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SAFETY EVALUATION FOR PACKAGING 222-S LABORATORY CARGO TANK FOR ONETIME TYPE B MATERIAL SHIPMENT (WHC-SD-TP-SEP-027)		ECN No. NA

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Page 1 of 1

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4,1	1	Cog.Eng. PM Nguyen	[signature]	8/15/94	G2-02	LM Hay	[signature]	08/15/94	G2-02	4,1	1
4,1	1	Cog. Mgr.: JG Field	[signature]	8/15/94	G2-02	JL Rathbun (PSAA)	[signature]	8/19/94	R3-09	4,1	1
4,1	1	QA: MA McGhan	[signature]	8/18/94	L6-35						
4,1	1	Safety: GW Mettler	[signature]	8/19/94	G2-03						
4,1	1	EF Votaw	[signature]	8/16/94	G2-02						
4,1	1	MJ Hall	[signature]	8/16/94	16-07						
4,1	1	JE Mercado	[signature]	8/15/94	G2-02						

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* * * * * * * * * * * * *

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7. Abstract

This Safety Evaluation for Packaging (SEP) demonstrates and documents that the 222-S U.S. Department of Transportation (DOT) MC-312 specification cargo tank packaging system meets the onsite safety criteria for a onetime shipment of Type B radioactive material from the 222-S Laboratory in the 200 West Area to the 204-AR in the 200 East Area.

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LIST OF TERMS

ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
DOT	U.S. Department of Transportation
IAEA	International Atomic Energy Agency
LSA	low specific activity
RL	U.S. Department of Energy, Richland Operations Office
SEP	Safety Evaluation for Packaging

SAFETY EVALUATION FOR PACKAGING 222-S LABORATORY CARGO TANK FOR ONETIME TYPE B MATERIAL SHIPMENT

PART A: DESCRIPTION AND OPERATIONS

1.0 INTRODUCTION

The purpose of this Safety Evaluation for Packaging (SEP) is to evaluate and document the safety of the onetime onsite shipment of bulk radioactive liquids in the 222-S Laboratory cargo tank (222-S cargo tank). The 222-S cargo tank is a U.S. Department of Transportation (DOT) MC-312 specification (DOT 1989) cargo tank, vehicle registration number HO-64-04275, approved for low specific activity (LSA) shipments in accordance with the DOT Title 49, *Code of Federal Regulations* (CFR). In accordance with the U.S. Department of Energy, Richland Operations Office (RL) Order 5480.1A, Chapter III (RL 1988), an equivalent degree of safety shall be provided for onsite shipments as would be afforded by the DOT shipping regulations for a radioactive material package. This document demonstrates that this packaging system meets the onsite transportation safety criteria for a onetime shipment of Type B contents.

This authorization expires on September 15, 1994, or when the shipment is completed, whichever date is earlier.

2.0 PACKAGING SYSTEM

The packaging system is a 5,000 gallon DOT MC-312 specification cargo tank truck with a cleanbore straight shape vessel. The container is constructed of an 8 gauge stainless steel, two piece barrel with one circumferential weld. The container has an American Society of Mechanical Engineers (ASME) tested 2 in. rupture disc with polyethylene drain tube located at the top center of the vessel. The 35 psig air inlet pressure package (consisting of a pressure gauge, ball valve, a coupler, and an ASME approved relief valve) is mounted in the dam area. The container also has a 3 in. stainless steel dip tube in the rear dam area, and another 3 in. stainless steel dip tube in the forward dam area. The dam is a part of the cargo tank flashing system, it is built as a stainless steel construction spillbox with polyethylene drain hoses on each side, located just ahead of the suspension.

The cargo tank has a 5,000 gallon capacity, however, the 222-S cargo tank capacity for this shipment shall be limited to 4,000 gallons. The maximum operating system pressure is 40 psi and the design temperature is 125 °F.

3.0 PACKAGE CONTENTS

The authorized contents for this shipment are 4,000 gallons (15,142 L) of aqueous radioactive liquid with an approximate density of 1 g/mL.

The isotopic composition transported in the 222-S cargo tank for this onetime shipment is as shown in Figure B2-1, based on the sample evaluation.

The 222-S cargo tank is currently operating under a SEP (WHC-SD-TP-SEP-011) which allows the transfer of up to 5% LSA material with an A_2 value of less than 0.05 Ci. However, a recent laboratory report (Figure B2-1) showed an abnormal amount of ^{241}Am and $^{89/90}$Sr (Part B, Section 2.0). The activity for ^{241}Am exceeds the limit for a Type A quantity set by the DOT regulation (49 CFR 173.435) by 20 times and the $^{89/90}$Sr limit by 2, as shown in Table A3-1. Therefore, these radionuclides contribute to causing the material content for this bulk shipment in the 222-S cargo tank to be of a Type B nature as shown in Figure B2-2.

Table A3-1. DOT A_2 Value Comparison with Nuclides.

Nuclide	Activity (Ci)	A_2 Value (Ci)
^{3}H	1.24 E-03	1000
^{14}C	2.30 E-04	60
$^{89/90}$Sr	8.95 E-01	0.4
^{99}Tc	5.18 E-04	25
^{129}I	6.55 E-04	2
^{137}Cs	9.08 E-01	10
^{147}Pm	6.71 E-02	25
^{233}U	5.19 E-11	0.1
^{235}U	1.01 E-06	0.2
^{238}U	1.98 E-05	N/A
$^{239/240}$Pu	5.58 E-04	0.002
^{241}Am	1.53 E-01	0.008
TOTAL	2.03 E+00	-----

4.0 TRANSPORT SYSTEM

The transport shall be accomplished during off-peak traffic hours during daylight. There shall be HPT's monitoring during the entire transport operation and the accepting facility HPT shall be contacted to perform a dose rate evaluation and radiological boundary posting if necessary. The emergency response team shall be notified of the shipment and ready to respond. All roads shall be barricaded and the transport route shall be limited to the shortest available route using normal Hanford Site paved roadways (see Figures A4-1 and A4-2). The cargo tank shall have an escort in front and back, and be limited to a speed of 45 mph on regular roadways and 10 mph on curves and/or turns. There shall be two drivers in the cab at all times during transport. The cab of the cargo tank shall be equipped with a fire extinguisher capable of extinguishing a Class A, B, or C fire, and the drivers shall be trained and qualified in its use. The filled cargo tank shall not be left unattended at any time during loading or enroute to its destination unless the vehicle is parked in a secured area.

The packaging external radiation levels shall meet the 49 CFR 173.441 requirements for an exclusive use shipment as follows:

> **(b) A package which exceeds the radiation level limits specified in paragraph (a) of this section shall be transported by exclusive use shipment only and the radiation levels for such shipment must not exceed the following during transportation:**
> **(1) 200 millirem per hour (2 millisievert per hour) on the external surface of the package unless the following conditions are met, in which case the limit is 1000 millirem per hour (10 millisievert per hour).**
> **(i) The shipment is made in a closed transport vehicle;**
> **(ii) The package is secured within the vehicle so that its position remains fixed during transportation; and**
> **(iii) There are no loading or unloading operations between the beginning and end of the transportation.**
>
> **(4) 2 millirem per hour (0.02 millisievert per hour) in any normally occupied space, except that this provision does not apply to private carriers if exposed personnel under their control wear radiation dosimetry devices and operate under provision of a State or federally regulated radiation protection program.**

Removable contamination on the exterior surfaces of the 222-S cargo tank will be held to the following limits (*WHC Radiological Control Manual*, WHC-CM-1-6):

Table B4-1. Decontamination Limits.

Nuclide (note 1)	Removable (dpm/100 cm^2) (note 2)	Total (Fixed + Removable) (dpm/100 cm^2) (note 3)
U-natural, ^{235}U, ^{238}U, and associated decay products.	220 alpha	5,000 alpha
Transuranics, ^{226}Ra, ^{228}Ra, ^{230}Th, ^{228}Th, ^{231}Pa, ^{227}Ac, ^{125}I, ^{129}I	20	500
Th-nat, ^{232}Th, ^{90}Sr, ^{223}Ra, ^{224}Ra, ^{232}U, ^{126}I, ^{131}I, ^{133}I	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above. Includes mixed fission products containing ^{90}Sr.	1,000 beta/gamma	5,000 beta/gamma

Table notes:
1. The values in this table apply to radioactive contamination deposited on, but not incorporated into the interior of the contaminated item. Where contamination by both alpha-and beta/gamma-emitting nuclides exists, the limits established for the alpha-and beta/gamma-emitting nuclides apply independently.
2. The amount of removable radioactive material per 100 cm^2 of surface area should be determined by swiping the area with dry filter or soft absorbent paper, while applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. For objects with a surface area less than 100 cm^2, the entire surface should be swiped, and the activity per unit area should be based on the actual surface area. Except for transuranic elements, ^{228}Ra, ^{227}Ac, ^{228}Th, ^{230}Th, ^{231}Pa, and alpha emitters, it is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual contamination levels are below the values for removable contamination.
3. The levels may be averaged over 1 m^2 provided the maximum activity in any area of 100 cm^2 is less than three times the values in this table.

Figure A4-1. 200 West Area Route.

- Leave 222-S Laboratory (219-S TSD Facility)
- East on 10th Street
- North on Beloit Avenue
- East on 20th Street
- East on Route 3

