AUG 06 1996

ENGINEERING DATA TRANSMITTAL

1. EDT № 613323

2. To: (Receiving Organization) Packaging Engineering	3. From: (Originating Organization) Packaging Engineering	4. Related EDT No.: 613302
5. Proj./Prog./Dept./Div.: 84100	6. Cog. Engr.: ~~S. S. Shiraga~~ M E Burnside	7. Purchase Order No.: NA
8. Originator Remarks: For Approval.		9. Equip./Component No.: NA
		10. System/Bldg./Facility: NA
11. Receiver Remarks:		12. Major Assm. Dwg. No.: NA
		13. Permit/Permit Application No.: NA
		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	WHC-SD-TP-PDC-032	—	0	CASTOR GSF Packaging Design Criteria	SQ D	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. Approval 2. Release 3. Information	4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment	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	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.
1	1	Cog.Eng.: SS Shiraga	[signature]	3/11/96	G1-11	EF Koehling	[signature]	3/12/96	G3-06	1	1
1	1	Cog. Mgr.: JG Field	[signature]	3/11/96	G1-11	GL Swearingen	[signature]	3/12/96	H8-37	1	1
1	1	QA: CR Hoover	[signature]	3/11/96	G1-11	KS Webster	[signature]	3/12/96	R7-75	1	1
1	1	Safety: DW McNally	[signature]	3/11/96	G1-11	WJ Schlauder	per telecon W J Schlauder	3/25/96	S7-84	1	1
		Env.									
1	1	Nuclear Lead: JR Green	[signature]	3/11/96							
1	1	Engineering Lead: RJ Smith	[signature]	3/11/96	G1-11						

18.	19.	20.	21. DOE APPROVAL (if required)
M. E. Burnside [signature] 03-08-96 Signature of EDT Originator Date	Authorized Representative Date for Receiving Organization	J. G. Field [signature] 3/11/96 Cognizant Manager Date	Ctrl. No. [X] Approved [] Approved w/comments [] Disapproved w/comments [signature] 8/6/96

BD-7400-172-2 (04/94) GEF097

CASTOR GSF PACKAGING DESIGN CRITERIA

~~S. S. Shiraga~~ M. E. Burnside
Westinghouse Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

EDT/ECN: EDT 613323 UC: 512
Org Code: 84100 Charge Code: BE1221
B&R Code: YN0100000 Total Pages: ~~45~~ 43

Key Words: CASTOR GSF, Packaging Design Criteria, 324 Building, 300 Area, Pacific Northwest National Laboratories

Abstract: Encapsulated vitrified materials (Isotopic Heat Sources) are currently stored in the Pacific Northwest National Laboratories (PNNL) 324 Building located in the 300 Area. As part of the 324 Building transition program, the vitrified material, encapsulated in stainless steel canisters, must be removed. These canisters were originally intended to be used by the German government, but are no longer desired. As part of an agreement with the German government, the Germans are providing the U.S. Department of Energy (DOE) with six (6) CASTOR GSF and four (4) GNS-12 casks. The canisters will be transported onsite in CASTOR GSF and GNS-12 casks for interim storage until final disposition of the material is determined.

AUG 06 1996
DATE: HANFORD RELEASE
STA: 34

Release Approval 8/6/96 Date

Release Stamp

Approved for Public Release

CONTENTS

CONTENTS (cont)

LIST OF FIGURES

LIST OF TABLES

LIST OF TERMS

ALARA	As Low As Reasonably Achievable
Bq	Bequerels
CFR	Code of Federal Regulations
Ci	Curies
CWC	Central Waste Complex
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
HRCQ	Highway Route Controlled Quantity
IAEA	International Atomic Energy Agency
mm	millimeters
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
PDC	Packaging Design Criteria
Pacific Northwest	Pacific Northwest National Laboratories
QA	Quality Assurance
R/h	Roentgen per hour
RL	U.S. Department of Energy, Richland Operations Office
RQ	Reportable Quantity
SAR	Safety Analysis Report
SARP	Safety Analysis Report for Packaging
Sv/h	Sieverts per hour
WHC	Westinghouse Hanford Company

CASTOR GSF PACKAGING DESIGN CRITERIA

1.0 INTRODUCTION

1.1 BACKGROUND

Encapsulated vitrified materials (Isotopic Heat Sources) are currently stored in the Pacific Northwest National Laboratories (Pacific Northwest) 324 Building located in the 300 Area. As part of the 324 Building transition program, the vitrified material, encapsulated in stainless steel canisters, must be removed. These canisters were originally intended to be used by the German government, but are no longer desired. As part of an agreement with the German government, the Germans are providing the U.S. Department of Energy (DOE) with six (6) CASTOR GSF and four (4) GNS-12 casks. The canisters will be transported onsite in CASTOR GSF and GNS-12 casks for interim storage until final disposition of the material is determined. This Packaging Design Criteria (PDC) covers the CASTOR GSF; the GNS-12 is addressed in a separate PDC. The CASTOR GSF cask was designed and fabricated by Gesellschaft für Nuklear-Service mbH, Essen, Germany to be a certified Type B(U) Packaging, which complies with the requirements of the International Atomic Energy Agency (IAEA) for transport of up to five (5) sealed canisters of vitrified radioactive materials. However, this cask was never actually certified for use.

1.2 PURPOSE AND SCOPE

The purpose of this PDC is to provide criteria for the onsite Safety Analysis Report for Packaging (SARP). The SARP will provide the evaluation to support packaging requirements for the safe and economic transport and storage of the 324 Building vitrified encapsulated material in the CASTOR GSF cask. In this application, the approved PDC provides a formal set of standards for the payload requirements, and guidance for the evaluation and tiedown design.

The SARP will be approved by Pacific Northwest, ICF Kaiser, and the Westinghouse Hanford Company (WHC), including Quality Assurance (QA) and Safety, to authorize onsite interarea transfer. Due to the large quantities of radioactive materials (>3000 A_2's), the shipment will be classified as Highway Route Controlled Quantity (HRCQ). Therefore, the SARP will also require the approval of the U.S. Department of Energy, Richland Operations Office (RL).

The SARP will evaluate how the vitrified encapsulated material will perform during normal transport conditions and after credible accident events. The packaging system and administrative controls set forth in the SARP will ensure the system meets the onsite transportation requirements of WHC-CM-2-14, *Hazardous Material Packaging and Shipping*.

1.3 JUSTIFICATION

Presently, there are thirty-four (34) steel canisters being stored in the 324 Building. This material must be removed to allow for the 324 Building to be decommissioned. The cask that will be used for onsite shipment and storage must:

1. Provide adequate shielding for operational personnel.
2. Maintain containment of the encapsulated vitrified material in its original configuration during normal and accident transport conditions.
3. Effectively dissipate thermal heat loads.
4. Maintain the material in a nonreactive environment during storage.
5. Be compatible with the 324 Building facility and operation requirements.
6. Provide ease of operation for loading, unloading, transporting, maintaining, and storing.

All of these requirements are met by the CASTOR GSF cask, which was specifically developed for this payload.

2.0 PACKAGE CONTENTS

2.1 PAYLOAD DESCRIPTION

The payload (Figure 1) for the CASTOR GSF packaging system will consist of borosilicate glass encapsulated in steel canisters (PNL-6790/UC-510). The borosilicate glass matrix constituents were immobilized to yield a product with a predetermined thermal decay heat and surface radiological dose rate. The canisters' radiochemical characteristics for thermal heat load, range between 1330 and 2285 W each. Radiological gamma exposure rates, on contact, are between 112,000 R/h (1,120 Sv/h) to 310,000 R/h (3,100 Sv/h). For purposes of this PDC, 100 R/h is conservatively assumed to equal 1 Sv/h. Each canister weighs approximately 250 kg (550 lb), with a density of 2.8 kg/0.1 m^3.

2.2 RADIOACTIVE MATERIALS

The vitrified encapsulated material to be transported contains significant amounts of ^{137}Cs and ^{90}Sr. Three specific production series (RLFCM-7, RLFCM-8, and RLFCM-9) were performed by Pacific Northwest during heat source (canister) development. Figure 2 shows the canister filling process. Figure 3 provides graphs depicting the specific oxide in glass weight percent of all three canister production series.

