TABLE I - COMPARISON OF A1 TO 1R AT 3 METERS

(Based on Large Radwaste Liners)

	xA1	Standard Deviation
Case 1 - All Co-60 (Theoretical)(1)	3.52	
Case 2 - Representative Cases with Microshield Calc. (50 + cases) (Theoretical)(1)	2.73	± 1.37
Case 3 - 1987 Shipping Data Base (500 + cases) - experimental)(2)	3.72	± 2.57
NRC Proposed Value	2.0	

1) Theoretical evaluations used to derive the 3m dose based on isotopic content and Microshield computer runs.

2) Experimental evaluations use the measured value of contact dose to determine the 3m dose.

TABLE II - SHIPMENT FREQUENCY TABLE

CASK TYPE	NO.	>1.60A1	>2.0A1	>3.0A1	>.8R/3m	>1.0R/3m
14-190	26	20 (2) (.77) (1)	15 (.58)	12 (.46)	17 (.65)	16 (.62)
14-195	275	14 (.05)	6 (.02)	4 (.015)	6 (.02)	2 (.01)
14-215	220	6 (.03)	5 (.025)	2 (.01)	6 (.03)	5 (.025)
6-80	19	16 (.84)	15 (.79)	14 (.73)	13 (.68)	12 (.63)
B-120A	44	34 (.77)	33 (.75)	30 (.69)	32 (.73)	30 (.69)
TOTAL	584	90 (.154)	74 (.126)	62 (.105)	74 (.126)	65 (.110)

NOTES: (1) Denotes the fraction of total cask usage.

(2) Represents the number of shipments that exceeds the defined limit.

Date: October 26, 1988
611-2387U-88

TO: DISTRIBUTION LOCATION: COLA/BARNWELL

FROM: R. ANDERSON RTA LOCATION: COLUMBIA

SUBJECT: EVALUATION OF TYPE B-LSA RULES - CASE STUDIES

This memorandum presents the results of an evaluation of 59 actual cask shipments to determine if a close correlation between liner radiation dose, R, and the liner contents activity exists. The content activity is expressed in terms of the 10CFR71 defined A1, (per the new IAEA regulations). The intent was to ascertain the validity of the proposed NRC regulations for Type B casks - LSA (incorporating the IAEA rules) where the NRC desires to substitute a 2A1 value for a measurement of 1R at 3 meters from the liner surface (R3m).

Two methodologies were used. In Case A, the measured value of the liner contact dose (data from RSM forms) was used to calculate R3m. In Case B, the isotopic contents (isotope, Ci from RSM) were used to calculate R3m. The Microshield computer program was used to perform the calculations.

A concern was evidenced with possible poor data being used for measured values of R. To alleviate this, a comparison was made between the Case A and B methods. It was determined that any cases where xA1 was less than 0.5, or greater than 12, resulted in extremely poor correlation. Table I shows the data for all 59 cases, and Table II presents data with 10 poor data points removed (probably due to poor measurement or data input).

A summary of the averaged results for xA1 is as follows:

	Table I	Table II
NRC proposed A1	2.0	2.0
Case A - A1	13.89 ± 53.9	4.01 ± 2.7
Case B-A1	2.69 ± 1.32	2.73 ± 1.37

It is clear that Table II data is far more realistic and representative. However, a close correlation between A1 and R3m (based on measurements) does not exist.

Some other facts of interest:

1. The drop in dose rate between liner contact and 3 meters is calculated to be about 19 for a typical 14 series liner. It is probably 25-30 for a 55 gallon drum. Hence, the bulk of our 14 series shipments will not be jeopardized by the proposed NRC rule.

2.

3. It seems reasonable to push the industry - NRC for a higher value of Al (say 3-4) based on our calculated data. We are performing a study of all 1987 cask shipments which we feel will show:

   - o Poor correlation between Al and R3m.
   - o xAl > 3

METHODOLOGY

1. All values were calculated from the data base based on proposed IAEA-Al values. Representative cases were selected (59) with most Al values in the proposed range.

   A total of 5 CNSI casks were included, and both concrete and dewatered liners were evaluated in the 59 shipments studied.

2. The Microshield computer program was used to calculate R3m based on either the measured value of R (Case A) or the liner isotopes (Case B).

3. The value of xAl was normalized to calculated values of Al and R3m.

4. A spreadsheet (LOTUS) was used to calculate average values and standard deviations, and is presented as Table I.

5. Ten poor data cases were deleted from the data base and used to develop Table II.

6. Cross-checks were made of the input data used to develop the Al values and Microshield computer runs.

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TABLE TWO

49 CASES; CASES 4-6-11-24-29-32-47-49-51-58 Deleted

Compilation of dose rate study

		C	D	
factors	14-190	21.76	22.2	<--- Rate
	14-195	19.94	20.11	
	14-215	19.33	19.65	
	6-80	32.26	32.26	
	8-120	24.30	24.91	

AS #	Case #	AS #	Liner	Waste vol	C/D	Total Ci	Ci/cuft	Ai	Measured Rcontact	Measured RJm	Measured xAi	Calculated Rcontact	Calculated RJm	Calculated xAi	Rate/RJm
47865	1	47865	14-190	145	C	31.47	0.217	2.163	12.0	0.55	3.97	7.93	0.36	6.06	22.04
48022	2	48022	14-190	145	D	37.60	0.259	1.663	25.0	1.13	1.47	15.45	0.70	2.38	22.07
46706	3	46706	14-190	145	D	45.20	0.312	1.688	30.0	1.35	1.25	16.26	0.73	2.31	22.27
47143	5	47143	14-190	145	D	97.00	0.669	2.824	40.0	1.80	1.57	25.63	1.15	2.46	22.26
47546	7	47546	14-190	145	D	64.00	0.441	3.458	65.0	2.93	1.18	32.44	1.44	2.40	22.53
47632	8	47632	14-190	145	D	203.54	1.724	6.001	25.0	1.13	5.31	52.00	2.34	2.56	22.22
47741	9	47741	14-190	145	D	103.00	0.710	2.618	45.0	2.03	1.29	26.92	1.21	2.16	22.45
49107	10	49107	14-190	145	D	78.60	0.562	3.876	70.0	3.15	1.23	40.46	1.80	2.25	22.48
49066	12	49066	14-190	145	D	115.47	0.796	4.472	30.0	2.25	1.99	16.60	0.74	6.04	22.44
49005	13	49005	14-190	145	D	102.00	0.703	4.728	50.0	2.25	2.10	48.02	2.13	2.22	22.54
47809	14	47809	14-190	145	D	150.00	1.034	3.938	24.0	1.08	3.65	31.73	1.41	2.79	22.51
48217	15	48217	14-190	145	D	30.10	0.206	1.06	25.0	1.13	0.94	9.88	0.40	2.65	24.71
48594	16	48594	14-190	145	D	142.00	0.972	2.486	35.0	1.58	1.57	24.93	1.11	2.24	22.45
48596	17	48596	14-190	145	C	148.76	1.005	7.297	29.0	1.33	5.94	30.69	1.14	6.93	27.10
46990	18	46990	14-195	172	C	122.00	0.709	2.135	10.0	0.51	4.19	7.37	0.37	5.77	19.93
48210	19	48210	14-195	172	D	43.50	0.253	2.128	7.0	0.35	6.07	16.85	0.84	2.53	20.05
46847	20	46847	14-195	172	D	180.30	1.048	5.799	39.0	1.95	2.97	47.70	2.39	2.43	19.96
46690	21	46690	14-195	172	D	77.60	0.451	3.683	18.0	0.90	3.87	26.08	1.30	2.88	20.06
47160	22	47160	14-195	172	D	180.00	1.047	4.683	26.9	1.33	3.45	38.06	1.90	2.36	20.03
47217	23	47217	14-195	172	D	380.00	2.209	7.823	30.0	1.50	5.22	65.41	3.23	2.42	20.25
47483	25	47483	14-195	172	D	100.00	0.581	2.763	7.0	0.35	7.89	24.33	1.22	2.26	19.95
47933	26	47933	14-195	172	C	33.02	0.192	2.296	12.0	0.61	3.76	7.39	0.37	6.21	19.97
47876	27	47876	14-215	183	D	50.54	0.276	2.643	4.0	0.20	12.22	18.06	0.92	2.86	19.63
47350	28	47350	14-215	183	D	52.38	0.286	2.381	5.0	0.25	9.40	17.80	0.91	2.56	19.56
48815	30	48815	14-215	183	C	48.20	0.263	2.234	8.0	0.39	6.82	7.54	0.39	5.85	19.34
48906	31	48906	14-215	183	D	73.05	0.399	3.655	18.0	0.92	3.97	28.61	1.32	2.79	19.70
46882	33	46882	6-80	74	D	174.06	2.352	3.636	111.0	3.44	1.12	73.92	2.29	1.61	32.29
47105	34	47105	6-80	74	D	93.20	1.259	5.595	40.0	1.24	4.51	93.59	2.90	1.93	32.27
48066	35	48066	6-80	74	D	105.68	1.428	3.943	43.7	1.35	2.92	62.39	1.93	2.04	32.33
48712	36	48712	6-80	74	D	86.40	1.168	6.228	35.0	1.08	5.77	104.32	3.23	1.93	32.30
48832	37	48832	6-80	74	D	91.53	1.237	3.733	32.0	0.99	3.77	67.74	2.10	1.78	32.26
48972	38	48972	6-80	74	D	83.10	1.123	3.738	35.0	1.08	3.46	62.16	1.93	1.94	32.20
49010	39	49010	6-80	74	D	52.10	0.704	2.503	15.0	0.46	5.44	41.35	1.28	1.91	32.31
49069	40	49069	6-80	74	D	35.18	0.475	1.857	35.0	1.08	1.72	31.21	0.97	1.91	32.18
49104	41	49104	6-80	74	D	67.50	0.912	3.72	80.0	2.48	1.50	62.84	1.95	1.91	32.22
46577	42	46577	8-120	105	D	118.30	1.127	5.173	20.0	0.80	6.47	65.64	2.63	1.97	24.96
47536	43	47536	8-120	105	D	46.60	0.444	2.645	50.0	2.01	1.32	31.64	1.27	2.08	24.91
47615	44	47615	8-120	105	D	119.00	1.133	5.495	60.0	1.61	3.41	67.23	2.70	2.04	24.90
47624	45	47624	8-120	105	D	64.50	0.614	2.614	25.0	0.60	4.36	31.46	1.26	2.07	24.97
47690	46	47690	8-120	105	D	24.35	0.232	0.509	6.0	0.24	2.12	6.03	0.24	2.12	25.11
47980	48	47980	8-120	105	D	174.00	1.657	8.016	35.0	1.40	5.73	103.50	4.15	1.93	24.94
48502	50	48502	8-120	105	D	629.00	5.990	11.813	30.0	1.20	9.84	168.27	6.71	1.76	24.63
49114	52	49114	8-120	105	C	216.75	2.064	10.163	20.0	1.03	9.87	50.06	2.06	4.93	24.30
48475	53	48475	8-120	105	D	55.43	0.528	2.041	20.0	0.80	2.55	25.73	1.04	1.96	24.74
46520	54	46520	8-120	105	D	105.22	1.001	3.406	50.0	2.01	1.69	45.59	1.85	1.84	24.64
48001	55	48001	8-120	105	D	178.96	1.704	8.239	30.0	1.20	6.87	106.48	4.32	1.91	24.65
48198	56	48198	8-120	105	D	35.44	0.338	1.695	50.0	2.01	0.79	18.74	0.76	2.10	24.65
47490	57	47490	8-120	105	D	137.40	1.309	5.227	40.0	1.61	3.16	65.46	2.66	1.92	24.61
47687	59	47687	8-120	105	D	129.00	1.229	6.437	52.0	2.09	3.06	82.29	3.34	1.93	24.64
averages:		averages:				110.37	0.945	4.156	32.862	1.32	4.01	43.76	1.76	2.73	24.60
std dev.:		std dev.:				97.45	0.899	2.353	20.588	0.755	2.700	32.186	1.300	1.371	4.193
variance:		variance:				9496.92	0.809	5.539	423.866	0.571	7.2913	1035.959	1.460	1.879	17.620

xAi - Ai multiple that would give you [illegible]

TABLE ONE - 59 CASES Compilation of dose rate study

		C	D	
factors	14-190	21.78	22.20	<--- Rctc
	14-195	19.75	19.99	
	14-215	19.16	19.65	
	6-80	32.26	32.26	
	8-120	24.34	24.91	

AS #	Case #	AS #	Liner	Waste vol	C/D	Total Ci	Ci/cuft	Ai	Measured Rcontact	Measured R3m	Measured xAi	Calculated Rcontact	Calculated R3m	Calculated xAi	Rctc/R3m
47665	1	47865	14-190	145	C	31.47	0.217	2.183	12.0	0.55	3.96	7.93	0.36	5.99	21.79
48022	2	48022	14-190	145	D	37.60	0.259	1.663	25.0	1.13	1.48	15.65	0.70	2.39	22.21
46706	3	46706	14-190	145	D	45.20	0.312	1.688	30.0	1.35	1.25	16.26	0.73	2.31	22.21
46478	4	46478	14-190	145	D	4.47	0.031	0.143	25.0	1.13	0.13	1.60	0.07	1.99	22.20
47143	5	47143	14-190	145	D	97.00	0.669	2.824	40.0	1.80	1.57	25.63	1.15	2.45	22.21
47185	6	47185	14-190	145	D	11.60	0.080	0.464	26.0	1.17	0.40	4.06	0.18	2.55	22.21
47546	7	47546	14-190	145	D	64.00	0.441	3.456	65.0	2.93	1.18	32.44	1.46	2.37	22.21
47632	8	47632	14-190	145	D	103.54	0.714	6.001	25.0	1.13	5.33	52.00	2.34	2.56	22.22
47741	9	47741	14-190	145	D	103.00	0.710	2.418	45.0	2.03	1.19	24.92	1.12	2.15	22.21
49107	10	49107	14-190	145	D	78.60	0.542	3.876	70.0	3.15	1.23	40.46	1.82	2.13	22.21
47103	11	47103	14-190	145	C	113.23	0.781	6.551	9.4	0.43	15.27	24.22	1.11	5.93	21.77
49066	12	49066	14-190	145	D	115.47	0.796	4.472	50.0	2.23	1.99	16.60	0.75	5.96	22.21
49005	13	49005	14-190	145	D	102.00	0.703	4.718	50.0	2.25	2.10	48.02	2.16	2.18	22.21
47809	14	47809	14-190	145	D	150.00	1.034	3.938	24.0	1.08	3.64	31.73	1.43	[illegible]	22.21
48217	15	48217	14-190	145	D	30.10	0.208	1.06	25.0	1.13	0.94	9.88	0.45	2.32	22.21
48594	16	48594	14-190	145	D	141.00	0.972	2.486	35.0	1.58	1.58	24.93	1.12	2.22	22.21
48596	17	48596	14-190	145	C	145.76	1.005	7.897	29.0	1.33	5.93	30.69	1.14	6.91	26.99
46990	18	46990	14-195	172	C	122.00	0.709	2.135	10.0	0.51	4.22	7.37	0.37	5.72	19.75
48210	19	48210	14-195	172	D	43.50	0.253	2.126	7.0	0.35	6.07	16.85	0.84	2.51	19.99
46847	20	46847	14-195	172	D	180.30	1.048	5.799	39.0	1.95	2.97	47.70	2.39	2.43	19.99
46690	21	46690	14-195	172	D	77.60	0.451	3.483	18.0	0.90	3.87	26.01	1.30	2.67	19.99
47160	22	47160	14-195	172	D	180.00	1.047	4.483	25.9	1.30	3.46	38.06	1.90	2.35	19.99
47217	23	47217	14-195	172	D	380.00	2.209	7.823	30.0	1.50	5.21	65.41	3.23	2.41	20.23
46665	24	46665	14-195	172	D	14.32	0.083	0.544	70.0	3.50	0.16	4.22	0.21	2.58	19.99
47463	25	47463	14-195	172	D	100.00	0.581	2.763	7.0	0.35	7.89	24.33	1.22	2.27	19.99
47933	26	47933	14-195	172	C	33.01	0.192	2.296	12.0	0.61	3.78	7.39	0.37	6.14	19.76
47576	27	47576	14-215	183	D	50.56	0.276	2.443	4.0	0.20	12.00	18.06	0.92	2.66	19.67
47380	28	47380	14-215	183	D	52.35	0.286	2.351	5.0	0.25	9.24	17.83	0.91	2.60	19.65
48211	29	48211	14-215	183	D	170.00	0.929	3.285	2.0	0.10	32.26	26.10	1.33	2.47	[illegible]
48615	30	48615	14-215	183	C	48.20	0.263	2.294	5.0	0.26	8.79	7.34	0.39	5.83	19.16
48906	31	48906	14-215	183	D	73.05	0.399	3.655	18.0	0.92	3.99	25.81	1.31	2.78	19.66
46849	32	46849	6-80	74	D	129.00	1.743	6.22	0.5	0.02	401.32	103.60	3.21	1.94	32.27
46882	33	46882	6-80	74	D	174.06	2.352	3.836	111.0	3.44	1.11	73.92	2.29	1.67	32.22
47105	34	47105	6-80	74	D	93.20	1.259	5.595	40.0	1.24	4.51	93.59	2.90	1.93	32.26
48066	35	48066	6-80	74	D	105.68	1.428	3.943	43.7	1.35	2.91	62.39	1.93	2.04	32.26
48712	36	48712	6-80	74	D	86.40	1.168	6.228	35.0	1.08	5.76	104.32	3.23	1.93	32.29
48832	37	48832	6-80	74	D	91.51	1.237	3.731	32.0	0.99	3.76	67.74	2.10	1.78	32.26
48972	38	48972	6-80	74	D	83.10	1.123	3.738	35.0	1.08	3.45	62.16	1.93	1.94	32.26
49010	39	49010	6-80	74	D	52.10	0.704	2.503	15.0	0.46	5.38	41.35	1.28	1.95	32.26
49069	40	49069	6-80	74	D	35.18	0.475	1.857	35.0	1.08	1.71	31.21	0.97	1.92	32.26
49104	41	49104	6-80	74	D	67.50	0.912	3.72	80.0	2.48	1.50	62.84	1.95	1.91	32.26
48577	42	48577	8-120	105	D	118.30	1.127	5.173	20.0	0.80	6.44	65.64	2.63	1.97	24.95
47536	43	47536	8-120	105	D	46.60	0.444	2.645	50.0	2.01	1.32	31.64	1.27	2.06	24.92
47615	44	47615	8-120	105	D	119.00	1.133	5.495	40.0	1.61	3.42	67.22	2.70	2.04	24.92
47624	45	47624	8-120	105	D	64.50	0.614	2.614	15.0	0.60	4.34	31.40	1.26	2.07	24.92
47690	46	47690	8-120	105	D	24.35	0.232	0.509	6.0	0.24	2.11	6.03	0.24	2.10	24.92
47805	47	47805	8-120	105	D	6.03	0.057	0.18	30.0	1.20	0.15	2.27	0.09	2.07	24.96
47980	48	47980	8-120	105	D	174.00	1.657	8.016	35.0	1.40	5.71	103.80	4.15	1.93	24.92
48689	49	48689	8-120	105	D	111.00	1.057	3.736	4.0	0.16	23.27	44.72	1.80	2.08	24.86
48502	50	48502	8-120	105	D	629.00	5.990	11.813	30.0	1.20	9.81	165.27	6.63	1.78	24.92
48575	51	48575	8-120	105	D	629.00	5.990	21.183	40.0	1.61	13.20	253.57	10.16	2.08	[illegible]
49114	52	49114	8-120	105	C	216.75	2.064	10.163	25.0	1.03	9.90	50.06	2.06	4.94	24.34
48475	53	48475	8-120	105	D	55.43	0.528	2.041	20.0	0.80	2.54	25.73	1.03	1.98	24.92
46520	54	46520	8-120	105	D	105.12	1.001	3.406	50.0	2.01	1.70	45.59	1.83	1.86	24.92
48001	55	48001	8-120	105	D	178.96	1.704	8.239	30.0	1.20	6.84	106.46	4.27	1.93	24.92
48198	56	48198	8-120	105	D	35.44	0.338	1.595	50.0	2.01	0.79	18.74	0.75	2.12	24.92
47490	57	47490	8-120	105	D	137.40	1.309	5.117	40.0	1.61	3.19	65.46	2.63	1.95	24.92
48778	58	48778	8-120	105	D	254.00	2.419	11.023	2.0	0.08	137.33	137.06	5.50	2.00	24.92
47687	59	47687	8-120	105	D	129.00	1.229	6.437	52.0	2.09	3.08	82.29	3.30	1.95	24.92
averages:		averages:				116.11	1.008	4.273	30.584	1.25	13.89	48.53	1.85	2.59	24.23
std dev.:		std dev.:				116.30	1.096	3.390	21.133	0.817	53.939	43.930	1.687	1.322	4.123
variance:		variance:				13525.52	1.200	11.489	446.521	0.668	2909.4	1929.831	2.845	1.749	16.999

Contact that would be [illegible] [illegible] OF [illegible]

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
** Shipper							
46532	14-215	194.10	R	2	0.1760	0.000	0.000
47548	FSV-1	26.20	R	14000	213.7290	0.245	0.368
47714	14-215	177.30	MR	120	0.0090	0.000	0.000
47835	14-195	178.80	MR	1500	0.4630	0.000	0.000
48066	6-80	83.40	R	44	3.9430	42.305	63.458
** Subtotal **		659.80					
** Shipper AL-FARLEY							
46631	HN-100	172.60	MR	800	0.0720	0.000	0.000
46851	14-195	121.00	MR	14000	0.2170	0.000	0.000
46903	HN-200	73.40	MR	80000	1.7970	0.000	0.000
46985	HN-100	172.60	MR	8	0.0240	0.000	0.000
47011	HN-100	172.60	MR	4	0.0380	0.000	0.000
47039	HN-200	73.40	R	200	12.8780	11.399	17.099
48006	HN-200	73.40	MR	60000	6.1330	23.936	35.904
48028	HN-200	73.40	R	60	6.2130	23.627	35.441
48142	HN-100	172.60	MR	1600	0.1620	0.000	0.000
48225	HN-100	172.60	MR	400	0.0110	0.000	0.000
48298	HN-100	172.60	MR	400	0.0050	0.000	0.000
48424	HN-200	73.40	R	250	6.0680	24.194	36.291
48467	HN-200	73.40	R	40	5.3770	27.303	40.955
48644	HN-100	172.60	R	2	0.0920	0.000	0.000
48735	HN-100	172.60	MR	300	0.0270	0.000	0.000
48940	14-195	172.60	MR	350	0.0780	0.000	0.000
48971	14-195	114.90	R	7	0.0520	0.000	0.000
** Subtotal **		2229.70					
** Shipper ARMY							
48368	SOURCE	10.50	MR	8	0.0560	0.000	0.000
48368.1	SOURCE	2.30	MR	8	0.0330	0.000	0.000
48368.2	SOURCE	1.10	MR	8	0.0000	0.000	0.000
48368.3	SOURCE	1.10	MR	8	0.0000	0.000	0.000
** Subtotal **		15.00					
** Shipper BATTELLE M							
47652	8-120	125.20	R	100	11.2530	22.251	33.377
47861	6-80	83.40	R	5	0.3510	0.000	0.000
47862	6-80	83.40	R	4	0.3460	0.000	0.000
47902	6-80	83.40	R	4	0.3860	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48012		114.90	MR	380	0.3060	0.000	0.000
48050	14-195	114.90	MR	425	0.3220	0.000	0.000
48051	14-195	114.90	MR	440	0.1870	0.000	0.000
** Subtotal **		720.10					
** Shipper BG-C CLIFF							
46847	14-195	194.10	R	39	5.7990	66.938	100.407
46882	6-80	83.40	R	111	3.8360	43.481	65.222
47396	8-120	125.20	R	1	0.2510	0.000	0.000
48342	14-195	194.10	R	5	0.1940	0.000	0.000
48605	6-80	83.40	R	265	14.4520	11.542	17.312
** Subtotal **		680.20					
** Shipper BOSTON-PIL							
46649	14-215	194.10	MR	15	0.2050	0.000	0.000
46650	14-215	194.10	MR	12	0.2030	0.000	0.000
46693	14-215	194.10	MR	11	0.2010	0.000	0.000
46735	14-215	120.30	MR	7	0.1610	0.000	0.000
46780	14-170	194.10	MR	20	0.3490	0.000	0.000
46888	14-215	202.10	MR	20	0.1990	0.000	0.000
46891	14-215	202.10	R	2500	0.6920	0.000	0.000
46924	14-215	202.10	MR	2000	0.2140	0.000	0.000
46925	14-215	202.10	MR	6	0.1880	0.000	0.000
46966	14-215	202.10	MR	500	0.1090	0.000	0.000
46968	14-215	202.10	MR	400	0.1490	0.000	0.000
46988	14-215	120.30	R	80	9.1470	0.000	0.000
47082	8-120	202.10	R	2	0.4750	26.304	39.457
47095	14-215	194.10	R	3	0.3010	0.000	0.000
47218	14-215	194.10	MR	1300	0.0630	0.000	0.000
47219	14-215	194.10	MR	2300	0.3450	0.000	0.000
47355	14-215	194.10	MR	380	0.0890	0.000	0.000
47356	14-215	194.10	R	510	0.0850	0.000	0.000
47657	14-215	194.10	MR	2	0.1300	0.000	0.000
47790	14-215	194.10	MR	600	0.2420	0.000	0.000
48096	14-215	194.10	MR	500	0.0490	0.000	0.000
48135	14-215	205.80	R	550	0.0770	0.000	0.000
48201	14-215	205.80	R	2	0.1690	0.000	0.000
49239	14-215	205.80	MR	1	0.2040	0.000	0.000
49330	14-215	205.80	MR	800	0.1430	0.000	0.000
49449	14-215			600	0.0930	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48012	14-195	114.90	MR	380	0.3060	0.000	0.000
48050	14-195	114.90	MR	425	0.3220	0.000	0.000
48051	14-195	114.90	MR	440	0.1870	0.000	0.000
** Subtotal **		720.10					
** Shipper BG-C CLIFF							
46847	14-195	194.10	R	39	5.7990	66.938	100.407
46882	6-80	83.40	R	111	3.8360	43.481	65.222
47396	8-120	125.20	R	1	0.2510	0.000	0.000
48342	14-195	194.10	R	5	0.1940	0.000	0.000
48605	6-80	83.40	R	265	14.4520	11.542	17.312
** Subtotal **		680.20					
** Shipper BOSTON-PIL							
46649	14-215	194.10	MR	15	0.2050	0.000	0.000
46650	14-215	194.10	MR	12	0.2030	0.000	0.000
46693	14-215	194.10	MR	11	0.2010	0.000	0.000
46735	14-170	120.30	MR	7	0.1610	0.000	0.000
46780	14-215	194.10	MR	20	0.3490	0.000	0.000
46888	14-215	202.10	MR	20	0.1990	0.000	0.000
46891	14-215	202.10	R	2500	0.6920	0.000	0.000
46924	14-215	202.10	MR	2000	0.2140	0.000	0.000
46925	14-215	202.10	MR	6	0.1880	0.000	0.000
46966	14-215	202.10	MR	500	0.1090	0.000	0.000
46968	14-2'	202.10	MR	400	0.1490	0.000	0.000
46988	8-120	120.30	R	80	9.1470	26.304	39.457
47082	14-215	202.10	R	2	0.4750	0.000	0.000
47095	14-215	194.10	R	3	0.3010	0.000	0.000
47218	14-215	194.10	MR	1300	0.0630	0.000	0.000
47219	14-215	194.10	MR	2300	0.3450	0.000	0.000
47355	14-215	194.10	MR	380	0.0890	0.000	0.000
47356	14-215	194.10	MR	510	0.0850	0.000	0.000
47657	14-215	194.10	R	2	0.1300	0.000	0.000
790	14-215	194.10	MR	600	0.2420	0.000	0.000
6	14-215	194.10	MR	500	0.0490	0.000	0.000
5	14-215	194.10	MR	550	0.0770	0.000	0.000
01	14-215	205.80	R	2	0.1690	0.000	0.000
239	14-215	205.80	R	1	0.2040	0.000	0.000
30	14-215	205.80	MR	800	0.1430	0.000	0.000
3449	14-215	205.80	MR	600	0.0930	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
** Subtotal **		5001.80					
** Shipper C ED-IP 2							
46989	14-215	120.30	MR	4000	0.5600	0.000	0.000
47331	14-215	170.80	MR	5000	0.0390	0.000	0.000
47480	14-195	177.50	R	4	0.6940	0.000	0.000
47520	14-215	177.50	MR	5000	0.6080	0.000	0.000
47611	14-195	125.20	R	2	0.4430	0.000	0.000
47624	B-120	120.30	R	15	2.6140	92.047	0.000
47648	B-120A	120.30	R	200	11.5720	20.791	31.187
47732	B-120A	120.30	R	300	13.8310	17.396	26.093
47816	14-215	194.10	MR	4500	0.2970	0.000	0.000
47979	B-120	120.30	R	850	19.3000	12.466	18.699
48071	14-215	170.80	R	10	0.0760	0.000	0.000
48198	B-120A	120.30	MR	50000	1.5950	0.000	0.000
48402	14-215	120.30	R	2	0.5770	0.000	0.000
** Subtotal **		1858.00					
** Shipper CECO-BYRON							
46578	HN-100	177.30	MR	1900	0.0310	0.000	0.000
46586	HN-200	73.40	R	15	7.0890	20.707	31.061
46668	HN-100	177.30	MR	10	0.0120	0.000	0.000
46710	HN-100	135.80	R	12	0.1120	0.000	0.000
46768	HN-100	177.30	MR	800	0.1200	0.000	0.000
46940	HN-100	177.30	MR	310	0.0480	0.000	0.000
47009	CECO14-2	177.30	MR	7	0.0110	0.000	0.000
47077	HN-100	177.30	MR	400	0.0210	0.000	0.000
47200	HN-100	177.30	MR	25	0.0020	0.000	0.000
47258	HN-100	163.30	R	2	0.0790	0.000	0.000
47361	14-D-2.0	177.30	MR	120	0.0050	0.000	0.000
47441	HN-100	177.30	MR	95	0.0190	0.000	0.000
47494	14-D-2.0	177.30	MR	40	0.0000	0.000	0.000
47637	14-D-2.0	177.30	MR	850	0.0120	0.000	0.000
47753	HN-100	177.30	MR	30	0.0020	0.000	0.000
47886	HN-100	177.30	MR	70	0.0020	0.000	0.000
47939	HN-100	177.30	MR	30	0.0020	0.000	0.000
48043	HN-100	177.30	MR	30	0.0010	0.000	0.000
48117	HN-100	177.30	MR	15	0.0000	0.000	0.000
48226	HN-100	177.30	MR	10	0.0020	0.000	0.000
48377	HN-100	177.40	MR	30	0.0020	0.000	0.000
48417	CECO14-1	163.30	MR	470	0.0160	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48481	HN-100	177.30	MR	200	0.0050	0.000	0.000
48665	14-D-2.0	177.30	MR	350	0.0090	0.000	0.000
48694	HN-100	177.40	MR	460	0.0780	0.000	0.000
48746	14-D-2.0	177.40	MR	290	0.0210	0.000	0.000
48975	HN-100	177.30	MR	250	0.0250	0.000	0.000
49008	HN-100	177.40	R	2	0.0520	0.000	0.000
49094	HN-100	177.40	R	2	0.0930	0.000	0.000
** Subtotal **		4968.80					
** Shipper CECO-DRESD							
46446	14-195	177.50	MR	800	0.1050	0.000	0.000
46460	14-195	177.50	MR	670	0.1730	0.000	0.000
46473	14-215	177.50	MR	836	0.0950	0.000	0.000
46500	14-195	105.00	MR	2	0.0870	0.000	0.000
46538	14-215	206.10	MR	900	0.0500	0.000	0.000
46556	14-195	170.80	MR	630	0.0370	0.000	0.000
46563	14-215	177.50	MR	760	0.1350	0.000	0.000
46576	21-300	328.50	MR	210	0.0230	0.000	0.000
46592	14-215	177.50	MR	1200	0.5180	0.000	0.000
46612	14-215	177.50	MR	3600	0.5510	0.000	0.000
46626	14-195	177.50	MR	600	0.1690	0.000	0.000
46633	14-195	178.80	MR	30	0.4560	0.000	0.000
46656	14-215	194.10	MR	4	0.0280	0.000	0.000
46665	14-215	206.10	MR	5	0.0240	0.000	0.000
46681	14-195	177.50	MR	6	0.0890	0.000	0.000
46689	14-195	178.80	MR	4000	0.3770	0.000	0.000
46700	14-195	206.10	MR	4	0.0210	0.000	0.000
46707	14-215	177.50	MR	450	0.0670	0.000	0.000
46708	14-195	178.80	MR	1900	0.4610	0.000	0.000
46730	14-215	206.10	MR	1800	0.0320	0.000	0.000
46736	14-195	178.80	MR	28	0.7900	0.000	0.000
46739	14-215	206.10	MR	7	0.0130	0.000	0.000
46748	14-215	177.50	MR	5	0.0860	0.000	0.000
46752	14-215	178.80	MR	7	0.0690	0.000	0.000
46772	14-195	206.10	MR	4	0.0150	0.000	0.000
46773	14-215	178.80	MR	30	0.4910	0.000	0.000
46777	14-170	178.80	MR	20	0.4470	0.000	0.000
46788	14-170	178.80	MR	21	0.5470	0.000	0.000
46816	14-215	178.80	MR	450	0.0160	0.000	0.000
46838	14-195	206.10	R	1	0.0310	0.000	0.000
46884	14-195	206.10	R	1500	0.0400	0.000	0.000
46892	14-195	206.10	MR	500	0.0270	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
46895	14-215	206.10	R	1500	0.0370	0.000	0.000
46919	14-195	178.80	MR	25	0.5900	0.000	0.000
46934	14-195	178.80	R	2	0.5560	0.000	0.000
46977	14-215	178.80	MR	350	0.0600	0.000	0.000
47015	14-215	178.80	MR	360	0.0440	0.000	0.000
47033	14-195	178.80	MR	475	0.0940	0.000	0.000
47253	14-195	178.80	R	2	0.2970	0.000	0.000
47367	14-195	178.80	R	2	0.1630	0.000	0.000
47374	14-195	178.80	R	2	0.2680	0.000	0.000
47409	21-300	177.50	MR	230	0.7380	0.000	0.000
47484	14-195	178.80	MR	1200	0.1600	0.000	0.000
47519	14-195	178.80	MR	900	0.1390	0.000	0.000
47570	14-195	177.50	MR	910	0.1520	0.000	0.000
47581	14-195	178.80	MR	1100	0.2490	0.000	0.000
47631	14-195	178.80	R	1	0.1930	0.000	0.000
47634	14-195	178.80	R	1	0.2280	0.000	0.000
47712	14-195	178.80	MR	1100	0.1840	0.000	0.000
47718	14-195	178.80	MR	1000	0.1270	0.000	0.000
47738	14-195	178.80	MR	1500	0.2780	0.000	0.000
47739	14-195	178.80	MR	1000	0.2050	0.000	0.000
47751	14-215	178.80	R	1	0.2480	0.000	0.000
47865	14-190	178.80	MR	12000	2.1830	163.837	0.000
47868	14-195	178.80	MR	1500	0.4160	0.000	0.000
47933	14-195	178.80	R	12	2.2960	155.741	0.000
47992	14-215	177.50	R	6	0.7520	0.000	0.000
48044	14-195	177.50	R	6	1.1740	0.000	0.000
48062	14-195	178.80	MR	6	0.9250	0.000	0.000
48075	14-195	178.80	MR	800	0.1290	0.000	0.000
48109	14-195	178.80	R	1	0.1610	0.000	0.000
48125	14-195	178.80	R	1	0.2300	0.000	0.000
48137	14-170	177.50	R	7	1.2710	0.000	0.000
48156	14-195	87.20	R	9	1.2140	0.000	0.000
48192	14-195	178.80	R	2	0.2520	0.000	0.000
48193	14-170	177.50	R	5	1.0470	0.000	0.000
48237	14-195	178.80	R	4	0.9300	0.000	0.000
48260	14-195	177.50	MR	4500	0.9020	0.000	0.000
48281	14-195	178.80	MR	5500	1.1640	0.000	0.000
48291	14-195	177.50	MR	5000	1.1640	0.000	0.000
48303	14-195	178.80	R	7	1.3980	0.000	0.000
48320	14-195	178.80	R	5	1.2830	0.000	0.000
48337	14-195	178.80	R	6	1.2250	0.000	0.000
48358	14-195	178.80	R	8	1.7510	0.000	0.000
48359	14-215	83.40	MR	240	0.0520	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48401	14-195	177.50	R	8	1.3440	0.000	0.000
48436	14-215	178.80	R	2	0.2790	0.000	0.000
48456	14-195	177.50	R	5	0.7260	0.000	0.000
48511	21-30[illegible]	206.10	MR	300	0.1870	0.000	0.000
48520	21-300	206.10	R	1	0.1110	0.000	0.000
48521	21-300	186.70	MR	500	1.0610	0.000	0.000
48540	14-170	178.80	MR	525	0.0870	0.000	0.000
48551	14-195	177.50	MR	450	0.1160	0.000	0.000
48690	14-170	178.80	MR	900	0.1880	0.000	0.000
48716	14-170	178.80	R	1	0.1290	0.000	0.000
48762	14-170	178.80	MR	830	0.1320	0.000	0.000
48768	14-170	178.80	MR	530	0.0830	0.000	0.000
48817	14-170	178.80	MR	430	0.0680	0.000	0.000
48876	14-170	178.80	R	2	0.1400	0.000	0.000
48894	14-170	177.50	MR	435	0.0710	0.000	0.000
48948	14-170	178.80	MR	510	0.0490	0.000	0.000
48956	14-190	178.80	R	29	7.8970	45.282	67.923
48974	14-170	178.80	MR	475	0.0540	0.000	0.000
48999	14-170	178.80	MR	600	0.0500	0.000	0.000
49089	14-170	178.80	MR	995	0.1340	0.000	0.000
** Subtotal **		17189.10					
** Shipper CECO-LASAL							
46667	CECO 14	163.30	MR	23	0.3630	0.000	0.000
46709	HN-100	163.30	MR	2800	0.3590	0.000	0.000
46858	HN-100	163.30	MR	32	0.3640	0.000	0.000
46876	HN-100	163.30	R	3	0.3720	0.000	0.000
46910	HN-100	163.30	MR	40	0.3980	0.000	0.000
46941	HN-100	163.30	R	4	0.3960	0.000	0.000
47205	HN-100	163.30	MR	2900	0.3480	0.000	0.000
47257	HN-100	163.30	R	4	0.3740	0.000	0.000
47342	HN-100	163.30	MR	3000	0.3740	0.000	0.000
47376	HN-100	163.30	R	3	0.3710	0.000	0.000
47377	CECO14-1	163.30	R	4	0.4030	0.000	0.000
47462	HN-100	163.30	MR	3500	0.3710	0.000	0.000
47491	HN-100	163.30	MR	2700	0.3720	0.000	0.000
47603	HN-100	163.30	R	3	0.3760	0.000	0.000
47761	HN-100	163.30	R	4	0.3430	0.000	0.000
[illegible]9074	HN-100	163.30	R	1	0.3970	0.000	0.000
48162	HN-100	163.30	ME	1500	0.2790	0.000	0.000
48219	HN-100	163.30	MR	5000	0.6670	0.000	0.000
48248	HN-100	163.30	MR	2400	0.6260	0.000	0.000

