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Informal Report

c.3

Shipping Container for Plutonium-238 as Fissile Material Class 1

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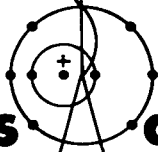
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SHIPPING CONTAINER FOR PLUTONIUM-238
AS FISSILE MATERIAL CLASS 1

by

Horace E. Noyes

ABSTRACT

The stainless steel shipping container is a small, right cylindrical assembly approximately 46 cm in diameter and 50 cm high, weighing approximately 91 kg. Access to the inner container is through a series of bolted flanges. The source material within the inner cavity must be doubly encapsulated. The contents must not exceed 720 g plutonium (oxide or metal), or be so reduced in quantity so as to not exceed the legally applicable external radiation limits at contact and at 1 m.

PLUTONIUM SHIPPING CONTAINER ASSEMBLY DESIGN CRITERIA

The Los Alamos Scientific Laboratory (LASL) has been involved in a contractural research and development program on plutonium-238 fuels, which includes preparing and characterizing candidate fuel forms for various tests and developing prototypes. As it became necessary to ship experimental specimens to other installations, a container was designed that would meet the requirements of AEC Manual Chapter 0529 and related regulations and provide for dissipation of the internal heat generated. The assembly consists of an inner and outer container, with powdered iron used for padding in the inner container to enhance the heat transfer out of the container. The outer container is equipped with heat dissipating fins, and a personnel shield is provided prohibiting direct contact with the surface of the container.

STRUCTURAL ANALYSIS

The structural analysis of the shipping container is attached as Appendix A.

QUALITY ASSURANCE

Quality assurance specifications, including welding specifications, are 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 AEC-AL-USA/6286/BLF, is attached as Appendix C.

CONTAINER DRAWINGS

LASL drawings ENG-E-324,D-1 through D-4 are attached as Appendix D.

ENG-6 Rp-8

STRUCTURAL ANALYSIS OF SHIPPING CONTAINER

FOR PLUTONIUM-238

Introduction

This section presents the structural analysis of a proposed shipping container for use with plutonium. 238. 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.

Comments and, in some cases, an analysis-summary are given for each applicable paragraph of Section II of AECM 0529. The actual analysis is at the end and is identified by the same paragraph number.

PLUTONIUM-238 SHIPPING CONTAINER
(Numbers Reference AECM Chap. 0529)

II.A.1.   The radioactive material is clad. The capsule
            stack is encased in approximately 1/2-inch of
            iron filings. These iron filings will alloy
            with any ^{238}Pu which could escape from a
            capsule and prevent spreading of any ^{238}Pu
            within the container. Package components,
            with the exception of the iron filings, are
            selected of materials not subject to corrosive
            or galvanic action.

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 of 200 lbs. Design
            calculations 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.   Not applicable.

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 (see
            calculations).

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.

II.D.2.   No controls by the shipper are anticipated.

II.D.3.   No deviations from requirements are anticipated.

II.E.   There should be no compromise of the integrity
          of the container or its contents as defined in
          Normal Conditions of Transport.

          Following is a summary of the findings of the Calcu-
          lations for the Normal Conditions of Transport.

          1. Heat - The nature of the shipment is such
              that the surface temperature of the capsules
              must be held below 573 K, while removing a
              maximum of 250 watts of heat; hence, heat
              removal is the critical factor in this
              instance. Calculations indicate the surface
              temperature of the capsules reaches a
              maximum value of 537 K. A personnel protec-
              tion screen is necessary as surface tempera-
              tures of as high as 463 K are anticipated
              at the fin tips. The results of an actual test
              are shown in the calculation section.

          2. Cold - Cold presents no problem for this
              container. Since the container will contain
              a heat source, it should remain warm under
              cold ambient conditions.

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3. Pressure - The seals used in this container are extreme pressure and temperature seals. Pressures of 1/2 atmosphere are completely insignificant in this application.

4. Vibration - This shipping container is not susceptible to vibration damage. Sufficient vibration damping materials are incorporated in the form of insulation, steel wool, and iron filings to protect the contents from damage.

5. Water Spray - The double 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 and should not compromise the integrity of the container.

7. Pentration - The 520 lb-in of energy should not exceed the elastic capability of the container and therefore would not affect the container integrity.

8. 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. There would be no release of radioactive materials or changes in radiation dose rates external to

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the container. Should the container be
subjected to the conditions specified in the
hypothetical accident conditions, the container
quite possibly should be opened only in a radio-
logical glovebox. Following is a summary of the
Hypothetical Accident Condition Calculations.

1. Free Drop - The worst damage condition
   resulting from a 30-foot free drop is the
   plastic deformation of 0.80 $in.^3$ on the outer
   edge of the container. The inner container
   will serve simply as a fail safe condition
   in this instance. (See calculations)

2. Puncture - Configuration of this container
   makes the requirements for the puncture test
   condition much less severe than the free drop
   test because the kinetic energies involved
   are less and, also, the fins were not used
   in the Free Drop Calculations.

3. Thermal - All materials required to seal the
   container were selected to function at $1500^{\circ}F$
   without danger of release of radioactive
   materials. The materials selected all have
   annealing temperatures above $1500^{\circ}F$. The
   asbestos in the stainless steel-asbestos,
   spiral wound gasket will decompose at $1300^{\circ}F$
   but the seal will remain effective until the
   flange joint is disassembled. The Inconel
   X-750 "O" ring will provide a seal on the
   inner container at the $1500^{\circ}F$ test temperature.
   (See calculations)

4. Water Immersion - The dual container is
   designed to preclude leakage of any water

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into the inner container. Should any
leakage into the outer container occur,
the water volume would be insignificant
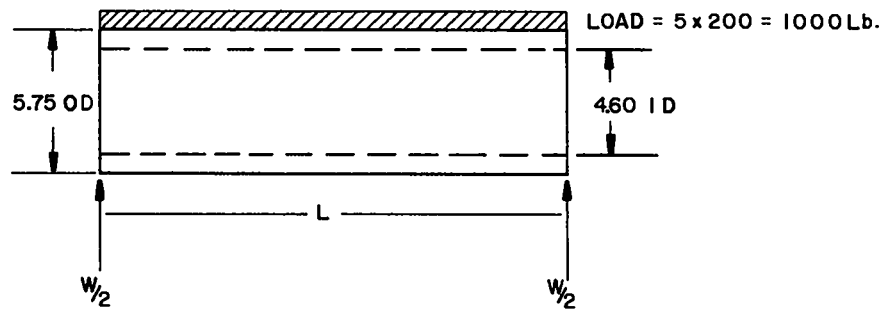due to the small void to volume ratio.

