April 17, 2007

Mr. J. Greg Field, President
Packaging Technology, Inc.
1102 Broadway Plaza, Suite 300
Tacoma, WA 98402-3526

SUBJECT: CERTIFICATE OF COMPLIANCE NO. 9328 FOR THE MODEL NO. TN-55 TRANSPORT PACKAGE

Dear Mr. Field:

As requested by your application dated August 28, 2006, as supplemented January 31, 2007, enclosed is Certificate of Compliance No. 9328, Revision No. 0, for the Model No. TN-55 package. The staff's Safety Evaluation Report is also enclosed.

Packaging Technology, Inc., has been registered as a user of the package under the general license provisions of 10 CFR 71.17. The approval constitutes authority to use the package for shipment of radioactive material and for the package to be shipped in accordance with the provisions of 49 CFR 173.471.

If you have any questions regarding this certificate, please contact me or Jessica Glenny of my staff at (301) 492-3285.

Sincerely,

/RA/

Robert A. Nelson, Chief
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards

Docket No. 71-9328
TAC No. L24011

Enclosures: 1. Certificate of Compliance No. 9328, Rev. No. 0
2. Safety Evaluation Report

cc w/encl: R. Boyle, Department of Transportation
J. Shuler, Department of Energy
RAMCERTS

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SAFETY EVALUATION REPORT

Docket No. 71-9328
Model No. TN-55
Certificate of Compliance No. 9328
Revision 0

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SAFETY EVALUATION REPORT
Docket No. 71-9328
Model No. TN-55
Certificate of Compliance No. 9328
Revision No. 0

SUMMARY

By application dated August 28, 2006, as supplemented January 31, 2007, Packaging Technology, Inc. (the applicant), requested the U.S. Nuclear Regulatory Commission (NRC) to approve the Model No. TN-55 Transport Package (Model No. TN-55). The Model No. TN-55 packaging is designed to transport uranium oxide powder enriched to a maximum of 1.2 weight percent (wt %). As described in the Model No. TN-55 Safety Analysis Report (SAR), the packaging consists of an overpack and 55-gallon drum with a reinforced closure system. The package is approximately 51-5/8 inches in height and 32 inches in diameter. The maximum gross weight of the package is 1,010 pounds (lbs).

The package was evaluated against the regulatory standards in Title 10 of the Code of Federal Regulations (10 CFR) Part 71, including the general standards for all packages, standards for fissile material packages, and performance standards under normal conditions of transport (NCT) and hypothetical accident conditions (HAC). Staff reviewed the application using the guidance in NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material."

Based on the statements and representations in the application, as supplemented, and the conditions listed in the Certificate of Compliance (CoC), the staff concludes that the design has been adequately described and evaluated and meets the requirements of 10 CFR Part 71.

REFERENCES

Letter to Director, Spent Fuel Project Office, from J. Greg Field, dated August 28, 2006.

Letter to Section Chief, Chris Regan, from J. Greg Field, dated January 31, 2007.

EVALUATION

1.0 GENERAL INFORMATION

1.1 Package Description

The Model No. TN-55 is a 55-gallon drum enclosed in an overpack with a reinforced closure system. The Model No. TN-55 is approximately 51-5/8 in overall height and 32 inches in overall diameter. The Model No. TN-55 is designed to transport uranium oxide (UO_2) powder enriched up to 1.2 wt % U^{235}. The maximum gross weight of the packages is 1,010 lbs.

The 55-gallon drum of the Model No. TN-55 is enclosed in an overpack design consisting of 18-gauge galvanized carbon steel. The overpack has four heavy duty latches, with eight closure screws, used to secure and lock, the overpack lid to the body. The inside of the overpack is reinforced with structural steel and filled with polyurethane foam to function as both impact and thermal protection

for the package. The 55-gallon drum is reinforced with a fiberglass liner which is molded to fit around the drum. The clamshell closure rings, reinforced by a 12-gauge by 2 inch tall ring, secure the drum lid. High-temperature ceramic gaskets are used with both the overpack lid and 55-gallon drum lid.

