Form NRC-618
(12-74)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE

For Radioactive Materials Packages

1.(a) Certificate Number	1.(b) Revision No.	1.(c) Package Identification No.	1.(d) Pages No.	1.(e) Total No. Pages
9152	0	USA/9152/B( )	1	3

2. PREAMBLE

2.(a) This certificate is issued to satisfy Sections 173.393a, 173.394, 173.395, and 173.396 of the Department of Transportation Hazardous Materials Regulations (49 CFR 170-189 and 14 CFR 103) and Sections 146-19-10a and 146-19-100 of the Department of Transportation Dangerous Cargoes Regulations (46 CFR 146-149), as amended.

2.(b) The packaging and contents described in item 5 below, meets the safety standards set forth in Subpart C of Title 10, Code of Federal Regulations, Part 71, "Packaging of Radioactive Materials for Transport and Transportation of Radioactive Material Under Certain Conditions."

2.(c) This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. This certificate is issued on the basis of a safety analysis report of the package design or application–

3.(a) Prepared by *(Name and address)*:

Chem-Nuclear Systems, Inc.
P.O. Box 1866
Bellevue, WA 98009

3.(b) Title and identification of report or application:

Chem-Nuclear Systems, Inc. application dated June 18, 1981, as supplemented.

3.(c) Docket No. 71-9152

4. CONDITIONS

This certificate is conditional upon the fulfilling of the requirements of Subpart D of 10 CFR 71, as applicable, and the conditions specified in item 5 below.

5. Description of Packaging and Authorized Contents, Model Number, Fissile Class, Other Conditions, and References:

(a) Packaging

(1) Model No.: CNS 1-13C II

(2) Description

A shipping cask for radioactive waste. The packaging consists of a double-walled steel circular cylinder separated by 16 ga wires, 39-1/8" in diameter and 68-1/2" high with a central steel lined cavity 26-1/2" in diameter and 54-1/16" high, approximately 5" of lead surrounds the central cavity. Closure is accomplished by a steel, plug type, lead filled cover secured by twelve (12), 1-1/4" bolts and seal provided by a flat silicone rubber gasket and a silicone rubber O-ring with a sealed 3/8" test port between the gaskets. Approximately 6" lead are in the base and cover. The cask is equipped with a cavity drain line sealed with a 3/8" cap screw and gasket, a steel lifting hook for the cover, and top and bottom impact limiters filled with 16.5 lb/cu ft rigid polyurethane foam clad in steel. The impact limiters are attached to the cask by six (6), 1" ratchet binders. The overall dimensions with impact limiters is 60" in diameter and 99-5/8" high. The package gross weight is approximately 27,000 lbs.

5. (a) Packaging (continued)

(3) Drawing

The packaging is constructed in accordance with Chem-Nuclear Systems, Inc., Drawing No. E-1-436-111, Sheets 1 and 2, Rev. D.

(b) Contents

(1) Type and form of material

(i) Greater than Type A quantities of nonfissile radioactive material as solidified or dewatered process solids (resins) within a sealed secondary container; or

(ii) Greater than Type A quantities of irradiated solid reactor components within a sealed secondary container.

(2) Maximum quantity of material per package

For the contents described in 5(b)(1)(i) and (ii):

Not to exceed a decay heat generation of 800 watts and 3,000 pounds including weight of the contents and seconary container; and

For the contents described in 5(b)(1)(i):

Residual water in the secondary container not to exceed the activity stated in Table 4.5.2-1 of the application.

6. As needed, appropriate shoring must be used in the cask cavity to limit movement of the secondary container during accident condition of transport.

7. The cask cover must be secured by twelve (12), SA-354, Type BD, 1-1/4"-7UNC x 2-1/4" long bolts torqued to 270 ft-lbs $\pm$ 10% (lubricated) or 360 ft-lbs $\pm$ 10% (dry).

8. Prior to each shipment, the leak tests described in Appendix 8B of the application must be performed. No package is to be delivered to a carrier for transport with a detectable leak using the method of Appendix 8B.

