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Title/Desc:

PACKAGING DESIGN CRITERIA FOR THE MCO CASK

Pages: 62

ENGINEERING CHANGE NOTICE

Page 1 of 31. ECN NO 625363
Proj. ECN

2. ECN Category (mark one) Supplemental <input type="checkbox"/> Direct Revision <input type="checkbox"/> Change ECN <input type="checkbox"/> Temporary <input type="checkbox"/> Standby <input type="checkbox"/> Supercedure <input type="checkbox"/> Cancel/Void <input type="checkbox"/>	3. Originator's Name, Organization, MSIN, and Telephone No. W. S. Edwards/84100/G1-12/ 376-2522	3a. USQ Required? [] Yes <input checked="" type="checkbox"/> No	4. Date 03/28/96	
	5. Project Title/No./Work Order No. LFO37	6. Bldg./Sys./Fac. No. NA	7. Approval Designator SQ	
	8. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC-SD-TP-PDC-030, Rev. 1	9. Related ECN No(s). NA	10. Related PO No. NA	
	11a. Modification Work [] Yes (fill out Blk. 11b) [X] No (NA Blks. 11b, 11c, 11d)	11b. Work Package No. NA	11c. Modification Work Complete NA	11d. Restored to Original Condi- tion (Temp. or Standby ECN only) NA
			Cog. Engineer Signature & Date	Cog. Engineer Signature & Date

12. Description of Change

1. The neutron source term was updated to reflect a more current analytical model.
2. A table describing the energy distribution of the (alpha,n) neutron source was added.
3. The target for the normal condition of transport free drop was changed from an unyielding surface to a more typical Hanford Site surface.
4. Acceptable external cask contamination was changed from U.S. Department of Transportation (DOT) limits to HSRM-1, *Hanford Site Radiological Control Manual*, limits.
5. Fabrication criteria for the MCO was revised to remove the requirement for volumetric inspection of the MCO closure weld.

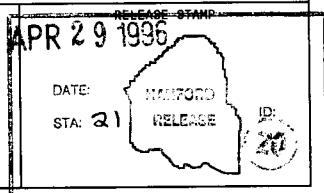
13a. Justification (mark one)	Criteria Change <input checked="" type="checkbox"/>	Design Improvement <input type="checkbox"/>	Environmental <input type="checkbox"/>	Facility Deactivation <input type="checkbox"/>
As-Found <input type="checkbox"/>	Facilitate Const <input type="checkbox"/>	Const. Error/Omission <input type="checkbox"/>	Design Error/Omission <input type="checkbox"/>	

13b. Justification Details

1. The source term for the MCO Cask was updated based on a change to the official neutron source term (WHC memo 8M730-LLC-95-011R1, dated November 16, 1995).
2. The table with energy distribution of the (alpha,n) neutrons came directly from the revision to the official neutron source term (WHC memo 8M730-LLC-95-011R1).
3. Changing the target surface for the normal condition of transport free drop makes that drop more realistic, and allows the SNF program to eliminate impact limiters from the MCO Cask, which will reduce personnel exposure.
4. Changing contamination limits to Hanford Site limits is conservative, since the Hanford Site limits are more restrictive than DOT limits.

See Continuation Sheet

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ENGINEERING CHANGE NOTICE

Page 2 of 3

1. ECN (use no. from pg. 1)

625363

15. Design Verification Required	16. Cost Impact				17. Schedule Impact (days)			
	ENGINEERING		CONSTRUCTION		Improvement	[NA]		
[X] Yes	Additional Savings	[NA]	\$	Additional Savings	[NA]	\$	Delay	[NA]

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]	N/A	[X]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
NA		

20. Approvals

Signature	Date	Signature	Date
<u>OPERATIONS AND ENGINEERING</u>			
Cog. Eng. W. S. Edwards	3/29/96	PE	
Cog. Mgr. J. G. Field	3/29/96	QA	
QA CR Hoover	4/1/96	Safety	
Safety D. W. McNally	4/4/96	Design	
Environ.		Environ.	
Other		Other	
W. D. Gallo WDG per telecom	4/16/96		
A. T. Kee ATK per telecom	4/8/96		
T. D. Merkling TDM per telecom	4/16/96		
W. J. Schlauder WJS per telecom	4/16/96		
J. R. Green J. R. Green	4/4/96	DEPARTMENT OF ENERGY	
S. S. Shiraga S. S. Shiraga	4/1/96	Signature or a Control Number that tracks the Approval Signature	
R. J. Smith R. J. Smith	4/1/96	D.W. Claussen D.W. C.	4/23/96
		ADDITIONAL	

ENGINEERING CHANGE NOTICE CONTINUATION SHEET

Page 3 of 3

ECN 625363

Date 03/28/96

No. 13b. Continued

5. Only requiring surface inspections of the MCO closure weld is acceptable since the design analyses will not take credit for the portions of the weld that cannot be examined.

