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**Safety Analysis Report for the
TREAT Capsule Assembly Shipping Container**

by

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SAFETY ANALYSIS REPORT FOR THE TREAT
CAPSULE ASSEMBLY SHIPPING CONTAINER
(Formerly DOT 5828)

by
Betty Lobb

ABSTRACT

Formerly known as the "MTR Shim Rod Shipping Container" and approved by the Department of Transportation under Special Permit 5828, this shipping container has been modified by the Los Alamos Scientific Laboratory to accommodate the movement of encapsulated fast reactor fuel pins for experimentation in the Transient Reactor Test (TREAT) Facility at the Argonne National Laboratory, Idaho Falls, Idaho. This report constitutes the Safety Analysis Report for Packaging as required by ERDA Manual Chapters 0529 and 5201.

INTRODUCTION

In November 1968, the Idaho Nuclear Corporation was issued Special Permit 5828 by the Department of Transportation. This permit authorized the shipment of fissile radioactive material, further described as "MTR Shim Rods" containing ^{235}U or recycled plutonium. The container became commonly known as the "MTR Shim Rod Shipping Container."

The Los Alamos Scientific Laboratory's (LASL) Group CMB-11 fabricates encapsulated fast reactor fuel pins to be shipped to Argonne National Laboratory (ANL), Idaho Falls, Idaho, for experimentation in the Transient Reactor Test (TREAT) Facility. The MTR Shim Rod Container was the most convenient and economical packaging for this purpose.

This container, with minor modifications, will be known as the "TREAT Capsule Assembly Shipping Container" and will be used by LASL for the movement of the fast reactor research fuel pins containing enriched uranium and recycled plutonium authorized for shipment as Fissile Class I.

DESIGN CRITERIA FOR THE TREAT CAPSULE ASSEMBLY
SHIPPING CONTAINER

Description of Packaging

Primary Container: The TREAT Capsule Assembly consists of a pressure vessel, 76.2-mm (3-in.) o.d. and 6.35-mm (0.25-in.) wall; made from AISI 4130 steel (Fig. 1). The pressure vessel is sealed with a cap (nose piece) in which all instrumentation leads go through a potting material seal [good below 260°C (500°F)]. This pressure vessel has been hydrostatically tested to 103 410 kPa (15 000 psi) at room temperature. Within the pressure vessel is a heater can made from a 31.75-mm (1.25-in.) o.d. by 0.89-mm (0.035-in.) wall tubing of 304 stainless steel, which surrounds an inner capsule containing the test fuel element. The inner capsule is a 304 stainless steel tube with a 28.57-mm (1.125-in.) o.d. by 1.24-mm (0.049-in.) wall. The fuel material (Fig. 1) is contained inside a hermetically sealed 316 stainless steel thin wall tube (fuel pin) which is then encapsulated within the inner capsule tube.

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The inner capsule tube is sealed with welded and brazed end caps [the melting point of the brazing compound is above 1093° C (2000° F)]. The pressure vessel, the heater can, the inner capsule, and the fuel element make up the TREAT Capsule Assembly and are considered to be the primary container.

The primary container is 1.83 m 894.08 mm (8 ft 11.2 in.) long and weighs approximately 120 lb. Provisions are made to ship two such containers at one time (Figs. 2 and 3). These containers are secured by three positioning blocks to a common 12.7-mm (0.5-in.) steel plate and placed in a steel-jacketed wooden box. The blocks are approximately 609.6 mm (2 ft) apart and are held in place by five 6.35-mm (0.25-in.) bolts.

