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TITLE: USE OF THE DEPARTMENT OF TRANSPORTATION SPECIFICATION 6M CONTAINER FOR SHIPPING POLYSTYRENE-PLUTONIUM COMPACTS

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USE OF THE DEPARTMENT OF TRANSPORTATION SPECIFICATION 6M CONTAINER FOR SHIPPING POLYSTYRENE-PLUTONIUM COMPACTS

by

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ABSTRACT

The LASL ONETRAN code has been used to provide values of plutonium-polystyrene loadings for the Department of Transportation 6M Specification Container. These values comply with Fissile Class I transport criteria.

I. STATEMENT OF PROBLEM

The need exists to ship a quantity of polystyrene that is loaded with plutonium oxide from Richland, WA to Los Alamos to recover the plutonium from the plastic. The material is in the form of small cubes, and contains plutonium oxide at densities between 0.03 and 4.1 gm/cm^3. There exist no shipping containers approved for this purpose, though the DOT Specification 6M appears to provide appropriate safety.

II. DESCRIPTION OF 6M

The specification 6M container consists of an outer DOT Specification drum, between 10 and 110 gallon capacity, and an inner Specification 2R container supported in cane fiberboard insulation. The 6M was originally intended for shipment of fissile material, and to provide maximum reasonable loadings all specified loadings are for unmoderated fissile material.

As a result of exposure of prototype 6M containers to the regulatory hypothetical accident conditions, measurements demonstrated a maximum temperature for the 2R inner container of 250°F. The contents are therefore restricted to materials which do not decompose at this temperature. The decomposition temperature of polystyrene is about 400°F, well in excess of the allowable value.

III. CRITICALITY EVALUATION

The only remaining safety consideration is that of criticality. To evaluate the criticality safety of these compacts if shipped in a 6M Specification container, cell calculations used the LASL transport code ONETRAN with Hansen-Roach 16 group cross sections. The loadings that would provide a multiplication factor of unity were evaluated for a reflected cell, thus providing a value for Fissile Class I loadings.

Delta calculations were performed on spherical cells having four regions. The innermost region was filled with polystyrene at a density of 1.08 g/cm^3 and plutonium at appropriate densities. This was surrounded with a spherical steel shell of 0.66 cm thickness, which is the value corresponding to 12.7 cm (5 in) schedule 40 pipe as used for fabrication of the 2R inner container of the 6M. Outside this steel was CH at a density of 0.24 g/cm^3 corresponding to the 15 pound per cubic foot cane fiberboard used as insulation in the 6M. Outside the CH was a 0.1 cm steel shell corresponding to the 18 ga. steel drum of the 15 gallon 6M. The outer radius of the cell was constrained to remain at 23.84 cm, providing a cell volume of 56.75 liters (15 gallon). As the volume of the innermost region was varied to achieve criticality, the radial thickness of the insulation also varied to keep the cell radius constant. The results of these calculations are tabulated below, with the radius and volume values applying to the fuel region at criticality, and the mass values representing the critical mass of plutonium, which was assumed to consist of 100% ^{239}Pu.

(Pu)	H/Pu	r(cm)	V(liters)	m(g)
1.0	20	8.89	2.95	2,927
0.5	40	9.46	3.55	1,774
0.3	67	9.85	4.00	1,201
0.1	200	10.83	5.33	533
0.08	250	11.10	5.73	458
0.066	300	11.36	6.53	406
0.057	350	11.60	6.53	372
0.050	400	11.82	6.93	346
0.044	450	12.05	7.34	324
0.040	500	12.28	7.75	308

Extension of these calculations to search for optimum moderation resulted in a minimum Fissile Class I loading of 250 g at a hydrogen-to-plutonium ratio of 1200.

Several factors of conservatism are associated with application of these values to a real situation.

The assumption of pure ^{239}Pu underestimates the actual situation, where the ^{240}Pu content will act as a neutron poison, increasing critical values.

Shipment will probably be in 30 or 55 gallon 6M containers, for which larger quantities of fissile material could be accommodated.

The cylindrical radius of the inner 2R container of the 6M may not exceed 6.67 cm (5.25 in diam). The volumes derived from spherical radii substantially above this value would, in the cylindrical case, be increased by appropriate shape factors.

Consideration of these several effects would justify increased loadings, but with attendant complexity in the specification of allowable loadings. The tabulated values support use of 6M containers, of 15 gallon or larger size, for the shipment of polystyrene compacts as Fissile Class 1. Since this result provides generous shipping capacity, extension of the calculations does not appear to be justified. Similarly, no calculations for Fissile Class II will be performed at this time.

IV. RECOMMENDED ALLOWABLE LOADINGS

Hydrogen/Plutonium Ratio	Maximum Quantity ^{239}Pu, grams
20	2900
40	1750
67	1200
200	525
250	450
300	400
350	370
400	340
450	320
500	300

These values apply to plutonium mixed with polystyrene (CH), when packaged in 6M Specification Containers of 15 gallon or greater size, and meet Fissile Class I criteria. For any moderation ratio, a loading of 250 g ^{239}Pu will comply with Fissile Class I.