Figure 1. Heat Source (Canister) Payload Configuration.

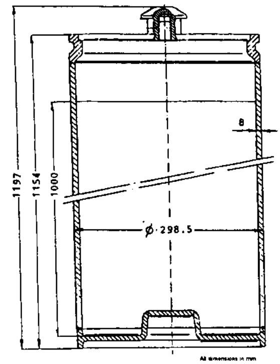
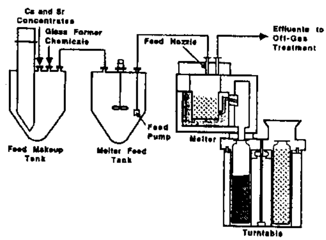


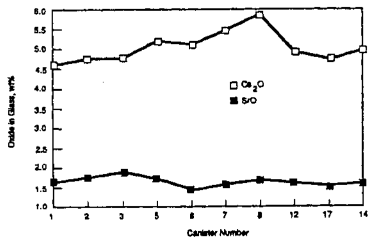
Figure 2. Canister Filling Process.



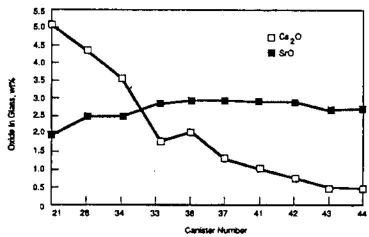
2.2.1 Source Term

The worst case cask canister inventory and source term composition were taken from the Safety Analysis Report (SAR) for the CASTOR GSF cask (GNS 1990). Section 6.2 contains source term information taken from the CASTOR GSF SAR. The CASTOR GSF cask will contain a maximum of five (5) canisters, and each canister is assumed to contain the worst case canister inventory identified in the CASTOR GSF SAR. Section 6.2 contains a spreadsheet which was used to convert the source term information from the CASTOR GSF SAR to activity values in curies (Ci). Note that the specific activities used in the spreadsheet were taken from the newly revised values

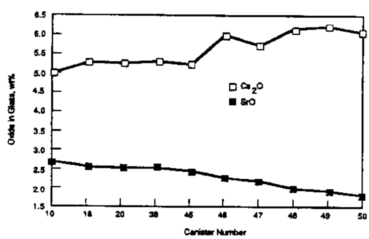
Figure 3. Canister Campaign Graphs.



RLFCM-7 Cesium and Strontium Concentrations



RLFCM-8 Cesium and Strontium Concentrations



RLFCM-9 Cesium and Strontium Concentrations published in Federal Register 50319 (FR 50319). These values will take effect in April 1996. Since the shipments will be made after this date, it was decided to use the newer values at this time.

The activities from the spreadsheet contained in Section 6.2 were input into the ORIGEN2 computer code (Schmittroth 1993) and decayed for 20 years to identify decay products which would be present in the waste. The ORIGEN2 input file and pertinent output information are included in Section 6.2. Table 1 lists the worst case canister activities from the CASTOR GSF SAR and the activities of the daughter products identified by ORIGEN2. It also lists the maximum cask activities assuming a loading of five (5) canisters per cask. If a daughter product identified by ORIGEN2 was not in equilibrium with the parent nuclide after 20 years, it was conservatively assumed to be in equilibrium with the parent nuclide. Note that numerous other decay products are calculated by ORIGEN2. However, these were not included because their activity is insignificant, and their effect on the radiological analysis is negligible.

Table 1. CASTOR GSF Source Term.

Nuclide	Single Canister Activity, Ci	Maximum Cask Activity, Ci[a]	Nuclide	Single Canister Activity, Ci	Maximum Cask Activity, Ci[a]
^{90}Sr	2.1 E+05	1.1 E+06	^{234}Th	3.4 E-06	1.7 E-05
^{90}Y	2.1 E+05	1.1 E+06	^{234m}Pa	3.4 E-06	1.7 E-05
^{137}Cs	3.0 E+05	1.5 E+06	^{234}U	5.3 E-06	2.7 E-05
^{137m}Ba	2.8 E+05	1.4 E+06	^{235}U	1.9 E-07	9.5 E-07
^{208}Tl	1.2 E-04	6.0 E-04	^{236}U	4.4 E-07	2.2 E-06
^{212}Pb	3.3 E-04	1.7 E-03	^{237}U	5.5 E-05	2.8 E-04
^{212}Bi	3.3 E-04	1.7 E-03	^{238}U	3.4 E-06	1.7 E-05
^{212}Po	2.1 E-04	1.1 E-03	^{239}Np	2.0 E-01	1.0 E+00
^{216}Po	3.3 E-04	1.7 E-03	^{238}Pu	1.7 E-01	8.5 E-01
^{220}Rn	3.3 E-04	1.7 E-03	^{239}Pu	1.7 E-01	8.5 E-01
^{224}Ra	3.3 E-04	1.7 E-03	^{240}Pu	5.6 E-02	2.8 E-01
^{228}Ra	3.3 E-04	1.7 E-03	^{241}Pu	2.3 E+00	1.2 E+01
^{228}Ac	3.3 E-04	1.7 E-03	^{242}Pu	4.6 E-05	2.3 E-04
^{228}Th	3.3 E-04	1.7 E-03	^{241}Am	3.4 E-01	1.7 E+00
^{231}Th	1.9 E-07	9.5 E-07	^{243}Am	2.0 E-01	1.0 E+00
^{232}Th	3.3 E-04	1.7 E-03	TOTALS	1.0 E+06	5.1 E+06

a - Assumes a maximum of five canisters will be loaded in the CASTOR GSF cask.

2.3 CHEMICAL CONSTITUENT SOURCE TERM

Table 2 gives the nominal glass compositions for all three canister production campaigns.

Table 2. Nominal Glass Chemical Composition.

Oxide Compound	Average Glass Composition RLFCM-7, wt%	Average Glass Composition RLFCM-8, wt%	Average Glass Composition RLFCM-9, wt%	Oxide Compound	Average Glass Composition RLFCM-7, wt%	Average Glass Composition RLFCM-8, wt%	Average Glass Composition RLFCM-9, wt%
Al_2O_3	2.88	2.58	2.17	MoO_3	0.05	0.00	0.00
B_2O_3	13.68	14.65	14.84	Na_2O	16.50	13.22	11.58
BaO	1.05	1.13	1.02	Nd_2O_3	0.65	0.71	0.89
CaO	1.52	1.25	0.79	Ne	0.39	0.25	0.44
CeO_2	0.06	0.05	0.07	PbO	0.16	0.00	0.00
Cr_2O_3	0.58	0.38	0.45	RuO_2	0.02	0.00	0.00
Cs_2O	5.02	2.08	5.74	SiO_2	41.25	48.02	46.59
Fe_2O_3	11.18	10.10	9.93	SrO	1.65	2.67	2.34
La_2O_3	1.04	1.07	1.53	TiO_2	0.19	0.07	0.03
Li_2O	0.31	0.00	0.00	ZnO	0.08	0.01	0.00
MgO	0.78	0.54	0.44	ZrO_2	0.15	0.04	0.05
MnO_2	0.80	1.20	1.11	TOTALS	100.00	100.00	100.00

2.4 GAS GENERATION

Based upon the glass form of the radioactive material and the containment provided by the canisters, there will be no gas generation.

2.5 TRANSPORTATION CLASSIFICATION

For transportation purposes, the vitrified encapsulated material of this packaging is considered Type B, Reportable Quantities (RQ), HRCQ, Yellow III, Radioactive Material in accordance with WHC-CM-2-14.

2.6 FISSILE CLASSIFICATION

There is less than 15 g of fissile material; therefore, the payload shall be classified as fissile excepted for transportation.

2.7 CONTENT RESTRICTIONS

A single CASTOR GSF cask may contain up to a maximum of five steel GNF/GSF canisters. Each canister can contain a maximum activity of 297.0 kCi (1.1×10^{16} Bq) ^{137}Cs and 207.9 kCi (7.7×10^{15} Bq) $^{90}Sr/^{90}Y$, respectively. The maximum thermal wattage of each canister is 2285 W. The maximum weight of the payload without the basket (five canisters loaded) is 1250 kg (2750 lb).