Outer Container: The outer container consists of a 25.4-mm (1-in.)-thick plywood box covered with 14 gauge steel, containing a "T" beam spacer-stiffener and a 0.51-mm (0.020-in.) cadmium lining on the top, bottom, and both sides of the divider. The cover is hinged (Fig. 4). The box is positioned by an aluminum roller-channel assembly within two concentric cylindrical metal tubes that are separated by a 76.2-mm (3-in.) thickness of phenolic foam. The outer tube is made of 16 gauge steel and the inner tube of 6.35-mm (0.25-in.) aluminum. A welded "Warren" truss (Fig. 5) made from 25.4-mm (1-in.) by 19.05-mm (0.75-in.) steel pipe completes the outer container assembly. The total weight of the container is 1800 lb. The outer container is shown in Figure 6.

Contents of Packaging

The allowable contents shall be not more than two fast reactor fuel pins each encapsulated in a pressure vessel [76.20-mm (3-in.) o.d. AISI 4130 Steel] which contains a heater can [31.75-mm (1.25-in.) o.d., 316 stainless steel] with welded or brazed end caps which contain the fuel pin.

The linear density of fissile material in the package shall not exceed 60 grams per centimeter of container length. For fuel elements with an active length of 350 mm, this corresponds to 2.1 kg of fissile material. Content of other radioactive materials will be limited to comply with 49 CFR, Part 173.363(1).

Structural Analysis

The structural evaluation of the TREAT Capsule Assembly Shipping Container has been compiled to demonstrate compliance with Section II, Packaging Standards, of ERDA Manual Chapter 0529 Safety Standards for Packaging of Radioactive Material and Fissile Materials. The evaluation is numbered to correspond to Section II of ERDAM 0529 and is presented as Appendix A.

Nuclear Criticality Safety

The criticality evaluation (Appendix B) demonstrates that this package, when loaded in accordance with the certificate of compliance, complies with Fissile Class I Criteria.

Quality Assurance Procedures

The Quality Assurance Program (Appendix C) has been compiled to demonstrate compliance with ERDAM 0529 Appendix, Part III, Quality Assurance Procedures, and with the applicable sections of the IASL Quality Assurance Manual for Engineering and Construction, LA-5220-M. The Quality Assurance requirements document the modifications to the TREAT Capsule Assembly Shipping Container in order to comply with Annex 1 and Annex 2 of ERDAM 0529.

Energy Research and Development Administration Certificate

The Certificate of Compliance issued by the Operational Safety Division Office, ERDA, identified as USA/5828/BLF (ERDA-AL) is attached as Appendix D.

APPENDIX A

STRUCTURAL EVALUATION OF THE TREAT CAPSULE ASSEMBLY SHIPPING CONTAINER

Introduction

This appendix presents the structural evaluation applicable to the TREAT Capsule Assembly Shipping Container.

The evaluation is to demonstrate compliance with Section II, Packaging Standards, of ERDAM 0529 Safety Standards for Packaging of Radioactive and Fissile Materials.

Comments and, in some cases, an analysis-summary are given for each applicable paragraph of Section II of ERDAM 0529.

STRUCTURAL EVALUATION OF THE TREAT CAPSULE ASSEMBLY SHIPPING CONTAINER

(Numbers refer to ERDAM 0529)

II.A. GENERAL PACKAGING STANDARDS

- II.A.1. The cask and cask insert materials are completely compatible with one another and with the package contents. No significant chemical, galvanic, or other reactions have occurred or will be expected to occur.
- II.A.2. Inadvertent opening of the package is prevented by redundant positive closure devices consisting of:
 - a. The access end of the outer container which is secured in place by a metal plate assembly bolted to the framework and by safety wire seals. Additionally, provision is made for security seals to indicate any evidence of tampering.
 - b. The containment access lid which is covered by (a) above and a safety wire seal.
- II.A.3.a. There is no system of lifting devices that is a structural part of the packaging.
- II.A.3.b. There is no system of lifting devices which is a structural part only of the lid.
- II.A.3.c. There is no structural part of the packaging which should be employed to lift the package. Lifting should be accomplished by slings or forklift.
- II.A.3.d. Failure of any lifting device under excess loading would not impair the containment or shielding properties of the package.
- II.A.4.a. This container does not have any built-in tie-down devices.
- II.A.4.b. No structural portion of the package which is important to containment could be employed as a tie-down device.
- II.A.4.c. The container includes no tie-down devices.

