269

1859

7-19LA-4686-MS

MASTER

Shielded Shipping Container for
Fissile Material Class I or
Large Quantities of Radioactive Material

los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87544

UNITED STATES
ATOMIC ENERGY COMMISSION
CONTRACT W-7405-ENG. 36

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

This report, like other special-purpose documents in the LA. .MS series, has not been reviewed or verified for accuracy in the interest of prompt distribution.

Printed in the United States of America. Available from
National Technical Information Service
U. S. Department of Commerce
8285 Port Royal Road
Springfield, Virginia 22151
Price: Printed Copy \$3.00; Microfiche \$0.95

LA-4586-MS

UC-41

ISSUED: June 1971

Shielded Shipping Container for Fissile Material Class I or Large Quantities of Radioactive Material

Report by:

Horace E. Noyes

Work done by:

Carl W. Buckland
Robert H. Hendron
John W. Schulte
David R. Smith

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

SHIELDED SHIPPING CONTAINER FOR FISSILE MATERIAL CLASS I OR LARGE QUANTITIES OF RADIOACTIVE MATERIAL

by

Horace E. Noyes

ABSTRACT

A small, well-shielded shipping container has been designed to accommodate whole or sectioned irradiated fast reactor fuel elements and associated hardware and components in compliance with existing regulatory requirements. Background material and approvals are given in appendixes.

Analytical Sample Shipping Cask

The selection of the Los Alamos Scientific Laboratory as one of the sites at which irradiated fuel elements are to be examined in support of the Fast Breeder Reactor Program necessitated consideration of, and provision for, adequate shipping containers for highly irradiated fuel elements prototypical of those used in that program.

Small samples of fuel sections, irradiated cladding, capsule hardware, and other components, as well as the fuel elements, are expected to be shipped.

Existing casks are disproportionately heavy or inadequate as to cavity size and shape, necessitating the consideration of design criteria for a small cask capable of accommodating up to 3 kg of any fissile material or materials and "large quantities"* of other radioactive material.

Radiological Safety

No exception is made to applicable external radiation levels.

Inner containment is designed so as to provide essentially contamination-free transfers from highly contaminated containment boxes.

The recipient of a radioactive shipment is provided with the following information prior to or at the time of shipping.

a. Appropriate sketches showing the containers used in packaging, and identification and location within the containers of their contents.

b. An assembly drawing of the shipping cask. A photograph may also be supplied if required.

c. Any technical detail regarding the encapsulated samples, such as the contamination level of the inner containers, beta-gamma activity levels of the samples, and physical conditions of the samples are discussed with the recipient prior to shipment.

Design Criteria

The packaging will consist of a right cylindrical weldment, which is a steel encased, depleted uranium shielded cask about 14 in. in diameter, 21 in. long, estimated to weight 2,000 lb. A drain with fusible plug will be provided. Contents must not exceed 3 kg total fissile material in "Special Form"* and may include "large quantities" of radioactive material. The container meets criteria for "Fissile Class I"* shipment.

Nuclear Criticality Safety

The container is a favorable geometry configuration having a cavity diameter too small to support criticality.

*Terms marked by an asterisk are defined in Title 49, Code of Federal Regulations, Part 173.389, "Radioactive Materials, Definitions."

Further consideration was given to compliance with Fissile Class I criteria. DTF IV calculations were performed in infinite cylindrical geometry with a white reflecting outer boundary. The inner region was plutonium to a radius of 1.336 cm surrounded by a 0.3 cm steel jacket. The next region consisted of normal uranium to a radius of 14.542 cm again surrounded by steel to an outer radius of 14.796 cm.

Normal uranium was used in the calculations so there would be no safety requirement for verification of the isotopic composition of the depleted uranium, which will be used in fabrication of the cask.

With the inner cavity filled with alpha-phase plutonium (^{239}Pu at 19.7 g/ml) the S4 calculation resulted in a value of K_{∞} of 0.82.

A second computation was performed using the concentration search routine, and the critical density of ^{239}Pu was found to be approximately 28 g/ml.

These calculations included no provision for the material which would encapsulate the plutonium, so were to that extent conservative as well as in the use of infinite length.

An infinite array of these containers would therefore be subcritical if loaded with any fissile material. Any addition of moderating material between container or replacement of fissile material with moderating material within the containers would reduce the array reactivity.

Structural Analysis

Attached as Appendix A.

Thermal Considerations

Assuming ambient temperature of 100°F, contents of container will be restricted to a maximum of 32 W thermal decay energy. The cask will withstand 1475°F without melting. (See Appendix A, Paragraph II.F.3.)

Quality Assurance

Welding Specification attached as Appendix B.

U. S. Atomic Energy Commission Approval

Certification of Approval issued by the Operational Safety Division, Albuquerque Operations Office, USAEC, identified as Al-L21 attached as Appendix C.

Department of Transportation Approval

Department of Transportation Special Permit 6421 attached as Appendix D.

Container Drawing

Drawing ENG-E 384 Sheets D-1 through D-7 attached as Appendix E.

APPENDIX A: STRUCTURAL ANALYSIS OF SHIPPING CONTAINER FOR RADIOACTIVE ANALYTICAL SAMPLES

Introduction

This document presents the structural analysis of a proposed shipping container for use with activated metal samples. The analysis is in compliance with Section II (packaging standards) of Chapter 0529 (Safety Standards for the Packaging of Radioactive and Fissile Materials) of USAEC Manual.

The analysis is numbered to correspond to Section II of 0529, and summarizes the mathematical analysis which is presented as an Appendix.

The container design is shown on drawings ENG-E 384, sheets D-1 through D-7.

SHIPPING CONTAINER FOR ANALYTICAL SAMPLES

(Numbers Reference AECM Chap. 0529)

- II.A.1. The radioactive material is special form.
- II.A.2. The positive closure device consists of multiple screws and safety wire seal.
- II.A.3.a. The container, which will be handled by fork lift or crane, has a weight approximately 2000 lbs. Design calculations (Appendix, pages 8 and 24) indicate the capability of the handle to support three times the weight of the total load without exceeding the yield strength of the material.
- II.A.3.b. Not applicable.
- II.A.3.c. The eye bolt conforms to (a).
- II.A.3.d. Failure of the lifting device would in no way affect the containment or shielding properties of the package.
- II.A.4. There are no tie down devices on this package.
- II.B.1. Load resistance is more than adequate (Appendix, page 15).
- II.B.2. An external pressure of 25 psi is a trivial condition for a thick walled cylinder.
- II.C. Criticality standards are discussed elsewhere.
- II.D.1. Evaluation of a single package was based on calculations as required by Annex 1 and Annex 2.

- II.D.2. No controls by the shipper are anticipated.
- II.D.3. No deviations from Annex 1 or Annex 2 requirements are anticipated.
- II.E. There should be no compromise of the integrity of the container or its contents as defined in Annex 1, Normal Conditions of Transport.

Following is a summary of the findings of the calculations for the Normal Conditions of Transport (Appendix, Annex 1).