The containment system of the package is the assembled 55-gallon drum, including the clamshell closure ring and bolts. The containment boundary consists of the drum body, lid, and ceramic gasket.

Due to the radioactive nature of the uranium oxide powder, shielding is not necessary and is not specifically provided in the design of the Model No. TN-55 packaging.

1.2 Contents

The Model No. TN-55 is designed to transport unirradiated uranium oxide powder enriched to a maximum of 1.2 wt %. The maximum weight of the payload is 650 lbs with maximum moisture content of 2%.

The fissile material is retained in the 55-gallon drum. The drum is closed by a reinforced closure ring and a high-temperature ceramic gasket.

The contents may include other non-fissile material with the exception of deuterium, tritium, graphite, and beryllium.

1.3 Criticality Safety Index

The criticality safety index (CSI) for the Model No. TN-55 is 1.7.

1.4 Drawings

The Model No. TN-55 packaging is constructed in accordance with Areva Drawing No. 60699-SAR, sheets 1 - 4, Revision 1, TN-55 Overpack SAR Drawing.

2.0 STRUCTURAL

2.1 Structural Design

TN-55 is a Type A(F)-96, fissile package designed to transport 650 lbs of UO_2 powder enriched to a maximum of 1.2 wt % of U^{235}. The package consists of an overpack enclosing a 55-gallon drum (DOT 7A Type A and UN1A2 specification ratings with 16-gauge body, bottom and lid) utilizing a reinforced closure system. The weight of the empty drum is 360 lbs and the total shipping weight of the package is 1,010 lbs.

The overpack body and lid sheet metal shells consist of nominal 18-gauge galvanized carbon steel wall. Four heavy duty tension latches, each with a minimum breaking strength of 4,400 lbs equally spaced, are used in securing the overpack lid to the body. The clamshell type, two-part closure ring is used to secure the drum lid. Two 5/8 inch 11 UNC hex head screws and jam nuts are used to lock the rings together. There is polyurethane foam within the overpack body and lid. Reinforced fiberglass liner and high-temperature ceramic gasket material are used on both the drum lid and overpack lid.

Latches and screws form the closure, using a reinforced closure ring. The drum

gasket is coated in RTV silicone sealant to reduce fraying and to secure the joint.

The reinforced fiberglass liners, made of durable composite materials, are molded to fit around the 55-gallon drum. The composite materials include the fire-retardant vinyl ester inner shell of the overpack, which is coated with a gel. Braided ceramic rope is used in both the overpack lid and the 55-gallon drum lid. The rope is encased within a one-inch-diameter braided ceramic sleeve. Drawing No. 60699-SAR, sheets 1 - 4, Revision 1, TN-55 Overpack SAR Drawing, specifies the material used for each TN-55 packaging component.

2.2 Materials

2.2.1 Mechanical Properties and Specifications

Properties of structural materials are controlled either by purchase to an ASTM or other standard or via a written specification, which is tailored to specific requirements for this application. The fracture toughness of the steel materials is based on their thin sections with drum and shell being less than 0.06 inches thick and the angle brackets less than 0.19 inches thick. This assessment of fracture toughness is consistent with NUREG/CR-1815.

2.2.2 Chemical, Galvanic, or Other Reactions

Chemical, galvanic, or other reactions have been considered and the materials of concern are regarded as essentially non-reactive for the environmental conditions expected for this application. Should corrosion occur in the drum, it can be readily detected. The staff finds that no deleterious corrosion or other reactions are anticipated during normal use.

2.2.3 Effects of Radiation on Materials

Since the payload of the Model No. TN-55 is slightly enriched UO_2, the radiation from the payload is negligible. The staff finds that the requirements of 10 CFR 71.43(d) are satisfied.