9. For all packages containing residual water or other substances which could radiolytically generate combustible gases, a determination must be made by tests and measurements of a representative package such that the following criteria are met over a period of time that is twice the expected shipment time:

(i) The hydrogen generated must be limited to a molar quantity that would be no more than 5% by volume (or equivalent limits for other inflammable gases) of the secondary container gas void if present at STP (i.e., no more than 0.063 g-moles/ft^3 at 14.7 psia and 70°F); or

(ii) The secondary container and cask cavity must be inerted with a diluent to assure that oxygen shall be limited to 5% by volume in those portions of the package which could have hydrogen greater than 5%.

9. (Continued)

For packages to be delivered to a carrier for transport, the secondary container must be prepared for shipment in the same manner in which determination for gas generation is made. Shipment period begins when the package is prepared (sealed) and must be completed within twice the expected shipment time.

10. In addition to the requirements of Subpart D of 10 CFR Part 71:

(i) Each package must meet the acceptance tests and be maintained in accordance with the Maintenance Program of Section 8 of the application.

(ii) Each package must be leak tested to insure a leak rate not greater than 3×10^{-5} atm-cm^3/sec at STP prior to first use, after the third use, and annually thereafter.

(iii) The O-ring, test port and drain line seals must be replaced quarterly with new seals. The flat lid gasket must be replaced annually.

11. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.12(b).

12. Expiration date: March 31, 1987.

REFERENCES

Chem-Nuclear Systems, Inc. application dated June 18, 1981.

Supplements dated: September 30 and December 31, 1981; and April 1, 1982.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald, Chief
Transportation Certification Branch
Division of Fuel Cycle and
Material Safety, NMSS

Date: APR 04 1982

U.S. Nuclear Regulatory Commission
Transportation Certification Branch
Safety Evaluation Report
Model No. CNS 1-13C II
Docket No. 71-9152

SUMMARY

By application dated June 18, 1981, as supplemented, Chem-Nuclear Systems, Inc. requested design approval of the Model No. CNS 13C II waste shipping package.

Based on the statements and representations contained in the application, and the conditions listed below, we have concluded that the Model No. CNS 1-13C II package meets the performance requirements of 10 CFR Part 71.

REFERENCES

1. Chem-Nuclear Systems, Inc. application dated June 18, 1981.

2. Supplement dated September 30, 1981.

3. Supplement dated December 31, 1981.

4. Supplement dated April 1, 1982.

DRAWING

The packaging is constructed in accordance with Chem-Nuclear Systems, Inc., Drawing No. E-1-436-111, Sheets 1 and 2, Rev. D.

PACKAGING DESCRIPTION

A steel encased, lead shielded shipping cask equipped with impact limiters (top and bottom). The packaging is a steel double-walled, lead-filled circular cylinder. A steel, plug-type, lead-filled lid is attached with twelve (12), 1-1/4" bolts. The lid is sealed by a flat silicone rubber gasket and a silicone rubber O-ring with a sealed test port (3/8") located between the gaskets. Outer stainless steel 1/4" and 1/2" thick sheets are separated from the cask walls with 16 ga wires. The lead shielding is 5" in the sides, 6" in the base and lid. The lid has a steel lifting hook. The cavity drain line is sealed with a 3/8" cap screw and gasket. The cask is 39-1/8" in diameter and 68-1/2" high. The cavity is 26-1/2" in diameter and 54-1/16" high formed by a 1/2" thick stainless steel plate. The top and bottom impact limiters increase the dimensions to 60" in diameter and 99-5/8" high. The impact limiters are filled with 16.5 lb/cu ft density rigid polyurethane foam encased in steel. The impact limiters are joined with six (6), 1" ratchet binders. The package gross weight is about 27,000 lbs.

CONTENTS

Type, form, and maximum quantity of material per package.

(i) Greater than Type A quantities of process solids (resins), either dewatered or solidified in a sealed secondary container.

(ii) Greater than Type A quantities of irradiated solid reactor components in a sealed secondary container.

The activity of the water in the dewatered resin must be limited to Table 4.5.2-1 of the application.