Design Verification of this change was performed and the changes were found not to adversely impact the underlying safety bases and parameters of the package. Nuclear verification was performed by J. R. Green. Structural/mechanical verification was performed by S. S. Shiraga.

Packaging Design Criteria for the MCO Cask

W. S. Edwards

Westinghouse Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

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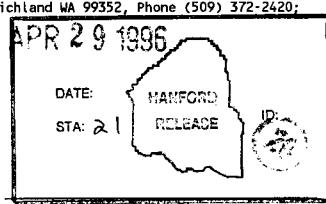
Key Words: Multiple Canister Overpack (MCO), Cask, Fuel Elements, K Basins, Canister Storage Building (CSB), Packaging, Package, Cask

Abstract: Approximately 2,100 metric tons of unprocessed, irradiated nuclear fuel elements are presently stored in the K Basins. To permit cleanup of the K Basins and fuel conditioning, the fuel will be transported from the K Basins to a Canister Storage Building in the 200 East Area. The purpose of this packaging design criteria is to provide criteria for the design, fabrication, and use of a packaging system to transport the large quantities of irradiated nuclear fuel elements positioned within Multiple Canister Overpacks.

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James J. Bishop 4-29-96
Release Approval Date



Approved for Public Release

RECORD OF REVISION

(1) Document Number

Page 1

(2) Title

Packaging Design Criteria for the MCO Cask

CHANGE CONTROL RECORD

CONTENTS

1.0	INTRODUCTION	1
1.1	BACKGROUND	1
1.2	PURPOSE	1
1.3	SYSTEM DESCRIPTION	1
1.4	JUSTIFICATION	2
2.0	PACKAGE CONTENTS	2
2.1	PHYSICAL FORM	2
2.1.1	MCOs	2
2.2	RADIOLOGICAL DESCRIPTION	2
2.2.1	N Reactor Fuel	4
2.3	CHEMICAL CONSTITUENT SOURCE TERM	7
2.4	GAS GENERATION	7
2.5	THERMAL DESCRIPTION	8
2.5.1	Thermal Source Term	8
2.5.2	MCO Surface Emittance	9
2.5.3	Payload and MCO Thermal Mass	9
2.5.4	MCO Dimensions and Gross Weight	9
2.5.5	Maximum MCO Temperature	9
2.6	TRANSPORTATION CLASSIFICATION	10
2.7	FISSILE CLASSIFICATION	10
2.8	CONTENT RESTRICTIONS	10
3.0	FACILITY OPERATIONS	11
3.1	ORIGINATING SITE--K BASINS	11
3.2	DESTINATION SITE--CSB	11
4.0	PACKAGING/TRANSPORT SYSTEM DESIGN	15
4.1	GENERAL	15
4.2	PACKAGING DESIGN CRITERIA	15
4.2.1	Packaging Materials	15
4.2.2	Fabrication Methods	16
4.2.3	Packaging Dimensions	16
4.2.4	Maximum Gross Weight	16
4.2.5	Lifting and Tiedown Attachments	17
4.2.6	Venting	17
4.2.7	Loading	17
4.2.8	Draining	17
4.2.9	Water Circulation	17
4.2.10	Closure	18
4.2.11	Containment	18
4.2.12	Shielding	18
4.2.13	Maintenance	18
4.2.14	Life Cycle	18
4.3	TRANSPORT SYSTEM	19
4.3.1	General	19
4.3.2	Truck Transport System	19
4.3.3	Additional Requirements	20
4.4	TIEDOWN SYSTEM	20

CONTENTS (cont)

5.0	GENERAL REQUIREMENTS	20
5.1	TRANSPORTATION SYSTEM	20
5.1.1	Normal Conditions of Transport	20
5.1.2	Accident Conditions	23
5.2	ALARA	25
5.3	QA	25
5.3.1	System Safety Class	25
5.4	DESIGN FORMAT	26
5.5	ENVIRONMENTAL COMPLIANCE	26
5.6	MAINTENANCE	26
5.7	SARP	26
6.0	REFERENCES	26

