OCT 16 2001 (20) Sta. 15

ENGINEERING DATA TRANSMITTAL

1. EDT 631182

2. To: (Receiving Organization) Distribution HPAB0261	3. From: (Originating Organization) Immobilized Waste Storage/Disposal	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Immobilized Waste Disposal	6. Design Authority/Design Agent/Cog. Engr.: T. C. Mackey/ D.A. Burbank	7. Purchase Order No.: N/A

8. Originator Remarks:
Document issued for approval and release.

9. Equip./Component No.: N/A
10. System/Bldg./Facility: N/A
11. Receiver Remarks:
11A. Design Baseline Document? ☒ Yes ☐ No
12. Major Assm. Dwg. No.: N/A
13. Permit/Permit Application No.: N/A
14. Required Response Date:

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	RPP-8313		0	Packaging Design Criteria (Onsite) Project W-520, Immobilized Low-Activity Waste Transportation System	SQ	1	1	

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5. Sec. 12.7)	1. Approva 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved wlwmment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(M) MSIN
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1	1	Safety K. R. Sandgren	KR Sandgren	10/4/01	B1-49				
		Env. N/A							

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H L Baune H. L. Baune 10/4/01	GL Parsons G.L. Parsons 10-9-01	T.C. Mackey T.C. Mackey 10/4/01	Ctrl No. N/A
Signature of EDT Originator / Date	Authorized Representative for Receiving Organization / Date	Design Authority/ Cognizant Manager / Date	☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments

BD-7400-172-2 (10197)

BD-7400-172-1

Packaging Design Criteria (Onsite) Project W-520, Immobilized Low-Activity Waste Transportation System

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U.S. Department of Energy Contract DE-AC27-99RL14047

EDT/ECN: 631182 UC: 2000
Cost Center: 7P100 Charge Code: 501050
B&R Code: EW01J2100 Total Pages: 37

Keywords: Packaging Design Criteria; Low Activity Waste; Disposal; ILAW; W-520; Immobilized; Transportation

Abstract: This document is to describe the Project W-520 onsite transportation packaging design criteria requirements.

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Janis Aardal 10-16-01
Release Approval Date Release Stamp

Approved For Public Release

RPP-8313
Revision 0

Packaging Design Criteria (Onsite) Project W-520, Immobilized Low-Activity Waste Transportation System

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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Richland, Washington
Contractor for the U.S. Department *of* Energy
Office of River Protection under Contract DE-AC06-99RL14047

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Packaging Design Criteria (Onsite) Project W-520. Immobilized Low-Activity Waste Transportation System

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October, 2001

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LIST OF TERMS

ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society **for** Testing and Materials
Bq	becquerel, a unit for measuring quantity of radioactive material, 1 Bq = 1 dis/s
Bq/m^2	becquerels per square meter
$BTU/h\text{-}ft^2$	British thermal units per hour per foot squared
CFR	***Code of Federal Regulations***
°C	degree Celsius
Ci	curie, 3.7 E+10 disintegrationslsecond
Ci/m^3	curies **per** cubic meter
$dis/s/ft^2$	disintegrations per second per square foot
DOE	U.S. Department of Energy
Dpm/100 cm2	disintegrations per minute **per** 100 square centimeters
°F	degree Fahrenheit
ft^3	cubic foot
g	gram
g/cc	grams per cubic centimeter
IHLW	immobilized high-level waste
ILAW	immobilized low-activity waste
in.	inch
k_{eff}	multiplication factor, the ratio of the number of fissions in any one generation to the number of fissions in the preceding generation.
kg	kilogram
kg/m^3	kilograms **per** cubic meter
km	kilometer
kPa	kilopascal
L	liter
Umin	liters per minute
lb	pound
m	meter
m^3	cubic meter
mrem/h	millirem per hour, a unit of dose equivalent rate
mSv/h	millisievert per hour, a unit of dose equivalent rate, 1 mSv = 10 mrem.
nCi/g	nanocuries per gram
PDC	packaging design criteria
psi	pounds per square inch
psia	pounds per square inch, absolute
PSSD	Package Specific Safety Document
RCRA	***Resource Conservation and Recovery Act*** of ***1976***
SARP	safety analysis report for packaging
s v	sievert, **a** dose equivalent unit, 1 Sv = 100 rem
TBq	terabecquerel, 1 E+12 becquerels = 27 Ci

LIST OF TERMS, cont

THI	Transportation Hazard Indicator
μm	micrometer
W	watt
yd	**yard**

Definitions

Immobilized low-activity waste (ILAW) canister; The **ILAW** canister is the innermost container of the **ILAW** package. It is a cylindrical metal container. The **ILAW** glass product will be poured directly into the **LAW** canister, forming a solid monolith, and then will be sealed. The **ILAW** canister is the containment boundary.

ILAW ***cask:*** This term refers to the shielded container that will contain the **ILAW** canister during transport from the low-activity waste process facility to the **ILAW** disposal complex. The ILAW cask may be constructed of steel or steel/lead plate. The ILAW cask will be fitted with a removable lid and securely mounted onto the flatbed transport trailer.

ILAW package: This term refers to the **ILAW** cask when it is loaded with the **ILAW** canister with its radioactive contents as presented for transport.

ILAW transportation system: This term refers to the entire system for transporting the **ILAW** package including the tractodtrailer, tiedowns, and blocking and bracing required to secure the package to the transport vehicle.

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PACKAGING DESIGN CRITIERIA (ONSITE) PROJECT W-520, IMMOBILIZED LOW-ACTIVITY WASTE TRANSPORTATION SYSTEM

1.0 INTRODUCTION

1.1 BACKGROUND

A plan is currently in place to process the high-level radioactive wastes that resulted from uranium and plutonium recovery operations from Spent Nuclear **Fuel** at the Hanford Site, Richland, Washington. Currently, millions of gallons of high-level radioactive waste in the form of liquids, sludges, and saltcake are stored in many large underground tanks onsite. This waste will be processed and separated into high-level and low-activity fractions. Both fractions will then be vitrified (i.e., blended with molten borosilicate glass) in order to encapsulate the toxic radionuclides. The immobilized low-activity waste (ILAW) **glass** will be poured into ILAW canisters, allowed to cool and harden to solid form, sealed by welding, and then transported to a double-lined trench in the 200 East Area for permanent disposal.

1.2 PURPOSE AND SCOPE

This document presents the packaging design criteria (PDC) for an onsite L A W transportation system (see Figure 1), which includes the ILAW canister (see Figure 2), ILAW package, and transport vehicle and defines normal and accident conditions. This PDC provides the basis for the ILAW onsite transportation system design and fabrication and establishes the transportation safety criteria that the design will be evaluated against in the Package Specific Safety Document (PSSD). It provides the criteria for the ILAW canister, cask and transport vehicles and defines normal and accident conditions.

The L A W transportation system is designed to transport stabilized waste from the vitrification facility to the ILAW disposal facility developed by Project W-520.

All ILAW transport will take place within the 200 East Area (all within the Hanford Site).

1.3 SYSTEM DESCRIPTION

The following sections describe the package specifications and physical and radiological contents. Table 1 shows the L A W transportation system component specifications.

The ILAW transportation system will be used to transport **ILAW** packages from the River Protection Project Waste Treatment Plant to the remote-handled ILAW Disposal Facility (see Figure **3** for facility locations).

Figure 1. Immobilized Low-Activity Waste Transportation System.