The maximum internal heat load must be limited to 800 watts and maximum gross weight of contents is 3,000 lbs including secondary container.

CONTAINMENT

The packaging containment has been shown to have no significant change following the normal condition tests or accident damage tests of 10 CFR Part 71.

For normal conditions, analysis was performed to show no deformation of the containment system and no damage to seals from thermal degradation.

For accident damage tests, leak tests were performed before and after the 30-foot drop test to show no significant leakage from the containment system. Thermal analysis showed that maximum seal temperatures are within acceptable limits. The leak tests before and after the 30-foot drop test were reported as having sensitivities of 2.7×10^{-4} atm-cm^3/sec and 5.8×10^{-4} atm-cm^3/sec (Paragraphs 2.11.3.6 and 2.11.3.11 in Rev. 1 of the application, deleted from Rev. 2, December 1981). The containment criteria established requires a somewhat more sensitive leak test than those reported for the 30-foot drop test. Demonstration of compliance with 10 CFR Part 71 containment requirements is based on each packaging containment system satisfying the more sensitive criteria established. This approach is adequate based on the fact that the containment system was shown to be undamaged for normal conditions and accident tests of 10 CFR Part 71.

A leak test with sensitivity and acceptance of 1.34×10^{-5} atm-cm^3/sec at the standard test conditions of ANSI N14.5 (air at 25°C and 1 atm pressure leaking to a 1×10^{-2} atm pressure) is specified in the application. This demonstrates a maximum leakage of 2.68×10^{-5} atm-cm^3/sec at the standard test conditions of ANSI N14.5 will be met.

A containment criteria in terms of a leakage test is specified in the application. The criteria is then verified as meeting the containment requirements of 10 CFR Part 71. This is done by using the procedures of ANSI N14.5, as recommended by Regulatory Guide 7.4. The maximum concentrations of the various radioisotopes in the content water is presented in the application (Table 4.5.2-1). Errors were found in the table; the effects of these errors are assessed in the NRC's independent containment evaluation. The specific, underlying error was the use of A_2 values for cesium isotopes (Cs-134 and Cs-137) that were higher than those presented in IAEA Safety Series No. 6, 1973. The result was to lower the composite or mixture A_2 value from 3.733 Ci to 3.115 Ci. The leakage test was shown to be acceptable for the concentrations specified in Table 1 (Table 4.5.2-11, of the application), and for pressures and temperatures assumed. Acceptability was verified independently by the staff using corrected A_2 values and assumed thermal properties for both normal and accident conditions of 10 CFR Part 71.

For normal conditions, concentrations specified (Table 1) and a maximum internal heat of 800 watts (with a corresponding cavity temperature (and pressure) of 214°F (19 psig)) were assumed to show that the maximum release satisfied ANSI N14.5 limits. The controlling release mechanism for normal conditions is water leakage.

For accident conditions, the controlling release mechanism assumed in the application was water vapor (steam). The specified (Table 1) concentrations and maximum internal heat of 800 watts (with a corresponding cavity temperature of 371°F (184 psig)) were shown to result in acceptably low release maximums to satisfy ANSI N14.5 limits. The staff verified that steam release rather than water release was controlling for accident conditions.

To assure adequate containment of the packaging in service, the leak test procedures specified in Appendix 8A and 8B of the application must be used. Appendix 8A is used before first use, after the third use (shake-down), and annually. Appendix 8B is used for leak test on the loaded package, and is performed prior to each use. The containment evaluation demonstrates compliance with the containment requirements of 10 CFR Part 71 provided that the specified radionuclide concentration limits are maintained during transport. The internal heat load is limited to 800 watts.

COMBUSTIBLE GAS MIXTURES

The applicant has proposed conditions to limit the accumulation of radiolytically generated gases over the shipping period to preclude the possibility of significantly reducing the packaging effectiveness due to explosion. The conditions require a representative package be prepared as for shipment, and a determination by tests and measurements be made to show that the limiting conditions are met over a time period of twice the expected shipping period. The contents are held in a secondary container prior to and during shipment. Tests and measurements are to be performed on the secondary containers as they will be representative of the packages for this purpose.