2.3 Fabrication and Examination

Fabrication is conducted with conventional metal forming and joining techniques, including welding and riveting, with the welder qualification and the inspection requirements of AWS D1.3 1998 being followed for all welds on the overpack.

Fabrication of the metallic components of the Model No. TN-55 packaging is specified in Areva Drawing No. 60699-SAR, sheets 1 - 4, Revision 1, TN-55 Overpack SAR Drawing.

Examination methods and acceptance criteria for the transportation package are described in Section 8 of the SAR, and on the design drawings. The staff reviewed the applicant's fabrication and examination procedures and finds that they meet the requirements of 10 CFR 71.31(c).

2.4 General Requirements for All Packages

The staff reviewed the design of the Model No. TN-55 for compliance with the general requirements for all packages including (a) minimum size of 4 inches; (b) tamper indicating features, such as lockwire and latches; and (c) positive closure. The staff concludes that the Model No. TN-55 meets the requirements of 10 CFR 71.43.

2.5 Lifting and Tie-Down Standards for All Packages

2.5.1 Lifting Devices

The Model No. TN-55 features an integral shipping skid/fork pocket structure on its lower end. The overpack lid is also equipped with lift points for lifting a fully loaded package or just the lid. The regulation in 10 CFR 71.45(a), requires that any lifting attachment that is a structural part of the package must be designed with a minimum safety factor three against yielding when used to lift the package in an unintended manner. The forklift pockets provided at the bottom of the overpack body are made of 12-gauge galvanized carbon steel. The four overpack lid lifting points may be used to lift a loaded package. The analysis presented indicates that the lift lug tear-out is the critical load path. The failure of this component under excessive load would not impair the ability of the package to meet other requirements of 10 CFR Part 71. The staff concludes that the requirements of 10 CFR 71.45(a) are satisfied.

2.5.2 Tiedown Devices

There are no tie-down devices that are a structural part of the Model No. TN-55 package. The features used to lift the overpack lid will be rendered unusable for tie-down. The staff finds that the requirements of 10 CFR 71.45(b)(2) are satisfied.

2.6 Normal Conditions of Transport

The certification testing utilized full-scale certification test units (CTU) to demonstrate that the key performance objectives are met by the Model No. TN-55 package. The physical demonstration by testing includes the free drop, crush, puncture, thermal, and immersion events.

2.6.1 Heat

The simple design of the Model No. TN-55 packaging does not have any features that could be affected by differential thermal expansion of the package components. The staff finds that the requirements of 10 CFR 71.43(g) and 71.71(c)(1) are satisfied.

2.6.2 Cold

The minimum design temperature the package is assumed to encounter under normal conditions of transport (NCT) is approximately -40°F. None of the materials used for construction of the Model No. TN-55 packagings, including the 16-gauge steel, reinforced fiberglass, polyurethane foam, fasteners, and overpack outer sheet steel, will undergo ductile-to-brittle at temperatures higher than or equal to -40°F. Thus, the NCT cold event will have insignificant consequence. The staff finds that the requirements of 10 CFR 71.71(c)(2) are satisfied.

2.6.3 Reduced External Pressure

The absolute internal pressure, including maximum normal operating pressure, of the Model No. TN-55 package is 17.7 psia. The differential or equivalent gauge pressure is 14.2 psig. The drum assembly is certified to an internal pressure of 29 psig. The margin of safety is approximately 1. The staff finds that the requirements of 10 CFR 71.71(c)(3) are satisfied.

2.6.4 Increased External Pressure

The Model No. TN-55 package was exposed to an increased external pressure of 20 psia. The internal pressure of the drum assembly is equal to ambient pressure of 14.7 psia, the differential, or equivalent gauge pressure, is 5.3 psig, external. Section 2.12.2 of the SAR, shows that the differential of 5.3 psig external was evaluated by test. The tests did not show any loss of payload material or any further deformation from the test. Therefore the requirements of 10 CFR 71.71(c)(4) are satisfied.