II.A.3 Lifting Device Strength
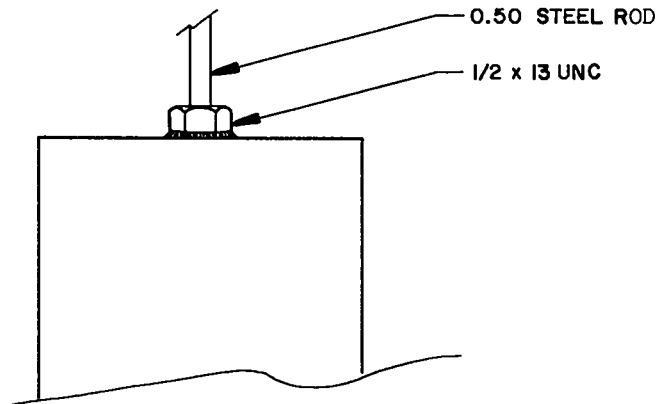
Wt assumed - 200 lbs
F.S.=3 → 600 lbs
Effective Area of 1/2 x 13 unc is 0.126 in.^{2}

$$F.S._3 = \frac{35,000 \times 0.126}{600} = \frac{4410}{600} = \underline{7.35}$$

This factor of safety indicates a strength of approximately 22 times the actual static load and 7 times the design condition which is more than adequate.

II.B.1   Load Resistance

$$\sigma = \frac{WL}{8Z} = \frac{1000 \times 12}{\dfrac{8\pi(D^4-d^4)}{32D}} = \frac{12000 \times 32 \times 5.75}{8\pi(5.75^4-4.60^4)}$$

$$= \frac{2{,}210{,}000}{25.1\ (1093-448)} = 136\ \text{psi}$$

This load stress is insignificant compared to a yield strength of 35,000 psi (347 S.S.)

II.E.1. Normal Conditions of Transport, <u>Heat</u>

A thermal analysis on the Pu 238 shipping container
using heat condition of direct sunlight at an ambient
temperature of 130^0F (328 K) in still air. A 250
Watt heat source was contained within the inner
container. TRUMP, a heat-flow computer program,
was used. A summary of the significant temperatures
resulting from this condition are presented in
Fig. 1.

CMB-11 PLUTONIUM SHIPPING CONTAINER

Design Condition - Direct sunlight at an ambient temperature of 130°F (328K)
in still air.

347 S.S.
INNER CONTAINER

IRON POWDER

347 S.S.
OUTER CONTAINER

400°F
(478K)

130°F
(328K)

373°F
(463K)

489°F
(527K)

347 S.S. FINS

INSULATION

INSULATION

NODE NO.

RADIAL SLICE
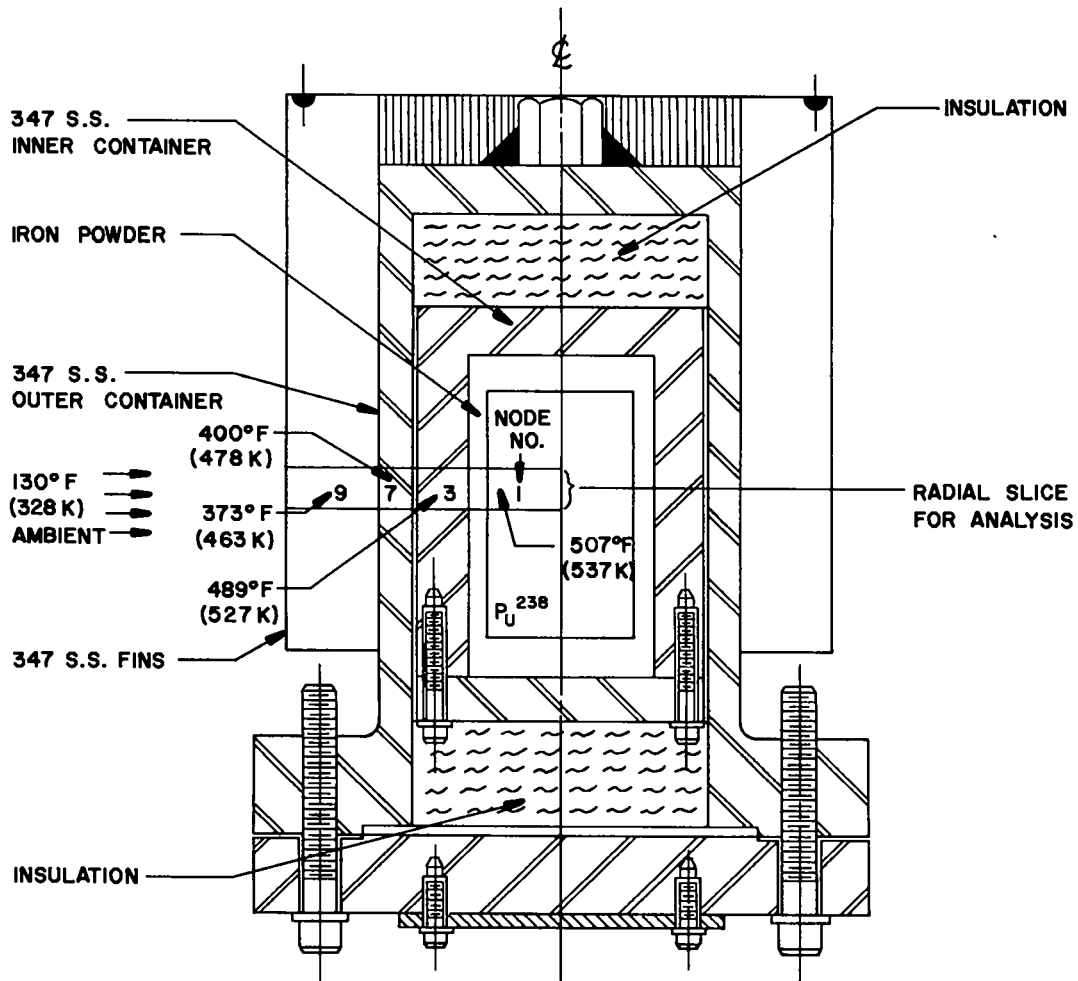FOR ANALYSIS

9 7 3 I

507°F
(537K)

Pu238

AMBIENT

FIG. 1

Showing Materials and Temperatures

II.E.1.   Shipping Container Heat Transfer Test

A heat transfer test was conducted with container
prepared for testing by removal of the personel
shield and base closure flange from the outer
container. The test container was positioned in
the center wtih a special cap with center adapter
hole for the heating element, and a thermocouple
adapter fitting, held in position by tightly packed
steel wool. This can was then positioned inside
the inner container of the assembly, and lowered
into the external container. A thermocouple was
inserted through the cap fitting and pushed into the
steel wool between the can and inner container
cap, and into the open and of the can. Rubberized
hair was then placed over the top of the inner
container and sealed with plastic tape. The wire
leads were connected to a power stat which was set
to supply a current of 3.7 amps at 75 volts to the
heating element, which had been previously calibrated
to measure it's heat output.