3.0 FACILITY OPERATIONS

3.1 ORIGINATING SITE - 324 BUILDING

The vitrified material will be loaded in the CASTOR GSF cask in the 324 Hot Cells. The casks will be loaded onto the transport vehicle with an appropriate engineered tiedown system. Hanford "Master Safety Rules" and applicable Occupational Safety and Health Administration (OSHA) standards will be followed during all loading operations.

3.2 DESTINATION SITE

The current storage site of the loaded CASTOR GSF Cask is unknown. A storage site will be agreed apon and discussed in the SARP. In addition, overpack requirements for transport and storage will be discussed and evaluated in the SARP. The cask(s) will be unloaded from the transport vehicle and placed in the appropriate storage area. Hanford "Master Safety Rules" and applicable OSHA standards will be followed during all unloading operations.

4.0 PACKAGING/TRANSPORT SYSTEM DESIGN

4.1 GENERAL

The CASTOR GSF cask consists of a ductile cast iron and lead composite structure. The cask body and primary closure lid and seals form the primary containment system ensuring the integrity of the package. A secondary closure lid and seals form a secondary containment boundary. A basket is inserted in the cavity of the cask in order to secure the contents. The cask is handled with two lifting rings diametrically installed on the head of the cask body. In order to reduce the shock loading during transport accidents, impact limiters are mounted over the ends of the cask.

An evaluation of the rigging requirements and the tiedown system will be provided in the SARP.

4.2 PACKAGING DESIGN CRITERIA

4.2.1 Packaging Specification and Materials

4.2.1.1 CASTOR GSF Cask. The CASTOR GSF cask (Figure 4) structural design covers all safety related parts of the packaging in compliance with the requirements for transport. This includes analysis of all considered loads, stresses, and safety factors which are essential to meet the transportation standards for a Type B packaging under normal operations and hypothetical accident conditions. The CASTOR GSF cask structural design is based on a 9 m (30 ft) drop criteria.

The CASTOR GSF cask incorporates four basic components which maintain the structural integrity and safe confinement of its payload.

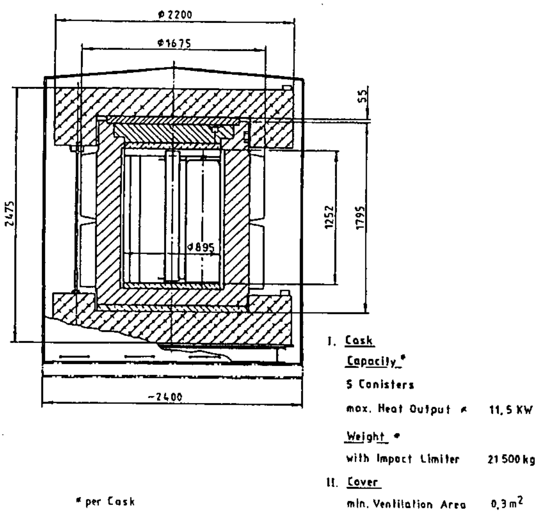
The four basic components are:

1. *Impact Limiter System.* The impact limiters consist of a closed sheet-steel construction filled with several plies of wood. The impact limiters protect the cask during hypothetical accident conditions.

2. *Cask Body and Primary Lid.* The main body of the cask is cast iron as a hollow cylinder of GGG 40. The disk-shaped cylindrical body of the primary lid is made of GGG 40. In the surface where the primary lid rests on the cask body, there are two grooves to accept seals. The inner grove is designed to accept a metal seal. The outer groove is designed to accept an elastomer (silicone) seal.

3. *Secondary Lid and Seal System.* The secondary lid is a disc-shaped cylindrical steel body. The bearing surface of the lid has two grooves to accept one inner metal seal and one outer elastomer seal.

Figure 4. CASTOR GSF Configuration.



4. *Basket*. The basket is a tubular structure with five positions in on a circle to keep the payload in position (canisters). Each position is formed by a continuous steel tube.

4.2.2 Packaging Dimensions

Table 3 provides the nominal dimensions of the CASTOR GSF cask.

4.2.3 Maximum Gross Weight

The maximum loaded weight of the CASTOR GSF cask with impact limiters is 22,930 kg (50,550 lb). The weight of five canisters is 1250 kg (2750 lb).

4.2.4 Tiedown Attachments

During shipment, the cask is attached onto a shipping pallet or the base plate of the shipping container (intermodal frame or container) by means of the bottom impact limiter. This attachment method used for securement of the CASTOR GSF cask, is evaluated for safe and compliant onsite transportation in the Structural Evaluation section (Part B) of the SARP.

Table 3. CASTOR GSF Cask Dimensions.

Description	Dimension	
	in.	cm
Outside diameter with impact limiters	86.6	220.0
Overall height with impact limiters	97.4	247.5
Outside diameter without impact limiters	65.9	167.5
Overall height without impact limiters	70.1	179.5
Inner cavity height	49.2	125.0
Inner cavity diameter	35.2	89.5
Lead Shielding thickness (ends)	2.2	5.5
Lead Shielding thickness (side)	1.1	2.8

The SARP will demonstrate the capacity of the CASTOR GSF cask to withstand, without generating stress in any material of the CASTOR GSF cask in excess of yield strength, a static force applied to the center of gravity of the CASTOR GSF cask. The static force must have a vertical component of two times the gross weight of the fully loaded CASTOR GSF cask, a horizontal component along the direction in which the vehicle travels of ten times the weight of the fully loaded cask, and a horizontal component in the transverse direction of five times the weight of the fully loaded cask.

The SARP will demonstrate that any structural part of the CASTOR GSF cask which could be used for securement must be capable of being rendered inoperable for securing the CASTOR GSF cask during transfer, or must have the strength equivalent required for the tiedown attachments to be used for such transfer applications.

The SARP will demonstrate that each tiedown attachment, which is a structural part of the CASTOR GSF cask, must be designed so that failure of the attachment under excessive load would not impair the ability of the CASTOR GSF cask to meet other requirements of this PDC.

4.2.5 Lifting Attachments

The cask lifting points consist of two lifting rings, which are press-fitted into the upper unfinned side surface. The cask is then handled with a special lifting device that engages in the holes of the lifting rings. The design and safety analysis of the cask lifting rings are evaluated based on current onsite lifting requirements. This evaluation is accomplished in the Structural Evaluation section (Part B) of the SARP.

The SARP will demonstrate the capability of lifting attachments for the packaging for 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.

4.2.6 Venting

As presently designed, the cask does not vent to the surrounding atmosphere once the primary lid is installed and secured.

4.2.7 Closure Design and Containment

Positive closure of the CASTOR GSF cask is achieved through bolting the primary lid to the cask body with 24 cap screws, size M 36. The secondary lid is fastened with 24 cap screws. Both lids have one metallic and one elastomeric seal which are leak testable.

4.2.8 Shielding

The shielding capability of the Castor GSF cask consists of a cylindrical cast-iron cask (GGG 40, 220 mm on the side, 205 mm on the bottom), with a lead liner (28 mm on the side, 55 mm on the bottom) inside. Further shielding is afforded by the canister material and the basket.

4.2.9 Service Life

For transportation, the assumed cask lifetime is forty years.

4.2.10 Chemical and Galvanic Reactions

The payload of the CASTOR GSF cask will be limited so reactions (e.g., chemical or galvanic reactions) among the components and the cask are minimized.

4.2.11 Heat Dissipation

In order to improve heat dissipation, longitudinal fins are arranged on the outside wall of the cask.

4.2.12 Surface Contamination

Before transfer, contamination on the external surfaces of the CASTOR GSF cask shall not exceed the limits given in Table 4.

Table 4. Decontamination Limits.

Contaminant	Maximum Permissible Limits	
	$\mu Ci/cm^2$	dpm/cm^2
Beta-gamma emitting radionuclides; all radionuclides with half-lives less than ten days; natural uranium; natural thorium; uranium-235; uranium-238; thorium-232; thorium-228 and thorium-230 when contained in ores or physical concentrates	10^{-5}	22
All other alpha emitting radionuclides	10^{-6}	2.2

Table from 49 CFR 173.443.