07/16/00

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48262	HN-100	163.30	MR	3000	0.6020	0.000	0.000
48274	HN-100	163.30	MR	2600	0.6740	0.000	0.000
48287	HN-100	163.30	MR	1800	0.5920	0.000	0.000
48299	HN-100	163.30	MR	2300	0.6560	0.000	0.000
48535	HN-100	163.30	MR	2400	0.6720	0.000	0.000
48579	HN-100	163.30	MR	2200	0.3410	0.000	0.000
49021	HN-100	163.30	R	3	0.2230	0.000	0.000
49091	10-142	135.80	R	60	6.6310	40.962	61.443
49117	HN-100	178.90	MR	3000	0.3490	0.000	0.000
49144	HN-100	178.90	R	30	0.2060	0.000	0.000
** Subtotal **		4739.40					
** Shipper CECO-QUAD							
46483	B-120	120.30	R	60	22.1550	10.860	16.290
46530	10-142	128.30	MR	4000	0.8740	0.000	0.000
46536	B-120	120.30	R	80	20.4480	11.767	17.650
46577	B-120	120.30	R	20	5.1730	46.509	69.764
46615	14-215	194.10	MR	2400	0.5280	0.000	0.000
46661	14-215	194.10	MR	16	0.3880	0.000	0.000
46704	14-215	194.10	MR	1200	0.4480	0.000	0.000
46747	14-215	194.10	MR	12	0.3280	0.000	0.000
46797	14-215	194.10	MR	11	0.2980	0.000	0.000
46824	14-215	194.10	R	2	0.6420	0.000	0.000
46852	14-215	194.10	MR	30	0.8070	0.000	0.000
46893	14-215	194.10	R	27000	0.9250	0.000	0.000
46939	14-215	205.80	R	4	1.6330	0.000	0.000
46986	14-215	205.80	R	3000	1.2490	0.000	0.000
47046	14-215	205.80	R	2	1.0670	0.000	0.000
47103	14-190	177.50	R	9	6.5910	53.861	80.791
47202	14-215	205.80	MR	1600	0.4710	0.000	0.000
47291	14-215	205.80	MR	3200	1.0610	0.000	0.000
47350	14-215	205.80	MR	5000	2.3510	175.106	0.000
47397	14-215	205.80	R	3	1.1170	0.000	0.000
47454	14-215	205.80	MR	2600	0.8010	0.000	0.000
47516	14-215	205.80	MR	2700	0.4970	0.000	0.000
47576	14-215	205.80	R	4	2.4430	168.488	0.000
47689	14-215	205.80	MR	2600	1.4250	0.000	0.000
47792	14-215	205.80	MR	2600	0.8710	0.000	0.000
47820	14-215	205.80	R	2	0.7880	0.000	0.000
47844	14-215	205.80	MR	1200	0.3660	0.000	0.000
47898	14-215	205.80	MR	1200	0.4100	0.000	0.000
47946	14-215	205.80	MR	800	0.3080	0.000	0.000

07/16/88

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47997	14-215	205.80	MR	800	0.3360	0.000	0.000
48072	14-215	205.80	R	2	0.5780	0.000	0.000
48124	14-215	205.80	R	1	0.3680	0.000	0.000
48182	14-215	205.80	MR	900	0.3590	0.000	0.000
48234	14-215	205.80	MR	740	0.2660	0.000	0.000
48258	14-215	205.80	MR	580	0.0540	0.000	0.000
48279	14-215	205.80	MR	700	0.3050	0.000	0.000
48321	14-215	205.80	MR	1000	0.2170	0.000	0.000
48378	14-215	205.80	MR	1200	0.6080	0.000	0.000
48435	14-215	205.80	MR	910	0.2990	0.000	0.000
48496	14-215	205.80	MR	840	0.3270	0.000	0.000
48538	14-215	205.80	MR	650	0.1660	0.000	0.000
48592	14-215	205.80	MR	520	0.1550	0.000	0.000
48651	14-215	205.80	MR	1500	0.3440	0.000	0.000
48703	14-215	205.80	R	2	0.4120	0.000	0.000
48765	14-215	205.80	MR	1800	0.4120	0.000	0.000
48809	14-215	205.80	MR	1400	0.3170	0.000	0.000
48849	14-215	205.80	MR	1200	0.3140	0.000	0.000
48889	14-215	205.80	R	3	0.4720	0.000	0.000
48958	14-215	205.80	MR	2500	0.8380	0.000	0.000
48990	14-215	205.80	R	38	0.6370	0.000	0.000
49029	14-215	205.80	R	2	0.5360	0.000	0.000
49079	14-215	205.80	MR	2400	0.5990	0.000	0.000
** Subtotal **		10245.70					
** Shipper CECO-ZION							
46481	14-215	194.10	MR	150	0.0270	0.000	0.000
46821	14-215	194.10	R	4	0.1470	0.000	0.000
46843	14-215	194.10	R	1	0.1470	0.000	0.000
47054	8-120	125.20	R	50	11.7220	21.361	32.041
47088	8-120	73.40	R	30	5.2280	28.081	42.121
47158	14-215	194.10	MR	1000	0.0750	0.000	0.000
47249	14-215	194.10	MR	800	0.0860	0.000	0.000
47438	14-215	194.10	R	2	0.0840	0.000	0.000
47488	14-215	125.20	MR	300	0.1000	0.000	0.000
47722	14-215	194.10	MR	300	0.0640	0.000	0.000
47981	14-215	205.80	MR	1	0.0150	0.000	0.000
48037	14-215	205.80	MR	200	0.0380	0.000	0.000
48046	14-170	105.00	R	2	0.0640	0.000	0.000
48120	14-215	194.10	MR	45	0.0140	0.000	0.000
48204	14-215	205.80	MR	600	0.0900	0.000	0.000
48255	14-195	125.20	R	10	0.1470	0.000	0.000

09/18/88

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48383	8-120	125.20	R	25	0.3350	0.000	0.000
48591	8-120B	125.20	R	18	8.1950	30.555	45.833
48657	14-215	205.80	MR	800	1.0290	0.000	0.000
48898	8-120B	120.30	R	32	5.1050	47.126	70.689
48902	14-215	205.80	MR	1200	0.2430	0.000	0.000
48988	8-120B	125.20	R	50	3.9600	63.235	94.853
49018	14-215	205.80	R	2	0.2170	0.000	0.000
49067	8-120B	125.20	R	60	3.8630	64.816	97.224
49078	14-215	205.80	R	4	0.5420	0.000	0.000
49137	8-120	125.20	R	70	3.9600	63.235	94.853
** Subtotal **		4293.70					
** Shipper CINTICHEM							
46449	TUX B-3	20.40	R	2	2.0630	19.774	0.000
46475	TUX B-3	20.40	R	32	1.9970	0.000	0.000
46489	TUX B-3	20.40	R	39	2.5700	15.877	0.000
46608	TUX 2 & 4	20.40	R	29	1.7240	0.000	0.000
46625	TUX B-3	20.40	R	28	2.8820	14.158	0.000
46655	TUX 2 & 4	20.40	R	35	4.0690	10.026	15.039
46671	TUX 1 & 3	20.40	R	52	5.6220	7.257	10.886
46702	TUX 2 & 4	20.40	R	28	1.7340	0.000	0.000
46712	TUX	20.40	R	0	2.3420	17.422	0.000
46741	TUX B-3	20.40	R	27	1.5670	0.000	0.000
46759	TUX B-3	20.40	R	7	4.5400	8.987	13.480
46789	TUX	20.40	R	1	5.1330	7.949	11.923
46812	TUX B-3	20.40	R	21	0.7920	0.000	0.000
46844	TUX B-3	20.40	R	32	3.1500	12.953	19.429
46881	TUX B-3	20.40	R	49	5.6530	7.218	10.827
46904	TUX B-3	20.40	R	0	4.6050	8.860	13.289
47289	TUX B-3	20.40	MR	24	2.5100	16.252	0.000
47338	TUX B-3	20.40	R	39	3.6010	11.329	16.993
47363	TUX B-3	20.40	R	35	3.9250	10.395	15.592
47384	TUX B-3	20.40	R	42	4.7980	8.503	12.755
47418	TUX B-3	20.40	R	49	4.3700	9.337	14.005
47435	TUX B-3	20.40	R	52	4.5110	9.044	13.566
47474	TUX B-3	20.40	R	25	3.2670	12.490	18.735
47531	TUX B-3	20.40	R	74	6.7640	6.032	9.048
47564	TUX B-3	20.40	R	56	5.1500	7.922	11.884
47674	TUX B-3	20.40	R	45	5.4290	7.515	11.272
47726	TUX B-3	20.40	R	52	5.9510	6.856	10.283
47772	TUX B-3	20.40	R	39	4.1900	9.738	14.607
47801	TUX B-3	20.40	R	50	5.5790	7.313	10.970

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47842	TUX B-3	20.40	R	42	4.1150	9.915	14.872
47859	TUX B-3	20.40	R	39	4.4270	9.217	13.825
47901	TUX B-3	20.40	MR	67	6.8800	5.931	8.896
47941	TUX B-3	20.40	R	46	5.3690	7.599	11.399
47967	TUX B-3	20.40	R	60	6.9840	5.842	8.763
47991	TUX B-3	20.40	R	49	5.3680	7.601	11.402
48026	TUX B-3	20.40	R	34	4.2300	9.645	14.467
48056	TUX B-3	20.40	R	53	4.9040	8.320	12.480
48090	TUX B-3	20.40	R	42	3.9480	10.334	15.501
48166	TUX B-3	20.40	R	49	5.1240	7.963	11.945
48197	TUX B-3	20.40	R	38	3.3410	12.212	18.318
48218	TUX B-3	20.40	R	53	4.1410	9.852	14.778
48268	TUX B-3	20.40	R	38	2.4240	16.831	0.000
48293	TUX B-3	20.40	R	22	1.4520	0.000	0.000
48312	TUX B-3	20.40	R	46	5.3830	7.579	11.369
48340	TUX B-3	20.40	R	25	1.9090	0.000	0.000
48585	TUX 1 & 4	20.40	R	52	5.8400	6.986	10.479
48613	TUX B-3	20.40	R	52	5.7980	7.037	10.556
48636	TUX B-3	20.40	R	38	4.4840	9.099	13.649
48680	TUX B-3	20.40	R	52	5.6400	7.234	10.852
48700	TUX B-3	20.40	R	60	6.2500	6.528	9.793
48736	TUX B-3	20.40	R	46	5.1010	7.998	11.997
48963	TUX B-3	20.40	R	39	4.0660	10.034	15.052
48982	TUX 2 & 3	20.40	R	60	6.7570	6.038	9.057
49009	TUX B-3	20.40	R	77	5.2850	7.720	11.580
49026	TUX 2 & 3	20.40	R	49	4.9540	8.236	12.355
49056	TUX B-3	20.40	R	40	3.8240	10.670	16.004
49084	TUX B-3	20.40	R	56	6.8910	5.921	8.881
49125	TUX B-3	20.40	MR	63000	6.9050	5.909	8.863
** Subtotal **		1183.20					
** Shipper CNSYD							
47003	NAVY	39.00	MR	20000	0.1800	0.000	0.000
48106	NAVYCASK	42.90	R	10	0.0960	0.000	0.000
48231	NAVY	39.00	R	4	0.2590	0.000	0.000
48631	NAVY CK	46.80	MR	8000	0.3480	0.000	0.000
48713	N. CASK	397.60	MR	1800	0.0310	0.000	0.000
** Subtotal **		565.30					
** Shipper CP&L-BRUNS							
46732	TN-8	22.40	R	13000	364.8390	0.123	0.184

09/18/88

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
46765	14-195	178.80	MR	600	0.1500	0.000	0.000
46782	TN-8	14.93	R	360	472.2220	0.063	0.095
46782.1	TN-8	7.47	R	36000	223.1340	0.067	0.100
46793	14-195	178.80	MR	5	0.1240	0.000	0.000
46809	14-195	178.80	MR	2	0.0530	0.000	0.000
46830	14-195	178.80	MR	150	0.0300	0.000	0.000
46839	TN-8	22.40	R	49000	351.1500	0.128	0.191
46850	14-195	178.80	MR	200	0.0550	0.000	0.000
46901	10-142	128.30	R	1	0.1790	0.000	0.000
46943	3-55	57.40	R	7500	121.2390	0.947	1.420
46946	14-195	178.80	MR	70	1.7480	0.000	0.000
47053	14-195	178.80	R	4	1.0900	0.000	0.000
47264	14-195	178.80	MR	6000	1.5590	0.000	0.000
47296	14-195	178.80	MR	6000	1.5050	0.000	0.000
47297	14-195	178.80	MR	7000	1.7730	0.000	0.000
47386	14-195	178.80	R	2	0.5720	0.000	0.000
47399	14-195	178.80	R	2	0.6200	0.000	0.000
47423	14-195	178.80	R	2	0.6010	0.000	0.000
47433	14-195	178.80	R	2	0.6090	0.000	0.000
47481	14-195	178.80	MR	1000	0.2940	0.000	0.000
47485	14-195	178.80	R	1	0.2800	0.000	0.000
47518	14-195	178.80	MR	2500	0.7630	0.000	0.000
47540	21-300	265.90	MR	600	0.6780	0.000	0.000
47572	21-300	265.90	R	2	1.5950	0.000	0.000
47709	14-195	178.80	MR	3000	0.8160	0.000	0.000
47767	21-300	265.90	MR	2000	1.8330	0.000	0.000
47778	21-300	265.90	MR	700	0.5610	0.000	0.000
47794	21-300	265.90	MR	1800	1.8120	0.000	0.000
47806	14-195	177.50	MR	200	0.0740	0.000	0.000
47821	14-195	177.50	MR	3000	0.9390	0.000	0.000
47849	14-195	178.80	MR	1500	0.4620	0.000	0.000
47883	14-195	178.80	MR	2000	0.6430	0.000	0.000
47895	14-195	178.80	MR	100	0.0310	0.000	0.000
47932	14-195	177.50	MR	100	0.0420	0.000	0.000
47944	14-195	178.80	MR	100	0.0320	0.000	0.000
47961	14-195	177.50	MR	200	0.0740	0.000	0.000
48038	14-195	177.50	MR	50	0.0160	0.000	0.000
48070	14-195	178.80	MR	120	0.0350	0.000	0.000
48097	14-195	194.10	R	5	0.1920	0.000	0.000
48107	14-195	194.10	MR	200	0.0070	0.000	0.000
48123	14-195	178.80	MR	200	0.0700	0.000	0.000
48177	14-195	178.80	MR	800	0.2560	0.000	0.000
48355	14-195	194.10	R	2	0.0480	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48441	14-195	194.10	MR	700	0.0220	0.000	0.000
48509	8-120	120.30	R	17	0.8400	0.000	0.000
48541	14-195	194.10	MR	750	0.0240	0.000	0.000
48567	14-195	194.10	R	2	0.0520	0.000	0.000
48710	21-300	265.90	MR	100	0.0990	0.000	0.000
48739	14-195	105.00	MR	8000	0.3070	0.000	0.000
48751	14-195	177.50	MR	350	0.1280	0.000	0.000
48753	14-195	194.10	MR	1000	0.0530	0.000	0.000
48763	14-195	177.50	MR	400	0.1530	0.000	0.000
48767	14-195	178.80	MR	250	0.0740	0.000	0.000
48788	14-195	177.50	MR	500	0.1840	0.000	0.000
48794	14-195	177.50	MR	700	0.2490	0.000	0.000
48799	14-195	177.50	MR	400	0.1490	0.000	0.000
48813	14-195	194.10	MR	700	0.0240	0.000	0.000
48830	14-195	177.50	MR	350	0.1310	0.000	0.000
48857	14-195	194.10	MR	1900	0.0710	0.000	0.000
48900	14-195	170.80	MR	8000	0.8820	0.000	0.000
48917	14-195	170.80	MR	7000	0.8610	0.000	0.000
48945	14-195	194.10	MR	800	0.0350	0.000	0.000
48969	14-195	170.80	MR	12000	1.2950	0.000	0.000
49013	14-195	170.80	MR	1500	0.1380	0.000	0.000
49039	14-195	170.80	MR	12000	1.3050	0.000	0.000
49065	14-195	170.80	MR	14000	1.3210	0.000	0.000
49085	14-195	170.80	MR	10000	1.1240	0.000	0.000
49109	14-195	170.80	MR	10000	1.1450	0.000	0.000
49141	8-120A	120.30	R	100	9.5210	25.270	37.906
** Subtotal **		12102.60					
** Shipper CP&L-ROBIN							
47089	14-195	206.10	MR	3000	0.1680	0.000	0.000
47460	14-210	202.10	MR	5000	0.9320	0.000	0.000
47805	8-120	120.30	R	30	0.1800	0.000	0.000
48573	14-195	202.10	R	2	0.5070	0.000	0.000
49051	8-120A	120.30	MR	3000	0.0720	0.000	0.000
49159	8-120A	120.30	R	100	6.1920	38.858	58.287
** Subtotal **		971.20					
** Shipper CP-B ROCK							
48416	1-13G	14.60	R	880	13.7720	2.120	3.180
48527	1-13G	14.60	R	1490	11.4350	2.553	3.830

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
** Subtotal **		29.20					
** Shipper CP-PALISAD							
46776	14-195	194.10	MR	50	0.2870	0.000	0.000
46973	14-195	205.80	R	3	0.6030	0.000	0.000
47131	21-300	150.00	MR	3000	0.1450	0.000	0.000
48546	21-300	157.50	MR	725	0.1560	0.000	0.000
48914	1-136	14.60	R	1100	6.0560	4.822	7.233
48962	1-136	14.60	R	6	47.9060	0.610	0.914
** Subtotal **		736.60					
** Shipper CT-H NECK							
46515	8-120A	120.30	R	10	0.4850	0.000	0.000
46737		960.00	MR	2	0.0120	0.000	0.000
46871.5		67.50	MR	110	0.0040	0.000	0.000
46982	14-195	120.30	R	0	0.4100	0.000	0.000
47110	14-195	120.30	MR	4	0.0700	0.000	0.000
47168	14-195	120.30	R	7	0.3630	0.000	0.000
47251	14-195	120.30	R	3	0.1590	0.000	0.000
47490	8-120A	120.30	R	40	5.1170	47.019	70.528
47690	8-120	120.30	MR	6	0.5090	0.000	0.000
48259	14-195	120.30	MR	350	0.1710	0.000	0.000
48344	14-195	120.30	R	2	0.0600	0.000	0.000
48409	14-195	120.30	R	2	0.0570	0.000	0.000
48475	8-120	120.30	R	20	2.0410	117.872	0.000
48571	14-195	120.30	MR	900	0.0580	0.000	0.000
48687	8-120	120.30	R	7	0.7260	0.000	0.000
48688	14-195	120.30	R	2	0.1100	0.000	0.000
** Subtotal **		2711.70					
** Shipper DET-FERMI							
46436	21-300	328.50	MR	18	0.0180	0.000	0.000
46470	21-300	328.50	MR	1300	0.5560	0.000	0.000
46575	21-300	328.50	MR	130	0.0770	0.000	0.000
46697	21-300	328.50	MR	14	0.0150	0.000	0.000
46783	21-300	328.50	MR	3	0.0650	0.000	0.000
47018	21-300	328.50	MR	1000	0.3190	0.000	0.000
47317	21-300	328.50	MR	420	0.2310	0.000	0.000
47470	21-300	328.50	MR	90	0.0150	0.000	0.000
47639	21-300	328.50	MR	35	0.0040	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47780	14-195	194.10	MR	3000	0.5360	0.000	0.000
47906	21-300	328.50	MR	60	0.0090	0.000	0.000
48016	21-300	328.50	MR	50	0.0090	0.000	0.000
48160	14-195	205.80	MR	5000	0.4190	0.000	0.000
48176	14-195	205.80	R	13	1.5330	0.000	0.000
48245	21-300	328.50	MR	100	0.0240	0.000	0.000
48691	14-195	205.80	R	14	1.3130	0.000	0.000
48740	21-300	328.50	MR	800	0.1830	0.000	0.000
48790	21-300	328.50	MR	135	0.0340	0.000	0.000
48927	21-300	328.50	R	2	0.2610	0.000	0.000
49016	21-300	328.50	MR	1500	0.4990	0.000	0.000
49111	21-300	328.50	MR	250	0.0380	0.000	0.000
** Subtotal **		6396.00					
** Shipper DPC-LACROS							
49062	HN-100	163.30	R	38	3.8210	85.486	128.228
** Subtotal **		163.30					
** Shipper DUKE-CATAW							
46831	8-120	87.20	MR	3	0.0110	0.000	0.000
46866	14-170	178.80	MR	400	0.0150	0.000	0.000
46931	14-195	194.10	MR	3000	0.3600	0.000	0.000
47007	14-195	205.80	MR	7000	0.4060	0.000	0.000
47109	14-195	205.80	R	7	0.9500	0.000	0.000
47483	14-195	205.80	MR	7000	2.7630	148.969	0.000
47645	14-195	194.10	R	2	0.3780	0.000	0.000
47850	8-120A	120.30	MR	4000	0.2350	0.000	0.000
47881	14-195	205.80	MR	1250	0.4580	0.000	0.000
48083	14-195	109.50	R	18	0.7800	0.000	0.000
48140	8-120	120.30	R	2	0.0770	0.000	0.000
48296	8-120A	120.30	MR	3000	0.1340	0.000	0.000
48324	14-195	205.80	MR	5000	0.7060	0.000	0.000
48936	14-215	205.80	MR	2500	0.2760	0.000	0.000
** Subtotal **		2359.40					
** Shipper DUKE-MCGUI							
46614	14-195	56.40	MR	2000	0.0490	0.000	0.000
46662	14-195	114.90	MR	3	0.5470	0.000	0.000
46724	14-195	114.90	MR	17000	0.1930	0.000	0.000
46865	14-195	114.90	MR	70000	0.5440	0.000	0.000

07/10/00

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
46916	14-195	114.90	R	4	0.1190	0.000	0.000
47169	14-215	541.60	MR	18	0.0020	0.000	0.000
47964	14-195	194.10	MR	1700	0.3950	0.000	0.000
47977	14-195	56.40	MR	500	0.0560	0.000	0.000
48099	14-195	56.40	MR	900	0.0460	0.000	0.000
48152	8-120	120.30	R	70	3.7890	63.502	95.252
48172	14-195	205.80	MR	1500	0.3070	0.000	0.000
48590	14-195	114.90	MR	2000	0.1680	0.000	0.000
48778	8-120A	120.30	R	2	11.0230	21.827	32.741
49157	14-195	114.90	MR	10000	0.3070	0.000	0.000
** Subtotal **		2040.70					
** Shipper DUKE-OCONE							
46546	14-195	114.90	MR	5000	0.4830	0.000	0.000
46796	14-195	206.10	MR	40	0.6070	0.000	0.000
46932	8-120	120.30	MR	900	7.8070	30.819	46.228
47008	14-195	114.90	R	10	0.5290	0.000	0.000
47191	14-195	114.90	MR	3000	1.5930	0.000	0.000
47387	14-195	114.90	R	5	0.5260	0.000	0.000
47440	14-195	114.90	MR	2000	0.5930	0.000	0.000
47679	14-195	114.90	MR	4000	0.3450	0.000	0.000
48055	3-55	57.40	R	590	247.8370	0.463	0.695
48069	3-55	57.40	R	1140	159.2880	0.721	1.081
48101	3-55	57.40	R	880	128.3960	0.894	1.341
48116	14-195	114.90	MR	3500	0.4140	0.000	0.000
48400	14-195	114.90	R	5	0.3530	0.000	0.000
48462	14-195	114.90	MR	4000	0.6120	0.000	0.000
48589	14-195	114.90	R	3	0.3400	0.000	0.000
48705	14-195	114.90	MR	3000	0.3520	0.000	0.000
48885	14-195	114.90	R	7	0.3350	0.000	0.000
49076	14-195	114.90	MR	900	1.3360	0.000	0.000
49131	14-195	114.90	R	9	1.3100	0.000	0.000
** Subtotal **		2107.20					
** Shipper DUQ-BEAVER							
46458	14-195	194.10	MR	1400	0.0540	0.000	0.000
47945	6-80	83.40	MR	69870	6.4590	25.823	38.735
47998	6-80	83.40	MR	64649	6.0030	27.785	41.678
48385	14-195	194.10	MR	800	0.0500	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
** Subtotal **		555.00					
** Shipper FP&L-ST LU							
46520	8-120A	120.30	R	50	3.4060	70.639	105.959
46571	14-195	194.10	R	13	1.4540	0.000	0.000
46619	14-195	194.10	R	0	1.3400	0.000	0.000
46867	6-80	83.40	R	300	8.3550	19.964	29.946
47271	14-195	194.10	R	2	0.3780	0.000	0.000
47349	14-195	205.80	R	2	0.9190	0.000	0.000
47923	8-120B	120.30	R	70	13.1910	18.240	27.360
47934	3-55	57.40	MR	15650	228.1710	0.503	0.755
48128	14-215	205.80	R	2	0.1120	0.000	0.000
48188	14-215	205.80	R	1	0.4530	0.000	0.000
48208	8-120B	120.30	R	5	0.2610	0.000	0.000
48832	6-80	83.40	R	32	3.7330	44.678	67.017
49161	8-120A	120.30	R	275	4.0580	59.296	88.930
** Subtotal **		1905.10					
** Shipper FP&L-TURKE							
46495	6-80	83.40	R	200	5.8600	28.466	42.698
46537	6-80	83.40	R	15	1.2600	0.000	0.000
46685	6-80	83.40	R	70	7.0390	23.695	35.543
46849	6-80	83.40	R	0	6.2200	26.818	40.227
47105	6-80	83.40	R	40	5.5950	29.810	44.715
47960	14-215	202.10	MR	2000	0.1880	0.000	0.000
48712	6-80	83.40	R	35	6.2280	26.783	40.174
48972	6-80	83.40	MR	35	3.7380	44.628	66.942
49010	6-80	83.40	MR	15000	2.5030	66.644	0.000
49069	6-80	83.40	R	35	1.8570	0.000	0.000
49071	14-215	202.10	R	4	1.4830	0.000	0.000
49104	6-80	83.40	R	80	3.7200	44.845	67.267
49110	14-215	202.10	R	2	0.1750	0.000	0.000
** Subtotal **		1440.30					
** Shipper FPC-CRYSTA							
46605	18-450	402.20	MR	0	0.0000	0.000	0.000
46935	18-450	402.20	MR	0	0.0000	0.000	0.000
47170	18-450	402.20	MR	0	0.0000	0.000	0.000
47250	18-450	402.20	MR	0	0.0000	0.000	0.000
47348	8-120B	120.30	R	30	6.6930	35.950	53.924

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47422	14-195	194.10	R	2	0.0640	0.000	0.000
47599	8-120	120.30	R	120	11.1290	21.619	32.428
47654	18-450	402.20	MR	0	0.0000	0.000	0.000
47976	18-450	402.20	MR	0	0.0000	0.000	0.000
48150	8-120B	120.30	R	140	20.1440	11.944	17.916
48174	8-120B	120.30	R	120	11.0310	21.812	32.718
48404	14-195	194.10	R	7	0.0680	0.000	0.000
48667	14-195	194.10	R	3	0.1370	0.000	0.000
48805	21-300	328.50	R	1	0.2910	0.000	0.000
** Subtotal **		3805.20					
** Shipper GA-HATCH — No Δ required							
46457	14-210	202.10	R	3	0.5810	0.000	0.000
46461	14-210	202.10	R	10	1.6370	0.000	0.000
46486	14-210	199.40	R	2	0.3390	0.000	0.000
46512	14-210	199.40	MR	400	0.0850	0.000	0.000
46531	14-210	199.40	R	1	0.1610	0.000	0.000
46604	14-210	132.40	R	2	0.2640	0.000	0.000
46652	14-210	202.10	R	1	0.8100	0.000	0.000
46703	14-210	202.10	R	35	0.7580	0.000	0.000
46733	14-210	199.40	R	4	0.2780	0.000	0.000
46814	14-210	199.40	R	2	0.4090	0.000	0.000
46872	14-210	202.10	R	2	0.4820	0.000	0.000
46905	14-210	199.40	R	1	0.3530	0.000	0.000
46914	14-210	202.10	R	5	0.8700	0.000	0.000
46956	14-210	202.10	R	1	1.7300	0.000	0.000
47027	10-142	132.40	R	200	9.4980	27.880	41.820
47064	14-210	199.40	R	2	0.3240	0.000	0.000
47086	14-210	202.10	R	3	0.6400	0.000	0.000
47106	10-142	132.40	R	100	5.5240	47.940	71.910
47148	14-210	199.40	R	2	0.5860	0.000	0.000
47225	14-210	199.40	R	2	0.4030	0.000	0.000
47272	14-210	114.90	R	0	0.2550	0.000	0.000
47370	14-210	199.40	R	2	0.2870	0.000	0.000
47398	14-210	202.10	R	6	0.9390	0.000	0.000
47482	14-210	199.40	MR	500	0.0120	0.000	0.000
47573	14-210	199.40	R	2	0.4850	0.000	0.000
47609	14-210	199.40	R	2	0.2190	0.000	0.000
47630	10-142	128.30	R	3	0.5560	0.000	0.000
47650	14-210	199.40	MR	300	0.0580	0.000	0.000
47695	10-142	132.40	R	50	2.3170	114.271	0.000
47759	14-210	199.40	MR	900	0.0840	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47796	14-210	202.10	R	7	0.6570	0.000	0.000
47811	10-142	132.40	MR	70	1.3920	0.000	0.000
47815	14-210	202.10	R	2	0.4410	0.000	0.000
47858	14-210	202.10	R	3	0.8060	0.000	0.000
47891	14-210	199.40	R	1	0.2080	0.000	0.000
47907	14-210	202.10	R	2	0.3710	0.000	0.000
47949	14-210	199.40	R	1	0.1140	0.000	0.000
48036	14-210	202.10	R	6	0.9730	0.000	0.000
48114	14-210	199.40	MR	600	0.1390	0.000	0.000
48136	14-210	202.10	R	3	0.8610	0.000	0.000
48222	14-210	38.30	R	7	0.1970	0.000	0.000
48233	14-210	202.10	MR	700	0.1360	0.000	0.000
48257	14-210	199.40	MR	400	0.0550	0.000	0.000
48271	14-210	199.40	MR	2000	0.2860	0.000	0.000
48310	14-210	199.40	MR	300	0.0620	0.000	0.000
48323	10-142	132.40	R	15	2.4420	108.432	0.000
48347	14-210	202.10	R	12	1.5860	0.000	0.000
48369	14-210	199.40	MR	700	0.0660	0.000	0.000
48396	14-210	202.10	R	6	1.2630	0.000	0.000
48472	10-142	132.40	R	18	1.9480	0.000	0.000
48513	14-210	202.10	R	2	0.3040	0.000	0.000
48543	14-210	202.10	R	3	0.4550	0.000	0.000
48569	14-210	202.10	R	5	0.6840	0.000	0.000
48587	14-210	202.10	R	5	0.5760	0.000	0.000
48618	14-210	199.40	R	2	0.1640	0.000	0.000
48649	14-210	202.10	R	3	0.3540	0.000	0.000
48684	14-210	202.10	R	5	0.5440	0.000	0.000
48807	10-142	132.40	R	13	0.3800	0.000	0.000
48865	14-210	202.10	R	2	0.4390	0.000	0.000
48896	14-210	199.40	MR	2	0.2910	0.000	0.000
48929	10-142	132.40	R	100	6.9750	37.966	56.949
48937	14-210	202.10	MR	2	0.3640	0.000	0.000
48954	14-210	202.10	MR	1200	0.2590	0.000	0.000
48978	14-210	202.10	MR	200	0.0480	0.000	0.000
48992	14-210	202.10	R	2	0.1610	0.000	0.000
49014	14-210	202.10	MR	4	0.5840	0.000	0.000
49035	14-210	202.10	R	2	0.8180	0.000	0.000
49082	10-142	132.40	MR	250	15.0540	17.590	26.385
49099	14-210	202.10	R	4	0.0420	0.000	0.000
49136	10-142	132.40	R	110	5.2050	50.874	76.312
49155	14-210	202.10	R	6	0.2360	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
** Subtotal **		13192.80					
** Shipper GA-VOGTLE							
48164	14-210	199.40	MR	5000	0.1170	0.000	0.000
48203	14-210	199.40	MR	180	0.0050	0.000	0.000
48944	14-210	132.40	MR	7000	0.1850	0.000	0.000
48967	14-210	202.10	MR	20000	0.4770	0.000	0.000
** Subtotal **		733.30					
** Shipper GENERAL DY							
47973	14-195	194.10	MR	0	0.0000	0.000	0.000
** Subtotal **		194.10					
** Shipper GPU-OYSTER							
46474	14-195	177.50	MR	1200	0.3160	0.000	0.000
46524	14-195	177.50	MR	2500	0.7430	0.000	0.000
46553	14-195	205.80	MR	6000	0.3040	0.000	0.000
46561	14-195	177.50	MR	1200	0.3060	0.000	0.000
46574	14-195	177.50	MR	1000	0.5850	0.000	0.000
46690	14-195	194.10	R	18	3.4830	111.448	167.172
46744	14-195	177.50	R	0	1.7540	0.000	0.000
46813	14-195	177.50	R	4	0.7860	0.000	0.000
46987	14-195	177.50	MR	70	1.5500	0.000	0.000
47024	14-195	177.50	R	2	0.3900	0.000	0.000
47293	14-195	177.50	R	10	1.5390	0.000	0.000
47369	14-195	177.50	MR	1000	0.3840	0.000	0.000
47452	14-195	205.80	MR	5000	0.7040	0.000	0.000
47571	FSV-1	26.20	R	14100	214.5700	0.244	0.366
47575	14-195	177.50	R	2	0.6350	0.000	0.000
47614	FSV-1	26.20	R	11000	190.1890	0.276	0.413
47649	FSV-1	26.20	R	12	207.7430	0.252	0.378
47687	8-120A	120.30	R	52	6.4370	37.379	56.069
47731	14-195	177.50	MR	3000	0.9080	0.000	0.000
47742	FSV-1	26.20	R	7000	207.0520	0.253	0.380
47762	FSV-1	26.20	MR	19500	207.9780	0.252	0.378
47783	14-195	177.50	MR	800	0.0680	0.000	0.000
47822	FSV-1	26.20	R	6300	207.9770	0.252	0.378
47836	FSV-1	26.20	MR	9800	208.9030	0.251	0.376
47925	14-195	177.50	MR	4000	1.8140	0.000	0.000
47980	8-120	120.30	R	35	8.0160	30.016	45.024