II.B. STRUCTURAL STANDARDS

- II.B.1. Load Resistance. The stresses generated in any material of the container are trivial for the condition that regards the container as a single beam, supported at its end and uniformly loaded to five times its fully loaded weight. Calculations (Eq. A-1) show that any one of the three protective structural components--steel truss, steel shell, and aluminum shell--could safely carry the maximum bending moment.
- II.B.2. External Pressure. An external pressure of 172.37 kPa (25 psig) is trivial for this container.
- II.C. CRITICALITY STANDARDS are discussed in Appendix B.
- II.D. EVALUATION OF A SINGLE PACKAGE
- II.D.1. The effects of the normal transport environment on the safety of the contents of the container are trivial from the following observations:
 - a. The contents are sealed and positioned within an inner steel pressure tested vessel, housed in a strong wooden box, and completely surrounded by two concentric shells separated by phenolic foam.
 - b. The outer steel shell is welded to a Warren Truss assembly to form the exterior of the container package.
- II.D.2. Evaluation package and vehicle together. Not applicable.
- II.D.3. Approval of different accident conditions. Not applicable.
- II.E. STANDARDS FOR NORMAL CONDITIONS OF TRANSPORT FOR A SINGLE PACKAGE
- II.E.1. The packaging is designed, constructed, and its contents limited such that when subjected to the normal conditions of transport specified in ERDAM 0529 Appendix, Annex 1:
 - a. There will be no release of radioactive materials from the containment vessel.
 - b. The effectiveness of the package will not be substantially reduced.
 - c. There will be no mixture of gases or vapor in the package which could, through any likely increase of pressure or an explosion, significantly reduce the effectiveness of the package.

- d. Not applicable.
- e. Not applicable.

II.E.2. The package is so *designed*, constructed, and its contents so limited that if subjected to the normal conditions of transport, specified in Annex 1:

- a. The package will be subcritical (Criticality Analysis-Appendix B).
- b. The geometric form of the contents will not be significantly altered. (Evaluation-Table A-1)
- c. While water leakage is considered unlikely, the presence of additional moderator would increase the effectiveness of the neutron absorber. No water could reach the fissile material.
- d. Package contents are limited to comply with Fissile Class I criteria. A reduction in spacing would have no safety significance.

II.E.3. The containment vessel will not be vented directly to the atmosphere.

II.F. The outer container shall act as an impact limiter, but will not be considered as thermal protection for the primary container. Calculations indicate that the primary container can safely sustain the Hypothetical Accident Conditions as specified by ERDAM 0529 Appendix, Annex 2.

Following is a summary of the Hypothetical Accident Condition calculations:

- a. FREE DROP: The LASL Computer Code IMPAC-2.0 (Table A-1) has been used to evaluate the effect of a 9.14-m (30-ft) drop test of this container. The code uses a one-dimensional spring-mass treatment and has been tested against the available experimental data. The most damaging attitude of the shipping container in its original unmodified state was the end-on drop because there were no impact limiting materials in the outer container that would cushion the fall of the primary container in this attitude. Analyses showed that:
 - 1. The capsules would break loose from their brackets, and
 - 2. would suffer stresses above the allowable compressive yield strength of steel.
 A solution to this problem was to modify the wooden box by placing at least 609.6 mm (24 in.) of plywood at each end to act as an impact limiting material for the containers (Fig. 4). Analyses on the modified wooden box showed that while the end drop is still the most extreme configuration:
 - 1. The containers would still break loose from their brackets, and
 - 2. that the maximum compressive stress in the inner container would be less than the compressive yield stress of steel 379 214 kPa (55 000 psi), thereby protecting the primary container from any permanent distortion.
- b. PUNCTURE: The position of maximum damage for the puncture test would occur when the package is inverted and is struck on the centerline at its midlength, because the primary capsules would have the least amount of resistance to penetration in this attitude.