The data and graph of the nine hour test indicate
that the inner temperature of the container stabi-
lized after approximately five hours at a temperature
below the design criteria of 300 C. In actual use,
the iron powder used for padding in the inner container
instead of the steel wool used during this test, will
improve the heat transfer out of the container.

HEAT - TRANSFER TEST DATA
Temperature vs Time
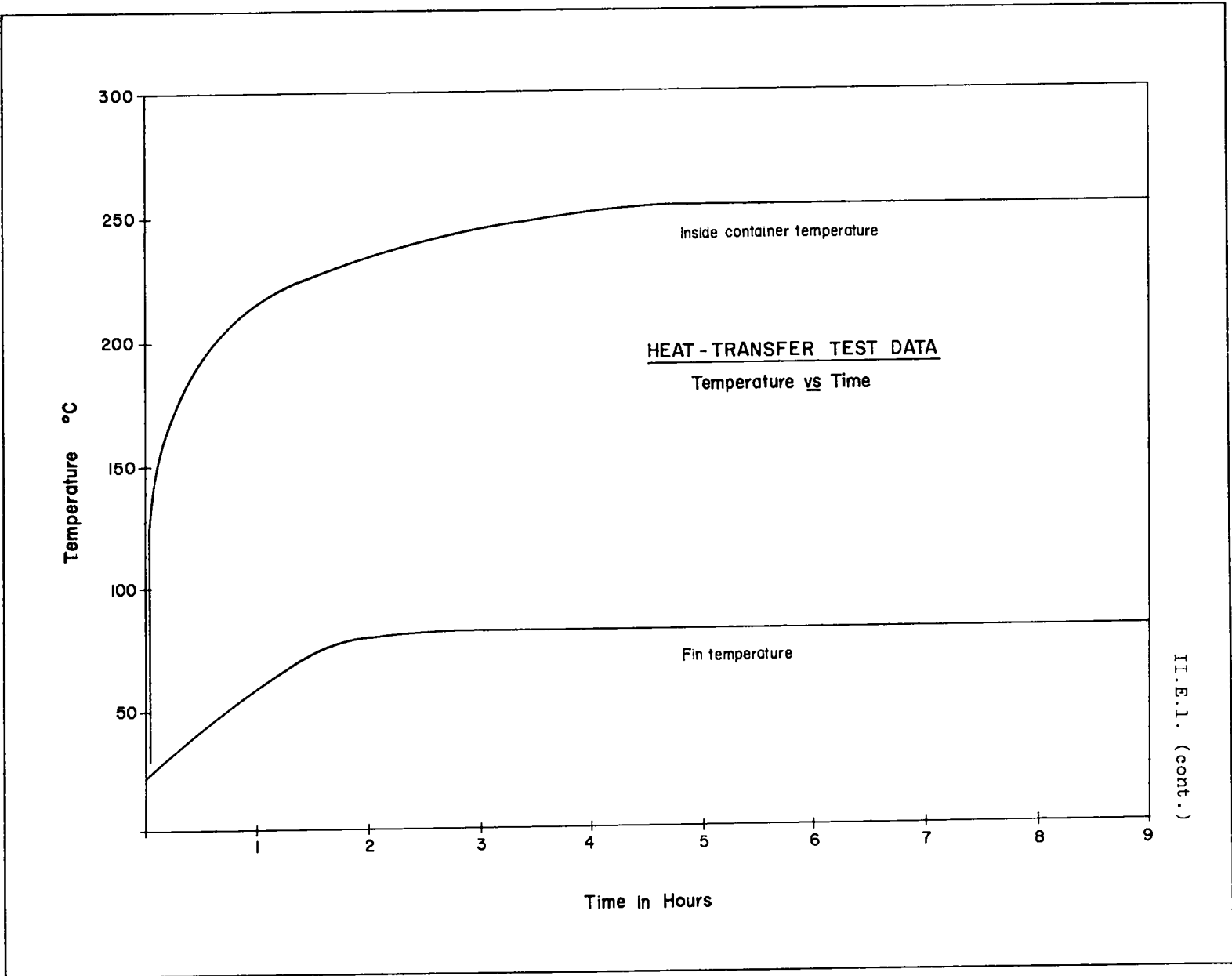
CMB-11 SHIPPING CONTAINER HEAT TRANSFER TEST
Lab Job No. 4424-0
E. S. Foster, ENG-6
June 25, 1970

EXPERIMENTAL DATA LOG

Time Hr:Min	Inside Temp °C	Fin Temp °C	Ambient Temp °C	Remarks
7:55	25	25	25	Start
7:56	35	25		Fin temp. taken ½ distance
7:57	65	25		between tip and root in
7:58	98	25		upper half of body.
7:59	125	25		
8:00	145	25		
8:01	151	27		
8:02	160	27		
8:03	165	27		
8:04	169	27		
8:05	172	28		
8:06	175			
8:07	177			
8:08	180	30		
8:09	181			
8:10	183	31		
8:15	189	35		Added screen to block sunlight
8:20	190	35		
8:25	191	37		
8:30	196	40		Smoke-removed top insulation
8:45	205	50		
9:00	210	57		
9:30	226	75		Top of fins feel hotter than
10:00	235	75		bottom
10:30	240	79		
11:00	243	80	33	Relocated fin thermo-couple
11:30	246	82		
12:00	248	83	33	
12:30	251	82		
13:00	254	83		
13:30	255	83	34	
14:00	255	80		Relocated fin thermo-couple
14:30	256	80		
15:00	256	82	32	
15:30	256	79		Relocated fin thermo-couple
16:00	256	79		
16:30	255	79	33	
17:00	255	75		Stop

II.E.8.   Compression Stress

$$\sigma_c = \frac{1000}{\frac{\pi}{4}\left(\overline{5.75}^2 - \overline{4.60}^2\right)} \qquad \text{(See Figure for II.B.1.)}$$

$\sigma_c = 107$ (psi)

This stress is insignificant compared to the allowable

stress of 347 S.S.