1. Heat - At 130°F no part of the cask or capsule will in any way be affected. O-Ring is good to 300°F.
2. Cold - Cold presents no problem for this container.
3. Pressure - The seals used in this container are rubber O-Rings. Pressures of $\frac{1}{2}$ atmosphere are completely insignificant in this application.
4. Vibration - This shipping container is not susceptible to vibration damage.
5. Water Spray - The sealed container should preclude entry of any moisture into the container.
6. Free Drop - A free drop of four feet is much less than the accident condition requirements of Annex II and should not compromise the integrity of the container.

II.E. (Continued)

7. Corner Drop - Not applicable.
8. Penetration - The 520 lb-in of energy should not exceed the elastic capability of the container and therefore would not affect the container integrity.
9. Compression stress is insignificant when compared to the yield strength of the container material.

II.F. Calculations indicate the containment capabilities of this container would not be impaired when subjected to the accident conditions specified in Annex 2. There would be no release of radioactive materials or changes in radiation dose rates external to the container. Following is a summary of the Hypothetical Accident Condition Calculations, Appendix, Annex 2.

1. Free Drop - The worst damage condition resulting from a 30-foot free drop is the plastic deformation of 1.41 in. on the outer edge of the container. The inner container will serve as a fail safe condition in this instance. (Appendix, pages 18-21.)
2. Puncture - Configuration of this container makes the requirements for the puncture test condition much less severe than the free drop test. (Appendix, page 16.)
3. Thermal - All materials required to fabricate the container were selected to function at 1500°F without danger of release of radioactive materials. The

II.F. 3. (Continued)

materials selected all have annealing temperatures above 1500°F.¹

4. Water Immersion - The dual container is designed to preclude leakage of any water into the inner container. Should any leakage into the outer container occur, the water volume would be insignificant due to the small void to volume ratio.

¹ The seal is a rubber O-Ring which will seal to 300°F. The primary container is of special form.

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
 ENGINEERING CALCULATIONS

JOB	SHIPPING CASK - CMB-14	DATE	7/23/70	SHEET No.	1
DESCRIPTION	WEIGHT - LOWER PORTION BASE PLATE	CALC. BY	WAB	APPROVED BY	

$$W = \pi (7.406)^2 (.625 \times .285) = \underline{30.69 \text{ LB}}$$

CLADDING - CYLINDER

$$W = \pi (5.875^2 - 5.625^2) (13.75 \times .285) = \underline{35.39 \text{ LB}}$$

SEAL FLANGE - BOTTOM

$$\begin{aligned}
 W = \pi (.285) \{ & (7.406^2 - 6.03^2) (1.625) + (6.03^2 - 3.25^2) (.375) \\
 & + (3.75^2 - 3.25^2) (1.25) + (3.5^2 - .875^2) (.375) \} \\
 & = \underline{43.33 \text{ LB}}
 \end{aligned}$$

CENTER TUBE - BOTTOM

$$\begin{aligned}
 W = \pi \{ & (.875^2 - .75^2) (2.625) + (.656^2 - .431^2) (7.375) \\
 & + (1.00^2) \} (.285)
 \end{aligned}$$

$$W = \underline{3.00 \text{ LB}}$$

DRAIN PIPE - 1/4" SCH

$$.43(.5)$$

$$W = \underline{.22 \text{ LB}}$$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
 ENGINEERING CALCULATIONS

JOB	DATE	SHEET No.
SHIPPING CASK - CMB 14	7/23/70	2
DESCRIPTION	CALC. BY	APPROVED BY
	WJB	

D-38 - No Hole

$$W = \pi (5.625)^2 (4.125 \times .675) = \underline{276.77}$$

D-38 - Smaller Hole

$$W = \pi (5.625^2 \cdot .656^2 \times 15.938 \times .675) = \underline{1054.84}$$

D-38 - Bottom of Larger Hole

$$W = \pi (5.625^2 \cdot .875^2 \times .625 \times .675) = \underline{40.92}$$

D-38 - Top of Larger Hole

$$W = \pi (2.375^2 \cdot .875^2 \times 1.625 \times .675) = \underline{16.80}$$

LIFTING PIECES

$$\pi (.5)^2 (2 \times 2 \times .285) = \underline{.90 \text{ LB}}$$

TOTAL WEIGHT OF BOTTOM HALF

1503 LB

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
 ENGINEERING CALCULATIONS

JOB	SLIPPING COCK - CMB 14	DATE	7/23/70	SHEET No.	3
DESCRIPTION	WEIGHT - LID	CALC. BY	LD/B	APPROVED BY	

FLANGE

$$\pi(.285) \left\{ (7.406^2 - 5.625^2)(.625) + (6.0^2 - 5.625^2)(1) \right. \\
+ (5.625^2 - 3.6875^2)(.25) \\
+ (3.75^2 - 3.5^2)(1.312) + (3.625^2 - .875^2)(.25) \left. \right\}$$

$$W = \underline{25.83}$$

CYLINDER - OUTSIDE

$$W = \pi (5.875^2 - 5.625^2) (2.875)(.285) = \underline{7.4}$$

FRUSTUM - CONE

$$W = .285(.2618)(3.875) \left\{ (11.75^2 + 11.75(4.125) + 4.125^2) \right. \\
- (11.125^2 + 11.125(3.5) + 3.5^2) \left. \right\}$$

$$W = \underline{8.27}$$

TOP PLATE

$$W = .285(\pi)(2)^2(.5) = \underline{1.79}$$

SCREW BLOCK

$$W = \pi(.625)^2(1.25)(.285) = \underline{.437}$$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
 ENGINEERING CALCULATIONS

JOB	SHIPPING CASK CMB-14	DATE	7/23/70	SHEET No.	4
DESCRIPTION	WEIGHT- LID D-38 - LOWER STEP	CALC. BY	DJB	APPROVED BY	

$$\pi(5.625^2 - 3.75^2)(1.5)(.675) = \underline{55.91}$$

D-38 - CYLINDER

$$\left\{ \pi(5.625^2 - .875^2)(1.5) + \pi(5.625^2)(1.625) \right\} (.675)$$

$$\underline{W = 207.24}$$

D-38 FRUSTRUM

$$W = \left[\frac{\pi}{12} (3.375) \left\{ 11.25^2 + 11.25(4.25) + 4.25^2 \right\} - \pi(.625^2)(1.25) \right] (.675)$$

$$= \underline{113.74}$$

TOTAL WEIGHT OF LID

421 LB

TOTAL WEIGHT OF CASK

1924 LB

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SHIPPING CASK CMB-14	DATE	7/24/70	SHEET No.	5
DESCRIPTION	CALCULATION OF FLANGE	CALC. BY	DJB	APPROVED BY	

"O" RING FORCE NECESSARY FOR SEAL
CATALOG GIVES 250 #/in.