Results of puncture test studies* have demonstrated that the primary capsule is adequately protected from the puncture bar in the 2.74-m 101.6-mm (40-in.) free drop test. Figure A-1 shows the puncture and nonpuncture zones resulting from the free fall of cylindrical steel casks a distance of 0.914 m 101.6 mm (40 in.) specified in the Hypothetical Accident Condition.

The primary capsules are completely protected by the outer container structure from coming in contact with the punch according to the following reasoning:

Assume that the punching resistance afforded by the outer tube, inner tube, and steel-jacketed wooden box are simulated by an equivalent thickness at the location of the outer tube or shell. This is conservative because the smaller dimensions of the inner tube and the box will actually provide more resistance to penetration than this assumption.

Equivalent Thicknesses

16 gauge outer steel tube	0.0598 in. (1.5 mm)
0.25 aluminum inner tube	0.083* in. (2.1 mm)
14 gauge steel jacket	0.0747 in. (1.9 mm)
	<hr/> 0.2175 in. or 5.3 mm

Total weight of the package	240 lb
Outer Container	1800 lb
	<hr/> 2040 lb or 0.93 tonne

Ultimate tensile strength of steel

$U = 80\ 000\ \text{psi (assumed) or } 56\ \text{kg/mm}^2$.

Therefore,

$$W/A_g = 0.03/56 = 0.017 \text{ (abscissa of Fig. A-1).}$$

From Fig. A-1, a thickness of 5.3 mm (0.21 in.) is well inside the puncture region. If only the outer tube and the inner tube are considered, the equivalent thickness of 3.6 mm (0.14 in.) falls just slightly into the no-puncture zone. It could be speculated from these results that the punch penetrates the shell of the outer tube and almost penetrates that of the inner tube. The steel-jacketed wooden box then would offer an ample margin of safety for the protection of the primary capsules.

- c. **THERMAL:** Not critical. The fuel material is completely encapsulated within a steel tube and the end caps are welded or brazed using a compound with a melting point above 1093° C (2000° F). Closures are tested to confirm encapsulation. Exposure to a fire for 30 minutes is assumed to bring the fuel material to the hypothetical fire temperature, 802° C (1475° F), because the thermal-insulating effects of the outer container have been neglected. The fuel material undergoes no instability at or below this temperature thereby eliminating the possibility of a pressure rise within the wooden box.

An actual fire test would be far less severe than this assumption. At a temperature above 149° C (300° F) the phenolic foam will begin to char and decompose. Even after all the foam is consumed, the double wall will greatly impede heat transfer. It is questionable that the inner container temperature would ever destroy the potting compound used on the capsule, but the only protection being relied upon is that provided by the high-temperature braze metal.

- d. **WATER IMMERSION:** Not critical. The primary containment vessel of the TREAT Capsule Shipping Container is comprised of the pressure vessel, the heater can, and the inner capsule. This primary container precludes leakage of water into the inner capsule.

REFERENCE

H. Nelms, "Effects of Jacket Physical and Curvature on Puncture Resistance," Structural Analysis of Shipping Casks, Vol. 3, ORNL-TM-1312, Vol. 3 (June 1968).

* $0.25 \times \frac{E_{\text{aluminum}}}{E_{\text{steel}}}$, where E is the modulus of elasticity.