2.6.5 Vibrations

The effects of vibration under NCT were evaluated by testing three 55-gallon drums loaded with sand and lead bricks, weighing between 900 and 1,000 lbs. The effects of vibration incidental to transport are negligible. The staff finds that the requirements of 10 CFR 71.71(c)(5) have been met.

2.6.6 Water Spray

The exterior of the Model No. TN-55 is made of galvanized sheet steel. The joint between the overpack body and lid is a small, downward facing skirt, which does not allow the collection of water or admittance of it into

the cavity of the overpack. Any openings into the overpack interior are closed with plastic pipe plugs. Thus, the staff finds that the requirements of 10 CFR 71.71(c)(6) are satisfied.

2.6.7 Free Drop

Since the package gross weight is less than 11,000 lbs the applicable free drop distance is 4 ft. The two orientations tested were the horizontal side and center of gravity (CG) over the top corner. The damage in each case was modest, and there was no loss or dispersal of package contents, and no substantial reduction in the effectiveness of the packaging. The staff finds that the requirements of 10 CFR 71.55(d)(4) and 71.71(c)(7) are satisfied.

2.6.8 Corner Drop

The Model No. TN-55 is used for transporting fissile material; however, the package weight of 1,010 lbs is greater than the 220 lb limit specified in the regulations. The test for corner drop is not applicable to the package. The staff finds that the requirements of 10 CFR 71.71(c)(8) have been met.

2.6.9 Compression

An undamaged test specimen was subjected to a compressive load of 5,075 lbs for a period of 24 hours. This load slightly exceeded five times the maximum transportation package weight of 1010 lbs. There was no damage observed to the test specimen. The staff concludes that the Model No. TN-55 adequately satisfies the requirements of 10 CFR 71.71(c)(9).

2.6.10 Penetration

A prototype of the Model No. TN-55 package, designated as the test specimen, was subjected to the penetration test. The penetration bar, weighing 13 lbs and 1-1/4 inches in diameter, was dropped from over 40 inches onto four different areas of the test specimen: the top center, the top between two foam fill ports, on the package side, and on one of the four latches. The test only left insignificant dents in the sheet metal shell. The staff concludes that the Model No. TN-55 adequately satisfies the requirements of 10 CFR 71.71(c)(10).

2.7 Hypothetical Accident Conditions

The Model No. TN-55 package was subjected to the HAC as required by 10 CFR Part 71.73. The package was subjected to the entire series of accident condition loadings by means of certification testing. Each test specified by 10 CFR 71.73 was applied sequentially, as specified in NRC Regulatory Guide 7.8 (Revision 1, March 1989). Three full-scale certification test units were subjected to the full series of free drop, crush, and puncture testing. From these one was subjected to the fire test and subsequent 3 ft immersion test, and a separate, undamaged unit was subjected to the 50 ft immersion test. It was noted that the free drops were performed from both 4 ft (NCT) and 30 ft (HAC) on the same location.

2.7.1 Free Drop

The free drop of the specimen was conducted onto a flat essentially unyielding surface in the orientation for which the maximum damage was expected. The free drop orientations selected were expected to result in the least amount of crushable medium remaining. For the Model No. TN-55 these were the horizontal side drop (Series A) and the CG over corner drop (Series B). There were no splitting, tearing, or fissures of the overpack outer skin. Due to the small height-to-diameter ratio (approximately 1.5:1) the oblique drop orientation was not performed for this package. The staff concludes that the requirements of 10 CFR 71.73(c)(1) are satisfied.

2.7.2 Crush

Fissile material packages with a mass less than 1,100 lbs and an overall density less than 62.4 lb/ft^3 are required to be subjected to the crush test. The crush test results indicated that few of the closure screws sheared partially or fully through the overpack lid hole, latches were deformed, the package diameter was reduced from the original diameter of 32 inches to 26-1/2 inches at the crease caused by the crush plate edge, the drum wall was deformed and pulled away from the lid, and in some case the drum lid was deformed. The largest deformations of the drums filled to 50 percent volumetric capacity occurred when the drum was pre-dented with two 2-3 inch dents on opposite sides of the drum located at mid height forcing a two-lobe crush pattern. The staff concludes that the Model No. TN-55 meets the requirements of 10 CFR 71.73(c)(2).