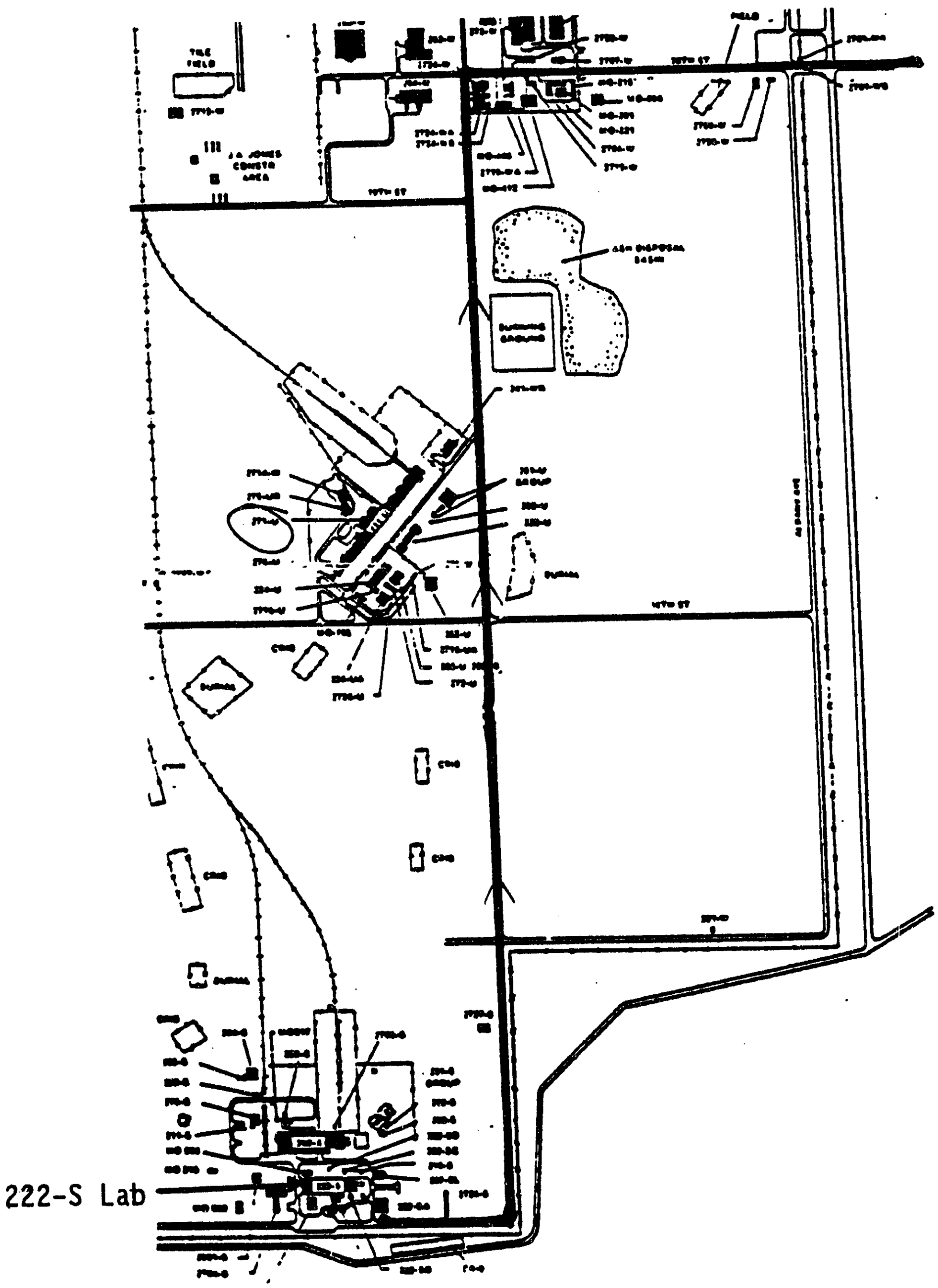
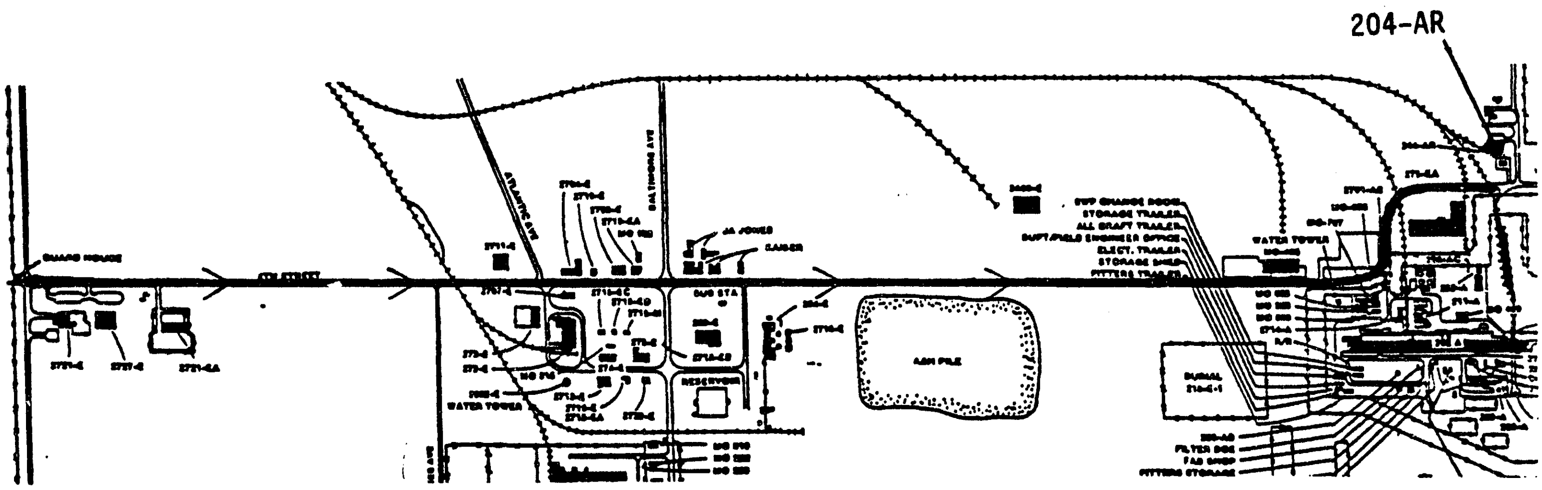


Figure A4-2. 200 East Area Route.

- East on 4th Street
- Arrive at 204-AR



5.0 ACCEPTANCE OF PACKAGING FOR USE

The cargo tank system shall meet DOT specification MC-312. The cargo tank shall be current in accordance with the DOT maintenance and inspection requirements as specified in 49 CFR 180 and in accordance with the manufacturer's recommendation for its mechanical system.

6.0 OPERATING REQUIREMENTS

The 222-S cargo tank handling and loading/unloading shall follow the operations procedure (*Transfer Tank 102 Liquid Waste to Tank Farms*, LO-100-160) in accordance with WHC practice.

This SEP shall be considered the controlling document for this onetime shipment of the 222-S cargo tank. Operation controls presented in this SEP (Part A, Section 4.0) shall take priority over similar requirements in other WHC manuals, unless such controls or requirements are more restrictive.

Applicable instructions and/or procedures for onsite shipment of radioactive materials shall be in compliance with WHC-CM-2-14, *Hazardous Material Packaging and Shipping*.

7.0 QUALITY ASSURANCE REQUIREMENTS

The 222-S cargo tank shall be subjected to the DOT MC-312 Quality Assurance requirements in accordance with WHC-CM-2-14, Part IV, "Radioactive Material Shipments" and Part VI "Cargo Tanks/Cargo Tank Motor Vehicles."

8.0 MAINTENANCE

The 222-S Laboratory cargo tank is constructed in accordance with DOT specification MC-312 and shall be current in its periodic inspection and maintenance requirements.

9.0 APPENDIX

9.1 REFERENCES

49 CFR 100-199, 1993, "Transportation," *Code of Federal Regulations*, as amended.

49 CFR 100-199, 1989, "Transportation," *Code of Federal Regulations*, as amended.

RL, 1988, *Environment, Safety and Health Program for Department of Energy Operations for Richland*, RL Order 5480.1A, Chapter III, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

WHC-CM-1-6, *WHC Radiological Control Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-2-14, *Hazardous Material Packaging and Shipping*, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993, *Safety Evaluation for Packaging for the 222-S Laboratory Cargo Tank*, WHC-SD-TP-SEP-011, Westinghouse Hanford Company, Richland, Washington.

WHC, 1994, *Transfer Tank 102 Liquid Waste to Tank Farms*, LO-100-160, Westinghouse Hanford Company, Richland, Washington.

PART B: PACKAGE EVALUATION

1.0 INTRODUCTION

1.1 SAFETY EVALUATION METHODOLOGY

This Safety Evaluation for Packaging (SEP) authorizes a onetime onsite shipment of Type B radioactive material in the 222-S Laboratory U.S. Department of Transportation (DOT) MC-312 specification cargo tank (222-S cargo tank).

The 222-S cargo tank is an authorized DOT transportation package for bulk liquid low specific activity (LSA) material in accordance with 49 CFR 173.425. The material which is usually shipped in this cargo tank is LSA or slightly greater in accordance with WHC-SD-TP-SEP-011. Due to an abnormal ^{241}Am and $^{89/90}$Sr concentration in the 222-S storage tank, however, the liquid contents are a Type B quantity of radioactive material, and greater than Type A (non-bulk) LSA.

This SEP demonstrates that the proposed onetime shipment of the Type B contents meets onsite transportation safety criteria. The safety evaluation method for this shipment is based on risk, shielding, and thermal analysis; on the institution of operational controls; and the cargo tank's up-to-date DOT and mechanical inspection records.

1.2 EVALUATION SUMMARY AND CONCLUSIONS

The shielding analysis (Part B, Section 5.0) shows that the cargo tank meets the DOT dose rate requirements for the Type B contents. The risk analysis shows that in the unlikely event of an accident, the predicted dose consequence meets the onsite acceptance limits as shown in Part B, Section 3.0, based on accident frequency. The decay heat generation study confirms that the contents do not generate sufficient heat to affect the cargo tank. In addition, the cargo tank recently completed its periodic DOT MC-312 and mechanical inspections in accordance with the DOT requirements and the manufacturer schedule.

1.3 APPENDIX

1.3.1 References

49 CFR 100-199, 1993, "Transportation," *Code of Federal Regulations*, as amended.

WHC, 1993, *Safety Evaluation for Packaging for the 222-S Laboratory Cargo Tank*, WHC-SD-TP-SEP-011, Westinghouse Hanford Company, Richland, Washington.

2.0 CONTENTS EVALUATION

2.1 CONTENTS

The allowable contents of the 222-S cargo tank are 4,000 gallons (15,142 L) of the 222-S laboratory liquids. The radioactive contents are based on the laboratory sample shown in Figure B2-1 and the transportation contents are shown in Figure B2-2. The contents are Type B (Part A, Section 3.0) and would also be LSA (greater than Type A) if this was not a bulk liquid shipment.

It should be noted that under the current International Atomic Energy Agency (IAEA) regulations (IAEA 1990), the contents would meet the definition of LSA II (Figure B2-3) and could be shipped in other countries in a packaging similar to the 222-S cargo tank. Therefore, considering the controls which have been mandated for this onetime shipment, the risk posed from these contents is minor.

Table B2-1. LSA and A_2 Limits for DOT and IAEA.

Radionuclide	DOT		IAEA	
	LSA (mCi/g)	A_2 (Ci)	LSA (Ci/g)	A_2 (Ci)
^{3}H	0.3	1000	1×10^{-2}	1000
^{14}C	0.3	60	5×10^{-4}	50
$^{89/90}Sr$	0.005	0.4	2×10^{-5}	2
^{99}Tc	0.3	25	2×10^{-4}	20
^{129}I	0.3	2	unlimited	unlimited
^{137}Cs	0.3	10	1×10^{-4}	10
^{147}Pm	0.3	25	2×10^{-4}	20
^{233}U	0.005	0.1	2×10^{-7}	0.02
^{235}U	0.005	0.2	unlimited	unlimited
^{238}U	unlimited	unlimited	unlimited	unlimited
$^{239/240}Pu$	0.0001	0.002	5×10^{-8}	0.005
^{241}Am	0.0001	0.008	5×10^{-8}	0.005

Figure B2-1. 222-S Laboratory Cargo Tank Lab Sample.

SAMPLE STATUS REPORT FOR S 9016. 102-LW TIME: 7/21/94 15: 1
DISPATCHED: 6/23/94 11: 1 SAMPLE HAS NOT BEEN SLURPED
RECEIVED: 6/23/94 11:40

