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SHIELDED SHIPPING CONTAINER FOR FISSILE MATERIAL CLASS 1 OR LARGE QUANTITIES OF RADIOACTIVE MATERIAL SUPPLEMENT

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**SHIELDED SHIPPING CONTAINER FOR FISSILE MATERIAL CLASS 1
OR LARGE QUANTITIES OF RADIOACTIVE MATERIAL
SUPPLEMENT**

by

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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, and is reported in LA-4686-MS. This supplement expands and clarifies the detail in that report, and includes the appropriate AEC certification of conformance under current requirements.

DESIGN CRITERIA

There is no change from the original packaging description as given in LA-4686-MS, "Shielded Shipping Container for Fissile Material Class 1 or Large Quantities of Radioactive Material." Material is in double encapsulation conforming to "Special Form" (49 CFR Part 173.389 Radioactive Materials, Definitions). The encapsulation consists of an inner steel tube, or a pipe cap and plug, all of stainless steel, reference drawing 54Y-110537 C-1, Detail "B" or "C." External encapsulation is a 303 stainless steel DOT Specification 2R container, Detail "A" of the same drawing; lengths may vary according to the size of the fuel element sample being shipped.

The cask is designed for loading or unloading under water, and for which a drainage tube is built in. Consisting of Schedule 40 304 stainless steel, it extends from the bottom of the cavity out the side wall of the cask, where it terminates in a flush-cut, full-penetration weld to the cask side wall. It is threaded internally and closed by a fusible plug.

THERMAL CONSIDERATIONS

Exposure of the container to a heat radiation environment of 1075 K (1475°F) for 30 min with an emissivity

coefficient of 0.9 will have no effect on the integrity of the container. The melting point of stainless steel is 1672 K (2550°F) and of uranium is 1405 K (2070°F). Heat calculations for this cask are for the radial slice shown in Figs. 1 and 2; data are given in Table I. There is no escape of radioactivity since the integrity of the metal is preserved.

QUALITY ASSURANCE

The quality assurance program plan is attached as Appendix A.

NUCLEAR CRITICALITY SAFETY

The nuclear safety calculations discussed in LA-4686-MS used Hansen-Roach 16-group cross sections. The cross sections were validated by comparison with the experimentally determined water reflected critical sphere¹ and with the Flattop data² for a plutonium

¹David R. Smith and William U. Geer, "Critical Mass of a Water Reflected Plutonium Sphere," Nucl. Appl. Tech. 7, No. 5, 405-408 (1969).

²G. E. Hansen and H. C. Paxton, "Reevaluated Critical Specifications of Some Los Alamos Fast-Neutron Systems," Los Alamos Scientific Laboratory report LA-4208 (September 1969).

