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ORNL/ENG/TM-3/A1

Safety Analysis Report for Packaging: The ORNL Tungsten-Shielded Cask

Addendum 1

J. H. Evans
R. W. Mouring

ORNL/ENG/TM-3/A1
Dist. Category UC-71

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ORNL Engineering

SAFETY ANALYSIS REPORT FOR PACKAGING:

THE ORNL TUNGSTEN-SHIELDED CASK

ADDENDUM 1

J. H. Evans
R. W. Mouring

Date Published: February, 1979

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

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SAFETY ANALYSIS REPORT FOR PACKAGING: THE ORNL TUNGSTEN-SHIELDED CASK ADDENDUM 1

J. H. Evans
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ABSTRACT

Described here are the modifications of the Oak Ridge National Laboratory (ORNL) tungsten-shielded cask necessary when the cask is used to transport materials of greater activity and heat load than those specified in the original Safety Analysis Report for Packaging (SARP) for the cask. Also included are the data and documentation to demonstrate that the cask complies with the regulations governing containers in which radioactive and fissile materials are transported, even under the previously stated circumstances.

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0. GENERAL INFORMATION

0.1 Introduction

The ORNL tungsten-shielded cask was developed at the Oak Ridge National Laboratory (ORNL) in 1967; 12 casks were built and are currently in use. The design was analyzed, and a Safety Analysis Report for Packaging (SARP)[1] was published in 1977 to demonstrate compliance with the regulations governing containers in which radioactive and fissile materials are transported.[2-4] It has become necessary to use the cask to transport contents (Type B and large-quantity radioactive materials) which emit more gamma radiation and have higher heat-generation rates than those contents specified in the original SARP. Calculations, engineering-logic test results, packaging modifications or additions, and all related documents that demonstrate compliance with the regulations are presented in subsequent sections of this addendum. Copies of the approval documents are presented in Appendix A.

0.2 Package Description

0.2.1 Container description and modifications

Each cask as described in the SARP has been modified only by the addition of a 1-in. pipe welded to the lid to ensure position of the contents. Also, a tungsten insert to provide additional shielding, a personnel heat shield to reduce accessible surface temperature, and a skid to facilitate handling have been added. The package is illustrated in Fig. 0.1, and as-built fabrication drawings are in Appendix B. The weight of the cask and insert is 404 lb. The weight of the total assembly is 565 lb; that of the basic cask remains 381 lb. The tungsten insert weighs 23 lb, the heat shield 70 lb, and the skid 91 lb. The center of gravity remains essentially at its original location.

0.2.2 Operational features

Operational features of the cask remain unchanged except that the heat shield renders the four 3/4-in.-diam holes in the gusset plates inaccessible for lifting or tie-down during transit. The skid has provisions for forklift handling of the package.

0.2.3 Contents

In addition to the contents specified in the original SARP, the cask with insert, heat shield, and skid in place will be used to ship nonfissile radioisotopes in solid form with a maximum internal heat load of 50 W. The radioactive materials will also be limited by compliance with the external radiation levels specified in Department of Transportation (DOT) regulations. All radioactive materials will be in special form containers, as described in the SARP.

0.2.4 Materials of the modifications

Modifications to the cask include the addition to the lid of a 1 in., sch. 40, stainless steel pipe capped with a 1/8-in.-thick stainless steel plate welded all around. The tungsten insert is of 18.6 special