09/18/88

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x Ai	Linr Vol If Limit 3 x Ai
48001	8-120A	120.30	R	30	8.2390	29.201	43.802
48060	14-195	205.80	R	2	0.2310	0.000	0.000
48092	14-195	177.50	R	2	0.6510	0.000	0.000
48146	14-195	177.50	MR	1400	0.5860	0.000	0.000
48353	14-195	177.50	R	12	1.8590	0.000	0.000
48469	14-195	205.80	R	1	0.6760	0.000	0.000
48477	14-195	177.50	R	1	0.3070	0.000	0.000
48611	14-195	177.50	MR	120	0.0540	0.000	0.000
48686	14-195	205.80	MR	340	0.1290	0.000	0.000
48717	14-195	177.50	R	4	0.5430	0.000	0.000
48795	14-195	177.50	MR	400	0.4420	0.000	0.000
48831	14-195	205.80	MR	325	0.0220	0.000	0.000
48994	14-195	177.50	R	2	0.1160	0.000	0.000
49070	8-120A	120.30	R	60	13.2450	18.166	27.249
49143	14-195	177.50	R	8	1.4300	0.000	0.000
** Subtotal **		6176.00					
** Shipper GPU-TMI							
47116	HN-200	73.40	R	35	1.2310	0.000	0.000
47149	8-120B	125.20	MR	1000	3.2880	76.164	114.247
47179	HN-200	73.40	R	35	1.2330	0.000	0.000
47285	HN-200	73.40	R	30	1.2310	0.000	0.000
47812	8-120B	125.20	MR	5000	2.9860	83.853	0.000
48663	8-120B	36.50	MR	400	8.3490	8.744	13.116
48718	8-120B	36.50	MR	1000	24.8870	2.933	4.400
48910	8-120B	36.50	MR	550	17.4080	4.193	6.290
48953	8-120B	36.50	MR	5000	119.0340	0.613	0.920
49003	8-120B	36.50	MR	3500	45.5950	1.601	2.402
49047	8-120B	36.50	MR	5000	48.9720	1.491	2.236
** Subtotal **		689.60					
** Shipper GULF-RIVER		1 - 200 ft³ liner affected.					
46714	14-195	206.10	MR	1750	0.0630	0.000	0.000
46734	14-195	206.10	MR	25	0.1180	0.000	0.000
46746	21-300	206.10	MR	1	0.0390	0.000	0.000
46750	14-195	206.10	MR	12	0.0990	0.000	0.000
46762	14-195	206.10	MR	20	0.1570	0.000	0.000
46787	21-300	206.10	MR	2	0.0490	0.000	0.000
46792	21-300	206.10	MR	2	0.0270	0.000	0.000
46801	21-300	206.10	MR	9	0.0720	0.000	0.000
46875	21-300	206.10	MR	50	0.0130	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
46890	21-300	206.10	MR	6	0.0520	0.000	0.000
47343	14-195	206.10	MR	4000	0.3620	0.000	0.000
47358	14-195	206.10	MR	3000	0.2210	0.000	0.000
47372	14-195	206.10	R	1	0.1040	0.000	0.000
47393	14-195	206.10	R	2	0.3110	0.000	0.000
47411	21-300	206.10	MR	700	0.0970	0.000	0.000
47426	21-300	206.10	R	1	0.0420	0.000	0.000
47447	21-300	206.10	MR	700	0.1110	0.000	0.000
47582	14-195	206.10	R	5	0.9330	0.000	0.000
47686	21-300	206.10	R	2	0.1310	0.000	0.000
47713	21-300	206.10	MR	800	0.1830	0.000	0.000
47746	21-300	206.10	MR	300	0.1550	0.000	0.000
47781	21-300	206.10	MR	490	0.1100	0.000	0.000
47996	21-300	206.10	MR	300	0.0400	0.000	0.000
48029	21-300	206.10	MR	500	0.1230	0.000	0.000
48127	14-195	206.10	R	2	0.7090	0.000	0.000
48144	14-195	206.10	MR	1500	0.0960	0.000	0.000
48348	14-195	206.10	R	2	0.3160	0.000	0.000
48408	21-300	206.10	MR	275	0.0600	0.000	0.000
48415	14-195	206.10	R	1	0.6440	0.000	0.000
48443	14-195	206.10	MR	1700	0.2080	0.000	0.000
48465	14-195	206.10	R	3	0.6390	0.000	0.000
48714	14-215	206.10	MR	5000	0.3560	0.000	0.000
48815	14-215	206.10	MR	5000	2.2940	179.662	0.000
48834	21-300	206.10	MR	700	0.2140	0.000	0.000
** Subtotal **		7007.40					
** Shipper I&M-DCCOOK							
46526	HN-100	163.30	MR	1	0.3750	0.000	0.000
46562	HN-100	163.30	MR	160	0.1550	0.000	0.000
46995	HN-200	73.40	R	200	40.9180	3.588	5.381
47173	HN-100	158.10	MR	15000	3.3700	93.821	140.732
47333	HN-100	172.60	MR	60	0.0240	0.000	0.000
47366	HN-100	158.10	MR	3000	0.4090	0.000	0.000
47560	HN-200	73.40	R	54	15.0280	9.769	14.653
47715	HN-100	158.10	MR	500	0.4320	0.000	0.000
48515	HN-100	177.90	MR	125	0.0240	0.000	0.000
48542	HN-100	163.30	MR	800	0.0180	0.000	0.000
48764	10-142	135.80	R	26	9.7910	27.741	41.612
48864	10-142	135.80	R	26	12.2730	22.129	33.194
48964	HN-100	163.30	R	2	0.0270	0.000	0.000
49116	HN-100	158.10	R	2	0.3820	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
** Subtotal **		2054.50					
** Shipper IOWA-D ARN							
46487	HN-100	163.30	MR	8000	1.6060	0.000	0.000
46552	HN-100	163.30	MR	5000	0.9850	0.000	0.000
46635	HN-100	163.30	MR	50	0.6700	0.000	0.000
46666	HN-200	73.40	MR	767	10.6800	13.745	20.618
46726	HN-200	73.40	MR	1470	18.5420	7.917	11.875
46826	HN-100	163.30	R	10	1.2460	0.000	0.000
46926	HN-100	163.30	MR	40	0.5860	0.000	0.000
46976	HN-100	163.30	MR	5000	0.5860	0.000	0.000
47041	HN-100	163.30	R	2	0.3190	0.000	0.000
47172	HN-100	163.30	MR	3000	0.4300	0.000	0.000
47256	HN-100	163.30	R	4	0.4470	0.000	0.000
47334	HN-100	173.00	MR	50	0.0130	0.000	0.000
47445	HN-100	163.30	R	4	0.5110	0.000	0.000
47584	HN-100	163.30	R	4	0.5590	0.000	0.000
47754	HN-100	173.00	MR	350	0.0210	0.000	0.000
47757	HN-100	163.30	MR	3000	0.5200	0.000	0.000
47845	HN-100	163.30	MR	2500	0.4250	0.000	0.000
47869	HN-100	163.30	R	4	0.3050	0.000	0.000
47909	HN-100	163.30	MR	2000	0.1930	0.000	0.000
48000	HN-100	163.30	MR	2000	0.2160	0.000	0.000
48212	HN-100	163.30	R	2	0.2060	0.000	0.000
48304	HN-100	163.30	MR	2000	0.1470	0.000	0.000
48433	HN-100	163.30	MR	2000	0.1260	0.000	0.000
48627	HN-100	178.90	MR	2000	0.2340	0.000	0.000
48692	HN-100	178.90	MR	700	0.0940	0.000	0.000
48931	HN-100	178.90	MR	900	0.1600	0.000	0.000
49112	HN-100	178.90	MR	1100	0.1130	0.000	0.000
** Subtotal **		4311.10					
** Shipper J.A. FITZ							
46468	LN-14-170	181.70	R	14	3.5340	102.819	154.229
46507	LN-14-170	181.70	MR	125	0.2290	0.000	0.000
46559	LN-14-170	105.00	MR	4500	0.0590	0.000	0.000
46692	LN-14-170	158.10	MR	1250	0.7820	0.000	0.000
46971	LN-14-170	181.70	R	2	0.5250	0.000	0.000
47146	LN-14-170	181.70	MR	2500	1.2640	0.000	0.000
47226	LN-14-170	181.70	R	4	1.3580	0.000	0.000
47305	LN-14-170	181.70	MR	3000	0.7510	0.000	0.000

09/18/88

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47353	LN-14-170	181.70	MR	9300	2.1580	168.404	0.000
47407	LN-14-170	181.70	MR	230	0.1080	0.000	0.000
47461	LN-14-170	181.70	MR	4100	1.6700	0.000	0.000
47549	LN-14-170	105.00	R	3	0.1230	0.000	0.000
47623	LN-14-170	181.70	R	4	1.5350	0.000	0.000
47730	LN-14-170	181.70	MR	3000	1.4890	0.000	0.000
47918	LN-14-170	181.70	MR	175	0.0800	0.000	0.000
47959	LN-14-170	181.70	MR	4000	0.7920	0.000	0.000
48098	LN-14-170	181.70	R	5	1.1810	0.000	0.000
48133	LN-14-170	181.70	MR	4000	1.4150	0.000	0.000
48186	LN-14-170	105.00	R	2	0.1230	0.000	0.000
48242	LN-14-170	181.70	MR	650	0.2600	0.000	0.000
48395	LN-14-170	181.70	MR	210	0.0650	0.000	0.000
48514	LN-14-170	181.70	MR	130	0.0620	0.000	0.000
48581	LN-14-170	158.10	R	10	1.4590	0.000	0.000
48658	LN-14-170	181.70	MR	1200	0.3440	0.000	0.000
48770	LN-14-170	181.70	MR	1120	0.2110	0.000	0.000
48877	LN-14-170	158.10	R	12	1.4440	0.000	0.000
48976	LN-14-170	158.10	R	12	1.3430	0.000	000
49045	LN-14-170	181.70	MR	128	0.0790	0.000	0.000
** Subtotal **		4763.10					
** Shipper KG-WOLF CR							
46465	HN-100	132.40	R	10	0.1090	0.000	0.000
48474	8-120	120.30	R	70	18.8350	12.774	19.161
48575	8-120	120.30	R	40	21.1830	11.358	17.037
48689	8-120	120.30	R	4	3.7360	64.404	96.606
** Subtotal **		493.30					
** Shipper LA-WATERFO — All type B							
46951	8-120	120.30	R	20	1.0120	0.000	0.000
47784	8-120	120.30	R	30	0.8140	0.000	0.000
** Subtotal **		240.60					
** Shipper MAINE YANK							
47717	14-195	158.10	R	2	0.1150	0.000	0.000
48338	HN-100	158.10	MR	2000	0.1540	0.000	0.000
48343	HN-100	158.10	R	55	0.2330	0.000	0.000
48397	14-215	114.90	MR	700	0.0210	0.000	0.000
48455	14-215	114.90	MR	5000	0.0610	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48461	14-215	114.90	MR	300	0.0250	0.000	0.000
48492	HN-100	170.80	R	6	0.4560	0.000	0.000
48659	HN-100	170.80	R	11	0.5400	0.000	0.000
48671	HN-100	158.10	R	55	9.0060	35.109	52.663
48708	14-215	158.10	R	20	0.5760	0.000	0.000
48773	HN-215	114.90	MR	6200	0.4190	0.000	0.000
48804	HN-215	114.90	MR	750	0.4480	0.000	0.000
48870	HN-215	114.90	MR	750	0.2290	0.000	0.000
** Subtotal **		1821.50					
** Shipper MARION							
49145	14-170	96.50	MR	5	0.0280	0.000	0.000
** Subtotal **		96.50					
** Shipper NE-MILLST							
46494	14-195	202.10	R	3	0.0960	0.000	0.000
46610	14-195	202.10	R	6	0.4610	0.000	0.000
46616	14-195	132.40	R	12	1.3530	0.000	0.000
46706	14-190	132.40	R	30	1.6880	0.000	0.000
46745	14-190	132.40	R	0	1.9840	0.000	0.000
46779	14-195	132.40	R	0	0.2430	0.000	0.000
46798	14-195	202.10	R	0	0.3010	0.000	0.000
46983	14-195	202.10	MR	500	0.0240	0.000	0.000
46990	14-195	181.70	R	10	2.1350	170.191	0.000
47040	14-195	202.10	R	2	0.1400	0.000	0.000
47241	14-195	202.10	R	4	0.4120	0.000	0.000
47357	14-195	206.10	R	2	0.0440	0.000	0.000
47427	14-190	132.40	R	20	1.9110	0.000	0.000
47504.2		13.80	MR	600	0.0000	0.000	0.000
47546	14-190	132.40	R	65	3.4580	76.586	114.879
47578	18-450	188.00	MR	1500	0.0820	0.000	0.000
47603	14-195	202.10	R	15	1.1860	0.000	0.000
47621	14-195	202.10	R	3	0.3090	0.000	0.000
47656	14-195	202.10	R	4	0.0600	0.000	0.000
47706	14-195	202.10	MR	3500	0.5600	0.000	0.000
47771	14-195	202.10	R	10	0.8740	0.000	0.000
47788	8-120B	120.30	R	72	4.9000	49.106	73.659
47854	14-195	132.40	R	15	1.4320	0.000	0.000
47864	14-195	202.10	R	17	1.2650	0.000	0.000
47894	21-300	157.50	MR	1100	0.1030	0.000	0.000
47928	14-195	132.40	R	12	0.7460	0.000	0.000

09/18/88

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47935	14-195	202.10	R	7	0.3370	0.000	0.000
47955	21-300	199.40	MR	2	0.0000	0.000	0.000
47963	21-300	199.40	MR	20	0.0000	0.000	0.000
47982	21-300	199.40	MR	10	0.0010	0.000	0.000
47987	14-195	131.60	MR	30	0.0620	0.000	0.000
48007	14-195	131.60	MR	300	0.0080	0.000	0.000
48022	14-190	132.40	R	25	1.6630	0.000	0.000
48078	14-195	202.10	R	3	0.4270	0.000	0.000
48079	21-300	199.40	MR	35	0.0030	0.000	0.000
48157	14-195	202.10	R	5	0.2210	0.000	0.000
48169	B-120B	120.30	R	13	0.8890	0.000	0.000
48185	14-195	202.10	MR	1500	0.3860	0.000	0.000
48210	14-195	202.10	MR	7000	2.1260	190.078	0.000
48325	14-195	202.10	MR	2000	0.2350	0.000	0.000
48394	14-190	132.40	R	150	13.9740	18.949	28.424
48431	14-195	132.40	R	16	1.0220	0.000	0.000
48463	14-195	202.10	R	2	0.0980	0.000	0.000
48529	14-195	202.10	MR	285	0.0560	0.000	0.000
48547	14-195	202.10	MR	200	0.0240	0.000	0.000
48574	14-195	202.10	MR	100	0.0070	0.000	0.000
48609	14-195	202.10	MR	1250	0.1650	0.000	0.000
48639	14-195	202.10	R	2	0.1490	0.000	0.000
48731	14-195	202.10	R	3	0.4820	0.000	0.000
48744	14-195	178.80	MR	38	0.0040	0.000	0.000
48781	14-195	202.10	R	2	0.3120	0.000	0.000
48787	TN-8	22.50	R	26000	978.8760	0.046	0.069
48846	TN-8	22.50	R	7420	970.1950	0.046	0.070
48920	3-55	57.40	R	2100	187.0950	0.614	0.920
48924	14-D-2.0	132.40	R	100	14.1240	18.749	28.123
49005	14-190	132.40	R	50	4.7180	56.128	84.192
49064	21-300	199.40	MR	1	0.0000	0.000	0.000
49107	14-190	132.40	R	70	3.8760	68.310	102.465
** Subtotal **		9637.30					
** Shipper NEUTRON							
48489	14-195	105.00	R	12	0.2640	0.000	0.000
48985	14-195	105.00	R	20	0.3350	0.000	0.000
** Subtotal **		210.00					
** Shipper NEWPORT							
46723	6-80	83.40	MR	2	0.0120	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
** Subtotal **		83.40					
** Shipper NIAG-9MILE							
47055	14-215	178.80	MR	500	0.1370	0.000	0.000
47069	14-215	205.60	MR	1500	0.9400	0.000	0.000
47134	14-195	178.80	MR	400	0.1250	0.000	0.000
47223	14-195	178.80	MR	450	0.1250	0.000	0.000
47306	14-195	178.80	MR	400	0.1250	0.000	0.000
47344	14-195	178.80	MR	450	0.1250	0.000	0.000
47408	14-215	178.80	R	5	1.0300	0.000	0.000
47956	14-195	205.80	R	2	0.0940	0.000	0.000
48019	14-195	170.80	MR	400	0.0510	0.000	0.000
48045	14-195	205.80	MR	700	0.0230	0.000	0.000
48104	14-195	205.80	MR	200	0.0650	0.000	0.000
48302	14-195	205.80	MR	200	0.0430	0.000	0.000
48499	14-195	170.80	MR	180	0.0310	0.000	0.000
48564	14-215	206.10	MR	350	0.2100	0.000	0.000
48598	14-195	205.60	MR	200	0.0350	0.000	0.000
48652	14-195	206.10	MR	100	0.0160	0.000	0.000
48816	14-195	177.50	R	6	0.8920	0.000	0.000
48905	14-195	205.80	MR	250	0.0380	0.000	0.000
49118	14-210	181.70	MR	130	0.0750	0.000	0.000
** Subtotal **		3626.40					
** Shipper NSP PRAIRI							
47509	8-120	120.30	R	33	14.9230	16.123	24.184
** Subtotal **		120.30					
** Shipper NSP-MONTIC							
46915	14-215	194.10	MR	26	0.5380	0.000	0.000
47056	14-215	194.10	R	2	0.4050	0.000	0.000
47523	14-215	194.10	MR	2200	0.3860	0.000	0.000
47866	14-215	194.10	MR	7000	1.6810	0.000	0.000
48155	14-215	205.80	R	4	0.8410	0.000	0.000
48244	14-215	205.80	R	4	0.5790	0.000	0.000
48285	14-215	205.80	MR	20000	1.2270	0.000	0.000
48906	14-215	205.80	MR	18000	3.6550	112.624	168.937
** Subtotal **		1599.60					