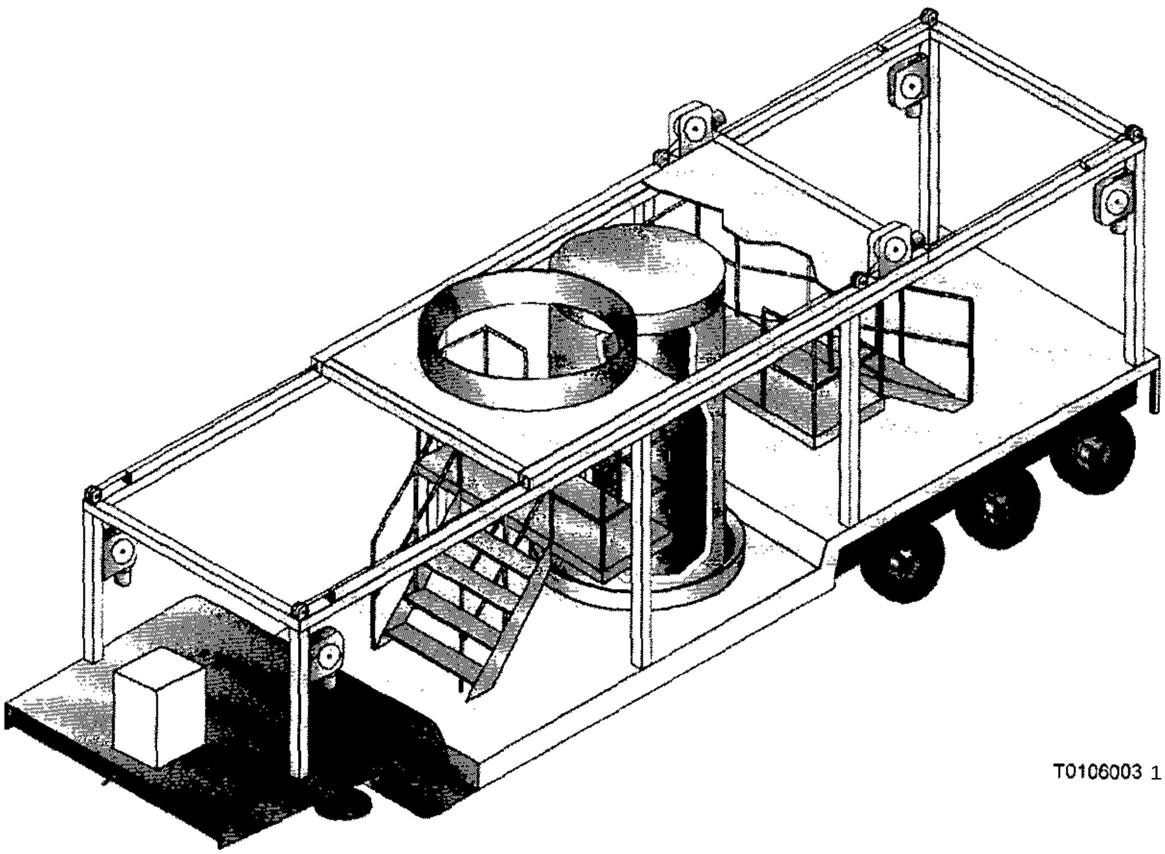

Figure 2. Immobilized Low-Activity Waste Canister.

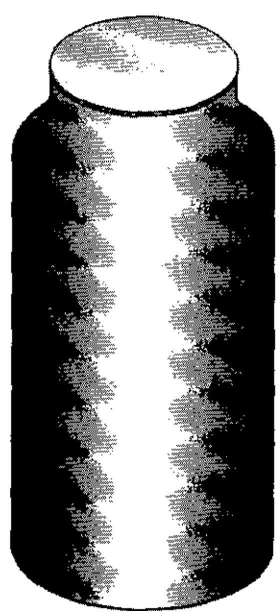

Table 1. Specification Matrix.

Equipment	Feature	Specification	Reference
ILAW canister	Material	Stainless Steel Plate ASME Part A, SA240 Type 321H and shall comply with requirements for materials given in ASME (1995b), Part UG-4 through UG-15	BNFL (2000)
	Size	Nominal 1.22 m (48-in.) diameter, 2.3 m (90 in.) high	DOE-ORP (2000)
		Wall thickness: 0.36 cm (9/64 in.) (10 gauge)	BNFL (2000)
		Volume: 2.51 m^3 (89 ft^3) internal	
	Weight	Maximum gross wt: 7,100 kg (15,580 lb)	DOE-ORP (2000)
	Temperature	Maximum external surface temp 50 °C	DOE-ORP (2000)
	Structural integrity	Loaded canister must withstand a compressive load of 100,000 kg per 49 CFR 173.465(d).	DOE-ORP (2000)
	Smearable contamination	Internal/external surfaces to 367 Bq/m^2 (34 dis/s/ft^2) alpha and 3,670 Bq/m^2 (340 dis/s/ft^2) gamma/beta	DOE-ORP (2000)
	Durability/cost	Service life: 50 years	DOE-ORP (2000)
	Leak resistance	Must meet ANSI (1998)	DOE-ORP (2000)
	Free liquid	No detectable free liquid	DOE-ORP (2000)
	Criticality safety	Fissile excepted	49 CFR 173.453
ILAW glass	Weight	6,700 kg (14,700 lb)	Haq (2001)
ILAW package	Dose rate limits	Contact: 2 mSv/h (200 mrem/h)	49 CFR 173.441
		Projection of vertical planes at edge of trailer: 2 mSv/h (200 mrem/h)	49 CFR 173.441
		2 m from projection of vertical planes: 0.1 mSv/h (10 mrem/h)	49 CFR 173.441
	Criticality safety	Fissile excepted	49 CFR 173.453
	Handling	Compatible with crane	DOE-ORP (2000)
	Contamination	See Table 6. Summary of Surface Contamination Values	HNF-5183
ILAW transportation system	Weight	Maximum gross weight: TBD	Burbank (2001a)
	Durability	Service life: 40 years	Burbank (2001a)
		Minimum re-use: must transport minimum of 81,000 packages	Haq (2001)
	Dose rate limit	Occupied area (driver) dose limit: 0.02 mSv/h (2 mrem/h) 0.05 mSv/h (5 mrem/h) if trained radiation worker	49 CFR 173.441

ANSI = American National Standards Institute.
ASME = American Society of Mechanical Engineers.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.

49 CFR 173, "Shippers—General Requirements for Shipments and Packagings," *Code of Federal Regulations*, as amended.
173.441. "Radiation level limitations."
173.443. "Contamination control."
173.453, "Fissile materials—exceptions."
173.465. "Type A packaging tests."

HNF-5183, *Tank Farms Raiological Control Manual (TFCRM)*, CHZM HILL Hanford Group. Inc., Richland. Washington.

ANSI. 1998. *American National Standard for Radioactive Materials—Leakage Tests on Packages for Shipment*, ANSI Standard N14.5-1997, American National Standards Institute. New York. New York.

ASME. 1995b, *Boiler and Pressure Vessel Code.* Section VIII, Division 1, American Society of Mechanical Engineers. New York. New York.

BNFL, 2000, *Interface Control Document for Immobilized Low-Activity Waste*, BNFL-5 193-ID-15, Rev. 5, British Nuclear Fuel Limited. Inc., Richland. Washington.