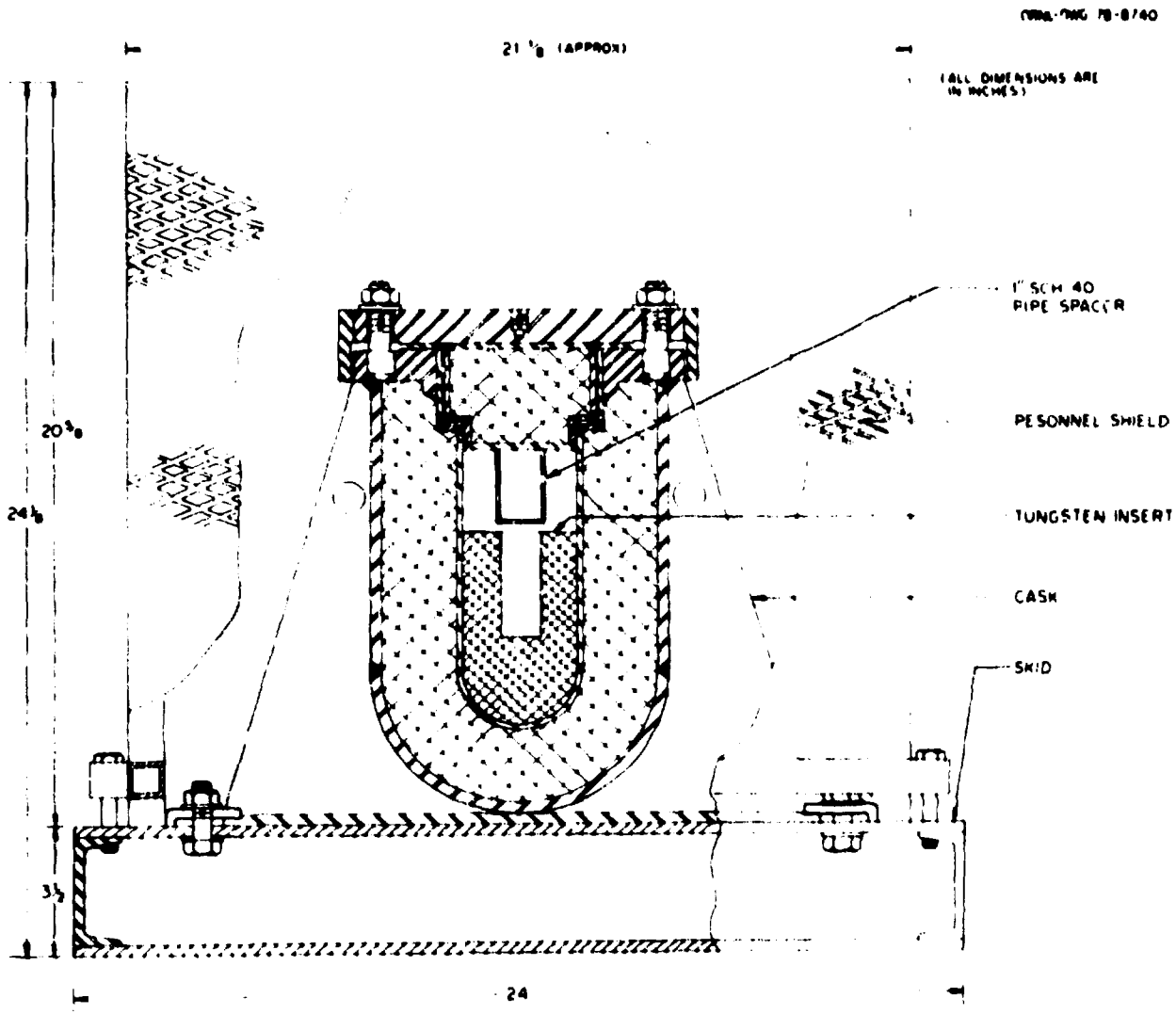

Fig. 0.1. ORNL tungsten-shielded cask.

grade tungsten alloy pressed and sintered with nickel-iron alloy as specified in Y-12 Technical Data Sheet No. 2.6.4.

The 1 x 1 x 1/8 in. rectangular tubing and 16-gauge expanded sheet added to the personnel shield are of carbon steel. The bolts, also of carbon steel, are 1/2-13 UNC-2, 2-1/4-in.-long bolts.

All components of the skid, the plates, channels, spacers, clamps, nuts, and bolts, are of low carbon steel. The bolts are 1/2-13 UNC-2, 1-3/4-in.-long bolts.

1. STRUCTURAL EVALUATION

For the purpose of structural evaluation, the effects of the personnel shield and skid will be neglected, except as outlined in the following discussion. This represents a conservative approach because these components protect the cask and would have a cushioning effect in any impact. The tungsten insert and the effects of the weight increase attributable to it are considered. The original evaluations affected are recalculated in Table 1.1 and are referenced to section and page number in the SARP. All stresses, etc., are below the acceptable limits. The impact calculations were also made using the increased weight. The changes in cask response are presented in Table 1.2. Changes are small and do not alter the conclusion reached in the SARP. The personnel shield makes the lifting lugs inaccessible for the tie-down; hence, this calculation was not made. When in transit, the cask is secured by the same techniques as conventional cargo without lifting lugs.