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	Dl CJ	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
** Shipper NUCLEAR ME							
47465	RANGER	240.00	MR	5	0.0000	0.000	0.000
** Subtotal **		240.00					
** Shipper NYPA IP 3							
46451	14-D-2.0	172.50	MR	4500	0.0270	0.000	0.000
46580	HN-100	158.10	R	10	0.7550	0.000	0.000
46883	HN-200	76.20	MR	420	4.5350	33.607	50.411
46898	14-D-2.0	172.60	MR	650	0.0810	0.000	0.000
46945	TVA-SNF	158.10	R	0	0.7750	0.000	0.000
48698	10-142	132.40	R	220	14.5040	18.257	27.385
** Subtotal **		869.90					
** Shipper PECO-LIMER							
46861	14-170	163.30	MR	74	1.5470	0.000	0.000
46865	14-170	163.30	R	1930	0.4530	0.000	0.000
46911	14-170	153.30	MR	400	0.0540	0.000	0.000
46937	HN-100	153.30	MR	1500	0.0680	0.000	0.000
46955	HN-100	153.30	MR	20	0.2220	0.000	0.000
46980	14-170	153.30	MR	8	0.0500	0.000	0.000
47021	HN-100	163.30	MR	1000	0.1470	0.000	0.000
47048	HN-100	153.30	MR	250	0.0230	0.000	0.000
47072	HN-100	153.30	R	1	0.2320	0.000	0.000
47084	HN-100	153.30	MR	247	0.0860	0.000	0.000
47129	HN-100	153.30	MR	248	0.0190	0.000	0.000
47143	14-190	163.30	MR	40000	2.8240	115.655	0.000
47154	HN-100	153.30	MR	147	0.0150	0.000	0.000
47160	14-195	163.30	MR	25900	4.4830	72.846	109.270
47163	HN-100	153.30	MR	148	0.0160	0.000	0.000
47180	HN-100	153.30	MR	147	0.0370	0.000	0.000
47187	HN-100	153.30	MR	3000	0.8210	0.000	0.000
47194	14-170	153.30	MR	400	0.0560	0.000	0.000
47208	HN-100	153.30	MR	400	0.0340	0.000	0.000
47217	14-195	163.30	MR	30000	7.8230	41.747	62.620
47237	HN-100	153.30	MR	100	0.0070	0.000	0.000
47265	14-190	153.30	MR	2000	0.8420	0.000	0.000
47335	HN-100	153.30	MR	170	0.0410	0.000	0.000
47364	HN-100	153.30	MR	600	0.0810	0.000	0.000
47431	HN-100	153.30	MR	600	0.0910	0.000	0.000
47450	HN-100	153.30	MR	296	0.0700	0.000	0.000
47477	HN-100	153.30	MR	300	0.0780	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Linear Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47503	HN-100	153.30	MR	700	0.1340	0.000	0.000
47538	14-170	153.30	MR	400	0.0370	0.000	0.000
47568	14-170	153.30	MR	337	0.0280	0.000	0.000
47606	14-170	153.30	MR	960	0.1430	0.000	0.000
47646	14-170	153.30	MR	313	0.1000	0.000	0.000
47728	14-170	153.30	MR	1180	0.2770	0.000	0.000
47748	14-170	153.30	MR	297	0.0390	0.000	0.000
47770	14-170	153.30	MR	698	0.1290	0.000	0.000
47809	14-190	163.30	R	24	3.9380	82.928	124.392
47813	14-170	153.30	MR	200	0.0630	0.000	0.000
47917	14-170	163.30	MR	7820	1.3180	0.000	0.000
47919	14-170	153.30	MR	128	0.0110	0.000	0.000
47929	14-170	153.30	MR	97	0.0320	0.000	0.000
47930	14-170	153.30	MR	124	0.0250	0.000	0.000
48063	14-215	206.10	R	69	0.0270	0.000	0.000
48145	21-300	328.50	MR	300	0.1830	0.000	0.000
48199	21-300	328.50	MR	71	0.0210	0.000	0.000
48211	14-215	205.80	MR	2000	3.2850	125.293	187.940
48346	8-120	120.30	R	25	7.8970	30.466	45.699
48349	14-215	205.80	R	4	1.4320	0.000	0.000
48363	14-170	153.30	MR	350	0.0450	0.000	0.000
48379	14-170	181.70	MR	50	0.0070	0.000	0.000
48405	14-170	153.30	MR	396	0.0370	0.000	0.000
48419	14-170	181.70	MR	24	0.0030	0.000	0.000
48497	14-170	153.30	MR	291	0.0280	0.000	0.000
48506	14-170	153.30	MR	243	0.0240	0.000	0.000
48702	HN-215	199.40	MR	68	0.0120	0.000	0.000
48709	HN-100	153.30	R	6	0.0110	0.000	0.000
48741	HN-215	199.40	MR	56	0.0110	0.000	0.000
48952	HN-215	208.00	MR	282	0.3330	0.000	0.000
48965	HN-215	208.00	MR	107	0.0690	0.000	0.000
49004	HN-215	202.10	MR	184	0.0190	0.000	0.000
49057	21-300	328.50	MR	90	0.0320	0.000	0.000
49097	21-300	328.50	MR	120	0.0510	0.000	0.000
** Subtotal **		10564.10					
** Shipper PECO-PEACH							
46466	HN-100	174.30	MR	10	1.5790	0.000	0.000
46527	HN-100	174.30	R	6	0.6400	0.000	0.000
46572	14-195	174.30	R	15	1.5990	0.000	0.000
46591	HN-100	174.30	R	2	0.4430	0.000	0.000
46613	14-195	174.30	R	10	1.8400	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
46620	DH-142	132.40	R	15	2.0610	128.485	0.000
46621	HN-100	174.30	R	0	0.1750	0.000	0.000
46688	HN-100	174.30	R	10	3.6250	96.167	144.250
46729	HN-100	174.30	R	0	0.6750	0.000	0.000
46806	HN-100	174.30	R	0	1.5090	0.000	0.000
46807	HN-100	174.30	R	0	1.5390	0.000	0.000
46835	10-142	132.40	R	130	28.0340	9.446	14.169
46869	HN-100	174.30	R	4	1.1660	0.000	0.000
46899	HN-100	174.30	R	3	0.7170	0.000	0.000
46918	HN-100	174.30	R	0	2.4430	142.712	0.000
46944.2		143.00	MR	2	0.0000	0.000	0.000
46965	HN-100	174.30	R	0	1.3920	0.000	0.000
47059	HN-100	174.30	R	6	0.8160	0.000	0.000
47181	HN-100	174.30	R	4	0.8940	0.000	0.000
47339	HN-100	174.30	R	7	1.0390	0.000	0.000
47381	HN-100	174.30	R	4	2.3470	148.536	0.000
47432	HN-100	174.30	R	4	1.4040	0.000	0.000
47506	HN-100	174.30	R	0	1.0970	0.000	0.000
47537	HN-100	174.30	R	2	0.4650	0.000	0.000
47539	14-195	174.30	R	8	1.9950	0.000	0.000
47563	HN-100	105.00	R	2	0.3980	0.000	0.000
47594	HN-100	174.30	MR	17	0.4470	0.000	0.000
47643	HN-100	174.30	R	2	2.2680	153.719	0.000
47665	HN-100	174.30	R	2	0.6990	0.000	0.000
47669	HN-100	105.00	R	2	0.2490	0.000	0.000
47673	HN-100	174.30	R	2	0.8860	0.000	0.000
47765	HN-100	105.00	MR	6000	0.4880	0.000	0.000
47789	HN-100	174.30	R	3	0.8520	0.000	0.000
47873	HN-800	180.00	MR	600	0.3200	0.000	0.000
47904	HN-100	174.30	R	2	0.4080	0.000	0.000
47950	HN-100	174.30	R	2	0.6540	0.000	0.000
47989	HN-100	174.30	R	2	0.6440	0.000	0.000
48010	HN-100	174.30	R	2	0.6480	0.000	0.000
48053	HN-100	105.00	R	2	0.3370	0.000	0.000
48064	HN-100	174.30	R	4	1.0770	0.000	0.000
48131	HN-100	174.30	R	2	0.9140	0.000	0.000
48175	HN-100	174.30	R	4	0.8970	0.000	0.000
48265	HN-100	174.30	R	2	0.3100	0.000	0.000
48276	HN-100	174.30	R	2	0.7040	0.000	0.000
48301	HN-100	174.30	R	3	0.6850	0.000	0.000
48316	HN-100	105.00	MR	1000	0.2520	0.000	0.000
48341	HN-100	174.30	R	2	0.7260	0.000	0.000
48392	HN-100	174.30	R	2	0.4500	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48454	HN-100	174.30	R	2	0.5860	0.000	0.000
48494	HN-100	105.00	MR	700	0.1790	0.000	0.000
48517	HN-100	174.30	R	3	1.1730	0.000	0.000
48559	HN-100	174.30	R	2	0.5390	0.000	0.000
48560	HN-100	174.30	R	2	0.5000	0.000	0.000
48576	14-195	120.30	R	1	0.0290	0.000	0.000
48584	14-195	67.80	MR	14000	0.2170	0.000	0.000
48615	HN-100	174.30	R	1	0.2940	0.000	0.000
48619	14-195	76.60	R	2	0.0910	0.000	0.000
48635	HN-100	170.80	R	3	1.1590	0.000	0.000
48642	HN-100	174.30	R	2	0.4980	0.000	0.000
48660	8-120	83.40	R	1	0.0300	0.000	0.000
48706	HN-100	174.30	R	1	0.3160	0.000	0.000
48737	14-195	120.30	R	1	0.0150	0.000	0.000
48791	HN-100	174.30	R	2	0.5950	0.000	0.000
48793	14-195	120.30	R	1	0.0160	0.000	0.000
48820	8-120B	120.30	R	80	6.8660	35.040	52.561
48826	HN-100	174.30	R	1	0.3690	0.000	0.000
48850	8-120B	120.30	R	14	0.8150	0.000	0.000
48858	HN-100	174.30	R	1	0.3170	0.000	0.000
48941	HN-100	174.30	R	1	0.3040	0.000	0.000
49034	HN-100	174.30	R	2	1.1040	0.000	0.000
49080	HN-100	105.00	R	3	0.4550	0.000	0.000
49120	HN-100	105.00	R	4	0.3100	0.000	0.000
** Subtotal **		11317.20					
** Shipper PERRY NPP							
46946	14-170	181.70	MR	600	0.0250	0.000	0.000
46921	14-170	181.70	MR	2	0.0530	0.000	0.000
47092	14-170	181.70	MR	600	0.1450	0.000	0.000
47508	14-170	181.70	MR	200	0.0190	0.000	0.000
47547	14-170	181.70	R	2	0.2870	0.000	0.000
47777	14-170	181.70	MR	600	0.1710	0.000	0.000
47988	14-170	181.70	MR	2000	0.4900	0.000	0.000
48042	14-170	181.70	R	2	0.4620	0.000	0.000
48266	14-170	181.70	R	3	1.138	0.000	0.000
48478	14-170	181.70	MR	5	0.0000	0.000	0.000
48519	14-170	181.70	MR	10	0.0000	0.000	0.000
48562	14-170	181.70	MR	9	0.0000	0.000	0.000
48580	14-170	181.70	MR	15	0.0000	0.000	0.000
48603	14-170	181.70	MR	20	0.0010	0.000	0.000
48623	14-170	181.70	MR	50	0.0010	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48721	14-170	181.70	MR	15	0.0000	0.000	0.000
48745	14-170	181.70	MR	75	0.0010	0.000	0.000
48798	14-170	181.70	MR	980	0.0100	0.000	0.000
48821	14-170	181.70	R	4	0.8840	0.000	0.000
48836	14-170	181.70	MR	2	0.0000	0.000	0.000
48869	14-170	181.70	MR	250	0.0400	0.000	0.000
48887	14-170	181.70	MR	400	0.1540	0.000	0.000
48909	14-170	181.70	MR	500	0.2630	0.000	0.000
** Subtotal **		4179.10					
** Shipper PP&L-SUSQ							
46445	14-215	177.30	MR	1500	0.4430	0.000	0.000
46482	14-215	177.30	MR	1000	0.0500	0.000	0.000
46496	14-215	177.30	MR	900	0.0370	0.000	0.000
46508	14-215	177.30	MR	1600	0.6970	0.000	0.000
46569	14-215	177.30	MR	400	0.0550	0.000	0.000
46582	14-170	177.90	MR	2800	0.5620	0.000	0.000
46596	14-215	177.30	MR	1500	0.1550	0.000	0.000
46598	14-215	177.30	MR	400	0.0160	0.000	0.000
46618	14-170	177.90	MR	9	0.1790	0.000	0.000
46648	14-215	177.90	MR	35	0.9570	0.000	0.000
46657	14-215	177.90	MR	4	0.1220	0.000	0.000
46673	14-215	177.90	MR	3	0.0410	0.000	0.000
46682	14-215	177.90	MR	2	0.0740	0.000	0.000
46694	14-215	177.30	MR	500	0.0410	0.000	0.000
46701	14-170	177.30	MR	300	0.0360	0.000	0.000
46705	14-215	177.30	MR	900	0.1600	0.000	0.000
46722	14-215	177.30	MR	300	0.0180	0.000	0.000
46731	14-215	177.30	MR	225	0.0750	0.000	0.000
46742	14-215	177.90	MR	1500	0.0720	0.000	0.000
46800	14-215	177.90	MR	2	0.0740	0.000	0.000
46912	14-215	177.30	MR	0	0.0070	0.000	0.000
46954	14-215	177.90	MR	2	0.0400	0.000	0.000
47026	14-215	177.30	MR	5	0.0590	0.000	0.000
47074	14-215	177.90	MR	220	0.0350	0.000	0.000
47132	14-215	177.90	MR	280	0.0860	0.000	0.000
47166	14-215	177.30	MR	1100	0.1000	0.000	0.000
47171	14-215	177.30	MR	800	0.0300	0.000	0.000
47190	14-215	177.30	MR	120	0.1020	0.000	0.000
47224	14-215	177.30	MR	250	0.0400	0.000	0.000
47254	14-215	177.30	MR	260	0.0300	0.000	0.000
47325	14-215	177.90	MR	1700	0.1170	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47388	14-215	177.90	MR	900	0.2140	0.000	0.000
47400	14-215	163.30	R	6	0.4550	0.000	0.000
47439	HN-200	73.40	R	75	2.1230	69.147	0.000
47479	HN-200	73.40	R	80	2.1210	69.226	0.000
47511	14-215	177.90	MR	3000	0.8250	0.000	0.000
47552	14-215	177.30	MR	280	0.0480	0.000	0.000
47566	14-215	177.90	MR	800	0.2290	0.000	0.000
47579	14-215	177.30	R	1	0.2990	0.000	0.000
47595	14-215	163.30	R	4	0.3290	0.000	0.000
47629	14-215	177.30	R	1	0.0100	0.000	0.000
47642	14-170	177.30	MR	2000	0.3400	0.000	0.000
47658	14-215	177.90	R	2	0.2180	0.000	0.000
47677	HN-200	73.40	R	70	2.0920	70.177	0.000
47766	HN-100	177.30	MR	320	0.1150	0.000	0.000
47774	HN-100	177.30	MR	1000	0.2290	0.000	0.000
47791	14-215	177.30	MR	800	0.2180	0.000	0.000
47802	HN-100	177.30	MR	950	0.0230	0.000	0.000
47828	HN-200	73.40	R	60	2.0860	70.385	0.000
47830	14-215	177.90	MR	800	0.1380	0.000	0.000
47839	14-215	177.30	MR	120	0.0260	0.000	0.000
47840	14-195	177.30	MR	200	0.0310	0.000	0.000
47846	HN-100	163.30	MR	220	0.0310	0.000	0.000
47856	14-215	163.30	MR	100	0.0030	0.000	0.000
47860	14-195	177.30	MR	200	0.0230	0.000	0.000
47863	14-215	163.30	MR	1000	0.0980	0.000	0.000
47867	14-215	163.30	MR	500	0.0220	0.000	0.000
47870	HN-100	163.30	MR	400	0.0540	0.000	0.000
47882	14-215	177.30	MR	250	0.0710	0.000	0.000
47903	14-215	163.30	MR	900	0.0690	0.000	0.000
47905	14-215	177.90	MR	1500	0.1240	0.000	0.000
47924	14-215	177.30	MR	1000	0.2320	0.000	0.000
47931	14-215	177.30	MR	1100	0.2190	0.000	0.000
47943	14-215	177.30	MR	500	0.1350	0.000	0.000
47957	14-215	177.30	MR	180	0.0600	0.000	0.000
47970	HN-100	177.30	MR	260	0.0990	0.000	0.000
47978	21-300	177.30	MR	190	0.0850	0.000	0.000
47985	HN-100	177.90	MR	480	0.1200	0.000	0.000
47994	HN-100	177.30	MR	140	0.0020	0.000	0.000
48011	14-215	177.90	MR	3	0.0280	0.000	0.000
48020	HN-100	177.90	MR	200	0.0310	0.000	0.000
48023	14-215	177.90	MR	200	0.0330	0.000	0.000
48024	14-215	177.30	MR	100	0.0090	0.000	0.000
48035	14-170	177.30	MR	200	0.0500	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48041	14-215	177.30	MR	200	0.0170	0.000	0.000
48080	21-300	177.30	MR	260	0.0690	0.000	0.000
48081	21-300	177.90	MR	350	0.1520	0.000	0.000
48084	14-215	177.90	MR	300	0.0360	0.000	0.000
48102	14-215	177.90	R	2	0.7500	0.000	0.000
48111	14-215	177.90	MR	260	0.0500	0.000	0.000
48121	14-170	177.30	MR	240	0.1070	0.000	0.000
48132	HN-100	177.30	MR	300	0.0460	0.000	0.000
48148	14-215	177.90	MR	600	0.1920	0.000	0.000
48158	14-215	177.90	R	2	0.5650	0.000	0.000
48230	14-215	177.90	MR	700	0.2550	0.000	0.000
48290	14-215	177.90	MR	160	0.0440	0.000	0.000
48345	14-215	177.90	MR	800	0.0870	0.000	0.000
48376	14-215	177.30	R	1	0.0700	0.000	0.000
48393	14-215	177.90	MR	220	0.0980	0.000	0.000
48414	14-215	177.90	MR	250	0.0680	0.000	0.000
48428	14-215	177.30	MR	100	0.0330	0.000	0.000
48458	14-215	177.30	MR	250	0.0290	0.000	0.000
48476	14-215	177.30	MR	800	0.0940	0.000	0.000
48487	HN-100	177.90	MR	480	0.2240	0.000	0.000
48723	14-215	177.90	MR	700	0.1370	0.000	0.000
48771	HN-100	135.80	R	75	0.9720	0.000	0.000
48822	14-215	177.30	MR	125	0.0230	0.000	0.000
48875	14-215	177.30	MR	125	0.0430	0.000	0.000
48895	14-215	163.30	R	12	0.0890	0.000	0.000
48966	14-215	177.90	MR	350	0.0590	0.000	0.000
48973	14-215	177.90	MR	1200	0.8130	0.000	0.000
48991	14-215	177.90	R	24	1.1680	0.000	0.000
49011	14-215	163.30	MR	180	0.0150	0.000	0.000
49123	HN-200	73.40	R	140	2.0820	70.507	0.000
** Subtotal **		17761.00					
** Shipper PSE&G-HOPE							
46478	14-190	170.80	MR	25000	0.1430	0.000	0.000
46550	14-210	194.10	MR	20	0.0200	0.000	0.000
46567	14-210	194.10	MR	180	0.0210	0.000	0.000
46594	14-210	194.10	MR	250	0.0180	0.000	0.000
46632	14-210	194.10	MR	250	0.0220	0.000	0.000
46754	14-210	194.10	MR	2	0.0340	0.000	0.000
46799	14-190	170.80	R	0	1.9850	0.000	0.000
46837	14-210	194.10	MR	700	0.0110	0.000	0.000
47035	14-215	194.10	R	1	0.0920	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit .2 x A1	Linr Vol If Limit 3 x A1
47051	14-210	194.10	R	2	0.0600	0.000	0.000
47062	14-215	206.10	R	2	0.0620	0.000	0.000
47085	14-215	206.10	MR	300	0.0070	0.000	0.000
47104	14-215	194.10	R	2	0.0740	0.000	0.000
47238	14-210	194.10	R	2	0.1360	0.000	0.000
47553	14-215	205.80	R	2	0.1440	0.000	0.000
47554	14-215	205.80	R	2	0.1420	0.000	0.000
47741	14-190	170.80	MR	45	2.4180	141.274	0.000
47799	14-215	205.80	R	2	0.1490	0.000	0.000
47803	14-215	205.80	MR	2000	0.1490	0.000	0.000
48003	14-215	205.80	MR	1200	0.0010	0.000	0.000
48288	14-215	205.80	MR	800	0.2280	0.000	0.000
48331	14-210	205.80	MR	1200	0.2950	0.000	0.000
48406	14-210	205.80	MR	300	0.1010	0.000	0.000
48439	14-210	205.80	R	2	0.3170	0.000	0.000
48502	8-120	120.30	R	30	11.8130	20.368	30.552
48516	14-215	206.10	MR	80	0.0030	0.000	0.000
48522	14-210	205.80	MR	800	0.1650	0.000	0.000
48528	8-120	120.30	R	170	11.7080	20.551	30.826
48539	8-120	120.30	R	70	10.3820	23.175	34.762
48565	8-120A	120.30	R	100	4.3500	55.316	82.974
48594	14-190	170.80	R	35	2.4860	137.388	0.000
48600	14-210	170.80	MR	2000	0.3800	0.000	0.000
48655	14-210	206.10	MR	300	0.0580	0.000	0.000
48732	8-120A	120.30	R	100	5.2140	46.147	69.220
49023	14-210	205.80	R	3	0.2710	0.000	0.000
** Subtotal **		6484.70					
** Shipper PSEG-SALEM							
46469	14-215	170.80	MR	3000	0.0260	0.000	0.000
46848	8-120	120.30	R	70	9.3790	25.654	38.481
47165	14-215	170.80	MR	4000	0.3350	0.000	0.000
47185	14-190	170.80	MR	26000	0.4640	0.000	0.000
47478	8-120A	120.30	R	7000	9.2170	26.104	39.156
47536	8-120	120.30	R	50	2.6450	90.951	0.000
47615	8-120	120.30	R	40	5.4950	43.782	65.673
47693	8-120A	120.30	MR	75000	14.1330	17.023	25.535
47848	8-120A	120.30	R	100	4.9370	48.734	73.101
48681	14-215	194.10	MR	3000	0.4010	0.000	0.000
48775	14-210	170.80	R	3	0.1930	0.000	0.000
49075	8-120	120.30	R	20	1.6470	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
** Subtotal **		1719.40					
** Shipper ROCH-GINNA							
46443	14-170	177.50	MR	60	0.0110	0.000	0.000
46751		607.70	MR	1	0.0110	0.000	0.000
47368	8-120	120.30	R	30	10.2090	23.567	35.351
** Subtotal **		905.50					
** Shipper SCE&G-SUMM							
46519	8-120	120.30	R	35	0.1520	0.000	0.000
46660	14-190	170.80	MR	0	0.0000	0.000	0.000
46698	8-120	120.30	R	0	4.1260	58.315	87.472
47628	14-170	131.60	R	2	0.1100	0.000	0.000
** Subtotal **		543.00					
** Shipper SCIENTIFIC							
47504.3		14.30	MR	600	0.0000	0.000	0.000
** Subtotal **		14.30					
** Shipper SYS-G GULF		2 liners (1 in 2) affected. Why?					
46584	14-210	199.40	MR	2000	0.1900	0.000	0.000
46628	14-210	199.40	MR	500	0.0640	0.000	0.000
46715	14-210	199.40	MR	5	0.0590	0.000	0.000
46948	14-210	199.40	MR	3	0.0780	0.000	0.000
47013	14-210	199.40	MR	500	0.0760	0.000	0.000
47196	14-210	199.40	MR	700	0.0710	0.000	0.000
47392	14-210	199.40	R	1	0.0440	0.000	0.000
47534	14-210	202.10	R	2	1.8970	0.000	0.000
47593	14-210	202.10	R	20	1.6190	0.000	0.000
-47640	14-210	202.10	MR	20000	2.2300	181.288	0.000
47655	1-136	14.60	R	8000	0.7890	0.000	0.000
-47810	14-210	202.10	R	20	2.2060	183.194	0.000
47965	14-210	199.40	R	1	0.1440	0.000	0.000
48002	14-210	199.40	MR	1000	0.0910	0.000	0.000
48067	14-210	199.40	MR	300	0.0260	0.000	0.000
48100	14-210	199.40	MR	200	0.0030	0.000	0.000
48108	14-210	199.40	MR	200	0.0830	0.000	0.000
48143	14-210	199.40	MR	150	0.0820	0.000	0.000
48209	14-210	199.40	R	3	0.2410	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit .2 x A1	Linr Vol If Limit 3 x A1
48238	14-210	199.40	R	2	0.2370	0.000	0.000
48269	14-210	199.40	MR	2000	0.2420	0.000	0.000
48292	14-210	199.40	MR	125	0.0020	0.000	0.000
48318	14-210	199.40	MR	150	0.0850	0.000	0.000
48371	14-210	199.40	MR	150	0.0780	0.000	0.000
48407	14-210	199.40	MR	150	0.0750	0.000	0.000
48425	14-210	199.40	MR	200	0.0760	0.000	0.000
48466	14-210	199.40	MR	200	0.0770	0.000	0.000
48485	14-210	199.40	MR	200	0.0780	0.000	0.000
48525	14-210	199.40	MR	150	0.0770	0.000	0.000
48533	14-210	199.40	MR	175	0.0770	0.000	0.000
48553	14-210	132.40	MR	15000	1.1710	0.000	0.000
48583	14-210	199.40	MR	200	0.0760	0.000	0.000
48607	14-210	132.40	MR	2000	1.1640	0.000	0.000
48647	14-210	199.40	MR	5000	0.2000	0.000	0.000
48669	14-210	132.40	MR	8000	1.1580	0.000	0.000
48727	14-210	199.40	MR	600	0.1210	0.000	0.000
48756	14-210	199.40	MR	600	0.0780	0.000	0.000
48783	14-210	199.40	MR	600	0.0770	0.000	0.000
48801	14-210	199.40	MR	200	0.0170	0.000	0.000
48824	14-210	199.40	MR	100	0.0160	0.000	0.000
48842	14-210	199.40	MR	100	0.0050	0.000	0.000
48872	14-210	199.40	MR	150	0.0210	0.000	0.000
48881	14-210	199.40	MR	800	0.0760	0.000	0.000
48913	14-210	199.40	MR	850	0.1190	0.000	0.000
48949	14-210	199.40	MR	800	0.1010	0.000	0.000
49127	14-210	199.40	MR	300	0.0070	0.000	0.000
** Subtotal **		8797.40					
** Shipper T ED-D BES							
47135	14-170	117.20	MR	1500	0.0640	0.000	0.000
47150	14-170	117.20	MR	80	0.0100	0.000	0.000
** Subtotal **		234.40					
** Shipper TVA-B FER							
46456	TV-55	170.80	MR	1000	0.1810	0.000	0.000
46480	TV-55	170.80	MR	1000	0.1650	0.000	0.000
46491	TV-83	120.30	MR	10000	1.3160	0.000	0.000
46501	TV-55	170.80	MR	1300	0.1650	0.000	0.000
46534	TV-55	170.80	MR	1300	0.1650	0.000	0.000
46543	TV-83	120.30	MR	10000	1.3160	0.000	0.000

No effect

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
46548	TV-55	170.80	MR	1000	0.1650	0.000	0.000
46570	TV-55	170.80	MR	700	0.1650	0.000	0.000
46588	TV-55	170.80	MR	800	0.1600	0.000	0.000
46617	TV-55	170.80	MR	70	0.1590	0.000	0.000
46624	TV-83	120.30	MR	8000	1.2350	0.000	0.000
46629	TV-55	170.80	MR	1000	0.1590	0.000	0.000
46663	TV-55	170.80	MR	12	0.1590	0.000	0.000
46680	TV-55	170.80	MR	20	0.2250	0.000	0.000
46758	TV-55	170.80	MR	20	0.2250	0.000	0.000
46764	TV-83	120.30	MR	10000	1.2350	0.000	0.000
46823	TV-83	120.30	R	9	1.3880	0.000	0.000
46828	TV-55	170.80	R	2	0.2250	0.000	0.000
46855	TV-55	170.80	MR	2000	0.2250	0.000	0.000
46897	TV-55	170.80	R	1500	0.3160	0.000	0.000
46908	TV-55	170.80	MR	150	0.3160	0.000	0.000
46947	TV-55	170.80	MR	15	0.3160	0.000	0.000
47022	TV-83	120.30	MR	1300	0.2260	0.000	0.000
47541	TV-55	170.80	MR	600	0.0800	0.000	0.000
47660	TV-55	170.80	MR	600	0.0800	0.000	0.000
47685	TV-55	170.80	R	1	0.2560	0.000	0.000
47755	TV-55	170.80	R	1	0.2920	0.000	0.000
47807	TV-55	170.80	R	1	0.2560	0.000	0.000
47872	758.10	758.10	MR	120	0.0210	0.000	0.000
47885	TV-55	170.80	MR	1000	0.2560	0.000	0.000
47938	TV-55	170.80	MR	3000	0.2460	0.000	0.000
47947	TV-55	170.80	MR	600	0.1510	0.000	0.000
48052	TV-55	170.80	R	2	0.1680	0.000	0.000
48068	TV-55	170.80	MR	500	0.1510	0.000	0.000
48163	TV-55	170.80	MR	500	0.1510	0.000	0.000
48213	TV-55	170.80	R	1	0.1440	0.000	0.000
48261	TV-55	170.80	MR	1800	0.2560	0.000	0.000
48275	TV-55	170.80	MR	1800	0.2560	0.000	0.000
48305	TV-55	170.80	MR	2000	0.2560	0.000	0.000
48322	TV-83	120.30	MR	4000	1.6870	0.000	0.000
48382	TV-55	170.80	R	2	0.2550	0.000	0.000
48423	TV-83	120.30	R	5	0.3710	0.000	0.000
48491	TV-45	194.10	R	2	0.2910	0.000	0.000
48500	TV-83	120.30	R	2	0.1830	0.000	0.000
48532	TV-45	194.10	MR	2000	0.1140	0.000	0.000
48577	TV-45	194.10	MR	450	0.1150	0.000	0.000
48593	TV-45	194.10	MR	1800	0.3820	0.000	0.000
48633	TV-45	194.10	MR	2000	0.3820	0.000	0.000
48695	TV-45	194.10	MR	1200	0.3820	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48749	TV-45	194.10	MR	700	0.3820	0.000	0.000
48797	TV-45	194.10	MR	250	0.0600	0.000	0.000
48840	TV-55	170.80	MR	300	0.0660	0.000	0.000
49025	TV-55	170.80	MR	400	0.0660	0.000	0.000
49036	TV-55	170.80	MR	400	0.0660	0.000	0.000
** Subtotal **		9542.40					
** Shipper TVA-SEQ — All OK							
46790	TVA-SNF	158.50	MR	12	0.1710	0.000	0.000
46909	TVA-SNF	158.50	MR	12	0.0060	0.000	0.000
46957	TVA-SNF	158.50	R	1	0.2560	0.000	0.000
47921	TVA-SNF	158.50	MR	1500	0.2320	0.000	0.000
48049	TVA-SNF	94.00	R	9	0.1230	0.000	0.000
48139	TVA-SNF	94.00	R	3	0.401[illegible]	0.000	0.000
48232	TVA-SNF	94.00	MR	90	0.023[illegible]	0.000	0.000
48264	TV-83	120.30	MR	20000	0.0070	0.000	0.000
48370	TVA-SNF	94.00	MR	9000	0.1380	0.000	0.000
48438	TVA-SNF	94.00	R	7	0.0900	0.000	0.000
48693	TVA-SNF	94.00	MR	4000	0.1480	0.000	0.000
48785	TVA-SNF	94.00	MR	3000	0.1750	0.000	0.000
48868	TVA-SNF	94.00	MR	3000	0.0480	0.000	0.000
** Subtotal **		1506.30					
** Shipper VA FW N AN — All OK							
46438	14-210	194.10	MR	2000	0.1220	0.000	0.000
46467	14-210	194.10	MR	2500	0.1310	0.000	0.000
46490	14-210	194.10	MR	15	0.0010	0.000	0.000
46539	14-210	194.10	MR	10	0.0000	0.000	0.000
46630	8-120	120.30	R	250	25.8190	9.319	13.978
~~46727~~	~~14-210~~	~~770.40~~	~~MR~~	~~2~~	~~0.0180~~	~~0.000~~	~~0.000~~
46760	14-210	194.10	MR	8	0.1020	0.000	0.000
46949	8-120B	120.30	R	0	8.6170	27.922	41.883
46974	14-210	194.10	R	7	0.0620	0.000	0.000
47012	8-120	120.30	R	400	32.1330	7.488	11.231
47139	14-210	194.10	MR	3000	0.1200	0.000	0.000
47216	14-210	194.10	MR	3000	0.0720	0.000	0.000
47302	14-210	194.10	MR	3000	0.0350	0.000	0.000
47395	14-210	194.10	MR	700	0.0270	0.000	0.000
47475	14-210	205.80	R	3	0.1640	0.000	0.000
47505	14-210	194.10	R	35	0.3020	0.000	0.000
47972	14-210	194.10	MR	2500	0.0740	0.000	0.000

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
48563	14-195	194.10	MR	700	0.0200	0.000	0.000
48645	14-210	202.10	MR	500	0.0370	0.000	0.000
48755	8-120B	120.30	R	100	20.2540	11.879	17.819
48800	8-120B	120.30	R	100	16.0050	15.033	22.550
49129	14-210	206.10	MR	600	0.2670	0.000	0.000
** Subtotal **		4509.20					
** Shipper VA PW-SUR		1 Affected					
46767	HN-200	28.00	R	15000	1.8020	0.000	0.000
46840	3-55	57.40	R	1500	79.1450	1.451	2.176
46857	3-55	57.40	R	2600	94.4370	1.216	1.823
46933	14-170	158.10	MR	80	0.3010	0.000	0.000
47010	3-55	57.40	R	4700	386.3470	0.297	0.446
47020	3-55	57.40	R	3130	203.9210	0.563	0.844
47535	14-195	158.10	R	9	0.5780	0.000	0.000
47653	14-195	158.10	R	2	0.1190	0.000	0.000
47668	14-195	158.10	R	12	0.5640	0.000	0.000
47855	14-170	158.10	MR	3000	0.0450	0.000	0.000
48217	14-190	158.10	R	25	1.0600	0.000	0.000
48278	10-142	135.80	R	30	0.5640	0.000	0.000
48484	14-190	135.80	R	75	5.6710	47.697	71.845
48679	14-170	158.10	R	2	0.0400	0.000	0.000
48697	14-170	158.10	R	2	0.0720	0.000	0.000
48729	8-120	83.40	R	10	0.5030	0.000	0.000
49031	14-170	158.10	R	3	0.1800	0.000	0.000
49054	14-170	158.10	MR	3000	0.1310	0.000	0.000
** Subtotal **		2193.60					
** Shipper VA TECH IN							
46786.4		3.30	MR	4	0.0000	0.000	0.000
** Subtotal **		3.30					
** Shipper VT YANKEE							
46755	14-170	158.10	MR	22	0.2980	0.000	0.000
46845	14-170	158.10	R	0	1.0820	0.000	0.000
46927	14-170	158.10	MR	65	0.7660	0.000	0.000
46996	14-170	158.10	MR	18	0.9090	0.000	0.000
47075	14-170	158.10	MR	1000	0.0970	0.000	0.000
47175	14-170	170.00	MR	400	0.0470	0.000	0.000
47321	14-170	158.10	MR	5000	0.6170	0.000	0.000

09/18/88

Sum of the Fractions Report

AS No.	Cask Type	Volume (Cubic Feet)	DR CD	Liner Dose Rate	Sum of Fractions	Linr Vol If Limit 2 x A1	Linr Vol If Limit 3 x A1
47382	HN-200	73.40	R	36	2.4030	61.090	0.000
47691	14-170	158.10	R	8	0.7210	0.000	0.000
48147	14-170	158.10	MR	1000	0.1050	0.000	0.000
48361	14-170	158.10	R	1	0.0830	0.000	0.000
48625	14-170	158.10	MR	3000	0.3440	0.000	0.000
48828	14-170	158.10	R	3	0.0430	0.000	0.000
48943	14-170	158.10	MR	3000	0.3700	0.000	0.000
49020	14-170	158.10	R	5	0.4950	0.000	0.000
49066	14-190	170.80	R	50	4.4720	76.390	114.586
** Subtotal **		2469.50					
** Shipper WEPCO							
46533	14-170	131.60	MR	320	0.0070	0.000	0.000
47580	21-300	157.50	R	3	0.0670	0.000	0.000
47586		660.00	MR	85	0.0080	0.000	0.000
47743	14-170	177.50	MR	200	0.1750	0.000	0.000
47744	14-170	177.50	MR	60	0.1750	0.000	0.000
47795	14-170	177.50	MR	110	0.0650	0.000	0.000
48357	14-170	177.50	R	7	1.2620	0.000	0.000
48621	14-170	177.50	MR	2500	0.8790	0.000	0.000
49114	8-120	125.20	R	25	10.1630	24.638	36.958
** Subtotal **		1961.80					
** Shipper WIS PUB							
46603	14-190	158.10	MR	7000	0.3500	0.000	0.000
47337	14-190	158.10	MR	17000	4.6150	68.510	102.765
47425	14-195	114.90	R	1	0.2190	0.000	0.000
47632	14-190	158.10	R	25	6.0010	52.694	79.042
** Subtotal **		589.20					
*** Total ***		235129.40					

EFFECT OF THE PROPOSED ADOPTION OF THE INTERNATIONAL ATOMIC ENERGY AGENCY REGULATIONS, 1985 REVISION, ON THE U.S. RADIOACTIVE WASTE TRANSPORTATION INDUSTRY

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ABSTRACT

The Nuclear Regulatory Commission (NRC) is proposing changes to 10 CFR 71 transportation regulations to achieve compatibility with the 1985 IAEA regulations. The intent of these changes is to be more compatible with the international standard on shipping containers, package requirements, and performance criteria. The NRC has, however, modified part of its regulations to restrict the packaging of LSA by limiting the total activity rather than adopting the IAEA standard.

This paper addresses how the proposed regulations will affect the low-level radioactive waste transportation industry. It describes the impacts on the transportation industry in three major areas - IAEA consistency, economic impact, and risk assessment. Available transport data from the Barnwell disposal site was used in the analysis of the proposed changes. The impacts addressed include possible increased radiation exposures, transportation risks and liability, transportation and processing costs, and waste disposal costs resulting in little health and safety benefit. Although the health and safety benefits of any change to the current regulations are minimal, suggested alternatives to the proposed regulations are discussed that more closely conform with the international standards while still maintaining health and safety.

INTRODUCTION

The Nuclear Regulatory Commission and the Department of Transportation are proposing changes to the regulations governing the transportation of low level radioactive waste (LLW). The NRC regulates the transport of greater than Type A quantities of radioactive material according to Title 10 Code of Federal Regulations Part 71. The Department of Transportation regulates the transport of all radioactive material according to Title 49 of the Code of Federal Regulations. Both regulatory bodies are preparing rulemaking to be more consistent with the 1985 International Atomic Energy Agency (IAEA) regulations, Safety Series #6.

Many changes are proposed in the new rulemaking. However, this paper focuses on the LSA limit proposed by the NRC and its effect on the LLW transportation industry. Other proposed changes affecting the transport of LLW include the redefinition of LSA, modifying and expanding the list of A1 and A2 values to meet the IAEA standards, and changing the regulatory authority for NRC licensed Type A casks from the NRC to the DOT. Enforcement of the proposed

2A1 LSA limit regulation is scheduled for one year from the regulation's implementation.

This paper reviews the proposed 2A1 LSA limit, describes three studies performed by Chem-Nuclear to evaluate the 2A1 value proposed by the NRC, reviews the draft EPRI economic report, addresses the Sandia LSA risk report, and recommends solutions derived from the studies to conform with the IAEA regulations. The three studies, performed by Chem-Nuclear in 1988, focus on the the NRC consistency with the IAEA standard.

The first study was an evaluation to determine what multiple of A1 is equal to the IAEA standard of 1 rem/hr at 3 meters from the unshielded LSA material assuming Co-60 to be the only radionuclide in the waste. The second study was an evaluation of the 2A1 limit using the dose rates from a select sample of 50 shipments made to the Barnwell Waste Management Facility (BWMF) and computer shielding equations. The third study was an evaluation of over 500 potentially affected cask shipments made to the BWMF over one a year period to determine the equivalent A1 limit based on the recorded and calculated unshielded liner dose rates using correlation factors and statistical analysis. These studies and their results are described in detail.

PROPOSED REGULATORY CHANGES

Transportation of radioactive material is regulated by the NRC in Title 10 Code of Federal Regulations (CFR) Part 71 regulations and by the Department of Transportation in the Title 49 regulations. The NRC regulations apply only to greater than Type A quantities of radioactive material. Current regulations require that greater than Type A quantities of low specific activity radioactive material consigned "exclusive use" be transported in an NRC licensed cask which meets Type A performance standards. No limitations are placed on the inner container's radiation doses.

One of the objectives of the U.S. nuclear industry and the regulatory agencies is to be consistent with the international standards. The International Atomic Energy Agency has developed standards with input from the United States. Their regulations are listed in the 1985 IAEA Safety Series #6 document. The U.S.DOT and NRC are preparing rulemaking to be more consistent with these regulations.

One proposed change with potential impact to the low level radioactive waste (LLW) transportation industry is the restriction of LSA through dose rate or total activity limits. The IAEA regulations require an unshielded LSA container radiating more than 1 rem/hr at 3 meters to be placed in a Type B cask. Only six Type B casks licensed by the NRC for the transport of processed waste are available in the U.S. industry. A majority of the processed waste material is shipped in NRC licensed Type A casks. The NRC authorizes the transport of LSA material which contains a total activity greater than A2 in Type A casks if the material is consigned exclusive use.

The NRC proposed rulemaking (NRC 1988) provides an alternative to the IAEA restriction of 1 rem/hr at 3 meters by limiting the total radionuclide activity. Current regulations identify activity limits signified by A1 and A2 values for each radionuclide. A1 values (for special form material) and A2 values (for normal form material) are used to determine the activity limits in

packages. Due to the industry's difficulty in complying with the 1 rem/hr at 3 meter radiation level standard, the NRC chose not to adopt the IAEA dose rate limit but proposed a multiple of the A1 value as the limit to meet the objective. Proposed rulemaking suggests that a total activity limit of 2x revised A1 value would equal the IAEA limit of 1 rem/hr at 3 meters from the unshielded LSA material. No information was provided on how the 2xA1 limit was derived. The NRC staff position stated that it was a close approximation of the IAEA standard.

ANALYSIS OF 2A1 LIMIT

Chem-Nuclear Systems evaluated how closely the 2x the revised A1 limit approximates the 1 rem/hr at 3 meters IAEA standard as it applies to LLW packages (Anderson 1988). The relationship of activity to dose rate depends on numerous factors including the type and quantity of radionuclides, material self-attenuation, and container volume. Actual LLW shipment data was used to analyze the impact of the proposed regulation change on the current LLW transportation industry.

Three studies were performed by CNSI to analyze the relationship. The data was compiled from records obtained at the Barnwell Waste Management Facility operated by Chem-Nuclear. The data reflects cask shipments during a twelve month period in 1987 and 1988. The data includes unshielded dose rate, waste material, radionuclide type, and concentration. This data and radiation shielding programs were used in the three studies with the results summarized in the table below.

The first study involved theoretical calculations of the multiple of A1 equivalent to 1 rem/hr at 3 meters. Since the Co-60 isotope is the predominant contributor in LLW dose through the walls of a shielded cask, a theoretical calculation of the surface dose and corresponding 3 meter dose was made using Co-60 only. The MICROSHIELD computer program (Grove, 1987) was used to calculate dose rate values and the A1 equivalent for a 200 cu.ft. disposal liner. The proposed A1 value of 10.4 curies for Co-60 was assumed. Based on limitations of 1 rem/hr at 3 meters and the density of resin waste, a multiple of the A1 was calculated to be 3.52. Dewatered resin waste was used in this analysis as the most conservative waste form. A limit of 3.52A1 is 76% greater than the 2A1 value proposed by the NRC and would allow a correspondingly greater activity content in the LSA package without exceeding the dose limit established by the IAEA.

The second study involved data from 50 representative shipments received at the BWMF. The 50 shipments involved six different cask/liner types containing either solidified or dewatered resins. Solidified and dewatered resins waste forms were used in this study because they represent the type wastes that might be affected by the NRC's proposed change. The multiple of A1 for each shipment ranged from 0.18 to 21 with an average of 4.27. The Microshield computer program was again used to determine the theoretical dose rate from the unshielded LSA material based on the specific radionuclide mix. The average multiple of A1 that corresponded to a dose rate of 1 rem/hr at 3 meters was calculated. This study showed an average A1 value of 2.73 with a standard deviation of $\pm$ 1.37. The data showed little correlation between activity and dose rate as indicated by a correlation factor or R squared equal to -0.2.

The third study involved the use of radiation dose and isotopic concentration data for over 500 shipments. Only cask shipments received at the BWMF spanning one year in 1987 and 1988 containing either solidified or dewatered resins were used. Data reflecting the measured container dose rate on contact recorded by the shipper, isotopic quantity and type were input into a computer program. The multiple of A1, again, based on the proposed A1 limits was calculated for each shipment. A normalization formula was used to relate a value of A1 to a dose rate at 3 meters. The statistical average A1 multiple calculated was 3.72 with a standard deviation of ± 2.57. A plot of the data showed little correlation between total activity and dose rate on radioactive waste packages.

CALCULATED A1 VALUE EQUIVALENT
TO THE IAEA STANDARD OF 1 REM/HR AT 3 METERS

		xA1	± Standard Deviation
Case 1 -	All Co-60 In Waste (Theoretical)	3.52	
Case 2 -	Select Cases Using Microshield Calculations (50+ Cases - Theoretical)	2.73	± 1.37
Case 3 -	Database of 1987/1988 Shipment Records (500+ Cases - Experimental)	3.72	± 2.57
NRC Proposed Value		2.0	

ECONOMIC IMPACT

Chem-Nuclear's analysis indicates an additional 300-600% increase in Type B processed waste shipments (i.e solidified or dewatered resins) will be made in order to comply with the proposed 2A1 LSA limit. There are approximately 20-30 processed waste shipments made each year to the BWMF that are required to be shipped in Type B casks. There are many more shipments made in Type B casks that are only require an NRC Type A cask. Type B casks are often scheduled and used prior to processing of the waste and an evaluation of the type package needed. The 2A1 limit will increase the number of Type B processed waste shipments to 90-120. Since the six(6) current Type B casks are utilized approximately 70% of the time, there be a shortage of available Type B casks and an additional 8 to 16 new casks will need to be manufactured to service the industry. Historically, design, licensing and manufacturing of new Type B casks take 3-4 years.

Disposal volumes and associated costs will also increase. As the higher volume Type A cask shipments are required to be shipped in the lower volume Type B casks, disposal volumes increase. Each disposal liner is not filled to the maximum to prevent spillage during processing and the burial volume on each liner is greater than the fill volume. If, for example, the waste

currently transported in 200 cu.ft. Type A casks is transported in 120 cu.ft. Type B casks due to the proposed 2A1 limit, it would take 1.7 Type B shipments to transport a Type A shipment. The disposal volume increase is 2% due to the inefficiency of processing smaller volume packages. Other associated disposal costs assessed by shipment that will increase due to an increase in the number of shipments include cask handling and curie surcharges that are assessed in activity ranges. The curie surcharge assessments favor a lower number of high volume, high activity shipments rather than a greater number of lower volume, medium to high activity shipments.