LOAD RESISTANCE (II, B, 1)

Container Regarded as Simple Beam
Supported at its ends

MAX B.M. @ C

$$M = \frac{WL}{8}$$

$$W = 5 \cdot 1800 = 9000 \text{ (LBS)}$$

$$L = 194 \text{ (IN.)}$$

$$M = \frac{9000(194)}{8} = 218300 \text{ (IN LBS)}$$

MAX. STRESS

$$\sigma = \frac{Mc}{I}$$

TRUSS

$$I = 4(0.494)^2 = 284 \text{ (IN}^4\text{)}$$

$$c = 12$$

STEEL SHELL

$$I = \frac{\pi}{4} (11^4 - 10.9375^4) = 259 \text{ (IN}^4\text{)}$$

$$c = 11$$

ALUMINUM SHELL

$$I = \frac{\pi}{4} (8^4 - 7.75^4) = 384 \text{ (IN}^4\text{)}$$

$$c = 8$$

Container Cross-Section

MAX. STRESS (CONT.)

$$\sigma_{TRUSS} = \frac{218300(12)}{284} = 9220 \text{ (LB/IN}^2\text{)}$$

$$\sigma_{STEEL} = \frac{218300(11)}{259} = 9270 \text{ (LB/IN}^2\text{)}$$

$$\sigma_{AL} = \frac{218300(8)}{384} = 4550 \text{ (LB/IN}^2\text{)}$$

YIELD STRENGTHS

STEEL

$$\sigma_y \approx 50,000 \text{ (LB/IN}^2\text{)}$$

ALUMINUM

$$\sigma_y \approx 30,000 \text{ (LB/IN}^2\text{)}$$

TABLE A-1

The following computer printout demonstrates that with the added 609.6 mm (24 in.) of marine plywood (slices 2 through 5) the maximum stress in the steel will occur at slice 19 and will be about 206 844 kPa (30 000 psi), or slightly more than half the compressive yield strength of 379 214 kPa (55 000 psi).

TREAT SHIPPING PACKAGE FOR CMB-11 (30-ft. drop using IMPAC-2.0)

DATA WHICH WAS ENTERED FOLLOWS

AUTOMATIC SLICING BEING USED TO DEFINE GEOMETRY, BASED ON FOLLOWING DATA

CYLINDR = 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
 HEIGHT = 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
 ANGLE = 00.00000 00.00000 00.00000 00.00000 00.00000 00.00000 00.00000 00.00000

INITIAL TIME INCREMENT = .100000E-04

STOP TIME = .200000

PRINTING INCREMENT = .010000

IMPACT VELOCITY = 527.20000 inches/sec

NUMBER OF MASSES = 23

CLAD YIELD STRESS = 0

SLICE	HEIGHT	VOLUME	AREA	RADIUS	EIGHT	MASS	RING 1	RING 2	RING 3	RING 4	CLADDING
1	0.00000	336.00	56.00	4.22	9.69	.021524	0	0	0	0	0.000
2	0.00000	336.00	56.00	4.22	5.79	.014986	0	0	0	0	0.000
3	0.00000	336.00	56.00	4.22	5.79	.014986	0	0	0	0	0.000
4	0.00000	336.00	56.00	4.22	5.79	.014986	0	0	0	0	0.000
5	0.00000	336.00	56.00	4.22	5.79	.014986	0	0	0	0	0.000
6	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
7	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
8	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
9	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
10	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
11	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
12	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
13	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
14	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
15	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
16	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
17	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
18	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
19	0.00000	12.95	2.16	.83	14.68	.037982	0	0	0	0	0.000
20	3.55000	7.66	2.16	.83	14.68	.037982	0	0	0	0	0.000
21	3.55000	7.66	2.16	.83	14.68	.037982	0	0	0	0	0.000
22	3.55000	7.66	2.16	.83	14.68	.037982	0	0	0	0	0.000
23	3.55000	7.66	2.16	.83	14.68	.037982	0	0	0	0	0.000