2. THERMAL EVALUATION

The increase in internal heat load would cause the surface of the cask proper, without the personnel shield, to approach or slightly exceed the normal operational limit of 122°F specified in the regulations.[4] With the personnel shield in place, the shield becomes the accessible surface, and temperatures are well below the operating limits. During the first week of October 1978, testing was conducted on a modified

Table 1.1. SARP changes caused by increase of cask weight

Page	Report section	Equation	Calculation with previous weight	Calculation with new weight	Remarks
8	1.2.2	$\sigma_b = P/dt$	3 050 psi	3 232 psi	
9	1.2.3	$\sigma = P/A$	14 750 psi	16 160 psi	
14	1.3.1	$\omega = 5(W/L)$	140.8 lb/in.	149.3 lb/in.	Equation is in Fig. 1.4a
15	1.3.1	$\sigma = Mc/I = 5(WL^2 r_0/8I)$	270 psi	286 psi	
27	1.4.7	$\sigma_c = P/A = 5W/\pi D_o t$	301 psi	320 psi	
35	1.5.2	$U = Wh$	15 240 in.·lb	16 160 in.·lb	
37	1.5.2		7.48×10^{-5}	7.94×10^{-4}	See pp. 35-37 for discussion
37	1.5.2		8.84×10^{-3}	8.85×10^{-3}	See pp. 35-37 for discussion
38	1.5.2	$a_{max} = \sigma Ag/W$	5 417 × g	5 111 × g	

Table 1.2. Comparison of cask responses for previous weight and new weight

Page	Report section	Drop condition			Calculations with previous weight		Calculations with new weight	
		Orientation of impact	Height (ft)	Specific energy (in.·lb/in.^{3})	Acceleration (× g)	Deformation (in.)	Acceleration (× g)	Deformation (in.)
24-26	1.4.6.2	Top corner (with center of gravity corner)	4	70 000	380	0.3028	396	0.3234
				230 000	597	0.184	641	0.2008
30-32	1.5.1.2		30	70 000	1 250	0.69	1 264	0.7152
				230 000	? 050	0.42	2 100	0.4474
22-23	1.4.6.1	Top	4		1 875	0.053	1 879	0.056
28-29	1.5.1.1		30		3 360	0.176	3 286	0.183

tungsten cask with insert, personnel shield, and skid in place (Appendix C). The testing was conducted indoors with an ambient temperature of 71°F. The cask was loaded with a 47.4-W ^{192}I source and allowed to reach equilibrium. The temperatures corrected for a 50-W source and 100°F ambient temperature are 110°F at the top of the personnel shield, 110°F at the side of the personnel shield, and 115°F at the bottom of the personnel shield. Because the temperatures were too low for significant radiation heat transfer, the temperature corrections were made on the basis of free convection alone. The corrected temperatures of the contents are well below the special form test temperature.[2,3]

The additional internal heat load would not significantly affect the results of the thermal accident (fire)[2,3] because, as described in the original SARP,[1] the cask approaches the fire temperature of 1475°F. As a result of its small weight, the cask has little heat capacity.

3. CONTAINMENT

The containment boundaries for the package are not altered or affected by these modifications.

4. SHIELDING

The shielding outlined in the SARP is supplemented by the tungsten insert. Radiation readings were taken on a tungsten-shielded cask loaded with a 47.4-W ^{192}I source (Appendix C). The radiation readings extrapolated for a 50-W source are 36 millirems/hr at the top of the personnel shield, 25 millirems/hr at the side of the personnel shield, and 5.3 millirems/hr at the bottom of the personnel shield. The highest radiation reading at a distance of 1 m was 2.1 millirems/hr. These readings are well within the allowable radiation dose-rate limitations of the DOT.[4]

5. CRITICALITY

Criticality evaluation is not necessary because no fissile materials are to be transported in this cask.

6. QUALITY ASSURANCE

Engineering quality assurance procedures established by Union Carbide Corporation, Nuclear Division (UCC-ND), which comply with the guidelines described in Chap. OR IMD 02XX of the *DOE Manual*,[5] were used to ensure the quality of the addition to the package. The necessary modifications to the cask as well as the inspections needed to ensure compliance with these specified modifications are outlined on the drawings in Appendix B.

REFERENCES

1. J. H. Evans, D. L. Levine, and R. A. Just, *Safety Analysis Report for Packaging: The ORNL Tungsten-Shielded Cask*, ORNL/ENG/TM-3 (October 1977).

2. *Code of Federal Regulations*, Title 10, Part 71, "Transport of Licensed Materials;" see also *Fed. Regist.* 31, 9941-49 (July 1966).