$$\text{FORCE} = \pi(3)(250) = 2360 \#$$

- 1) ASSUME FLANGE ON BODY OF CASK
IS NOT SUPPORTED BY THE D-38
- 2) ASSUME FLANGE IS A FLAT PLATE

ROARK. CASE 3 P195

$$\begin{aligned}
 S_r = S_t &= \frac{3W}{2\pi m t^2} \left[\frac{1}{2}(m-1) + (m+1) \ln \frac{a}{r_0} - \frac{(m-1)r_0^2}{2a^2} \right] \\
 &= \frac{3(2360)}{2\pi(3)(.1406)} \left[1 + 4 \ln \frac{6}{1.5} - \frac{2(1.5)^2}{2(36)} \right] \\
 &= 2671.442 [6.482] \\
 &= 17,318 \text{ psi}
 \end{aligned}$$

$$(\text{AT CENTER}) S_{\max} = \frac{3W(m^2-1)}{2\pi E m^2 t^3} \left[\frac{(3m+1)a^2 - (m-1)r_0^2}{2(m+1)} - r_0^2 \left(\ln \frac{a}{r_0} + 1 \right) \right]$$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SHIPPING CRISK - CMB-14	DATE	7/24/70	SHEET No.	6
DESCRIPTION	CALCULATION OF FLANGE	CALC. BY	DAB	APPROVED BY	

$$S_{max} = \frac{3(2360)(8)}{2\pi(28 \times 10^6)(9)(.052734)} \left[\frac{360 - 2(2.25) - 2.25(2.3862)}{8} \right]$$

$$= .0006783(37.0685)$$

$$= .0265 \text{ IN.}$$

THIS MEANS A MIN. GAP OF .026 BETWEEN FLANGES.

S @ "V" SEAL GROOVE

$$S = \frac{3W(m^2-1)}{2\pi E m^2 r^3} \left[\frac{(3m+1)(a^2-r^2)}{2(m+1)} - (r^2+r_0^2) \ln \frac{a}{r} - \frac{(m-1)r_0^2(a^2-r^2)}{2(m+1)a^2} \right]$$

$$= .0006783 \left[\frac{10(36-2.25)}{8} - 2(2.25)(1.3863) - \frac{2(2.25)(36-2.25)^{3.75}}{2(4)(36)} \right]$$

$$= .0006783 [35.4218]$$

$$= .024 \text{ IN.} \quad \text{ACTUAL MIN BETWEEN FLANGES}$$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SNIPPING CASK - CMB-14	DATE	7/24/70	SHEET No.	7
DESCRIPTION	CALCULATION OF FLANGE	CALC. BY	NEWB	APPROVED BY	

THE UPPER FLANGE POSES NO PROBLEM IF THE TOLERANCES OF CASE & D-38 ARE PROPERLY DONE. THE D 38 SHOULD REST ON THE CENTER PORTION OF THE CASE.

EYE BOLT & TURENDED HOLE FOR TOP

WEIGHT OF LID - 421 LB

FROM MACH. HANDBOOK SAFE LOAD FOR A $3/4"$ EYE BOLT = 1500 LB. TENSION
STRESS IN BOLT = 5000 PSI VERY SAFE,
EVEN IF ENTIRE CASK IS HANDLED
WITH THE EYE BOLT.

STRESS IN TOP PLATE - EYE BOLT HOLDING
ENTIRE CASK.

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SNIPPING CASE CMB-14	DATE	7/24/70	SHEET No.	8
DESCRIPTION	TOP PLATE STRENGTH	CALC. BY	AMB	APPROVED BY	

$$\begin{aligned}
 S_{max} &= \frac{3W}{2\pi m t^2} \left[\frac{1}{2}(m-1) + (m+1) \ln \frac{a}{b} - (m-1) \frac{r_o^2}{a^2} \right] \\
 &= \frac{6000}{2\pi(3)(.25)} \left[1 + 4 \ln \frac{2}{.625} - \frac{2(.625)^2}{4} \right] \\
 &= 1273.236 [5.451] \\
 &= 6948 \text{ psi} - \text{NO PROBLEM}
 \end{aligned}$$

SHEAR OF WELD

$$S = \frac{2000}{\pi(1.5)(.25)} = 1698 \text{ psi} - \text{NO PROBLEM}$$

STRENGTH OF LIFTING BARS

$$S = \frac{MC}{I}$$

ALLOWABLE STRESS: 10,000 psi

$$10000 = \frac{1000 \left(\frac{1}{2} \right) (D) \left(\frac{16}{64} \right)}{\pi D^3 \frac{2}{2}} = \frac{16000}{\pi D^3}$$

$$D^3 = \frac{16000}{\pi(10000)} = .5092$$

$$D = .798 \text{ IN MIN}$$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SWAPPING COCK CMB-14	DATE	7/24/70	SHEET No.	9
DESCRIPTION	STRENGTH LIFTING BRK	CALC. BY	W/R	APPROVED BY	

STRENGTH OF .875 ϕ BRK

$$S_{TENS} = \frac{1000(4)}{\pi(.875)^2} = 1663 \text{ psi}$$

$$BENDING : \frac{1000(.5)(.875)(64)}{\pi(.875)^4} = 7602 \text{ psi}$$

$$MAX \text{ STRESS} : \sqrt{1663^2 + 7602^2} = 7782 \text{ psi}$$

STRENGTH OF BOTTOM PLATE

ASSUME UNIFORM LOAD - SIMPLY SUPPORTED

$$S_t = S_b = \frac{3W(3m+1)}{8\pi m t^2} \quad t = .625$$

$$= \frac{3(2000)(10)}{8\pi(3)(.3906)} = 2037 \text{ psi}$$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SNIPPING CRACK CMB-14	DATE	7/24/70	SHEET No.	10
DESCRIPTION	30' DROP SIDE IMPACT	CALC. BY	DWB	APPROVED BY	

SIDE IMPACT

TOTAL ENERGY TO DISSIPATE = $30(1916)(12) = 6.9264 \times 10^3$
IN LB

ASSUME THAT FLANGE AND BOTTOM ARE
CRUSHED TANGENT TO THE CRACK BODY.

FIND ENERGY TO DO
ABOVE ASSUMPTION

$$\text{SHADED AREA} = \frac{1}{2} [r \cdot c(r-h)]$$

$$= \frac{1}{2} [r(.01745r\alpha) \cdot c(r-h)]$$

FROM SCALED DRAWG

$$r = 7.375$$

$$c = 8.9375$$

$$h = 1.5$$

$$\alpha = 2(37.258) = 74.516^\circ$$

$$\begin{aligned} \text{SHADED AREA} &= .5 [7.375(.01745)(7.375)(74.516) \\ &\quad - 8.9375(5.875)] \\ &= 9.108 \text{ IN}^2 \end{aligned}$$

FROM CARPENTER DATA BOOK, TENSILE STRENGTH
IS 85,000 PSI FOR STN STL - TYPE 304

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT. ENGINEERING CALCULATIONS		
JOB	DATE	SHEET No.
SHIPPING CRISK - CMB-14	7/31/70	11
DESCRIPTION	CALC. BY	APPROVED BY
30' DROP - SIDE IMPACT	WAB	

FIND ENERGY STN STL FLANGES ABSORB WHEN THEY CRUSH.

$$\text{TOTAL VOL} = 9.108 (.625 + 2.25) = 26.1855 \text{ IN}^3$$

$$\begin{aligned} \text{TOTAL ENERGY ABSORBED BY FLANGES} \\ = 26.1855 (85,000) = 2225.767 \times 10^3 \text{ IN LB} \end{aligned}$$

FOR A SIDE DROP, THE D-38 WOULD NOT BE AFFECTED TO ANY GREAT EXTENT.