TOTAL HEIGHT = 126.20

TOTAL VOLUME = 1892.61

TOTAL WEIGHT = 272.45

1 = STEEL
 2 = CLAD LEAD
 3 = URANIUM
 4 = POKEROSSA PINE
 5 = LEAD
 6 = Balsa
 7 = MARINE PLYWOOD
 8 = OAK

TREAT SHIPPING PACKAGE FOR CM8-11

TIME = .0062350

INPUT ENERGY = 97966.99

SLICE	THICK	O.R.	MASS	FORCE	STRAIN	RATE	ACCELERATION	VELOCITY	PERM SET	ENERGY	STRAIN	STRESS
1	6.000	4.22	.023520	-58591.40	.0		-167	.01	.000000	.00	.000698	-1046
2	5.146	4.56	.014986	-57077.67	.1		309	.65	.053791	.00	.143173	-874
3	5.648	4.35	.014986	-59332.07	.5		-223	-2.30	.351842	.04	.059630	-997
4	5.754	4.31	.014986	-58038.87	.1		-364	-1.96	.245604	.03	.081928	-994
5	5.829	4.28	.014986	-55428.38	2.2		-969	-15.05	.170816	1.70	.029440	-978
6	5.972	.83	.037982	-58316.52	.3		-1215	-13.48	.027677	3.45	.004642	-873
7	6.000	.83	.037982	-32487.76	.5		-688	-10.50	.000000	2.13	.002502	-15847
8	6.000	.83	.037982	-23561.33	.6		-703	-14.05	.000000	3.75	.000364	-10913
9	6.000	.83	.037982	-13238.76	1.0		-758	-8.29	.000000	1.30	.000204	-6132
10	6.000	.83	.037982	-2236.15	.7		69	-4.18	.000000	.32	.000035	-1036
11	6.000	.83	.037982	-3249.78	.1		249	-4.68	.000000	.42	.000050	-1505
12	6.000	.83	.037982	-6909.39	1.1		-301	1.97	.000000	.07	.000107	-3200
13	6.000	.83	.037982	-2489.38	.8		-194	6.73	.000000	.86	.000038	-1153
14	6.000	.83	.037982	357.36	1.3		-134	-1.24	.000000	.03	.000006	166
15	6.000	.83	.037982	2317.44	1.6		48	-10.99	.000000	2.30	.000036	1073
16	6.000	.83	.037982	1616.25	1.3		133	-3.05	.000000	.18	.000025	749
17	6.000	.83	.037982	-338.71	2.0		24	9.11	.000000	1.58	.000005	-157
18	6.000	.93	.037982	-683.83	1.8		252	-1.45	.000000	.04	.000011	-317
19	6.000	.83	.037982	-4382.85	1.3		-267	-9.28	.000000	1.63	.000068	-2030
20	3.550	.83	.022472	-458.36	.8		-387	-6.42	.000000	.46	.000007	-212
21	3.550	.83	.022472	2902.62	1.0		-226	-2.74	.000000	.08	.000005	1344
22	3.550	.83	.022472	4865.29	.5		129	-1.04	.000000	.21	.000075	2253
23	3.550	.83	.022472	3745.31	.0		431	-1.08	.000000	.01	.000058	1735

1.684399539

ENERGY REMAINING/ENERGY INPUT = .00021

TOTAL PERMANENT SET = 1.684488

TIME	SLICE	MAXIMUM STRAIN
.0048530	2	.14329855

TABLE OF TIME VS. MAXIMUM ACCELERATION FOR ALL SLICES

SLICE	TIME	ACCELERATION
1	.00007	-28702.1
2	.00005	-8575.8
3	.00012	-6018.6
4	.00015	-4925.8
5	.00022	-2365.5
6	.00020	-2452.2
7	.00027	-1856.3
8	.00034	-1756.2
9	.00041	-1651.8
10	.00047	-1627.6
11	.00054	-1577.4
12	.00060	-1537.7
13	.00066	-1499.9
14	.00072	-1464.6
15	.00079	-1435.7
16	.00085	-1409.4
17	.00091	-1380.6
18	.00097	-1328.5
19	.00136	-1643.3
20	.00108	-1365.0
21	.00114	-1605.5
22	.00118	-2116.2
23	.00120	-2510.4

TIME	MATERIAL	SLICE	RING	MAX. COMPR.	STRESS
.001123	1	19	5	-38517	(Primary Container)
.000000	2	0	0	0	
.000000	3	0	0	0	
.000000	4	0	0	0	
.000000	5	0	0	0	
.000000	6	0	0	0	
.000000	7	0	0	0	
.000066	8	1	5	-5659	
.000062	9	2	5	-1000	
.000000	10	0	0	0

Fig. A-1.