EXT.	DETER.	RESULTS OR STATUS		OUT OF RANGE?	GOOD ANS?	CHARGE CODE
****	********	***********************************		***	***	******
1001	APPR/OTR	CLEAR COLORLESS NO SOLIDS PHASES				YLDDA
1206	TB	2.62000E 02 uCi/L		N	Y	YLDDA
1266	AT	1.81000E 01 uCi/L		N	Y	YLDDA
1331	As	INCOMPLETE				YLDDA
1454	C/R	OUT FOR RERUN				YLDDA
1454	C/R	1.61000E-01 lbNaOH/gal		N	Y	YLDDA
1557	Cl	3.65000E-02 M		N	Y	YLDDA
1601	TIC	5.80000E-04 M		N	Y	YLDDA
1621	TOC	4.03000E 00 G/L C		N	Y	YLDDA
1831	DSC	NO EXOTHERMS				YLDDA
1907	F	7.02000E-03 M		N	Y	YLDDA
2101	GEA	7.14000E 01 uCi/L	Cs-137	N	Y	YLDDA
~~2101~~	~~GEA~~	~~1.99000E-01 uCi/L~~	~~Am-241~~	N	Y	YLDDA
2216	H+	1.44000E-01 M		N	Y	YLDDA
2385	Hg	OUT FOR RERUN				YLDDA
2385	Hg	3.68000E-01 mG/L		N	Y	YLDDA
2456	ICP	1.04000E 04 PPB	Cr	N	Y	YLDDA
2456	ICP	5.21000E 02 PPB	Ba	N	Y	YLDDA
2456	ICP	4.70000E 01 PPB	Ag	N	Y	YLDDA
2456	ICP	8.30000E 03 PPB	Pb	N	Y	YLDDA
2456	ICP	4.20000E 01 PPB	Cd	N	Y	YLDDA
2456	ICP	8.75000E 05 PPB	Na	N	Y	YLDDA
2456	ICP	3.18000E 04 PPB	Al	N	Y	YLDDA
2456	ICP	1.03000E 02 PPB	As	N	Y	YLDDA
2456	ICP	< 1.00000E 02 PPB	Se	N	Y	YLDDA
2491	I129	< 5.15000E-02 uCi/L		N	Y	YLDDA
2912	NO2	5.57000E-04 M		N	Y	YLDDA
2937	NO3	1.46000E-01 M		N	Y	YLDDA
3201	pH	1.20000E 00 NONE		N	Y	YLDDA
3201	pH	1.18000E 00 NONE		N	Y	YLDDA
3244	Pm	OUT FOR RERUN				YLDDA
3244	Pm	5.28000E 00 uCi/L		N	Y	YLDDA
3267	PO4	2.65000E-03 M		N	Y	YLDDA
3336	Pu239/40	4.39000E-02 uCi/L	PU239/240	N	Y	YLDDA
3371	Pu-Total	9.09000E-03 GRAMS		N	Y	YLDDA
3531	Se	2.59000E 01 uG/L		N	Y	YLDDA
3707	SO4	1.54000E-02 M		N	Y	YLDDA
3804	Sr89/90	7.04000E 01 uCi/L		N	Y	YLDDA
4193	Tc99	4.07000E-02 uCi/L		N	Y	YLDDA
4419	U	3.93000E-03 G/L		N	Y	YLDDA
~~4022~~	~~Am241~~	~~1.20000E 01 uCi/L~~		N	Y	YLDDA
5701	VOA	INCOMPLETE				YLDDA
5712	TGA	9.90900E 01 % H2O		N	Y	YLDDA
7687	H3	9.75000E-05 uCi/ML		N	Y	YLDDA
7688	C14	1.81000E-05 uCi/ML		N	Y	YLDDA

END OF REPORT

Figure B2-2. LSA and A_2 Determination under DOT.
Fissile-Exempt Material Determination.

Tanker Shipment 94-3							
	Done by:	Reid Chesterfield	8/19/94		Checked by:	[illegible]	8/19/94
Volume = 4000 gallons = 15140 L							
Assume density = 1g/mL							
	Concentration						
Nuclide	(uCi/L)	(mCi/g)	Activity (Ci)	A2 (Ci)	Fi	Fi/A2	LSA Fraction
H-3	9.75E-02	9.75E-08	1.48E-03	1000	6.12E-04	6.12E-07	3.25E-07
C-14	1.81E-02	1.81E-08	2.74E-04	60	1.14E-04	1.89E-06	6.03E-08
Sr-89/90	7.04E+01	7.04E-05	1.07E+00	0.4	4.42E-01	1.10E+00	1.41E-02
Tc-99	4.07E-02	4.07E-08	6.16E-04	25	2.55E-04	1.02E-05	1.36E-07
I-129	5.15E-02	5.15E-08	7.80E-04	2	3.23E-04	1.62E-04	1.72E-07
Cs-137	7.14E+01	7.14E-05	1.08E+00	10	4.48E-01	4.48E-02	2.38E-04
Pm-147	5.28E+00	5.28E-06	7.99E-02	25	3.31E-02	1.33E-03	1.76E-05
U-233	4.08E-09	4.08E-15	6.18E-11	0.1	2.56E-11	2.56E-10	8.16E-13
U-235	7.92E-05	7.92E-11	1.20E-06	0.2	4.97E-07	2.49E-06	1.58E-08
U-238	1.31E-03	1.31E-09	1.98E-05	n/a	8.22E-06	0.00E+00	n/a
Pu-239/240	4.39E-02	4.39E-08	6.65E-04	0.002	2.76E-04	1.38E-01	4.39E-04
Am-241	1.20E+01	1.20E-05	1.82E-01	0.008	7.53E-02	9.41E+00	1.20E-01
Totals		1.59E-04	2.41E+00			1.07E+01	1.35E-01
Type B	LSA				Mix. A2 =	9.34E-02	
Fissile Determination							
Nuclide	Activity (Ci)	Spec. Act. (Ci/g)	Amount (g)				
U-233	6.18E-11	9.50E-03	6.51E-09				
U-235	1.20E-06	2.10E-06	5.71E-01				
Pu-239/240	6.65E-04	6.20E-02	1.07E-02				
Total			5.82E-01				
Since 5.82E-01 < 15 grams, fissile exempt							

Figure B2-3. 222-S Laboratory Contents under IAEA.

Tanker Shipment 94-3			*IAEA VERSION*				
	Done by:	Reid Chesterfield	8/15/94	Checked by:	J. E. Meacham	8/15/94	
Volume = 4000 gallons = 15140 L							
Assume density = 1g/mL							
	Concentration			IAEA			IAEA
Nuclide	(uCi/L)	(Ci/g)	Activity (Ci)	A2 (Ci)	Fi	Fi/A2	A2/g
H-3	9.75E-02	9.75E-11	1.48E-03	1000	6.12E-04	6.12E-07	9.75E-14
C-14	1.81E-02	1.81E-11	2.74E-04	50	1.14E-04	2.27E-06	3.62E-13
Sr-89/90	7.04E+01	7.04E-08	1.07E+00	2	4.42E-01	2.21E-01	3.52E-08
Tc-99	4.07E-02	4.07E-11	6.16E-04	20	2.55E-04	1.28E-05	2.04E-12
I-129	5.15E-02	5.15E-11	7.80E-04	n/a			
Cs-137	7.14E+01	7.14E-08	1.08E+00	10	4.48E-01	4.48E-02	7.14E-09
Pm-147	5.28E+00	5.28E-09	7.99E-02	20	3.31E-02	1.66E-03	2.64E-10
U-233	4.08E-09	4.08E-18	6.18E-11	0.02	2.56E-11	1.28E-09	2.04E-16
U-235	7.92E-05	7.92E-14	1.20E-06	n/a			
U-238	1.31E-03	1.31E-12	1.98E-05	n/a			
Pu-239/240	4.39E-02	4.39E-11	6.65E-04	0.005	2.76E-04	5.51E-02	8.78E-09
Am-241	1.20E+01	1.20E-08	1.82E-01	0.005	7.53E-02	1.51E+01	2.40E-06
Totals		1.59E-07	2.41E+00			1.54E+01	2.45E-06
Type B	LSA II				Mix. A2 =	6.50E-02	
Total (Ci/g)/mixture A2 =		2.45E-06	A2's/g				

2.2 APPENDIX

2.2.1 Reference

IAEA, 1990, *Regulations for the Safe Transport of Radioactive Material 1985 Edition*, IAEA Safety Series No. 6, as amended 1990, International Atomic Energy Agency, Vienna, Austria.

3.0 RADIOLOGICAL RISK EVALUATION

The section provides the result of the accident frequency evaluation of the 222-S cargo tank used to transport the material listed in Figure B2-1.

3.1 ACCIDENT FREQUENCY ANALYSIS

An accident frequency evaluation was performed for the 222-S cargo tank shipment from the 222-S Laboratory in the 200 West Area to the 204-AR located in the 200 East Area. The shipping distance was determined to be 6.3 miles and is illustrated in Figures A4-1 and A4-2. The purpose of this analysis was to determine the predicted accident frequency for the shipment.

The following data was extracted from the *Standard Transportation Risk Assessment Methodology* report (WHC 1993):

reportable accidents/mile	4.38×10^{-6}
major accidents/reportable accidents	0.27
random fire/major accident	1/31
collision/major accident	23/31
rollover	2/31
uncontrolled fire/fire	0.033
icy road	not allowed

In order to reduce the potential of a collision (to 5% of the recorded value), the following controls shall be imposed:

- No vehicles allowed on the road segment being traveled by the cargo tank except the escort vehicles.
- Patrol escort.
- Second driver in the cab.
- Speed limited to 45 mph or posted speed, whichever is less.

Therefore, the calculated accident release frequency is as follows:

$$\frac{\textit{accident releases}}{\textit{mile}} = \frac{\textit{reportable accidents}}{\textit{mile}} \times \frac{\textit{major accidents}}{\textit{reportable accidents}} \times$$

$$\left(\frac{\textit{random fire}}{\textit{major accident}} \times \frac{\textit{uncontrolled fire}}{\textit{fire}} + \frac{\textit{rollover}}{\textit{major accident}} \times \frac{\textit{5\% collision}}{\textit{major accident}}\right)$$

$$= 4.38 \times 10^{-7} \times 0.27 \left(\frac{1}{31} \times 0.033 + \frac{2}{31} + \frac{23}{31}(0.05)\right)$$

$$= 1.2 \times 10^{-6} \times 0.102$$

$$= 1.22 \times 10^{-7} \frac{\textit{accident releases}}{\textit{mile}}$$

$$1.22 \times 10^{-7} \frac{\textit{accident releases}}{\textit{mile}} \times 6.3 \frac{\textit{miles}}{\textit{year}} = 7.7 \times 10^{-7} \frac{\textit{accident releases}}{\textit{year}}$$

The 7.7×10^{-7} accident releases/year is considered incredible, and the predicted offsite dose consequence is shown to meet the onsite transportation safety criteria (WHC-SD-TP-RPT-001) for this frequency range in Part B, Section 4.0.

3.2 APPENDIX

3.2.1 References

49 CFR 100-199, 1993, "Transportation," *Code of Federal Regulations*, as amended.

WHC, 1993, *Standard Transportation Risk Assessment Methodology*, WHC-SD-TP-RPT-007, Westinghouse Hanford Company, Richland, Washington, December 1993.

WHC, 1994, *Report on Equivalent Safety for Transportation and Packaging of Radioactive Materials*, WHC-SD-TP-RPT-001, Westinghouse Hanford Company, Richland, Washington.

4.0 CONTAINMENT EVALUATION

The cargo tank is designed and constructed in accordance with the DOT specification for MC-312 cargo tanks. The MC-312 cargo tank is authorized for the shipment in commerce of many acutely hazardous liquids, including nitric acid. The cargo tank has been inspected and tested per the DOT maintenance schedule. Its mechanical service record is current per the manufacturer's recommendation. The dose consequence analysis was performed for the cargo tank in Part B, Section 4.2.2 to evaluate the dose in the event of a release due to an accident.

4.1 DOSE CONSEQUENCE

The dose consequence analysis was performed to determine the dose received by the maximum exposed individual offsite due to a release of material from the cargo tank. The analysis was based on the waste sample data in Figure B2-1.

The dose consequence analysis shows that the effective dose equivalent for the offsite individual would be 1.0×10^{-4} rem at the worst case site boundary, which is well below the 25 rem limit established for incredible accident frequencies as documented the *Report on Equivalent Safety for Transportation and Packaging of Radioactive Materials* (WHC 1994).

4.2 APPENDICES

4.2.1 Reference

WHC, 1994, *Report on Equivalent Safety for Transportation and Packaging of Radioactive Materials*, WHC-SD-TP-RPT-001, Westinghouse Hanford Company, Richland, Washington.

