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MAXIMUM LIABILITY EVALUATION STRONTIUM AND CESIUM SHIPMENTS ON DECALSO MEDIA

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March 13, 1961

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AUTHOR

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March 13, 1961

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RICHLAND, WASHINGTON

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MAXIMUM LIABILITY EVALUATION
STRONTIUM AND CESIUM SHIPMENTS
ON DECALSO MEDIA

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MAXIMUM LIABILITY EVALUATION
STRONTIUM AND CESIUM SHIPMENTS
ON DECALSO MEDIA

This report summarizes the evaluations of the maximum monetary liability associated with cesium-137 shipments in the STT Casks and strontium-90 shipments in the HAPO-IA Cask. These evaluations are of most immediate importance since these shipments are planned for the month of March, 1961.

These liability evaluations concern the direct consequences of a release of the fission product shipment in each case, but do not cover the probability of such events occurring. Tables II and III show the order-of-magnitude maximum monetary liability for the STT cesium-137 shipment and the HAPO-IA strontium-90 shipment to be Seven Billion Dollars and Six Hundred Million Dollars, respectively. Earlier correspondence, References 1, 2, 3, and 4, covered the establishment of the Maximum Credible Incident, recorded design evaluations, and discussed the abilities of the STT and the HAPO-IA Cask to withstand credible events.

Rail routings for the two shipments of concern in this report have been selected by the Atomic Energy Commission. Since these routings are included as a condition of the Bureau of Explosives permit, in each cask, they may be considered firm. Pertinent information on these routings is given in Table IV.

The liability evaluation of the STT shipment of cesium-137, 90,000 curies per car, was based upon the following premises. Cesium is a relatively volatile material, and the entire shipment quantity can be vaporized and released as a cloud during involvement of the car in a fire of sufficient magnitude and duration to rupture the cask. This mechanism would create, by far, the greatest potential exposure of personnel and property to the fission product. As stated in Reference 4, the STT is not capable of withstanding fire of extended duration. St. Louis, Missouri, the largest population center onroute, served as the assumed location of the incident. Table II covers the radiological consequences of such an event. The bases used for translating the radiological consequences to monetary liability are listed in Table V.

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The most effective mechanism for dispersal of the strontium content of the HAPO-IA Cask would be leaching from the Decalso into river water after the cask has failed. Reference 2 covers the ability of the HAPO-IA Cask to withstand impact loads. Each major river crossing along the proposed route, Table IV, was investigated. Strontium would be eluted from the Decalso at rates dependent upon the strontium concentration in the Decalso bed and upon the mineral content and velocity of the water flow over the Decalso in each river under consideration. Data from Oak Ridge indicate that 36 curies of strontium-90 would be eluted per hour from a 40-gallon batch of Decalso loaded to a concentration of 0.4 grams of strontium per gallon and exposed to water of 6 ppm sodium content. The HAPO-IA Cask contains 10.5 gallons of Decalso loaded to a strontium concentration of about 40 grams per gallon. Consequently, the HAPO-IA shipment would release strontium-90 initially at about 970 curies per hour in water of 6 ppm sodium. This strontium elution rate was corrected for the various rivers in direct proportion to the individual sodium contents. Strontium-89 activity was assumed to be 2.5 times that of strontium-90. Translation of the resulting strontium-90 concentrations in river water to monetary liability, as presented in Table III, are without precedent in the Company. However, liability estimates were used which appear consistent with those derived for other situations as listed in Table V. River mileage-population data in support of the calculation of the personnel and property liability appear in Table VI.

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References:

No. 1. HAPO-I — HW-65268, "Design Criteria and Hazards Evaluation - Fission Product Shipping Cask," by C. W. Smith, dated May 20, 1960.

No. 2. HAPO-IA — HW-68301, "Annular Decalso Insert for Cerium Cask," by C. W. Smith, dated January 27, 1961.

No. 3. "Hazards Evaluation of the Shielded Transfer Tank, Model II," by J. A. Swartout, Deputy Directory, Oak Ridge National Laboratory, dated December 2, 1960.

No. 4. Letter, J. H. Warren, to U. S. Atomic Energy Commission, Hanford Operations Office, Attention: J. T. Christy, subject: "Fission Products Shipping," dated February 22, 1961.

Cask	HAPO-I	HAPO-IA	HAPO-II	ORNL-STT
Type Insert	Slurry Filter	Inorganic Ion-Exchange	Slurry Filter	Shielded Tank
Weight: Cask	40,000 lbs.	40,000 lbs.	18,000 lbs.	38,000 lbs.
Buffer	35,000 lbs.	35,000 lbs.	23,000 lbs.	No Buffer
Size: Cask	52" Dia. x 71" High	52" Dia. x 71" High	40" Dia. x 56" High	72" Dia. x 84" high
Buffer	10' Dia. x 14' High	10' Dia. x 14' High	8' Dia. x 12' High	No Buffer
Date Available	March, 1961	March, 1961	June, 1961	In Use
Number Available	1	1	2	6
Heat Transfer Medium	Woods-Metal (MP=160°F)	Woods-Metal (MP=160°F)	Woods-Metal (MP=160°F)	Water
Lead Thickness, in.	8.75	8.75	6.5	3.75
Emergency Design	Impact at 44 ft/sec	Impact at 44 ft/sec	Impact at 44 ft/sec	Impact at 4.4 ft/sec
Conditions	Total Insulation for 48 hours	Total Insulation for 48 hours	Total Insulation for 48 hours	Total Insulation for 48 hours
	Flame Impingement for 2 hours	Flame Impingement for 2 hours	Flame Impingement for 2 hours	None
Design Pressure	20 psig	300 psig	200 psig	Approx. 100-150 psig
Design Temperature	1000°F	400°F	1000°F	Approx. 300°F
Max. Allowable Shipping Pressure	10 psig	100 psig	100 psig	Approx. 25 psig
Proposed Shipment				
Desired Isotope	Cerium-144	Strontium-90	Strontium-90	Cesium-137
Curies	500,000	80,000	Up to 170,000	30,000
Rated Max. Heat Gen. BTU/hr.	17,000	5,000	11,600	1,750
Chemical Composition	$CeSO_4 \cdot XNa_2SO_4$	Sr^{++} adsorbed on exchange material	$SrCO_3$	Cs^{++} adsorbed on exchange material
Physical State	Stable, dried salt	Adsorbed cation in demineralized water	Stable, dried salt	Adsorbed cation in demineralized water
Radioactive Impurities	Ce-141, Zr-Nb-95 Sr-89, Ru-Rh-103, Y-91, Sr-90, Ru-Rh-106, Ba-La-140	Sr-89	Sr-89	Cs-134