Adoption of the NRC proposed regulations will economically impact the U.S. nuclear industry by $4 to $5 million per year according to EPRI (Daloisio 1988). EPRI's study utilized shipping information from a 1985/1986 database. The study evaluated solidified and dewatered primary and non-primary resin from BWRs and PWRs that were transported in three different casks. The $4 to $5 million impact identified in this study is the direct cost increase in package use, transportation, and disposal. The study did not evaluate the cost of new equipment (i.e., cask and trailer) design, licensing, and manufacture.

RISK ASSESSMENT

Sandia National Laboratories was contracted by the U.S. Department of Transportation and the Department of Energy to evaluate the impacts of the United States adopting the IAEA standards associated with LSA and the 1 rem/hr at 3 meters from the unshielded cask restriction. In their risk assessment (Ostmeyer et al. 1988), they assumed the worse case scenerio of high radiation level LSA waste, dewatered spent resin, with a specific activity at the existing regulatory limit (0.3 mCi/g). Although Sandia used the worst case scenerio for their risk assessment, they commented that in the typical accident the radioactivity levels are likely to be orders of magnitude less than those assumed for their calculation and a release of 100% of the waste material is unlikely. They assessed the radiological impacts and risks in the event of a highway accident. Some of their conclusions are:

* "... current LSA limitations are sufficient to prevent excessive external radiation exposure to an individual following a severe transportation accident. Although package dose-rate restrictions could provide a higher level of confidence that external radiation doses are not excessive, these restrictions would have a substantial impact on shipping practices and costs for transportation of LSA material."

* "Additionally, because the package dose-rate restrictions would substantially increase the number of shipments, the number of traffic fatalities and injuries from accidents involving transportation of waste materials would also rise."

We agree with these qualitative conclusions. However, one of the risks that Sandia did not address is the increased dose to the worker at the nuclear facilities while processing and preparing to transport the additional shipments that will result if either the 2A1 or 1 rem/hr at 3 meter restriction is invoked by the NRC. The proposed, more restrictive limit, will

lead to more shipments, higher risk of accidents, higher costs for transportation and disposal, and a higher dose to radiation workers.

CONCLUSION

Based on Chem-Nuclear's analysis two conclusions were reached.

1) There is no close correlation between waste activity (multiple of A1) and unshielded dose rate (1 rem/hr at 3 meters). The activity of alpha and beta emitters have no bearing on the external dose rate, but would restrict the package using an activity limit.

2) If an activity limit is to be used, a limit of 3.4A1 for gamma emitting radionuclides is closer to the IAEA standard of 1 rem/hr at 3 meters than the proposed 2A1 limit for LSA.

Based on these conclusions, it is doubtful that the objective of consistency with the IAEA regulations will be achieved using a 2A1 activity limit. The 1 rem/hr at 3 meters dose limit, while being consistent with the IAEA standards, also has its negative factors including ALARA concerns and the inability to determine classification and compliance prior to waste package preparation.

Chem-Nuclear is continuing to study these impacts to determine the need for additional Type B shipping casks, since many LSA shipments previously made in NRC Type A casks will now require NRC Type B casks. Since Type B casks are more expensive to use per day and typically have a smaller capacity, the proposed change will result in more liners processed, more shipments made, and higher burial costs. Type B casks will be harder to secure and more expensive to use in the future if and when the proposed regulations are implemented.

Sandia's risk analysis has concluded that any change to the current regulations would be costly with little health and safety benefit. EPRI has proposed a possible cost to the industry of $4 to $5 million per year. Many other independent studies were conducted by industry groups and shippers. At the time this paper was prepared comments on this proposed regulation change are being solicited and accepted by the NRC. Once adopted, the regulations have a one year implementation period. Comments and preparations should be made by the affected LLW industry on this major regulatory change.

REFERENCES

Anderson, R. Compiled Evaluation Of Type B-LSA Cask Shipping Requirements Under New NRC/IAEA Rules; CNSI 661-246U-88; 1988

Daloisio, G.S. Evaluation Of Proposed NRC Changes In Determining LSA, Type A and Type B Transportation Classification; EPRI RP2414-10; 1988

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Nuclear Regulatory Commission. Transportation Regulations; Compatibility With The International Atomic Energy Agency (IAEA); Proposed Rule; Federal Register, Vol.53, No.110; June 8, 1988: 21550-21581.

Ostmeyer, R.M.; Finley, N.C.; Cashwell, J.W.; McClure, J.D. The Potential Consequences and Risks Of Highway Accidents Involving Gamma-Emitting Low Specific Activity (LSA) Waste. Sandia Report; SAN87-2808; 1988.

CHEM-NUCLEAR SYSTEMS, INC.

220 Stoneridge Drive • Columbia, South Carolina 29210

February 8, 1990

Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
Attn: Docketing and Service Branch

Re: Proposed Rule, Federal Register, Wednesday, June 8, 1988

Dear Secretary:

The following and the enclosed are Chem-Nuclear Systems' comments concerning the proposed rule, "Transportation Regulations; Compatibility With the International Atomic Energy Agency (IAEA)", published in the Federal Register on Wednesday, June 8, 1988.

In summary, the proposed rule did, in most cases, achieve a level of compatibility with the regulations of the International Atomic Energy Agency, thus facilitate international commerce, and will increase the overall level of safety as it relates to the transportation of radioactive material. Those areas addressed by the proposed rule that have been in need of revision, are well received, and have Chem-Nuclear's support include:

* Documenting the timely renewal system for certificates of compliance and quality assurance programs as proposed in 71.38.

* Changing the activity value at which advance notification is required of a shipment of nuclear waste to coincide with the Department of Transportation's highway route controlled quantity value as proposed in 71.97. This proposed rule will lead to less shipper confusion when shipping higher activity waste.

* Expansion of and revision to the A1/A2 values as proposed in 71 Appendix A-1.

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Also enclosed, are a number of comments in areas of concern to Chem-Nuclear. Because of the extent of our comments and concerns, as well as, comments and concerns of our customers and many other shippers of radioactive material, Chem-Nuclear believes it is necessary for the Nuclear Regulatory Commission to revised this proposed rule and publish a second set of proposed rules for another series of comments before publishing a final rule based solely on this first set of comments.

As always, Chem-Nuclear appreciates the opportunity to be a part of this rulemaking process that establishes the safe system of radioactive material transportation. If you need further clarification concerning any of these comments, please contact us.

Sincerely,

CHEM-NUCLEAR SYSTEMS, INC.

Mark S. Lewis
Radiological Engineer

MSL/nhs

Enclosures

COMMENTS CONCERNING THE 10 CFR 71 PROPOSED REGULATION CHANGES

1. Department of Transportation (DOT) References, 10 CFR 71.5

Many of the NRC regulations continue to be a duplication of the Department of Transportation (DOT) regulations. All DOT regulations that are applicable to NRCD regulated quantities for transportation purposes need to be incorporated by Reference in 71.5.

Specifically, the regulations that listed below are a duplicate of the DOT regulations or so similar that the majority can be incorporated by reference with the differences identified:

NRC Reference	DOT Equivalent
10 CFR Part 71.41	49 CFR Part 173.461
71.43	173.412
71.45	173.411
71.47	173.441
71.52	173.453
71.71	173.412, 465, 466
71.75, 77	173.469
71.87	173.441, 442, 443, 475
71 App A	173.443, 435

Incorporating the regulations by reference to DOT will eliminate the problems that have occurred in the past and may again occur in the future with a change by one agency resulting in conflicting regulations until such time the other agency can make the similar change.

2. LSA-I Definition, 10 CFR 71.4

The new definition of LSA-I that includes a consideration for decommissioning/decontamination waste (LSA-I (iv)) is too restrictive to include a majority of the uranium mill tailings that are currently being transported in bulk, unpackaged. The LSA-I limit for contaminated earth needs to be 4e-6 A2/g, in order to ship mill tailings bulk, or mill tailings needs to be included as LSA-I by definition, such as the ores (LSA-I (i)).

Mill tailings are not:

* ores as defined for LSA-I (i),

* solid unirradiated natural or depleted uranium or natural thorium as defined for LSA-I (ii), or

* radioactive material with an unlimited A2 value as defined for LSA-I (iii).

Some mill tailings can be shipped according to definition LSA-I (iv) as contaminated earth having a concentration less than 1e-6 A2/g which equates to approximately 552 pCi/g total. Some of the mill tailings that are being transported from mill site to storage location to disposal are in concentrations up to 1000 pCi/g total. Radium 226 and Thorium 230, the most restrictive isotopes, effect the sum-of-the-fractions in such a manner that simply doubling the concentration limit will not allow a majority of the tailings to be classified as LSA-I. In order for the majority of mill tailings to be classified as LSA-I and be shipped in bulk, ie. unpackaged in a dump truck style vehicle with a canvas top to complete the closed transport requirements, then the LSA-I (iv) limit for contaminated earth needs to be increased to 4e-6 A2/g.

If the industry is to be allowed by the DOT to continue the current bulk transport practice of all mill tailings, the regulations need to reflect that acceptance by modifying the concentration limits of the LSA-I (iv) definition or identifying mill tailings as LSA-I by definition without an activity or concentration limit.

3. Purpose and Scope, 10 CFR 71.0(a)(2)

It seems more appropriate to identify in the "Purpose and Scope" NRC requirements by type of packaging rather than quantity of material. Specifically, the part of the sentence "...in excess of a Type A quantity." could be replaced with "...required by this Part to be transported in a Type B packaging." and NRC's jurisdiction would be better defined.

The following statement in the Federal Register notice in the section titled Discussion of Major Changes under the heading Updating of Requirements for Shipment of LSA Material helps to reenforce the fact that NRC's enforcement is over licensed material required to be transported in Type B packagings.

> "This action, if adopted, would have the effect of raising the threshold level of radioactivity at which NRC regulates shipments of LSA radioactive material from the Type B quantity level to the level at which Type B packages are required."

The other material regulated by the NRC is also required to be transported in a Type B packages, ie. materials in excess of a Type A quantity or is specifically identified, ie. fissile material.

4. Acceptance Criteria for Packages Subject To The Normal Conditions Of Transport Conditions 10 CFR 71.43(f) and 71.51(a)(1)

There needs to be a measurable acceptance criteria for packages subject to the normal conditions of transport conditions. The IAEA recommended criteria of up to 20 percent increase in external radiation levels as a result of subjecting the package to the normal conditions of transport is a criteria that needs to be considered.

The criteria "no significant increase" has historically been interpreted as "no increase". By defining "significant" the package designing engineer and the NRC review engineer have a measurable goal for the design and review that is not only compatible with the IAEA, but is consistent with engineering practice.

With the United States of America being a Member State of the International Atomic Energy Agency (IAEA) there should be an obligation to fully adopt the IAEA standards. If the NRC feels the IAEA standards are inappropriate, as a member, the NRC should lobby for a change in the international standard rather than develop inconsistent rules.

5. Environmental Impacts, Preamble of the Proposed Regulations

The significant environmental impacts in terms of the person-rem are associated with these proposed regulations. Through an extensive study (discussed in detail below) of high specific activity LSA waste shipments made to the Barnwell Waste Management Facility during the second half of 1987 and the first half of 1988, it is estimated that additional processing and shipping by generators will increase total person-rem over 10 rem/y.

The Type B packages that have been available for shipping have a smaller payload volume than the 200 cubic feet packages that are commonly used to transport the high specific activity LSA waste. For every three of the 200 cubic feet Type A packages that exceed the 2 x A1 LSA limit there will have to five of the approximately 120 cubic feet packages processed and transported for disposal.

During the time period analyzed there were over 40 LSA shipments in the 200 cubic feet size NRC Type A casks that exceeded the 2 x A1 limit. These shipments that exceeded the 2 x A1 limit will have to be transported in Type B

casks according to the proposed rule. With the ratio of 5 to 3, there will be over 20 additional packages to process and ship. With exposures approximately 0.5 person rem/shipment, there will be an increase of over 10 person-rem/year. If shippers choose to reduce the volume of the waste in order to achieve a less than 2xA1 industrial package shipment, the number of packages being processed and total number of shipments could be as high as 50 increasing exposures to as high as 25 person-rem/year.

6. Reports, 10 CFR 71.95(c)

The new reporting criteria needs to be more specific than is indicated by "Instances in which the conditions of approval in the certificate of compliance were not observed in making a shipment."

Most if not all of the cask Certificate of Compliances reference a set of handling procedures prepared by the license holder that has many very minor conditions of handling that if unobserved while shipping have no safety significance; ie. lute on a bolt, dual department seals, or a signature by the manager rather than the director.

7. LSA With Greater Than 2xA1 in Type B Packagings

Based on an analysis, Chem-Nuclear came to two conclusions concerning the proposed 2xA1 limit on LSA in non-Type B packagings:

* There is no close correlation between waste activity (multiple of A1) and unshielded dose rate (1 rem/hr at 3 meters). The activity of alpha and beta emitters have no effect on the external dose rate, but would restrict the package using an activity limit.

* If an activity limit is to be used, a limit of 3.4A1 for gamma emitting radionuclides is closer to the IAEA standard of 1 rem/hr at 3 meters than the proposed 2A1 limit for LSA.

Clearly, the proposed rule is not consistent with the IAEA regulations. However, consistency with the IAEA regulations for the transport of LSA material is unnecessary. Since LSA material is rarely if ever transported internationally, no change to the current regulations is required. Current regulations have historically proven to be sufficient to protect the public health and safety and, without a recorded accident resulting in a release of radioactivity, emergency responders are at little if any risk.

ANALYSIS OF 2A1 LIMIT

Chem-Nuclear Systems evaluated how closely the 2x the revised A1 limit approximates the 1 rem/hr at 3 meters IAEA standard as it applies to LLW packages (Anderson 1988). The relationship of activity to dose rate depends on numerous factors including the type and quantity of radionuclides, material self-attenuation, and container volume. Actual LLW shipment data was used to analyze the impact of the proposed regulation change on the current LLW transportation industry.

Three studies were performed by CNSI to analyze the relationship. The data was compiled from records obtained at the barnwell Waste Management facility operated by Chem-nuclear. The data reflects cask shipments during a twelve month period in 1987 and 1988. The data includes unshielded dose rate, waste material, radionuclide type, and concentration. This data and radiation shielding programs were used in the three studies with the results summarized in the table below.

The first study involved theoretical calculations of the multiple of A1 equivalent to 1 rem/hr at 3 meters. Since the Co-60 isotope is the predominant contributor in LLW dose through the walls of a shielded cask, a theoretical calculation of the surface dose and corresponding 3 meter dose was made using Co-60 only. The MICROSHIELD computer program (Grove, 1987) was used to calculate dose rate values and the A1 equivalent for a 200 cu.ft. disposal liner. The proposed A1 value of 10.4 curies for Co-60 was assumed. Based on limitations of 1 rem/hr at 3 meters and the density of resin waste, a multiple of the A1 was calculated to be 3.52. Dewatered resin waste was used in this analysis as the most conservative waste form. A limit of 3.52A1 is 76% greater than the 2A1 value proposed by the NRC and would allow a correspondingly greater activity content in the LSA package without exceeding the dose limit established by the IAEA.

The second study involved data from 50 representative shipments received at the Barnwell Waste Management Facility (BWMF). The 50 shipments involved six different cask/liner types containing either solidified or dewatered resins. Solidified and dewatered resins waste forms were used in this study because they represent the type wastes that might be affected by the NRC's proposed change. The multiple of A1 for each shipment ranged from 0.18 to 21 with an average of 4.27. The Microshield computer program was again used to determine the theoretical dose rate from the unshielded LSA material based on the specific radionuclide mix. The average multiple of A1 that corresponded to a dose rate of 1 rem/hr at 3 meters was calculated. This study showed an average A1 value of 2.73 with a standard deviation of +/-

1.37. The data showed little correlation between activity and dose rate as indicated by a correlation factor or R squared equal to -0.2.

The third study involved the use of radiation dose and isotopic concentration data for over 500 shipments. Only cask shipments received at the BWMF spanning one year in 1987 and 1988 containing either solidified or dewatered resins were used. Data reflecting the measured container dose rate on contact recorded by the shipper, isotopic quantity and type were input into a computer program. The multiple of A1, again, based on the proposed A1 limits was calculated for each shipment. A normalization formula was used to relate a value of A1 to a dose rate at 3 meters. The statistical average A1 multiple calculated was 3.72 with a standard deviation of +/- 2.57. A plot of the data showed little correlation between total activity and dose rate on radioactive waste packages.

CALCULATED A1 VALUE EQUIVALENT TO THE IAEA STANDARD OF 1 REM/HR AT 3 METERS

		xA1	+/- Standard Deviation
Case 1 -	All Co-60 in waste (theoretical)	3.52	
Case 2 -	Select Cases Using Microshield Calculations (50+ Cases - Theoretical)	2.73	+/- 1.37
Case 3 -	Database of 1987/1988 Shipment Records (500+ Cases - Experimental)	3.72	+/- 2.57
NRC Proposed Value		2.00	

ECONOMIC IMPACT

Chem-Nuclear's analysis indicates an additional 300-600% increase in Type B processed waste shipments (i.e. solidified or dewatered resins) will be made in order to comply with the proposed 2A1 LSA limit. There are approximately 20-30 processed waste shipments made each year to the BWMF that are required to be shipped in Type B casks. There are many more shipments made in Type B casks that are only require an NRC type A cask. Type B casks are often scheduled and used prior to processing of the waste and an

evaluation of the type package needed. The 2A1 limit will increase the number of Type B processed waste shipments to 90-1209. Since the six (6) current vendor available Type B casks are utilized approximately 70% of the time, there will be a shortage of available Type B casks and an additional 8 to 16 new casks will be needed to be manufactured to service the industry. Historically, design, licensing and manufacturing of new Type B casks could take years.

Disposal volumes and associated costs will also increase. As the higher volume Type A cask shipments are required to be shipped in the lower volume Type B casks, disposal volumes increase. Each disposal liner is not filled to the maximum to prevent spillage during processing and the burial volume on each liner is greater than the fill volume. If, for example, the waste currently transported in 200 cu.ft. Type A casks is transported in 120 cu.ft. Type B casks due to the proposed 2A1 limit, it would take 1.7 Type B shipments to transport a Type A shipment. The disposal volume increase is 2% due to the inefficiency of processing smaller volume packages. Other associated disposal costs assessed by shipment that will increase due to an increase in the number of shipments include cask handling weight and curie surcharges that are assessed in activity ranges. The curie surcharge assessments favor a lower number of high volume, high activity shipments rather than a greater number of lower volume, medium to high activity shipments.

Adoption of the NRC proposed regulations will economically impact the U.S. nuclear industry by $4 to $5 million per year according to EPRI (Daloisio 1988). EPRI's study utilized shipping information from a 1985/1986 database. The study evaluated solidified and dewatered primary and non-primary resin from BWRs and PWRs that were transported in three different casks. The $4 to $5 million impact identified in this study is the direct cost increase in package use, transportation, and disposal. The study did not evaluate the cost of new equipment (i.e., cask and trailer) design, licensing, and manufacture.

RISK ASSESSMENT

Sandia National Laboratories was contracted by the U.S. Department of Transportation and the Department of Energy to evaluate the impacts of the United States adopting the IAEA standards associated with LSA and the 1 rem/hr at 3 meters from the unshielded cask restriction. In their risk assessment (Ostmeyer et al. 1988), they assumed the worse case scenario of high radiation level LSA waste, dewatered spent resin, with a specific activity at the existing regulatory limit (0.3 mCi/g). Although Sandia used the worst case scenario for their risk assessment, they commented that in the typical accident the radioactivity

levels are likely to be orders of magnitude less than those assumed for their calculation and a release of 100% of the waste material is unlikely. They assessed the radiological impacts and risks in the event of a highway accident. Some of their conclusions are:

* "...current LSA limitations are sufficient to prevent excessive external radiation exposure to an individual following a severe transportation accident. although package dose-rate restrictions could provide a higher level of confidence that external radiation doses are not excessive, these restrictions would have a substantial impact on shipping practices and costs for transportation of LSA material."

* "Additionally, because the package dose rate restrictions would substantially increase the number of shipments, the number of traffic fatalities and injuries from accidents involving transportation of waste materials would also rise."

We agree with these qualitative conclusions. However, one of the risks that Sandia did not address is the increase dose to the worker at the nuclear facilities while processing and preparing to transport the additional shipments that will result if either the 2A1 or 1 rem/hr at 3 meter restriction is invoked by the NRC. The proposed, more restrictive limit, will lead to more shipments thus a higher risk of accidents, higher costs for transportation and disposal, and a higher dose to radiation workers.

8. <u>Simplification of Fissile Material Classes, 10 CFR 71.55</u>

Although the proposed rule does begin to simplify the system of shipping fissile material, most of the difficulties still exist. A system of performance-oriented packaging needs to be developed to reduce the current complexity of the design-oriented package choices.

CHEM-NUCLEAR SYSTEMS, INC.

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February 8, 1990

Dockets Unit
Office of Hazardous Material Transportation, DHM-30
U.S. Department of Transportation
Washington, DC 20590

Re: Docket Number HM-169A

Dear Dockets Unit:

The following and the enclosed are Chem-Nuclear Systems' comments concerning the proposed rule, Docket Number HM-169A, "Transportation Regulations; Compatibility With the Regulations of the International Atomic Energy Agency", published in the Federal Register on Tuesday, November 14, 1989.

In summary, the proposed rule did, in most cases, achieve a level of compatibility with the regulations of the International Atomic Energy Agency, thus facilitate international commerce, and will increase the overall level of safety as it relates to the transportation of radioactive material. Those areas addressed by the proposed rule that have been in need of revision, are well received, and have Chem-Nuclear's support include:

* Minimum design requirements for radioactive material packages as proposed in 173.410. These standards will increase the overall integrity and, hopefully, public confidence of radioactive material packages in transport.

* Training requirements in the areas of radiation hazards and associated precautions for transport workers as proposed in 173.405(c).

* Revision to the table used to identify the category of label to be applied to a packages as proposed in 172.403. This revised table will clarify the labeling requirements.

* Expansion of and revision to the A1/A2 values as proposed in 173.435.

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Also enclosed, are a number of comments in areas of concern to Chem-Nuclear. Because of the extent of our comments and concerns, as well as, comments and concerns of our customers and many other shippers of radioactive material, Chem-Nuclear believes it is necessary for the Department of Transportation to revised this proposed rule and publish a second set of proposed rules for another series of comments before publishing a final rule based solely on this first set of comments.

As always, Chem-Nuclear appreciates the opportunity to be a part of this rulemaking process that establishes the safe system of radioactive material transportation. If you need further clarification concerning any of these comments, please contact us.

Sincerely,

CHEM-NUCLEAR SYSTEMS, INC.

Mark S. Lewis
Radiological Engineer

MSL/nhs

Enclosure

COMMENTS CONCERNING DOT's PROPOSED REGULATION CHANGES

1. LSA-I Definition, 49 CFR 173.403

The new definition of LSA-I that includes a consideration for decommissioning/decontamination waste (LSA-I (iv)) is too restrictive to include a majority of the uranium mill tailings that are currently being transported in bulk, unpackaged. The LSA-I limit for contaminated earth need to be 4e-6 A2/g, in order to ship mill tailings bulk, or mill tailings needs to be included as LSA-I by definition, such as the ores (LSA-I (i))

Mill tailings are not:

* ores as defined for LSA-I (i),

* solid unirradiated natural or depleted uranium or natural thorium as defined for LSA-I (ii), or

* radioactive material with an unlimited A2 value as defined for LSA-I (iii).

Some mill tailings can be shipped according to definition LSA-I (iv) as contaminated earth having a concentration less than 1e-6 A2/g which equates to approximately 552 pCi/g total. Some of the mill tailings that are being transported from mill site to storage location to disposal are in concentrations up to 1000 pCi/g total. Radium 226 and Thorium 230, the most restrictive isotopes, effect the sum-of-the-fractions in such a manner that simply doubling the concentration limit will not allow a majority of the tailings to be classified as LSA-I. In order for the majority of mill tailings to be classified as LSA-I and be shipped in bulk, ie. unpackaged in a dump truck style vehicle with a canvas top to complete the closed transport requirements, then the LSA-I (iv) limit for contaminated earth needs to be increased to 4e-6 A2/g.

If the industry is to be allowed by the DOT to continue the current bulk transport practice of all mill tailings, then the regulations need to reflect that acceptance by modifying the concentration limits of the LSA-I (iv) definition or identifying mill tailings as LSA-I by definition without an activity or concentration limit.

2. Environmental Impacts, Preamble of the Proposed Rule

There is a significant environmental impact in terms of the additional person-rem that will result from these proposed regulations. Through an extensive study (discussed in detail below) of high specific activity LSA waste shipments made to the Barnwell Waste Management Facility during the second half of 1987 and the first half of 1988, it is estimated that additional processing and shipping by generators will increase total person-rem over 10 rem/y.

The Type B packages that have been available for shipping have a smaller payload volume than the 200 cubic feet packages that are commonly used to transport the high specific activity LSA waste. For every three of the 200 cubic feet Type A packages that exceed the 2 x A1 LSA limit there will have to be five of the approximately 120 cubic feet packages processed and transported for disposal.

During the time period analyzed there were over 40 LSA shipments in the 200 cubic feet size NRC Type A casks that exceeded the 2 x A1 limit. These shipments that exceeded the 2 x A1 limit will have to be transported in Type B casks according to the proposed rule. With the ratio of 5 to 3, there will be over 20 additional packages to process and ship. With exposures of approximately 0.5 person-rem/shipment, there will be an increase of over 10 person-rem/year. If shippers choose to reduce the volume of the waste in order to achieve a less than 2xA1 industrial package shipment, the number of packages being processed and total number of shipments could be as high as 50 increasing exposures to as high as 25 person-rem/year.

3. LSA With Greater Than 2xA1 in Type B Packagings, 49 CFR 173.425(a)

Based on an analysis, Chem-Nuclear came to two conclusions concerning the proposed 2xA1 limit on LSA in non-Type B packagings:

* There is no close correlation between waste activity (multiple of A1) and unshielded dose rate (1 rem/hr at 3 meters). The quantity of alpha and beta emitters do not contribute to the external dose rate, but would restrict the package using an activity limit.

* If an activity limit is to be used, a limit of 3.4A1 for gamma emitting radionuclides is closer to the IAEA standard of 1 rem/hr at 3 meters than the proposed 2A1 limit for LSA.

Clearly, an activity limit is not consistent with the IAEA regulations. However, consistency with the IAEA regulations for the transport of LSA material is unnecessary. Since LSA material is rarely if ever transported internationally, no change to current regulations is needed. Current regulations have historically proven to be sufficient to protect the public health and safety and, without a recorded accident resulting in a release of radioactivity, emergency responders are at little if any risk.

ANALYSIS OF 2A1 LIMIT

Chem-Nuclear Systems evaluated how closely the 2x the revised A1 limit approximates the 1 rem/hr at 3 meters IAEA standard as it applies to LLW packages (Anderson 1988). The relationship of activity to dose rate depends on numerous factors including the type and quantity of radionuclides, material self-attenuation, and container volume. Actual LLW shipment data was used to analyze the impact of the proposed regulation change on the current LLW transportation industry.

Three studies were performed by CNSI to analyze the relationship. The data was compiled from records obtained at the barnwell Waste Management facility operated by Chem-nuclear. The data reflects cask shipments during a twelve month period in 1987 and 1988. The data includes unshielded dose rate, waste material, radionuclide type, and concentration. This data and radiation shielding programs were used in the three studies with the results summarized in the table below.

The first study involved theoretical calculations of the multiple of A1 equivalent to 1 rem/hr at 3 meters. Since the Co-60 isotope is the predominant contributor in LLW dose through the walls of a shielded cask, a theoretical calculation of the surface dose and corresponding 3 meter dose was made using Co-60 only. The MICROSHIELD computer program (Grove, 1987) was used to calculate dose rate values and the A1 equivalent for a 200 cu.ft. disposal liner. The proposed A1 value of 10.4 curies for Co-60 was assumed. Based on limitations of 1 rem/hr at 3 meters and the density of resin waste, a multiple of the A1 was calculated to be 3.52. Dewatered resin waste was used in this analysis as the most conservative waste form. A limit of 3.52A1 is 76% greater than the 2A1 value proposed by the NRC and would allow a correspondingly greater activity content in the LSA package without exceeding the dose limit established by the IAEA.

The second study involved data from 50 representative shipments received at the Barnwell Waste Management Facility (BWMF). The 50 shipments involved six different cask/liner types containing either solidified or dewatered resins. Solidified and dewatered resins waste forms were used in this study because they represent the type wastes that might be affected by the NRC's proposed change. The multiple of A1 for each shipment ranged from 0.18 to 21 with an average of 4.27. The Microshield computer program was again used to determine the theoretical dose rate from the unshielded LSA material based on the specific radionuclide mix. The average multiple of A1 that corresponded to a dose rate of 1 rem/hr at 3 meters was calculated. This study showed an average A1 value of 2.73 with a standard deviation of +/- 1.37. The data showed little correlation between activity and dose rate as indicated by a correlation factor or R squared equal to -0.2.

The third study involved the use of radiation dose and isotopic concentration data for over 500 shipments. Only cask shipments received at the BWMF spanning one year in 1987 and 1988 containing either solidified or dewatered resins were used. Data reflecting the measured container dose rate on contact recorded by the shipper, isotopic quantity and type were input into a computer program. The multiple of A1, again, based on the proposed A1 limits was calculated for each shipment. A normalization formula was used to relate a value of A1 to a dose rate at 3 meters. The statistical average A1 multiple calculated was 3.72 with a standard deviation of +/- 2.57. A plot of the data showed little correlation between total activity and dose rate on radioactive waste packages.

CALCULATED A1 VALUE EQUIVALENT TO THE IAEA STANDARD OF 1 REM/HR AT 3 METERS

		xA1	+/- Standard Deviation
Case 1 -	All Co-60 in waste (theoretical)	3.52	
Case 2 -	Select Cases Using Microshield Calculations (50+ Cases - Theoretical)	2.73	+/- 1.37
Case 3 -	Database of 1987/1988 Shipment Records (500+ Cases - Experimental)	3.72	+/- 2.57
NRC Proposed Value		2.00	

ECONOMIC IMPACT

Chem-Nuclear's analysis indicates an additional 300-600% increase in Type B processed waste shipments (i.e. solidified or dewatered resins) will be made in order to comply with the proposed 2A1 LSA limit. There are approximately 20-30 processed waste shipments made each year to the BWMF that are required to be shipped in Type B casks. There are many more shipments made in Type B casks that are only require an NRC type A cask. Type B casks are often scheduled and used prior to processing of the waste and an evaluation of the type package needed. The 2A1 limit will increase the number of Type B processed waste shipments to 90-1209. Since the six (6) current vendor available Type B casks are utilized approximately 70% of the time, there will be a shortage of available Type B casks and an additional 8 to 16 new casks will be needed to be manufactured to service the industry. Historically, design, licensing and manufacturing of new Type B casks could take years.

Disposal volumes and associated costs will also increase. As the higher volume Type A cask shipments are required to be shipped in the lower volume Type B casks, disposal volumes increase. Each disposal liner is not filled to the maximum to prevent spillage during processing and the burial volume on each liner is greater than the fill volume. If, for example, the waste currently transported in 200 cu.ft. Type A casks is transported in 120 cu.ft. Type B casks due to the proposed 2A1 limit, it would take 1.7 Type B shipments to transport a Type A shipment. The disposal volume increase is 2% due to the inefficiency of processing smaller volume packages. Other associated disposal costs assessed by shipment that will increase due to an increase in the number of shipments include cask handling, weight, and curie surcharges that are assessed in activity ranges. The curie surcharge assessments favor a lower number of high volume, high activity shipments rather than a greater number of lower volume, medium to high activity shipments.

Adoption of the NRC proposed regulations will economically impact the U.S. nuclear industry by $4 to $5 million per year according to EPRI (Daloisio 1988). EPRI's study utilized shipping information from a 1985/1986 database. The study evaluated solidified and dewatered primary and non-primary resin from BWRs and PWRs that were transported in three different casks. The $4 to $5 million impact identified in this study is the direct cost increase in package use, transportation, and disposal. The study did not evaluate the cost of new equipment (i.e., cask and trailer) design, licensing, and manufacture.

RISK ASSESSMENT

Sandia National Laboratories was contracted by the U.S. Department of Transportation and the Department of Energy to evaluate the impacts of the United States adopting the IAEA standards associated with LSA and the 1 rem/hr at 3 meters from the unshielded cask restriction. In their risk assessment (Ostmeyer et al. 1988), they assumed the worse case scenario of high radiation level LSA waste, dewatered spent resin, with a specific activity at the existing regulatory limit (0.3 mCi/g). Although Sandia used the worst case scenario for their risk assessment, they commented that in the typical accident the radioactivity levels are likely to be orders of magnitude less than those assumed for their calculation and a release of 100% of the waste material is unlikely. They assessed the radiological impacts and risks in the event of a highway accident. Some of their conclusions are:

* "...current LSA limitations are sufficient to prevent excessive external radiation exposure to an individual following a severe transportation accident. although package dose-rate restrictions could provide a higher level of confidence that external radiation doses are not excessive, these restrictions would have a substantial impact on shipping practices and costs for transportation of LSA material."

* "Additionally, because the package dose rate restrictions would substantially increase the number of shipments, the number of traffic fatalities and injuries from accidents involving transportation of waste materials would also rise."

We agree with these qualitative conclusions. However, one of the risks that Sandia did not address is the increase dose to the worker at the nuclear facilities while processing and preparing to transport the additional shipments that will result if either the 2A1 or 1 rem/hr at 3 meter restriction is invoked by the NRC. The proposed, more restrictive limit, will lead to more shipments thus a higher risk of accidents, higher costs for transportation and disposal, and a higher dose to radiation workers.

4. <u>Simplification of Fissile Material Classes, 49 CFR 173.417</u>

Although the proposed rule does begin to simplify the system of shipping fissile material, most of the difficulties still exist. A system of performance-oriented packaging needs to be developed to reduce the current complexity of the design-oriented package choices.

5. Marking and Labeling Exceptions For Exclusive Use LSA, 49 CFR 173.425(f)

Low specific activity material (LSA) and surface contaminated objects (SCO) that are transported exclusive use should continue to be excepted from specification marking and labeling.

Specification markings and labelings are a communication primarily to the carrier. LSA and SCO when shipped exclusive-use are not handled by the carrier in transit, thus eliminating the need for those communications. The current mechanism of requiring the non-specification marking "Radioactive-LSA" to be on the package, a radioactive placard on the vehicle, and properly executed and accessible hazardous material shipping papers are the appropriate communications to the carrier and any emergency response personnel in the event of an accident.

In addition, LSA and SCO materials are typically waste materials destined for processing and/or disposal. Low-level radioactive waste is rarely if ever shipped internationally, so there will be no significant impact by the domestic regulations not being compatible in this area.

6. Bulk Package Markings on LSA and SCO, 49 CFR 172.329

If LSA and SCO materials being shipped exclusive-use are not excepted from specification marking and labeling in the final rule (see comment #5 above), they should be excepted from the bulk package markings (ID# on orange panel or square-on-point configuration) of 49 CFR 173.329.