4.2.2 Dose Consequence Analysis

Westinghouse Hanford Company **Internal Memo**

From: Radiation Physics and Shielding 8D530-SMC-94-001
Phone: 376-3765 H0-35
Date: August 14, 1994
Subject: DOSE CONSEQUENCE ANALYSIS OF TANKER SHIPMENT 94-3 AQUEOUS MIXTURE -- SAFETY CLASS ASSESSMENT
To: J. E. Mercado G2-02

cc: J. G. Field G2-02
J. Greenborg H0-35
R. J. Chesterfield G2-02
HJG File/SM

3360 Gallons of aqueous waste are to be moved from 222S Labs (in the 200 West area) to tank farm 204-AR (200 East area). The source term is;

Table 1. Source Term

Isotope	Activity (Ci)
^{3}H	1.24×10^{-3}
^{14}C	2.30×10^{-4}
^{90}Sr	8.95×10^{-1}
^{90}Y	8.95×10^{-1}
^{99}Tc	5.18×10^{-4}
^{129}I	6.55×10^{-4}
^{137}Cs	9.08×10^{-1}
^{137m}Ba	9.08×10^{-1}
^{147}Pm	6.72×10^{-2}
^{233}U	5.19×10^{-11}
^{235}U	1.01×10^{-6}
^{238}U	1.67×10^{-5}
$^{239/40}Pu$	5.58×10^{-4}
^{241}Am	1.53×10^{-1}

For the purposes of this analysis it has been assumed that the entire inventory in the container has been released from any engineered barriers and is at risk for release. The respirable aerodynamic release fraction was taken from the recommendations of J. Mishima (Recommended Values and Technical Bases for Airborne Fractions [ARFs], Airborne Release Rates [ARRs], and Respirable Fractions [RFs] for Materials from Accidents in DOE Fuel Cycle, Ex-Reactor Facilities, Revision 2).

For aqueous liquids on equipment that is dropped three meters or less onto a hard surface the recommended bounding value is 1.4×10^{-4}. The receptor is assumed to be immersed in the cloud for the entire time of its passage.

J. E. Mercado 8D530-SMC-94-001
Page 2
August 10, 1994

The computer program GXQ was run to find the meteorology which is not exceeded more than 0.5% of the time according to Hanford meteorological data. The nine year (1983 - 1991) averaged Hanford data for 200 area release at a height of 10m (created 8/26/92) was used. Two release sites were considered; 222S Labs, and 204-AR. The worst case normalized exposure (χ/Q) was the same for both release sites, although the direction of worst case exposure varied. The value was calculated to be 1.55×10^{-5} sec/m^3 for an individual at the site boundary directly west of the spill if it occurred at the 222S Labs, and the same for an individual at the site boundary directly east of the spill if it occurred at the 204-AR area. Doses were calculated for inhalation and ingestion through drinking water, aquatic foods, terrestrial foods, animal products, and soil (inadvertent). The doses for both drinking water and aquatic foods were zero, since there was no means to contaminate either of them.

The computer code GENII was then used to calculate the actual dose received. The libraries used were as tabulated below;

GENII Default Parameter Values (28-Mar-90 RAP)
Radionuclide Library - Times<100 years (23-July-93 PDR)
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
PNL Food Transfer Factor Library (by Z, with Fr&Os 7/19/93 PDR)
Bioaccumulation Factor Library (30-Aug-88) RAP
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

The off-site individual at the worst case site boundary is expected to receive a committed effective dose equivalent of 1.0×10^{-4} rem.

Sebastian McClendon
Radiation Physics and Shielding

Jess Greenborg
Manager, Radiation Physics and Shielding

```
*** Output file for GXQ - 222S site release ***
                    ____________________
                      GXQ Version 3.1 B
                        June 8, 1993
                    ____________________

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 0.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 0.
Code Custodian is Brit E. Hey, WHC, ext. 6-2921.

Run Date =  8/ 9/1994
Run Time = 14: 1  2.30


INPUT ECHO:
222S Area Release - Farmer
c GXQ Ver. 3.1 Input File
c   mode
    1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c    ifox  inorm icdf  ichk  isite ipop  icon
     T      F     F     F     F     F     F
c ifox  = t then joint frequency used to compute frequency to exceed X/Q
c       = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
c       = f then joint frequency data is un-normalized
c icdf  = t then cumulative distribution file created (CDF.OUT)
c       = f then no cumulative distribution file created
c ichk  = t then X/Q parameter print option turned on
c       = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c       = f then X/Q based on joint frequency data of individual sectors
c ipop  = t then X/Q is population weighted
c       = f then no population weighting
c icon  = t then X/Q is air concentration
c       = f then X/Q is integrated exposure
c
c MODEL CHOICES:
c    idep  iwake ipm   irise igrav iwash iflow iwind
     0      0     0     0     0     0     0     0
c idep  = 1 then plume depletion model turned on (Chamberlain model)
c iwake = 1 then NRC RG 1.145 building wake model turned on
c       = 2 then MACCS virtual distance building wake model turned on
c ipm   = 1 then NRC RG 1.145 plume meander model turned on
c       = 2 then 5th Power Law plume meander model turned on
c       = 3 then sector average model turned on
c irise = 1 then momentum/buoyancy plume rise model turned on, buoyancy
c            rise based on sensible heat emission
c       = 2 then momentum/buoyancy plume rise model turned on, buoyancy
c            rise based on initial plume density
c igrav = 1 then gravitational settling model turned on
c iwash = 1 then stack downwash model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c iwind = 1 then wind speed corrected for plume height
c       = 0 to turn any of the above models off
c
c PARAMETER INPUT:
c    stack         wind                           frequency
```

```
c   release       speed         mixing        to            scaling
c   height        height        height        exceed        factor
c   (m)           (m)           (m)           (%)           (?)
    0.00000E+00   1.00000E+01   1.00000E+03   5.00000E-01   1.00000E+00
c
c                                                           gravitational
c   building      building      release       deposition    settling
c   width         height        duration      velocity      velocity
c   (m)           (m)           (hr)          (m/s)         (m/s)
    5.00000E+00   5.00000E+00   1.00000E+00   1.00000E-03   1.00000E-03
c
c                 initial                     sensible
c   initial       plume                       heat
c   plume         flow          stack         emission
c   density       rate          diameter      rate
c   (g/cc)        (m3/s)        (m)           (cal/s)
    1.22000E-03   0.00000E+00   1.00000E+00   4.18000E+05
c
c RECEPTOR DEPENDENT DATA
c FOR MODE      make          RECEPTOR DEPENDENT DATA
c 1 (site specific)           sector distance z-height
c 2 (by class & wind speed)   class windspeed distance offset z-height
c 3 (create plot file)        class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION:
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = meters
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = m/s
c offset = meters offset from plume centerline
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size

MODE:
Site specific X/Q calculated

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on
  frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for single sector.
Output is atmospheric dispersion coefficient.

MODELS SELECTED:

WARNING/ERROR MESSAGES:
WARNING #3 - Scaled X/Q units (shown as s/m3 or 1/m3
             below) do not reflect the user specified
             scaling factor.

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR


222S Area Release - Farmer
```

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
S	12520	0	6.30	1	8.48E-06	8.48E-06	E	.89
SSW	12720	0	4.53	1	5.21E-06	5.21E-06	F	2.65
SW	15430	0	2.93	1	5.24E-06	5.24E-06	F	2.65
WSW	13200	0	2.72	1	6.40E-06	6.40E-06	F	2.65
W	12950	0	4.80	1	1.55E-05	1.55E-05	G	2.65
WNW	13190	0	3.98	1	8.50E-06	8.50E-06	G	4.70
NW	17170	0	4.72	1	1.13E-05	1.13E-05	G	2.65
NNW	18130	0	4.58	1	1.06E-05	1.06E-05	G	2.65
N	20340	0	4.36	1	9.82E-06	9.82E-06	G	2.65
NNE	28770	0	2.49	1	2.77E-06	2.77E-06	E	.89
NE	26360	0	3.90	1	3.35E-06	3.35E-06	E	.89
ENE	23170	0	6.17	1	6.80E-06	6.80E-06	G	2.65
E	24920	0	14.05	1	8.33E-06	8.33E-06	F	.89
ESE	28720	0	18.80	1	6.69E-06	6.69E-06	F	.89
SE	21950	0	10.83	1	8.82E-06	8.82E-06	G	2.65
SSE	18110	0	4.78	1	5.42E-06	5.42E-06	G	4.70

Execution Time = 0 hr 0 min .55 sec
Stop - Program terminated.

*** Output file for GXQ- 204-AR site release ***

GXQ Version 3.1 B
June 8, 1993

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 0.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 0.
Code Custodian is Brit E. Hey, WHC, ext. 6-2921.

Run Date = 8/ 9/1994
Run Time = 14: 2 14.03

```
INPUT ECHO:
204ar Tank Farm Release - Farmer
c GXQ Ver. 3.1 Input File
c   mode
    1
c
c MODE CHOICE:
c mode = 1 then X/Q based on Hanford site specific meteorology
c mode = 2 then X/Q based on atmospheric stability class and wind speed
c mode = 3 then X/Q plot file is created
c
c LOGICAL CHOICES:
c   ifox  inorm icdf  ichk  isite ipop  icon
    T     F     F     F     F     F     F
c ifox  = t then joint frequency used to compute frequency to exceed X/Q
c       = f then joint frequency used to compute annual average X/Q
c inorm = t then joint frequency data is normalized (as in GENII)
```

```
c        = f then joint frequency data is un-normalized
c icdf  = t then cumulative distribution file created (CDF.OUT)
c        = f then no cumulative distribution file created
c ichk  = t then X/Q parameter print option turned on
c        = f then no parameter print
c isite = t then X/Q based on joint frequency data for all 16 sectors
c        = f then X/Q based on joint frequency data of individual sectors
c ipop  = t then X/Q is population weighted
c        = f then no population weighting
c icon  = t then X/Q is air concentration
c        = f then X/Q is integrated exposure
c
c MODEL CHOICES:
c   idep  iwake ipm   irise igrav iwash iflow iwind
    0     0     0     0     0     0     0     0
c idep  = 1 then plume depletion model turned on (Chamberlain model)
c iwake = 1 then NRC RG 1.145 building wake model turned on
c        = 2 then MACCS virtual distance building wake model turned on
c ipm   = 1 then NRC RG 1.145 plume meander model turned on
c        = 2 then 5th Power Law plume meander model turned on
c        = 3 then sector average model turned on
c irise = 1 then momentum/buoyancy plume rise model turned on, buoyancy
c            rise based on sensible heat emission
c        = 2 then momentum/buoyancy plume rise model turned on, buoyancy
c            rise based on initial plume density
c igrav = 1 then gravitational settling model turned on
c iwash = 1 then stack downwash model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c iwind = 1 then wind speed corrected for plume height
c        = 0 to turn any of the above models off
c
c PARAMETER INPUT:
c   stack           wind                            frequency
c   release         speed           mixing          to              scaling
c   height          height          height          exceed          factor
c   (m)             (m)             (m)             (%)             (?)
    0.00000E+00     1.00000E+01     1.00000E+03     5.00000E-01     1.00000E+00
c
c                                                                   gravitational
c   building        building        release         deposition      settling
c   width           height          duration        velocity        velocity
c   (m)             (m)             (hr)            (m/s)           (m/s)
    5.00000E+00     5.00000E+00     1.00000E+00     1.00000E-03     1.00000E-03
c
c                   initial                         sensible
c   initial         plume                           heat
c   plume           flow            stack           emission
c   density         rate            diameter        rate
c   (g/cc)          (m3/s)          (m)             (cal/s)
    1.22000E-03     0.00000E+00     1.00000E+00     4.18000E+05
c
c RECEPTOR DEPENDENT DATA
c FOR MODE      make          RECEPTOR DEPENDENT DATA
c 1 (site specific)           sector distance z-height
c 2 (by class & wind speed) class windspeed distance offset z-height
c 3 (create plot file)        class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION:
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = meters
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = m/s
c offset = meters offset from plume centerline
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
```

MODE:
Site specific X/Q calculated

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on
frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for single sector.
Output is atmospheric dispersion coefficient.

MODELS SELECTED:

WARNING/ERROR MESSAGES:
WARNING #3 - Scaled X/Q units (shown as s/m3 or 1/m3 below) do not reflect the user specified scaling factor.