FOR A 1" CRUSH $C = 7.4375 \alpha = 60.5$

$$\begin{aligned} \text{AREA} &= \frac{1}{2} [7.375 (.01745) (7.375) (60.5) - \\ &\quad (7.4375) (6.375)] \\ &= 5.003 \end{aligned}$$

$$\begin{aligned} \text{ENERGY ABSORBED} &= 5.003 (2.875) (85,000) \\ &= 1222.608 \times 10^3 \text{ IN LB} \end{aligned}$$

FOR A .875" CRUSH $C = 6.9375 \alpha = 56.173$

$$\text{AREA} = \frac{1}{2} [7.375^2 (.01745) (56.173) - 6.9375 (6.5)] = 4.11 \text{ IN}^2$$

$$\text{ENERGY ABSORBED} = 4.11 (2.875) (85,000) = 1004.5 \text{ IN LB}$$

DEFLECTION LESS THAN .875 IN

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
 ENGINEERING CALCULATIONS

JOB	SHIFTING CRACK - CMB-14	DATE	7/31/30	SHEET No.	12
DESCRIPTION	30' DROP SIDE IMPACT	CALC. BY	WLC	APPROVED BY	

Assume .75" CRUSH $C = 6.50$ $\alpha = 52.26$

$$\text{AREA} = .5 \left[7.375^2 (.0745 \times 52.26) - 6.625 (6.5) \right]$$

$$= 3.269 \text{ in}^2$$

$$\text{ENERGY ABSORBED} = 3.269 (2.875 \times 85,000) = 798.9 \times 10^3 \text{ in-lb}$$

TAKING TOLERANCE, MINTL PROPERTIES, ECT., INTO

ACCOUNT, 3/4" CRUSH IS PROBABLY REASONABLE.

SIDE IMPACT = .75" CRUSH OF FLANGE
 & BOTTOM. NO EFFECT
 ON D-3B.

$$\text{FORCE ON SIDE IMPACT} \approx \text{AREA (ULTIMATE STRENGTH)}$$

$$= 3.269 (85,000) = 277.865 \times 10^3$$

$$g \text{ LOADING} = \frac{277865}{1916} = 145 g's$$

NO PROBLEM

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB SHIPPING CASE CMB-14	DATE 7/31/70	SHEET No. 13
DESCRIPTION 30' DROP - END IMPACT	CALC. BY DJB	APPROVED BY

$$\text{ENERGY TO DISSIPATE} = 30(12)(1916) = 69264 \times 10^3 \text{ IN-LB}$$

PLASTIC DEFORMATION, ASSUMING NO ELASTIC ENERGY STORED IN CASE.

URANIUM PROPERTIES		
YIELD	28,000 psi	YOUNG'S MODULUS 24×10^6
ULTIMATE	56,000	
ELONG	4%	
POISSON RATIO	.21	
VOLUME CHANGE IN COILING	8%	

$$\begin{aligned} \text{AREA OF BOTTOM OF CASE} &= \pi(5.875)^2 \\ &= 108.43 \text{ IN}^2 \\ 692.64 \times 10^3 &= (56 \times 10^3)(108.43) S \end{aligned}$$

$$S = .114 \text{ IN PLASTIC DEFORMATION}$$

$$\text{FORCE} = 56,000(108.43) = 6.072 \times 10^6 \text{ LB}$$

$$g \text{ LOAD} = \frac{6.072 \times 10^6}{1924} = 3156 g's$$

ELASTIC DEFORMATION

$$S = \frac{PL}{AE} \quad S = .114$$

$$P = \frac{.114(108.43)(24 \times 10^6)}{22.5(12)} = 1.098 \times 10^6 \text{ LB}$$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SHIPPING CASK - CMB 14	DATE	7/31/70	SHEET No.	14
DESCRIPTION	30' DROP - END IMPACT	CALC. BY	WLB	APPROVED BY	

IF ELASTIC $\sigma = \frac{1.098 \times 10^6}{108.43} = 10,126 \text{ psi}$

VERY LITTLE IF ANY PLASTIC DEFORMATION
WILL TAKE PLACE IF THE CASK IS DROPPED
ON THE BOTTOM END.

g FORCES - ELASTIC DROP

$g = \frac{1.098 \cdot 10^6}{1924} = 568.37 g$

POSSIBLE (VERY UNLIKELY)
SHEAR BREAK

$\sigma_s = \frac{1.098 \times 10^6}{\pi (0.875)^2 (4.75)} = 96,104 \text{ psi}$

CAN HAPPEN

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
 ENGINEERING CALCULATIONS

JOB SNIPPING CASE - CMB-14	DATE 8/9/70	SHEET No. 15
DESCRIPTION BENDING RESISTANCE	CALC. BY RLB	APPROVED BY

ASSUME A HOLLOW CYLINDER FOR CASE, SINCE
 MAX. STRESS WILL BE IN THE CENTER.

* DIMENSIONS ARE FOR D-38 ONLY. THE CLAD
 IS NOT INCLUDED

$$W = 1924(5) = 9620 \text{ LB}$$

$$\sigma = \frac{Mc}{I} = \frac{(6.125)(9620)(23.375)(11.25)(64)}{\pi (11.25^4 - 1.75^4) \cdot 2}$$

16009

$$\sigma = 200 \text{ psi}$$

BENDING IS NO PROBLEM

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SWIRLING CRACKS - SILE 14	DATE	8/3/70	SHEET No.	16
DESCRIPTION	40" LASH ON 6" SPIKE	CALC. BY	WNB	APPROVED BY

$$\text{AREA OF SPIKE} = 28.27 \text{ IN}^2$$

$$\begin{aligned} \text{ENERGY TO DISSIPATE} &= 40(1924) \\ &= 76960 \text{ IN LB} \end{aligned}$$

$$\text{SNEAR AREA} = \pi(6 \times 5) = 94.248 \text{ IN}^2$$

ASSUME SHEARING YIELD STRESS OF $\frac{1}{2}$ TENSILE
YIELD = $\frac{1}{2}(28,000) = 14,000 \text{ psi}$

IF ASSUME NO ELASTIC DEFORMATION

$$\begin{aligned} 76,960 &= Vol(14,000) = 28.27(d)(14,000) \\ d &= .194 \text{ " } \quad \text{VERY SMALL} \end{aligned}$$

IF ASSUME NO PLASTIC DEFLECTION

$$\text{FROM ABOVE } F = 28.27(14,000) = 395,780 \text{ LB}$$

$$S = \frac{PL}{AE_s} = \frac{395,780(5)}{28.27(12 \times 10^6)} = .00583 \text{ "}$$