4.3 TRANSPORT SYSTEM

4.3.1 Transport Vehicle

The single CASTOR GSF cask shall be transported by tractor-trailer or railcar either as a closed or open transport vehicle. The SARP will document the requirements of the transport configurations and any modifications that must be performed to allow for the safe onsite interarea transfer of the cask.

4.3.2 Tiedowns

The CASTOR GSF cask securement/tiedown system, all modifications to this system (if required) shall be in accordance with the requirements of the following criteria. Tractor-trailer tiedowns shall meet Title 49, *Code of Federal Regulations* (CFR), Part 393 as paraphrased below. Note: Intermodal frames or containers may be used and must comply with applicable DOT/ISO Regulations.

4.3.2.1 Securement Systems.

4.3.2.1.1 Application and Scope of the Criteria in This Section. The criteria in Section 4.3.2.1 apply to tiedown assemblies, other securement devices, and attachment or fastening devices that are used with the assemblies and devices, which are used to secure cargo to motor vehicles in transit. All devices which are used to secure cargo to the transporter must conform to the criteria in this section.

4.3.2.1.2 Tiedown Assemblies. The aggregate working load limit of the tiedown assemblies used to secure an article against movement in any direction must be at least one-half times the weight of the article.

4.3.2.1.3 Load Binders and Hardware. The strength of the load binders and hardware that are part of, or used with, a tiedown assembly must be equal to or greater than the minimum strength specified for that tiedown assembly in Section 4.3.2.1.2.

4.3.2.1.4 Attachments to the Vehicle. The hook, bolt, weld, or other connector by which a tiedown assembly is attached to a vehicle, and the mounting place and means of mounting the connector, must be at least as strong as the tiedown assembly when that connector is loaded in any direction in which the tiedown assembly may load it.

4.3.2.1.5 Winches or Other Fastenings. The anchorages of a winch or other fastening device mounted on a vehicle and used with a tiedown assembly must have a combined tensile strength equal to, or greater than, the strength of the tiedown assembly.

4.3.2.2 Blocking and Bracing.

4.3.2.2.1 Protection Against Longitudinal Movement. The cargo must be secured so that, when the vehicle decelerates at a rate of 20 ft/s/s (6.0 m/s/s), the cargo will remain on the vehicle and will not penetrate the vehicle's front-end structure.

4.3.2.2.2 Protection Against Lateral Movement. The cargo must either be securely blocked or braced against the side, sideboards, or stakes of the vehicle or be secured by devices that conform to either of the following:

1. The vehicle must have at least one tiedown assembly that meets the requirements of Section 4.3.2.1.2 for each 10 linear feet (3 linear meters) of lading or fraction thereof.

2. The vehicle must have other means of preventing shifting or falling cargo which are similar to, and at least as effective as, the requirement specified in (1).

4.3.2.3 Additional Tiedown Requirements. Consideration shall be given to tiedown methods (such as remote operations or permanent systems integral to the packaging and transport vehicle) to maximize the distance and/or minimize the time spent near the payload.

5.0 GENERAL REQUIREMENTS

5.1 TRANSPORTATION EVALUATION REQUIREMENTS

The SARP shall evaluate all packaging requirements for the transport of Type B radioactive material as required by IAEA. This evaluation shall be based on the existing SAR (GNS 1990). Since many of the documents referenced in the SAR (GNS 1990) are German, and may not be readily available, additional analysis will be performed as necessary to form the basis for the safety evaluations. The use of ductile cast iron will be thoroughly evaluated to ensure safety requirements are met, including the insensitivity of ductile cast iron to brittle fracture.

5.1.1 Normal Transfer Conditions

The CASTOR GSF cask shall meet IAEA Safety Series No. 6 for normal conditions of transport and shall have the capacity to retain the contents, limit direct radiation and adequately disperse thermal heat from the payload, and maintain subcriticality during normal transfer conditions.

a. **Containment.** The CASTOR GSF cask shall prevent the loss or dispersal of the radioactive contents during normal transfer conditions. The payload canister is considered part of the containment system. Containment of the CASTOR GSF cask shall be maintained to $10^{-6}/A_2$ per hour during normal conditions of transport.

b. **Shielding.** Contents of the CASTOR GSF cask shall be transported as a full load. Therefore, the shielding of the CASTOR GSF shall limit the average accessible contact dose rate to 200 mrem/h (0.002 Sv/h). The dose rate at 6.6 ft (2 m) from the cask surface shall be limited to 10 mrem/h (0.0001 Sv/h). The dose rate at any normally occupied space in the transfer vehicle shall be limited to less than 2 mrem/h (0.00002 Sv/h). Transport of the casks shall fall under exclusive use.

c. **Criticality.** The amount of fissile material within the CASTOR GSF cask payload (radioactive nuclides - five canisters) is less than 15 g. Consequently, subcriticality is maintained for any arrangement of the cask which fall under fissile excepted quantity.

5.1.2 Accident Events

The SAR (GNS 1990), available supporting documents, and additional analyses shall be used to show that the CASTOR GSF Cask meets IAEA Safety Series No. 6 for hypothetical accident conditions. If necessary, a dose consequence and risk analysis will be performed to ensure the packaging system meets the onsite transportation safety requirements (Mercado 1994).

5.1.3 Thermal

The CASTOR GSF cask SARP shall ensure the maximum thermal payload currently described in the SAR (GNS 1990) does not compromise the integrity of the cask during normal conditions of transport. Additionally, thermal heat dissipation from the cask payload shall be limited so that the maximum exterior temperature of the cask will be less than 85 °C (185 °F) during the hottest Hanford Site day without considering solar insolation. If required, the SARP will also limit the climatic conditions under which the cask may be transported. Both open and closed transport methods will be considered. Based on current information, gas generation is not a concern.

In addition, the SARP will ensure that under hypothetical accident conditions, the integrity of the CASTOR GSF cask is maintained by demonstrating that the cask is able to withstand the thermal test specified by IAEA 1990, *Regulations for the Safe Transport of Radioactive Material 1985*, IAEA Safety Series 6.

5.2 AS LOW AS REASONABLY ACHIEVABLE

The design features of the CASTOR GSF cask shall be consistent with the requirements of the *ALARA Program Manual*, WHC-CM-4-11. Exposure of personnel to radiological and other hazardous materials associated with the loading, closure, tiedown, transfer, and off-loading of the package shall be minimized.

The Castor GSF cask shielding is designed such that the dose rate is no greater than a maximum of 200 mrem/h on contact with the package and 10 mrem/h or less at 2 m (6.6 ft) from the package. Additionally, dose rates in any normally occupied space of the transport vehicle will be below 2 mrem/h.

5.3 QUALITY ASSURANCE

QA program requirements for activities such as design, procurement, fabrication, inspection, testing, component handling, and documentation of the CASTOR GSF cask and their components are specified in the SAR (GNS 1990).

To establish a QA plan for the CASTOR GSF cask, a graded approach is used to define the safety class of both the system and individual components of the packaging system. The application of the safety class system is fully documented in *Management Requirements and Procedures* (MRP) 5.46, WHC-CM-1-3. QA instructions or plans shall be developed for the procurement, fabrication, and inspection of the package based on the assigned safety class of the package. The *QA Program Plan for the Hazardous Materials Transportation and Packaging Program*, WHC-IP-0705 (WHC 1995), and *Standard Engineering Practices* (EP) 1.4, WHC-CM-6-1, defines the WHC QA and safety class implementation, respectively, for radioactive material shipping packages.

5.3.1 System Safety Class

The transportation safety class of the CASTOR GSF cask was determined by a transportation safety class evaluation included in Section 6.3. This evaluation assumed the total failure of the packaging system and the release of all of its contents to the environment at the worst possible location on the transportation route. For the shipment of the 324 Building vitrified material, the worst case release location is within the 300 Area, 100 m (330 ft) from the release point.

The safety class evaluation guidelines contained in *Nonreactor Facility Safety Analysis Manual*, WHC-CM-4-46, Section 9.0, were followed. A worst case event is postulated which results in a dose to the maximum onsite and offsite receptor of 22 rem (2.2×10^{-1} Sv). The onsite and offsite doses are the same because although the roads maybe closed for shipment, the 300 Area is not a public exclusion area. The onsite and offsite receptor locations are therefore both assumed to be 100 m from the release point. Since the maximum offsite dose is greater than 0.5 rem, the required Safety Class for the CASTOR GSF cask is Safety Class 1.