TABLE I

DOT SP 6421, CM8-14 CONTAINER FIRE

AXISYMMETRIC SOLID

TIME = .1800E+04

NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE	NODE	TEMPERATURE
1	741,668	2	741,676	3	741,682	4	741,688	5	741,695
6	741,734	7	741,696	8	741,704	9	741,710	10	741,715
11	741,721	12	741,729	13	741,749	14	741,754	15	741,760
16	741,765	17	741,778	18	741,776	19	741,829	20	741,833
21	741,838	22	741,844	23	741,849	24	741,853	25	741,937
26	741,941	27	741,947	28	741,952	29	741,958	30	741,962
31	742,875	32	742,880	33	742,885	34	742,891	35	742,897
36	742,182	37	742,139	38	742,145	39	742,151	40	742,157
41	742,163	42	742,168	43	742,215	44	742,221	45	742,227
46	742,233	47	742,240	48	742,246	49	742,300	50	742,308
51	742,314	52	742,320	53	742,327	54	742,335	55	742,396
56	742,425	57	742,412	58	742,418	59	742,425	60	742,434
61	742,581	62	742,512	63	742,519	64	742,525	65	742,532
66	742,544	67	743,869	68	743,874	69	743,880	70	743,885
71	743,898	72	743,895	73	743,822	74	743,826	75	743,830
76	743,834	77	743,838	78	743,841	79	744,754	80	744,757
81	744,760	82	744,763	83	744,766	84	744,769	85	745,860
86	745,862	87	745,865	88	745,867	89	745,870	90	745,873
91	747,135	92	747,137	93	747,140	94	747,142	95	747,144
96	747,147	97	748,578	98	748,580	99	753,582	100	748,584
101	748,586	102	748,588	103	750,186	104	750,188	105	750,190
106	750,192	107	752,194	108	750,195	109	751,957	110	751,959
111	751,961	112	751,962	113	751,964	114	751,966	115	753,890
116	753,891	117	753,893	118	753,894	119	753,896	120	753,898
121	755,982	122	755,983	123	755,985	124	755,986	125	755,988
126	755,989	127	758,233	128	758,234	129	758,235	130	758,237
131	758,238	132	758,239	133	760,648	134	760,641	135	760,643
136	760,644	137	760,645	138	760,646	139	763,203	140	763,204
141	763,205	142	763,207	143	763,208	144	763,209	145	765,920
146	765,921	147	765,922	148	765,923	149	765,924	150	765,925
151	768,799	152	768,798	153	768,791	154	768,792	155	768,793
156	768,794	157	771,809	158	771,810	159	771,811	160	771,812
161	771,813	162	771,814	163	774,979	164	774,983	165	774,988
166	774,981	167	774,982	168	774,983	169	778,296	170	778,297
171	778,298	172	778,298	173	778,299	174	778,300	175	781,759
176	781,760	177	781,761	178	781,761	179	781,762	180	781,763
181	785,366	182	785,367	183	785,368	184	785,369	185	785,369
186	785,370	187	789,116	188	789,117	189	789,117	190	789,118
191	789,119	192	789,120	193	793,806	194	793,807	195	793,808
196	793,808	197	793,809	198	793,810	199	797,835	200	797,835
201	797,836	202	797,837	203	797,838	204	797,838	205	801,200
206	801,200	207	801,201	208	801,202	209	801,202	210	801,203
211	805,499	212	805,500	213	805,500	214	805,501	215	805,501
216	805,502	217	809,931	218	809,931	219	809,932	220	809,932
221	809,932	222	809,933	223	814,492	224	814,493	225	814,493
226	814,493	227	814,493	228	814,493	229	819,181	230	819,181
231	819,181	232	819,180	233	819,180	234	819,180	235	823,996
236	823,995	237	823,994	238	823,993	239	823,991	240	823,991
241	828,936	242	828,932	243	828,929	244	828,927	245	828,924
246	828,928	247	831,292	248	831,289	249	831,286	250	831,284
251	831,281	252	831,277	253	833,665	254	833,662	255	833,659
256	833,657	257	833,654	258	833,651	259	836,855	260	836,852
261	836,849	262	836,846	263	836,843	264	836,840	265	838,461
266	838,457	267	838,454	268	838,451	269	838,448	270	838,444
271	848,864	272	848,878	273	848,875	274	848,872	275	848,869
276	848,863

Fig. 1.

DOT SP 6421 container. Design condition: Exposure of the container to a radiation temperature environment of 1474°F for 30 min with an emissivity coefficient of 0.9.

Fig. 2.

Radial slice showing maximum temperatures in analytical model. Design condition: Exposure of the container to a thermal radiation environment of 1475°F for 30 min with an emissivity coefficient of 0.9.

sphere reflected by natural uranium. In each test one obtains agreement between calculation and experiment of about 1/2% in k_{eff} . The margins of subcriticality reported in the original nuclear safety discussion are therefore far greater than any uncertainty in the calculations.

RADIOLOGICAL SAFETY

In designing the cask for transporting small sections of irradiated pins, it was assumed that the highest activity to be shipped was from pins which had reached a burnup of 10% (this figure was considered at that time an economical target goal for Fast Breeder Reactors). The uranium and plutonium compounds contained in the fuel pin are considered as Special Form for the purpose of shipping.

Previous experimental pins from the Hanford Engineering Development Laboratories that had received approximately 10% burnup exposures were shown to have beta-gamma activities of approximately 1000 R/h after 2 months of cooling. The radiation was primarily from the fuel region which is generally about 13-1/2 in. in length. The design of the cask was therefore based upon being able to provide adequate shielding and containment for a section (or sections) of the 13-1/2 in. length of fuel column. Appropriate containment equivalent to 2R containers was also taken into account in allowing for the length and diameter of the shielded cavity (9.7 in. long by 1.05 in. in diameter).