Outer shell thickness versus weight of cask to cause puncture.

APPENDIX B

NUCLEAR CRITICALITY SAFETY ANALYSIS

The "MTR Shim Rod Shipping Container" configuration proposed for the movement of experimental fast reactor fuel pins, as encapsulated for exposure in the TREAT Facility, was evaluated for criticality safety.

The container previously held a DOT Special Permit 5828, with an overly restrictive allowable loading of fissile material.

The plutonium loading which would be required to make an infinite array of undamaged containers critical has been calculated. For plutonium at Alpha Phase Density ($\sim 19.86 \text{ g/cm}^3$) this value is in excess of 300 grams per cm of container length. The cross section of the container that was calculated follows.

<u>Radius (cm)</u>	<u>Material</u>
0	
2.297	Plutonium (19.86 g/cm^3)
2.377	Steel
6.363	Void
8.903	Plywood (0.5 g/cm^3)
8.953	Cadmium
20.01	Void
27.47	CH (0.23 g/cm^3)
27.79	Steel

The plutonium radius (2.297 cm), which would make an infinite array of packages like this critical, exceeds the single parameter limit (2.2 cm) recommended in N 16.1-1969, The American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors. Since the value also far exceeds anything contemplated for shipment, a limit is recommended corresponding to a 1.0-cm radius, or 60 grams plutonium or other fissile material per cm of container length. This is equivalent to a mass of 2 kg fissile material for the fuel pins that have an active material length of 35 cm. If this loading is not exceeded, the package will comply with Fissile Class 1 Criteria.

APPENDIX C

QUALITY ASSURANCE PROGRAM PLAN TREAT CAPSULE ASSEMBLY SHIPPING CONTAINER

The Quality Assurance Program Plan has been prepared to demonstrate compliance with the applicable sections of LASL Quality Assurance Manual for Engineering and Construction, LA-5220-M, for a Type I consequence-of-failure; and with ERDAM Chapter 0529 Appendix, Part III, Quality Assurance. The Quality Assurance requirements shall basically consist of documenting the modifications done to the TREAT Capsule Assembly Shipping Container in order to comply with ERDAM 0529 Appendix, Annex 1 and 2.

1. Design Control: The project engineer shall be responsible for designing the modifications required in the container. Calculations shall be done on the proposed design before the modification is incorporated in the shipping container.
2. Document and Record Control: A copy of the following records will be kept in LASL Engineering 3.
 - a. LA Report on the shipping container. This QA Plan shall be part of the LA Report.
 - b. Calculations done on the modifications (WX-8).
 - c. Calculations needed to meet the requirements of ERDAM 0529 Appendix, Annex 1 and 2 (WX-8).
 - d. Information describing the container configuration (CMB-11).
 - e. Step-by-step description of the modifications (CMB-11).
3. Procurement: No procurement activities shall be required.
4. Fabrication: No specific fabrication procedures shall be required. The fabrication shall consist of incorporating the proposed modification, which is adding a 609.6-mm (24-in.) stack of Marine Grade, 25.4-mm (1-in.)-thick plywood to both ends of the packaging box of the shipping container. The modification requires no welding, machining, testing, or similar operations. It shall be the responsibility of the project engineer to incorporate and inspect the modification of the container. The Review Board shall review the modifications after they have been incorporated.
5. Selection of the Review Board Members: A list of the Review Board Members is shown on the attached "Project Personnel Directory."