JOINT FREQUENCY DATA:
200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

204ar Tank Farm Release - Farmer

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
S	19950	0	6.30	1	4.66E-06	4.66E-06	E	.89
SSW	17230	0	4.53	1	3.57E-06	3.57E-06	F	2.65
SW	17580	0	2.93	1	4.45E-06	4.45E-06	F	2.65
WSW	21210	0	2.72	1	3.53E-06	3.53E-06	F	2.65
W	20800	0	4.80	1	8.57E-06	8.57E-06	G	2.65
WNW	21320	0	3.98	1	4.65E-06	4.65E-06	G	4.70
NW	20890	0	4.72	1	8.85E-06	8.85E-06	G	2.65
NNW	21090	0	4.58	1	8.78E-06	8.78E-06	G	2.65
N	24150	0	4.36	1	7.95E-06	7.95E-06	G	2.65
NNE	23150	0	2.49	1	3.66E-06	3.66E-06	E	.89
NE	17810	0	3.90	1	5.49E-06	5.49E-06	E	.89
ENE	15130	0	6.17	1	1.15E-05	1.15E-05	G	2.65
E	15050	0	14.05	1	1.55E-05	1.55E-05	F	.89
ESE	19930	0	18.80	1	1.05E-05	1.05E-05	F	.89
SE	24140	0	10.83	1	7.85E-06	7.85E-06	G	2.65
SSE	20080	0	4.78	1	4.76E-06	4.76E-06	G	4.70

Execution Time = 0 hr 0 min .60 sec
Stop - Program terminated.

```
######################### Program GENII Input File ########### 8 Jul 88 ####
Title: 222-s and 204-ar farmer dose
       \GENII\222s-f.in                         Created on 08-09-1994 at 14:28
OPTIONS======================== Default ====================================
F    Near-field scenario?        (Far-field)    NEAR-FIELD: narrowly-focused
F    Population dose?           (Individual)                release, single site
T    Acute release?               (Chronic)     FAR-FIELD:  wide-scale release,
     Maximum Individual data set used                       multiple sites
                                  Complete                              Complete
TRANSPORT OPTIONS============ Section      EXPOSURE PATHWAY OPTIONS===== Section
T  Air Transport                   1        F  Finite plume, external       5
F  Surface Water Transport         2        T  Infinite plume, external     5
```

```
F  Biotic Transport (near-field)  3,4    F  Ground, external           5
F  Waste Form Degradation (near)  3,4    F  Recreation, external       5
                                         T  Inhalation uptake          5,6
REPORT OPTIONS=======================    T  Drinking water ingestion   7,8
T  Report AEDE only                      T  Aquatic foods ingestion    7,8
F  Report by radionuclide                T  Terrestrial foods ingestion 7,9
F  Report by exposure pathway            T  Animal product ingestion   7,10
F  Debug report on screen                T  Inadvertent soil ingestion

INVENTORY ##################################################################

 4   Inventory input activity units: (1-pCi  2-uCi  3-mCi  4-Ci  5-Bq)
 0   Surface soil source units (1- m2  2- m3  3- kg)
     Equilibrium question goes here

     --------|----Release Terms------|----------Basic Concentrations---------|
     Use when|  transport selected   |  near-field scenario, optionally      |
     --------|-----------------------|---------------------------------------|
     Release |        Surface Buried |        Surface Deep    Ground  Surface|
     Radio-  |Air     Water   Waste  |Air     Soil    Soil    Water   Water  |
     nuclide |/yr     /yr     /m3    |/m3     /unit   /m3     /L      /L     |
     --------|------- ------- -------|------- ------- ------- ------- -------|
     H 3      1.2E-03
     C 14     2.3E-04
     SR90     8.9E-01
     Y 90     8.9E-01
     TC99     5.2E-04
     I 129    6.5E-04
     CS137    9.1E-01
     PM147    6.7E-02
     U 233    5.2E-11
     U 235    1.0E-06
     U 238    1.7E-05
     PU239    5.6E-04
     AM241    1.5E-01

     --------|----Derived Concentrations-----|
     Use when|   measured values are known   |
     --------|-------------------------------|
     Release |Terres. Animal  Drink   Aquatic|
     Radio-  |Plant   Product Water   Food   |
     nuclide |/kg     /kg     /L      /kg    |
     --------|------- ------- ------- -------|

TIME #######################################################################

1    Intake ends after (yr)
50   Dose calc. ends after (yr)
0    Release ends after (yr)
0    No. of years of air deposition prior to the intake period
0    No. of years of irrigation water deposition prior to the intake period

FAR-FIELD SCENARIOS (IF POPULATION DOSE) ###################################

0          Definition option: 1-Use population grid in file POP.IN
0                             2-Use total entered on this line

NEAR-FIELD SCENARIOS #######################################################

           Prior to the beginning of the intake period: (yr)
0            When was the inventory disposed?  (Package degradation starts)
0            When was LOIC?  (Biotic transport starts)
0          Fraction of roots in upper soil (top 15 cm)
0          Fraction of roots in deep soil
0          Manual redistribution: deep soil/surface soil dilution factor
0          Source area for external dose modification factor (m2)
TRANSPORT ##################################################################
           ====AIR TRANSPORT==================================SECTION 1=====
                   0-Calculate PM          |0        Release type (0-3)
```

```
1         Option: 1-Use chi/Q or PM value    |F        Stack release (T/F)
                  2-Select MI dist & dir     |0        Stack height (m)
                  3-Specify MI dist & dir    |0        Stack flow (m3/sec)
1.55E-5   Chi/Q or PM value                  |0        Stack radius (m)
0         MI sector index (1=S)              |0        Effluent temp. (C)
0         MI distance from release point (m)|0        Building x-section (m2)
F         Use jf data, (T/F) else chi/Q grid|0        Building height (m)

          ====SURFACE WATER TRANSPORT=========================SECTION 2=====
0         Mixing ratio model: 0-use value, 1-river, 2-lake
0         Mixing ratio, dimensionless
0         Average river flow rate for: MIXFLG=0 (m3/s), MIXFLG=1,2 (m/s),
0         Transit time to irrigation withdrawl location (hr)
          If mixing ratio model > 0:
0           Rate of effluent discharge to receiving water body (m3/s)
0           Longshore distance from release point to usage location (m)
0           Offshore distance to the water intake (m)
0           Average water depth in surface water body (m)
0           Average river width (m), MIXFLG=1 only
0           Depth of effluent discharge point to surface water (m), lake only

          ====WASTE FORM AVAILABILITY=========================SECTION 3=====
0         Waste form/package half life, (yr)
0         Waste thickness, (m)
0         Depth of soil overburden, m

          ====BIOTIC TRANSPORT OF BURIED SOURCE================SECTION 4=====
T         Consider during inventory decay/buildup period (T/F)?
T         Consider during intake period (T/F)?    | 1-Arid non agricultural
0         Pre-Intake site condition.............| 2-Humid non agricultural
                                                 | 3-Agricultural

EXPOSURE ###################################################################

          ====EXTERNAL EXPOSURE==============================SECTION 5=====
          Exposure time:                  |   Residential irrigation:
0           Plume (hr)                    | T         Consider: (T/F)
0           Soil contamination (hr)       | 0         Source: 1-ground water
0           Swimming (hr)                 |                   2-surface water
0           Boating (hr)                  | 0         Application rate (in/yr)
0           Shoreline activities (hr)     | 0         Duration (mo/yr)
0         Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)
0         Transit time for release to reach aquatic recreation (hr)
1.0       Average fraction of time submersed in acute cloud (hr/person hr)

          ====INHALATION=====================================SECTION 6=====
8766.0    Hours of exposure to contamination per year
0         0-No resus-  1-Use Mass Loading          2-Use Anspaugh model
0           pension      Mass loading factor (g/m3)  Top soil available (cm)

          ====INGESTION POPULATION===========================SECTION 7=====
 1        Atmospheric production definition (select option):
0           0-Use food-weighted chi/Q, (food-sec/m3), enter value on this line
            1-Use population-weighted chi/Q
            2-Use uniform production
            3-Use chi/Q and production grids (PRODUCTION will be overridden)
0         Population ingesting aquatic foods, 0 defaults to total (person)
0.0       Population ingesting drinking water, 0 defaults to total (person)
F         Consider dose from food exported out of region (default=F)

          Note below: S* or Source: 0-none, 1-ground water, 2-surface water
                                    3-Derived concentration entered above
          ==== AQUATIC FOODS / DRINKING WATER INGESTION========SECTION 8====

F         Salt water? (default is fresh)

          USE        TRAN-  PROD-    -CONSUMPTION- |
          ?   FOOD   SIT    UCTION   HOLDUP   RATE |
          T/F TYPE   hr     kg/yr    da       kg/yr|       DRINKING WATER
```

```
 --- ------ ----- ------- ------ ----- |-------------------------
 T   FISH   0.00 0.0E+00   1.00  40.0 | 0     Source (see above)
 T   MOLLUS 0.00 0.0E+00   0.00   6.9 | T     Treatment? T/F
 T   CRUSTA 0.00 0.0E+00   0.00   6.9 | 1.0   Holdup/transit(da)
 T   PLANTS 0.00 0.0E+00   0.00   6.9 | 730.0 Consumption (L/yr)

 ====TERRESTRIAL FOOD INGESTION========================SECTION 9=====

 USE        GROW   --IRRIGATION--           PROD-    --CONSUMPTION--
 ?   FOOD   TIME   S RATE  TIME    YIELD   UCTION   HOLDUP   RATE
 T/F TYPE   da     * in/yr mo/yr   kg/m2   kg/yr    da       kg/yr
 --- ------ -----  - ----- -----   -----   -------  ------   ------
 T   LEAF V 90.00  0  0.0   0.0     1.5    0.0E+00    1.0     30.0
 T   ROOT V 90.00  0  0.0   0.0     4.0    0.0E+00    5.0    220.0
 T   FRUIT  90.00  0  0.0   0.0     2.0    0.0E+00    5.0    330.0
 T   GRAIN  90.00  0  0.0   0.0     0.8    0.0E+00  180.0     80.0

 ====ANIMAL PRODUCTION CONSUMPTION===================SECTION 10====

           ---HUMAN---- TOTAL  DRINK   -------------STORED FEED-------------
USE        CONSUMPTION  PROD-  WATER   DIET  GROW  -IRRIGATION--        STOR-
?   FOOD   RATE  HOLDUP UCTION CONTAM  FRAC- TIME  S RATE  TIME   YIELD AGE
T/F TYPE   kg/yr  da    kg/yr  FRACT.  TION  da    * in/yr mo/yr  kg/m3 da
--- ------ ------ ----- ------ ------- ----  ----  - ----- -----  ----- -----
T   BEEF    80.0  15.0  0.00    0.00   0.00  90.0  0  0.0  0.00   0.80   0.0
T   POULTR  18.0   1.0  0.00    0.00   0.00  90.0  0  0.0  0.00   0.80   0.0
T   MILK   270.0   1.0  0.00    0.00   0.00  45.0  0  0.0  0.00   2.00   0.0
T   EGG     30.0   1.0  0.00    0.00   0.00  90.0  0  0.0  0.00   0.80   0.0
                                        -------------FRESH FORAGE-----------
    BEEF                               0.00  45.0  0  0.0  0.00   2.00 100.0
    MILK                               0.00  30.0  0  0.0  0.00   1.50   0.0

###############################################################################
```

```
--------------------------------------------------------------------------
                      GENII  Dose Calculation Program
                        (Version 1.485 3-Dec-90)

Case title:   222-s and 204-ar farmer dose

Executed on:  08/09/94 at 14:28:50                              Page A.  1
--------------------------------------------------------------------------

          This is a far-field (wide-scale release, multiple site) scenario.
          Release is acute
          Individual dose

          THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
               Air

          THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
               Infinite plume, external
               Inhalation uptake
               Drinking water ingestion
               Aquatic foods ingestion
               Terrestrial foods ingestion
               Animal product ingestion
               Inadvertent soil ingestion

          THE FOLLOWING TIMES ARE USED:
               Intake ends after (yr):                 1.0
               Dose calculations ends after (yr):     50.0

========== FILENAMES AND TITLES OF FILES/LIBRARIES USED ======================

 Input file name: \GENII\222s-f.in
 GENII Default Parameter Values (28-Mar-90 RAP)
 Radionuclide Library - Times<100 years  (23-July-93 PDR)
 PNL Food Transfer Factor Library (by Z, with Fr&Os 7/19/93 PDR)
 Bioaccumulation Factor Library - (30-Aug-88) RAP
 External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R
 Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

==============================================================================
```