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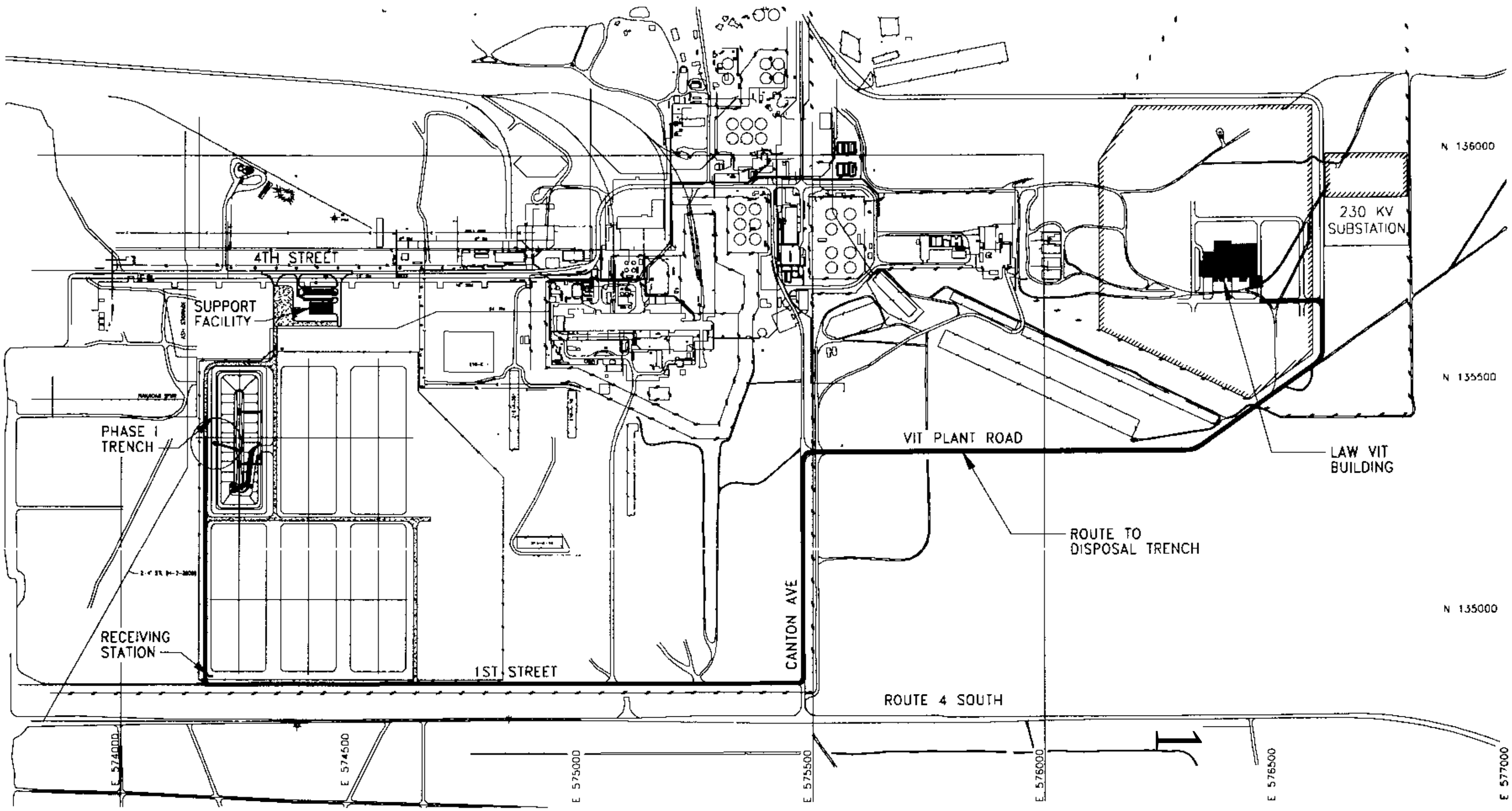
Haq, M. A.. 2001, *Conceptual Design Report Immobilized Low-Activity Waste Disposal Facility: Project W-520*, RPP-7908. Rev. 0, prepared by Fluor Federal Services for CHZM HILL Hanford Group, Inc., Richland, Washington.

Figure 3. Immobilized Low-Activity Waste Facility Locations.



1.4 JUSTIFICATION

Currently, no packaging licensed or specified by the U.S. Nuclear Regulatory Commission (NRC), the **U.S**. Department of Transportation, or the **U.S.** Department of Energy is physically compatible with the anticipated dimensions of the ILAW. The processing and immobilization of Hanford radioactive wastes is a very high priority issue with stakeholders on the local, state, and national levels. Therefore, the U.S. Department of Energy has instructed the Hanford Site contractors to design and build an ILAW transportation system for use onsite (DOE/ORP-2000- 10, ***River Protection Project Mission Analysis Report*** [DOE-ORP 20011).

2.0 PACKAGE CONTENTS

2.1 PHYSICAL FORM

The ILAW content is a solid glass monolith formed by pouring molten glass into the ILAW canister with nominal dimensions of 1.22 m (48-in.) diameter by 2.3 m (90-in.) height with a wall thickness of 0.36 cm (9/16 in.) (10 gauge). For the purposes of this document, these dimensions will be assumed to be fixed as indicated above. The ILAW canister will have an internal volume of approximately 2.51 m^3 (89 ft^3).

2.2 RADIOLOGICAL DESCRIPTION

The maximum source term for ILAW glass is a composite list drawn from HNF-SD-WM-SP-012, ***Tank Farm Contractor Operation and Utilization Plan*** (Kirkbride et al. 2000) (Case 3S6E R2A). Only isotopes with activity in excess of 1×10^{-9} Ci/canister were included in the source term. This maximum composite source term of 635 A_2s is shown in Table 2.

The third and fourth columns of Table 2 show the activity of radionuclides found in the ILAW glass. The data in these columns was calculated as the multiplication product of the radionuclide concentrations from Kirkbride et **al.** (2000) (Case 3S6E R2A) and the waste volume, 2.51 m^3 (89 ft^3). The fifth column shows A_2 values as defined in 49 CFR 173, "Shippers—General Requirements for Shipments and Packagings," 173.435, "Table of A_1 and A_2 values for radionuclides," which are limits used for shipping classifications. The last column in Table 2 is the result of the third column (activity) divided by the fifth column (A_2 value). The last column shows the source term with respect to the A_2 limits in order to identify the ILAW package shipping type and class.

Table 2. Maximum Immobilized Low-Activity Waste Glass Radionuclide Inventory Per Canister. (2 sheets total)