Past experience has shown that the use of tenth value thicknesses as obtained from J. Motteff's Chart on Shielding Constants³ is adequate in providing general purpose shielding for attenuating beta-gamma radiation from fission products (decayed for 2 months or more).

Assuming that the effective energy of the decayed fission products is 1 MeV, then the uranium thickness required to attenuate radiation (of this energy) by a factor of ten is 0.63 in.

Example: 10^3 R/h at 1 meter = 10^6 mR/h at 1 meter.

Assuming that 5.0 in. of uranium and 0.5 in. of stainless steel (actual thicknesses are 4.94 in. of uranium and 0.51 in. of stainless steel) or air gap would be between the source of the radiation and the outside of the container then at a distance of 5.5 in. (5.0 + 0.5), a "10⁶ mR/h at 1 meter source" would have a radiation level of $(39.37 \text{ in./5 in.})^2 \times 10^6$ mR/h or 6.19×10^7 mR/h at 5.5 in. from the source.

³ John Motteff, "Tenth-Value Thicknesses for Gamma-Ray Absorption" (Data Sheet No. 5, Shielding Constants), Nucleonics, 13, No. 5, p. 24 (July 1955).

If one interposed 5.0 in. of uranium shielding having an attenuation factor of 9×10^7 [(5.0 in.)/0.63 in./tenth thickness) = 7.95 tenth thicknesses = 9×10^7 factor of attenuation], then the approximate resulting radiation at 5.5 in. (even from a point source) would be

$$\frac{6.19 \times 10^7 \text{ mR/h}}{9 \times 10^7 \text{ atten. factor}} \text{ or } 0.69 \text{ mR/h}$$

CONCLUSION

It appears that 4.94 in. of uranium shielding (exclusive of any stainless steel shielding) is adequate for reducing the radiation from sections of fuel pins, which have been irradiated to a level of 10% burnup, to a safe level.

A precise mathematical treatment of this problem was not made since the controlling criteria for shipping radioactive materials is based on the actual radiation measurements made with radiation survey instruments.

The guidelines of Chapter 0529 of the AEC Manual currently restrict the radiation to <200 mrem/h at contact with the surface of the container and <10 mrem/h at 3 ft from the container.

QUALITY ASSURANCE

The quality assurance program plan for CMB-14 Analytical Samples Cask is attached as Appendix A.

U. S. ATOMIC ENERGY COMMISSION APPROVAL

The U. S. Atomic Energy Commission Certificate of Compliance is attached as Appendix B.

CONTAINER DRAWINGS AND PHOTOGRAPHS

Container drawings and photographs are attached as Appendix C.

QUALITY ASSURANCE PROGRAM PLAN
for
CMB-14 ANALYTICAL SAMPLES CASK
(DOT SP-6421)
LAB JOB 5172-0

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 for the design, operation, maintenance and modification (if any) phases of the CMB-14 Shipping Cask for Analytical Samples, hereafter 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 fissile material Class I and large quantities of radioactive material. The operating organization for the Container is CMB-14.

2. QUALITY PROGRAM ELEMENTS AND ACTIONS

The Quality Assurance Program for the Container will be in accordance with the "LASL Quality Assurance Program for Engineering and Construction Projects", including the Quality Assurance Manuals, design, documentation, procedures, inspection and other activities pertaining to quality assurance of all organizations performing quality assurance 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:

<u>Function</u>	<u>Organizations or Individuals</u>
Design	LASL Engineering Department CMB-14 QA Review Board
Stress Analysis	LASL Engineering Department
Failure Studies	LASL Engineering Department
Purchasing	LASL Supply and Property Department
Supplier Qualifications	LASL Supply and Property Department LASL Engineering Department
Source Inspection	LASL Engineering Department LASL Shop Department
Receiving	LASL Supply and Property Department
Receiving Inspection	LASL Supply and Property Department LASL Engineering Department LASL Shop Department
Warehousing and Material	
Protection and Control	LASL Supply and Property Department
Fabrication	LASL Shop Department Contractor