II.F.1.   Drop Condition Calculations

1. Free drop to unyielding surface (30').

    a. Drop distance assumed to be 30 ft.
    b. Weight assumed to be 200 lbs.
    c. Worst possible condition assumed to be impact at corner of
        least structural mass positioned directly below center of
        gravity.
    d. Fins and protective screen assumed to absorb no energy.
    e. Inner container assumed to remain fixed with relation to
        outer container.
    f. No energy absorbtion assumed due to plastic flow dynamics.
    g. Elastic energy absorbtion assumed to be insignificant -
        calculations substantiate this assumption at end of this
        section.
    h. All energy is assumed to be absorbed by plastic deformation
        of container.
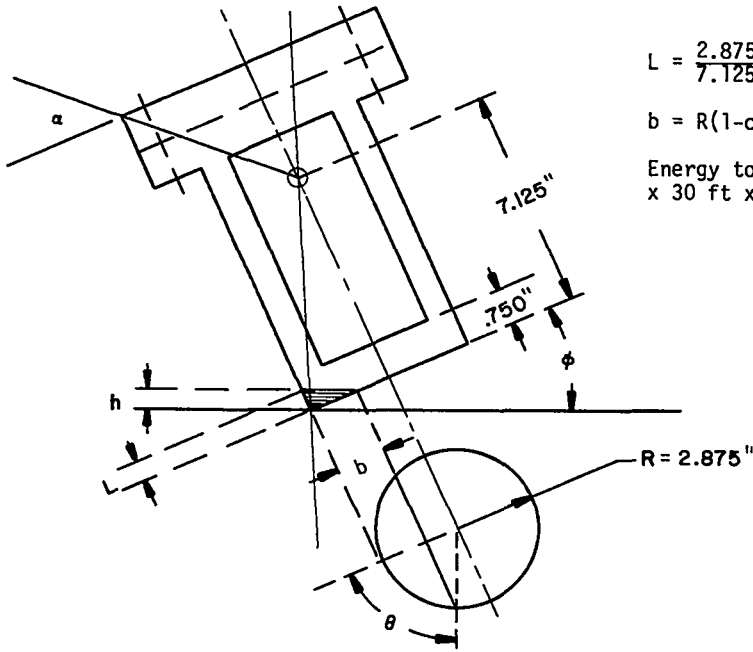
$$\phi = Tan^{-1} \frac{2.875}{7.125} = 21.63°$$
$$= .3775 \text{ Rad}$$

$$L = \frac{2.875}{7.125} b = .396 b$$

$$b = R(1-\cos\theta) = 2.875(1-\cos\theta)$$

Energy to be dissipated 200^{lbs}
x 30 ft x 12 = 72,000 Lb-in

7.125"

.750"

ϕ

h

α

b

R = 2.875"

θ

II.F.1.(cont.)

Plastic deformation assumed at lowest ultimate stress of 347 s.s.
σ_u = 90,000 (psi).

Volume deformed = $\dfrac{72 \times 10^3 \text{ in-lb}}{90 \times 10^3 \text{ lb/in}^2}$ = .80 in^{-3}

$Vo = .80 = \dfrac{R^3 L}{b} [\sin\theta - \dfrac{\sin^3\theta}{3} - \theta \cos\theta]$

$= \dfrac{(2.875)^3 \, (\frac{2.875}{7.125})b}{b} [\quad] = \dfrac{(2.875)^4}{7.125} [\quad]$

$[\quad] = \dfrac{.80 \, (7.125)}{(2.875)^4} = .08343$

For: θ = 54°50', $[\quad]$ = .817 - $\dfrac{.546}{3}$ - .958(.576) = .083

θ = 55°0', $[\quad]$ = .819 - $\dfrac{.549}{3}$ - .961(.574) = .084

So for limits of accuracy let θ = 55°-0'.

ϕ = 21.6°
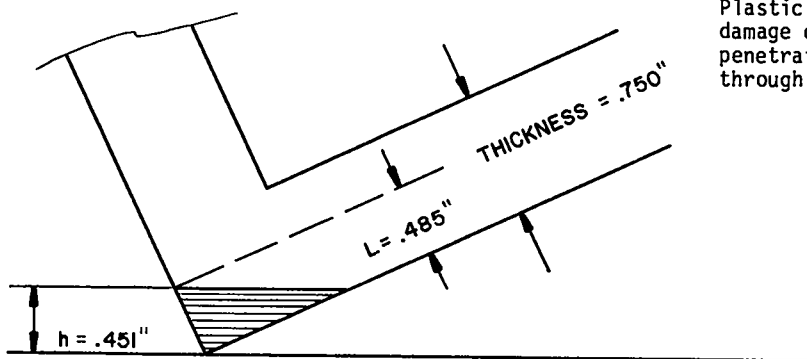θ = 55°
b = 2.875(1-cosθ)=2.875(1-.574)=2.875(.426)=1.225 in
L = .396b=.396(1.225)=.485"
h = cosϕL=cos 21.6L=.930(.485)=.451"

Plastic deformation ends with damage only to the outer edge, penetrating less than halfway through the material.

II.F.1.(cont.)

Ref Item G.

Elastic Energy Absorbed:
yield stress of 347 (s.s.) assumed to be 35,000 psi

$F_{max} = 35,000 \ (1.225 \times 2.50) = 107,000$ lbs

$$\Delta_{el} = \frac{107,000 \text{ Lb} \qquad\qquad h}{3.06 \text{ in}^2 \ (30 \times 10^6 \text{ Lb/in}^2)} = .00117 \ h$$

$$= .00117(.451) = .000526 \text{ in}$$

Energy (Elastic) $= 1/2 \ (107,000 \text{ Lb}) \ (.000526 \text{ in})$

$$= 28.12 \text{ Lb - in}$$

This is insignificant compared to 72000 in.-lb dissipated by plastic deformation so the assumption of only plastic deformation is valid.

Bolt Stress:

The worst condition for bolt stress would occur with the edge of the blind flange being directly beneath the c.g. at impact. This is at an angle (α on sketch) of $\tan^{-1} \frac{4.92}{5.00}$ or 44.4°

$$F_s = M\alpha \cos\alpha = 200 \ \frac{2(32.2) \ (30)}{\frac{2(.451)}{12}} \ (\frac{1}{32.2}) \ (.714)$$

$$F_s = 113100^{\#}$$

1. Shear force absorbed due to friction between flanges.

   Bolt tension assumed to be 17500 psi.

   M assumed to be .15.

   Total friction $= 17500 \times 12 \times .142 \times .15$
   $$= 4470 \text{ Lbs which is negligible.}$$

2. Shear stress on bolts.

   Use high strength bolts as specified in ASTM A574-67.

   Shear ultimate is 12,000 Lbs/bolt for 1/2" dia. bolts.

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II.F.1.(cont.)

Factor of safety = $\frac{12 \times 12000}{113,100}$ = 1.27

This indicates the bolts should not fail in shear.

