December 6, 2005

Mr. Patrick L. Paquin
Duratek, Inc.
140 Stoneridge Drive
Columbia, SC 29210

SUBJECT: AUTHORIZATION FOR SHIPMENT IN THE MODEL NO. UX-30 PACKAGE

Dear Mr. Paquin:

As requested by your application dated July 15, 2005, as supplemented August 4, and October 5 and 13, 2005, and pursuant to 10 CFR Part 71, Certificate of Compliance No. 9196 for the Model No. UX-30 package is amended to authorize contents and Criticality Safety Index, as follows:

Contents

Type and form of material

Uranium hexafluoride within small (less than 19 inches in diameter) metal cylinders packaged within the containment vessel constructed and assembled in accordance with Duratek, Inc., Drawing No. C-067-005311-009, Rev. 0. The uranium may be of any enrichment.

Maximum quantity of material per package

The maximum weight of the containment vessel, dunnage, uranium hexafluoride, and any secondary packaging not to exceed 4,000 pounds.

The maximum mass of uranium-235 not to exceed the following:

Maximum uranium enrichment in any single small cylinder (weight percent U-235)	Maximum U-235 mass per package (total mass in all small cylinders) (grams U-235)
5	1600
15	1000
100	800

Criticality Safety Index **0.0**

The following additional conditions apply:

1. Each small (less than 19 inches in diameter) cylinder containing uranium hexafluoride shall be transported one time only, from the East Tennessee Technology Park near Oak Ridge, TN, to the Gaseous Diffusion Plant Environmental Restoration Facility, near Portsmouth, OH.

2. The package shall be prepared for shipment and operated in accordance with Section 7.1 of the application dated July 15, 2005, as supplemented.

3. Each packaging must meet the Acceptance Tests and Maintenance Program of Section 8 of the application dated July 15, 2005, as supplemented.

All other conditions of Certificate of Compliance No. 9196 shall remain the same.

This authorization shall expire December 31, 2007.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

/RA/

Robert A. Nelson, Chief
Licensing Section
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9196
TAC Nos. L23877

Enclosure: Safety Evaluation Report

cc: R. Boyle, Department of Transportation

The following additional conditions apply:

1. Each small (less than 19 inches in diameter) cylinder containing uranium hexafluoride shall be transported one time only, from the East Tennessee Technology Park near Oak Ridge, TN, to the Gaseous Diffusion Plant Environmental Restoration Facility, near Portsmouth, OH.

2. The package shall be prepared for shipment and operated in accordance with Section 7.1 of the application dated July 15, 2005, as supplemented.

3. Each packaging must meet the Acceptance Tests and Maintenance Program of Section 8 of the application dated July 15, 2005, as supplemented.

All other conditions of Certificate of Compliance No. 9196 shall remain the same.

This authorization shall expire December 31, 2007.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

/RA/

Robert A. Nelson, Chief
Licensing Section
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9196
TAC Nos. L23877

Enclosure: Safety Evaluation Report

cc: R. Boyle, Department of Transportation

Distribution: Closes TAC L23877 RBellamy,RI JMadera,RIII BSpitzberg,RIV Doug Collins,RII SBaggett JCuadrado JCaverly MRahimi JUmana SWilliams
Letter Amendments Notebook
Filename: E:\Filenet\ML053400267.wpd

OFC	SFPO	E	SFPO	E	SFPO	E	SFPO		SFPO		SFPO		SFPO	
NAME	NLOsgood		MRDeBose		ABBarto		HWLee		LLCampbell		GSBjorkman		RANelson	
DATE	11/29/05		11/29/05		12/05/04		11/30/04		12/05/05		12/01/05		12/01/05	

C=Without attachment/enclosure E=With attachment/enclosure N=No copy **OFFICIAL RECORD COPY**

SAFETY EVALUATION REPORT
Model No. UX-30 Package
Certificate of Compliance No. 9196

SUMMARY

By application dated July 15, 2005, Duratek, Inc., requested an amendment to Certificate of Compliance No. 9196 for the Model No. UX-30 package. Duratek requested authorization to ship uranium hexafluoride in small (less than 19 inches in diameter) cylinders within an ASME code stamped vessel in the UX-30 overpack. The small cylinders, which do not conform to ANSI N14.1 "Uranium Hexafluoride - Packaging for Transport," contain various quantities of uranium hexafluoride of various enrichments. The applicant provided an evaluation of the ASME vessel to demonstrate that it provided a containment system comparable to the ANSI N14.1 Model 30B cylinder, currently authorized for transport in the UX-30 package. In addition, the applicant provided a new criticality analysis to demonstrate that, with the new contents, the package meets the requirements in 10 CFR Part 71 for fissile material packages. The applicant also provided thermal, containment, and shielding evaluations for the package with the new contents, to show that they are bounded by previously authorized contents.

