

**Safety Evaluation Report for the  
Request for Continued Use of EnergySolutions  
10-160B Type B Cask**

Docket Number: 12-18-9204

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Date: 5/31/12

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## Background

Revision 0 of the Department of Energy (DOE) Certificate of Compliance (CoC) USA/9204/B(U)F-96(DOE) was issued based on Revision 13 of the Nuclear Regulatory Commission (NRC) CoC. Revision 13 of the NRC CoC was based on the *Consolidated Safety Analysis Report for Model 10-160B Type B RADWASTE Shipping Cask*, EnergySolutions, Revision 0, December 2007 and the four applications with minor changes to the Consolidated Safety Analysis Report (CSAR). The NRC CoC Revision 13 updated the 10-160B to the “-96” requirements and consolidated all of the previous applications to NRC for the 10-160B. The DOE CoC Revision 0, which was equivalent to the NRC CoC Revision 13, was issued on December 29, 2009. This revision was issued so that changes to 10-160B for DOE shipments would be made to the DOE CoC and not the NRC CoC.

The NRC issued Revision 14 to the NRC CoC on February 17, 2010. This revision was a renewal of the CoC, extended the expiration date by five years to October 31, 2015, and had only minor changes to text of the CoC (mainly the extension of the expiration date).

On February 28, 2011, the NRC-issued Revision 15 of the CoC USA/9204/B(U)F-96, for the 10-160B packaging. Revision 15 of the NRC CoC had significant changes and NRC’s Safety Evaluation Report (SER) addressed the rationale for these changes. Revision 1 of the DOE CoC was based on *Consolidated Safety Analysis Report for Model 10-160B Type B RADWASTE Shipping Cask*, EnergySolutions, Revision 3, January 2011, which superseded the previous revisions of the Safety Analysis Report. The NRC SER stated that the CSAR (Revision 3, January 2011) submitted under the January 24, 2011, application supersedes all previous revisions of the application; and the CoC only lists this application under references. The DOE Packaging Certification Program (PCP) reviewed the changes in Revision 15 of the NRC CoC and the supporting NRC SER and concurred with the needs for these changes. Revision 1 of the DOE CoC 9204, which was equivalent to Revision 15 of the NRC CoC and the DOE SER for Revision 1 of the CoC was based on the NRC SER for Revision 15 of the NRC CoC were issued on April 6, 2012.

On April 1, 2012 NRC issued Revision 16 to CoC 9204 to add the condition “Total quantity of radioactive material not to exceed 3,000 A<sub>2</sub>.” On May 2, 2011 DOE issued Revision 2 of the DOE CoC 9204 to add this condition.

On March 13, 2012 DOE issued Revision 3 to the DOE CoC. This revision was issued for a one-time DOE shipment from the Argonne National Laboratory to the Nevada National Security Site for disposal. The radioactive contents are normal-form Co-60 and Ra-226 radioactive sources packaged in the Argonne Source Container Assembly.

EnergySolutions (ES) is the certificate holder for DOE CoC 9204 Revision 3. Revision 3 of DOE CoC 9204 is equivalent to and based on Revision 16 of the NRC CoC 9204 except for approval of one additional content for shipment by DOE. ES is also the certificate holder for the NRC CoC 9204 for the 10-160B and the NRC CoC 9168 for the CNS 8-120B package.

## Summary

During the course of responding to any NRC request for additional information for an amendment to NRC CoC 9168, Model No. CNS 8-120B package, ES identified that an accident sequence not previously evaluated as part of the design basis may be more damaging than those

previously considered. ES stated that in the event of a top drop onto the puncture pin, the 12-gauge thick sheet metal covering the outside of the toroidal impact limiters would be penetrated. During the subsequent 30-minute hypothetical accident condition fire test, ES thermal calculations showed that the maximum temperature of the secondary lid O-rings exceed their maximum rated service temperature specified by the manufacturer, and as a result, could potentially compromise the containment function of the package.

ES informed NRC that the Model No. 10-160B package (NRC CoC 9204) could have similar design issues since the impact limiters are designed similar to the impact limiters on the Model No. CNS 8-120B package. ES informed NRC and DOE that it had voluntarily removed all of the 10-160B packages (NRC CoC 9204 and DOE CoC 9204) from service effective April 27, 2012.