APPENDICES

A	SAFETY CLASSIFICATION FOR THE K BASIN CASK	A-1
B	ONSITE SARP TABLE OF CONTENTS	B-1

LIST OF FIGURES

1	MCO Preliminary Design Description	3
2	N Reactor Fuel Assembly	5
3	K Basin Layout	12
4	K Basin East and West Loadout Area	13
5	Canister Storage Building Loadout Area	14

LIST OF TABLES

1	Worst-Case Source Term for N Reactor Fuel	4
2	Photon Source: Mark IV Fuel, 16% ^{240}Pu , 13 Years Decay	6
3	Energy Distribution of Neutrons from (α, n) Source	7
4	Heat Source Term	8
5	Heat Source Term for Accident Conditions	9
6	Preliminary Dimensions and Weight of the MCO	10
7	External Cask Contamination Limits	11
8	Load Factors for Tiedown Systems	20
9	Hanford Air Temperature	21
10	Maximum Solar Radiation Received from the Sun (BTU/h-ft 2)	21

LIST OF TERMS

ALARA	as low as reasonably allowable
ANSI	American National Standards Institute
ARF	airborne release fraction
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CFR	<i>Code of Federal Regulations</i>
Ci	curie
CSB	Canister Storage Building
CVD	Cold Vacuum Drying
EDE	effective dose equivalent
g	gram
HRCQ	Highway Route Controlled Quantity
in.	inch
kg	kilogram
km	kilometer
kPa	kilopascal
L/min	liters per minute
lb	pound
m	meter
MCO	Multiple Canister Overpack
mR/h	milliroentgens per hour
mrem/h	millirems per hour
MTU	metric tons of uranium
oz	ounce
PDC	packaging design criteria
psi	pounds per square inch
QA	quality assurance
SARP	Safety Analysis Report for Packaging
SNF	spent nuclear fuel
SPR	Single Pass Reactor
μm	micrometer
W	watt

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PACKAGING DESIGN CRITERIA FOR THE MCO CASK**1.0 INTRODUCTION****1.1 BACKGROUND**

Approximately 2,100 metric tons of unprocessed, irradiated nuclear fuel elements are presently stored in the K Basins (including possibly 700 additional elements from PUREX, N Reactor, and 327 Laboratory). The basin water, particularly in the K East Basin, contains significant quantities of dissolved nuclear isotopes and radioactive fuel corrosion particles. To permit cleanup of the K Basins and fuel conditioning, the fuel will be transported from the 100 K Area to a Canister Storage Building (CSB) in the 200 East area. In order to initiate K Basin cleanup on schedule, the two-year fuel-shipping campaign must begin by December 1997.

1.2 PURPOSE

The purpose of this packaging design criteria (PDC) is to provide criteria for the design, fabrication, and use of a packaging system to transport large quantities of irradiated nuclear fuel elements positioned in Multiple Canister Overpacks (MCO), within the boundaries of the Hanford Site. The PDC will provide the basis for the system design and fabrication. It also sets the transportation safety criteria that the design will be evaluated against in the Safety Analysis Report for Packaging (SARP) (onsite). The approved PDC provides a formal set of standards early in the design and analytic process, and prevents costly delays later due to multiple and iterative interpretations of the requirements. The PDC will be approved by Westinghouse Hanford Company, including Quality Assurance, Safety, the Safety and Environmental Advisory Council, and the U.S. Department of Energy, Richland Operations Office.

1.3 SYSTEM DESCRIPTION

This packaging design criteria defines the requirements for the MCO cask and conveyance. The term "packaging" defines the cask without the MCO and fuel elements. The term "package" defines the cask, MCO, and the fuel elements. The MCO is the cask payload because it is loaded into and out of the cask and remains at the storage destination. The MCO provides a level of containment for the fuel elements. The MCO cask provides the transportation containment barrier for the payload, as defined in this PDC.

Fuel elements will be removed from their current canister storage containers in the K Basins, cleaned, and placed in baskets. The baskets will then be loaded into the MCO. The MCO may be top or bottom loaded into the cask. If the MCO is bottom loaded, there will be access to the top of the MCO for the cold vacuum drying process. Cold vacuum drying, which involves water

circulation and vacuum drying, is performed at the K Basins. After cold vacuum drying is complete, the MCO package is then transported to the CSB where further fuel conditioning and storage occur.