The limiting conditions proposed are:

"(i) The hydrogen generated must be limited to a molar quantity that would be no more than 5% by volume at STP (or equivalent limits for other inflammable gases) of the secondary container gas void (i.e., no more than 0.063 g-moles/ft^3; or

(ii) The secondary container and cask cavity (if required) must be inerted with a diluent to assure that oxygen, including that radiolytically generated, shall be limited to 5% by volume in those portions of the package which could have hydrogen greater than 5%."

Furthermore, shipments must be completed within a time period equal to the test period (i.e., twice the expected shipping period), and shipment time begins when the package is sealed.

Condition (i) limits the quantity of hydrogen to 0.063 g-moles/ft^3, but does not require any inerting of the container (air environment is assumed). This mixture, if ignited, could result in a combustion reaction, but it has been shown that such a reaction would yield a pressure rise of about 2.3 psig. The limit may be satisfied by shipments exhibiting sufficiently low rates of radiolytic gas generation, or by the use of a recombiner device which could catalytically recombine the hydrogen/oxygen to produce water and maintain a steady state hydrogen concentration below 5%.

Condition (ii) requires inerting the secondary container and cask cavity with a diluent gas (e.g., nitrogen) to limit the maximum oxygen concentration to 5% in any portion of the package where hydrogen may exceed 5% by volume. It is shown that a mixture limited to 5% oxygen in any combination of hydrogen and nitrogen will not support combustion.

The applicant also proposes approaches that may be used in preparing the package to meet the conditions. They are categorized under the general description of: 1) combustible gas control by inerting, and 2) combustible gas supression. The approaches described should be useful to other potential users in setting up administrative procedures for satisfying the approval condition.

The proposed conditions and the possible approaches to satisfy those conditions have been reviewed by the staff, and found to be adequate to assure that there will be no mixture of gases in the package which could, through an explosion, significantly reduce the effectiveness of the package.

STRUCTURAL

Structural integrity of the Model No. CNS 1-13C II package was evaluated by finite element analyses supported by two successive full scale hypothetical accident drop tests. The analysis followed the criteria of Regulatory Guide 7.6 and Regulatory Guide 7.8.

A. General Standards for all Packaging

Chemical and Galvanic Reaction

There are no significant chemical, galvanic or other known corrosive reactions among the packaging components or between the packaging components. (Radiolytical decomposite of the contents is discussed above.)

Positive Closure

Positive closure is provided by bolts. Sufficient bolt torque to prevent inadvertent opening and adequate closure of the package was determined by analysis.

Lifting Devices

The lifting devices are removed during transit. Therefore, the lifting devices are not considered a structural part of the package.

Tie-Down Devices

The tie-down system for transporting the package has been designed to load conditions defined in 10 CFR §71.31(d). The applicant has demonstrated that failure of the tie-down devices under excessive loads would not impair package effectiveness of the package to meet other requirements of Part 71.

B. Structural Standards for Type B and Large Quantity Packaging

Load Resistance

The package was shown by analysis to be capable of withstanding statically five times of its fully loaded weight uniformly distributed along its length without generating stress in any material of the packaging in excess of its yield strength. The safety factor has been shown to be approximately 14.6.

External Pressure

The applicant has shown by analysis that the packaging design meets the 25 psig external pressure requirement.

C. Normal Conditions of Transport

Heat

Assuming 130°F ambient air full solar insulation and 800 watt decay heat, the maximum cask cavity and seal temperatures will be 214°F. This temperature will have no detrimental effects on the package.

Cold

The effects of cold environment at -40°F ambient temperature on material properties and packaging effectiveness are judged not significant.

Pressure

The 0.5 atmospheric pressure will have no effect on the welded steel packaging and containment vessel.

Vibration

The package is a welded cylindrical shell without fragile attachments. The cask lid is installed to the cask body by twelve (12) equally spaced 1-1/4-inch closure bolts. Sufficiently large torque has been applied to these closure bolts to ensure no inadvertent opening of the cask. Based on past operating experience with similar packages, it is judged that vibrations normally incident to transport will have no significant effects on the package.