{ SINCE BOTH PLASTIC & ELASTIC DEFORMATION
WILL OCCUR, THE STRESS WILL BE LESS THAN
14,000 PSI AND THE DEFORMATION LESS THAN .1936"
 $g's = 395,780/1916 = \underline{206.56 \text{ g's}}$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB <u>SNIPPING CORK CMB-14</u>	DATE <u>8/3/70</u>	SHEET No. <u>17</u>
DESCRIPTION <u>40" DROP ON 6" SPIKE</u>	CALC. BY <u>DA B</u>	APPROVED BY

CHECK BENDING STRESSES - ASSUME D-38 ONLY

$$M = \frac{1924(206.56)(5.843)}{2}$$

$$= 1.161067 \times 10^6 \text{ IN LB}$$

$$\sigma = \frac{(1.161067 \times 10^6)(11.25)(64)}{\pi(11.25^4 - 1.75^4) \cdot 2}$$

16009

$$\sigma = 8310 \text{ psi} \quad \text{NO PROBLEM IN BENDING}$$

CHECK SHEAR

$$\tau_s = \frac{VQ}{It}$$

$$V = \frac{1924(206.56)}{2} = 198710 \text{ LB}$$

$$I = \frac{\pi}{64}(11.25^4 - 1.75^4)$$

$$= 785.826 \text{ IN}^4$$

$$Q = \frac{\pi r^2}{2} \left(\frac{4r}{3} \right) = \frac{2r^3}{3} = \frac{2(5.625^3)}{3} - \frac{2(.875^3)}{3} = 118.205 \text{ IN}^3$$

$$\tau_s = \frac{198710(118.205)}{785.826(11.25)} = 2657 \text{ psi}$$

NO PROB. IN SHEAR

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.

ENGINEERING CALCULATIONS

JOB	SNIPING CASE - CME-14	DATE	8/3/70	SHEET No.	18
DESCRIPTION	30' DROP ON EDGE	CALC. BY	DJB	APPROVED BY	

Assume Case All I-38 & Also Assume:
 1. No Energy Dissipated From B Plane
 2. No Elastic Energy Storage

$$\text{Energy} = 30(12 \times 1924) = 692.64 \times 10^3 \text{ in LB}$$

$$692.64 \times 10^3 = 56000 \int dV$$

$$\theta = \tan^{-1} \frac{5.625}{11.6875} = 25.7^\circ$$

$$= .48128$$

$$dV = z dA$$

$$z = z(y) \text{ or } z(\theta)$$

$$dA = 2 \int_c^r x dy$$

$$z = (y-c) \frac{d}{c}$$

$$= (y-c) \tan \theta$$

$$692.64 \times 10^3 = 56 \times 10^3 \int_c^r 2 \tan \theta x (y-c) dy$$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
 ENGINEERING CALCULATIONS

JOB	SNIPPING CRACK CMB-14	DATE	8/3/70	SHEET No.	19
DESCRIPTION	30' DROP ON EDGE	CALC. BY	10/HB	APPROVED BY	

$$692.64 = 56 \int_c^r 2(.48128) \sqrt{r^2 - y^2} (y - c) dy$$

$$12.850 = \int_c^r \{ y (\sqrt{r^2 - y^2}) - c \sqrt{r^2 - y^2} \} dy$$

SEE TABLE OF CNEB, & FNY - 32ND EDITION, P253

$$12.85 = \left\{ -\frac{1}{3} \sqrt{(r^2 - y^2)^3} - \frac{c}{2} \left[y \sqrt{r^2 - y^2} + r^2 \sin^{-1} \frac{y}{r} \right] \right\}_c^r$$

$$12.85 = \left\{ -\frac{1}{3} (\sqrt{r^2 - r^2} - \sqrt{r^2 - c^2}) - \frac{c}{2} \left[r \sqrt{r^2 - r^2} + r^2 \sin^{-1} \frac{r}{r} \right] \right. \\ \left. + \frac{c}{2} \left[c \sqrt{r^2 - c^2} + r^2 \sin^{-1} \frac{c}{r} \right] \right\}$$

$$12.85 = \left\{ \frac{1}{3} \sqrt{(r^2 - c^2)^3} - \frac{c r^2}{2} \left[\sin^{-1}(1) - \sin^{-1} \frac{c}{r} \right] + \frac{c^2}{2} \sqrt{r^2 - c^2} \right\}$$

SOLVE BY TRIAL & ERROR FOR "C". $r = 5.625$

$$12.85 = \left\{ \frac{1}{3} \sqrt{(31.64 - c^2)^3} - 15.82 C \left[\frac{\pi}{2} - \sin^{-1} \frac{c}{r} \right] + \frac{c^2}{2} \sqrt{(31.64 - c^2)} \right\}$$

$$C = 2.75$$

$$12.85 = 11.8189$$

$$C = 2.625$$

$$12.85 = 13.1106$$

$$\underline{C = 2.6875}$$

$$12.85 = 12.4551 \quad \leftarrow$$

$$d = 2.9375 (.48128) = \underline{1.4138''}$$

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SNIPPING CASE CMB-14	DATE	8/4/70	SHEET No.	20
DESCRIPTION	30' DROP ON EDGE	CALC. BY	DJB	APPROVED BY	

$$A = 2 \int_c^r \sqrt{r^2 - y^2} dy$$

$$= 2 \cdot \frac{1}{2} \left[y \sqrt{r^2 - y^2} + r^2 \sin^{-1} \frac{y}{r} \right]_c^r$$

$$= \left[r \sqrt{r^2 - r^2} + r^2 \sin^{-1}(1) - c \sqrt{r^2 - c^2} - r^2 \sin^{-1} \frac{c}{r} \right]$$

$$r = 5.625 \quad c = 2.6875$$

$$A = 5.625^2 \left(\frac{\pi}{2} \right) - 2.6875 \sqrt{5.625^2 - 2.6875^2} - 5.625^2 \sin^{-1} \frac{2.6875}{5.625}$$

$$= 49.7011 - 13.2801 - 15.7519$$

$$A = 20.6631 \text{ IN}^2$$

$$\text{MAX ACCELERATION} = \frac{56000(20.6631)}{1924} = 601 \text{ g's}$$

DEFORMATION PATTERN

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB <u>SHIPPING CASE CMC-14</u>	DATE <u>8/4/70</u>	SHEET No. <u>1</u>
DESCRIPTION <u>30' DROP ON EDGE</u>	CALC. BY <u>Wet</u>	APPROVED BY

APPROX. SHEAR AREA DUE TO ACCELERATION

$$A_{\text{REQ}} = \frac{2(5)(23.315)}{\cos 25.7^\circ} = 259.41 \text{ IN}^2$$

.90108

$$\text{SHEAR STRESS} = \frac{W}{2} \frac{g}{A}$$

$$\tau_s = \frac{1916(604)}{2(259.41)}$$

$$\tau_s = \underline{2231 \text{ psi}}$$

WELL BELOW SHEAR YIELD
OF 14000 psi.