Based on the statements and representations in the application, as supplemented, the applicant has demonstrated and the staff agrees that the changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

EVALUATION

1. GENERAL INFORMATION

1.1 Packaging

The UX-30 package is designed to transport fissile uranium hexafluoride within ANSI N14.1 standard 30-inch diameter cylinders. The UX-30 package consists of a foam filled overpack for impact and thermal protection, and the inner Model 30B cylinder that serves as the containment vessel. The overpack is a right circular cylinder construction of two stainless steel shells with the volume between the shells filled with rigid polyurethane foam. A stepped and gasketed horizontal joint permits the top half of the overpack to be removed from the base. The overall dimensions of the overpack are approximately 44 inches in diameter and 96 inches in length.

The containment vessel for the UX-30 package is normally an ANSI-N14.1 Model 30B or 30C cylinder. For this amendment, the containment vessel is a open head steel cylinder with a bolted closure, as opposed to the ANSI cylinders that are filled and emptied through a valve and plug. The new containment vessel is a right circular cylinder, with overall dimensions of approximately 30 inches in diameter and 81-1/2 inches in length. The vessel is constructed of SA 516 Gr. 70 steel. The cylindrical shell is 1/2 inch thick and approximately 19 inches in diameter. The bottom plate and the top flange are approximately 2 inches thick and 30 inches in diameter. The closure lid is 2-inch thick steel plate, and is closed by 20, 1-1/8-inch - 7 UNC closure bolts and a neoprene flat gasket. There are two penetrations in the containment system - a leak test port and a vent port. These ports are sealed with bolts and seals and are leak-testable. The cylindrical shell is surrounded by rigid polyurethane foam that provides a close fit within the UX-30 overpack.

The uranium hexafluoride is contained within small cylinders that vary in size and configuration. In general the cylinders are right circular cylinders with diameters of approximately 1, 2, 5, 8, and 12 inches, and lengths up to approximately 57 inches not including possible appurtenances. Each small cylinder is closed within a Tyvek bag, and one or more of the small cylinders are positioned within rigid foam insert inside the containment vessel.

1.2 Contents

1.2.1 Type and form of material

Uranium hexafluoride within small (less than 19 inches in diameter) metal cylinders packaged within the containment vessel constructed and assembled in accordance with Duratek, Inc., Drawing No. C-067-005311-009, Rev. 0. The uranium may be of any enrichment.

1.2.2 Maximum quantity of material per package

The maximum weight of the containment vessel, dunnage, uranium hexafluoride, and any secondary packaging not to exceed 4,000 pounds.

The maximum mass of uranium-235 not to exceed the following:

Maximum uranium enrichment in any single small cylinder (weight percent U-235)	Maximum U-235 mass per package (total mass in all small cylinders) (grams U-235)
5	1600
15	1000
100	800

1.3 Criticality Safety Index **0.0**

1.4 Drawings

The applicant provided an engineering drawing of the new containment system, including the arrangement of the small cylinders within it (Duratek, Inc., Drawing No. C-067-005311-009, Rev. 0).

2. STRUCTURAL

This amendment request is to allow shipment of cylinders containing small quantities of uranium hexafluoride from the East Tennessee Technology Park (ETTP), near Oak Ridge, TN, to the Gaseous Diffusion Plant Environment Restoration Facility near Portsmouth, OH. Only a limited number of cylinders will be shipped, and each cylinder will be transported only once. The cylinders are less than 19 inches in diameter and are referred to as “ETTP<30" cylinders in the application.