Conclusion:

The only probable damage to the container should be some superficial plastic deformation. Considering the worst case together with rather conservative assumptions, the damage (plastic deformation) penetrates less than half way through the outer container, therefore the inner container should remain undisturbed throughout all specified conditions.

II.F.3.   Thermal Considerations

Reference AECM D529 Hypothetical Accident Conditions.

A thermal analysis was concluded on the Pu 238 shipping container when exposed to a heat radiation environment of (1475° F) 802 C for thirty minutes. The Trump transient heat-flow computer program was used for this purpose. A summary of the resulting temperatures, including material types and their melting points is shown in Fig. 2. The temperatures throughout the assembly approach the heat radiation environment of 802 C by the time of conclusion of the test period. There is a slight valley in the vicinity of the inner vessel caused by the 250 Watt heat source contained within. (See Fig. 1.)

Since the melting points of the structural materials are well above the 802 C temperature radiation environment, there is no capability of release of radioactive material form melting of of the containment vessel even though the assembly may suffer some superficial heat damage. The asbestos in the stainless steel-asbestos spiral-wound gasket of the outer vessel will decompose at 704.5 C (1300 F), however the seal will remain effective until the flange joint is broken by dissassembly. The silver solder braze joining the fins and outer container will melt during this 30 minute exposure, but fails to constitute a danger by release of radioactive materials. The arrangement of an inner and outer vessel containment assures that in the event of a severe impact preceding the heat radiation environment, all damage is absorved by the outer vessel.

II.F.3.(cont.)

CMB-11 PLUTONIUM SHIPPING CONTAINER

Design Condition - Exposure to a temperature radiation environment of
1475°F (1075 K) for 30 minutes with an emissivity coefficient of 0.90.
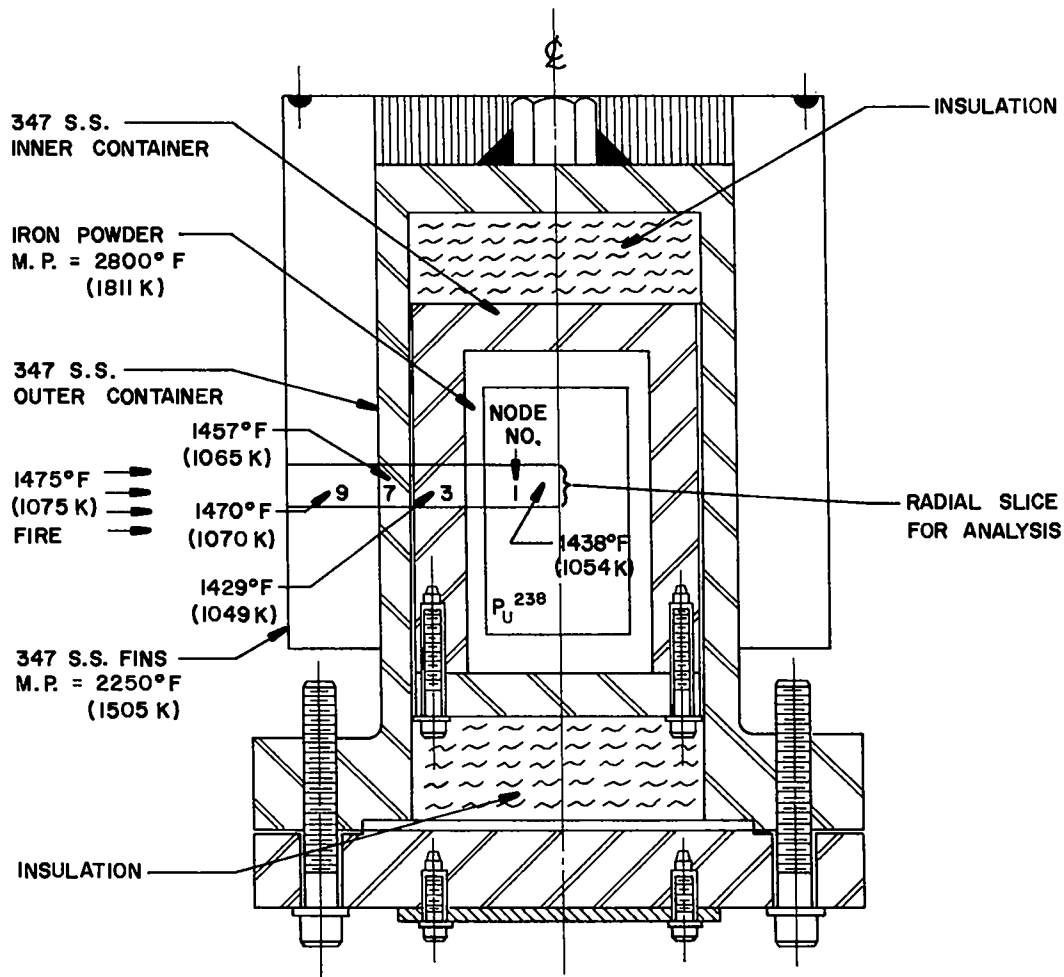

FIG. 2

Showing Materials, Melting Points
and Temperatures

RADIOLOGICAL SAFETY CONSIDERATIONS

Radiation shielding was not the primary design criteria for the shipping container (DOT SP 6286). The source limitation of 750 gm of plutonium, with no more than 520 gm of ^{238}Pu was based on the heat dissipation from the 520 gm of ^{238}Pu. The allowance of 230 gm of other isotopes of plutonium is simply taking cognizance of the fact that pure ^{238}Pu is not the common form.

The primary radiation from the ^{238}Pu is neutrons and the emission rate depends on the exact chemical form. Considering a single chemical form, specifically PuO_2, the neutron emission rate differs by as much as a factor of 10, depending on the ratio of oxygen isotopes. Since the neutron emission is not generally known, it is meaningless to attempt by calculation to show that the shielding will reduce the dose rates at the surface to 200 mrem/h and at three feet from the surface to 10 mrem/h.

It is recognized by the shippers that radiation measurements made at the time of shipment must not exceed 200 mrem/h at the surface nor 10 mrem/h at three feet, and that compliance with these radiation levels may impose lower mass limits on the quantity of ^{238}Pu which may be shipped.

No exception is made to applicable external radiation levels. Inner containment requires double encapsulation of the source material, and the _outer_ walls of the doubly encapsulated source are swipe-free before loading into the shipping container cavity. Early calculation was very conservative in assigning radiation levels to $^{238}PuO_2$ and subsequent measurements have shown such levels to be well within prescribed limits. For example, the current fuel module used by SNS/AEC is a 100-W sphere approximately 2.7 cm (1.5 in.) in diameter. The following radiation measurements were made on January 22, 1974, on such a sphere inside a DOT-6286 shipping container.