3. *AEC Manual*, vol. 0000, Pt. 0500, Chap. 0529, U.S. Atomic Energy Commission, Aug. 22, 1966.

4. *Code of Federal Regulations*, Title 49, Part 173, "Transportation"; see also *Fed. Regist.* 33, 14920-31 (October 1968).

5. *DOE Manual*, vol. 0000, Pt. 0200, Chap. OR IMD 02XX (supersedes Chap. OR IMD 0820), TN 0200-1, U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tenn., Jan. 30, 1978.

Appendix A

APPROVAL DOCUMENTS

TC 78-1

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

June 13, 1978

To: J. H. Evans

Subject: Approval of Safety Analysis Report for Packaging: The ORNL Tungsten-Shielded Cask, Addendum 1

The draft (received June 1, 1978) of the subject SARP has been reviewed by the Transportation Committee. The SARP is approved for technical content and approach -- for submission to DOE. Comments from individual members of the Committee have been forwarded for consideration.

E. M. King

E. M. King
Transportation Committee

cc: Committee Members
G. H. Burger
J. A. Cox
J. H. Evans
R. W. Schaich

Appendix B

AS-BUILT DRAWINGS

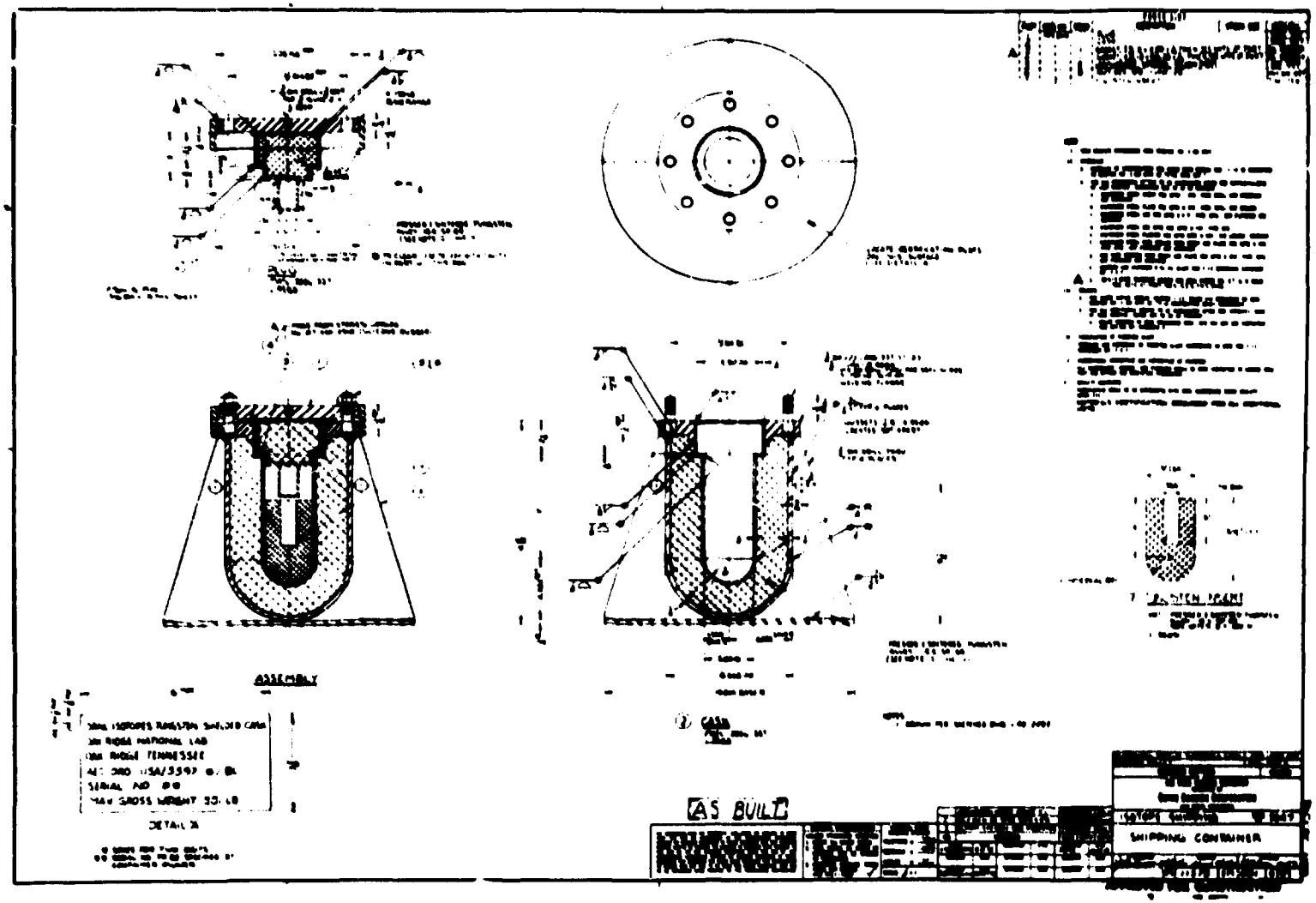

Fig. B.1. As-built drawing of the ORNL tungsten-shielded cask and insert.

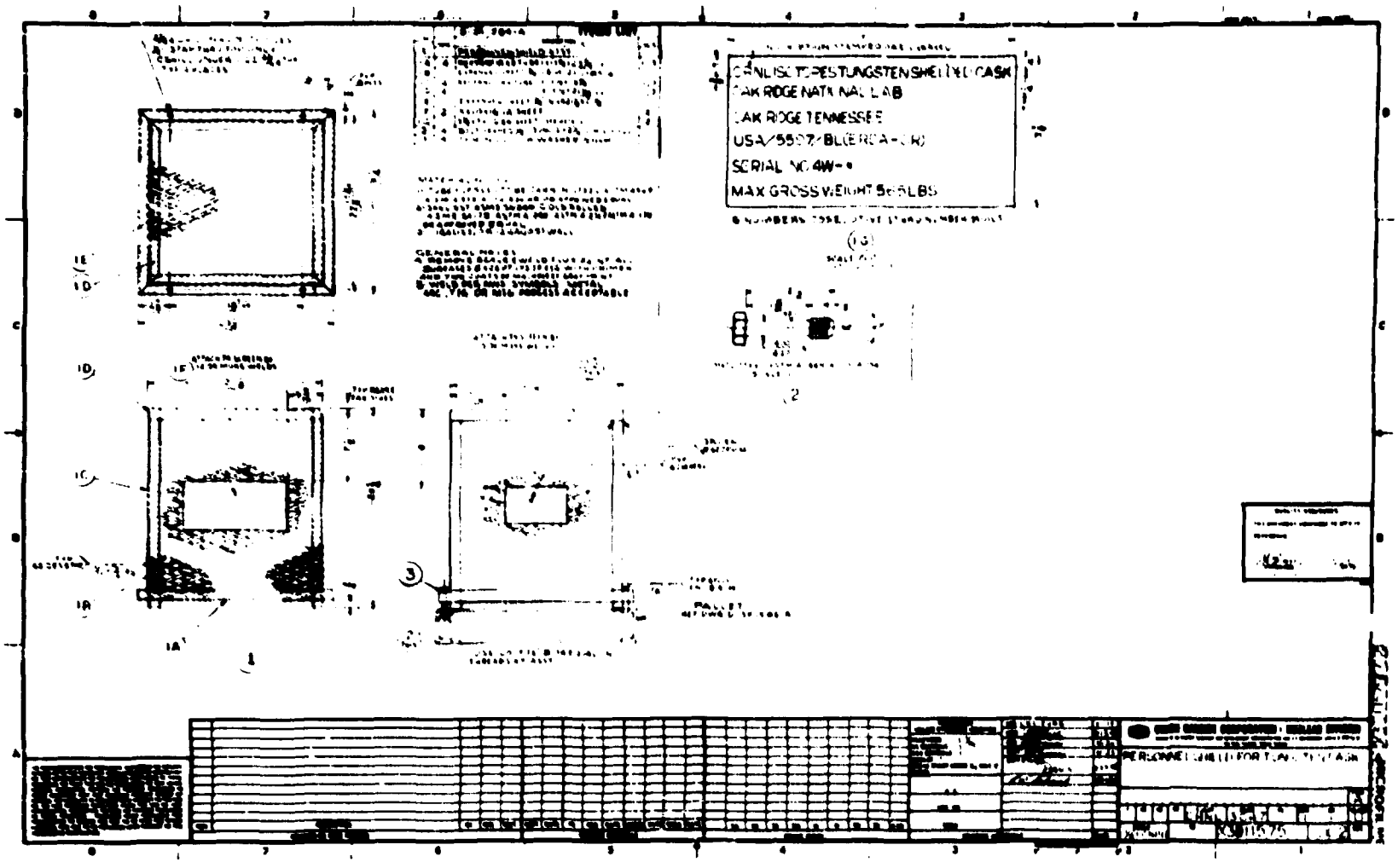

Fig. B.2. As-built drawing of the personnel shield for the ORNL tungsten-shielded cask.