1.4 JUSTIFICATION

At present, no packagings licensed by either the U.S. Nuclear Regulatory Commission or the U.S. Department of Energy are capable of transporting the K Basins spent nuclear fuel (SNF) within the constraints of the project requirements. The project requires that the SNF be moved in MCOs. The only onsite packaging system that may be compatible is the three-well-railcar system, which is geometrically incompatible with the MCOs. A packaging and transportation system must be developed that can transport the irradiated fuel within current safety standards, protect the environment, and be economically and operationally feasible.

2.0 PACKAGE CONTENTS

2.1 PHYSICAL FORM

The payload will consist of an MCO that provides a level of containment for the irradiated fuel elements. MCOs are 61-cm (24-in. [outside diameter]) stainless steel pipe approximately 406 cm (160 in.) long, with the metallic uranium fuel elements in baskets stacked inside (Figure 1).

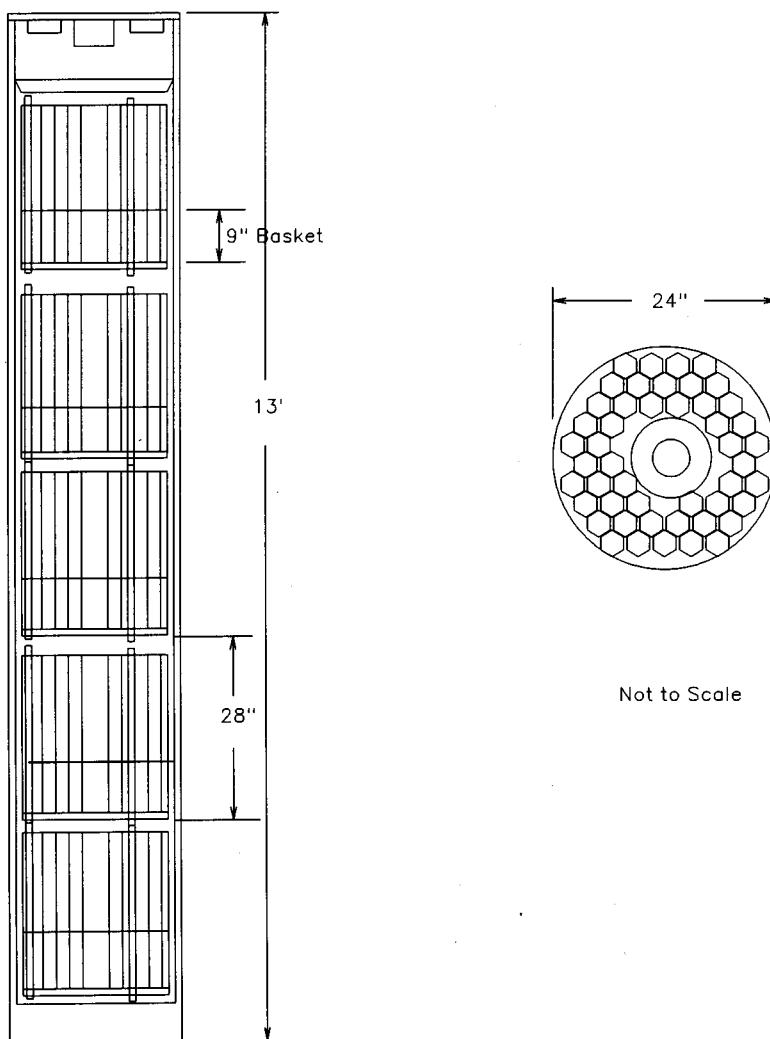
2.1.1 MCOs

The MCO will serve as a long-term storage vessel for the irradiated fuel elements, as well as the processing vessel during the conditioning process. For transport, the MCO is assumed to provide a level of containment. The MCO payload configuration is shown in Figure 1. The MCO will be drained and dried prior to shipment to the CSB.

2.2 RADIOLOGICAL DESCRIPTION

The irradiated fuel contains large quantities of fission products, such as ^{137}Cs and ^{90}Sr , and actinides, such as ^{239}Pu , ^{240}Pu , and ^{241}Pu . To a lesser extent, it also contains cladding activation products, such as ^{60}Co . A bounding worst-case radiological source term has been defined and is given in Table 1.