Position of Detector	Beta-Gamma mr/h	Neutrons mrem/h
Contact	1.5	15
0.9 m (3 ft)	0.2	3

These levels are well below the 200 mrem/h (total beta-gamma + neutrons) at contact and 10 mrem/h at 0.9 m. Even if two spheres were packaged in one container, the 200 mrem limit would not be approached. Dimensional limitations would not permit more than two spheres in the inner cavity.

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.

NUCLEAR CRITICALITY SAFETY EVALUATION FOR
SHIPMENT OF PLUTONIUM-238

The assumption was made that the recently designed shipping container, Drawing ENG-E 324 (D1-D4), would be used for shipment of plutonium in quantities not to exceed 750 grams. For a criticality safety evaluation it was further assumed that this might be all ^{238}Pu or all ^{239}Pu, to represent two extreme cases.

The volume of the cavity in the inner container (Part No. 4) is approximately 660 cc, which corresponds to a spherical radius of 5.4007 cm. The thickness of stainless steel radially and axially about this cavity provides a volume of steel of 3.005 liters, neglecting fins, bolts, flanges, etc.

Spherical cells were calculated with the DTF IV code using the S_4 approximation. Stainless steel was placed in a spherical shell from 5.4007 cm radius to 9.5637 cm radius, to provide the volume of 3.005 liters of steel. The inner cavity was filled uniformly with low density (1.137 g/cc) plutonium to provide a net plutonium loading of 660 grams. The outer boundary of the cell was made reflecting, to simulate an infinite array.

When the cell was loaded with plutonium 238, the k value for an infinite array was found to be 0.58. Replacing the ^{238}Pu with ^{239}Pu resulted in a k_∞ value of 1.073. Next, the steel was surrounded by 0.44-cm-thick water to check the effect of inter-unit moderation. The value of k_∞ for the ^{239}Pu loading was now found to be 0.53. The corresponding value for ^{238}Pu would be even lower.

A fourth calculation was performed to determine the thickness of steel required for an infinite array to be critical with the ^{239}Pu-filled cavity. The resulting radius for the outside of the steel was 9.8974 cm, for a volume of steel of 3.401 liters corresponding to 26.74 kg or 58.8 lbs.

The actual weight of steel in a package should be more than 150 lbs, so there is sufficient steel in a package to maintain an infinite array of packages subcritical. The validity of averaging in all the steel in a package is indicated by consideration of the size of a bare critical array at the average density of plutonium in the cell, ignoring the presence of steel.

Such an array would be more than 200 feet in each dimension. The presence of steel reduces the k_∞ from about 2.9 (for pure ^{239}Pu) to below the calculated 1.073. This implies that neutrons would traverse many cells in an array before being absorbed and would therefore tend to "average out" the gross inhomogeneities in the steel distribution in the individual cells.

The assumption of uniform low density for the plutonium in the cavity is conservative, in that lumping the plutonium to metal density would reduce the multiplication factor of the array.

The presence of other isotopes of plutonium (240, 241, 242) would not increase the multiplication factor above that for ^{239}Pu.

Since for the proposed loading an infinite array of these containers would be sub-critical, either as prepared for shipment or as damaged through exposure to the hypothetical accident of AECM 0529, these containers comply with the criteria for Fissile Class I.

QUALITY ASSURANCE PROGRAM PLAN
FOR
CMB-11 PLUTONIUM SHIPPING CONTAINER

LAB JOB 4424-0

1. Scope

   This document sets forth the elements of a program for quality
   assurance and methods of quality control and verification which
   will be used during the design (review), operation and maintenance
   phases of the Plutonium Shipping Container, CMB-11, hereinafter
   called the Container. The quality assurance program presented
   in this document is based on meeting the requirements of the LASL
   Quality Assurance Program Manual (LASL unclassified release
   LA-UR-73-603), including all supplemental Quality Specifications
   (e.g., Quality Assurance Requirements, QAR's, and Quality Assurance
   Instructions, QAI's).

   The container is intended for the shipment of Pu-238 metal/oxide.
   The operating organization for the container will be CMB-11.

2. Quality Program Elements and Actions

   The Quality Assurance Program for the container will be in accordance
   with the "LASL Quality Assurance Program", including the Quality
   Assurance manuals, designs, documentation, procedures, inspection and
   other activities pertaining to quality assurance of all organizations
   performing quality functions for the project.

   The consequence-of-failure for the container has been established as
   Type I (failure could cause an incident affecting public health and
   safety) and its component complexity category is L (simple parts).
   The Component Quality Assurance Level Classification for the container
   is therefore C. Table 1 lists the Quality Assurance activities
   required for the container.

3. Organization

   The requirements of this document will be imposed on all organizations
   performing work on the container. Services of other groups will be
   required to carry out project functions including, but not limited to,
   those listed below:

Function	Organization or Individuals
Design	LASL Engineering Department CMB-11 QA Design Review Board
QA Design Review Board	See LASL Internal Supplemental Information Bulletin
Operation Administration	CMB-11

4. Documentation

   A. Records Accumulation and Retention

      All Quality Assurance documentation shall be retained in the
      "QA Binder" of the Lab Job 4424-0 Folder or, in the "QA files"
      of group CMB-11. The lab job is an internal Engineering
      Department numbering system that allows documentation for any
      given project to be filed and retrieved.

Table 1

QUALITY ASSURANCE ACTIVITIES REQUIRED FOR CONTAINER

<u>Management</u>

Quality Assurance Planning

Quality Assurance Records, Accumulation, Retention, and Distribution

<u>Design</u>

Design Criteria

Design Review

Failure Study

<u>Operation and Maintenance</u>

Document Control

Operator Training and Qualification

Controlled Operating Procedures

Controlled Maintenance Procedures

In-Service Inspection Program

Failure and Incident Report

Corrective Action

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

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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 reinspected 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.

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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)	Weld Size Convexity 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%.

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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 1/2T in a weld length of 6T or a single defect exceeds 1/2T (See Note 2). If the weld length is less than 6T, the greatest summation shall not exceed 1/4 the length of the weld or a single defect exceed 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)	Weld Size	Convexity(Max)
	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.

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U.S. ATOMIC ENERGY COMMISSION

CERTIFICATE OF COMPLIANCE

For Radioactive Materials Packages

1a. Number	1b. Revision No.	1c. Page No.	1d. Total No. Pages
AEC -AL USA /6286/BLF	Original	1	1

2. Authority

This certificate is issued pursuant to Sections 173.394, 173.395, and 173.396 of the Department of Transportation Hazardous Materials Regulations as amended (49 CFR 170- 189 and 14 CFR 103), and AEC Manual Chapters 5201 and 0529.