2.7.3 Puncture

A puncture test was performed by dropping the package onto a 6-inch diameter steel bar from a height of 40 inches. Oblique puncture drop tests on CTU side and CTU corner were performed. Although the puncture bar created up to 1-1/4 inch deep indentation on the overpack body and slightly deformed the overpack, there were no tears or fissures in the overpack outer skin. During the corner drop a 6 inch diameter imprint was clearly identifiable at the point of impact; there were no tears or fissures in the overpack outer skin as well. The staff finds that the requirements of 10 CFR 71.73(c)(3) are satisfied.

2.7.4 Thermal

Subsequent to all of the above mentioned tests, the full scale CTU package was tested in a fully engulfing hydrocarbon fuel fire as required by 10 CFR 71.73(c)(4). The results of the thermal test are described in Section 3.0 of this SER.

2.7.5 Immersion - Fissile Material

After the fire test, the CTU was immersed under water with an external pressure equivalent to a 3 foot head of water for 8 hours. Conservatively, the overpack was removed, and only the drum assembly was tested. There was no leakage of water or powder from the drum. A small amount of water did leak in to the drum such that the powder formed clumps near the top. Since the criticality consequences of water in-leakage were accounted for, and leakage of the payload from the drum did not occur, the immersion test for fissile material requirements in compliance with the 10 CFR 71.73 (c)(5) are considered to be satisfied.

2.7.6 Immersion - All Packages

An undamaged specimen of the Model No. TN-55 drum was immersed under water with an external pressure equivalent to a 50 ft head of water for 8 hours. The drum assembly (without the overpack structures) was filled to 50 percent with powder. The drum was also pre-dented with two 2-3 inch dents on opposite sides of the drum located at mid height forcing a two-lobe crush pattern. There was no leakage of water or powder from the drum. Although a small amount of water leaked into the drum such that the powder formed clumps near the top, the criticality consequences of water in-leakage are accounted for and leakage of the payload from the drum did not occur. The Model No. TN-55 package is considered to have met the requirements for immersion of all packages of 10 CFR 71.73(c)(6), and 10 CFR 71.51(a)(2) since A_2 is unlimited.

2.8 Evaluation Findings

In summary the Model No. TN-55 has met all the structural approval standards of Subpart E of 10 CFR Part 71.

3.0 THERMAL

3.1 Description of Thermal Design

The applicant provided the design features, decay heat of the content, temperature summaries, and a summary of the maximum pressures. In addition, the material properties and component specifications were addressed.

3.2 Normal Conditions of Transport

For NCT, the applicant used hand calculations from a reliable text to determine the temperatures of the package consistent with Part 71. The staff evaluated the calculations and found that the analyses were acceptable.

3.3 Hypothetical Accident Conditions

The applicant conducted full scale mechanical and thermal tests in compliance with 10 CFR 71.73. The staff evaluated the tests and determined that they satisfied and are consistent with 10 CFR 71.73.

3.4 Conclusions

Based on the staff's review of the Model No. TN-55 package application, the staff concludes that the thermal design has been adequately described and evaluated, and that the thermal performance of the package meets the thermal requirements of 10 CFR Part 71.

4.0 CONTAINMENT

The applicant provided a containment evaluation as part of a request for approval to transport the Model No. TN-55 package. The Model No. TN-55 is a Type A Fissile package that will be used to transport unirradiated, low-enriched uranium oxide powder.

4.1 Description of the Containment System

The containment system of the Model No. TN-55, which is protected by an overpack, consists of a 55-gallon drum with a 16-gauge minimum body, bottom, and lid; a reinforced clamshell closure ring and bolts that serve as the drum closure mechanism; and a high-temperature, ceramic gasket used on the drum lid.