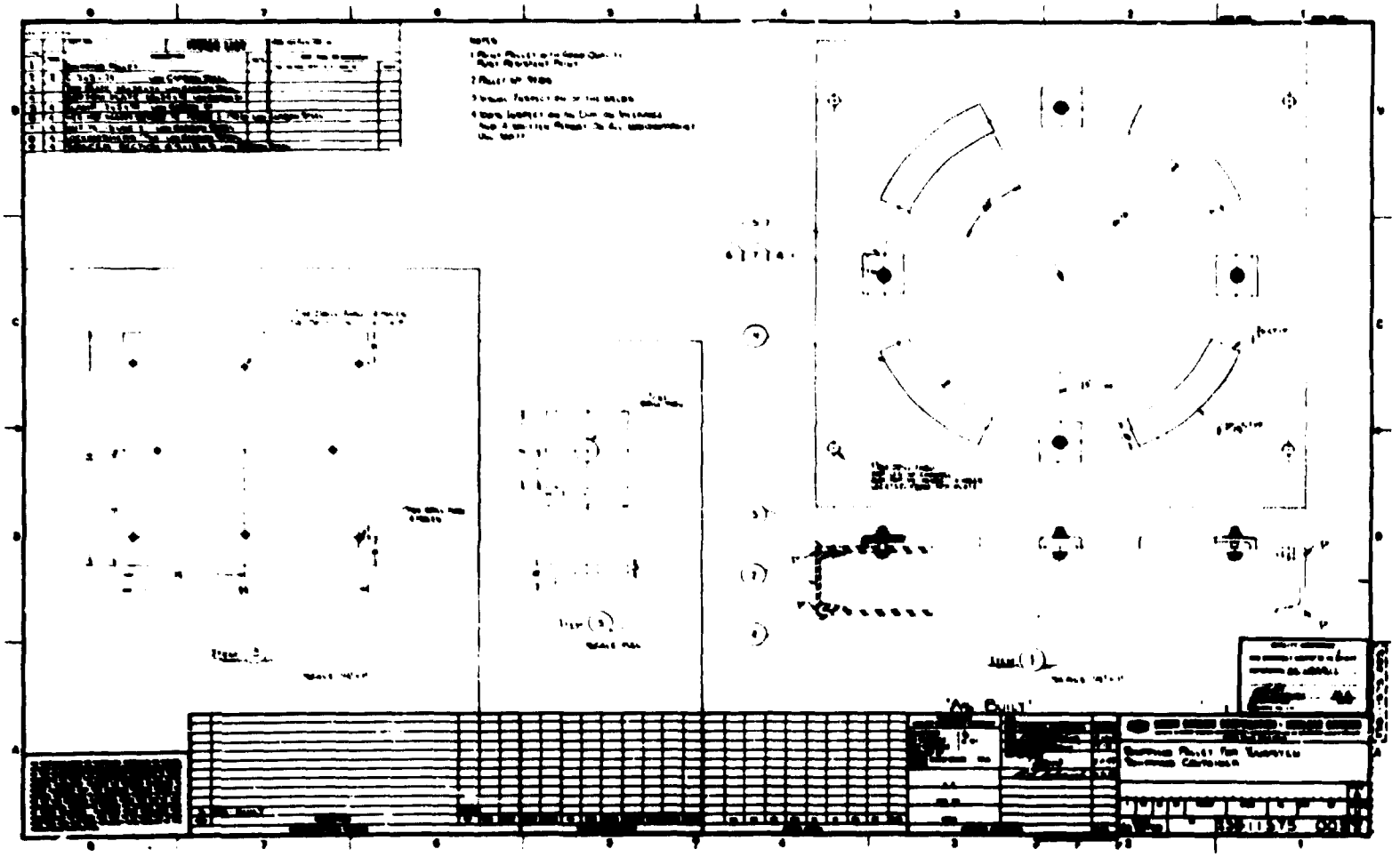

Fig. B.3. As-built drawing of the shipping pallet for the ORNL tungsten-shielded cask.