3. CONDITIONS

3a. This certificate is issued on the basis of SAFETY ANALYSIS REPORT FOR PACKAGING (SARP)

(1) Prepared by

University of California, LASL

David R. Smith   Thomas K. Keenan

J.N.P. Lawrence   Horace E. Noyes

(2) Number   LA-5589

(3) Date Published   May 1974

3b. The packaging described in the SARP and further described in item 4 below, when constructed and assembled as prescribed in the SARP, with the contents as authorized herein, meets the standards prescribed in DOT regulations.

3c. The outside of each package must be plainly and durably marked with the letters and number shown in item 1a. on this form in accordance with the standards for markings in paragraph 173.24(b) of 49 CFR 173.

3d. This certificate does not relieve the consignor from compliance with any requirements of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies.

3e. Each user of packages approved under this certificate shall register his name and address with the issuing office.

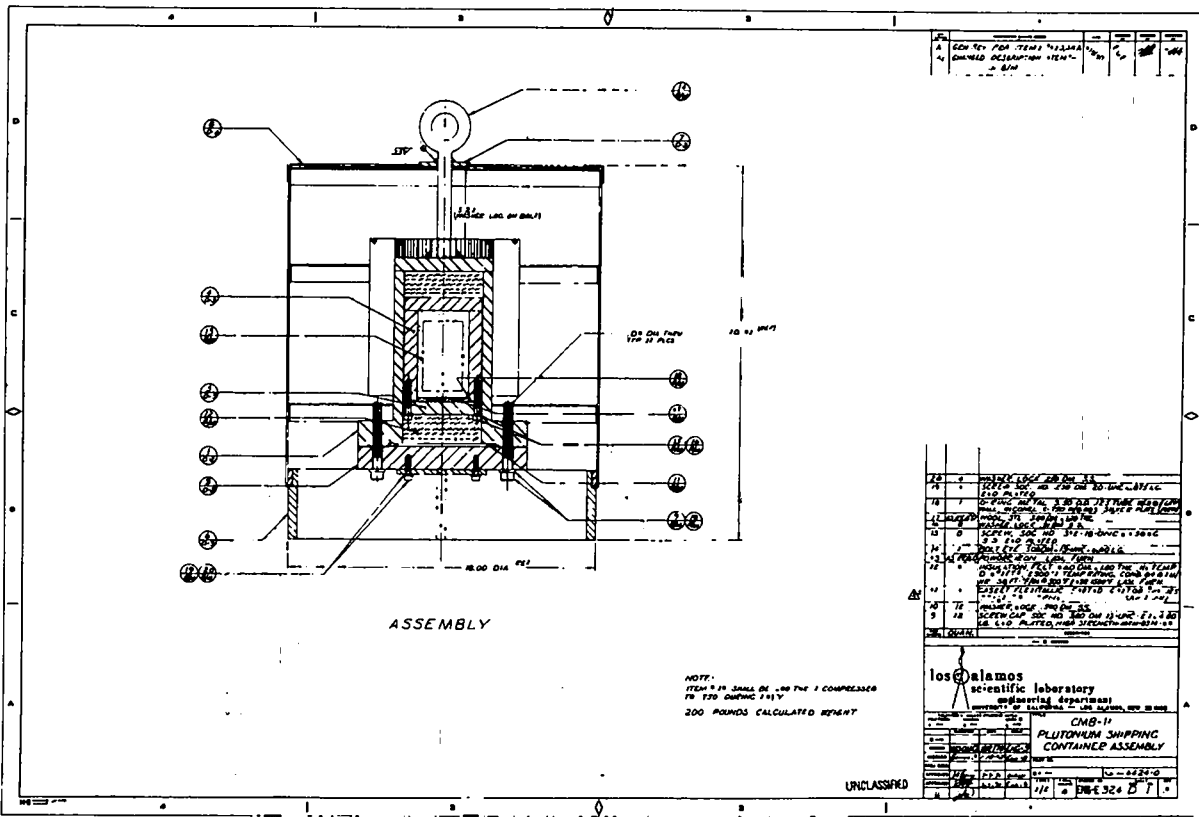**4. Description of Packaging and Authorized Contents, Restrictions, and References:**

a. Description - This container consists of a cylindrical stainless steel weldment with external cooling fins. It contains internal heat dissipating materials surrounding the central cavity. The cask body is mounted to a base/closure assembly and enclosed within an outer steel mesh cage. The package is approximately 18 inches in diameter by 20 inches high and weighs about 200 pounds. The package is identified as the CMB-11 Plutonium Shipping Container and is described in LASL drawings ENG-E324-D-1 thru D-4.

b. Authorized Contents - Contents must be doubly encapsulated and not exceed 750 grams of Plutonium (Oxide or Metal) or be so reduced in quantity as not to exceed applicable external radiation limits at contact and one meter. Heat load of the contents is not to exceed 250 watts. Container and contents as limited above meets the requirements for shipment as Fissile Class I.

TO BE COMPLETED BY AEC

5a. Address (of AEC Approving Official)	5b. Signature (of AEC Approving Official)
Albuquerque Operations Office P. O. Box 5400 Albuquerque, New Mexico 87115	5c. Name and Title (of AEC Approving Official) Jack R. Roeder, Director Operational Safety Division
	6. Expiration Date (If appropriate) --	7. Date April 19, 1974