5.4 DESIGN FORMAT

Development of the design drawings, design changes, and other design documentation, if required, shall be in accordance with WHC-CM-6-1, and the *Drafting Standards* manual, WHC-CM-6-3.

5.5 ENVIRONMENTAL COMPLIANCE

Actions and conditions for the protection of the environment during transfer of the CASTOR GSF cask shall comply with the requirements of the *Environmental Compliance* manual, WHC-CM-7-5.

5.6 MAINTENANCE

The maintenance schedule for the cask shall be in accordance with As Low As Reasonably Achievable (ALARA) principles and the SAR (GNS 1990).

5.7 REUSE

The SARP will define guidelines on inspection and maintenance that will allow the cask to be reused in accordance with WHC-CM-2-14.

6.0 APPENDICES

6.1 REFERENCES

49 CFR 393, "Protection Against Shifting or Falling Cargo," *Code of Federal Regulations*, as amended.

GNS, 1990, *Safety Analysis Report CASTOR GSF*, GNS B 69/85, Rev. 10, Gesellschaft für Nuklear-Service mbH, Essen, Germany.

Holten, L. K., Jr., and J. E. Surma, 1989, *Processing Summary Report: Fabrication of Cesium and Strontium Heat and Radiation Sources*, PNL-6790/UC-510, Pacific Northwest Laboratories, Richland, Washington, February 1989.

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.

Mercado, J. E., 1994, *Report on Equivalent Safety for Transportation and Packaging of Radioactive Materials*, WHC-SD-TP-RPT-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Schmittroth, F. A., 1993, *Conversion of ORIGEN2 to Sun Workstations*, WHC-SD-NR-SWD-006, Rev. 0-A, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-1-3, *Management Requirements and Procedures*, Westinghouse Hanford Company, Richland, Washington.

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

WHC-CM-4-11, *ALARA Program Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-6-1, *Standard Engineering Practices*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-6-3, *Drafting Standards*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-7-5, *Environmental Compliance*, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993, *Hanford Solid Waste Acceptance Criteria*, WHC-EP-0063, Westinghouse Hanford Company, Richland, Washington.

WHC, 1995, *QA Program for the Hazardous Materials Transportation and Packaging Program*, WHC-IP-0705, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

6.2 SOURCE TERM INFORMATION FROM THE CASTOR GSF SAR

SAFETY ANALYSIS REPORT

CASTOR GSF

Report No.	GNS B 69/85
Date (first issue):	December 1985
Rev. 10	July 1990

Checked by author:	/initials/
Released by GNS:	/initials/

0 - 1

1.3 Cask Inventory

A maximum of five stainless steel canisters filled with vitrified nuclides are stored and shipped in the CASTOR GSF. The composition of the glass and the design of the canister is described in what follows. Data are taken from the GSF design principles [1-1] and represent the upper design limit. The worst-case canister inventory have been taken into account with the upper tolerance limits. Some of the canisters encountered have values markedly below these design limits, so that these loading variants are also covered.

The principal dimensions and weights of the GSF glass canisters can be found in Fig. 1-1 and Table 1-7.

A summary of the glass composition is presented in Table 1-8.

The inventories as well as the heat output for the upper design limit are given in Table 1-9.

The GSF glass canister is to be regarded as a tight containment with regard to activity release [1-1].

Table 1-7. Dimensions and weights, GSF glass canister.

<u>Height</u>	
- Without head	1154 mm
- With head	1197 mm
- Filling	1000 mm
<u>Outside diameters</u>	
- Empty at room temperature	$298.5\ ^{+3}_{-1}$ mm
- Filled (out of round)	306 ± 1 mm
<u>Inside diameters</u>	
- Empty at room temperature	282.5 mm
- Wall thickness	8 mm
<u>Weight</u>	
- Total weight	250 kg
- Weight of glass	168 kg
- Volume of glass	60 dm^3
- Density of glass	2.8 kg/dm^3

<u>Drawing No.:</u> GSF No. 84.52.01.00 a
Date: June 3, 1985

Table 1-8. Glass composition, GSF glass canister.

Material	Content, wt. %	Density, g/cm^3
B	4.623	0.1294
O	43.873	1.2284
Na	8.834	0.2474
Mg	0.778	0.0218
Al	1.260	0.0353
Si	20.874	0.5845
Cl	0.151	0.0042
Ca	0.879	0.0246
Ti	0.149	0.0042
Cr	0.149	0.0042
Mn	0.999	0.0280
Fe	6.596	0.1559
Ni	0.234	0.0066
Sr	1.611	0.0451
Zr	0.051	0.0014
Cs	5.414	0.1515
Ba	1.155	0.0324
La	1.015	0.0284
Nd	0.910	0.0255
Pb	0.046	0.0130

Table 1-9. Inventory, heat output, GSF glass canister.

<u>Max. activity of added nuclides</u>

- Cesium-137
  $1 \cdot 10^{16}$ Bq + 10% = $1.1 \cdot 10^{16}$ Bq

- Strontium-90/yttrium-90
  $7 \cdot 10^{15}$ Bq + 10% = $7.7 \cdot 10^{15}$ Bq

<u>Residual quantities of actinides (per canister)</u>

- Natural thorium dioxide ThO_2	< 2 wt. % (based on glass)
- Total plutonium	< 3 g
<u>Nuclide vector, plutonium:</u>	
Pu-238	0.34 wt. %
Pu-239	90.00 wt. %
Pu-240	8.17 wt. %
Pu-241	0.77 wt. %
Pu-242	0.39 wt. %
- Total uranium	< 10.0 g
<u>Nuclide vector, uranium:</u>	
U-234	0.00859 wt. %
U-235	0.87458 wt. %
U-236	0.06831 wt. %
U-238	99.03 wt. %
- Americium-241	< 0.1 g
- Americium-243/244	< 1.0 g

<u>Heat output</u>

2065 W/canister + 10% = 2285 W

<u>Dose rate at canister surface</u>

Gamma: $5 \cdot 10^5$ R/h + 10% = $5.5 \cdot 10^5$ R/h
Neutrons: None

SPREADSHEET FOR SOURCE TERM

Natural ThO2 Composition - < 2 wt % (Based on glass)

Nat Thor	232.0381	g/g-atom	1.1E-07 Ci/g
O2	32	g/g-atom	
ThO2	264	g/g-atom	

Wt glass	168000	g/canister
Th activ	3.25E-04	Ci

Pu Composition - < 3 g per canister

Nuclide	WGT %	SPEC ACT Ci/g*	Act, Ci
Pu238	0.34	17	1.73E-01
Pu239	90	0.062	1.67E-01
Pu240	8.17	0.23	5.64E-02
Pu241	0.77	100	2.31E+00
Pu242	0.39	0.0039	4.56E-05

U Composition - < 10 g per canister

Nuclide	WGT %	SPEC ACT Ci/g*	Act, Ci
U234	0.00859	0.0062	5.33E-06
U235	0.87458	2.2E-06	1.92E-07
U236	0.06831	6.5E-05	4.44E-07
U238	99.03	3.4E-07	3.37E-06

Am-241 Composition - < 0.1 g per canister
Am-243/244 Composition - < 1.0 g per canister

Nuclide	WGT g	SPEC ACT Ci/g*	Act, Ci
AM241	0.1	3.4	3.40E-01
AM243	1	0.2	2.00E-01

* Specific Activities from 49 CFR 173 - 60 FR 50283-50289

Max. Activity of Added Nuclides

Cs137	1E+16 Bq	+ 10% =	1.1E+16 Bq	2.97E+05 Ci
Sr/Y90	7E+15 Bq	+ 10% =	7.7E+15 Bq	2.08E+05 Ci