2.1 Structural Design

The small cylinders will be transported by placing them inside a larger cylinder which is called the "30ECV" cylinder in the application. The 30ECV cylinder is designed specifically to be transported in the UX-30 cavity and will serve as the containment vessel for the package. The 30ECV consists of two major components: the insert and the containment vessel. The insert consists of two half-cylindrical shells with a large, interior cavity. The wall of the insert is made from rigid polyurethane foam (8-10 lbs/ft^3) and an exterior steel shell. The small cylinders are placed inside Tyvek sacks, which are then placed inside the cavity of the insert along with soft, low density foam (approximately 4 lbs/ft^3), which acts as protective dunnage. The two half-cylindrical shells of the insert are fastened together. Multiple small cylinders may be placed inside the insert cavity, subject to limitations of size, weight, enrichment and fissile mass of the contents, and the Type A quantity limits as discussed in the application. The loaded insert is then slid horizontally into the containment vessel, and the lid of the vessel is bolted on. The containment vessel shell is protected by approximately 5 inches of high density polyurethane foam (8-10 lbs/ft^3) as shown on Duratek Drawing C-067-005311-009. The loaded assembly is then placed inside the UX-30 overpack for transport. Thus, the shipping configurations of the package will be one or more small cylinders placed inside the insert, the insert is inside a containment vessel cylinder which is then placed inside a UX-30 overpack.

2.2 Structural Evaluation of 30ECV Cylinder (Containment Vessel)

The overall dimensions of the 30ECV are similar to the standard 30B cylinder used in the UX-30 package. The shells of both 30ECV and 30B cylinders are 1/2-inches thick. However, the diameter of the 30ECV shell is 20 inches whereas the diameter of the standard 30B is 30 inches. The differences in the diameter of the shells are compensated by the 5-inch thick protective layer of polyurethane foam that surrounds the 30ECV shell. The 30ECV has 2-inch thick flat end plates as compared to the ½ inch thick semi-elliptical heads of the 30B cylinder. The head and shell materials are identical for the 30ECV and the 30B cylinders (i.e., SA 516, Grade70). The top lid on the 30ECV is secured to the body with twenty 1-1/8" bolts. A gasket is positioned between the lid and the bolt flange. A pre-shipment leak test will be performed to ensure the lid, gasket, and bolts are properly installed. The 30ECV cylinder is designed for 200 psig internal pressure and hydrostatically tested to 400 psig. Additionally, the 30ECV cylinder is designed, fabricated, tested, and stamped to the requirements of the ASME B&PV Code, Section VIII.

The major difference between the 30ECV and the standard 30B cylinder is the closure. The 30ECV cylinders use a bolted flange closure versus the welded closure of the 30B. However, the gross weight of the 30ECV is significantly less than the 30B. An evaluation of the bolted connection performed by the applicant has shown that the bolted closure is capable of maintaining the seal under the most severe hypothetical accident test loading. Although the small cylinders and the Tyvek sacks are expected to retain the uranium hexafluoride, no credit is taken for these components in the package evaluation.

The 30ECV cylinder has an additional outside protective layer of 5-inch thick polyurethane foam surrounding the shell, and the walls of the insert include an approximate 2-inch thick shell of rigid, closed-cell polyurethane foam as well as foam dunnage in the insert cavity. The total weight of the 30ECV, including payload, is 4000 pounds, compared to approximately 6620 pounds for the standard 30B and 30C cylinders, for which analysis and drop tests were performed in the UX-30 safety analysis report. The multiple layers of foam will provide added protection and limit the severity of potential damage to the 30ECV and the small cylinders under hypothetical accident conditions. Based on the analysis results and the comparison of weight differences and the design features of the 30ECV and the standard 30B cylinders, it is concluded that the 30ECV in the UX-30 is capable of providing adequate protection of its contents.

2.3 Chemical, Galvanic, and Other Reactions

The small cylinders will be transported in the 30ECV by placing them in the cavity of the 30ECV insert, which will in turn be placed inside the containment vessel. When they are placed inside the insert cavity, each small cylinder will be placed inside a Tyvek sack and surrounded by soft, open-celled, polyurethane foam dunnage. Although there is only limited information available with regard to the compatibility of Tyvek sack and polyurethane foam with uranium hexafluoride specifically, both materials are reported to have good or excellent compatibility with a wide range of other chemicals and are thus expected to have adequate compatibility with uranium hexafluoride. The Tyvek sack will contain any uranium hexafluoride that may leak from the small cylinder. To provide additional protection from any potential uranium hexafluoride exposure, the inside surface of the 30ECV Insert is coated with a water-based paint or plastic coating.