By letter dated May 15, 2012, as supplemented on May 17, 2012, ES requested a revision to the NRC CoC 9204, for the 10-160B package under the provisions of 10CFR 71.41(c). The regulation in 10 CFR 71.41(c) states that the NRC may authorize a package using environmental and test conditions different from those specified in either 10 CFR 71.71, "Normal Conditions of Transport" or 10 CFR 71.73, "Hypothetical Accident Conditions," if the controls proposed by the shipper are demonstrated to be adequate to provide the equivalent level of safety.

The NRC issued Revision 19 to CoC 9204 and its SER with the following conditions that would allow shipments to be made for 90 days after the issue date of May 25, 2012 (August 23, 2012):

- The Maximum speed of the truck during a Type B shipment shall be limited to 55 mph.
- Each Type B shipment must be accompanied by a clearly recognizable escort vehicle that provides enhanced emergency response notification, maintains continuous visual and radio communication with the tractor-trailer performing the Type B shipment, and separates the shipment from other hazardous material shipments.
- All shipments shall be treated as if the package contains radioactive material quantities of concern (RAM QC) quantities of radioactive material, regardless of quantity of radioactive material in the package, to provide:
  1. Increased inspections of equipment to prevent mechanical issues,
  2. Increased communications requirements,
  3. Mandatory installation of Qualcomm Global Positioning System (GPS) Hardware Equipment,
  4. Automated Ping/Email to Logistics Staff after Accident Conditions, and
  5. Route selection planning and enhanced driver training.

DOE PCP has reviewed the ES submittals of March 15 and March 17, 2012 and the NRC SER and concurs with the finding and actions of the NRC. This DOE SER for Revision 4 of the CoC is based on Revision 19 of the NRC CoC and incorporates the NRC SER. A copy of the NRC SER is attached on the following pages. The DOE CoC Revision 4 is issued with equivalent conditions to those listed in Revision 19 of the NRC CoC 9204 and the supporting NRC SER. Revision 4 of the DOE CoC is issued with an expiration date of August 23, 2012, which is equivalent to the 90 day NRC restriction.



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT  
Docket No. 71-9204  
Model No. 10-160B  
Certificate of Compliance No. 9204  
Revision No. 19

During the course of responding to a request for additional information for an amendment to Certificate of Compliance No. 9168, for the Model No. CNS 8-120B package, EnergySolutions (ES) identified that an accident sequence not previously evaluated as part of the design basis may be more damaging than those previously considered. ES stated that in the event of a top drop onto the puncture pin, the 12-gauge thick sheet metal covering the outside of the toroidal impact limiters would be penetrated. During the subsequent 30-minute hypothetical accident condition fire test ES thermal calculations show that the maximum temperature of the secondary lid O-rings exceed their maximum rated service temperature specified by the manufacturer, and, as a result, could potentially compromise the containment function of the package.

ES informed the U.S. Nuclear Regulatory Commission (NRC) that the Model No. 10-160B package could have similar design issues since its impact limiters are designed similar to the impact limiters on the Model No. CNS 8-120B package. ES informed NRC that it had voluntarily removed all of the 10-160B packages from service effective April 27, 2012.

By letter dated May 15, 2012, as supplemented on May 17, 2012, ES requested a revision to Certificate of Compliance No. 9204, for the Model No. 10-160B package under the provisions of Title 10 Code of Federal Regulations (10 CFR) 71.41(c). The regulation in 10 CFR 71.41(c) states that the NRC may authorize a package using environmental and test conditions different from those specified in either 10 CFR 71.71, "Normal Conditions of Transport" and 10 CFR 71.73, "Hypothetical Accident Conditions," if the controls proposed by the shipper are demonstrated to be adequate to provide the equivalent level of safety.