L. J. 5538-0

<p>Los Alamos Scientific Laboratory of the University of California</p>	<p>LA-5220-M</p> <p>ENGINEERING & CONSTRUCTION</p> <p>QUALITY ASSURANCE PROGRAM</p>	<p>NO ENG-DO/QA-1386</p>
		<p>DATE 9 February 1976</p>
<p>Project Personnel Directory</p>		<p>SUPERSEDES ENG-DO/QA-1367</p>
<p>APPROVED: H. E. Martinez, CMB-11 E. L. Brazier, Jr., ENG-DO/QA</p>		<p>PAGE <u>1</u> OF <u>1</u></p>

Lab Job 5538-0

TREAT CAPSULE ASSEMBLY SHIPPING CONTAINER

Key Personnel

Operating Manager:	D. G. Clifton, CMB-11
Project Engineer:	H. E. Martinez, CMB-11
Quality Assurance Engineer:	Henry P. Nunes, ENG-DO/QA

Design Review Board

Criticality:	Dave R. Smith, R-5
Health Physics:	Carl Buckland, H-1
Industrial Hygiene:	Leroy Garcia, H-5
Records Management:	J. Bennie Montoya, ENG-3
Shipping/Licensing:	Betty Lobb, SP-DO
Structures:	Richard W. Andrae, WX-8

APPENDIX D

UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Form AEC-418
(17-73)
10 CFR 71
AECM5761

CERTIFICATE OF COMPLIANCE
For Radioactive Materials Packages

1a. Certificate Number USA/5828/BLF (ERDA-AL)	1b. Revision No. Original	1c. Package Identification No. USA/5828/BLF (ERDA-AL)	1d. Page No. 1	1e. Total No. Pages 1
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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 170.149 and 14 CFR 103) and Sections 146-19-10a and 146-19-100 of the Department of Transportation Dangerous Cargues Regulations (46 CFR 146-145), as amended.
- 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 Material for Transport and Transportation of Radioactive Material 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)

(2) Title and Identification of report or application

(3) Date

Betty Lobb
Los Alamos Scientific Laboratory
University of California
Los Alamos, New Mexico 87545

LA-6606-MS
The TREAT Capsule Assembly Shipping Container
(Formerly DOT SP 5828)

December 1976

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** - The authorized packaging consists of a 1-in. thick plywood box, covered with 14 gauge steel, with an interior "T" beam spacer-stiffener and 0.020-in. cadmium lining on the top, bottom, and both sides of the divider, and a hinged cover; plus an outer container which consists of two concentric cylindrical metal tubes that are separated by a 3-in. thickness of phenolic foam, plus a roller channel assembly to hold the inner container in place. The outer container is enclosed in a "Warren" truss metal framework which serves as a structural member and shipping pallet. The outer package dimensions are 183 in. long by 24 in. by 26 in. The gross weight is 1800 lbs.
- B. **CONTENTS** - Not more than two fast reactor fuel pins each encapsulated in a pressure vessel (3 in. o.d., AISI 4130 Steel) which contains a heater can (1.25 in. o.d., 304 Stainless Steel) surrounding an inner container (1.125 in. o.d., 316 Stainless Steel) with welded or brazed end caps, which contains the fuel pin.
- C. **RESTRICTIONS** - Fissile material not to exceed 60 grams per centimeter of container length.

6a. Date of Issuance November 17, 1976	6b. Expiration Date N/A
FOR THE U.S. ERDA	
7a. Address (of ERDA Issuing Office) Albuquerque Operations Office P. O. Box 5400 Albuquerque, New Mexico 87115	7b. Signature, Name, and Title of ERDA Approving Official Jack R. Koerner, Director Operational Safety Division

Fig. 1. TREAT Capsule Assembly.

Fig. 2. TREAT Capsule Assembly Container.

Fig. 3. Configuration of a typical advanced fuel off-normal irradiation capsule assembly.

Fig. 4. TREAT Capsule Assembly Container.

Fig. 5. TREAT Capsule Assembly Shipping Container;
Shipping Pallet (Warren Truss).

Fig. 6. TREAT Capsule Assembly Shipping Container.