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SNIPPING CRCK - CMB-14	DATE	8/4/70	SHEET No.	22
DESCRIPTION	BOLT LOADS FOR LIC.	CALC. BY	DAW	APPROVED BY	

THE BOLT LOADINGS ASSUMED ARE THOSE LISTED
IN THE

CASK DESIGNER'S GUIDE
ORNL - NSIC - 68
UC - 80 - REACTOR TECHNOLOGY

FORCES THAT CAN ACT ON BOLTS

1. INTERNAL PRESSURE FORCES - ASSUME 250PSIG
2. FORCE REQ'D TO SEAT GASKET
3. FORCE REQ'D TO MAINTAIN TIGHT GASKET SEAL - ASSUMED TO BE ZERO WITH THE V-SEAL GASKET
4. DECELERATION LOAD

$$1. F_P = \frac{\pi d^2 p}{4} = \frac{\pi (9)(250)}{4} = 1767 \text{ LB}$$

2. GASKET REQUIRES 250 LB/IN

$$F_G = \pi (3)(250) = 2356 \text{ LB}$$

3. $F_{G'} = 0$

4. THE WORST "g" LOAD CALCULATED IS FOR THE END IMPACT - 30' DROP. THE "g" FORCE CALCULATED HERE WAS 3169 g's FOR THE PLASTIC ONLY AND 568 g's FOR THE ELASTIC ONLY. THESE VALUES ARE HIGH, AS MUCH OF THE ENERGY WILL GO INTO THE CASK BOUNCING, ETC.

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT. ENGINEERING CALCULATIONS		
JOB SHIPPING CASK - CMB-14	DATE 8/4/70	SHEET No. 23
DESCRIPTION BOLT LOAD FOR LID	CALC. BY DRB	APPROVED BY

4.) THEREFORE, SINCE NO INFORMATION IS AVAILABLE, USE 200 g's FOR DESIGN PURPOSES.

$$F_D = 421(200) = 84,200 \text{ LB}$$

$$\text{TOTAL FORCE ON BOLT} = 88323 \text{ LB}$$

$$\text{BOLT AREA REQD} = \frac{88323}{50,000} = 1.766 \text{ in}^2$$

THIS ASSUMES A BOLT WITH A YIELD STRENGTH OF 50,000 PSI, NOT A VERY LARGE FIGURE.

CHOOSE 16 BOLTS FOR CLOSURE

$$\text{TOTAL STRESS AREA} = 16(.1416) = 2.265 \text{ in}^2$$

SIXTEEN 1/2" BOLTS WILL CONTAIN THE LID FOR THE ASSUMED CONDITIONS.

NO SHEAR CAN BE ON THE BOLTS DUE TO THE CLOSURE CONFIGURATION.

EYE BOLT FOR LIFTING: STRESS AREA = .334 in²
FOR YIELD = 30,000 (CONSERVATIVE)
LOAD = 10,000(.334) = 3340 LB.

EYE BOLT MEETS CRITERIA FOR 3x YIELD

LOS ALAMOS SCIENTIFIC LABORATORY - ENGINEERING DEPT.
ENGINEERING CALCULATIONS

JOB	SNIPPING CASK CMR-14	DATE	8/7/70	SHEET No.	24
DESCRIPTION	THERMAL CONSIDERATIONS	CALC. BY	WJB	APPROVED BY	

REF DEC MANUAL CHAPTER 0529
SAFETY STANDARDS FOR THE PACKING OF
RADIOACTIVE & FISSILE MATERIALS

ANNEX 2 - HYPOTHETICAL ACCIDENT CONSIDERATIONS

THE CASK WILL WITHSTAND 1475° F WITHOUT
MELTING. IT IS ASSUMED THAT IN A
CATASTROPHIC ACCIDENT, THE FUEL SAMPLE
MAY BE RUMMED FOR TESTING. HOWEVER,
NO RADIOACTIVITY WILL ESCAPE FROM THE
CASK; AND THE CASK WILL NOT CHANGE
SHAPE OR MELT, WHICH WOULD INCREASE
THE ACTIVITY LEVEL.

ALL THERMAL CRITERIA ARE MET.

APPENDIX B: QUALITY ASSURANCE WELDING SPECIFICATIONS

LOS ALAMOS SCIENTIFIC LABORATORY ENGINEERING DEPARTMENT

WELDING SPECIFICATION ENG-6 Sp-8

1.0 PURPOSE

- 1.1 The purpose of this specification is to govern the welding of corrosion resistant steels, aluminum alloys, and carbon and low alloy steels.

2.0 SCOPE

- 2.1 This specification covers the requirements for process control, inspection, and acceptance of welds of corrosion-resistant steels, aluminum alloys, and carbon and low alloy steels. Use of manual, semiautomatic, and automatic techniques are within the scope of this specification.
- 2.2 Drawing references to particular welds and callout of particular processes will be in addition to the requirements of these specifications.

3.0 APPLICABLE DOCUMENTS

- 3.1 MIL-STD-410, "Certification of Penetrant Inspection Personnel".
- 3.2 MIL-I-6866, "Inspection, Penetrant Method of."
- 3.3 MIL-I-6868, "Inspection Process, Magnetic Particle".
- 3.4 MIL-C-7701, "Certification of Magnetic Particle Inspection Personnel".
- 3.5 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Sections VIII and IX.
- 3.6 AWS Welding Handbook (Welding Symbol Interpretations).

4.0 REQUIREMENTS

4.1 Qualification and Certification of Welders.

- 4.1.1 Welders and welding operators using manual, semiautomatic, and automatic equipment shall pass qualification tests and be certified per the ASME Boiler and Pressure Vessel Code, Section IX, for the applicable material thickness, alloy, and process.
- 4.1.2 The supplier shall furnish evidence of such qualification to the buyer.

4.1.3 The welding procedure to be used by the supplier shall be submitted to the buyer for approval. In addition to standard items, this procedure shall specify a list showing which filler materials will be used on each alloy, or combination of alloys as called out on the drawings of parts to be welded. Also included shall be a detailed description of the cleaning procedure to be used before welding.

4.1.4 The welding equipment used shall be capable of consistently producing satisfactory welds, when used by a competent operator.

4.2 Weld Preparation

4.2.1 All scale, slag, grease, oil, rust and other foreign matter shall be removed from the area within four inches on both sides of the welding zone before welding is started.

5.0 QUALITY ASSURANCE PROVISIONS

5.1 All flux, slag, and spatter shall be thoroughly removed from the weldment before final inspection.

5.2 Weldments shall be inspected after any heat treatment and prior to machining or surface finishing operations which might obscure defects.

5.3 Evidence of lack of control over the welding process, poor workmanship, or poor appearance shall be cause for rejection by the buyer's inspector.