In lieu of demonstrating that the package can meet the containment criteria release rate of less than an  $A_2$  per week, as specified in 10 CFR 71.51(a)(2), after the tests for hypothetical accident conditions required by 10 CFR 71.73, the applicant proposed the following compensatory measures to lessen the likelihood of an accident that could reduce the effectiveness of the O-ring seals, and with the intent of providing an equivalent level of safety during shipment:

1. The maximum speed of the truck during a Type B shipment shall be limited to 55 mph;
2. Each Type B shipment must be accompanied by a clearly recognizable escort vehicle that provides enhanced emergency response notification, maintains continuous visual and radio communication with the tractor-trailer performing the Type B shipment, and separates the shipment from other hazardous material shipments; and

3. All Type B shipments shall be treated as if the package contains radioactive material quantity of concern (RAM QC), regardless of quantity of radioactive material in the package, to provide:
  - a. Increased inspections of equipment to prevent mechanical issues,
  - b. Increased communications requirements,
  - c. Mandatory installation of Qualcomm GPS Hardware Equipment,
  - d. Automatic Ping/Email to Logistics Staff after Accident Conditions, and
  - e. Route selection planning and enhanced driver training.

Using the data in NUREG/CR-7035, "Analysis of Severe Roadway Accidents Involving Long Duration Fires", ES estimated that the accident frequency for radioactive material in transit involving a fire that is large enough to fully engulf a Type B package such as the 10-160B is  $1.99 \times 10^{-3}$  per million radioactive material transportation vehicle-miles. For the years 1997 to 2008, there were five accidents involving radioactive material transport in which a fire occurred. Of those five accidents, only one involved more than one vehicle.

ES estimated the accident frequency for radioactive material shipments by truck over a longer period of time (1993 to 2012). Given that there were five accidents involving radioactive material shipments that were associated with a Type B package, and over 70 million radioactive material vehicle-miles per year, the accident frequency rate is  $3.7 \times 10^{-9}$  per mile of transport. The ES estimate is within a factor of two, compared to the NRC's estimate when the NRC's value is divided by one million miles.

ES stated that instituting the compensatory measures listed above will reduce the already very low frequency of occurrence of an accident that may challenge the seals on this package. In addition to the compensatory measures stated above, ES has proposed utilizing this approval for a 90-day period and intends to limit the number of shipments to a maximum of 12 shipments (although only four have been scheduled) during this period. In addition, based on the data provided by ES in the application, the average shipment for this package is less than 1,000 miles, such that even if the accident frequency were multiplied by this distance, the estimated frequency of an accident or an accident that would result in a fire large enough to challenge the seals is on the order of one in a million. ES' historical data on shipments of the 10-160B show that there have been over 1,000 safe shipments traveling over 600,000 shipping miles total.

The applicant stated that the proposed compensatory measures would reduce the likelihood of an accident and, if an accident were to occur, its severity. Reductions in speed are likely to reduce the damage in an accident and for some roads, the likelihood of the truck rolling over. ES anticipates that the escort vehicle would trail the shipment, so that for the reduced speed on an interstate highway, hazardous material carriers overtaking the shipment would be warned of the shipment, potentially reducing the likelihood of an accident with a consignment of flammable or other hazardous material. The escort would also be able to provide warning for other traffic of the shipment and an enhanced emergency response notification capability, thus reducing the likelihood of an accident and in the event of a fire, reducing its effect on the package.

The shipper would treat all 10-160B shipments as RAM QC, regardless of the quantity of radioactive material in the package, to increase the safety of the shipment and reduce the likelihood of an accident or mitigate its consequences and not for security purposes as is traditionally associated with RAM QC shipments. The RAM QC compensatory measures proposed by the applicant have been incorporated into the certificate of compliance and will increase the number of vehicle inspections detecting mechanical issues. The increased inspections should reduce the number of mechanical failures that, if undetected, could fail and

lead to an accident. Other RAM QC requirements such as 2-way radio and Qualcomm GPS hardware will provide for route monitoring and automatic notification in the event of an accident. RAM QC requirements also specify additional driver training and route selection planning which will reduce time in transit and the likelihood of transit during times of significant traffic congestion.

ES is developing a thermal shield to attach to the secondary lid that would not be punctured during either the 30-foot drop or the 40-inch puncture test, in order to mitigate the self-identified design issue. ES is preparing an application to submit to NRC for this design, will seek NRC approval, fabricate, and install the thermal shield on all 10-160B packages within the 90-day period authorized by this approval.