ORIGEN2 INPUT AND PERTINENT OUTPUT

```
                                                     CARD IMAGE
INPUT  WRITE   CARD
UNIT   UNIT    NUMBER
 5      50       1    -1
 5      50       2    -1
 5      50       3    -1
 5      50       4    TIT     GNS-12/GSF - SOURCE TERM - DECAYED 20 YEARS
 5      50       5    BAS     DECAY IN 4 YEAR INTERVALS
 5      50       6    LIP     0 0 0
 5      50       7    LIB     0 1 2 3 204 205 206 9 0 0 1 1
 5      50       8    PHO     101 102 103 10
 5      50       9    RDA     GNS-12/GSF -  SOURCE TERM
 5      50      10    INP     -1 1 -1 -1 1 1
 5      50      11    RDA     SHORT DECAY TO BUILD IN PROGENY FOR SHORT HALF LIFE PARENTS
 5      50      12    MOV     -1 1 0 1.00
 5      50      13    RDA
 5      50      14    DEC     4.00      1  2  5  2     DECAY FOR 4 YEARS
 5      50      15    DEC     8.00      2  3  5  0     DECAY FOR 4 MORE YEARS TO 8  YRS
 5      50      16    DEC     12.0      3  4  5  0     DECAY FOR 4 MORE YEARS TO 12 YRS
 5      50      17    DEC     16.0      4  5  5  0     DECAY FOR 4 MORE YEARS TO 16 YRS
 5      50      18    DEC     20.0      5  6  5  0     DECAY FOR 4 MORE YEARS TO 20 YRS
 5      50      19    RDA
 5      50      20    CUT     5  1.E-10  7  1.E-10  9  1.E-10  -1
 5      50      21    OPTL    4*8 8 8 8 8 16*8
 5      50      22    OPTF    4*8 8 8 7 8 16*8
 5      50      23    OPTA    4*8 8 8 7 8 16*8
 5      50      24    OUT     6 1 -1 0
 5      50      25    STP     4
 5      50      26    2   902320 2.964E+03 942380 1.011E-02 942390 2.687E+00 942400 2.476E-01
 5      50      27    2   942410 2.243E-02 942420 1.195E-02 922340 8.532E-04 922350 8.884E-02
 5      50      28    2   922360 6.864E-03 922380 1.003E+01 952410 9.908E-02 952430 1.003E+00
 5      50      29    3   551370 3.415E+03 380900 1.525E+03      0 0.000E+00      0 0.000E+00
 5      50      30    0
 5      50      31    END
```

* GNS-12/GSF - SOURCE TERM - DECAYED 20 YEARS

ACTINIDES+DAUGHTERS
POWER= 1.00000E+00 MW, BURNUP= 1.00000E+00 MWD, FLUX= 1.00E+00 N/CM**2-SEC
7 SUMMARY TABLE: RADIOACTIVITY, CURIES
DECAY IN 4 YEAR INTERVALS

	0.0S	4.0YR	8.0YR	12.0YR	16.0YR	20.0YR
TL208	0.000E+00	1.962E-05	4.796E-05	7.024E-05	8.582E-05	9.632E-05
PB212	0.000E+00	5.478E-05	1.335E-04	1.955E-04	2.389E-04	2.681E-04
BI212	0.000E+00	5.478E-05	1.335E-04	1.955E-04	2.389E-04	2.681E-04
PO212	0.000E+00	3.510E-05	8.551E-05	1.253E-04	1.530E-04	1.718E-04
PO216	0.000E+00	5.478E-05	1.335E-04	1.955E-04	2.389E-04	2.681E-04
RN220	0.000E+00	5.478E-05	1.335E-04	1.955E-04	2.389E-04	2.681E-04
RA224	0.000E+00	5.478E-05	1.335E-04	1.955E-04	2.389E-04	2.681E-04
RA228	0.000E+00	1.102E-04	1.831E-04	2.312E-04	2.631E-04	2.841E-04
AC228	0.000E+00	1.102E-04	1.831E-04	2.312E-04	2.631E-04	2.841E-04
TH228	0.000E+00	5.478E-05	1.334E-04	1.953E-04	2.386E-04	2.678E-04
TH230	0.000E+00	2.270E-10	5.225E-10	8.844E-10	1.311E-09	1.799E-09
TH231	0.000E+00	1.928E-07	1.934E-07	1.941E-07	1.947E-07	1.954E-07
TH232	3.252E-04	3.252E-04	3.252E-04	3.252E-04	3.252E-04	3.252E-04
TH234	0.000E+00	3.373E-06	3.373E-06	3.373E-06	3.373E-06	3.373E-06
PA233	0.000E+00	4.484E-07	9.098E-07	1.381E-06	1.861E-06	2.346E-06
PA234M	0.000E+00	3.373E-06	3.373E-06	3.373E-06	3.373E-06	3.373E-06
PA234	0.000E+00	4.385E-09	4.385E-09	4.385E-09	4.385E-09	4.385E-09
U234	5.333E-06	7.266E-06	9.139E-06	1.095E-05	1.271E-05	1.441E-05
U235	1.921E-07	1.928E-07	1.934E-07	1.941E-07	1.947E-07	1.954E-07
U236	4.443E-07	4.509E-07	4.576E-07	4.643E-07	4.710E-07	4.776E-07
U237	0.000E+00	4.678E-05	3.858E-05	3.183E-05	2.625E-05	2.165E-05
U238	3.373E-06	3.373E-06	3.373E-06	3.373E-06	3.373E-06	3.373E-06
NP237	0.000E+00	4.484E-07	9.098E-07	1.381E-06	1.861E-06	2.346E-06
NP239	0.000E+00	2.000E-01	1.999E-01	1.998E-01	1.997E-01	1.997E-01
PU238	1.731E-01	1.678E-01	1.625E-01	1.575E-01	1.526E-01	1.478E-01
PU239	1.671E-01	1.671E-01	1.671E-01	1.671E-01	1.671E-01	1.671E-01
PU240	5.644E-02	5.642E-02	5.639E-02	5.637E-02	5.635E-02	5.632E-02
PU241	2.312E+00	1.907E+00	1.573E+00	1.297E+00	1.070E+00	8.827E-01

PU242	4.565E-05	4.565E-05	4.564E-05	4.564E-05	4.564E-05	4.564E-05
AM241	3.402E-01	3.515E-01	3.603E-01	3.671E-01	3.723E-01	3.762E-01
AM243	2.000E-01	2.000E-01	1.999E-01	1.998E-01	1.997E-01	1.997E-01
SUMTOT	3.249E+00	3.050E+00	2.721E+00	2.447E+00	2.221E+00	2.032E+00
OTOTAL	3.249E+00	3.050E+00	2.721E+00	2.447E+00	2.221E+00	2.032E+00

6.3 SAFETY CLASS EVALUATION

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino [signature] Date 12/27/95
Checker [signature] Date 1/19/96

I. Objectives:

This engineering analysis documents a transportation safety class evaluation for the CASTOR GSF Cask which will be used to transport canisters containing activated vitrified glass material from the 324 Building in the 300 Area to the 200 West Area.

II. References:

60 FR 50319, 1995, "Hazardous Materials, Transportation Regulations; Compatibility With Regulations of the International Atomic Energy Agency (IAEA); Final Rule," 49 CFR Part 171, *Federal Register*, Vol. 60, No. 188, pp. 50319-50325.

DOE, 1994, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, DOE-HDBK-3010-94, U. S. Department of Energy, Washington, D. C.

Hey, B. E., 1995a, *GXQ 4.0 Program Users' Guide*, WHC-SD-GN-SWD-30002, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Hey, B. E., 1995b, *GXQ 4.0 Program Verification and Validation*, WHC-SD-GN-SWD-30003, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Napier, B. A., et al., December 1988, *GENII - The Hanford Environmental Radiation Dosimetry Software System*, Pacific Northwest Laboratory, Richland, Washington, PNL-6584 Vol. 1, UC-600.

NRC, 1982, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*, Regulatory Guide 1.145, U.S. Nuclear Regulatory Commission, Washington, D.C.

Schmittroth, 1993, *Conversion of ORIGEN2 to Sun Workstations*, WHC-SD-NR-SWD-006 Rev. 0-A, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*, Westinghouse Hanford Company, Richland, Washington.