The small cylinders will be transported inside the 30ECV insert cavity, and the two halves of the insert fastened together. Although it is unlikely, the potential for uranium hexafluoride exposure inside the containment vessel cavity is still considered possible. The containment vessel is constructed of SA516 carbon steel, the same as the ANSI-Standard 30B cylinders. To minimize any chemical reactions, the exterior wall of the insert and the interior walls of the containment vessel cavity will be coated with a water-based paint as protection from corrosion and to facilitate loading and unloading of the insert. In addition, the containment vessel will be chemically cleaned after fabrication to ensure all solvents and hydrocarbons used during fabrication are removed. The operating procedures for the 30ECV (Chapter 7 of the application) includes provisions to inspect the interior of the insert and the containment vessel after each usage for signs of chemical reactions and to replace any degraded components. In view of the design features and many steps of precautions, it is concluded that the package design has met the requirements of 10 CFR 71.43(d) for precluding significant chemical, galvanic, or other reactions.

2.4 Structural Evaluation Conclusions

The application has shown that the UX-30/30ECV package configuration provides substantial protection of the small cylinders containing uranium hexafluoride and that the containment vessel (30ECV) in combination with the UX-30 overpack can provide adequate protection of its contents against release of uranium hexafluoride. There are only a limited number of small cylinders that need to be shipped, and each small cylinder is only transported a single time. The contents are limited to a Type A quantity of radioactive material, and the criticality safety of the package does not rely on the cylinder preventing water inleakage or on the small cylinders retaining the fissile material.

Thus, based on the statements and representations in the application, it is concluded that the requested amendment will not have significant adverse effects on package safety and will not affect the ability of the package to meet the structural requirements of 10 CFR Part 71.

3. THERMAL

The radioactive material content of the package is unirradiated uranium hexafluoride of any enrichment. The maximum mass of uranium hexafluoride is 900 pounds, including the small, secondary cylinder. The decay heat of the radioactive content is negligible. The UX-30 package is authorized to transport up to 5,020 pounds of low-enriched uranium hexafluoride within ANSI N14.1 Model 30B and 30C cylinders. The maximum temperature of the package with the small cylinders under normal conditions of transport, including the heat test, is within the temperatures previously analyzed for the package.

The package with a Model 30B cylinder was subjected to the hypothetical accident test sequence described in 10 CFR 71.73, including the fire test. The test results demonstrated that the temperature of the 30B cylinder remained well below the melting point of uranium hexafluoride. For this new packaging configuration there is more than 5 inches of additional insulating foam between the small cylinders containing the uranium hexafluoride and the outer wall of the UX-30 overpack. Therefore it is concluded that the maximum temperature of the small cylinders will remain well below the melting point of uranium hexafluoride.

The applicant calculated the maximum normal operating pressure (MNOP) for the new containment vessel. Assuming an initial pressure of 14.7 psia, the MNOP was calculated as 36.2 psig. The MNOP was based on the vapor pressure of uranium hexafluoride at a maximum temperature of 124 ^{o}F, which was previously determined for the Model 30B cylinder. This is well below the design pressure of the new containment vessel, which is 200 psig.

The staff concludes that the package, with the modified contents, meets the thermal performance requirements of 10 CFR Part 71.

4. CONTAINMENT

The package contents include unirradiated uranium hexafluoride, with uranium enriched in the U-235 isotope. Any enrichment is authorized, provided the maximum mass of U-235 is limited, as described above (see Section 1.2, "Contents"). Any mass of uranium hexafluoride is authorized, provided the total mass of the uranium hexafluoride, dunnage, secondary containers, and the new containment vessel is less than 4,000 pounds. The radioactivity is limited to a Type A quantity per package. The containment vessel is the new, ASME-code stamped vessel specified in Section 1.3, "Drawings," above.