### **THERMAL EVALUATION**

The applicant provided the results of its thermal evaluation for the package when the damaged package is exposed to a 30-minute fire for hypothetical accident conditions. Since the top drop onto the puncture pin will result in at least a 6-inch diameter penetration in the sheet metal covering the impact limiter central cavity, the applicant conservatively removed the entire sheet metal cover on the 47.5-inch diameter cavity in the middle of the impact limiter.

The applicant's thermal analysis demonstrates that for the configuration analyzed, the silicone O-rings on the secondary lid reach their maximum service temperature in less than 19 minutes and that the maximum temperature reached by the secondary lid inner O-ring is 765°F approximately 20 minutes after cessation of the fire. These seals have a maximum service temperature of 400°F as rated by the manufacturer for the 10-160B package, as shown in the drawings referenced in the certificate of compliance.

The applicant referenced NUREG-7115, "Performance of Metal and Polymeric O-Ring Seals in Beyond-Design-Basis Temperature Excursions," which tested metallic, ethylene-propylene, and polytetrafluoroethylene seals. Three tests were performed on the non-metallic seals, two on the ethylene-propylene seal and one on the polytetrafluoroethylene seal. The two tests on ethylene-propylene seals had different results. In one test, at a vessel temperature of 300°C (572°F) the seal maintained its integrity with no observable leakage for over 20 hours, whereas in the second test, at a higher temperature (450°C [842°F]), the vessel started leaking soon after attaining the target temperature. The time-average leakage rate during this test was  $9.2 \times 10^{-4}$  ref-cm<sup>3</sup>/sec.

None of the seals used in the testing described above is identical to the seals installed by ES in this package. The maximum operating temperatures of the ethylene-propylene compound is 149°C (300°F), compared to 400°F for the 10-160B package secondary lid O-rings. However, the tests on non-metallic seals indicate that seals subjected to temperatures well above their maximum rated service temperature, do not release vessel pressure instantaneously, and retain some level of reduced effectiveness over time.

A "worst case" scenario where the vessel lacks a seal in its configuration provides an estimated upper bound on the possible release from the package, and, using engineering judgment, NRC staff concludes that the leakage would be less if a seal is present, even if the maximum temperature of the seal is above its rated temperature.

## CONTAINMENT EVALUATION

To maintain the containment function, all components that make up the containment boundary must perform in accordance with their design to ensure that the regulatory release limits in 10 CFR 71.51 ( $10^{-6}$  A<sub>2</sub> per hour after the tests for normal conditions of transport, and an A<sub>2</sub> per week after the tests for hypothetical accident conditions) are met.

The analysis provided by the applicant indicates that the O-ring seals on the secondary lid will exceed the short-term rated temperature of 400°F for the fire test specified in 10 CFR 71.73. Given the results of the applicant's analysis, the ability of the containment boundary seals to meet the requirements after the tests for hypothetical accident conditions may be compromised.

While some leakage is expected from seals, regardless of the seal material or the package lid design(s), the amount of leakage that is experienced will directly determine whether the package will meet the regulatory requirements for release after the tests for hypothetical accident conditions. The 10-160B package is demonstrated to remain leak-tight under normal conditions, and, therefore, will enter the series of tests for hypothetical accident conditions in a leak-tight condition. The NRC staff reviewed the question of the potential for a release as a result of the fire exposure, if a puncture were to occur in the sheet metal covering the impact limiter.

Since the impact limiters will limit the effect of hypothetical accident conditions on the primary lid, the only path for a potential release (due to the hypothetical accident conditions fire exposure) would be through a degraded seal in the secondary lid (in this case the inner O-ring seal which makes up the containment boundary).