Isotope	Radionuclide concentration (Ci/m^3)	Activity (Ci)	Activity (Bq)	A_2 (Ci)*	No. of A_2
^{3}H	2.30 E-01	5.78 E-01	2.14 E+10	1.08 E+03	5.35 E-04
^{14}C	1.06 E-01	2.66 E-01	9.86 E+09	5.41 E+01	4.93 E-03
^{59}Ni	4.25 E-03	1.07 E-02	3.94 E+08	1.08 E+03	9.87 E-06
^{60}Co	5.13 E-02	1.29 E-01	4.76 E+09	1.08 E+01	1.19 E-02
^{63}Ni	3.26 E-01	8.19 E-01	3.03 E+10	8.11 E+02	1.01 E-03
^{79}Se	5.47 E-02	1.37 E-01	5.08 E+09	5.41 E+01	2.54 E-03
^{90}Sr	2.00 E+01	5.02 E+01	1.86 E+12	2.70 E+00	1.86 E+01
$+^{90}Y$	2.00 E+01	5.02 E+01	1.86 E+12	Daughter	Daughter
^{93m}Nb	9.01 E-03	2.26 E-02	8.36 E+08	1.62 E+02	1.40 E-04
^{93}Zr	5.30 E-02	1.33 E-01	4.93 E+09	5.41 E+00	2.46 E-02
^{99}Tc	9.96 E-02	2.50 E-01	9.25 E+09	2.43 E+01	1.03 E-02
^{106}Ru	1.26 E-07	3.17 E-07	1.17 E+04	5.41 E+00	5.86 E-08
^{113m}Cd	7.91 E-02	1.99 E-01	7.35 E+09	2.43 E+00	8.17 E-02
^{125}Sb	2.67 E-01	6.70 E-01	2.48 E+10	2.43 E+01	2.76 E-02
^{126}Sn	3.29 E-02	8.26 E-02	3.06 E+09	8.11 E+00	1.02 E-02
^{129}I	1.63 E-03	4.09 E-03	1.51 E+08	Unlimited	Unlimited
^{134}Cs	2.10 E-01	5.27 E-01	1.95 E+10	1.35 E+01	3.90 E-02
^{137}Cs	3.00 E+00	7.53 E+00	2.79 E+11	1.35 E+01	5.58 E-01
$+^{137m}Ba$	2.84 E+00	7.12 E+00	2.64 E+11	Daughter	Unlimited
^{151}Sm	1.97 E+01	4.95 E+01	1.83 E+12	1.08 E+02	4.59 E-01
^{152}Eu	3.34 E-03	8.37 E-03	3.10 E+08	2.43 E+01	3.45 E-04
^{154}Eu	7.86 E-01	1.97 E+00	7.30 E+10	1.35 E+01	1.46 E-01
^{155}Eu	1.10 E+00	2.76 E+00	1.02 E+11	5.41 E+01	5.10 E-02
^{226}Ra	5.92 E-07	1.48 E-06	5.49 E+04	5.41 E-01	2.74 E-06
^{227}Ac	7.93 E-07	1.99 E-06	7.36 E+04	5.41 E-04	3.68 E-03
^{228}Ra	1.23 E-04	3.08 E-04	1.14 E+07	1.08 E+00	2.85 E-04
^{229}Th	1.66 E-05	4.17 E-05	1.54 E+06	8.11 E-04	5.14 E-02
^{231}Pa	7.55 E-06	1.89 E-05	7.01 E+05	1.62 E-03	1.17 E-02
^{232}Th	8.06 E-05	2.02 E-04	7.49 E+06	Unlimited	Unlimited
^{232}U	2.99 E-04	7.49 E-04	2.77 E+07	8.11 E-03	9.24 E-02
^{233}U	1.52 E-03	3.82 E-03	1.41 E+08	2.70 E-02	1.41 E-01
^{234}U	8.49 E-04	2.13 E-03	7.89 E+07	2.70 E-02	7.90 E-02
^{235}U	4.03 E-05	1.01 E-04	3.75 E+06	Unlimited	Unlimited
^{236}U	4.08 E-05	1.02 E-04	3.78 E+06	2.70 E-02	3.79 E-03
^{237}Np	1.91 E-03	4.80 E-03	1.78 E+08	5.41 E-03	8.87 E-01
^{238}Pu	2.90 E-03	7.27 E-03	2.69 E+08	5.41 E-03	1.34 E+00
^{238}U	8.49 E-04	2.13 E-03	7.89 E+07	Unlimited	Unlimited
^{239}Pu	8.24 E-02	2.07 E-01	7.65 E+09	5.41 E-03	3.82 E+01
^{240}Pu	1.41 E-02	3.55 E-02	1.31 E+09	5.41 E-03	6.56 E+00
^{241}Am	1.22 E+00	3.06 E+00	1.13 E+11	5.41 E-03	5.66 E+02

Table 2. Maximum Immobilized Low-Activity Waste Glass Radionuclide Inventory Per Canister. (2 sheets total)

Isotope	Radionuclide concentration (Ci/m^3)	Activity (Ci)	Activity (Bq)	A_2 (Ci)*	No. of A_2
^{241}Pu	8.85 E-02	2.22 E-01	8.22 E+09	2.70 E-01	8.23 E-01
^{242}Cm	3.54 E-13	8.89 E-13	3.29 E-02	2.70 E-01	3.29 E-12
^{242}Pu	1.02 E-06	2.55 E-06	9.43 E+04	5.41 E-03	4.71 E-04
^{243}Am	1.37 E-04	3.45 E-04	1.28 E+07	5.41 E-03	6.37 E-02
^{243}Cm	2.07 E-04	5.19 E-04	1.92 E+07	8.11 E-03	6.40 E-02
^{244}Cm	3.52 E-03	8.83 E-03	3.27 E+08	1.08 E-02	8.18 E-01
Total		1.77 E+02	6.54 E+12		6.35 E+02

Source: Kirkbride, R. A., et al., 2000, ***Tank Farm Contractor Operation arid Utilization Plan.*** HNF-SD-WM-SP-012, Rev. 2 (Case 3S6E R2A), CH2MHill Hanford Group, Inc.. Richland. Washington.

*49 CFR **173,** "Shippers — General Requirements for Shipments and Packagings," 173.435, Table of A_1 and A_2 values for Radionuclides," ***Code of Federal Regulations,*** as amended.

+Daughter.

Key isotopes are ^{60}Co, ^{90}Sr, ^{106}Ru, ^{125}Sb, ^{126}Sn, ^{137}Cs, ^{152}Eu, and ^{154}Eu. Note that most of these isotopes are listed in the Best-Basis Inventory with ^{137}Cs and ^{90}Sr coming from the Tank Waste Remediation System Operation and Utility Plan. Per Contract Number DE-AC27-01RV 14136, ***Bechfel National, Inc. Design, Construction, and Commissioning of the Hanford Tank Waste Treafmentand Immobilization Plant*** (DOE-ORP 2000), the radioisotope concentrations of ILAW must be limited to Class C limits as defined in 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," 61.55, "Waste classification." Therefore, ^{137}Cs must be less than 3 Ci/m^3, ^{90}Sr must be less than 20 Ci/m^3, and ^{99}Tc must be less than 0.3 Ci/m^3. In addition, transuranics are limited to 100 nCi/g. Because detailed information on transuranics was not available, transuranic content was conservatively estimated to be all ^{241}Am for dose calculations. ^{241}Am decays by emitting a 5.4 MeV alpha particle. Thus, ^{241}Am creates maximum inhalation dose and heat load as a worst-case assumption. All isotopes are assumed to be uniformly distributed and completely soluble in the supernatant, and sludge wash liquids will be captured in the ILAW glass matrix. The contents will be dried (no free liquids) prior to sealing within the ILAW canister. The maximum fissile content is 50 g as shown in Table 3.

Table 3. Maximum Immobilized Low-Activity Waste Glass Fissile Radionuclide Inventory

Isotope	Radionuclide concentration (Ci/m^3)	Activity (Ci)	Activity (Bq)	g
233-U	1.52E-03	3.82E-03	1.41E+08	3.94E-01
235-U	4.03E-05	1.01E-04	3.75E+06	4.59E+01
238-Pu	2.90E-03	7.27E-03	2.69E+08	4.28E-04
239-Pu	8.24E-02	2.07E-01	7.65E+09	3.34E+00
241-Pu	8.85E-02	2.22E-01	8.22E+09	2.22E-03
Total		4.40E-01	1.63E+10	4.96E+01

Source: Kirkbride, R. **A..** et al., 2000, ***Tank Farm Contractor Operation and Utilization Plan,*** HNF-SD-WM-SP-012, Rev. ***2*** **(Case** 3S6E R2A), CH2MHill Hanford **Group,** Inc., Richland, Washington.