The bulk package markings required for the other hazardous materials are necessary because there may be many different ID#'s associated with one placard. The large, visible display of the ID# on a bulk package is helpful to an emergency responder in actions taken at an accident scene when there may be many different ID#'s and responses that may need to be taken for each placard type, ie. flammable liquid or solid. The radioactive placard has few ID#'s and associated responses that an emergency responder would need to know to appropriately respond at an accident scene. When the radioactive hazard is significant, a placard is required, which is sufficient communication to the emergency responder in the event of an accident without the presence of a bulk package marking.

7. Labeling on LSA and SCO Material, 49 CFR 172.403(a)

If LSA and SCO materials being shipped exclusive-use are not excepted from specification marking and labeling in the final rule (see comment #5 above), then 49 CFR

172.403(a) should not include the reference to 173.425. The reference should only include "... excepted from labeling by 173.421 through 173.424...".

8. Type A and Type B Quantity Definition. 49 CFR 173.403

A definition of Type A quantity and Type B quantity needs to be added to the definition section, 173.403, similar to the way the NRC has added these definitions in their proposed regulations.

Through definitions and activity limits one can derive what quantity of material goes in which type package, but there is currently not a defined term for the quantity of material that is less than or equal to the A1/A2 value or greater than the A1/A2 value. The exceptions, ie limited quantity, and the additions, highway route controlled quantity, are well defined. Type A and Type B quantity should also be well defined.

9. Mixtures of Radionuclides. 49 CFR 173.433(d)

It is not clear how the mixture formula found in 173.433(d) is used when determining if a mixture of radionuclides in a package can be shipped limited quantity or if and how this mixture is used to determine if a material has to be shipped as a highway route controlled quantity (HRCQ).

The reference from Table 7, 173.423, does not indicate that the excepted quantity values be placed in the denominator rather than the A1 or A2 value. Since 173.433(d) only makes reference to the A1 and A2 value in the denominator of the formula, is a shipper subject to the HRCQ requirements if the sum-of-the-fractions using the HRCQ values in the denominator of this formula is greater than 1 for a mixture of high activity radionuclides in the same package?

10. Contamination Limits. 49 CFR 173.443(d)

The contamination limits that apply to a package at the time of shipment on a vehicle that is marked "For Radioactive Material Use Only" are not clearly identified by 173.443(d).

This paragraph does identify a value of 10 times the levels prescibed in paragraph (a), 173.433, but does not clearly state if this limit applies to the packages at the time of transport or the release of the vehicle after the packages have been taken off.

11. **Exclusive-Use Radiation Level Limitations, 49 CFR 173.441(c) and (e)**

The requirements of instructions for the maintenance of exclusive use are found in both paragraphs 173.441(c) and (e). These two paragraphs need to be combined and one paragraph reference eliminated to simplify the requirements.

12. **Radiation Symbols on Type B, B(U), and B(M) Packages, 49 CFR 172.310(d)**

Type B, B(U), and B(M) packages should not be required to have the additional radiation symbol marking.

Shipments of material in Type B, B(U), or B(M) packages will require a DOT White I, Yellow II, or Yellow III label affixed to its surface. The radiation symbol is part of these label designs. The size of the label's symbol is bigger than the size of the proposed marking radiation symbol. The duplication of radiation symbols on a package at and during transport seems unnecessary.

13. **Table 7, Clarifications, 49 CFR 173.423**

Table 7, 173.423, remains a very confusing table. To help clarify the table, here are some suggestions:

* In the Nature of contents column under the Gasses form the words Special form and other form should be directly below Tritium. It should appear as Tritium, Special form, and Other form gasses not as Special form and Other form Tritium as a gas.

* Rather than using the term "Other Form", use "Normal Form". By definition if a material is not special form it is normal form. "Other Form" is not defined.

* Title the last column as "Limited Quantity Material package limit", rather than just "Material package limit".

* In the heading for each column put the part and section notation to help cross reference the table to the original reference. For example: Material package limit, 173.421.

14. SI and Customary Units, 49 CFR 172.203(d)(1)(iii) and 172.403(g)(2)

Recording of activity on shipping papers and making the activity notation on labelr should be authorized for domestic shipments in customary or SI units, not "SI or SI and customary units".

The U. S. radiation industry has not adopted, does not feel comfortable with, does not have equipment or instrumentation reading in, and are bound to make many mistakes by beginning to use SI units. The use of SI units needs to be phased in over several years, by using both units all of the time.

15. Radioactive Markings for Instruments and Articles, 49 CFR 173.422(h)

An alternative to having the marking "Radioactive" on each instrument and article should be to have the marking "Radioactive" on the package that contains the instruments and articles.

16. General Radiation Protection Principles, 173.405(e)

Compliance with these standards would require shippers to maintain dose rates on the exterior of a vehicle at less than 100 mrem per week (0.6 mrem/hr) since a member of the public could stand next to a parked vehicle and be exposed. Since this is clearly not DOTs intent, this section should be revised or deleted.

A vehicle with a contact dose rate of 200 mrem/hr (within D.O.T. limits) that is stopped at a truck stop for an hour is the potential source of an exposure that exceeds either 2 mrem in an hour or 100 mrem in the week. It is not practical for the exposure to occur above these limits, but the potential exists if, as the proposed regulations state, "an individual were continuously present in the area".

17. General Radiation Protection Principles, 173.405(d)

Given the package exterior dose limits, it seems highly unlikely that a transport worker could be exposed to more than 1500 mrem/yr. Before imposing dosimetry requirements, actual measurements of transport worker exposures should be made. If dosimetry requirements are imposed, requirements on documentation, reporting, and quality control are necessary. See 10 CFGR 20.401 - .409, as an example.

18. General Typographical Errors

The following is a list of what is presumed to be typographical errors:

* 172.403(c) - for a Yellow III label, the maximum radiation level at any point on external surface (middle column) should read "More than 0.5 mSv/h ..." rather than "More than 0.005 mSv/h...".

* 173.425(a) - "... exceed 2A2" should read "... exceed 2A1".

* 173.423 Table 7 - the subscript under the table should read "... see 173.433(c)-(e)" rather than "... see 173.443(b)".

* 173.443(d) - "... by public highway rail of..." should read "... by public highway of..." or "...by public highway or rail of...".

* 173.403 Radioactive Material definition - "... greater than 70 Bq (0.002..." should read "...greater than 70 Bq per gram (0.002...".

* 173.465(c) Table 12 - all of the greater than and less than signs are missing.

* 173.405(e)(3) - "5.0 mSv (50 mrem) in any twelve-month period" should read "5.0mSv (500 mrem) in any twelve-month period."

December 12, 1985
LC 8512-08
File: C.1.2, E.13.0

To: W. Didgeon [Columbia, SC]

cc:

R. Anderson		L. Poppe	[Columbia, SC]
M. Benjamin	[Barnwell, SC]	D. Presley	
M. Kirshe		G. Rae	[Columbia, SC]
M. Lewis	[Columbia, SC]	L. Toner	[Barnwell, SC]
J. Mason	[Barnwell, SC]	S. Zdanuk	
		B. Zibung	[Midwest Office]

From: M. Macher Martin S. Macher

Subject: **Additional CNSI Cask Shielding Curves**

References:

1. "CNSI Cask Data," W. A. Didgeon, October 22, 1985, MR-10391-85.

2. "CNSI Cask Data," W. A. Didgeon, October 28, 1985, MR-10399-85.

3. "Revised CNSI Cask Shielding Curves," M. Macher, April 16, 1985, LC 8503-47.

INTRODUCTION

The shielding curves presented in this memorandum are calculated in response to your requests (References 1 and 2). The methodology used to calculate the curves follows the procedure given in Reference 3.

DISCUSSION

Sets of cask shielding curves already exist for eight casks. Appendix A shows the maximum allowable total activity concentrations and the maximum allowable liner dose rates for the following six additional casks:

CNS 1-13C/G

CNS 3-55

CNS 4-85

CNS 6-75

CNS 7-100

CNS 8-120B

Appendix A also contains curves for the eight casks previously analyzed. Thus, Appendix A is a complete reference of the shielding capabilities of CNSI casks. Note that only one set of curves has been prepared for the casks CNS 1-13C and CNS 1-13G. The only difference between these two casks from a shielding standpoint is that the CNS 1-13C has an additional thickness of 0.25 inches of steel that the CNS 1-13G does not have. This is not significant from a shielding point of view, as both casks have 5.0 inches of lead shielding. Similarly, casks CNS 14-170 Series II and CNS 14-170 Series III are identical from a shielding viewpoint.

Appendix B shows the same data as plotted in Appendix A except all graphs are plotted on semi-log paper instead of on linear paper. The graphs in Appendix B allow a quick determination of a suitable cask for a shipment. A cask chosen from the curves shown in Appendix B should then be checked against the Appendix A curves to insure that the semi-log curves have been read properly.

The CASC computer program (which calculates dose rates from any waste mixture) has been updated to include data for the six additional casks. The revised CASC program and its documentation will be released shortly. The CASC program provides better estimates of shielding capabilities than the shielding curves, especially for waste mixtures with a low percentage of Co-60.

Appendix C shows point source shielding curves from the SAR's for the CNS 8-120B and the CNS 10-160 casks, as you requested. Please note that these curves are *not* useful from a marketing viewpoint. The sources shipped by CNSI nearly always resemble line sources rather than point sources.

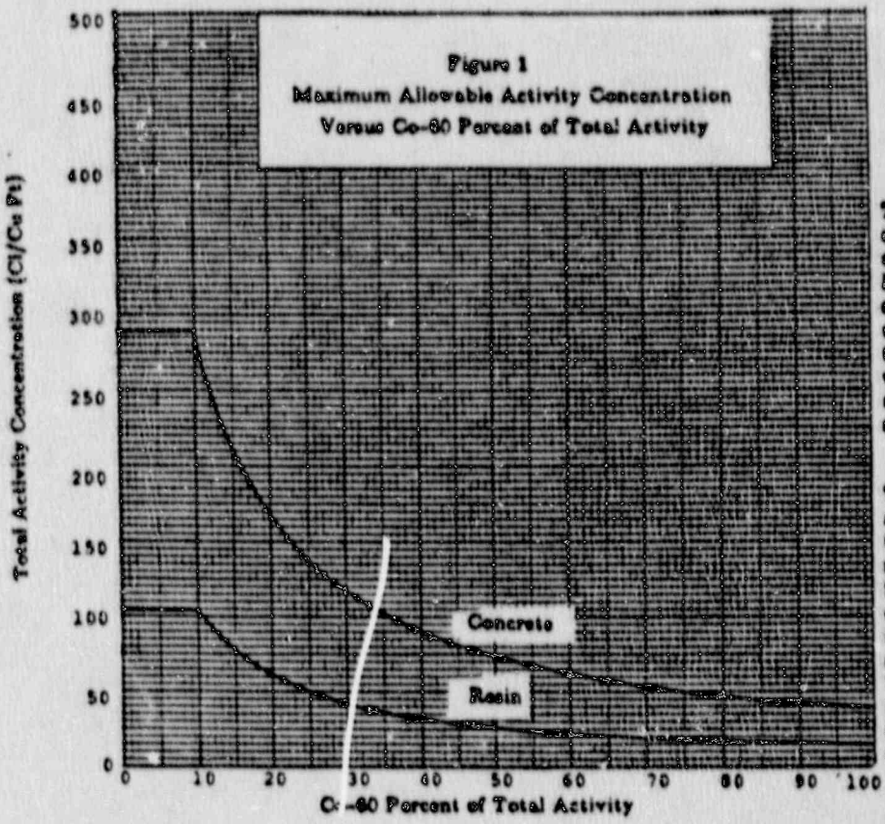
CONCLUSION

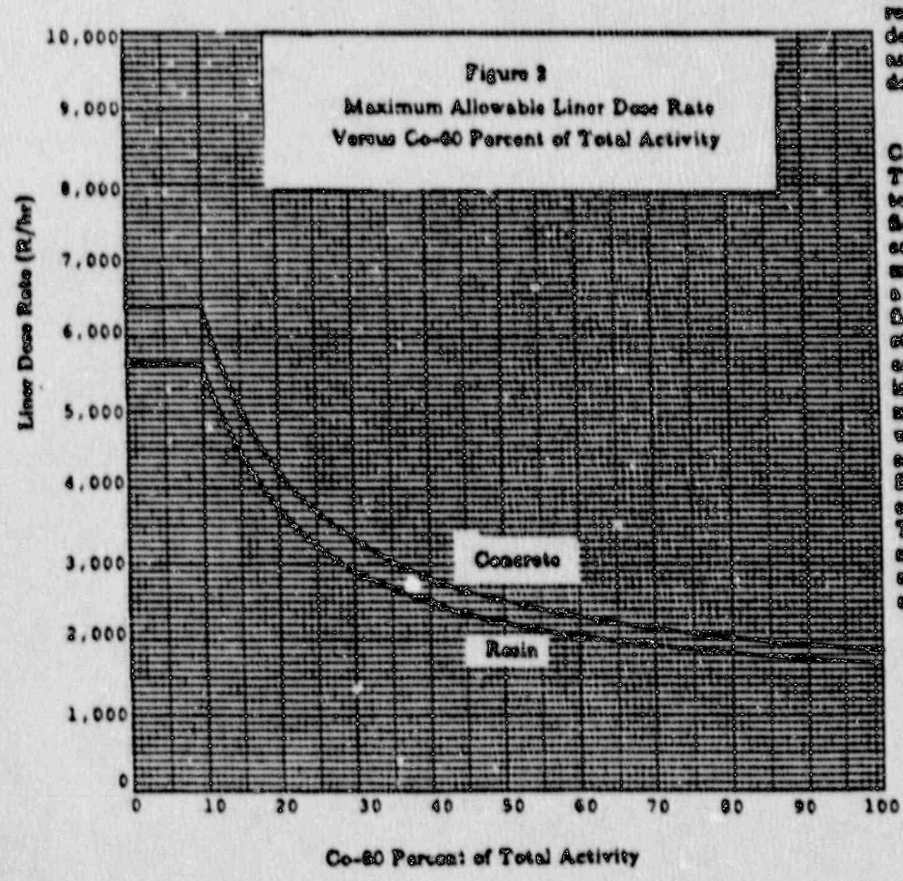
The shielding curves shown in Appendices A and B complete the shielding evaluation for CNSI's casks. They (and the CASC computer program) provide a consistent and simple method for choosing the optimum cask for transport.

/mm

APPENDIX A

CASK SHIELDING CURVES ON LINEAR PAPER





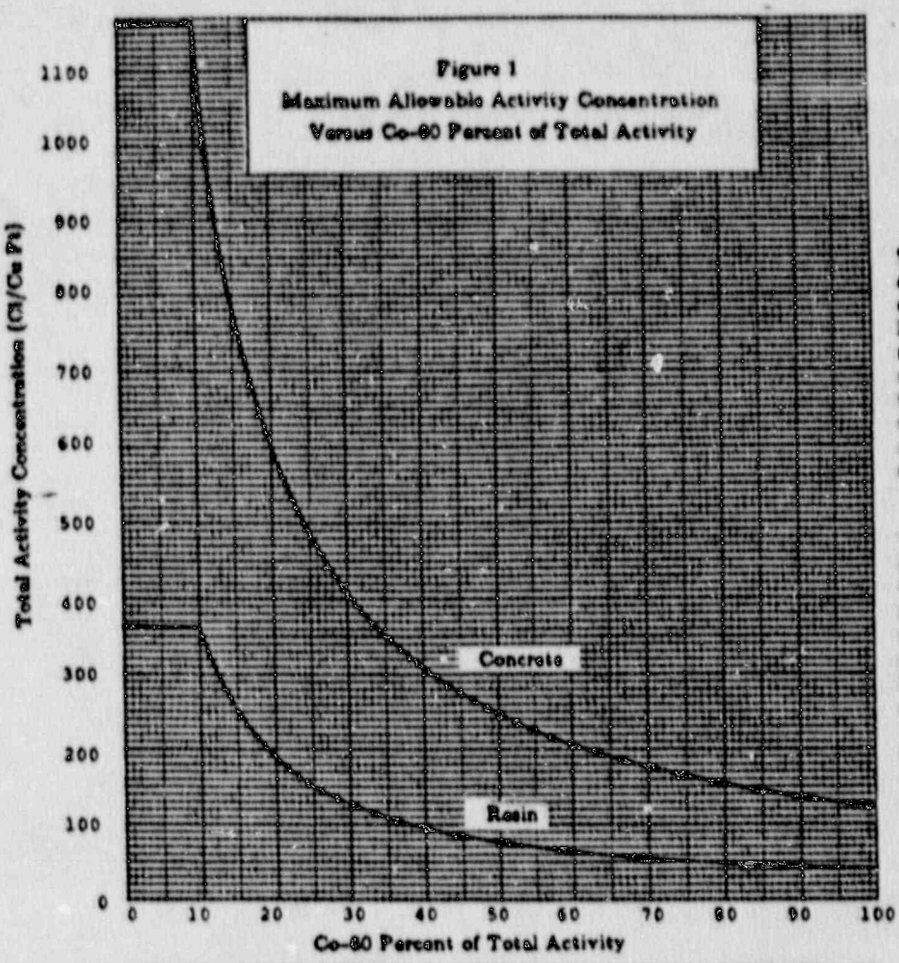
The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

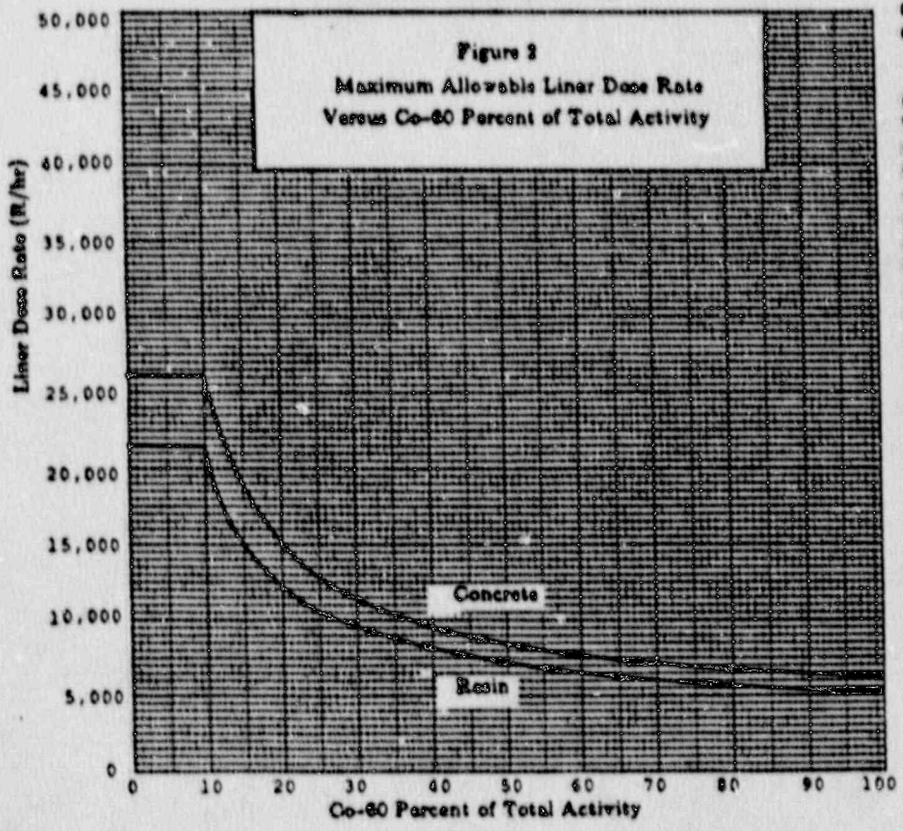
These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is a dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.8 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in at least 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.





The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is a dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in at least 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.

Figure 1
Maximum Allowable Activity Concentration
Versus Co-60 Percent of Total Activity

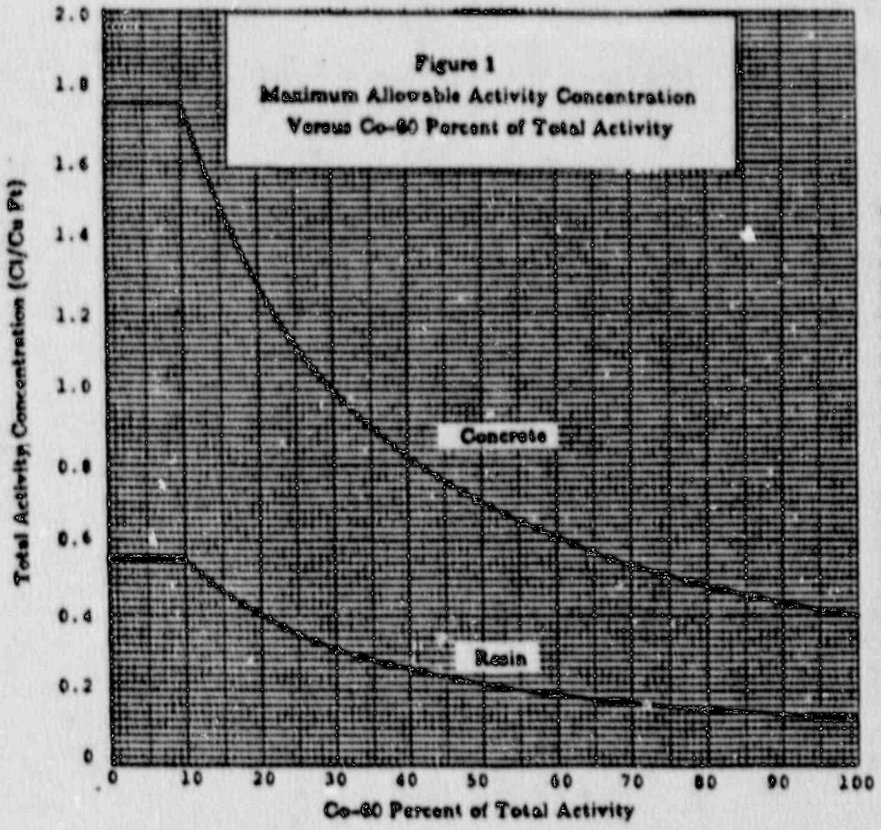
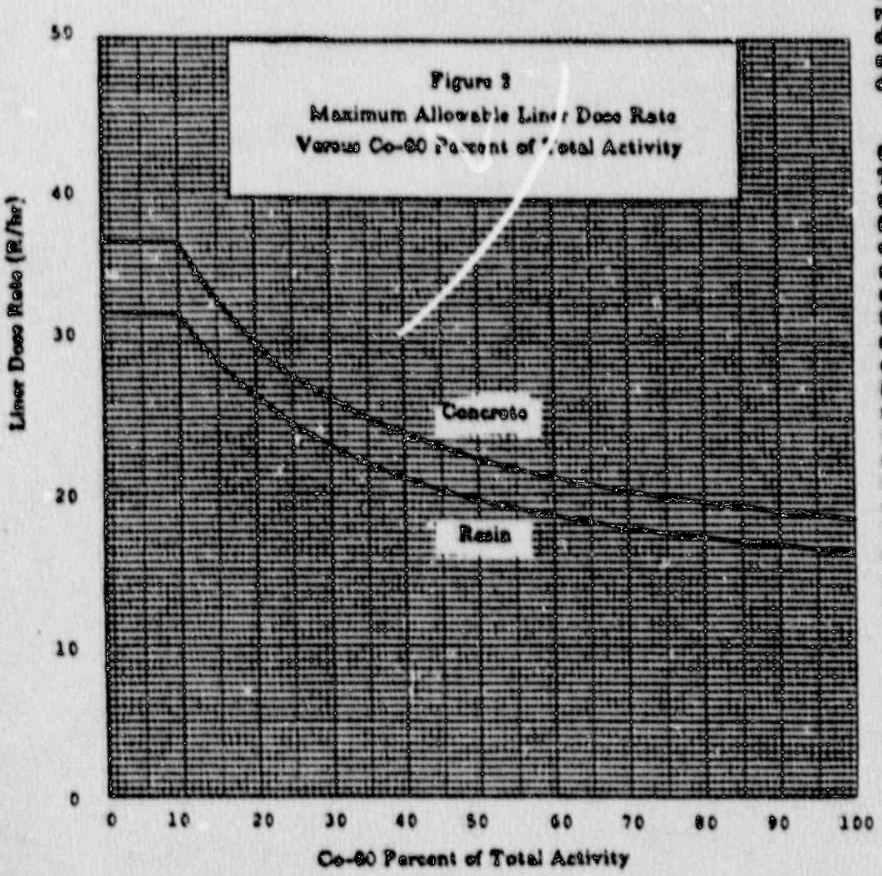


Figure 2
Maximum Allowable Liner Dose Rate
Versus Co-60 Percent of Total Activity



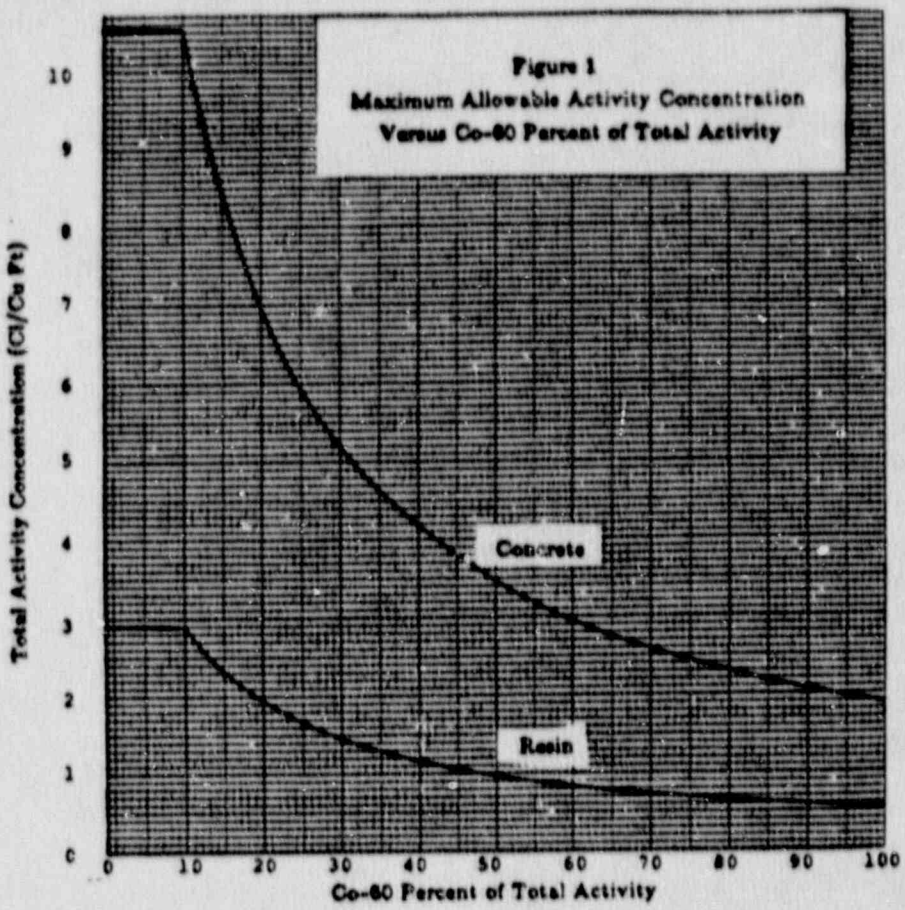
The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

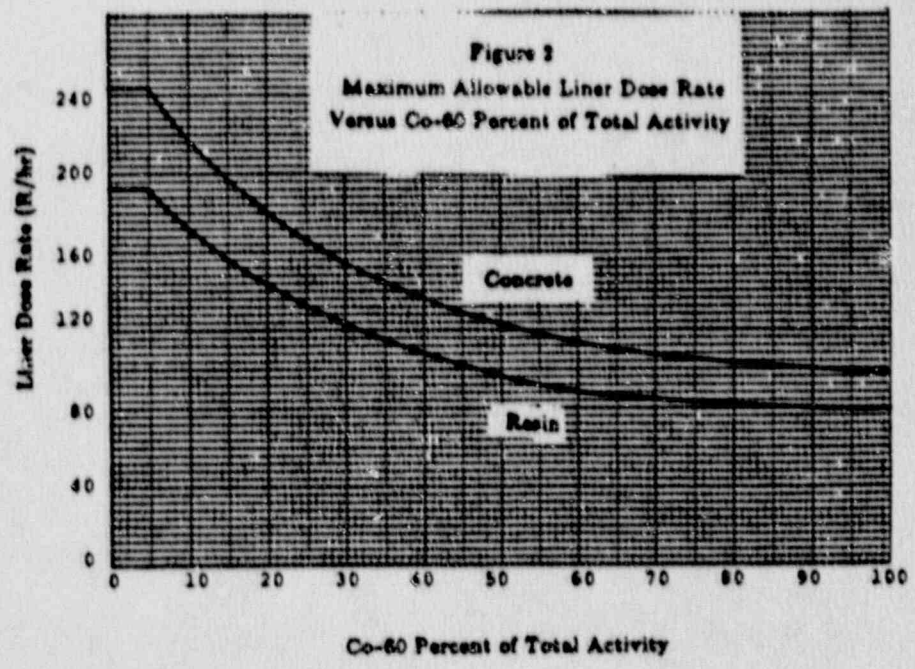
These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is a dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 3.0 g/cc for concreted wastes and 0.8 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 3.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in at least 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.





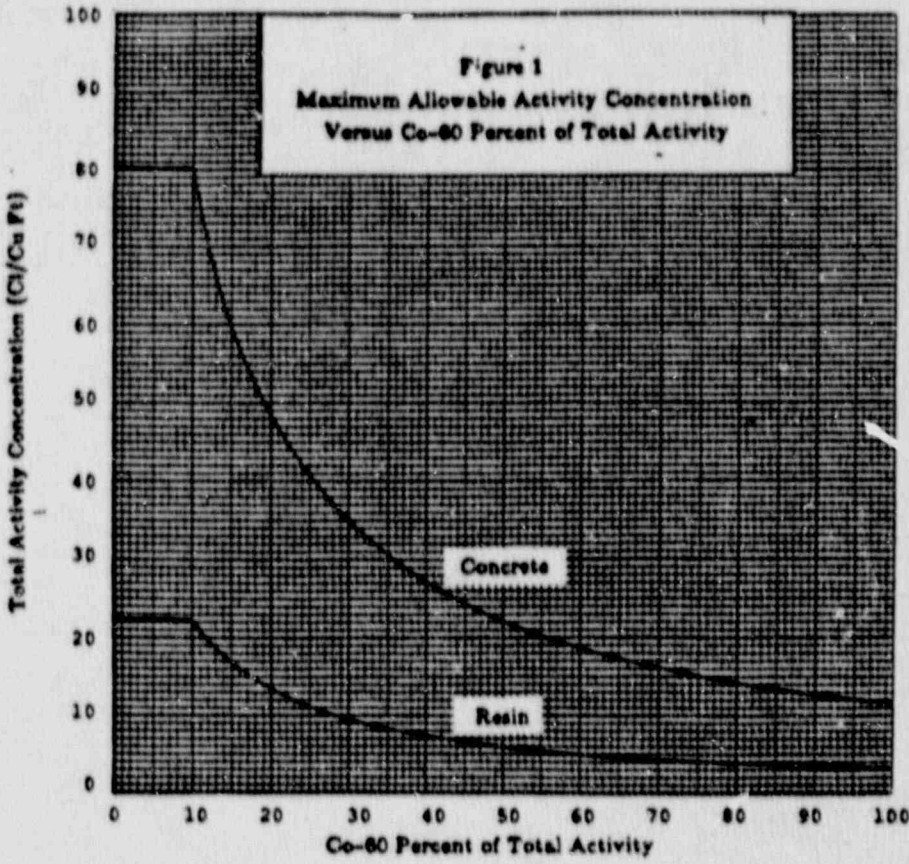
The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is a dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in at least 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.



The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

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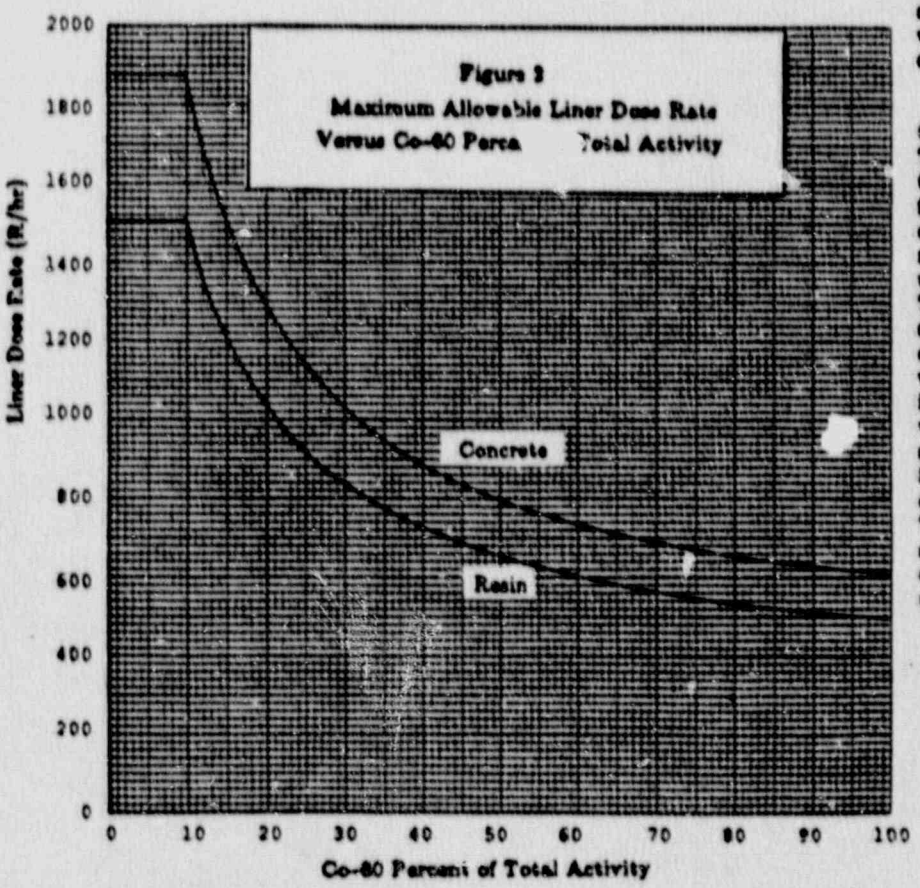
Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.