5.4 Inspection - Class I

5.4.1 Unless otherwise specified on the product drawing, the inspection requirements for Class I welds shall be (1) 100 percent visual, (2) 100 percent magnetic particle or penetrant, and (3) 100 percent radiographic inspection of each weldment. Limits of imperfections in acceptable welds are shown in Table I. Magnetic particle and penetrant inspection shall be in accordance with MIL-I-6868 and MIL-I-6866, respectively. Magnetic particle and penetrant inspection personnel shall be certified in accordance with MIL-C-7701 or MIL-STD-410, as applicable. Radiographic inspection shall be in accordance with Para. UW-51, Section VIII of ASME Pressure Vessel Code.

5.5 Inspection - Class II

5.5.1 Unless otherwise specified on the product drawing, the inspection requirements for Class II welds shall be 100 percent visual. Limits of imperfections in acceptable welds are shown in Table II. Magnetic

- 5.5.1 particle and penetrant inspection, if required, shall be in accordance with MIL-I-6868 and MIL-I-6866, respectively. Magnetic particle and penetrant inspection personnel shall be certified in accordance with MIL-C-7701 or MIL-STD-410, as applicable.

5.6 Repair of Defects

- 5.6.1 Repair of defects is permissible if the repaired weldment, the repair weld itself, and the adjacent parent metal meet the requirements of the original weldment. A repaired weldment shall be re-inspected in the same manner as the original weldment.

6.0 CARBON AND LOW ALLOY STEEL

6.1 Method

- 6.1.1 Welding shall be done by any of the arc welding processes or by the oxyacetylene process where applicable.
- 6.1.2 Beveling and weld preparation may be done by any conventional means including oxyacetylene cutting, provided precautions are taken to prevent cracking.
- 6.1.3 All low alloy steels having a carbon content greater than 0.25 percent and carbon steels having a carbon content greater than 0.35 percent shall be preheated to, and maintained at, a minimum temperature of 350°F during welding.
- 6.1.4 Welds shall be cooled no more severely than by still air at room temperature.
- 6.2 Repair of Defects in Heat Treated Parts
- 6.2.1 Weldments that are heat treated after welding may be repair-welded only after reduction to a strength level lower than 125,000 psi tensile ultimate and provided that heat treatment follows repairing.

7.0 CORROSION RESISTANT STEELS

7.1 Method

- 7.1.1 Welding shall be done by any of the arc welding processes.
- 7.2 Repair of Defects in Heat Treated Parts
- 7.2.1 Weldments that are heat treated after welding may be repair-welded only after reduction to a strength level lower than 125,000 psi tensile ultimate and provided that heat treatment follows repairing.

8.0 ALUMINUM

8.1 Method

- 8.1.1 Welding shall be done by the inert-gas-shielded metal arc process using a consumable electrode, or the inert-gas-shielded tungsten arc process.

CLASS I WELDS
TABLE I
LIMITS OF IMPERFECTIONS IN ACCEPTABLE WELDS

Imperfection	Limit	
Cracks in weld bead	Unacceptable	
Cracks in parent metal	Unacceptable	
Crater cracks	Unacceptable	
Incomplete fusion	Unacceptable	
Inadequate joint penetration	Unacceptable	
Porosity	Porosity may be scattered, aligned, or a combination of both. The maximum size and population of porosity as seen on the radiographic film shall be in accordance with Appendix IV of Section VIII of the ASME Pressure Vessel Code.	
Inclusions	Inclusions shall be evaluated as porosity.	
Undercut	Unacceptable	
Overlap	Unacceptable	
Convexity of butt welds either side (reinforcement height maximum)	<u>Weld Size</u> Up to 0.125 0.125 to 0.500 0.500 and over	<u>Convexity</u> 0.050 inch 25% of weld size 0.125 inch
Concavity	Unacceptable in butt welds. In fillet welds, actual throat shall be not less than theoretical throat for specified weld size.	
Fillet weld size limits	Specified weld size (leg) +50%, -0%.	

CLASS II WELDS
TABLE 2
LIMITS OF IMPERFECTIONS IN ACCEPTABLE WELDS

Imperfection	Limit	
Cracks in weld bead	Unacceptable	
Cracks in parent metal	Unacceptable	
Crater cracks	Unacceptable (See Note 1)	
Incomplete fusion or Inadequate joint penetration	Added together. Unacceptable if greatest summation exceeds a length of $1 \frac{1}{2}T$ in a weld length of $6T$ or a single defect exceeds $\frac{1}{2}T$ (See Note 2). If the weld length is less than $6T$, the greatest summation shall not exceed $\frac{1}{4}$ the length of the weld or a single defect exceed $\frac{1}{12}$ the length.	
Porosity	Internal spherical porosity is not a factor in the acceptability.	
Undercut	Unacceptable (See Note 3)	
Overlap	Unacceptable (See Note 3)	
Convexity of butt welds, either side (reinforcement height)	<u>Weld Size</u>	<u>Convexity(Max)</u>
	Up to 0.125	0.050 inch
	0.125 to 0.500	25% of weld size
	0.500 and over	0.125 inch
Concavity	Unacceptable in butt welds. In fillet welds, actual throat shall be not less than theoretical throat for specified weld size.	
Fillet weld size limits	Specified weld size (leg) $+50\%$, -0%	

NOTES:

1. Infrequent star or single crater cracks that do not extend beyond the crater itself may be acceptable, as judged by an approved inspector from LASL.

CLASS II WELDS
TABLE 2

NOTES: (Continued)

2. (T) is the specified weld size.
3. Infrequent undercut and overlap may be acceptable, as judged by an approved inspector from LASL.

APPENDIX C: U.S. AEC CERTIFICATION

UNITED STATES
ATOMIC ENERGY COMMISSION
ALBUQUERQUE OPERATIONS OFFICE
P.O. BOX 9400
ALBUQUERQUE, NEW MEXICO 87115

JAN 21 1971

5-112-11
H. E. Noyes, SP-DO, LASL
THRU: H. J. Blackwell, Area Manager, LAAO

APPLICATION FOR APPROVAL OF STEEL ENCASED
DEPLETED URANIUM SHIPPING CONTAINER -
DRAWINGS ENG-E-384 D-1 THRU D-7

This refers to your letter of December 16, 1970,
subject as above with enclosures and your letter of
January 15, 1971, which included supplemental data.

Above referenced enclosures and data have been re-
viewed and the proposed container is hereby approved.
Enclosed is a signed Certification of Approval. Our
records list this approval as AL-L21.

Please send us a copy of the Special Permit you ob-
tain for this container.

WOR:ELE

Enclosure:
As stated

Jack R. Roeder
Jack R. Roeder, Director
Operational Safety Division

CERTIFICATION OF APPROVAL FOR FISSILE, LARGE-QUANTITY
SHIPPING CONTAINERS, ALBUQUERQUE OPERATIONS OFFICE

I. ALO Contractor

University of California
Los Alamos Scientific Laboratory
P. O. Box 990
Los Alamos, New Mexico 87544

H. E. Noyes

II. Identification of Shipping Container

Analytical Sample Cask
Drawings ENG-E-304 D-1 through D-7
ALO No. AL-L21

III. General Information Concerning Container

Container is a steel encased, depleted uranium shielded, shipping container for the transportation or storage of large quantities, Type B, double encapsulated "special form" fissile materials not to exceed 3 kilograms of any fissile material or materials; and large quantities of other radioactive materials.