2.3 CHEMICAL CONSTITUENT SOURCE TERM

The ILAW glass will be chemically inert and stable with respect to the anticipated containment materials. Hydrogen generation due to chemical reactions is not expected. Table **4** shows the expected ILAW glass composition.

Table 4. Immobilized Low-Activity Waste Glass Chemical Composition.

Oxide	Mass %	Oxide	Mass %
Al_2O_3	10.000	Na_2O	20.000
B_2O_3	9.250	P_2O_5	0.080
Cl	0.580	SO_3	0.100
Cr_2O_3	0.020	SiO_2	41.890
F	0.040	TiO_2	2.490
Fe_2O_3	2.500	ZnO	2.600
K_2O	2.200	ZrO_2	5.250
La_2O_3	2.000	Total	100.00
MgO	1.000		

Source: PNNL, 1999, ***Waste Form Release Data Parkagefor the 2001 lmmobilized Low-Activity Waste Performance Assessment,*** PNNL-13043, Rev. I, Pacific Northwest National Laboratory, Richland. Washington.

2.4 THERMAL LOAD

Based upon assessment of Phase 1 tank waste data, a maximum heat load of 0.425 W per L A W package would be expected (HNF-SD-W465-PSE-001, ***Preliminary Safety Evaluationfor Project W-465, Immobilized Low-Activity Waste Interim Storage Facility*** [FDNW 19971).

2.5 TRANSPORTATION CLASSIFICATION

Based on the curie loading shown in Table **2,** the ILAW package is classified as Type B, but less than highway route controlled quantity.

2.6 FISSILE CLASSIFICATION

The package is fissile excepted for transportation per 49 CFR 173.453, "Fissile materials–exceptions," 173.453(d). The maximum fissile content per package is less than 50 g. Since the volume is 2510 L, this equals approximately 0.2 g fissile radionuclides per 10 L. This is below the limit of 5 g fissile radionuclides per 10 L.

3.0 FACILITY OPERATIONS

3.1 ORIGINATING FACILITY

The low-activity waste process facility is expected to be located about 700 m to the east of 241 AP Tank Farm in the 200 East Area. The low-activity waste will be chemically pretreated and pH adjusted prior to incorporation into a molten borosilicate glass medium.

The pretreatment process will involve removal of excess cesium prior to vitrification. The waste glass monoliths formed by the vitrification process will be inert, homogeneous and without inclusions or free liquid wastes. These glass monoliths will be formed by pouring molten glass into ILAW canisters with close-fitting lids. The lids will be welded closed.

The ILAW canister will be decontaminated; surveyed to meet Table 1 specifications; and loaded into the ILAW cask secured to the trailer using overhead cranes The ILAW cask will carry a single ILAW canister. The ILAW package will then be shipped to the ILAW Disposal Facility (about 2.7 km [1.7 mi]).

3.2 RECEIVING FACILITY—ILAW TRANSFER TO DISPOSAL TRENCH

A mobile crane will be used to unload the ILAW canister from the **ILAW** cask and place the canister into the lined trench. Each trench will provide for approximately 13,500 ILAW waste packages. Each trench will contain three layers of ILAW canisters that will be separated vertically by 1 m of soil to provide shielding during canister placement. Each layer will contain multiple cells or canister arrays, spanning the length of the trench. A closure cover designed to provide long-term containment and hydrologic protection will be installed. The closure cover is a modified ***Resource Conservation and Recovery Act of 1976*** (RCRA), Subtitle C barrier. The closure consists of a topsoil layer, a lateral drainage area, and a barrier area. The closure provides a minimum of 5 m of soil cover above the surface of the top of the uppermost layer of ILAW canisters and extends at least 5 m beyond the surface edge of the secondary trench liner.

After exhausting the 13,500 ILAW canister capacity of the Phase 1 trench, up to five additional, identical trenches will be constructed in Phase 2.

4.0 PACKAGING/TRANSPORT SYSTEM DESIGN CRITERIA

4.1 GENERAL

The packaging shall be approved for use within the boundaries of the Hanford Site. It will be authorized to transfer Type B radioactive material in the form of immobilized low activity waste glass. A PSSD shall be written to demonstrate the safety of the transfer through a combination of cask performance and administrative controls. The PSSD will include the evaluation of the packaging system to provide containment and shielding for the payload during normal transfer conditions (Section 5.1.1) and accident conditions (Section 5.1.2). The packaging and transportation shall be performed in accordance with DOE/RL-2001-0036, ***Hanford Sitewide Transportation Safety Document*** (RL 2001), and HNF-IP-0842, ***RPP Administration***, Vol. XVIII, "Waste Management," Section 2.1, "Radioactive Waste/Material Shipments." Additionally, a hazards assessment may have to be performed to support Site emergency planning per DOE Order 151.1A, ***Comprehensive Emergency Management System*** (DOE 2000). Approval of the PSSD provides authorization for onsite transport.

4.2 PACKAGING DESIGN CRITERIA

The ILAW transportation system shall be designed as a reusable system capable of transporting one 2.51 m^3 (89 ft^3) ILAW canister. The ILAW package performance requirements will be verified through either analysis or a combination of analytical and test methods for bounding case scenarios defined in the PSSD.

4.2.1 Construction Materials

The structural containment boundary materials for the ILAW package shall comply with material requirements identified in NUREG/CR-3854, ***Fabrication Criteria for Shipping Containers*** (Fischer and Lai 1985). The materials of construction shall meet the fracture toughness guidelines of Regulatory Guide 7.11, ***Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness*** of ***4 Inches*** (NRC 1991).

All metals shall be American Society of Mechanical Engineers (ASME) or American Society for Testing and Materials (ASTM)-certified materials. Nonmetallic materials, such as gaskets and O-rings, shall meet ASTM requirements. All construction materials shall be compatible with the ILAW glass product. The materials shall be selected to minimize chemical-galvanic reactions between the ILAW canister and the transport containers.

4.2.2 ILAW Cask

The dimensions for the ILAW cask are based upon the ILAW canister dimensions listed in Section 2.1 and the shielding requirements given in Section 4.2.10. Internal dimensions will be at least 2.4 m high by 1.27 m diameter per DOE-ORP (2000).

4.2.3 Weight of Contents

The maximum weight of the contents is 6,700 kg (14,700 lb). The likely weight of the contents, which is based upon a 90-percent fill volume and a maximum specific density of the waste glass, may be calculated as follows: 0.90 x 2.51 m^3 x 2,660 kg/m^3 = 6,010 kg.

4.2.4 Maximum Gross Weight

Table 5 shows the maximum gross weight of the ILAW transportation system and components.

Table 5. Maximum Gross Weight.

Component	Weight, kg (lb)
Empty immobilized low-activity waste (ILAW) canister	400 (880)
Empty ILAW cask	4,000 (8,800)
ILAW cask with ILAW canister (empty)	4,400 (9,680)
Contents (max)	6,700 (14,700)
Loaded ILAW canister (max)	7,100 (15,580)
Total loaded gross weight ILAW package (max)	11,100 (24,380)

4.2.5 Venting/Hydrogen Gas Generation

The ILAW glass product will be chemically inert. Specifications for residual moisture and organic contents of the ILAW glass product prevent the risk of hydrogen gas generation.

Venting of the ILAW package will not be required provided the hydrogen concentration remains below 5 percent in half the shipping window.