III. Results and Conclusions:

The safety class evaluation guidelines contained in WHC-CM-4-46, Section 9, were followed. A worst case event is postulated which results in a dose to the maximum onsite and offsite receptor of 22 rem (2.2 x 10^{-1} Sv). The onsite

* GNS-12/GSF - SOURCE TERM - DECAYED 20 YEARS FISSION
+
PRODUCTS
POWER= 1.00000E+00 MW, BURNUP= 1.00000E+00 MWD, FLUX= 1.00E+00 N/CM**2-SEC
0 7 SUMMARY TABLE: RADIOACTIVITY, CURIES
DECAY IN 4 YEAR INTERVALS

	0.0S	4.0YR	8.0YR	12.0YR	16.0YR	20.0YR
SR 90	2.081E+05	1.892E+05	1.720E+05	1.564E+05	1.422E+05	1.293E+05
Y 90	0.000E+00	1.892E+05	1.721E+05	1.564E+05	1.422E+05	1.293E+05
CS137	2.972E+05	2.709E+05	2.470E+05	2.252E+05	2.053E+05	1.872E+05
BA137M	0.000E+00	2.563E+05	2.337E+05	2.131E+05	1.942E+05	1.771E+05
SUMTOT	5.053E+05	9.057E+05	8.248E+05	7.511E+05	6.840E+05	6.229E+05
0TOTAL	5.053E+05	9.057E+05	8.248E+05	7.511E+05	6.840E+05	6.229E+05

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino AVS Date 12/27/95
Checker [signature] Date 1/19/96

and offsite doses are the same because several 300 Area locations have roads which are accessible to the public. The onsite and offsite receptor locations are therefore both assumed to be 100 m from the release point. Since the maximum offsite dose is greater than 0.5 rem, the required transportation safety class for the CASTOR GSF cask is transportation safety class 1.

IV. Engineering Evaluation:

1.0 Introduction

The CASTOR GSF cask is designed to hold five activated glass canisters. A glass canister is a container with vitrified radioactive materials manufactured at Hanford. These casks will be transported from the 300 Area to the 200 West Area. An evaluation is necessary to determine the required transportation safety class for the cask.

2.0 Source Term

Table 1 lists the source term for the CASTOR GSF cask which was developed in Section 2 of the PDC.

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino AVS Date 12/27/95
Checker JK Green Date 1/19/96

Table 1 - CASTOR GSF Source Term		
Nuclide	Single Canister Activity, Ci	Maximum Cask Activity, Ci[a]
SR90	2.1E+05	1.1E+06
Y90	2.1E+05	1.1E+06
CS137	3.0E+05	1.5E+06
BA137m	2.8E+05	1.4E+06
TL208	1.2E-04	6.0E-04
PB212	3.3E-04	1.7E-03
BI212	3.3E-04	1.7E-03
PO212	2.1E-04	1.1E-03
PO216	3.3E-04	1.7E-03
RN220	3.3E-04	1.7E-03
RA224	3.3E-04	1.7E-03
RA228	3.3E-04	1.7E-03
AC228	3.3E-04	1.7E-03
TH228	3.3E-04	1.7E-03
TH231	1.9E-07	9.5E-07
TH232	3.3E-04	1.7E-03
TH234	3.4E-06	1.7E-05
PA234m	3.4E-06	1.7E-05
U234	5.3E-06	2.7E-05
U235	1.9E-07	9.5E-07
U236	4.4E-07	2.2E-06
U237	5.5E-05	2.8E-04
U238	3.4E-06	1.7E-05
NP239	2.0E-01	1.0E+00
PU238	1.7E-01	8.5E-01
PU239	1.7E-01	8.5E-01
PU240	5.6E-02	2.8E-01
PU241	2.3E+00	1.2E+01
PU242	4.6E-05	2.3E-04
AM241	3.4E-01	1.7E+00
AM243	2.0E-01	1.0E+00
TOTALS	1.0E+06	5.1E+06

[a] Assumes a maximum of 5 canisters will be loaded in the CASTOR GSF cask.

3

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino AVS Date 12/27/95
Checker [signature] Date 1/19/96

3.0 Analysis

The safety class evaluation guidelines contained in WHC-CM-4-46, Section 9, were followed. A worst case airborne release fraction was determined based on a review of the potential accident scenarios which the package may experience.

The ARF and RF were calculated using a formula contained in DOE (1994), *Free-Fall Spill and Impaction Stress for Nonmetallic or Composite Solids*. This formula is associated with "fragmentation of an aggregate solid that can undergo brittle fraction." It is assumed for this analysis that an event occurs where the package is breached by an external force causing the vitrified material to be released and impact the ground. This impact causes fragmentation of the material at risk and subsequent release to the environment. The formula given is as follows:

$$ARF \times RF = (A)(P)(g)(h)$$

where:

ARF x RF = (Airborne Release Fraction)(Respirable Fraction)
A = empirical correlation, 2×10^{-11} cm^3 per $g\text{-}cm^2/s^2$
P = specimen density, g/cm^3
g = gravitational acceleration, 980 cm/s^2 at sea level
h = fall height, cm.

A fall height of 1 m is assumed for this analysis. This is a typical height used for objects falling off of a truck. The density of the waste is 2.8 g/cc, which results in an ARF x RF of 5.5×10^{-6}. This ARF x RF is applied to the material at risk, which is conservatively assumed to be the entire cask inventory, to obtain the quantity of radioactive material that is made airborne for the postulated accident scenario. The accident release quantities are listed in Table 2.

A fire scenario was also considered, but based on information contained in DOE (1994), *Thermal Stress - Vitrified Waste (Section 4.3.1.1)*, "any release under industrial-type fire conditions appears to be negligible." Therefore, no airborne release fire scenario is included in this analysis.

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino AVS Date 12/27/95
Checker [signature] Date 1/19/96

Table 2 - Accident Release Quantities		
Nuclide	Maximum Cask Activity, Ci[a]	Accident Release Quantity, Ci[b]
SR90	1.1E+06	6.1E+00
Y90	1.1E+06	6.1E+00
CS137	1.5E+06	8.3E+00
BA137m	1.4E+06	7.7E+00
TL208	6.0E-04	3.3E-09
PB212	1.7E-03	9.4E-09
BI212	1.7E-03	9.4E-09
PO212	1.1E-03	6.1E-09
PO216	1.7E-03	9.4E-09
RN220	1.7E-03	9.4E-09
RA224	1.7E-03	9.4E-09
RA228	1.7E-03	9.4E-09
AC228	1.7E-03	9.4E-09
TH228	1.7E-03	9.4E-09
TH231	9.5E-07	5.2E-12
TH232	1.7E-03	9.4E-09
TH234	1.7E-05	9.4E-11
PA234m	1.7E-05	9.4E-11
U234	2.7E-05	1.5E-10
U235	9.5E-07	5.2E-12
U236	2.2E-06	1.2E-11
U237	2.8E-04	1.5E-09
U238	1.7E-05	9.4E-11
NP239	1.0E+00	5.5E-06
PU238	8.5E-01	4.7E-06
PU239	8.5E-01	4.7E-06
PU240	2.8E-01	1.5E-06
PU241	1.2E+01	6.6E-05
PU242	2.3E-04	1.3E-09
AM241	1.7E+00	9.4E-06
AM243	1.0E+00	5.5E-06
TOTALS	5.1E+06	2.8E+01

[a] Assumes a maximum of 5 canisters will be loaded in the CASTOR GSF cask.

[b] Calculated using the maximum cask activities from column 1 and applying the ARF x RF value of 5.5×10^{-6} to all radionuclides.

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino *AVS* Date 12/27/95
Checker *J R Green* Date *1/15/96*

Discussion of Atmospheric Relative Concentration Value (χ/Q')

After the radioactive material becomes airborne, it is transported downwind and inhaled by onsite workers or the public. The concentration of this material is reduced, or diluted, as it is being transported due to atmospheric mixing and turbulence. An atmospheric relative concentration value (χ/Q') is used to characterize the dilution of the airborne contaminants during atmospheric transport and dispersion. It is equal to the time-integrated normalized air concentration at the receptor. χ/Q' (s/m^3) represents the dilution of an airborne contaminant caused by atmospheric mixing and turbulence. χ/Q' is a function of the atmospheric conditions (i.e., wind speed, stability class) and the distance to the receptor.