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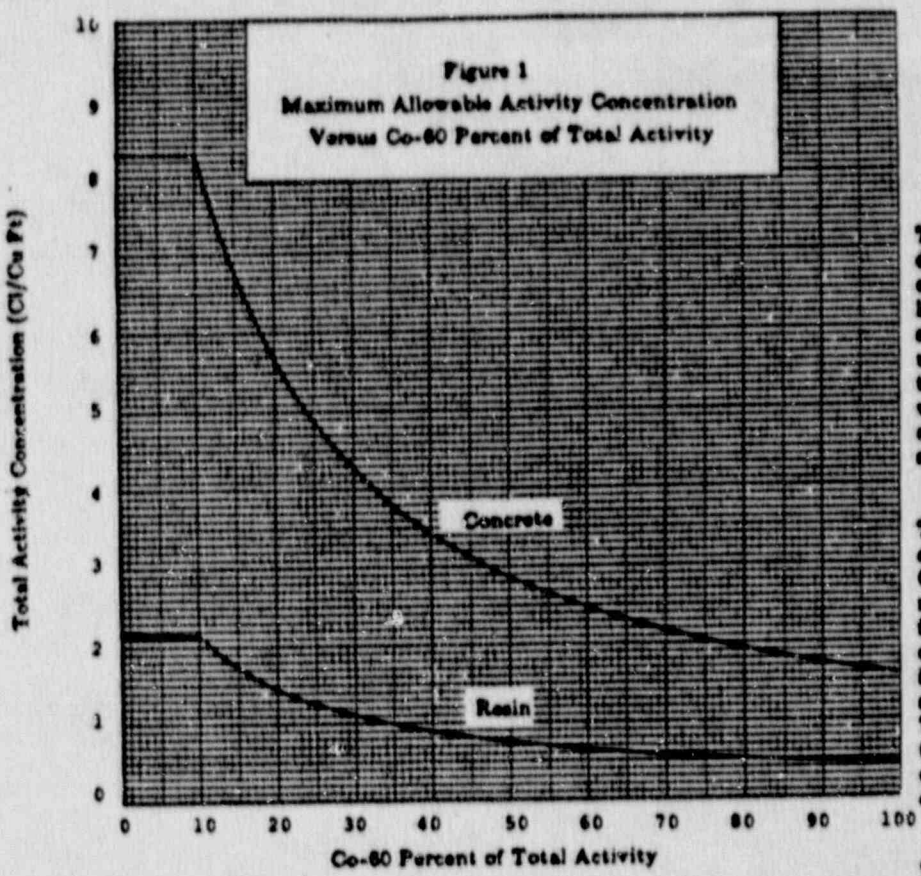

The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

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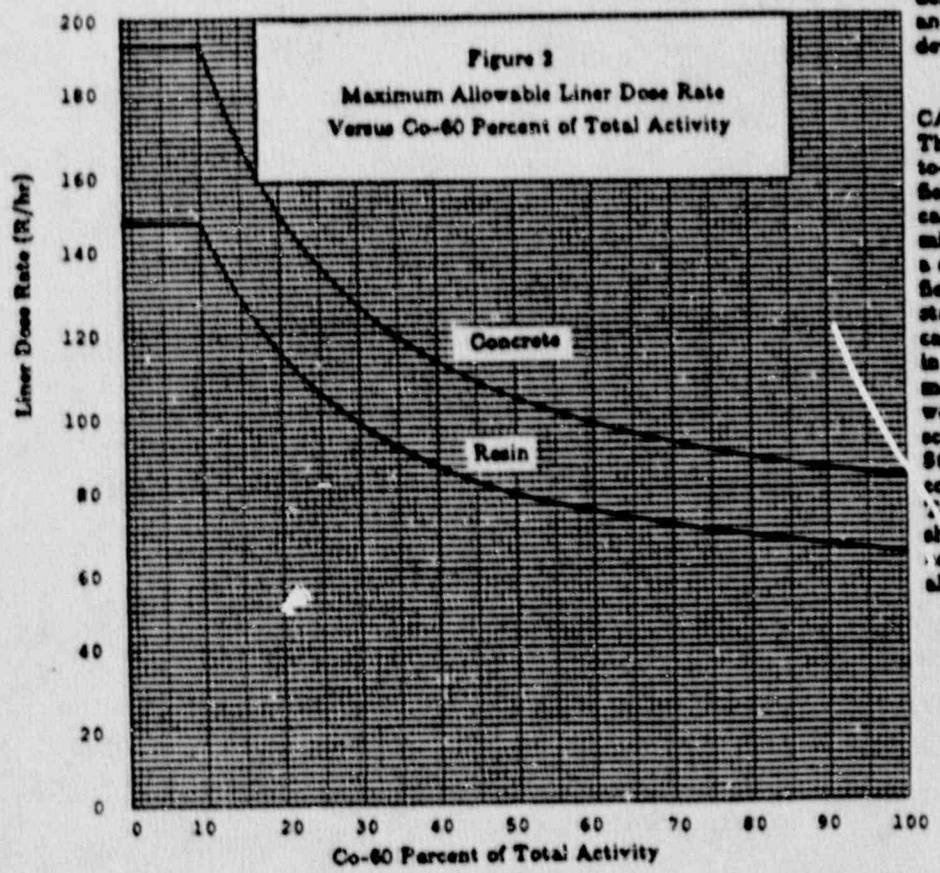
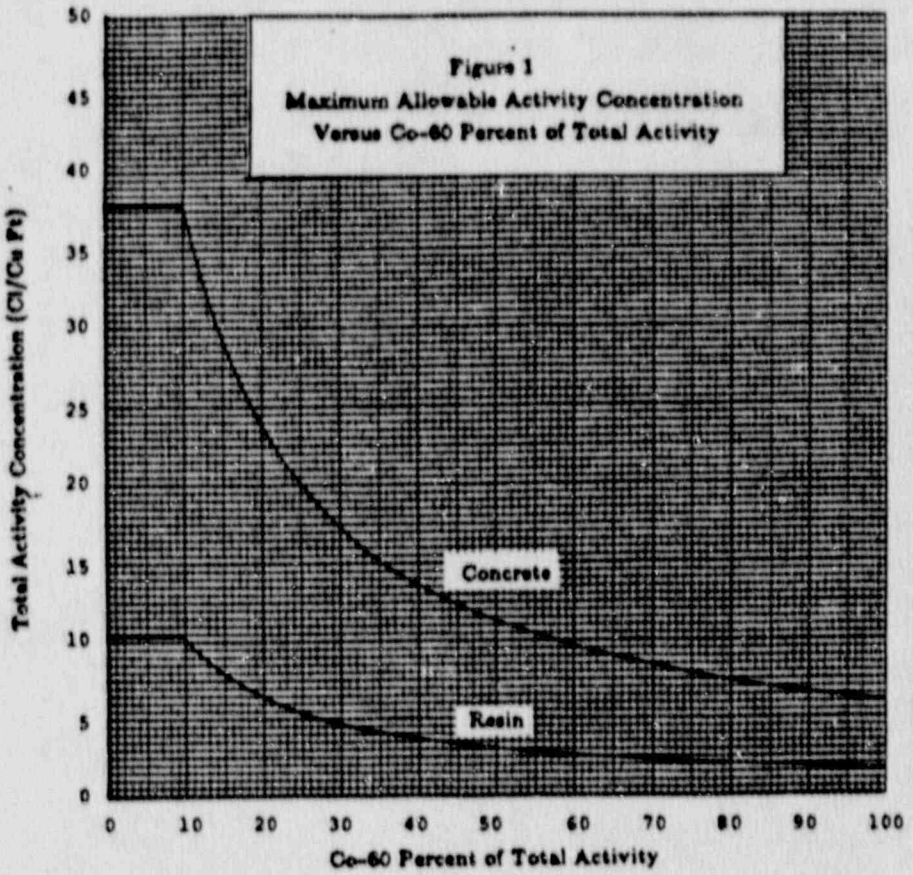
Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.



CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in at least 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.



The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

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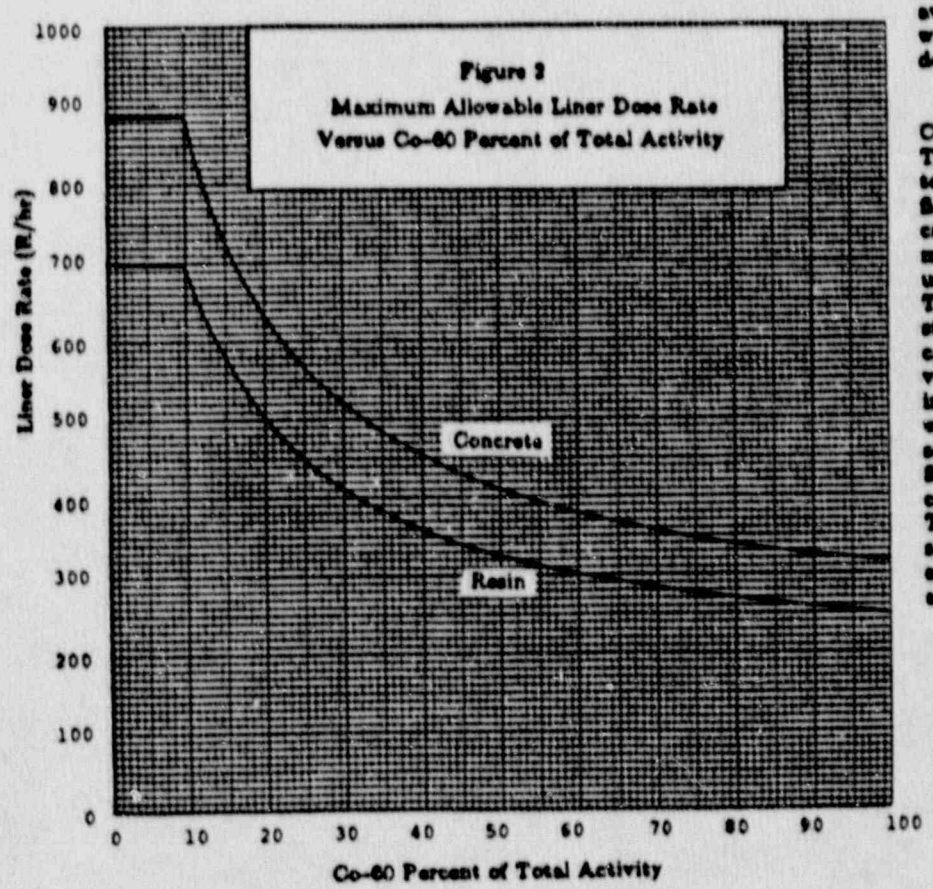
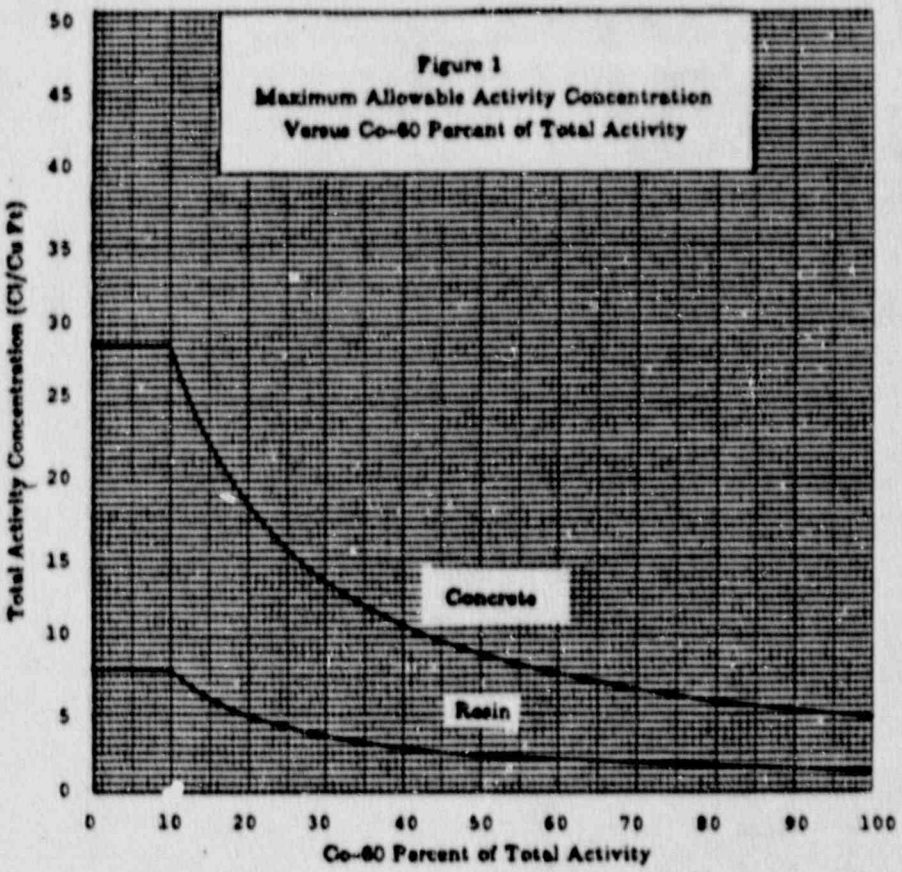
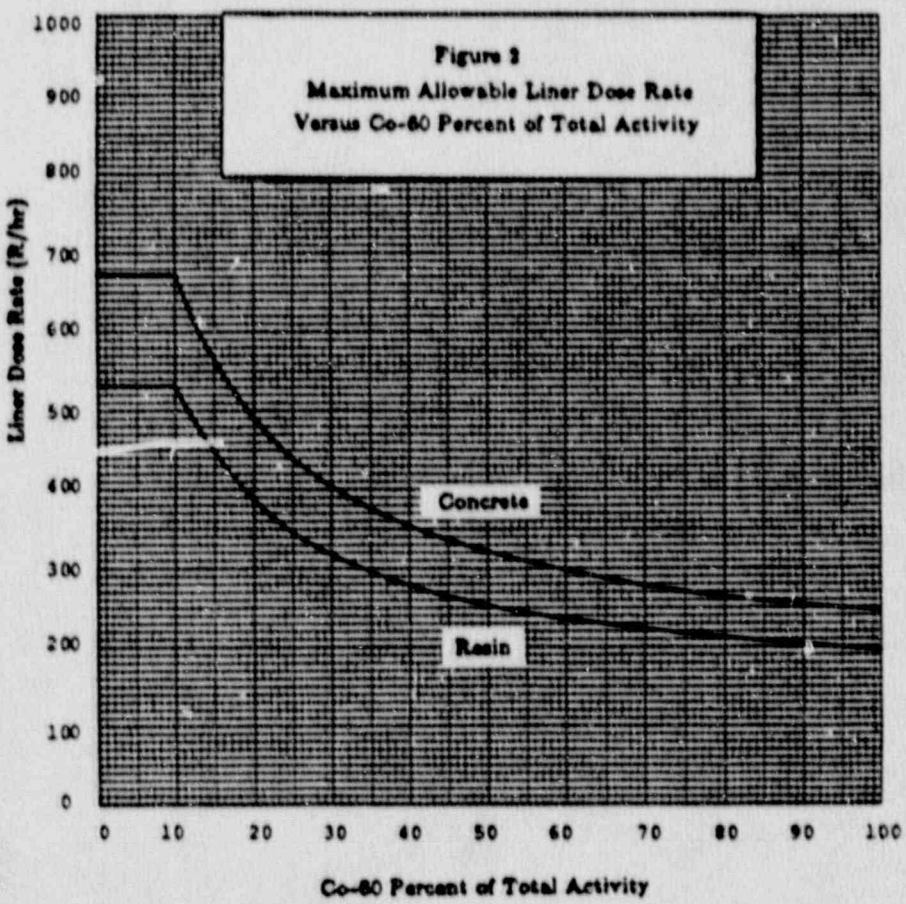
Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.



CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in about 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.





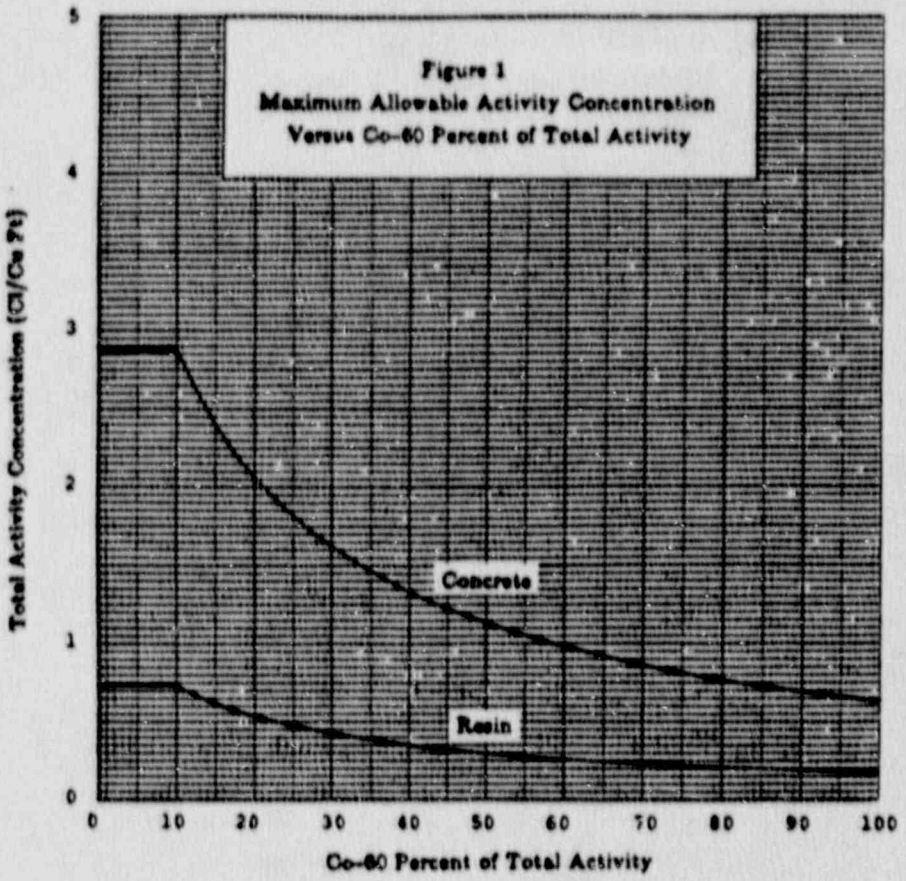
The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

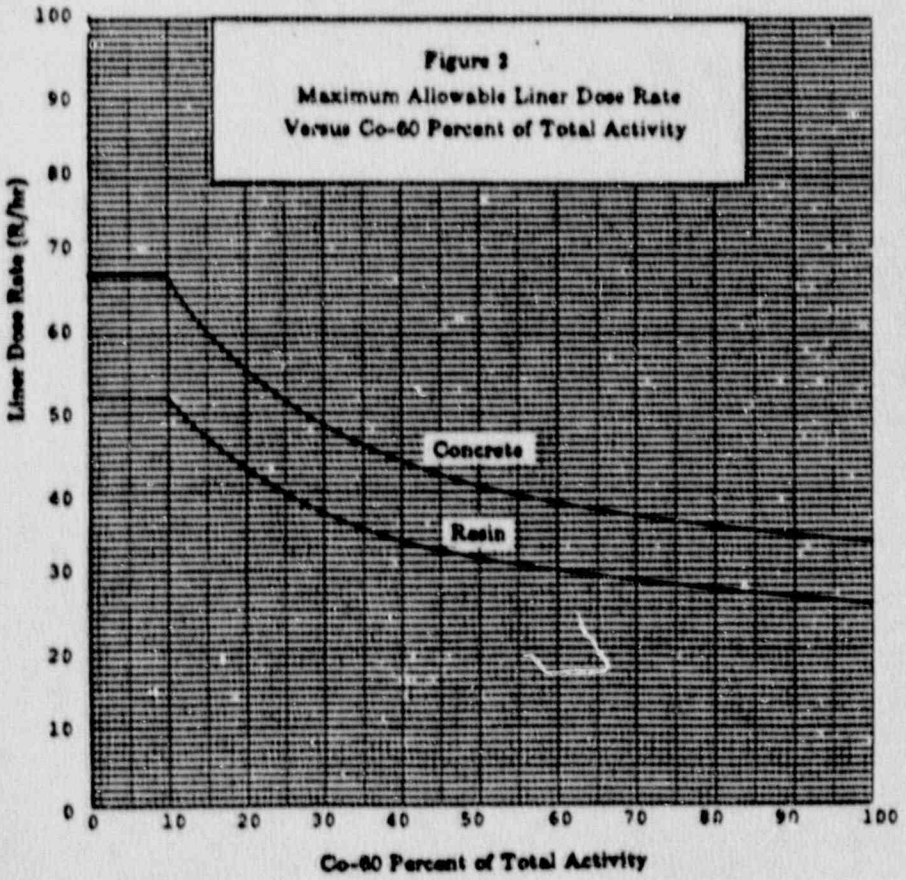
These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is a dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in at least 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.





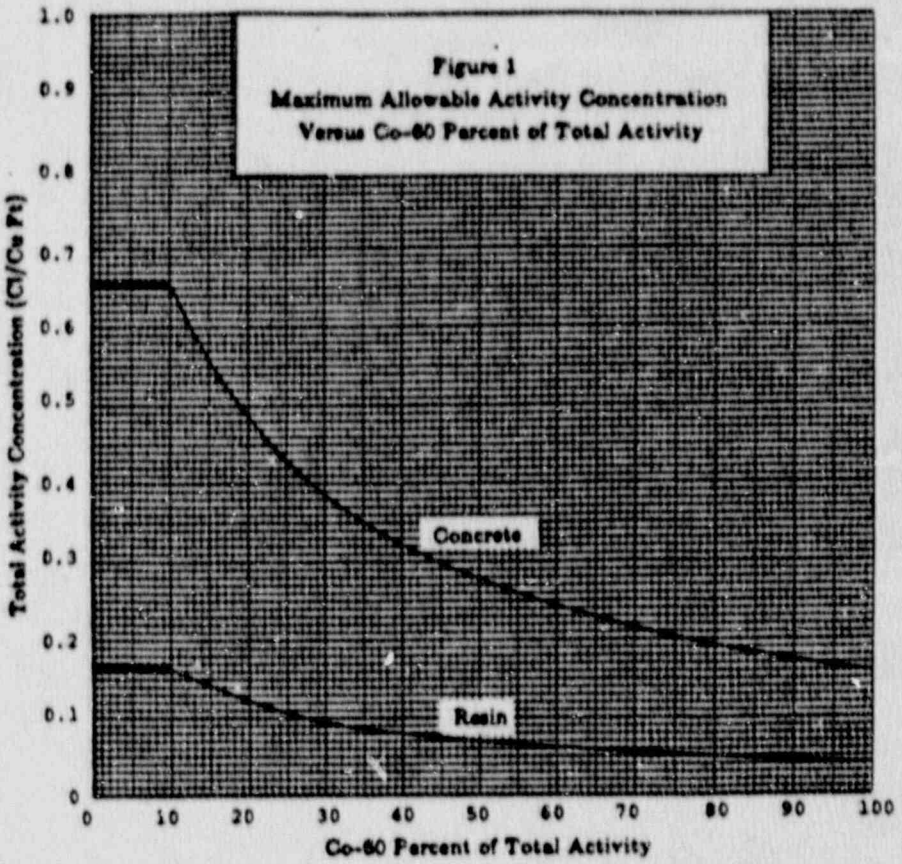
The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

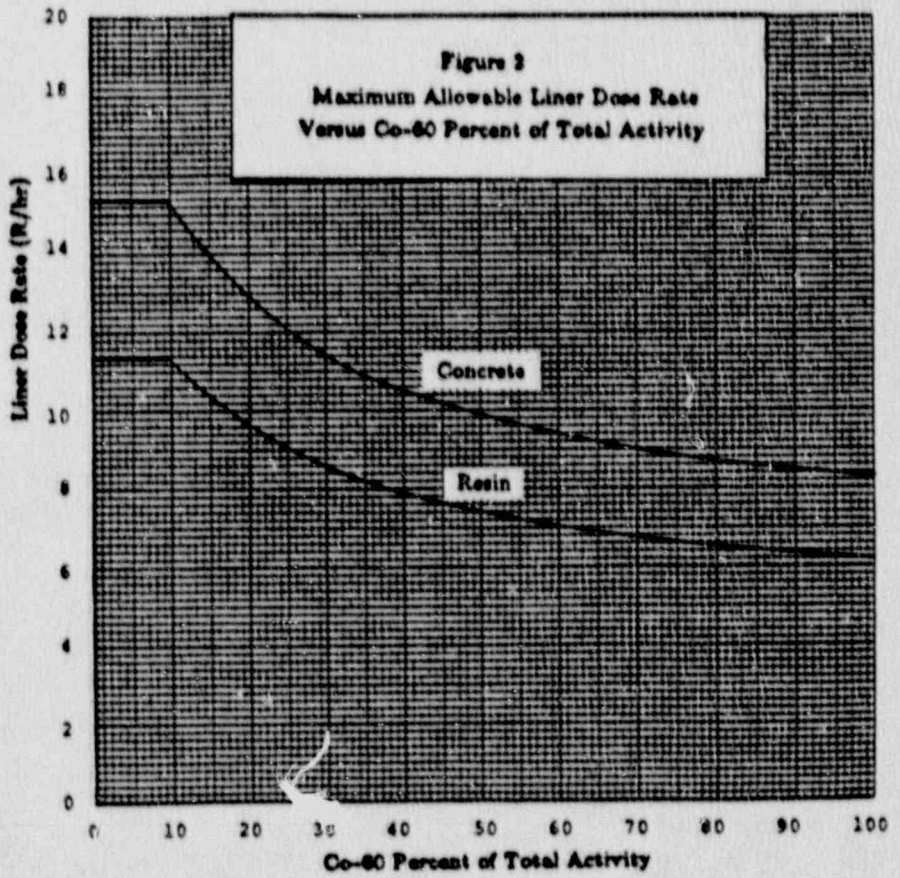
These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is a dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 3.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in about 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.





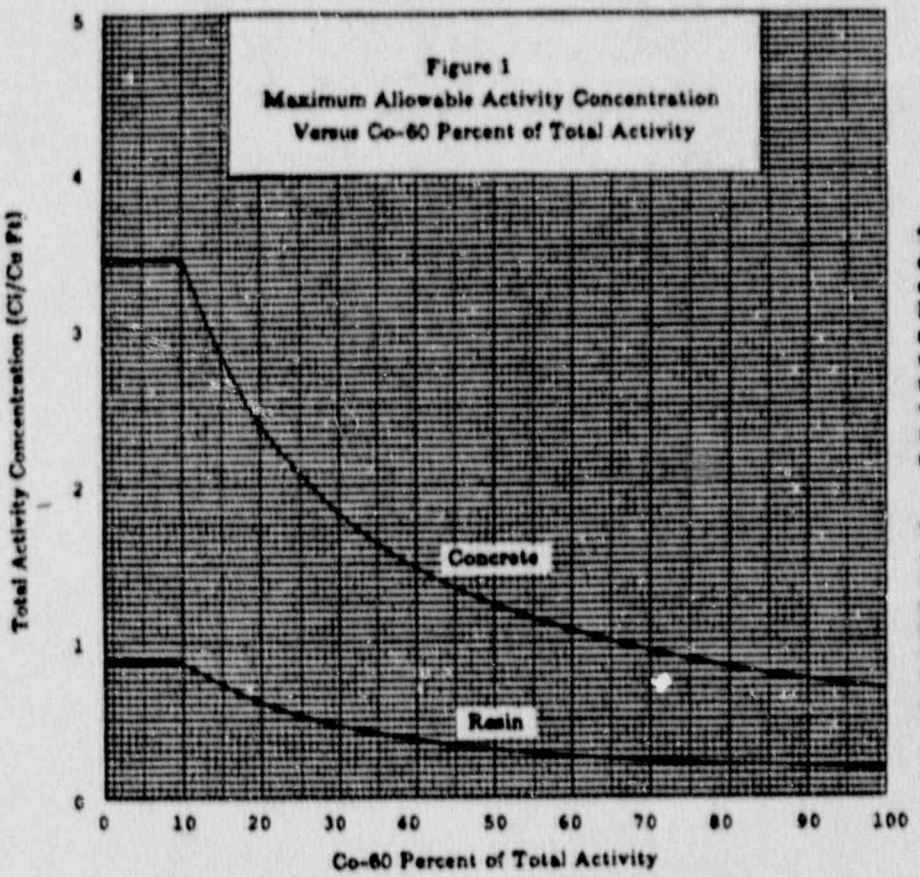
The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is a dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in about 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.



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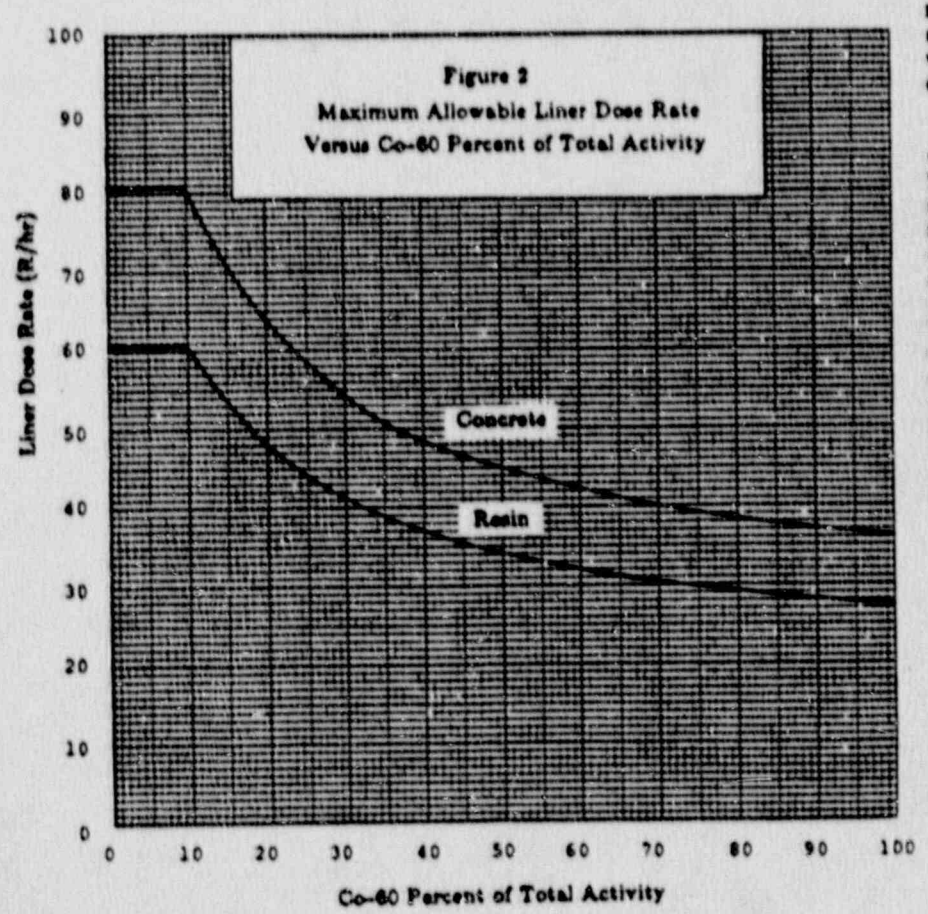
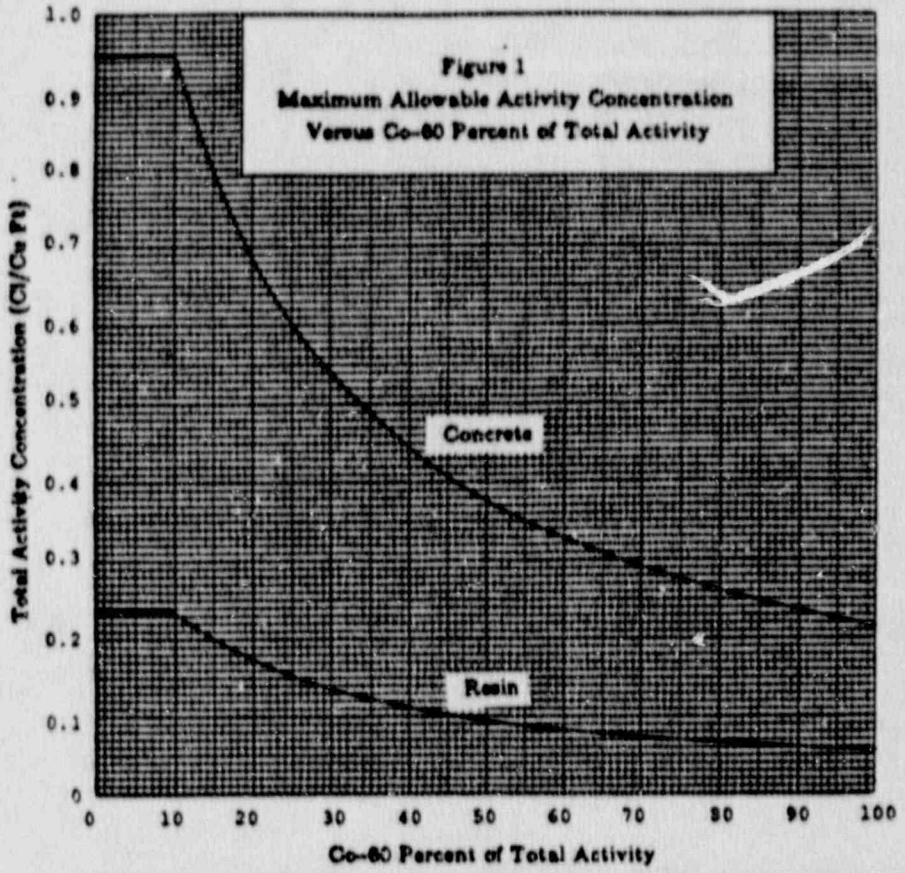
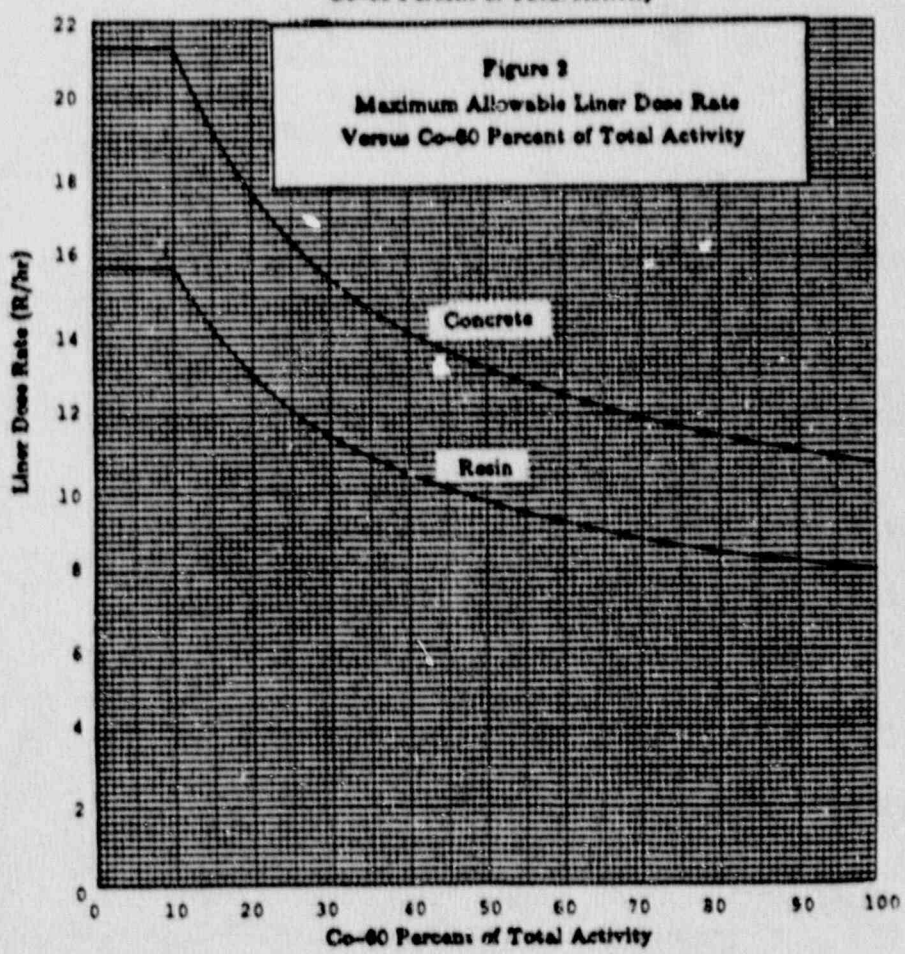


Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculation were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in about 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.