4.2.6 Lifting Attachments

The lifting attachments for the ILAW package shall be capable of lifting three times the total suspended weight without generating a combined stress or maximum tensile stress at any point in the load path in excess of the corresponding minimum yield strength of their materials of construction. The lifting attachments shall be designed so that failure of any lifting device under excessive load would not impair the ability of the package to meet other requirements. Any other structural part of the package that would be used to lift the package must be either capable of being rendered inoperable for lifting the package during transport or designed with strength equivalent to that required for lifting attachments (10 CFR 71, "Packaging and Transportation of Radioactive Material," 71.45, "Lifting and tie-down standards for all packages"). The lifting attachments shall be compatible with the vitrification building load-out area, production and receiving facilities, and storage and disposal facilities.

4.2.7 Tiedown Attachments

If the tiedown attachments are a structural part of the package, they shall be designed to withstand a force of ten times the cask weight in the forward and aft directions; five times the loaded cask weight in the lateral directions; and two times the cask weight in the vertical directions without yielding. Any structural part other than the tiedown attachments that could be used to tie down the package shall be either capable of being rendered inoperable for tying down the package during transport or designed with strength equivalent to that required for tiedown devices. Each tiedown device that is a structural part of a package shall be designed so that failure of the device under excessive load would not impair the ability of the package to meet other requirements (10 CFR 71.45[b]).

4.2.8 Closure Design

The lid for each ILAW canister shall be sealed by welding per DOE-ORP (2000).

4.2.9 Containment

The containment boundary, which is the ILAW canister, shall be designed to meet containment requirements defined by the Hanford Site TSD (DOE 2001) during normal transfer conditions (leakage rate of less than $10^{-6} A_2 s/h$) and accident conditions (a leakage rate of less than 1 A_2/wk except 10 A_2s ^{85}Kr/wk). Compliance with these requirements shall be demonstrated by testing or analysis. Package performance will be assessed in accordance with the ***Boiler and Pressure Vessel Code,*** Section III, Subsection **NE** (ASME 1995a), Service Level A and C limits . The combined stress intensities from temperature, pressure, and free drop are evaluated against the requirements defined for service level C limits. Stress intensities from all other load combinations are to be evaluated against the requirements defined for Service Level A limits. For structural evaluation purposes, maintenance of containment/confinement **is** defined as the ability of the packaging system to sustain the applied loading without exceeding ASME allowable stress intensity values. Also at closure locations, the seals must be demonstrated to remain sufficiently compressed under normal condition loads as to maintain containment/confinement.

Leakage rate analysis will be performed per ANSI N14.5.

4.2.10 Shielding

The ILAW package and closures (e.g., lid, personnel barriers) shall be designed to meet as a minimum the dose rate limits for an exclusive-use shipment as defined in 49 CFR 173.441, "Radiation level limitations," 173.441(b). The dose rate limits are as follows:

- 2 mSv/h (200 mrem/h) at the cask surface
- 2 mSv/h (200 mrem/h) at any point on the vertical planes projected from the outer edges of transport trailer, on the upper surface of the package, and on the lower external surface of the transport trailer
- 0.1 mSv/h (10 mrem/h) at 2 m from the vertical planes projected by the outer edges of the transport trailer (excluding the top and underside of the transport trailer)
- At the driver's location either 0.02 mSv/h (2 mrem/h) if the driver is a nonradiation worker or 0.05 mSv/h (5mrem/h) if the driver is a trained radiation worker.

The limits listed here are maximum allowable values. An analysis based on as low as reasonably achievable (ALARA) should be performed to determine the dose rates to be used in the design.

4.2.11 Service Life

The ILAW transportation system shall be capable of being used a minimum of 81,000 times. The ILAW transport system has five casks, and three trucks. Each cask shall be capable of being reused 16,200 times. Additionally, the ILAW transport system shall have a minimum transport service life of 40 years. Design features of the ILAW transportation system (including the transport container) shall minimize maintenance, refurbishing, and decontamination procedures required for reuse. It is recommended that the ILAW transportation system be designed to meet the vibration and fatigue requirements of ANSI N14.23. Features requiring refurbishment prior to reuse shall be designed in accordance with ALARA principles.

4.2.12 Decontamination

The smearable surface contamination on the surface of the loaded ILAW package must not exceed Table XXX values (per HNF-5183, ***Tank Farms Radiological Control Manual (TFRCM)).***

Table 6. Summary of Surface Contamination in Values in dpm/100cm^2.

Radionuclide	Removable	Total (Fixed+ Removable)
U-nat, U-235, U-238, and associated decay products	1000	5000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	500
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, u-232, I-126, I-131, I-133	200	1000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90	1000	5000
Tritium and tritiated compounds	10000	**N/A**

4.3 TRANSPORT SYSTEM

4.3.1 General

The transport vehicle will be a shielded ni-truck and tractorhailer unit with an approximate overall trailer length of 12 m (40 ft) and an approximate trailer width of 2.4 m (8 ft), which will be capable of transporting a single **ILAW** package loaded with ILAW glass product. General requirements follow.

- The maximum gross weight per axle for a fully loaded tractor/trailer combination shall not exceed 9,000 kg (20,000 lb) (per RPP-7307, ***System Specification for Immobilized Low-Activity Waste Disposal System*** [Burbank 2001b]).

- The maximum width of the tractorhailer combination shall not exceed **3** m (10 ft); the maximum length of the tractor/trailer combination shall not exceed 18.3 m (60 ft).

- The height of the trailer bed shall be limited so that the overall height of the ILAW transportation system shall not exceed 5.2 m (17 ft) which includes structures and components mounted above the cask.

- The trailer shall be equipped with tiedown points sufficient to secure the containers in accordance with the requirements set forth in Section 4.3.2.

4.3.1.1 Additional Requirements. To prevent the trailer from tipping over during normal transport, the trailer shall be designed in accordance with American National Standards Institute (ANSI) Standard N14.30, *Nuclear Materials – Semi Trailers Employed in the Highway Transport of Weight-Concentrated Radioactive Loads – Design, Fabrication, and Maintenance* (ANSI 1992b). This standard requires the center of gravity of the trailer and its load to be within 5.08 cm (2.0 in.) of the transverse center of the trailer and requires the height of the center of gravity to be less than 120 percent of the trailer track (center-to-center width of the trailer tire group).

Shielding may be incorporated into the design of the tractorhailer in order to reduce the dose rates. This shielding may be in the form of steel or lead plate attached to the floor or sides of the trailer. Additional shield plates may be attached to the back of the tractor in order to reduce the dose rate to the driver. These additional shield plates are not considered for the shielding analysis for this package.

4.3.2 Tiedowns

An engineered tiedown system shall be used to secure the ILAW package to the transport vehicle(s). The tiedown system shall meet the requirements and be designed per 49 CFR 393, "Parts and Accessories Necessary for Safe Operation." The lesser of the allowable or working load limits of the tiedown attachments shall be capable of resisting the forces as shown in Table 7.

Table 7. Load Factors for Tiedown Systems.

Forward	Backward	Lateral	Vertical
0.62*g*	0.5*g*	0.5*g*	0.5*g*

Consideration shall be given to tiedown methods (such as remote operations or permanent systems integral to the ILAW transportation system and transport vehicle) to maximize the distance and/or minimize the time spent near the payload.

4.3.3 Shielding

An ALAR analysis sh ıld be performed to determir appropriate dose rates based on necessary access to the loaded package. The package shall be designed such that the dose rate limits specified in Section 4.2.10 are not exceeded.

4.4 DESIGN CRITERIA RELATIVE TO PRODUCING/RECEIVING FACILITIES

ILAW transportation system equipment and ILAW Production Facility/ILAW Disposal Facility equipment must be mutually compatible. This section addresses equipment design and selection issues that will affect both the L A W transportation system and production facility design.