The applicant provided an evaluation of the containment system under normal conditions of transport. The containment vessel is closed by a lid, neoprene gasket, and 20 closure bolts. The containment penetrations include a vent port and a leak test port. Each port is closed by a socket-head cap screw and stat-o-seal. The main closure lid and ports are leak tested prior to each shipment, after loading. The tests must show no leakage with a sensitivity of 1×10^{-3} ref-cm^3/sec. These leakage tests are comparable to those performed for the Model 30B cylinder under the ANSI N14.1 standard.

Physical tests performed on the UX-30 package, with the Model 30B cylinder were used to confirm that the containment system would not be damaged under hypothetical accident conditions. The new containment vessel was designed to provide a containment system comparable to the ANSI N14.I Model 30B. The applicant concluded that the new vessel would withstand the regulatory tests, based on the results of the physical tests of the UX-30 package, as described in Section 2 of the application. In addition, criticality safety of the requested contents does not rely on the containment system remaining leak-tight to water. The staff agrees that the containment system of the package, with the new containment vessel, is adequate to meet the containment requirements of 10 CFR 71.43(f) for Type AF packages.

5. SHIELDING

The package does not include radiation shielding. The contents of the package include uranium hexafluoride with uranium that may be enriched in the U-235 isotope. The material is unirradiated, and does not need shielding to meet the dose rate limits in 10 CFR 71.47.

6. CRITICALITY

The contents of the package are described in Section 1 and 6 of the application, as supplemented. The contents are composed of uranium hexafluoride contained within small (less than 19-inch diameter) cylinders. These cylinders are contained within Tyvek bags, positioned within solid foam dunnage, contained within the new ASME code containment vessel. The uranium may be of any enrichment. The contents are limited in fissile content as follows:

Maximum uranium enrichment (weight percent U-235)	Maximum U-235 mass (grams U-235) per package
5	1600
15	1000
100	800

Multiple small cylinders may be contained in one package, provided that the fissile material does not exceed the mass limits for U-235 given in the table above. The mass limit must be met for the highest enrichment of any small cylinder within the package.

The applicant revised the safety analysis report for the Model No. UX-30 to incorporate the transport of the small cylinders that have not been certified to be in compliance with ANSI N14.1, “Uranium Hexafluoride Packaging for Transport.” These include 12 inch, 8 inch, 5 inch, and smaller sized sample cylinders. The uranium hexafluoride in these cylinders varies in enrichment, and the package may contain several cylinders totaling 1,600 grams U-235 for up to 5 weight percent enrichment, 1,000 grams U-235 for up to 15 weight percent enrichment, and 800 grams U-235 for up to 100 weight percent enrichment. These U-235 mass limits are based on the highest enrichment determined to be in any individual cylinder contained in the UX-30. Cylinders are to be placed inside the 30ECV ASME pressure vessel, a bolted steel and polyurethane foam cylinder designed specifically to be placed in the UX-30 overpack.

The applicant revised the criticality analysis for the Model No. UX-30 to consider single units and arrays of the UX-30 package containing small cylinders. All models considered water in-leakage resulting in a homogeneous mixture of UO_2F_2, with uranium enriched to 5, 15, or 100 percent by weight, and water.

For all criticality analyses, the applicant used the CSAS25 module of the SCALE 4.4 code package, with KENO V.a and the 238-group ENDF/B-V cross-section library. KENO V.a is a three-dimensional Monte Carlo multi-group neutron transport code used by the SCALE system to calculate k_{eff}. This code is a standard in the nuclear industry for performing criticality analyses.

The applicant's single unit model of the UX-30 containing the 30ECV cylinder consisted of horizontally or vertically oriented configurations of a UO_2F_2 solution within the 30ECV insert, ignoring the structural material and confinement provided by the uranium hexafluoride cylinders themselves. The applicant varied the height and concentration of the solution in the cylinder, as well as the density of water in the remaining void volume of the cylinder, in order to find the optimum degree of moderation and reflection within the package. Optimum external reflection of the single unit model was investigated by varying the modeled composition of UX-30 polyurethane foam. The most reactive condition for the single unit model was found for H/U ratios of 30, 110, and 700 for 5, 15, and 100 weight percent U-235, respectively, with full water density in the remaining cylinder volume. Variations in the UX-30 foam composition were not found to be statistically significant with respect to k_{eff}.