Appendix C

TESTING OF TUNGSTEN-SHIELDED CASK WITH PERSONNEL SHIELD

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

To: John Evans Date: October 9, 1978

From: R. W. Schaich

Subject: TESTING OF TUNGSTEN SHIELDED CASK WITH PERSONNEL SHIELD

A Tungsten Shielded Cask with a tungsten insert was loaded with 8,320 curies (47.4 watts) of iridium-192 to determine radiation and temperature measurements on the personnel shield (see attached).

The radiation measurements were made by Health Physics personnel using a calibrated (9/6/78) Victoreen Model 440.

Reading Position	Radiation, mrem/hr
Top of personnel shield	34
Side of personnel shield	24
Bottom of personnel shield	5
Highest reading @ 1 meter	2

The temperature measurements were made by R. W. Schaich using three calibrated thermocouples and Simplitrol Temperature meters at various points on the personnel shield after the cask temperatures reached equilibrium.

Reading Position	Temperature, °F
Top of personnel shield	75
Side of personnel shield	75
Bottom of personnel shield	80
Ambient temperature	71

R. W. Schaich

R. W. Schaich

RWS:drw

Attachment

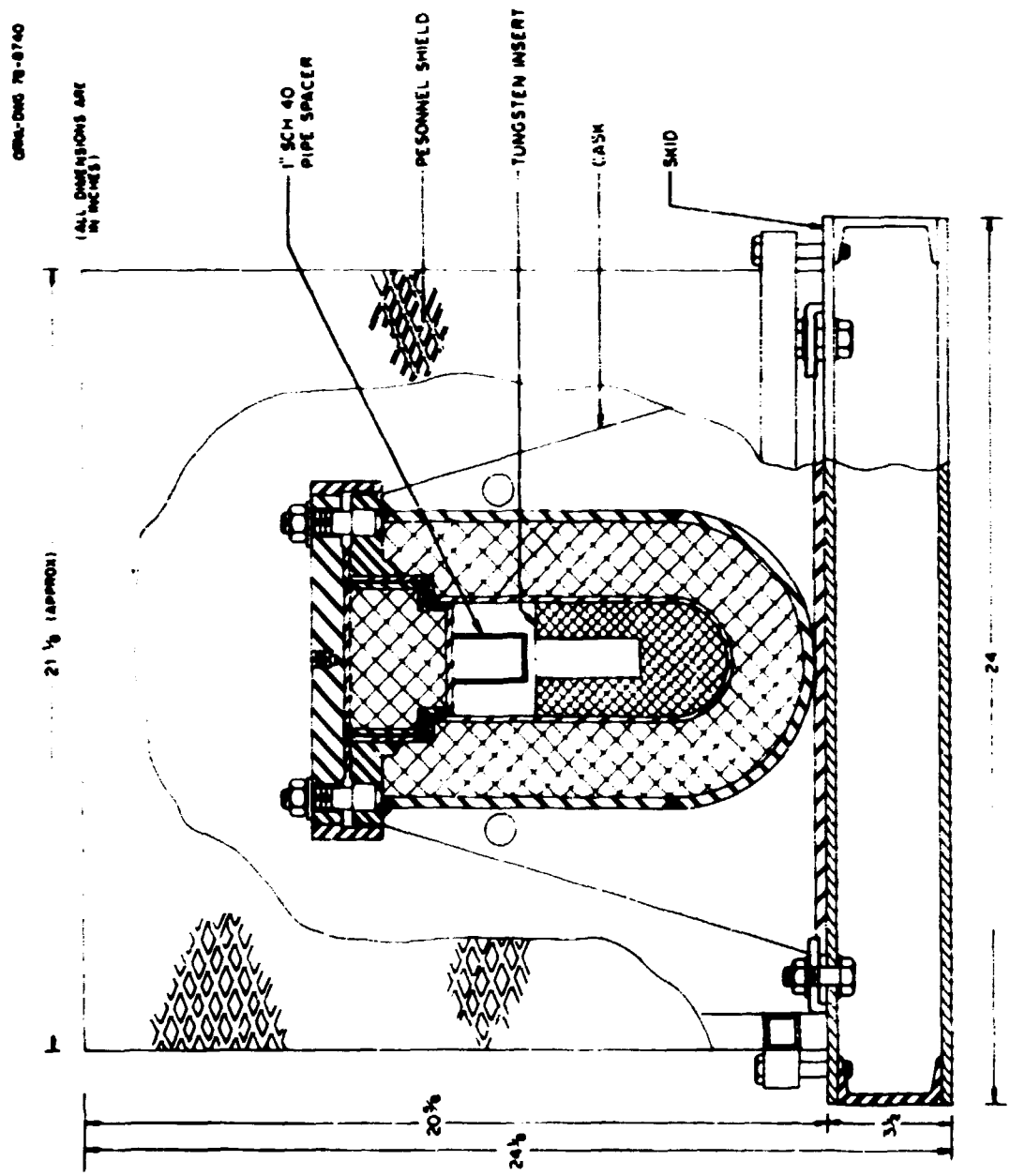

Fig. C.1. ORNL tungsten-shielded cask.