<u>Function</u>	<u>Organizations or Individuals</u>
Chemical, Physical and Spectrographic Analyses	LASL CMB Division
Nondestructive Testing	LASL M-1 Group Contractor
Inspection of Fabrication	LASL Engineering Department LASL Shop Department LASL Supply and Property Department Contractor
Third Party Inspection for Compliance	As Required
Fabrication Administration	LASL Engineering Department
Acceptance Test Procedures	LASL Engineering Department CMB-14
Acceptance Test Performance	LASL Engineering Department CMB-14 Contractor
Welding Qualification	Contractor
Auditing	LASL Quality Assurance Head
Quality Assurance Review Board Members	See LASL Internal Supplemental Information Bulletin
Quality Assurance Waiver Board Members	See LASL Internal Supplemental Information Bulletin
Operation Administration	CMB-14

4. DOCUMENTATION

A. Records Accumulation and Retention

All quality assurance documentation shall be retained in the "Quality Assurance Binder" of the Lab Job 5172-0 Folder. 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

Management

Quality Assurance Planning
 Quality Assurance Records Accumulation, Retention, and Distribution

Design

Design Document Release and Change Controls
 Design Criteria
 Fabrication Drawings and Specifications
 Procurement Drawings and Specifications
 Special or Industrial Standards
 Design Review
 Failure Study
 Operability and Maintainability Study

Procurement

Q.A. Review of Procurement Document and Changes
 Purchase Order to Include Necessary Standards
 Qualified Suppliers
 Qualified LASL Inspectors and NDT Personnel
 Control of Received Items
 Controls on Handling, Packaging, etc.
 Source Inspection
 Control of Nonconforming Items
 Corrective Action
 Warehouse Control

Fabrication

Qualified Welders and Procedures
 Qualified NDT Personnel and Procedures
 Certified Materials
 Acceptance Testing
 Certified Inspection
 Control on Nonconforming Items
 Corrective Action
 Control of Measuring and Test Equipment
 Cleaning and Cleanliness Control
 Handling, Packaging, and Shipping Controls
 Auditing of Shop

Operation and Maintenance

Document Control
 Operator Training and Qualification
 Controlled Operating Procedures
 Controlled Maintenance Procedures
 In-Service Inspection Program
 Failure and Incident Report
 Corrective Action

APPENDIX B: U. S. ATOMIC ENERGY COMMISSION APPROVAL

Form AEC-618
(9-72)
AECM 5201

**U.S. ATOMIC ENERGY COMMISSION
CERTIFICATE OF COMPLIANCE
For Radioactive Materials Packages**

1a. Number AEC - AL	1b. Revision No. 'JSA /6421/BLF Original	1c. Page No. 1	1d. Total No. Pages 2
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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 <div style="text-align: center;">Los Alamos Scientific Laboratory Los Alamos, New Mexico</div>	(2) Number LA-4686-MS including Supplement No. 1 (3) Date Published June 1971 and March 1974
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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 DDT 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) The packaging authorized by this certificate 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.

(b) The contents of each package authorized by this certificate consist of large quantities of "special form" 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.

(c) The packaging authorized by this certificate meets the requirements for shipment as Fissile Class I. The transport

TO BE COMPLETED BY AEC

5a. Address (of AEC Approving Official) Albuquerque Operations Office P. O. Box 5400 Albuquerque, New Mexico 87115	5b. Signature (of AEC Approving Official) <hr/> 5c. Name and Title (of AEC Approving Official) Jack R. Raeder, Director Operational Safety Division <hr/> 6. Expiration Date (if appropriate) 7. Date February 19, 1974
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index must be assigned based on external radiation levels.

- (d) The outside of each package must be plainly and durably marked "AEC-AL USA/6421/BLF," 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 "AEC-AL USA/6421/BLF," in connection with the commodity description thereon.
- (e) Each package must have its gross weight plainly and durably marked on the outside of the package.

APPENDIX C: CONTAINER DRAWINGS AND PHOTOGRAPHS

The drawings 54Y-110529 B-1, 54Y-110537 C-1, and ENG-E384 D-1 are available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22151. Photographs of the CMB-14 cask for shipping analytical samples (with the cover attached and removed) are included.

CONCLUSIONS AND RECOMMENDATIONS

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