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

ASSEMBLY

UNCLASSIFIED

④ INNER CONTAINER
SCALE - 1/1

⑤ INNER CONTAINER CAP
1 REQ'D - MAT'L: TS STL 44 1 2 B
SCALE - 1/1

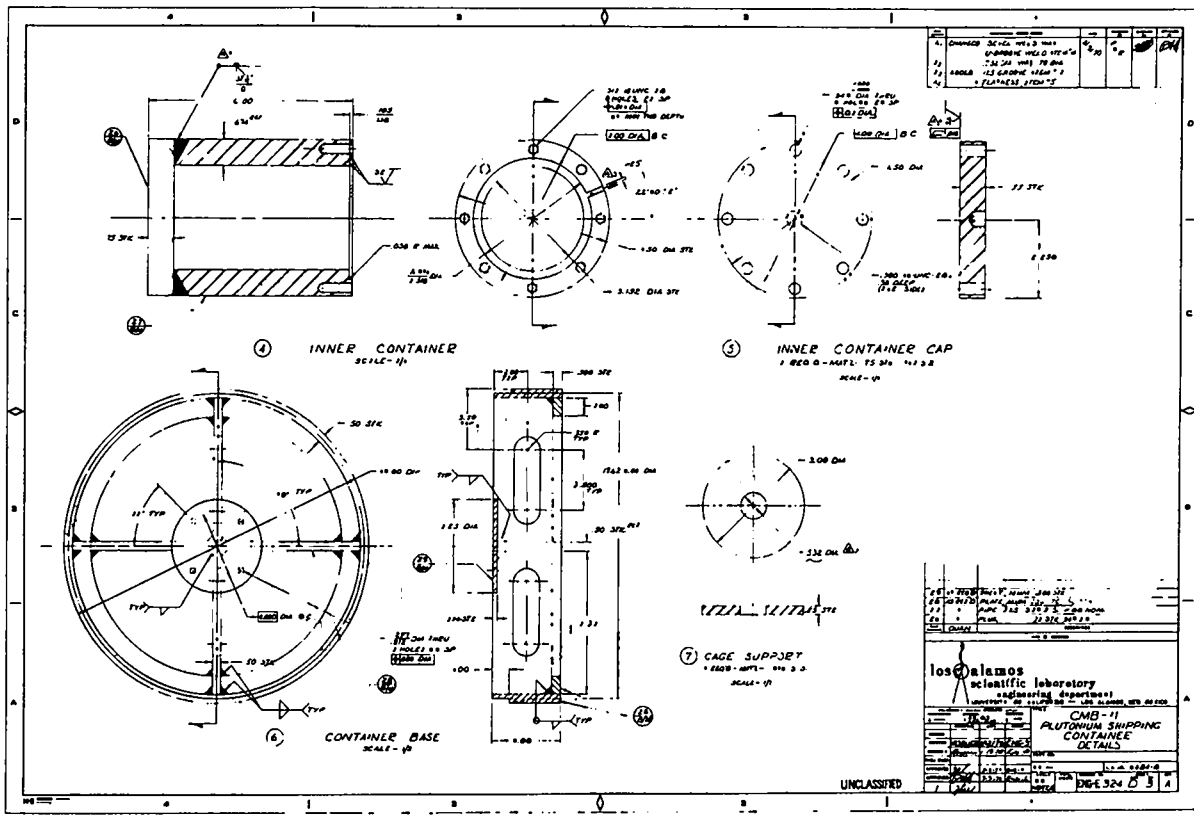⑥ CONTAINER BASE
SCALE - 1/1

⑦ CAGE SUPPORT
1 REQ'D - MAT'L: STL 44 3 3
SCALE - 1/1

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UNIVERSITY OF CALIFORNIA — LOS ALAMOS, NEW MEXICO

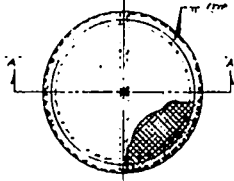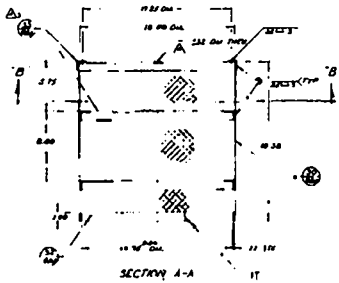CMB - 11
PLUTONIUM SHIPPING
CONTAINER
DETAILS
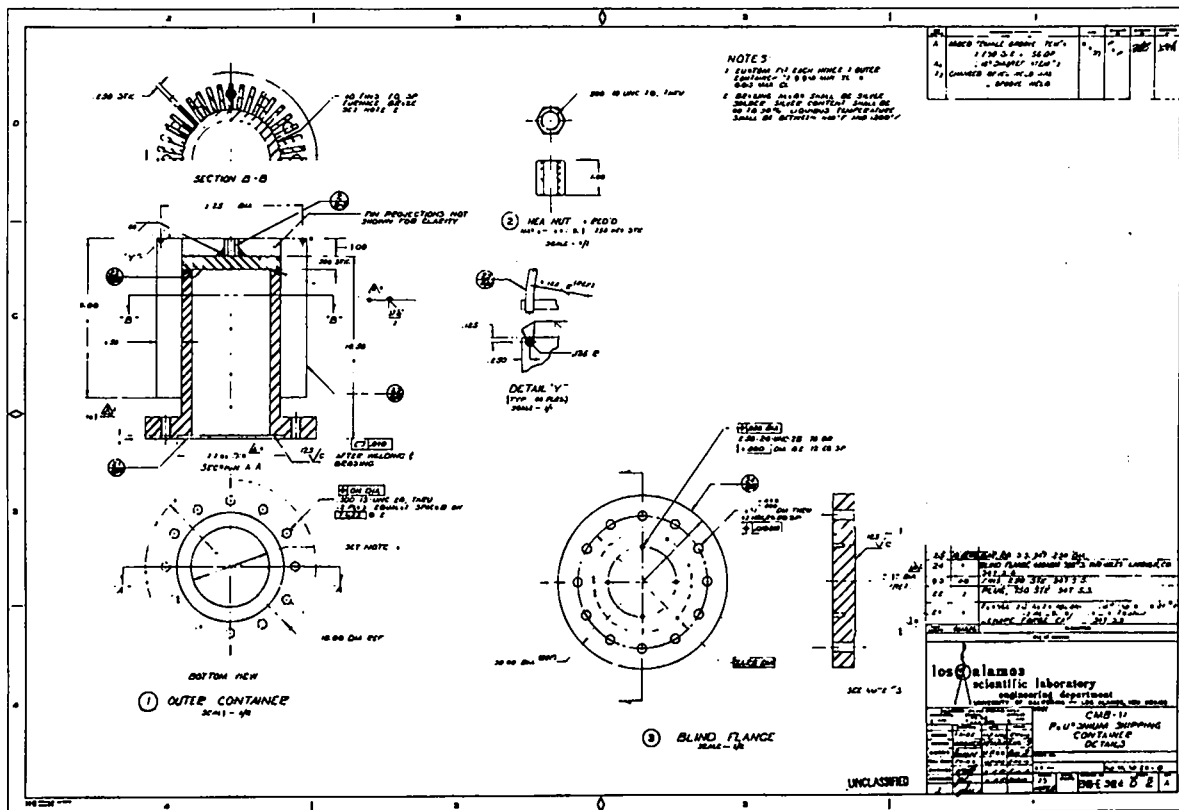
UNCLASSIFIED

NOTE
ALUMINUM SPRAY PAINT - ⑧ ASSEMBLY

SECTION B·B

SECTION A-A

⑧ CAGE ASSEMBLY

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CMB-4
PLUTONIUM SHIPPING
CONTAINER
DETAILS