The applicant's array model consisted of four half-single units in a triangular pitch, with reflected conditions on six sides to create an infinite array of packages. Polyurethane foam density was varied in both the UX-30 and the 30ECV cylinder in order to determine the most reactive condition. Also, water density in the void volume of the 30ECV cavity, and interstitial moderation between packages were varied in the array model. The most reactive condition was found to be with the maximum foam density in the UX-30 and 30ECV cylinder and with full density water in the 30ECV void space. Interstitial moderation was found to have little effect on the overall system reactivity. The applicant also investigated the effect of 5 percent by volume water absorbed into all the foam regions of the UX-30 and the 30ECV cylinder. This condition provides better reflection conditions in the package and therefore increases k_{eff}. The maximum resulting $k_{eff} + 2\sigma$ for an infinite array of UX-30 packages containing the 30ECV cylinder was 0.9313.

The applicant selected a group of critical experiments involving low and high enriched uranyl fluorides from which to benchmark the SCALE 4.4 code for this application. The low enriched experiments involved systems of UF_4 and UO_2F_2, enriched from 1 to 6 weight percent U-235, and reflected by paraffin or water. The high enriched experiments involved solutions of UO_2F_2, enriched from 84 to 100 weight percent U-235, and reflected water. Table 1 of Attachment 2 summarizes the determination of the area of applicability defined by these experiments. The upper subcritical limit determined from the benchmark analysis is 0.932, which is greater than the maximum calculated k_{eff} of the system.

The NRC staff performed confirmatory criticality calculations using the CSAS25 criticality analysis sequence in the SCALE 5 code system, along with the 44-group neutron cross section set. The staff modeled the most reactive infinite array case from the applicant's criticality analysis using assumptions similar to those used by the applicant. The results of the staff's confirmatory criticality analysis agreed with the applicant's results, with respect to both the maximum calculated k_{eff} and the degree of moderation which produced the maximum k_{eff}.

The applicant has shown and the staff agrees that the Model No. UX-30 containing less than 30-inch uranium hexafluoride cylinders in a 30ECV ASME pressure vessel meets the criticality safety requirements of 10 CFR Parts 71.55 and 71.59, when limited to 1,600 grams U-235 for up to 5 weight percent enrichment, 1,000 grams U-235 for up to 15 weight percent enrichment, and 800 grams U-235 for up to 100 weight percent enrichment.

7. PACKAGE OPERATIONS

The applicant provided supplemental package operations for shipment of the small cylinders. These operations are intended to supplement the package operations specified for the Model No. UX-30 package, as defined in Chapter 7 of the safety analysis report. The supplemental operations include special provisions for the limited loading for criticality safety, as well as restrictions for the total weight of the contents. The revised package operations also specify that each small cylinder is to be transported only once, from the ETTP facility near Oak Ridge, TN, to the Gaseous Diffusion Plant Environmental Restoration Facility, located near Portsmouth, OH.

The supplemental operations include: sealing each small cylinder within a Tyvek bag; placing the small cylinders and dunnage within an insert that is loaded into the new containment vessel; closing the containment vessel; and performing leak tests. The leak tests include a soap bubble test of the main closure lid and vent port (if it has been opened), and a pressure drop test for the leak test port. The leakage tests to be performed prior to each shipment are described in Section 8 of the application. In addition, the applicant proposed specific operational controls for the shipment of these cylinders. Table 7.1 of the application lists elements of the Transportation Plan.

8. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The applicant provided acceptance tests for the new containment vessel. These include: hydrostatic and leak tests consistent with ANSI N14.1; weld inspection in accordance with the requirements of the ASME Code, Section VIII (the vessel is ASME code stamped); and load tests for lifting points for the cylinder. The applicant provided a maintenance program for the containment vessel. The maintenance includes the visual inspections of the lid bolts, closure screws for the vent and leak test ports, and sealing surfaces.

CONCLUSIONS

The applicant provided an evaluation of the Model No. UX-30 package with the new containment vessel and modified authorized contents. Based on the statements and representations in the application, as supplemented, the applicant has demonstrated and the staff agrees that the changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued on 12/6/05.