Table 7 shows specifications appearing in BNFL-5193-ID-15, *Interface Control Document for Immobilized Low-Activity Waste* (BNFL *2000).*

Additional design criteria that need to be established include the following:

- Transport container dimensions
- Transport container lid design
- Operations criteria.

Table 8. Interface Control Document-15 Specification Matrix.

Equipment	Feature	Specification
ILAW canister	Material	Stainless Steel Plate ASME Part A, SA240 Type 321H and shall comply with requirements for materials given in ASME (1995b), Part UG-4 through UG-15
	Maximum height	2.4 m (7.9 ft)
	Labeling	Unique identification number on two sides and the top. Must be remotely readable.
	Maximum canister Production rate	Approximately five/day
ILAW package	Dose rate limits	Contact: 2 mSv/h (200 mrem/h)
		Projection of vertical planes at edge of trailer: 2 mSv/h (200 mrem/h)
		2 m from projection of vertical planes: 0.10 mSv/h (10 mrem/h)
	Number of canisters per package	One
	Handling	Compatible with crane
	Contamination	Decontamination: internal/external surfaces to 367 Bq/m^2 (34 dis/s/ft^2) alpha and 3,670 Bq/m^2 (340 dis/s/ft^2) gamma/beta
	Loading orientation	Top loaded
	Shielding	U.S. Department of Transportation regulations
ILAW transportation system	Weight	Maximum gross weight: TBD
	Length (max)	18.3 m (60 ft)
	Width (max)	3 m (10 ft)

Source: BNFL. 2000. ***Interface Control Document for Immobilized Low-Activity Waste*****, BNFL-5193-ID-I5 Rev. 5. British Nuclear Fuel Limited. Inc., Richland. Washington.**

ASME = American Society of Mechanical Engineers
ILAW = immobilized low-activity waste.

ASME, 1995b. ***Boiler and Pressure- Vessel Code-*****, Section VIII, Division 1. American Society of Mechanical Engineers. New York, New York.**

5.0 GENERAL REQUIREMENTS

5.1 TRANSPORTATION SAFETY

This section describes the package requirements for the **ILAW** packages that will be transported to the **ILAW** Disposal Facility—located **2.7** km (1.7 mi) away.

The following general standards for packaging are taken from 10 CFR 71. In some cases changes have been adopted for the Hanford Site.

- The smallest overall dimension of the package shall not be less than 10 cm (**4** in).
- The outside of a package shall incorporate a feature, such as a seal, that is not readily breakable and that, while intact, would be evidence that the package has not been opened by unauthorized persons.

- Each package shall include a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by a pressure that may arise within the package.

- **A** package shall be made of materials and construction that ensure that there will be no significant chemical, galvanic, or other reaction among the packaging components, among package contents, or between the packaging components and the packaging contents. The evaluation shall include possible reaction resulting from inleakage of water to the maximum credible extent. Account shall be taken of the behavior of materials under irradiation.

- **A** package valve or other device, the failure of which would allow radioactive contents to escape, shall be protected against unauthorized operation and except for a pressure relief device must be provided with an enclosure to retain any leakage.

- **A** package shall be designed, constructed, and prepared for shipment so that under the tests identified in Section **5.1.1**, without relying on filters or a mechanical cooling system, the following would result:

  - No loss or dispersal of radioactive contents (as demonstrated to a sensitivity of 10^{-6} A_2s per hour)

  - No significant increase in external surface radiation levels

  - No substantial reduction in the effectiveness of the packaging.

- **A** package shall be designed, constructed, and prepared for shipment so that under the conditions identified in Section 5.1.2, the following would result:

  - No escape of krypton-85 exceeding 10 A_2s in 1 week

  - No escape of radioactive material other than krypton-85 exceeding 1 A_2 in 1 week

  - No external radiation dose rate exceeding 10 mSv/h (1 rem/h) at 1 m (40 in) from the external surface of the package.

- **A** package must be designed, constructed, and prepared for transport so that in still air at **46°C** (115°F) and in the shade, no accessible surface of the package would have a temperature exceeding 85°C (185°F) in an exclusive-use shipment.

- **A** package may not incorporate a feature to allow continuous venting during shipment

5.1.1 Normal Transfer Conditions

For conditions normally incident to transfer, the PSSD shall evaluate the packaging design for its ability to maintain containment, shielding, and nuclear criticality control when subjected to the following conditions.

- **Environmental Conditions.** The design temperature limits for the individual components, parts, and materials of the ILAW package shall be determined by analyses and/or testing. The analyses and/or tests shall be based upon the conditions listed below. The operational temperatures shall be shown to not exceed the design limits. Hanford Site environmental conditions are derived from WHC-SD-TP-RPT-004, ***Environmental Conditions for On-Site Hazardous Materials Packages*** (Fadeff 1992). The ambient temperatures at the Hanford Site for the peak summer month are shown in Table 9.

Table 9. Hanford Air Temperature.

Time	Temperature (°F)	Time	Temperature (°F)	Time	Temperature (°F)
12 a.m.	82	8 a.m.	85	4 p.m.	115
2 a.m.	78	10 a.m.	97	6 p.m.	113
4 a.m.	75	12 p.m.	103	8 p.m.	100
6 a.m.	74	2 p.m.	111	10 p.m.	89

- Maximum heat generation rate of worst-case source from Section 2.2 plus maximum solar heat load (see Table 9) plus maximum air temperature of 46 °C (115 °F)

- Minimum air temperature of -33 °C (-27 °F) plus maximum heat generation rate from worst-case source in Section 2.2

- Minimum air temperature of -33 °C (-27 °F) and zero heat generation rate

- Maximum accessible outside surface temperature of the transport container less than 85 °C (185 "F) in 38 °C (100 "F) air temperature and in the shade.

Table 10. Maximum Solar Radiation Received from the Sun (Btu/h-ft^2).

Time	Vertical surfaces facing								Horizontal surface facing up
	N	NE	E	SE	S	SW	W	NW	
4 a.m.	0	0	0	0	0	0	0	0	0
6 a.m.	57	192	211	105	17	17	17	17	64
8 a.m.	35	173	268	208	42	32	32	32	127
10 a.m.	42	56	177	213	126	45	42	42	281
12 noon	45	45	49	120	167	120	49	45	314
2 p.m.	42	42	42	45	126	213	177	56	281
4 p.m.	35	32	32	32	52	208	268	173	127
6 p.m.	57	17	17	17	17	105	211	192	64
8 p.m.	0	0	0	0	0	0	0	0	0

- **Reduced External Pressure.** Reduced external pressure shall be 24.5 kPa, absolute (3.5 psia).

- **Increased External Pressure.** Increased external pressure shall be 140 kPa, absolute (**20** psia).

- **Vibration.** Vibration shall be normally incident to transport. The ILAW package shall be evaluated per ANSI Standard N 14.23, ***Draft American National Standard Design Basis for Resistance to Shock and Vibration of Radioactive Material Packages Greater than One Ton in Truck Transport*** (ANSI 1992a), to demonstrate containment when exposed to normal vibration due to the transfer from the vitrification facility to the grout vaults by the selected transport vehicle. Tiedowns and hold-down bolts shall also be evaluated for this scenario.

- **Water Spray.** The ILAW package shall be evaluated to demonstrate containment through a water spray that simulates exposure to rainfall of approximately 5 cm (2 in.) per hour for at least 1 hour.
- **Penetration.** The test requires the impact of the hemispherical end of a vertical steel test cylinder of 3.2 cm (1.25-in.) diameter and 6 kg (13-lb) mass, dropped from a height of I m (40 in.) onto the exposed surface of the ILAW package that is expected to be most vulnerable to puncture. The long axis of the test cylinder must be perpendicular to the ILAW package surface.