--------	----Release Terms------		
Release Radio-nuclide	Air Ci/yr	Surface Water Ci/yr	Buried Source Ci/m3
H 3	1.2E-03	0.0E+00	0.0E+00
C 14	2.3E-04	0.0E+00	0.0E+00
SR90	8.9E-01	0.0E+00	0.0E+00
Y 90	8.9E-01	0.0E+00	0.0E+00
TC99	5.2E-04	0.0E+00	0.0E+00
I 129	6.5E-04	0.0E+00	0.0E+00
CS137	9.1E-01	0.0E+00	0.0E+00
PM147	6.7E-02	0.0E+00	0.0E+00
U 233	5.2E-11	0.0E+00	0.0E+00
U 235	1.0E-06	0.0E+00	0.0E+00
U 238	1.7E-05	0.0E+00	0.0E+00
PU239	5.6E-04	0.0E+00	0.0E+00
AM241	1.5E-01	0.0E+00	0.0E+00

```
========== AIR TRANSPORT =====================================================
1.5E-05    Input E/Q value (s/m3)

========== EXTERNAL EXPOSURE =================================================
 1.0E+00   Fraction of time spent in cloud

========== INHALATION ========================================================
           Resuspension not considered
```

========== INGESTION POPULATION ==========

1 Atmospheric production definition: 1 - Use population-weighted chi/Q

========== DRINKING WATER SOURCE/IRRIGATION ==========

7.3E+02	Drinking water consumption rate (l/yr)
0	Drinking water source: 1-ground, 2-surface, 3-system
T	Drinking water treatment: T/F
1.0	Drinking water transit/holdup time (d)

========== AQUATIC FOODS INGESTION ==========

FOOD TYPE	TRANSIT h	PRODUCTION kg/yr	----CONSUMPTION---- HOLDUP d	RATE kg/yr
Fish	0.00E+00		1.00E+00	4.00E+01
Mollusc	0.00E+00		0.00E+00	6.90E+00
Crustace	0.00E+00		0.00E+00	6.90E+00
Aqu Plnt	0.00E+00		0.00E+00	6.90E+00

========== TERRESTRIAL FOOD INGESTION ==========

FOOD TYPE	GROW TIME d	--IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m2	PRODUCTION kg/yr	--CONSUMPTION-- HOLDUP d	RATE kg/yr
Leaf Veg	90.0	0	0.0	0.0	1.5		1.0	3.0E+01
Oth. Veg	90.0	0	0.0	0.0	4.0		5.0	2.2E+02
Fruit	90.0	0	0.0	0.0	2.0		5.0	3.3E+02
Cereals	90.0	0	0.0	0.0	0.8		180.0	8.0E+01

========== ANIMAL FOOD INGESTION ==========

FOOD TYPE	---HUMAN---- CONSUMPTION RATE kg/yr	HOLDUP d	TOTAL PRODUCTION kg/yr	DRINK WATER CONTAM FRACT.	----STORED FEED---- DIET FRACTION	GROW TIME d	-IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m3	STORAGE d
Meat	8.0E+01	15.0		0.00		90.00	0	0.0	0.0	0.80	
Poultry	1.8E+01	1.0		0.00		90.00	0	0.0	0.0	0.80	
Cow Milk	2.7E+02	1.0		0.00		45.00	0	0.0	0.0	2.00	
Eggs	3.0E+01	1.0		0.00		90.00	0	0.0	0.0	0.80	
					----FRESH FORAGE----						
Meat						45.00	0	0.0	0.0	2.00	
Cow Milk						30.00	0	0.0	0.0	1.50	

==========

Input prepared by: ____________________ Date: __________

Input checked by: ____________________ Date: __________

==========

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Winter: 222-s and 204-ar farmer dose

Executed on: 08/09/94 at 14:29:18 Page C. 1

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	8.8E-02	2.5E-01	2.2E-02
Breast	1.9E-04	1.5E-01	2.9E-05
R Marrow	5.1E-01	1.2E-01	6.1E-02
Lung	5.2E-02	1.2E-01	6.3E-03
Thyroid	7.0E-04	3.0E-02	2.1E-05
Bone Sur	6.3E+00	3.0E-02	1.9E-01
Liver	1.1E+00	6.0E-02	6.7E-02
LL Int.	3.5E-03	6.0E-02	2.1E-04
UL Int.	1.3E-03	6.0E-02	8.0E-05
S Int.	4.2E-04	6.0E-02	2.5E-05
Stomach	3.0E-04	6.0E-02	1.8E-05

Internal Effective Dose Equivalent 3.5E-01
External Dose 1.7E-06

Annual Effective Dose Equivalent 3.5E-01

Controlling Organ: Bone Sur
Controlling Pathway: Inh
Controlling Radionuclide: AM241

Total Inhalation EDE: 3.4E-01
Total Ingestion EDE: 2.3E-03

```
--------------------------------------------------------------------------
                     GENII  Dose Calculation Program
                       (Version 1.485 3-Dec-90)

Case title:   Winter: 222-s and 204-ar farmer dose

Executed on:  08/09/94 at 14:29:18                            Page C.  2
--------------------------------------------------------------------------

Acute release
Uptake/exposure period:                                        1.0
Dose commitment period:                                       50.0
Dose units:                                                Rem


             Dose Commitment Year
                   1         2         3    ...
            _________________________________
Internal  : |
Intake    : |
Year:     3 |                     0.0E+00   ...
            |                        +
          2 |           0.0E+00   0.0E+00   ...              Internal
            |              +         +                       Effective
          1 | 1.6E-02 + 1.1E-02 + 1.0E-02 + ...  =  3.5E-01  Dose
                                                              Equivalent
                 ||        ||        ||
Internal                                                      Cumulative
Annual        1.6E-02 + 1.1E-02 + 1.0E-02 + ...  =  3.5E-01  Internal
Dose                                                          Dose
                 +         +         +                 +
External
Annual        1.7E-06   0.0E+00   0.0E+00   ...     1.7E-06
Dose
                 ||        ||        ||                ||
Annual                                                        Cumulative
Dose          1.6E-02 + 1.1E-02 + 1.0E-02 + ...  =  3.5E-01  Dose

                                                              Maximum
                                                    1.6E-02  Annual
                                                              Dose Occurred
                                                              In Year   1
______________________________________________________________________
```

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Winter: 222-s and 204-ar farmer dose

Executed on: 08/09/94 at 14:29:18 Page C. 3

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
H 3	5.5E-10	0.0E+00	4.3E-19	5.5E-10	5.5E-10
C 14	2.5E-09	0.0E+00	5.7E-15	2.5E-09	2.5E-09
SR 90	9.4E-04	2.1E-03	5.7E-10	3.0E-03	3.0E-03
Y 90	4.0E-05	1.7E-04	2.1E-08	2.1E-04	2.1E-04
TC 99	2.4E-08	4.9E-07	6.4E-14	5.1E-07	5.1E-07
I 129	5.0E-07	1.5E-05	1.8E-11	1.5E-05	1.5E-05
CS 137	1.4E-04	2.4E-05	1.6E-06	1.7E-04	1.7E-04
PM 147	1.3E-05	6.1E-09	4.5E-12	1.3E-05	1.3E-05
U 238	1.0E-05	2.1E-10	7.6E-15	1.0E-05	1.0E-05
TH 234	0.0E+00	1.1E-11	0.0E+00	1.1E-11	1.1E-11
PA 234	0.0E+00	2.8E-15	0.0E+00	2.8E-15	2.8E-15
AM 241	3.4E-01	1.5E-05	5.1E-09	3.4E-01	3.4E-01
U 233	3.6E-11	7.1E-16	4.0E-20	3.6E-11	3.6E-11
TH 229	0.0E+00	8.0E-19	0.0E+00	8.0E-19	8.0E-19
RA 225	0.0E+00	6.4E-20	0.0E+00	6.4E-20	6.4E-20
AC 225	0.0E+00	3.1E-20	0.0E+00	3.1E-20	3.1E-20
PU 239	1.3E-03	2.7E-08	1.9E-13	1.3E-03	1.3E-03
U 235	6.3E-07	1.2E-11	0.0E+00	6.3E-07	6.3E-07
TH 231	0.0E+00	6.0E-14	0.0E+00	6.0E-14	6.0E-14

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Spring: 222-s and 204-ar farmer dose

Executed on: 08/09/94 at 14:29:24 Page C. 4

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	9.3E-02	2.5E-01	2.3E-02
Breast	3.8E-03	1.5E-01	5.7E-04
R Marrow	5.2E-01	1.2E-01	6.2E-02
Lung	5.6E-02	1.2E-01	6.7E-03
Thyroid	7.2E-03	3.0E-02	2.2E-04
Bone Sur	6.4E+00	3.0E-02	1.9E-01
Liver	1.1E+00	6.0E-02	6.8E-02
LL Int.	9.1E-03	6.0E-02	5.5E-04
UL Int.	5.9E-03	6.0E-02	3.5E-04
S Int.	4.5E-03	6.0E-02	2.7E-04
Stomach	4.3E-03	6.0E-02	2.6E-04

Internal Effective Dose Equivalent	3.5E-01
External Dose	1.7E-06
Annual Effective Dose Equivalent	3.5E-01

Controlling Organ:	Bone Sur
Controlling Pathway:	Inh
Controlling Radionuclide:	AM241
Total Inhalation EDE:	3.4E-01
Total Ingestion EDE:	1.0E-02

```
---------------------------------------------------------------------------
                       GENII  Dose Calculation Program
                         (Version 1.485 3-Dec-90)

Case title:   Spring: 222-s and 204-ar farmer dose

Executed on:  08/09/94 at 14:29:24                               Page C.  5
---------------------------------------------------------------------------

Acute release
Uptake/exposure period:                                         1.0
Dose commitment period:                                        50.0
Dose units:                                                 Rem


             Dose Commitment Year
                  1         2         3     ...
            ________________________________
Internal  : |
Intake    : |
Year:     3 |                    0.0E+00   ...
            |                       +
          2 |          0.0E+00   0.0E+00   ...            Internal
            |             +         +                     Effective
          1 | 2.0E-02 + 1.1E-02 + 1.1E-02 + ...  =  3.5E-01  Dose
                                                          Equivalent
                 ||        ||        ||
Internal                                                  Cumulative
Annual        2.0E-02 + 1.1E-02 + 1.1E-02 + ...  =  3.5E-01  Internal
Dose                                                      Dose
                 +         +         +               +
External
Annual        1.7E-06   0.0E+00   0.0E+00   ...     1.7E-06
Dose
                 ||        ||        ||              ||
Annual                                                    Cumulative
Dose          2.0E-02 + 1.1E-02 + 1.1E-02 + ...  =  3.5E-01  Dose

                                                          Maximum
                                                    2.0E-02  Annual
                                                          Dose Occurred
                                                          In Year  1
```

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Spring: 222-s and 204-ar farmer dose