Figure 1. MCO Preliminary Design Description.



2.2.1 N Reactor Fuel

The bounding source term used for dose consequence is the rerack of 270 Mark IV fuel elements 66.3 cm (26.1 in.) long (E length [see Figure 2]). The worst anticipated N Reactor fuel, for shielding and dose consequence purposes, is 0.95% ^{235}U fuel irradiated to 16% ^{240}Pu 13 years after discharge from the reactor at the time of first fuel shipment (12/31/97). Table 1 presents the anticipated worst-case activity per unit mass, per assembly, and per MCO (reracked fuel).

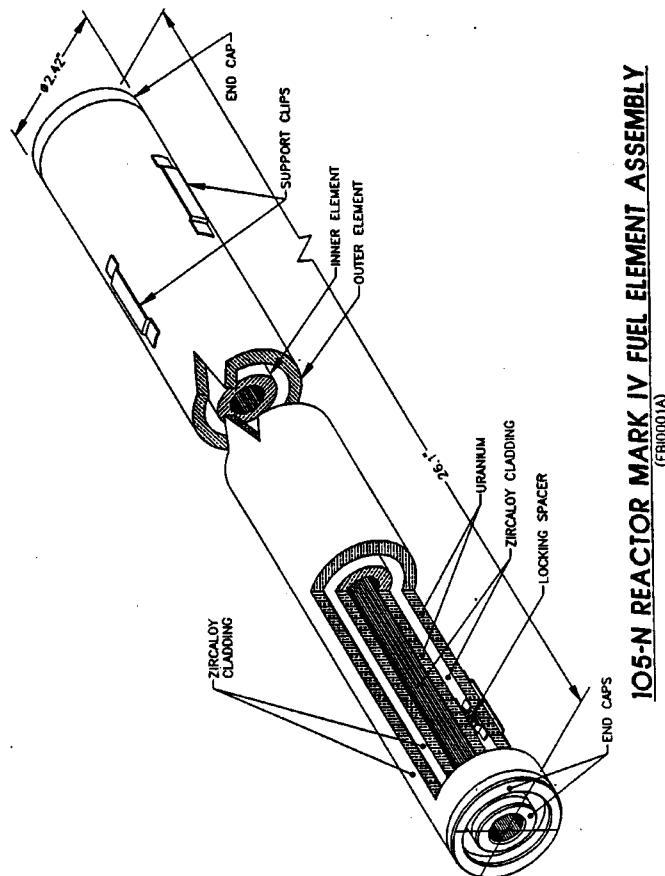
Table 1. Worst-Case Source Term for N Reactor Fuel.

Isotope	Curies per MTU	Curies per single assembly	Curies per MCO-270 assemblies	Isotope	Curies per MTU	Curies per single assembly	Curies per MCO-270 assemblies
^3H	38.8	0.91	246	^{144}Ce	2.5	0.06	16
^{55}Fe	6.8	0.16	43	^{144}Pr	2.5	0.06	16
^{60}Co	160.9	3.78	1020	^{147}Pm	2,423.2	56.9	15,363
^{85}Kr	611.5	14.36	3,877	^{151}Sm	102.7	2.41	651
^{90}Sr	7,893.2	185.34	50,043	^{154}Eu	192.3	4.51	1219
^{90}Y	7,893.2	185.34	50,043	^{155}Eu	33.4	0.79	212
^{106}Ru	11.5	0.27	73	^{238}Pu	147.3	3.46	934
^{106}Rh	11.5	0.27	73	^{239}Pu	152.1	3.57	964
^{125}Sb	99.1	2.33	628	^{240}Pu	115	2.70	729
^{125m}Te	24.1	0.57	153	^{241}Pu	9,139.9	214.62	57,947
^{134}Cs	115	2.70	729	^{241}Am	272.9	6.41	1730
^{137}Cs	10,734.9	252.07	68,059	^{244}Cm	39.9	0.94	253
^{137m}Ba	10,162.3	238.63	64,429				

MCO = Multiple Canister Overpack.

MTU = Metric tons of uranium.

Figure 2. N Reactor Fuel Assembly.



These isotopes have been used to calculate the gamma and neutron spectra generated in the fuel, as tabulated in Table 2.

Table 2. Photon Source: Mark IV Fuel, 16% ^{240}Pu , 13 Years Decay.