Water Spray

Water spray is judged to have no effect on the all steel package.

Free Drop

The applicant has shown by analysis that the package with impact limiters is not significantly effected by the free drop.

Penetration

Impact energies resulting from a 13-pound rod dropping from a height of 40 inches is not expected to have significant effects on the steel cask. No valves, valve covers or unprotected protrusions which are vulnerable to penetration are present.

D. Hypothetical Accident Condition

30-Foot Free Drop

The applicant has shown by analysis and tests the expected condition of the package when subjected to the 30-foot free drop.

The applicant performed impact analyses for a bottom end drop, top end (lid) oblique drop and side drop. The analysis was reviewed by the staff and shows adequate factor of safety for stresses and acceptable deformations of the cask for all three drop orientations.

Two full scale, successive drop tests were performed by the applicant to substantiate the above conclusions. The first drop was the vertical bottom end impact case. Visual examination of the package after the drop indicated no damage to the cask body or lid; the impact limiter and ratchet binders suffered moderate damage. The package was then subjected to the top end oblique drop with replaced impact limiters. Visual inspection of the package after the oblique drop revealed crushing of the impact limiters but some energy absorbing material was still present. The cask lid and body were not damaged except one cracked bolt hole in the lid bolt boss. The crack extended around 3/4 of the circumference of the bolt hole and the boss was also raised 1/8" above the cask top surface. There were no cracks extending into the base metal. The crack was attributed to the impact load on the sides of the custom made load cells placed directly under the bolt heads. In service, no such impact loads would be incurred since no instrumentation would be present. The applicant has demonstrated by test and analysis as confirmed by the staff that the primary cask features, cask body, and lid will not be effected when subjected to the 30-foot free drop.

Puncture

Using the method given by the "Cask Designers Guide," the applicant has shown a safety factor of 1.36 against puncture of the 1/2-inch outer shell. The 1/4-inch thick sheet was not considered in the analysis. Bending mode stresses were also investigated and the safety factor against general yielding of the cask shell due to puncture induced bending was well above 2.0.

Fire Test

The maximum temperatures and pressures resulting from the hypothetical accident conditions were used in the finite element analysis. The resultant stresses of thermal and pressure were shown to be less than the stress limits defined in Regulatory Guide 7.6.

Water Immersion

Not applicable, fissile packages only.

THERMAL

The packaging is a stainless steel encased, lead shielded container, it has foam filled impact limiters at each end which also act as thermal insulation; thermal protection for the 1/2-hour fire test is provided by a 1/4-inch thick stainless steel plate separated from the outer shell by 16-gage wire wrapped on 6-inch centers. A two-dimensional model was developed for a thermal analyzer program (THAN, based on the Lockheed Thermal Analyzer program); solutions were obtained for normal conditions of transport and hypothetical accident conditions of 10 CFR Part 71.

The applicant reports a maximum containment cavity and seal temperature (and pressure) of 214°F (19 psig) for the normal condition heat test of 10 CFR Part 71 with 800 watts internal heat; this is below the maximum silicon seal service temperature of 400°F, and is within the allowable temperatures for the cask structure. The maximum cavity and seal temperature (and pressure) is 191°F (12.4 psig) for a 100°F ambient and solar heating.

For the accident conditions the applicant reports a maximum containment cavity and seal temperature of 371°F which results in a maximum internal pressure of 184 psig. The reported temperature is below the maximum service temperature of 400°F for the silicon seal. The maximum internal heat will be 800 watts.

We find the applicant's evaluation of the thermal performance of the packaging under normal conditions and hypothetical accident conditions of 10 CFR Part 71 to be satisfactory.

SHIELDING

The packaging has an effective biological cylindrical shield composed (in the radial and axial directions) of 5 inches of lead sandwiched by an inside cylinder (1/2" thick) and an outside cylinder (3/4" thick) of steel. The applicant intends to load the radioactive inventory within the cask such that the cask surface dose rate of 200 mrem/hr or 10 mrem/hr at six feet from the surface of the package will not be exceeded. Structural and fire analyses performed by the applicant and confirmed by the staff shows no significant damage to the shield effectiveness for the 30-foot drop, puncture, and fire test.