The components of the containment system are depicted on sheets 2 and 3 of Areva Drawing No. 60699-SAR, Revision 1, TN-55 Overpack SAR Drawing. The package is securely closed by a positive fastening device that cannot be opened unintentionally or by a pressure that may arise within the package. There is no package feature that allows for continuous venting, and the containment system does not rely on any filter or mechanical cooling system to comply with the containment requirements in 10 CFR Part 71.

The 55-gallon drum, which has a 23-1/2 inch outside diameter (at the hoops) and is 34-5/8 inches high (without the closure ring), meets the requirements of DOT 7A Type A qualifications and UN1A2 drum qualifications, based on a minimum weight of 900 lbs. The drum closure mechanism is a reinforced, 12-gauge by 2-inch-tall, two-part closure ring, secured by two 5/8-inch, 11 UNC hex head screws and jam nuts. The 1-inch diameter, braided, ceramic gasket is fully coated in high-temperature RTV silicone sealant to reduce fraying. The gasket does not provide an air- or water-tight sealing capability, but contains the contents such that the containment requirements for Type A Fissile packages are met.

4.2 General Considerations for a Type A Fissile Package

For Type A fissile packages, no loss or dispersal of radioactive material is permitted under normal conditions of transport, as specified in 10 CFR 71.42(f).

The package must adequately contain the contents to ensure subcriticality under both normal conditions of transport and hypothetical accident conditions. The applicant has adequately demonstrated that combustible gas generated in one year do not exceed 5% (by volume) of the free gas volume in any confined region of the package.

4.3 Normal Conditions of Transport

The applicant has adequately demonstrated, by tests described in Sections 2.6 and 3.3 of the SAR, that no loss or dispersal of the contents under normal conditions of transport will occur. Additionally, the applicant has demonstrated that there is no substantial reduction in the effectiveness of the packaging and that subcriticality is ensured under normal conditions of transport. The high-temperature gasket was unaffected by both the hot and cold conditions specified in 10 CFR 71.71.

4.4 Hypothetical Accident Conditions

The staff has not officially approved the methodology discussed in Section 2.12.3.1.3 of the application, which describes simple tests performed with paper cups. Fissile material is confined within the package due to the following: 1) the inner drum container lid and ceramic fiber gasket remained attached over all the hypothetical accident conditions tests performed, and 2) although one of the certification test drums showed a small leakage of dry powder, the overpack lid and gasket remained in place to prevent this material from escaping the package.

The applicant has demonstrated, by physical testing of the package described in Sections 2.7 and 3.3 of the application, that the package adequately confines the contents to ensure subcriticality under hypothetical accident conditions.

4.5 Leak Rate Testing

Leak testing is not required for this package. The applicant has demonstrated, through physical testing, that no loss or dispersal of radioactive material will occur under normal conditions of transport. Further, the applicant has demonstrated that the package contains the contents to ensure subcriticality under both normal conditions of transport and hypothetical accident conditions. Sections 7 and 8 of the application identifies the steps that must be taken to ensure that the package is prepared for transport, tested, and maintained such that the package will be expected to meet the containment requirements of 10 CFR Part 71.

Leak testing is not required for this package. The applicant has demonstrated, through physical testing, that no loss or dispersal of radioactive material will occur under normal conditions of transport. Further, the applicant has demonstrated that the package contains the contents to ensure subcriticality under both normal conditions of transport and hypothetical accident conditions. Sections 7 and 8 of the application identify the steps that must be taken to ensure that the package is prepared for transport, tested, and maintained such that the package will be expected to meet the containment requirements of 10 CFR Part 71.

5.0 SHIELDING

Shielding is not needed for the package to meet the external radiation standards in 10 CFR 71.47.