Bounding χ/Q' values are generated consistent with the methods described in *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*, Regulatory Guide 1.145 (NRC 1982). Since atmospheric conditions fluctuate, a bounding atmospheric condition is determined to be that condition that causes a downwind concentration of airborne contaminants that is exceeded only a small fraction of time because of weather fluctuations. Regulatory Guide 1.145 defines this fraction of exceedance as 0.5% for each sector or 5% for the overall Hanford Site. The Hanford Site is broken up into 16 sectors that represent 16 compass directions (i.e., S, SSW, SW, ..., ESE, SE, SSE). χ/Q' values are generated for weather conditions that result in downwind concentrations exceeded only 0.5% of the time in the maximum sector or 5% of the time for the overall Site. These χ/Q' values are also referred to as 99.5% maximum sector and 95% overall Site χ/Q' values. The greater of these two values is called the bounding χ/Q' value and is used to assess the dose consequences for accident scenarios. The bounding χ/Q' value represents minimum dispersing conditions that result in maximum downwind concentrations (i.e., concentrations exceeded only a very small fraction of the time). This χ/Q' value will therefore result in very conservative estimates of accident consequences.

The χ/Q' values in this report were generated using the GXQ computer program, Version 4 (Hey 1995a, 1995b). The meteorological data used by GXQ are in the form of joint frequency tables. The joint frequency data are the most recent data available; they are nine-year averaged data (1983-1991) from the Hanford Site meteorology towers. As mentioned above, the χ/Q' values are generated using the methods described in Regulatory Guide 1.145 for a ground release with no credit taken for plume rise, plume meander, plume depletion, or any other models. This is conservative because all of these models reduce the airborne concentration at the downwind receptor locations.

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino Date 12/27/95
Checker Date 1/19/96

The CASTOR GSF packages will be transported from the 300 Area to the 200 Area. Therefore, χ/Q' values for the maximum onsite receptor (assumed to be located 100 m from the release point) were calculated using the joint frequency data for these two areas (i.e., 200, 300 Areas), and the highest value was selected. The highest χ/Q' value of 4.2×10^{-2} s/m^3 occurs for the 300 Area.

The worst case offsite receptor (i.e., highest χ/Q') will be located in the 300 Area due to the short distances between the potential transport routes and an offsite receptor. Several 300 Area locations have roads which are accessible to the public. It is conservatively assumed for this analysis that the offsite receptor is located 100 m from the release point in any compass direction. The maximum onsite and offsite receptor χ/Q' value will therefore be the same, and since the highest χ/Q' occurs for the 300 area, the maximum offsite χ/Q' value is 4.2×10^{-2} s/m^3. The titles of the joint frequency files used by GXQ are listed below.

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
300 AREA - 10 M - Pasquill A - G (1983 - 1991 Average)

Inhalation & Submersion Dose Calculations

The GENII computer code Version 1.485 (Napier 1988) was used to calculate the inhalation and submersion dose for the maximum onsite and offsite receptors using the χ/Q' value mentioned in the previous paragraph. The GENII input deck is listed in Attachment 1. The "Worst Case" solubility class library in GENII was selected since the form of the radioactive material is not known with a high degree of certainty. This solubility class is the most conservative library used in GENII. The GENII libraries used were as follows:

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
Worst-Case Solubilities, Yearly Dose Increments (23-Jul-93 PDR)

The Effective Dose Equivalent (EDE) for the inhalation and submersion pathways is 22 rem (2.2×10^{-1} Sv) for the maximum onsite and offsite receptors at 100 m. The inhalation dose contribution to the EDE is based on a 50 year dose commitment period. Table 3 summarizes the results. Note that $^{90}Sr/^{90}Y$ contribute 82% to the total dose, and ^{137}Cs contributes 17% to the total dose.

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino AVS Date 12/27/95
Checker J R Green Date 1/19/96

Table 3: Summary of Inhalation and Submersion Dose, rem		
	Maximum Onsite Receptor at 100 m	Maximum Offsite Receptor at 100 m
Whole Body EDE	22	22

Note: 100 rem = 1 Sv

4.0 Conclusion

The maximum offsite dose of 22 rem (2.2×10^{-1} Sv) is greater than 0.5 rem. Therefore, the required transportation safety class for the CASTOR GSF cask is transportation safety class 1.

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino AVS Date 12/27/95
Checker JRGauss Date 1/19/96

Attachment 1

GENII INPUT FILE

```
######################### Program GENII Input File ############ 8 Jul 88 ####
Title: Onsite at 100 m -  Inhalation/Submersion - CASTOR GSF - 300 Area
     \SAMPL\G-AIR.AC                             Created on 01-22-1990 at 07:30
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======================     F  Drinking water ingestion     7,8
T  Report AEDE only                      F  Aquatic foods ingestion      7,8
F  Report by radionuclide                F  Terrestrial foods ingestion  7,9
F  Report by exposure pathway            F  Animal product ingestion     7,10
F  Debug report on screen                F  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     |
     --------|------- ------- -------|------- ------- ------- ------- -------|
     SR90     6.1E+00
     Y 90     6.1E+00
     CS137    8.3E+00
     PB212    9.4E-09
     BI212    9.4E-09
     RA224    9.4E-09
     RA228    9.4E-09
     AC228    9.4E-09
     TH228    9.4E-09
     TH231    5.2E-12
     TH232    9.4E-09
     TH234    9.4E-11
     U 234    1.5E-10
     U 235    5.2E-12
     U 236    1.2E-11
     U 237    1.5E-09
     U 238    9.4E-11
     NP239    5.5E-06
     PU238    4.7E-06
     PU239    4.7E-06
     PU240    1.5E-06
     PU241    6.6E-05
```

9

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino [signature] Date 12/27/95
Checker [signature] Date 1/17/96

```
PU242    1.3E-09
AM241    9.4E-06
AM243    5.5E-06

--------|----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)
1    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)
4.2E-2     Chi/Q or PM value               |0       Stack radius (m)
9          MI sector index (1=S)           |0       Effluent temp. (C)
100.0      MI distance from release point (m)|0     Building x-section (m2)
T          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)
```

10

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino Date 12/27/95
Checker Date 1/19/96

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 2-surface water
0	Swimming (hr)		
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=====
0 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 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 ? T/F	FOOD TYPE	TRAN-SIT hr	PROD-UCTION kg/yr	-CONSUMPTION- HOLDUP da	RATE kg/yr	DRINKING WATER	
F	FISH	0.00	0.0E+00	0.00	0.0	0	Source (see above)
F	MOLLUS	0.00	0.0E+00	0.00	0.0	T	Treatment? T/F
F	CRUSTA	0.00	0.0E+00	0.00	0.0	0	Holdup/transit(da)
F	PLANTS	0.00	0.0E+00	0.00	0.0	0	Consumption (L/yr)

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

USE ? T/F	FOOD TYPE	GROW TIME da	--IRRIGATION-- S*	RATE in/yr	TIME mo/yr	YIELD kg/m2	PROD-UCTION kg/yr	--CONSUMPTION-- HOLDUP da	RATE kg/yr
F	LEAF V	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
F	ROOT V	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
F	FRUIT	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
F	GRAIN	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0

11

ENGINEERING ANALYSIS

Subject TRANSPORTATION SAFETY CLASS EVALUATION FOR CASTOR GSF CASK
Revision 0 Project Title CASTOR GSF CASK WO BE1221
Originator A. V. Savino AVS Date 12/27/95
Checker JR Green Date 1/19/96

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

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

##

12

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Packaging Engineering	Date 03/08/96
Project Title/Work Order		EDT No. 613323
CASTOR GSF Packaging Design Criteria (WHC-SD-TP-PDC-032)		ECN No. NA

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
J. G. Field	G1-11	X			
J. R. Green	G1-11	X			
C. R. Hoover	G1-11	X			
E. F. Koeling	G3-06	X			
W. J. Schlauder	S7-84	X			
R. J. Smith	G1-11	X			
G. L. Swearingen	K8-37	X			
D. W. McNally	G1-11	X			
K. S. Webster	P7-75	X			
WHC-SD-TP-PDC-032 File	G1-11	X			
Central Files	A3-88	X			