The applicant determined the controlling criteria for loading and shielding considerations using a point source model and an equivalence expression between dose rate D(R/HR) and Ø (photon flux) through the expression $D=2.3\times10^{-6}(R/HR)/Ø$ for Cobalt-60. The factor 2.3×10^{-6} is derivable from the well known expression Dose Rate = $2ØE\times10^{-6}$ (Ø=photons/cm^2sec; E=Mev). For Co-60, the Ø in this latter expression must be doubled (since there are 2 photons per-dis in Co-60) at an average energy of (1.17+1.33)/2 or 1.25 Mev. The applicant failed to incorporate this doubling factor into his analysis and hence his calculated allowable source strengths (permitted loadings) are high by a factor of two. The permitted loadings are closer to 10 Curies rather than 20 curies of Co-60. The applicant's conclusion that the surface dose rate loading criteria is controlling is nevertheless correct. This will be established by gamma measurements on the cask surface.

The staff performed its own shielding analysis verifying the factor of two error in the applicant's analysis. Other than this latter error, the staff concurs with the applicants geometric and nuclear data and methodology used in the shielding analysis.

Since gamma measurements are required to be made prior to each shipment and there is no shielding loss under accident conditions, the requirement of 10 CFR §71.36(a)(1) will be met.

CRITICALITY

Not applicable, no fissile material.

OPERATING, ACCEPTANCE, AND MAINTENANCE

General operating procedures for use of the package are provided in Section 7 of the application.

The acceptance tests and maintenance program is described in general terms in Section 8 of the application. The details of initial, periodic, and assembly verification leak testing are described under the containment section and the leaktests are specified as approval conditions. The additional requirements in this section will also contribute to safe use of the package; therefore, Section 8 has been specified as a condition of approval.

CONDITIONS

1. As needed, appropriate shoring must be used in the cask cavity to limit movement of the secondary container during accident condition of transport.

2. The cask cover must be secured by twelve (12), SA-354, Type BD, 1-1/4"-7UNC x 2-1/4" long bolts torqued to 270 ft-lbs $\pm$ 10% (lubricated) or 360 ft-lbs $\pm$ 10% (dry).

3. Prior to each shipment, the leak tests described in Appendix 8B of the application must be performed. No package is to be delivered to a carrier for transport with a detectable leak using the method of Appendix 8B.

4. For all packages containing residual water or other substances which could radiolytically generate combustible gases, a determination must be made by tests and measurements of a representative package such that the following criteria are met over a period of time that is twice the expected shipment time:

   (i) The hydrogen generated must be limited to a molar quantity that would be no more than 5% by volume (or equivalent limits for other inflammable gases) of the secondary container gas void if present at STP (i.e., no more than 0.063 g-moles/ft^3 at 14.7 psia and 70°F); or

   (ii) The secondary container and cask cavity must be inerted with a diluent to assure that oxygen shall be limited to 5% by volume in those portions of the package which could have hydrogen greater than 5%.

   For packages to be delivered to a carrier for transport, the secondary container must be prepared for shipment in the same manner in which determination for gas generation is made. Shipment period begins when the package is prepared (sealed) and must be completed within twice the expected shipment time.

5. In addition to the requirements of Subpart D of 10 CFR Part 71:

   (i) Each package must meet the acceptance tests and be maintained in accordance with the Maintenance Program of Section 8 of the application.

   (ii) Each package must be leak tested to insure a leak rate not greater than 3×10^{-5} atm-cm^3/sec at STP prior to first use, after the third use, and annually thereafter.

   (iii) The O-ring, test port and drain line seals must be replaced quarterly with new seals. The flat lid gasket must be replaced annually.

CONCLUSION

Based on our review, the statements and representations contained in the application and the conditions listed above, we find that the Model No. CNS 1-13C II package meets the requirements of 10 CFR Part 71.

Charles E. MacDonald, Chief
Transportation Certification Branch
Division of Fuel Cycle and
Material Safety, NMSS

Date: APR 04 1982