- **Free Drop.** The ILAW package shall be evaluated to demonstrate containment subsequent to a 0.3 m (1-ft) free drop onto a 20 cm (8-in.-) thick concrete surface with a concrete strength of 4,000 psi, grade 60, no. 7 rebar spaced 30 cm (12 in.) apart with a 5 cm (2-in.) cover. The properties of the soil under the concrete shall be in accordance with ***On the Effects of Soil Constitutive Parameters on Impact-Induced Cask Accelerations*** (Marlow 1997). The package shall impact in an orientation expected to cause maximum damage.

5.1.1.1 Containment. The ILAW package shall be designed, constructed, and prepared for shipment so that when subjected to normal transfer conditions, the containment boundary, which is the ILAW canister, shall meet the requirements of 10 CFR 71.51, "Additional requirements for Type B packages," specifically, no loss or dispersal of radioactive contents as demonstrated to a sensitivity of 10^{-6} A_2s/h. For conditions normally incident to transfer, the ILAW package shall be evaluated by analysis to meet the containment criteria listed above.

5.1.1.2 Shielding. The general surface dose on the accessible surface of the ILAW package shall not exceed the dose rate limits specified in Section 4.2.10.

5.1.1.3 Criticality. The ILAW package contents are fissile excepted per 49 CFR 173.453(d) A criticality evaluation of the ILAW transport system is not required.

5.1.2 Accident Conditions

The conditions that follow are based on proposed ***Hanford Sitewide Transportation Safety Document,*** DOE/RL-2001-0036 . The PSSD will analyze the ILAW canister design to ensure that the following standards are met.

For purposes of onsite package evaluation, these events are assumed to occur sequentially. For design evaluation, these accidents shall be evaluated at an ambient temperature between -33 °C (-27 °F) and 46 °C (115 °F), whichever is more severe for the individual incident. Additionally, the ILAW canister will be evaluated carrying the worst-case payload as described in Section 2.0. The ILAW canister will meet the following accident conditions without exceeding the leakage rate requirements specified in Section 5.1.2.1.

- **Free Drop.** The evaluation for the loaded ILAW canister will be a free drop of, at least 9 m (30 ft) onto a 20 cm (8-in.-) thick concrete surface with a compression strength of 4,000 psi, Grade 60, No. 7 rebar spaced 12 in. apart with a 5 cm (2-in.) cover, each way, each face, and soil properties in accordance with Marlow (1997).

- **Puncture.** The worst-case credible puncture incident is equivalent to a free drop of the loaded ILAW canister through a distance of 1 m (40 in.) in a position expected to cause the maximum damage onto the upper end of a solid, vertical, cylindrical, mild-steel bar. The bar must be 15 cm (6 in.) in diameter with the top horizontal and its edge rounded to a radius of not more than 6 mm (0.25 in.) and of a length to cause maximum damage to the ILAW package, but not less than 20 cm (8 in.) long. The puncture bar is mounted on a 20 cm (8-in.-) thick concrete horizontal surface with a compression strength of 4,000 psi. This concrete contains Grade 60, No. 7 rebar spaced 30 cm (12 in.) apart with a 5 cm (2-in.) cover each way, each face, and soil properties in accordance with Marlow (1997).

- **Thermal.** The fire that the loaded ILAW canister is exposed to is a 30-minute, 800°C (1475 °F), engulfing fire that has an emissivity coefficient of 0.9. The surface absorptivity of the package shall be the greater of the anticipated absorptivity or 0.8.

Active cooling **of** the package following the 30-minute fire can be assumed. If assumed, the active cooling shall consist of quenching the outer package surfaces using water spray from a fire hose rated at 473 Umin (125 gal/min). Flow at this maximum flow rate shall be assumed to occur for a maximum of 45 minutes. If needed, additional quenching water flow can be assumed for an additional period of 100 minutes at a maximum flow rate of 189 Umin (50 gal/min). Assume a water temperature of 29 °C (85 °F) for the analysis.

5.1.2.1 Containment. During and subsequent to all accident events described in Section 5.1.2, the ILAW canister shall provide the containment function. The containment function shall be demonstrated to be a release of no more than 10 A_2s of ^{85}Kr in I week and no more than 1 A_2 in 1 week of radioactive material other than ^{85}Kr.

5.1.2.2 Shielding. Subsequent to all accident events described in Section 5.1.2, the dose 1 m (3.3 ft) from the surface of the ILAW canister shall not exceed 1 rem/h.

5.1.2.4 Criticality. The ILAW package contents are fissile excepted per 49 CFR 173.453(d). A criticality evaluation of the ILAW canister is not required.

5.2 ALARA

Exposure of personnel to radiological and other hazardous materials associated with the loading, closure, tiedown, transfer, and off-loading of the ILAW package shall be ALARA. Cost benefit analyses should be performed, as needed, to determine the best balance between exposure and economical design.

The contamination limits, as directed by 49 CFR 173.443 will be met prior to transport of the container.

5.3 QUALITY ASSURANCE

The quality assurance program requirements for such activities as design, procurement, fabrication, inspection, testing, component handling, and documentation of the ILAW packages and their components shall be equivalent to the applicable portions of RPP-MP-600, ***Quality Assurance Program Description,*** and RPP-QAPP-008, ***CHG Projects Quality Assurance Program Plan.***

5.4 PACKAGING AND SHIPPING

Packaging and shipping shall be in accordance with HNF-IP-0842, Vol. XVIII, Section 2.1.

5.5 DESIGN FORMAT

Development of the design drawings, design changes, and other design documentation, if required, shall be in accordance with HNF-IP-0842 series procedures.

5.6 MAINTENANCE

Maintenance, as required and specified in the PSSD, shall be performed on the ILAW transportation system to ensure packaging integrity is maintained. Ease and minimization of maintenance shall be considered in the design of the ILAW transportation system. Vendor-supplied spare parts and maintenance data, if applicable, shall be provided for equipment specified in the design. Special tools required to operate the packaging system and/or replace/repair components shall also be provided as part of the project.

5.7 PSSD

A PSSD will be prepared based upon the above design criteria that will provide the safety analysis necessary to demonstrate that the packaging meets or exceeds all Hanford Site packaging safety acceptance criteria. Operational (loading and off-loading), maintenance, acceptance, and quality assurance criteria will be included in the PSSD, ensuring that operation, maintenance, and transport of the ILAW transport system meets the requirements of this PDC.

6.0 REFERENCES

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," ***Code of Federal Regulations,*** as amended.

10 CFR 71, "Packaging and Transportation of Radioactive Material," ***Code of Federal Regulations,*** as amended.

29 CFR 1910, "Occupational Safety and Health Standards," ***Code of Federal Regulations,*** as amended.

49 CFR 173, "Shippers – General Requirements for Shipments and Packagings, "***Code of Federal Regulations,*** as amended.

49 CFR 393, "Parts and Accessories Necessary for Safe Operation," ***Code of Federal Regulations,*** as amended.

HNF-IP-0842, ***RPP Administration,*** CH2M HILL Hanford Group, Inc., Richland, Washington. Section **IX,** "Safety."

Section **XI,** "Quality Assurance."
Section XVIII, "Waste Management."

HNF-5183, *Tank Farm Radiological Control Manual,* CH2M Hill Hanford Group, Inc., Richland, Washington.

RPP-MP-600, *Quality Assurance Program Description,* CH2M HILL Hanford Group, Inc., Richland, Washington.

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