6.0 CRITICALITY

The Model No. TN-55 package is designed to transport up to 650 lbs (295 kg) of unirradiated UO_2 powder, enriched up to 1.2 wt % in U^{235}. The powder is contained in a 55-gallon carbon steel drum with a reinforced closure ring and ceramic fiber gasket. This 55-gallon drum is contained within a fiberglass, polyurethane foam, and carbon steel overpack, also closed with a ceramic fiber gasket.

The applicant evaluated a single package and arrays of packages under both normal conditions of transport and HAC. The single package under normal conditions of transport was modeled with the overpack and dry drum contents, as water does not enter the package during the tests required by 10 CFR 71.71. The contents are assumed to contain residual water from the manufacturing process, as well as the polyethylene bags used to contain the powder. The single package under HAC was modeled assuming water in-leakage to the most reactive extent, and conservatively ignoring the overpack. The height of the water-fuel mixture was varied to find the most reactive degree of moderation.

For the HAC single package models, the applicant considered the package upright, with the package contents represented by an upright cylinder, and also on its side, with the contents modeled as a hemi-cylinder. The applicant found that the upright cylinder model was more reactive for a single package.

For arrays of packages under NCT, the applicant placed the single package model in a 7 x 7 x 4 array of 196 packages. The array model included varying interstitial moderation, including varying the polyurethane foam density. For the array under hypothetical accident conditions, the applicant placed the single package model in a 4 x 5 x 3 array of 60 packages. The applicant modeled the array in both square and hexagonal configurations, with the cylinders upright or on their sides, to determine the most reactive condition. The array model included varying internal and interstitial moderation and a close water reflector. The applicant also considered the reactivity effect on the array of flattening of the circular cross-section of the drum during the side-drop.

The applicant used the SCALE 5.0 code system with KENO V.a Monte Carlo criticality code and the 238 group ENDF/B-V cross section library for all k_{eff} calculations, with the exception of the array of oval cross-section drums under hypothetical accident conditions. For this calculation, the applicant used the SCALE 5.0 code system with KENO VI and the 238 group ENDF/B-V cross section library to perform an "information only" calculation. Both of these codes are standard in the industry for the calculation of k_{eff} and are considered appropriate for this application.

The applicant performed a benchmark analysis of the selected code and cross section sets by modeling 95 homogeneous low enriched UO_2 critical experiments using the same calculation methodology. The benchmark analysis included experiments that were as similar as possible to the modeled Model No. TN-55 system with respect to enrichment, degree of moderation, and neutron energy spectrum. The applicant calculated an upper subcritical limit (USL) for the Model No. TN-55 calculations using the Oak Ridge National Lab USLSTATS code, which follows the guidance in NUREG/CR-6361, "Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages." The applicant determined trending parameters based on the ratio of hydrogen number density (H) to ^{235}U number density (X), energy of average lethargy of fission, and ^{235}U enrichment, all of which showed little correlation. Since the Model No. TN-55 payload enrichment of 1.2 wt % is below the range of applicability of the selected critical experiments, and noting that the USL based on this parameter is at a minimum at the minimum enrichment, the applicant conservatively used the USL extrapolated to zero enrichment. The enrichment USL was greater than that calculated based on H/X ratio, which the applicant determined to be 0.9279. This minimum USL was conservatively chosen for the criticality analysis of the TN-55.

Sections 6.4 through 6.6 of the application discuss the results of the normal and hypothetical accident conditions single package and array cases, as well as the results of the evaluation of the package on its side and damaged packages with an oval cross section in an array. As expected, all of the normal conditions of transport models result in k_{eff}'s well below the USL, due to the lack of moderation inside the package. Also, the single package model under HAC produces a k_{eff} well below the USL due to the limited amount of low enriched fissile material in the package. The applicant calculated the highest k_{eff} for the array of packages under hypothetical accident conditions, due to the large amount of moderated fissile material present in the array. Analysis of oval cross section drums in a similar array showed that the cylindrical cross section drums are more reactive. The maximum k_{eff} determined for each scenario are summarized in Table 6.1-1 of the application, and in the following table.

