifications for periodic maintenance.

The package is maintained according to INVAP Inspection and Maintenance Manual CDAD-10001-3MSGC-006-A

CONCLUSION

Based on the review of the statements and representations contained in the application, as supplemented on December 11, 2014, April 9 and June 9, 2015, and for the reasons stated in this safety evaluation report, the staff agrees that the Model No. MG1 package, authorized by the Argentine Certificate of Approval No RA-009-B(U)F-96, Revision 2, meets the requirements of IAEA Safety Standard Series No. TS-R-1, 2009.

The staff recommends revalidation of the package with the conditions stated in the safety evaluation report.

Issued with letter to R. Boyle, Department of Transportation,
on August 5, 2015.