Energy (MeV)	Photons/sec/element	Photons/sec/MCO	Photons/sec/MTU
0.015	5.845E+12	1.578E+15	2.489E+14
0.025	12.399E+11	3.348E+14	5.280E+13
0.038	13.951E+11	3.767E+14	5.941E+13
0.058	11.75E+11	3.174E+14	5.006E+13
0.085	6.474E+11	1.748E+14	2.757E+13
0.125	4.799E+11	1.296E+14	2.044E+13
0.225	5.480E+11	1.480E+14	2.334E+13
0.375	2.586E+11	0.698E+14	1.101E+13
0.662	9.364E+12	2.568E+15	3.988E+14
0.850	20.309E+10	5.484E+13	8.649E+12
1.250	3.816E+11	1.030E+14	1.625E+13
1.750	3.578E+9	0.966E+12	1.524E+11
2.250	3.299E+7	0.872E+10	1.375E+09
2.750	21.798E+5	5.885E+8	9.283E+7
3.500	2.952E+5	0.797E+8	1.257E+7
5.000	6.338E+3	1.711E+6	2.699E+5
7.000	7.294E+2	1.969E+5	3.106E+4
11.000	8.371E+1	2.260E+4	3.565E+3
Total	21.540E+12	5.816E+15	9.173E+14

MCO = Multiple Canister Overpack.

MeV = Megaelectronvolt.

MTU = Metric tons of uranium.

The following is the neutron source for Mark IV fuel 16% ^{240}Pu at 13 years decay (Schwarz 1995).

- The spontaneous fission source is $8.732E+05$ neutrons/sec/MTU, and the (α, n) neutron source is $4.861E+05$ neutrons/sec/MTU.
- The neutron energy spectrum for the spontaneous fission source is assumed to be that for ^{244}Cm , a predominant nuclide contributing to spontaneous fission. That spectrum is given by the following:

$$f(E) = C \cdot \exp(-E/0.906) \cdot \sinh(\sqrt{3.848} \cdot E)$$

C is a normalization constant so that the integral is unity.

- The neutron energy spectrum for the (alpha,n) neutron source is given in Table 3.

Table 3. Energy Distribution of Neutrons from (alpha,n) Source.

Upper energy (MeV)	Cumulative probability	Probability of bin	Upper energy (MeV)	Cumulative probability	Probability of bin
0.00	0.00000	0.00000	2.30	0.59751	0.04128
0.10	0.01590	0.01059	2.40	0.63707	0.03956
0.20	0.02243	0.01184	2.50	0.67492	0.03785
0.30	0.03396	0.01153	2.60	0.71137	0.03645
0.40	0.04766	0.01371	2.70	0.74611	0.03474
0.50	0.06636	0.01869	2.80	0.77819	0.03209
0.60	0.08738	0.02103	2.90	0.80935	0.03115
0.70	0.11044	0.02305	3.00	0.83863	0.02928
0.80	0.13567	0.02523	3.10	0.86449	0.02586
0.90	0.15981	0.02414	3.20	0.88879	0.02430
1.00	0.17975	0.01994	3.30	0.90966	0.02087
1.10	0.20062	0.02087	3.40	0.92664	0.01698
1.20	0.22321	0.02259	3.50	0.94097	0.01433
1.30	0.24860	0.02539	3.60	0.95327	0.01231
1.40	0.27601	0.02741	3.70	0.96324	0.00997
1.50	0.30405	0.02804	3.80	0.97181	0.00857
1.60	0.33349	0.02944	3.90	0.97928	0.00748
1.70	0.36542	0.03193	4.00	0.98536	0.00607
1.80	0.40093	0.03551	4.10	0.99081	0.00545
1.90	0.43785	0.03692	4.20	0.99439	0.00358
2.00	0.47664	0.03879	4.30	0.99720	0.00280
2.10	0.51558	0.03894	4.40	0.99891	0.00171
2.20	0.55623	0.04065	4.50	1.0000	0.00109

2.3 CHEMICAL CONSTITUENT SOURCE TERM

The reracked fuel will be cold vacuum dried within the MCO prior to transport. There will be not greater than 2 kg of water remaining in the MCO following the cold vacuum drying operation.

2.4 GAS GENERATION

The packaging design shall incorporate features that will prevent the concentration of hydrogen gas in the cask annulus from exceeding 5% by volume

during a period of time twice the maximum expected shipping time (NRC 1984). If hydrogen concentration in the MCO is above the 5% limit, appropriate administrative and safety precautions will be provided to meet onsite equivalent safety requirements.