Executed on: 08/09/94 at 14:29:24 Page C. 6

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
H 3	5.5E-10	0.0E+00	4.3E-19	5.5E-10	5.5E-10
C 14	2.5E-09	0.0E+00	5.7E-15	2.5E-09	2.5E-09
SR 90	9.4E-04	3.2E-03	5.7E-10	4.1E-03	4.1E-03
Y 90	4.0E-05	2.4E-04	2.1E-08	2.8E-04	2.8E-04
TC 99	2.4E-08	4.8E-07	6.4E-14	5.0E-07	5.0E-07
I 129	5.0E-07	1.0E-04	1.8E-11	1.0E-04	1.0E-04
CS 137	1.4E-04	3.6E-03	1.6E-06	3.8E-03	3.8E-03
PM 147	1.3E-05	9.5E-07	4.5E-12	1.4E-05	1.4E-05
U 238	1.0E-05	3.7E-08	7.6E-15	1.0E-05	1.0E-05
TH 234	0.0E+00	1.0E-09	0.0E+00	1.0E-09	1.0E-09
PA 234	0.0E+00	2.6E-13	0.0E+00	2.6E-13	2.6E-13
AM 241	3.4E-01	3.1E-03	5.1E-09	3.4E-01	3.4E-01
U 233	3.6E-11	1.2E-13	4.0E-20	3.7E-11	3.7E-11
TH 229	0.0E+00	1.4E-17	0.0E+00	1.4E-17	1.4E-17
RA 225	0.0E+00	5.0E-19	0.0E+00	5.0E-19	5.0E-19
AC 225	0.0E+00	1.4E-19	0.0E+00	1.4E-19	1.4E-19
PU 239	1.3E-03	1.1E-05	1.9E-13	1.3E-03	1.3E-03
U 235	6.3E-07	2.3E-09	0.0E+00	6.3E-07	6.3E-07
TH 231	0.0E+00	9.4E-12	0.0E+00	9.4E-12	9.4E-12

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Summer: 222-s and 204-ar farmer dose

Executed on: 08/09/94 at 14:29:30 Page C. 7

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	1.1E-01	2.5E-01	2.7E-02
Breast	8.1E-03	1.5E-01	1.2E-03
R Marrow	6.3E-01	1.2E-01	7.5E-02
Lung	6.1E-02	1.2E-01	7.3E-03
Thyroid	1.6E-02	3.0E-02	4.9E-04
Bone Sur	7.3E+00	3.0E-02	2.2E-01
Liver	1.3E+00	6.0E-02	7.6E-02
LL Int.	2.9E-02	6.0E-02	1.7E-03
UL Int.	1.6E-02	6.0E-02	9.5E-04
S Int.	1.0E-02	6.0E-02	6.1E-04
Stomach	9.4E-03	6.0E-02	5.7E-04
Internal Effective Dose Equivalent			4.1E-01
External Dose			1.7E-06
Annual Effective Dose Equivalent			4.1E-01

Controlling Organ:	Bone Sur
Controlling Pathway:	Inh
Controlling Radionuclide:	AM241
Total Inhalation EDE:	3.4E-01
Total Ingestion EDE:	6.6E-02

```
-----------------------------------------------------------------------
                    GENII  Dose Calculation Program
                      (Version 1.485 3-Dec-90)

Case title:   Summer: 222-s and 204-ar farmer dose

Executed on:  08/09/94 at 14:29:30                          Page C.  8
-----------------------------------------------------------------------

Acute release
Uptake/exposure period:                                       1.0
Dose commitment period:                                      50.0
Dose units:                                              Rem


            Dose Commitment Year
                 1        2         3      ...

Internal  : ________________________________
Intake    : |
Year:     3 |                    0.0E+00   ...
            |                       +
          2 |          0.0E+00   0.0E+00   ...                 Internal
            |             +         +                          Effective
          1 | 2.8E-02 + 1.4E-02 + 1.3E-02 + ...  =  4.1E-01    Dose
                                                               Equivalent
               ||        ||        ||
Internal                                                       Cumulative
Annual        2.8E-02 + 1.4E-02 + 1.3E-02 + ...  =  4.1E-01    Internal
Dose                                                           Dose
                +         +         +                 +
External
Annual        1.7E-06   0.0E+00   0.0E+00   ...     1.7E-06
Dose
               ||        ||        ||                ||
Annual                                                         Cumulative
Dose          2.8E-02 + 1.4E-02 + 1.3E-02 + ...  =  4.1E-01    Dose

                                                               Maximum
                                                    2.8E-02    Annual
                                                               Dose Occurred
                                                               In Year   1
_______________________________________________________________
```

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Summer: 222-s and 204-ar farmer dose

Executed on: 08/09/94 at 14:29:30 Page C. 9

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
H 3	5.5E-10	0.0E+00	4.3E-19	5.5E-10	5.5E-10
C 14	2.5E-09	0.0E+00	5.7E-15	2.5E-09	2.5E-09
SR 90	9.4E-04	1.2E-02	5.7E-10	1.3E-02	1.3E-02
Y 90	4.0E-05	9.8E-04	2.1E-08	1.0E-03	1.0E-03
TC 99	2.4E-08	5.6E-07	6.4E-14	5.8E-07	5.8E-07
I 129	5.0E-07	2.5E-04	1.8E-11	2.5E-04	2.5E-04
CS 137	1.4E-04	7.8E-03	1.6E-06	8.0E-03	8.0E-03
PM 147	1.3E-05	5.7E-06	4.5E-12	1.9E-05	1.9E-05
U 238	1.0E-05	3.8E-07	7.6E-15	1.1E-05	1.1E-05
TH 234	0.0E+00	1.8E-08	0.0E+00	1.8E-08	1.8E-08
PA 234	0.0E+00	4.8E-12	0.0E+00	4.8E-12	4.8E-12
AM 241	3.4E-01	4.5E-02	5.1E-09	3.9E-01	3.9E-01
U 233	3.6E-11	1.3E-12	4.0E-20	3.8E-11	3.8E-11
TH 229	0.0E+00	9.1E-16	0.0E+00	9.1E-16	9.1E-16
RA 225	0.0E+00	5.2E-17	0.0E+00	5.2E-17	5.2E-17
AC 225	0.0E+00	2.4E-17	0.0E+00	2.4E-17	2.4E-17
PU 239	1.3E-03	1.7E-04	1.9E-13	1.4E-03	1.4E-03
U 235	6.3E-07	2.3E-08	0.0E+00	6.5E-07	6.5E-07
TH 231	0.0E+00	1.1E-10	0.0E+00	1.1E-10	1.1E-10

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Autumn: 222-s and 204-ar farmer dose

Executed on: 08/09/94 at 14:29:35 Page C. 10

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	2.4E-01	2.5E-01	6.0E-02
Breast	8.2E-02	1.5E-01	1.2E-02
R Marrow	1.2E+00	1.2E-01	1.5E-01
Lung	1.4E-01	1.2E-01	1.6E-02
Thyroid	1.6E-01	3.0E-02	4.7E-03
Bone Sur	1.2E+01	3.0E-02	3.5E-01
Liver	1.9E+00	6.0E-02	1.1E-01
LL Int.	1.9E-01	6.0E-02	1.1E-02
UL Int.	1.2E-01	6.0E-02	7.4E-03
S Int.	9.6E-02	6.0E-02	5.8E-03
Stomach	9.2E-02	6.0E-02	5.5E-03

Internal Effective Dose Equivalent	7.3E-01
External Dose	1.7E-06
Annual Effective Dose Equivalent	7.3E-01

Controlling Organ:	Bone Sur
Controlling Pathway:	Ing
Controlling Radionuclide:	AM241
Total Inhalation EDE:	3.4E-01
Total Ingestion EDE:	3.9E-01

```
--------------------------------------------------------------------------
                    GENII  Dose Calculation Program
                     (Version 1.485 3-Dec-90)

Case title:   Autumn: 222-s and 204-ar farmer dose

Executed on:  08/09/94 at 14:29:35                           Page C. 11
--------------------------------------------------------------------------

Acute release
Uptake/exposure period:                                  1.0
Dose commitment period:                                 50.0
Dose units:                                          Rem


             Dose Commitment Year
                    1         2         3     ...

Internal   :  ______________________________
Intake     : |
Year:      3 |                     0.0E+00   ...
             |                        +
           2 |          0.0E+00    0.0E+00   ...                Internal
             |             +          +                         Effective
           1 | 1.1E-01 + 3.1E-02 + 2.4E-02 + ...  =  7.3E-01    Dose
                                                                Equivalent
                  ||        ||         ||
Internal                                                        Cumulative
Annual         1.1E-01 + 3.1E-02 + 2.4E-02 + ...  =  7.3E-01    Internal
Dose                                                            Dose
                  +          +          +                +
External
Annual         1.7E-06   0.0E+00   0.0E+00   ...     1.7E-06
Dose
                  ||        ||         ||               ||
Annual                                                          Cumulative
Dose           1.1E-01 + 3.1E-02 + 2.4E-02 + ...  =  7.3E-01    Dose

                                                                Maximum
                                                     1.1E-01    Annual
                                                                Dose Occurred
                                                                In Year  1
_____________________________________________________________
```

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Autumn: 222-s and 204-ar farmer dose

Executed on: 08/09/94 at 14:29:35 Page C. 12

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
H 3	5.5E-10	5.0E-08	4.3E-19	5.1E-08	5.1E-08
C 14	2.5E-09	1.7E-09	5.7E-15	4.2E-09	4.2E-09
SR 90	9.4E-04	6.1E-02	5.7E-10	6.2E-02	6.2E-02
Y 90	4.0E-05	4.7E-03	2.1E-08	4.8E-03	4.8E-03
TC 99	2.4E-08	5.8E-07	6.4E-14	6.1E-07	6.1E-07
I 129	5.0E-07	2.3E-03	1.8E-11	2.3E-03	2.3E-03
CS 137	1.4E-04	8.1E-02	1.6E-06	8.1E-02	8.1E-02
PM 147	1.3E-05	3.6E-05	4.5E-12	4.9E-05	4.9E-05
U 238	1.0E-05	2.2E-06	7.6E-15	1.2E-05	1.2E-05
TH 234	0.0E+00	1.2E-07	0.0E+00	1.2E-07	1.2E-07
PA 234	0.0E+00	3.0E-11	0.0E+00	3.0E-11	3.0E-11
AM 241	3.4E-01	2.4E-01	5.1E-09	5.8E-01	5.8E-01
U 233	3.6E-11	7.5E-12	4.0E-20	4.4E-11	4.4E-11
TH 229	0.0E+00	5.7E-15	0.0E+00	5.7E-15	5.7E-15
RA 225	0.0E+00	3.0E-16	0.0E+00	3.0E-16	3.0E-16
AC 225	0.0E+00	1.3E-16	0.0E+00	1.3E-16	1.3E-16
PU 239	1.3E-03	8.9E-04	1.9E-13	2.1E-03	2.1E-03
U 235	6.3E-07	1.3E-07	0.0E+00	7.6E-07	7.6E-07
TH 231	0.0E+00	6.3E-10	0.0E+00	6.3E-10	6.3E-10

HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

Document Reviewed: Dose Consequence Analysis of Tanker Shipment 94-3 Aqueous Mixture, S. McClendon 8D530-SMC-94-001

Submitted by: S. McClendon Date Submitted:

Scope of Review: Entire Document

YES	NO*	N/A		
[X]	[ ]	[ ]	1.	A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[X]	[ ]	[ ]	2.	Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
[X]	[ ]	[ ]	3.	HEDOP-approved code(s) were used.
[X]	[ ]	[ ]	4.	Receptor locations were selected according to HEDOP recommendations.
[X]	[ ]	[ ]	5.	All applicable environmental pathways and code options were included and are appropriate for the calculations.
[X]	[ ]	[ ]	6.	Hanford site data were used.
[X]	[ ]	[ ]	7.	Model adjustments external to the computer program were justified and performed correctly.
[X]	[ ]	[ ]	8.	The analysis is consistent with HEDOP recommendations.
[ ]		[X]	9.	Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
[X]	[ ]		10.	**Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.**

* All "NO" responses must be explained and use of nonstandard methods justified.