Appendix D

CERTIFICATE OF COMPLIANCE

DOE Form EV-4.0
(11-**)
10 CFR 71

U.S. DEPARTMENT OF ENERGY

CERTIFICATE OF COMPLIANCE

For Radioactive Materials Packages

1a Certificate Number	1b Revision No.	1c Package Identification No.	1d Page No.	1e Total No. Pages
5597	2	USA/5597/BL(DOE-ORO)	1	2

2 PREAMBLE

2a 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).

2b 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 Materials Under Certain Conditions."

2c 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

(1) Prepared by (Name and address):

Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

(2) Title and identification of report or application:

a) Safety Analysis Report for the ORNL Tungsten-Shielded Cask, Report No. ORNL/ENG/TM-3 — (3) Date: a) Oct. 1977

b) Safety Analysis Report for the ORNL Tungsten-Shielded Cask, Addendum 1, Report No. ORNL/ENG/TM-3, Addendum 1. — (3) Date: b) March 1979

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: Tungsten-Shielded Cask

(2) Description:

The packaging consists of a right circular cylinder with a hemispherical bottom. It has a maximum outside diameter of 16-in. at the base. The cask itself has an outside diameter of 8-in. The overall height is 15-1/4-in. Inner cavity dimensions are 3.120-in. diam. by 6-1/2-in. high. Shielding is composed of a 2" thickness of isostatically pressed and sintered tungsten alloy containing 95% tungsten, 3.5% nickel, and 1.5% iron, with a 1/4-in. type 304L stainless steel cladding outside and a 1/8-in. type 304L stainless steel cladding inside. The gasketed lid consists of a 150-lb. flange to which the top shield plug is attached and is held in place by eight 5/8-in. studs and bolts. A capped 1-in. pipe is welded to the underside of the cask lid to position the contents. The gross weight of the basic cask is 381 lbs.

A tungsten insert, heat shield, and skid are utilized for shipping radioactive materials having higher internal heat loads and external radiation levels. The gross weight of the cask, insert, heat shield and skid is 565 lb.

6a Date of Issuance: JAN 25 1979

6b Expiration Date:

FOR THE U.S. DEPARTMENT OF ENERGY

7a Address (of DOE Issuing Office):

U. S. Department of Energy
Post Office Box E
Oak Ridge, Tennessee 37830

7b Signature, Name, and Title (of DOE Approving Official):

William H. Travis, Director
Safety and Environmental Control Division

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(3) Drawings:

The packaging is as described and fabricated in accordance with Oak Ridge National Laboratory Drawings No. M-11575-EM-001-E-Rev. 2, X3D11575-002, and X3D-11575-003-Rev. 3.

b. Contents:

(1) Type and Form of Material:

Non-fissile radioactive materials as solid and in special form.

(2) Maximum quantity of material per package may be a large quantity and not to exceed 25 watts of thermal decay energy without the insert, heat shield, and skid and not to exceed 50 watts of thermal decay energy with the insert, heat shield, and skid. The radioactive contents will be further limited by authorized external radiation levels specified in Department of Transportation (DOT) Regulations.

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Dist. Category UC-71

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67. C. L. Hanson, Lawrence Livermore Laboratory, University of California, Post Office Box 808, Livermore, California 94550.
68. R. E. Harris, DOE, ORO.
69. R. J. Hart, DOE, ORO.
70. J. W. Langhaar, E. I. du Pont de Nemours & Company, Wilmington, Delaware 19898.
71. Assistant Manager, Energy Research and Development, DOE-ORO
72. E. C. Lusk, Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio 43201.

73. W. G. O'Quinn, DOE, Savannah River Operations Office, Post Office Box A, Aiken, South Carolina 29801.
74. R. H. Odegaarden, NRC, Office of Regulation, Washington, D.C. 20545.
75. R. W. Peterson, Allied General Nuclear Services, Post Office Box 847, Barnwell, South Carolina 29812.
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