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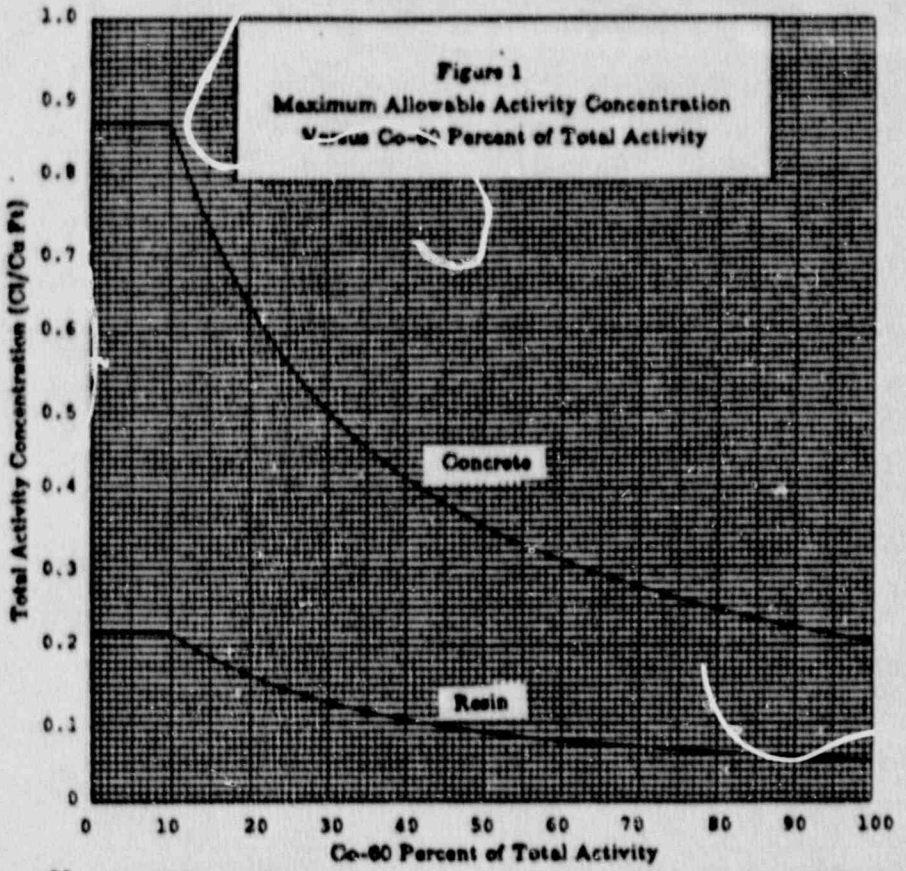
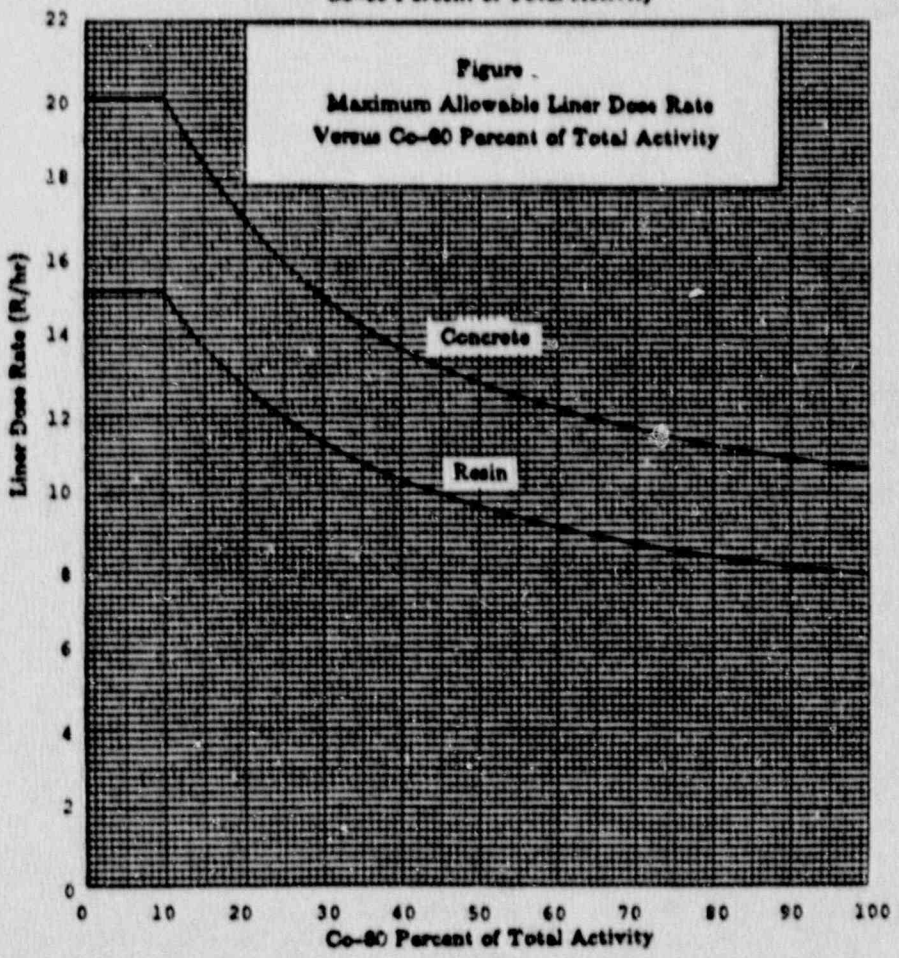
These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is a dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in about 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.





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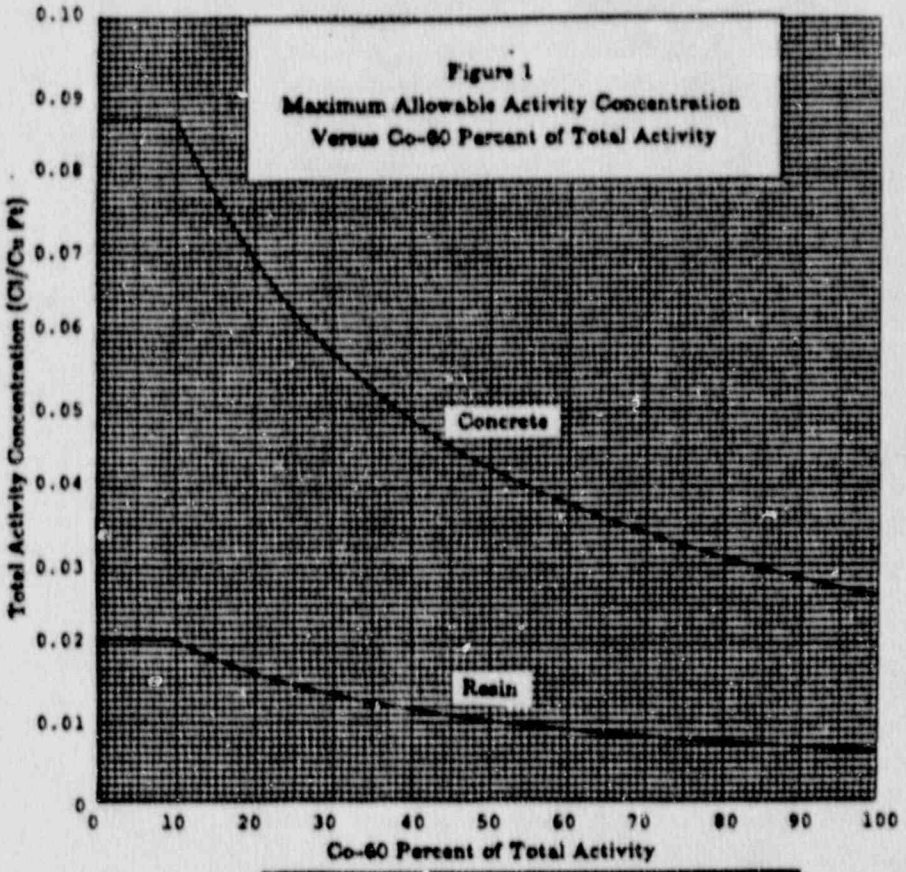
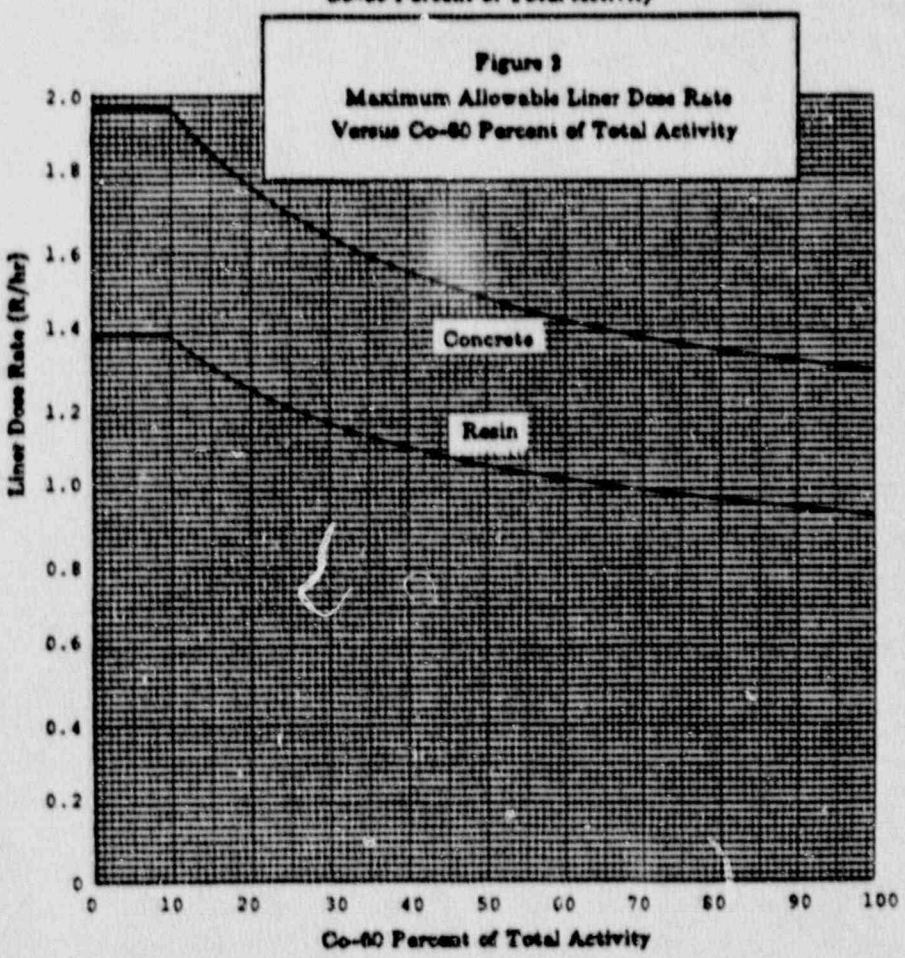
Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE

The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, the curves yield compliance for about 60% of the shipments. To obtain compliance in about 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.





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These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is a dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and filter media. A nominal average density of 2.0 g/cc for concreted wastes and 0.6 g/cc for resins was used in developing the curves.

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The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerance in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in about 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.

APPENDIX B

CASK SHIELDING CURVES ON SEMI-LOG PAPER

Figure 1
Concrete Waste
Maximum Allowable Activity Concentration
Versus Co-60 Percent of Total Activity

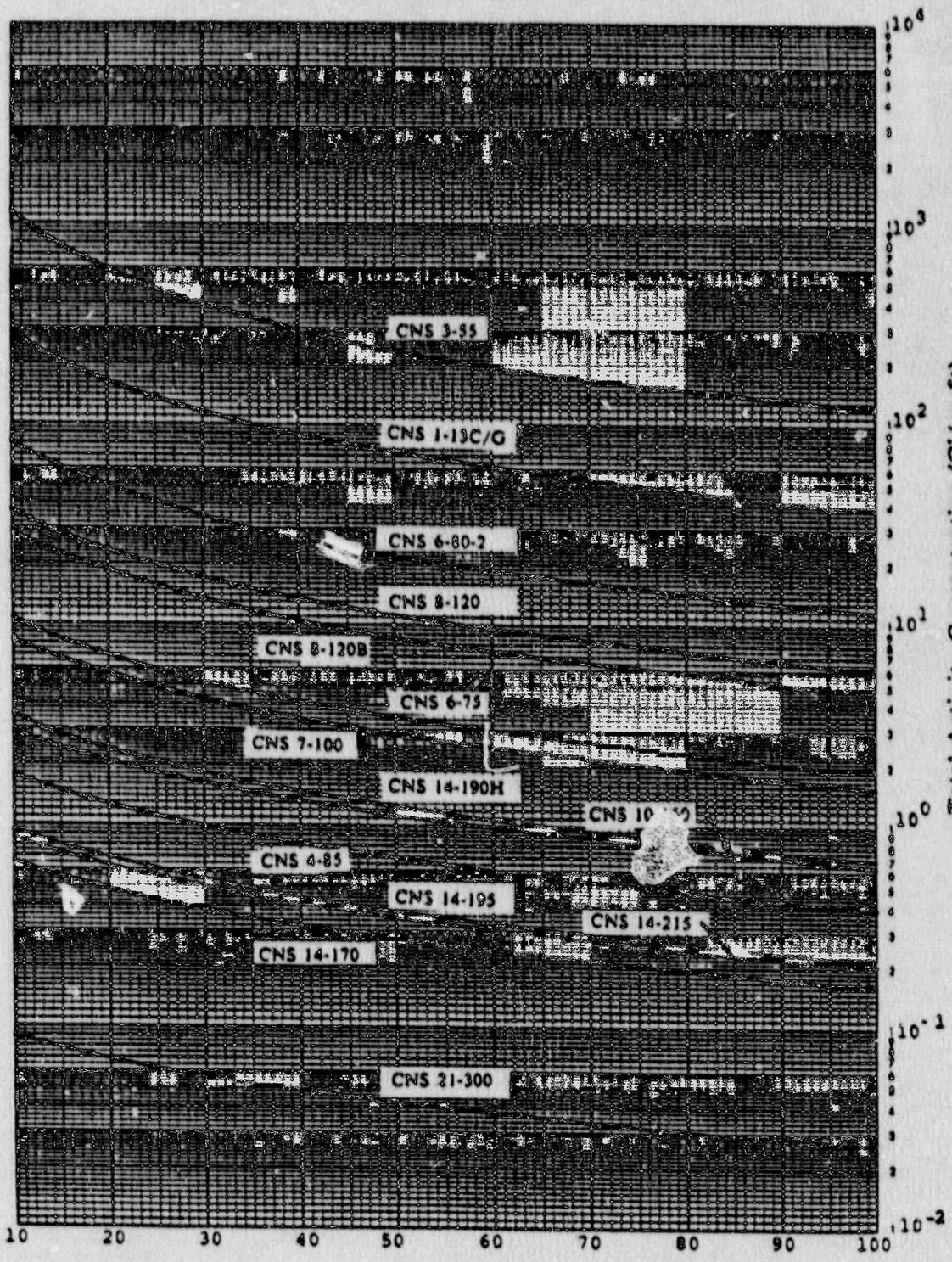


Figure 2
Concrete Waste
Maximum Allowable Liner Dose Rate
Versus Co-60 Percent of Total Activity

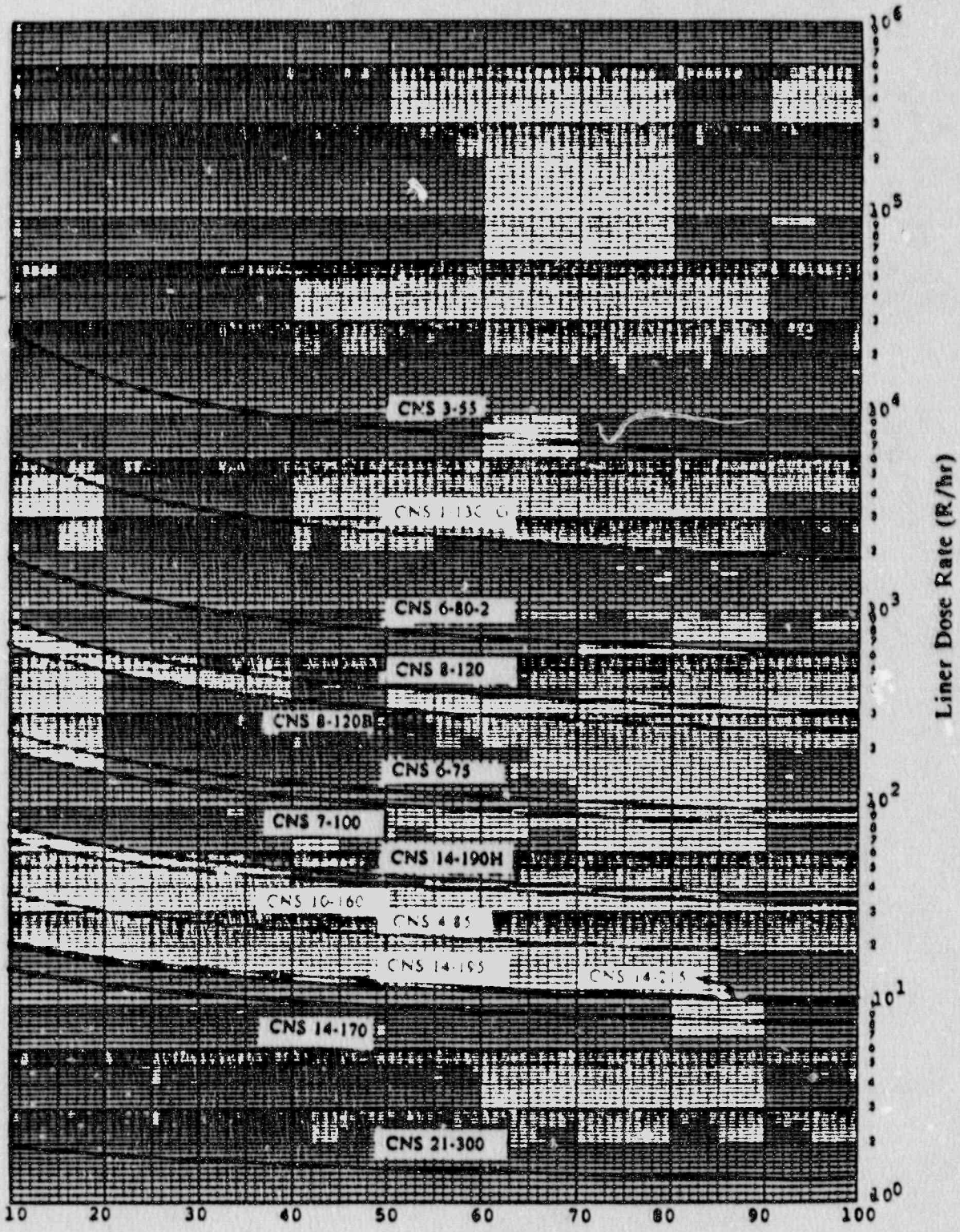


Figure 3
Resin Waste
Maximum Allowable Activity Concentration
Versus Co-60 Percent of Total Activity

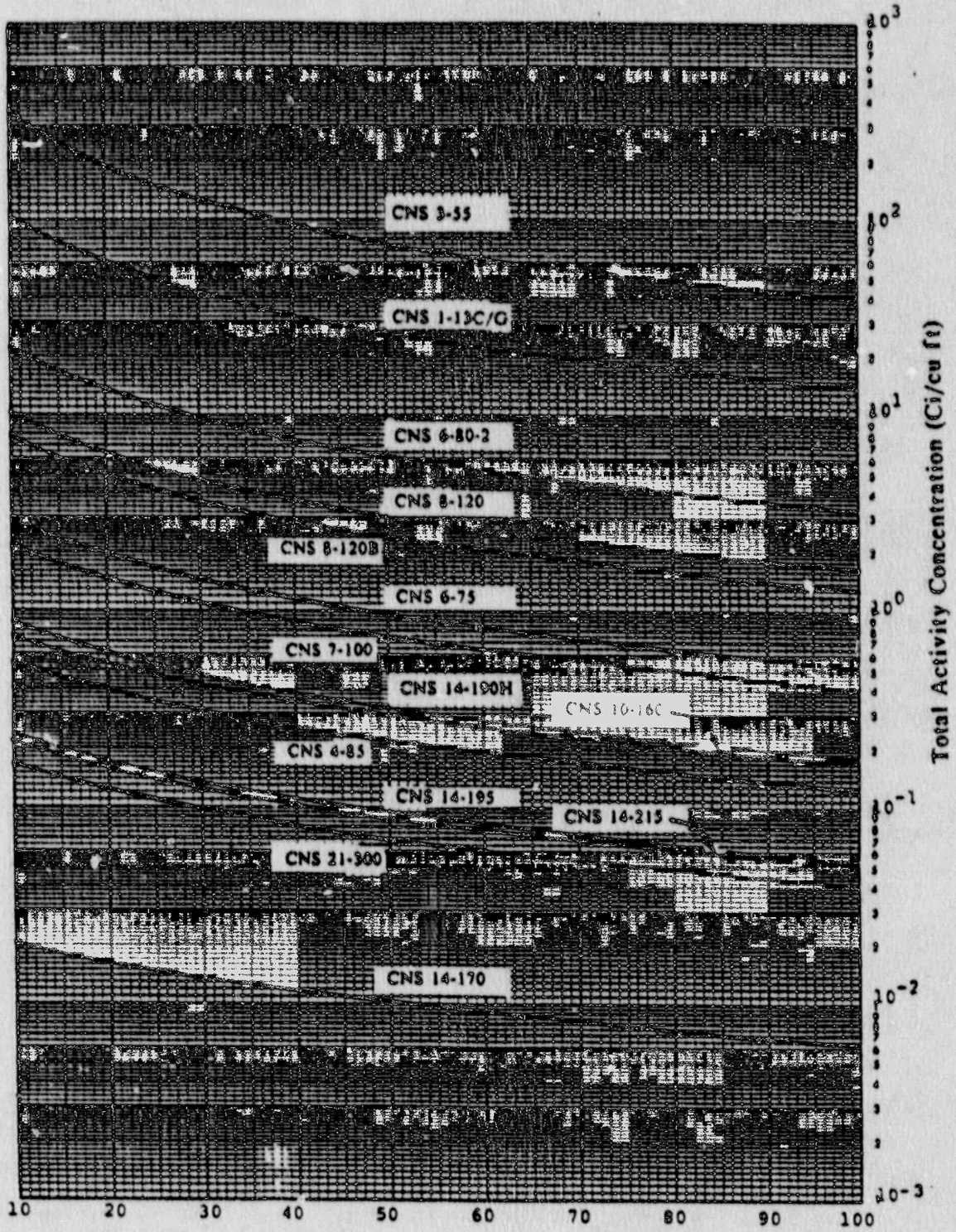
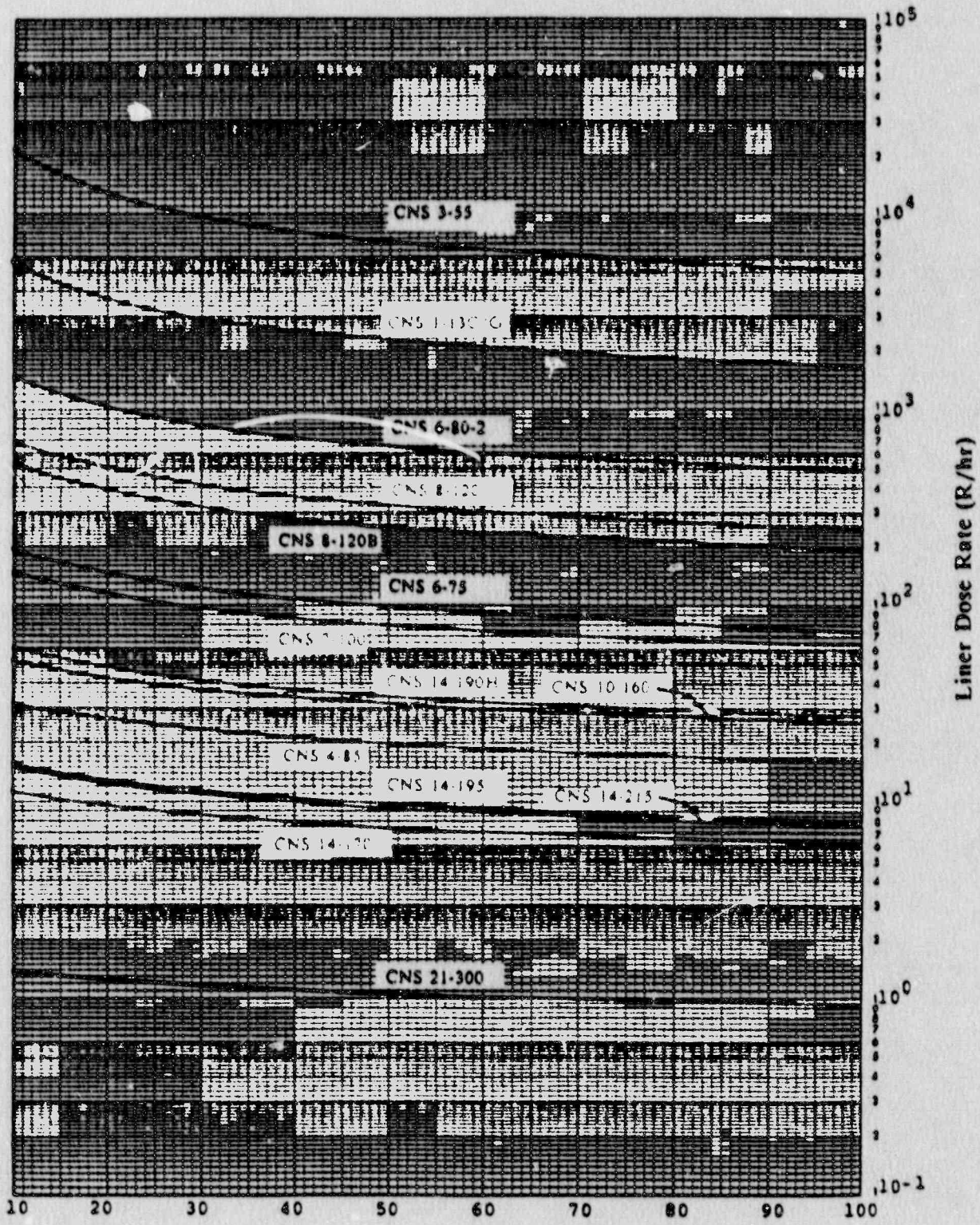


Figure 4
Resin Waste
Maximum Allowable Liner Dose Rate
Versus Co-60 Percent of Total Activity



APPENDIX C

POINT SOURCE SHIELDING CURVES FROM SAR'S

WARNING: DO NOT USE THESE CURVES FOR MARKETING PURPOSES

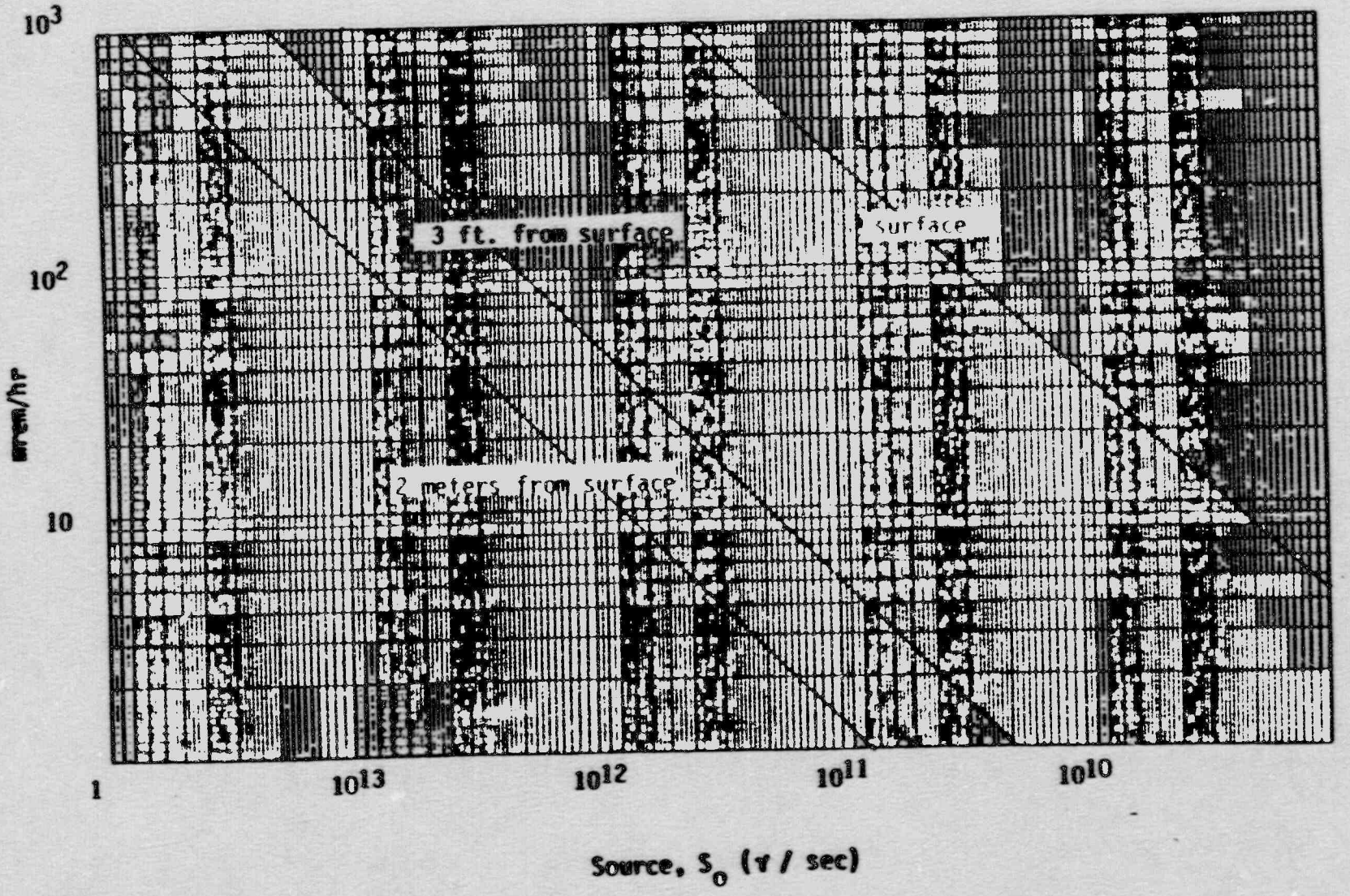


FIGURE 5.4.1-1 Dose Rate vs. Source Strength- Side of Cask

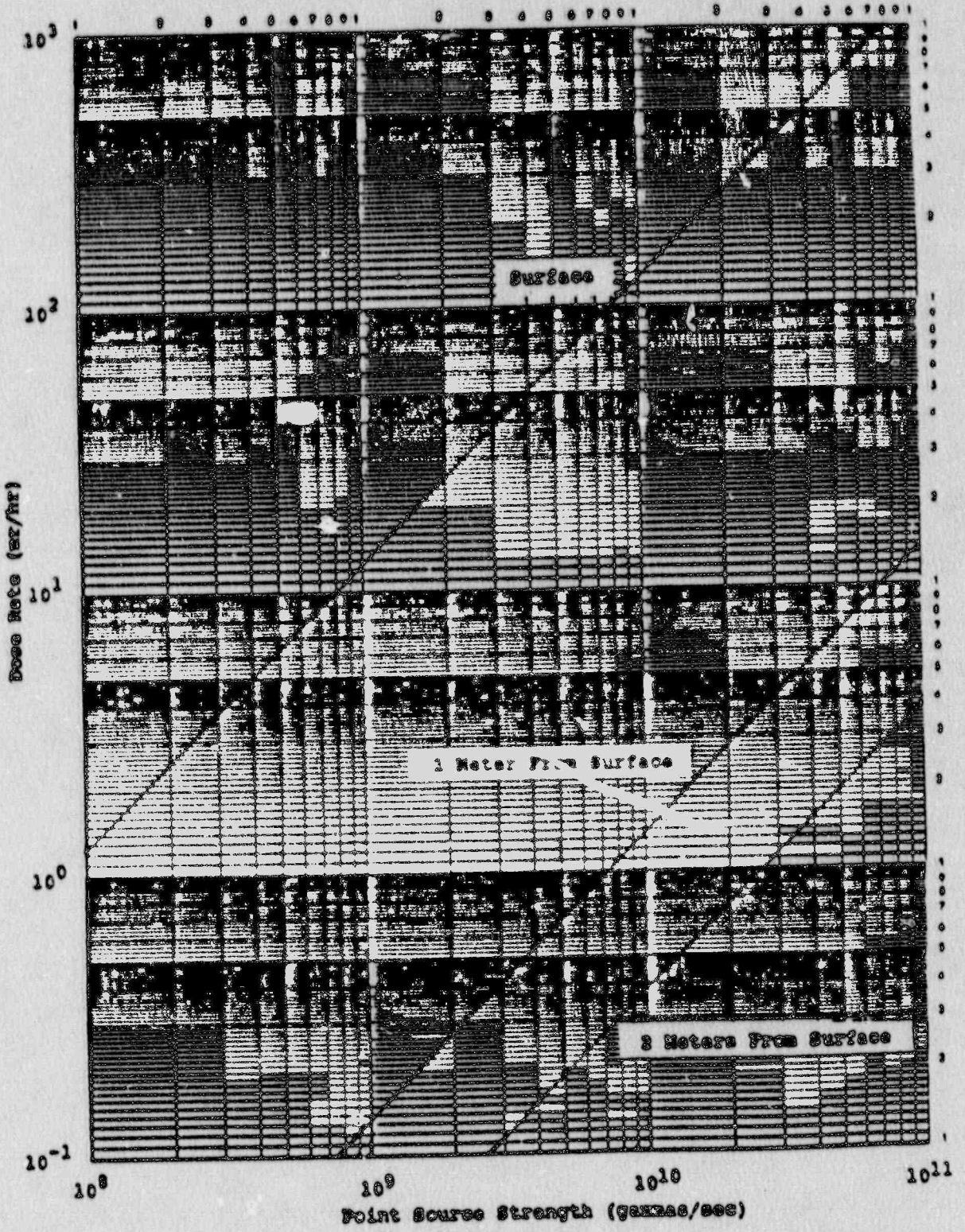


Figure 5.3
Dose Rate Versus Point Source Strength - Side of Cask