TABLE V

DEFINITION OF ZONES[1]

Zone	Effect	Dose	Likely Recommended Action	Basis for Value of Damage
A	Possibly Lethal	> 450 rads[2]	Evacuate and treat	$25,000/person
B	Injury Likely	100-450 rads[2]	" " "	$50,000/person
C	Medical Attention Required	5-100 rads[2]	" " "	$ 5,000/person
D	Medical attention required but no biological effect likely due to long term evacuation of people	10 rads/yr[3]	Evacuate, Decontaminate Property, Confiscate Crops, Restrict use of Land	$ 5,000/person
E	No biological effect due to short term evacuation of people	1 rad/yr[3]		$25,000/mi^2

(1) Based on "Memorandum of Meeting of Risk Evaluations Subcouncil" M. C. Leverett, J. W. Healy, Karl Cohen, dated June 16, 1959.

(2) First year dose to whole body due to inhalation plus radiation from cloud passage.

(3) Dose from Ba^{137m} as a result of ground deposition of Cs^{137}.

TABLE III

CONSEQUENCES OF ELUTING 80,000 c (Sr^{90}) FROM "DECALSO" IN SELECTED RIVERS

River	Community[1]	Concentration[2] Sr^{90}	Dose[3] $Sr^{90} + Sr^{89}$	Estimated Damage[4] (10^6 Dollars)
Columbia	Trinidad, Washington	5×10^{-5} uc/cc	0.2 rad	$100
Missouri	Yakton, South Dakota	4×10^{-2}	200	$500
Mississippi	LaCrosse, Wisconsin	3×10^{-3}	20	$600
Ohio	Cario, Illinois	3×10^{-3}	20	$300

(1) Community nearest railroad crossing for which flow data are available.

(2) Assumes total inventory available for dispersion. Concentration is based on elution rates as discussed in text. Minimum flows were used for all calculations.

(3) Critical Organ dose during first year due to consumption of 2.4 liters of contaminated water. Sr^{89} concentration is assumed to be 2.5 times the Sr^{90} concentration. (Normal consumption rate by a "standard man" is 1.2 liters/day.)

(4) Property damage is based on $100/person for communities adjacent to the river. Estimates of personnel damages are arbitrarily based on $5000/person for possible claims arising from alleged injuries, by those receiving greater than 5 rads as defined in column 4. The population for 200 miles downstream is assumed to be so exposed.

TABLE IV

Shipment	Route	Railway	River Crossings	
			River	Place
Cesium-STT	Richland to Council Bluffs, Iowa	Union Pacific	Missouri	Omaha, Nebraska
	to East St. Louis, Illinois	Wabash	Mississippi	St. Louis, Missouri
	to Oak Ridge	Southern	Ohio	Louisville, Kentucky
Strontium - HAPO-IA	Riverland to Spaulding, Illinois	Milwaukee	Columbia	Beverly, Washington
			Missouri	Mobridge, South Dakota
			Mississippi	La Crosse, Wisconsin
	to Matteson, Illinois	EJ&E		
	to Corinth, Mississippi	I.C.	Ohio	Cairo, Illinois
	to Oak Ridge	Southern		

TABLE V

DEFINITION OF ZONES(1)

Zone	Effect	Dose	Likely Recommended Action	Basis for Value of Damage
A	Possibly Lethal	> 450 rads(2)	Evacuate and treat	$25,000/person
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C	Medical Attention Required	5-100 rads(2)	" " "	$ 5,000/person
D	Medical attention required but no biological effect likely due to long term evacuation of people	10 rads/yr(3)	Evacuate, Decontaminate Property, Confiscate Crops, Restrict use of Land	$ 5,000/person
E	No biological effect due to short term evacuation of people	1 rad/yr(3)		$25,000/mi^2

(1) Based on "Memorandum of Meeting of Risk Evaluations Subcouncil" M. C. Leverett, J. W. Healy, Karl Cohen, dated June 16, 1959.

(2) First year dose to whole body due to inhalation plus radiation from cloud passage.

(3) Dose from Ba^{137m} as a result of ground deposition of Cs^{137}.

TABLE VI

RIVER DISTANCE - POPULATION RELATIONSHIPS
TOTAL POPULATION

River	Crossing Point	Total Population To: 200 Miles Below Crossing	Total Population To: Ocean	Distance to Ocean, Miles
Missouri	Mobridge, S.D.	15,000	4,000,000	2,380
Mississippi	LaCrosse, Wisc.	60,000	3,200,000	1,800
Ohio	Cairo, Ill.	30,000	1,500,000	1,000
Columbia	Beverly, Wn.	100,000	1,100,000	400

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