The applicant's containment calculations in the SAR show the release rate after the tests for accident conditions needed to release an A<sub>2</sub> per week is  $1.53 \times 10^{-2}$  cm<sup>3</sup>/sec. The NRC staff converted this release rate to a reference leak rate using the methodology in ANSI N14.5-1997, "Radioactive Materials - Leakage Tests on Packages for Shipment," that reference leak rate is  $1.4 \times 10^{-3}$  ref-cm<sup>3</sup>/sec. This reference leak rate is consistent with the experimental leak rate observed for a vessel, pressurized to an internal pressure of 5.62 bar (81.5 psi) at room temperature with no seal ( $2.4 \times 10^{-3}$  ref-cm<sup>3</sup>/sec) from Figure 3-2 in NUREG/CR-7115. Note that the torque on each of the four bolts on the test vessel was similar to the torque requirements on the 10-160B package (307 ft-lbs on test vessel compared to 300 ft-lbs on the secondary lid bolts on the package). In the judgment of the NRC staff, the leak rate from a pressure vessel with no seal would, in this case, likely bound the leak rate from a pressure vessel with a O-ring that was potentially degraded from an exposure to a temperature beyond its rated temperature.

Given these results, the staff finds that the release rates are likely to be on the order of an A<sub>2</sub> per week assuming the 10-160B package is subjected to the tests for hypothetical accident conditions of both puncture and the 30 minute fire exposure and assuming that the seals fail on the secondary lid. As described above, the likelihood of this sequence of events occurring during transport is extremely low.

## CONDITIONS

The conditions specified in the certificate of compliance have been revised to incorporate the changes indicated below:

Condition No. 6 has been revised to add:

- c. The maximum speed of the truck during a Type B shipment shall be limited to 55 mph;
- d. Each Type B shipment must be accompanied by a clearly recognizable escort vehicle that provides enhanced emergency response notification, maintains continuous visual and radio communication with the tractor-trailer performing the Type B shipment, and separates the shipment from other hazardous material shipments; and
- e. All shipments shall be treated as if the package contains RAM QC quantities of radioactive material, regardless of quantity of radioactive material in the package, to provide:
  - 1. Increased inspections of equipment to prevent mechanical issues,
  - 2. Increased communications requirements,
  - 3. Mandatory installation of Qualcomm GPS Hardware Equipment,
  - 4. Automatic Ping/Email to Logistics Staff after Accident Conditions, and
  - 5. Route selection planning and enhanced driver training.

Condition No. 12 has been revised to state that the package authorized by this certificate is approved for use under the general license provisions of 10 CFR 71.17, for 90 days from the date of issuance of this certificate.

Condition No. 13 was removed since it expired on February 28, 2012.

Condition No. 14 was renumbered and a provision added to ensure that Revision No. 17 of this certificate may be used until December 31, 2012, provided the compensatory measures in Condition 6(c) through (e) of Revision No. 19 of this certificate are followed. The authorization to use Revision No. 17 of this certificate expires 90 days from the date of issuance of Revision No. 18 of this certificate.

## CONCLUSION

Based on the thermal and containment analyses, assessment of compensatory measures and the review of the transportation risk, the staff has reasonable assurance that the combination of compensatory measures and package design provide an equivalent level of safety in accordance with regulatory requirements of 10 CFR Part 71.41(c). The applicant demonstrated that the compensatory measures proposed to be exercised by the shipper, and incorporated into the certificate, provide an equivalent level of safety when compared to evaluating the sequence of tests in 10 CFR 71.73 (30-foot drop, 40-inch puncture and 30-minute fire test).

In evaluating the equivalent level of safety, the staff considered available risk-related insights including (1) the very low probability of an accident involving both puncture in the center of the impact limiter and direct exposure to a fully engulfing 30-minute fire; (2) the additional reduction in probability and mitigation of potential consequences provided by the compensatory measures as well as limited time frame of this approval; (3) the expected performance of the package for fire accident tests of approximately 19 minutes; and (4) the consequences of potential release from an O-ring that has been exposed to elevated temperatures beyond its maximum rated service temperature as specified by the manufacturer.

The staff notes that this finding is only valid for the design of the 10-160B in combination with both the proposed compensatory measures and 90-day timeframe associated with this approval. Staff expects that within 90 days, the ES will demonstrate compliance with the requirements of 10 CFR 71.41(a) for this self-identified design issue and add the thermal shield to all packages prior to each Type B shipment.

Issued with Certificate of Compliance No. 9204, Revision No. 19,

on May 25, 2012.