IV. Specific Limitations and Restrictions

Container is designed to accommodate not to exceed 3 kilograms of any fissile material or mixture of materials, with internal double encapsulation comparable to DOT 2-R double containment, with a drain provided for cleaning and for draining the cavity, which will be closed with a fusible plug. The steel-uranium eutectic is provided for by copper covering of the D-38 by .004 to .006 thickness. A tamper seal will be applied through the lid closure bolts.

Quantity will be so limited in loading that at no time will the external radiation levels as provided be exceeded. Shipment will be classed as Fissile Class I based on Nuclear Criticality Safety evaluation.

V. Certification of Approval

Pursuant to Chapter AEC 0529, this container is approved subject to the limitations described above. This certification does not relieve the shipper of his responsibility to obtain a DOT Special Permit and to comply with the requirements of other Federal Regulations as appropriate.

Date: 1/21/71

Frank R. Cook
Certification Official
Albuquerque Operation
U.S. Atomic Energy Commission

APPENDIX D: DOT SPECIAL PERMIT 6421

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 6421

This special permit is issued pursuant to 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the February 1, 1971, petition by the Los Alamos Scientific Laboratory, Los Alamos, New Mexico as amended on February 26, 1971.

1. Shipments of fissile and large quantities of radioactive materials, special form, are hereby authorized in the packaging as described in this special permit. This packaging, when constructed and assembled as prescribed herein, with the contents as authorized herein meets the standards prescribed in the DOT regulations, Sections 173.394(c)(2), 173.396(c)(3), and 173.398(c). Shipments must be in accordance with the provisions of the U.S. Atomic Energy Commission (USAEC), Albuquerque Operations Office certificate of number AL-L21 dated January 21, 1971, and as further provided for herein.

2. Each shipper, under this permit, other than the petitioner named above, shall register his identity with this Board prior to his first shipment, and shall have a copy of this permit in his possession before making any shipment.

3. The packaging authorized by this permit consists of a right cylindrical weldment, which is a steel-encased, depleted uranium shielded cask about 14" diameter by 21" long, weighing about 2000 pounds. The package is identified as the Analytical Sample Cask, Model No. CMB-14, and is described on Los Alamos Scientific Laboratory's drawing numbers ENG-E-384, D-1 through D-7.

4. The contents of each package authorized by this permit consist of large quantities of "special form" (§73.389(g)) radioactive material, including fissile radioactive material. The total fissile material content shall not exceed 3.0 Kilograms. The maximum thermal decay energy of the contents shall not exceed 32 watts.

5. The packaging authorized by this permit meets the requirements for shipment as Fissile Class I. The transport index must be assigned based on external radiation levels.

6. The outside of each package must be plainly and durably marked "DOT SP 6421" and "TYPE B", in connection with and in addition to the other markings and labels prescribed by the DOT regulations. Each shipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 6421", in connection with the commodity description thereon.

7. Each package must have its gross weight plainly and durably marked on the outside of the package.

8. This permit authorizes shipments only by cargo-only aircraft, motor vehicle and rail. For shipments by air, a copy of this permit must be carried aboard any aircraft transporting radioactive material under these terms.

9. Prior to each shipment authorized by this permit, the shipper shall notify the consignee of the dates of shipment and expected arrival.

10. Any incident involving loss of contents of the package must be reported to this Board at the earliest feasible moment.

11. The permit does not relieve the shipper or carrier from compliance with any requirement of the DOT regulations, except as specifically provided for herein.

This permit expires on March 31, 1973.

Issued at Washington, D.C.:

S. Schneider
For the Administrator
Federal Aviation Administration

W.R. Fists
For the Administrator
Federal Highway Administration

Mac E. Rogers
For the Administrator
Federal Railroad Administration

89 FEB 22

(DATE)

March 17 1971
(DATE)

MAR 19 1971

(DATE)

Continuation of SF 6421

Page 3

Address all inquiries to: Secretary, Hazardous Materials
Regulations Board, U.S. Department of Transportation,
Washington, D.C. 20590. Attention: Special Permits.

Dist: a, c, d, e, h, i

APPENDIX E: CONTAINER DRAWING ENG-E 384 D-1 THROUGH D-7

**These drawing are available from the
National Technical Information Service,
U.S. Department of Commerce, 5285 Port
Royal Road, Springfield, Virginia 22151.**

SECTION A-A

SECTION B-B

⑦ DETAIL SUB ASSY.
 1/4" DIA. 1/8" DIA.
 1/4" DIA. 1/8" DIA.

los Alamos
 scientific laboratory

PROJECT	10-1000
DATE	10-10-54
BY	J. L. HARRIS
CHECKED BY	J. L. HARRIS
APPROVED BY	J. L. HARRIS
REVISIONS	
1	10-10-54
2	10-10-54
3	10-10-54
4	10-10-54
5	10-10-54
6	10-10-54
7	10-10-54
8	10-10-54
9	10-10-54
10	10-10-54
11	10-10-54
12	10-10-54
13	10-10-54
14	10-10-54
15	10-10-54
16	10-10-54
17	10-10-54
18	10-10-54
19	10-10-54
20	10-10-54
21	10-10-54
22	10-10-54
23	10-10-54
24	10-10-54
25	10-10-54
26	10-10-54
27	10-10-54
28	10-10-54
29	10-10-54
30	10-10-54
31	10-10-54
32	10-10-54
33	10-10-54
34	10-10-54
35	10-10-54
36	10-10-54
37	10-10-54
38	10-10-54
39	10-10-54
40	10-10-54
41	10-10-54
42	10-10-54
43	10-10-54
44	10-10-54
45	10-10-54
46	10-10-54
47	10-10-54
48	10-10-54
49	10-10-54
50	10-10-54
51	10-10-54
52	10-10-54
53	10-10-54
54	10-10-54
55	10-10-54
56	10-10-54
57	10-10-54
58	10-10-54
59	10-10-54
60	10-10-54
61	10-10-54
62	10-10-54
63	10-10-54
64	10-10-54
65	10-10-54
66	10-10-54
67	10-10-54
68	10-10-54
69	10-10-54
70	10-10-54
71	10-10-54
72	10-10-54
73	10-10-54
74	10-10-54
75	10-10-54
76	10-10-54
77	10-10-54
78	10-10-54
79	10-10-54
80	10-10-54
81	10-10-54
82	10-10-54
83	10-10-54
84	10-10-54
85	10-10-54
86	10-10-54
87	10-10-54
88	10-10-54
89	10-10-54
90	10-10-54
91	10-10-54
92	10-10-54
93	10-10-54
94	10-10-54
95	10-10-54
96	10-10-54
97	10-10-54
98	10-10-54
99	10-10-54
100	10-10-54