Reviewer Name:
(print or type)

Paul Rittmann — Aug 12, 1994

HEDOP-Approved Reviewer (Signature) — Date

CHECKLIST FOR INDEPENDENT TECHNICAL REVIEW

DOCUMENT REVIEWED
NUMBER: 8D530-SMC-94-001
TITLE: Dose Consequence Analysis of Tanker Shipment 94-3 Aqueous Mix
AUTHOR(s): S. McClendon

I. Method(s) of Review

- (X) Input data checked for accuracy
- (X) Independent calculation performed
  - ( ) Hand calculation
  - ( ) Alternate computer code:
- ( ) Comparison to experiment or previous results
- ( ) Alternate method (define)

II. Checklist (either check or enter NA if not applied)

- (✓) Task completely defined
- (✓) Activity consistent with task specification
- (✓) Necessary assumptions explicitly stated and supported
- (✓) Resources properly identified and referenced
- (✓) Resource documentation appropriate for this application
- (✓) Input data explicitly stated
- (✓) Input data verified to be consistent with original source
- (na) Geometric model adequate representation of actual geometry
- (na) Material properties appropriate and reasonable
- (na) Mathematical derivations checked including dimensional consistency
- (✓) Hand calculations checked for errors
- (✓) Assumptions explicitly stated and justified
- (✓) Computer software appropriate for task and used within range of validity
- (na) Use of resource outside range of established validity is justified
- (✓) Software runstreams correct and consistent with results
- (✓) Software output consistent with input
- (✓) Results consistent with applicable previous experimental or analytical findings
- (✓) Results and conclusions address all points and are consistent with task requirements and/or established limits or criteria
- (✓) Conclusions consistent with analytical results and established limits
- (na) Uncertainty assesment appropriate and reasonable
- (na) Other (define)

III. Comments:

IV. REVIEWER: Paul Rittmann DATE: Aug 12, 1994

5.0 SHIELDING EVALUATION

5.1 INTRODUCTION

The computer code ISO-PC Version 1.98 (Rittmann 1994), formerly ISOSHLD-II, was used to assess the dose rate at various positions on tanker shipment 94-3. Surface dose rates at the center of the tanker end and the lateral midpoint of the tanker were calculated. Dose rates were also calculated 2 m from the center end of the tanker and 2 m from the lateral midpoint of the outside surface. In addition, a dose rate at 100 in. (2.54 m) from the tanker end, a distance assumed to approximate the position of the driver, was found.

5.2 SHIELDING PARAMETERS

The activities shown in Figure B2-1 were used as the source term in the shielding analysis. The tanker is assumed to contain the maximum allowable liquid, 4000 gallons (15,000 L), which is an homogenous mixture composed of the source term mixed with water. The tanker was modelled as a right circular cylinder with a length of 1128 cm (444.0 in.) and a reduced radius that is just large enough so that the tanker holds 4000 gallons. The wall thickness of the tanker is 0.4176 cm (0.1644 in.) and is composed of stainless steel. This wall thickness is less than one mean free path, therefore, the buildup was assumed to take place within the water. The density of the source material may vary from 1.0 g/cc to 1.9 g/cc, so a density of 1.0 g/cc for the source material was used because it yields the highest dose rate with the given radionuclides. Surface dose rates in the center of the tanker end and at the lateral midpoint of the tanker, at 2 m from these two points, and at the driver's seat were calculated. Input files can be found in the Part B, Section 5.4.2.

5.3 SHIELDING RESULTS

The dose rates calculated meet 49 CFR requirements and can be seen in Table B5-1. The surface dose rate at the end of the tanker is 37.7 mrem/h. The dose rate 2 m from the end is 2.05 mrem/h and the dose rate 100 in. from the end is 1.34 mrem/h. The lateral midpoint of the tanker surface dose rate is 36.3 mrem/h and the rate 2 m from this point is 6.40 mrem/h. These dose rates are within DOT specifications of 200 mrem/hr on contact and 10 mrem/h at 2 m.

Table B5-1. Dose Rates of Cargo Tank.

Position of Detector	Dose Rate
Surface of Midpoint Tanker End	37.7 mrem/h (0.377 mSv/h)
2 m from Midpoint Tanker End	2.05 mrem/h (0.0205 mSv/h)
100 in. (2.54 m) from Midpoint Tanker End	1.34 mrem/h (0.0134 mSv/h)
Surface of Lateral Midpoint	36.3 mrem/h (0.363 mSv/h)
2 m from Lateral Midpoint Surface	6.40 mrem/h (0.0640 mSv/h)

5.4 APPENDICES

5.4.1 Reference

Rittman, P. D., 1994, *ISO-PC*, Version 1.98, Westinghouse Hanford Company, Richland, Washington, August 1994.

5.4.2 ISO-PC Computer Code Runs

```
0        2  Tanker Shipment 94-3, August 12, 1994, tnkr1b.in
Dose 100 in. away from end surface (in air)
 &Input  Next= 1,  Igeom= 9,  Slth= 65.37, Dunit= 1,
   Ntheta= 26, Delr= 0.5,   X= 1382.2, T(1)= 1127.76,
   T(2) = .4176, Nshld= 2, Jbuf= 1,
   Weight(451)= 2.74e-4,    Weight(76)= .535,
   Weight(82)= .535,       Weight(84)= 1.07,
   Weight(141)= 6.16e-4,   Weight(290)= 7.8e-4
   Weight(335)= 1.08,      Weight(336)= 1.08,
   Weight(388)= 7.99e-2,   Weight(519)= 6.18e-11,
   Weight(476)= 1.2e-6,    Weight(526)= 1.98e-5,
   Weight(493)= 3.325e-4,  Weight(494)= 3.325e-4,
   Weight(496)= 1.82e-1   &
  Water  1  1.0
1 Fe     9          7.86
Dose on End Surface Contact
 &Input  Next= 4, X= 1128.1776    &
Dose 2 m away from end surface (in air)
 &input Next= 4, X= 1328.1776    &
END OF RUN
 &Input Next= 6  &

0        2  Tanker Shipment 94-3, August 12, 1994, tnkr2b.in
Dose 2 m away from surface (in air), (density = 1.0)
 &Input  Next= 1,  Igeom= 7,  Slth= 1127.8,
 X= 265.7913,  T(1)= 65.3737, T(2)= .4176, Y= 563.9, Ntheta= 26,
 Delr= .5, Npsi= 26, Nshld= 2, Jbuf= 1, Dunit= 1,
   Weight(451)= 2.74e-4,    Weight(76)= .535,
   Weight(82)= .535,       Weight(84)= 1.07,
   Weight(141)= 6.16e-4,   Weight(290)= 7.8e-4
   Weight(335)= 1.08,      Weight(336)= 1.08,
   Weight(388)= 7.99e-2,   Weight(519)= 6.18e-11,
   Weight(476)= 1.2e-6,    Weight(526)= 1.98e-5,
   Weight(493)= 3.325e-4,  Weight(494)= 3.325e-4,
   Weight(496)= 1.82e-1   &
  Water  1  1.0
1 Fe     9          7.86
Dose at surface
 &Input next= 4, X= 65.7913   &
END OF RUN
 &Input Next= 6  &
```

PEER REVIEW CHECKLIST

Document Reviewed: *Safety Evaluation for Packaging 222-S Laboratory Cargo Tank for One Time Type B Material Shipment*

Scope of Review: Section 9.0 Shielding Evaluation

Yes	No	N/A	
[X]	[ ]	[ ]	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[X]	[ ]	[ ]	Problem completely defined.
[X]	[ ]	[X]	Accident scenarios developed in a clear and logical manner.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[X]	[ ]	[ ]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[ ]	[ ]	[X]	Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[X]	[ ]	[ ]	Software input correct and consistent with document reviewed.
[X]	[ ]	[ ]	Software output consistent with input and with results reported in document reviewed.
[ ]	[ ]	[X]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[X]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[ ]	[ ]	[X]	Format consistent with appropriate NRC Regulatory Guide or other standards
[ ]	[ ]	[X]	Review calculations, comments, and/or notes are attached.
[X]	[ ]		**Document approved.**

Peer Reviewer: P. D. Rittmann, PhD CHP

Paul Rittmann 8-15-94

Signature Date

6.0 CRITICALITY EVALUATION

The cargo tank fissile material content provided by the 222-S Laboratory detailed in Figure B2-1 meets 49 CFR 173.453, "Fissile Material Exception." The payload contains less than 15 g of fissile material as shown in Figure B2-2. Therefore, a criticality evaluation is not required.

6.1 APPENDIX

6.1.1 Reference

49 CFR 100-199, 1993, "Transportation," *Code of Federal Regulations*, as amended.

7.0 STRUCTURAL EVALUATION

The cargo tank is designed, constructed, tested, and maintained in accordance with the DOT MC-312 requirements for the purpose of transporting bulk hazardous liquids. The authorized payload does not exceed the weight limits of the cargo tank. The payload will not result in pressurization of the tank in excess of the operating limits as discussed in Part B, Section 9.0. No additional evaluation is required.

8.0 THERMAL EVALUATION

8.1 INTRODUCTION

A thermal evaluation was performed for the 222-S Laboratory DOT MC-312 cargo tank to determine the decay heat generated by the material content of the cargo tank to assess any effect on the system.

8.2 SUMMARY OF RESULTS

The maximum decay heat generation for the cargo tank payload is 0.019 W (0.065 Btu/h) or 1.5×10^{-3} W/m^3. This decay heat is negligible; therefore, further thermal analysis of the cargo tank is not required.

8.3 THERMAL SOURCE SPECIFICATION

Table B8-1 contains the decay heat generation for the worst case payload. The maximum possible heat generation is 0.019 W (0.065 Btu/h).

Table B8-1. Decay Heat Generation for Worst Case Payload.

Nuclide	(W/Ci)	Activity (Ci)	Heat (W)
^{3}H	2.69 E-05	1.24 E-03	3.34 E-08
^{14}C	4.10 E-04	2.30 E-04	9.43 E-08
^{89}Sr	3.49 E-03	8.95 E-01	3.13 E-03
^{90}Sr/^{90}Y	6.84 E-03	8.95 E-01	6.12 E-03
^{99}Tc	5.01 E-04	5.18 E-04	2.60 E-07
^{129}I	5.37 E-04	6.55 E-04	3.52 E-07
^{137}Cs/^{137m}Ba	4.87 E-03	9.08 E-01	4.42 E-03
^{147}Pm	3.57 E-04	6.72 E-02	2.40 E-05
^{233}U	2.96 E-02	5.19 E-11	1.54 E-12
^{235}U	2.82 E-02	1.01 E-06	2.85 E-08
^{238}U	2.57 E-02	1.67 E-05	4.30 E-07
^{239}Pu	3.16 E-02	5.58 E-04	1.76 E-05
^{240}Pu	3.15 E-02	5.58 E-04	1.76 E-05
^{241}Am	3.39 E-02	1.53 E-01	5.19 E-03
		TOTAL HEAT	1.89 E-02

9.0 PRESSURE AND GAS GENERATION EVALUATION

The cargo tank is built per DOT MC-312 specification. This specification requires that the container is designed, constructed, and tested per American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) code requirements. The proposed payload does not develop any gas generation or pressure that exceeds the MC-312 cargo tanks design. Therefore, a pressure and gas generation evaluation is not required.

9.1 APPENDIX

9.1.1 Reference

ASME, 1992, *American Society of Mechanical Engineers Boiler and Pressure Vessel Code*, American Society of Mechanical Engineers, New York, New York.

10.0 PACKAGE TIEDOWN SYSTEM EVALUATION

The cargo tank system is a certified DOT MC-312 packaging system. It is a self-contained transportation packaging. Therefore, a package tiedown system evaluation is not required.

DATE FILMED

10/17/94

END