Table 1: Maximum $K_{eff} + 2\sigma$

	Normal Conditions of Transport	Hypothetical Accident Conditions
Single Package	0.35543	0.81555
Array of Packages	0.73632	0.91979

Since the applicant determined that a 196-package array is subcritical under normal conditions of transport (5N = 196; N=39), and a 60-package array is subcritical under HAC (2N = 60; N = 30), the limiting value of N is 30. The CSI for the TN-55, determined per the requirements of 10 CFR 71.59, is 1.7.

The staff performed a confirmatory analysis of an array of the Model No. TN-55 packages under HAC using assumptions largely similar to the applicant's. One difference was that the staff chose to model the contents inside the overpack, conservatively ignoring the inner drum, the opposite of the applicant's model which ignored the overpack. The staff also modeled a different array configuration (5 x 6 x 4) with a larger number of packages (120).

The staff used the SCALE 5.0 code system with KENO V.a and the 44 group ENDF/B-V cross section library. The results of the staff's analysis were comparable to the applicant's analysis. The maximum $k_{eff} + 2\sigma$ of 0.89256 was slightly lower than that calculated by the applicant, due to the modeling differences which resulted in less neutron communication between packages in the array, and this maximum occurred at the same moderator density as in the applicant's analyses.

All of the resulting maximum k_{eff} calculated by the applicant are below the USL. The applicant has shown and the staff agrees that the Model No. TN-55 package meets the criticality safety requirements for fissile material single packages under 10 CFR 71.55, and for arrays of packages under 10 CFR 71.59, when limited to 650 lbs. of UO_2 powder enriched to a maximum of 1.2 wt % ^{235}U.

7.0 PACKAGE OPERATIONS

The staff reviewed Chapter 7 of the SAR to verify that it meets the requirements of 10 CFR Part 71 and is adequate to assure the package will be operated in a manner consistent with its evaluation for approval.

Section 7 of the application includes the preparation for loading the package, loading the contents, preparation for transport, radiation survey, and package unloading.

Based on the statements and representations in the application, the staff concludes that the package operations meet the requirements of 10 CFR Part 71 and that they are adequate to assure the package will be operated in a manner consistent with its evaluation for approval. Further, the CoC has been conditioned to specify that the package must be prepared for shipment and operated in accordance with the Package Operations in Chapter 7 of the application, as supplemented.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The staff reviewed Section 8 of the application to verify that the acceptance tests for the packaging meet the requirements of 10 CFR Part 71 and that the maintenance program is adequate to assure the packaging performance during its service life.

Section 8.1 of the application specifies the acceptance tests required to be performed prior to first use of the package. Further, fabrication specifications are listed in Areva Drawing No. 60699-SAR, sheets 1 through 4, Revision No. 1, TN-55 Overpack SAR Drawing.

Section 8.2 of the application specifies a maintenance program to ensure continued performance of the package. The maintenance program ensures that packagings not in conformance with the license drawings are removed from service until they are brought back into compliance.

Based on the statements and representations in the application, the staff concludes that the acceptance tests for the packaging meet the requirements of 10 CFR Part 71 and that the maintenance program is adequate to assure packaging performance during its service life. Further, the CoC has been conditioned to specify that each package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application.

CONDITIONS

In addition to the authorized contents listed in Sections 1.2 and the drawings listed in Section 1.4 of this safety evaluation report, the CoC includes the following conditions of approval:

Condition No. 6: Transport by air is not authorized.

Condition No. 7: In addition to the requirements of Subpart G of 10 CFR Part 71:

(a) The package shall be prepared for shipment and operation in accordance with Package Operations in Chapter 7 of this application, as supplemented.

(b) Each package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application, as supplemented.

CONCLUSION

Based on the statements and representation contained in the application, as supplemented, and the conditions listed above, the staff concludes that the Model No. TN-55 Transport Package meets the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance no. 9328, Revision No. 0,
on April 17, 2007.