2.5 THERMAL DESCRIPTION

The heat source term will vary according to the type, condition, and amount of SNF to be transported. For the purposes of this PDC, the thermal source term for the payload (fuel elements) within the MCO is defined as a surface heat flux at the boundaries of the MCO. In addition, the surface emittance, thermal mass, temperature limits, etc., to be assumed for the MCO and payload assembly are defined.

2.5.1 Thermal Source Term

2.5.1.1 Thermal Source Term for Normal Transport Conditions. The range of anticipated heat flux at the inside surfaces of the MCO under normal transport conditions is defined in Table 4. The defined sidewall surface heat flux occurs over the lower 3.51 m (11.5 ft) of the MCO.

Table 4. Heat Source Term for Normal Transport Conditions.

Payload	Surface heat flux at MCO sidewalls	Surface heat flux at MCO top	Surface heat flux at MCO bottom	Total watts per MCO/cask
Maximum--dry	12.7 W/ft ²	5 W/ft ²	5 W/ft ²	950
Minimum	0.00	0.00	0.00	0.00

MCO = Multiple Canister Overpack.

2.5.1.2 Thermal Source Term for Accident Conditions. Due to possible chemical reaction of the SNF at elevated temperatures, the maximum surface heat flux will vary during the accident transport conditions from that defined for the normal transport conditions. This variation in surface heat flux at the inside boundaries of the MCO is defined in Table 5. The surface heat fluxes in Table 4 are to be used in establishing the steady-state conditions preceding the accident conditions.

The surface heat flux at the MCO top and bottom is the same as defined for the normal transport conditions. The variation in heat flux with location on the MCO circumference can be ignored during the accident transient.

Table 5. Heat Source Term for Accident Conditions.

Payload	Surface heat flux at center 28-in. section of MCO sidewall	Surface heat flux at remainder of MCO sidewall	Total watts per MCO
Maximum	30.0 W/ft ²	12.7 W/ft ²	1200
Minimum	0	0	0

MCO = Multiple Canister Overpack.

2.5.2 MCO Surface Emittance

For the purpose of calculating radiative heat transfer between the MCO and the packaging system, the surface emittance of the MCO surfaces shall be assumed to be 0.25.

2.5.3 Payload and MCO Thermal Mass

No credit for the thermal mass of the payload shall be taken when calculating the transient performance of the packaging system under either the normal conditions of transport or the accident conditions, as defined in Section 5.1. The thermal mass of the MCO shell may be included.

2.5.4 MCO Dimensions and Gross Weight

The dimensions of the MCO and its gross weight (including the fuel elements) to be assumed for the thermal calculations is defined in Table 6.

2.5.5 Maximum MCO Temperature

The maximum temperature allowed for the MCO shell under normal transport conditions shall be 75 °C (167 °F).

Under the accident conditions, the temperature of the MCO shell may exceed the temperature limit for the normal conditions of transport for a time period not to exceed 180 minutes following the fire and shall not exceed a maximum of 122 °C (252 °F).

Table 6. Preliminary Dimensions
and Weight of the MCO.

Payload configuration	Figure 1
MCO length	160 in.
MCO diameter	24 in.
MCO wall	0.5 in.
MCO volume	272 gal
MCO empty	1,954 lb
Basket weight	750 lb
MCO top 10-in. shield	1,226 lb
Zr cladding	980 lb
Fuel and cladding	15,050 lb/MCO
Total MCO weight	19,000 lb

MCO = Multiple Canister Overpack.

2.6 TRANSPORTATION CLASSIFICATION

For transportation purposes, the irradiated fuel payload of the packaging is considered Type B, Highway Route Controlled Quantity (HRCQ), fissile, spent fuel. The transport will be administratively controlled based on the potential dose consequences associated with the payload.

2.7 FISSILE CLASSIFICATION

The payload shall be classified as fissile material for transportation. The maximum fissile content per cask is 60,036 g for the worst-case Mark IV fuel rerack scenario. A criticality analysis will be performed to determine the fissile classification of the shipment and will be evaluated in the SARP.

2.8 CONTENT RESTRICTIONS

The MCO cask payload shall be limited to nuclear fuel elements cleaned and placed in baskets that have been loaded into an MCO.

3.0 FACILITY OPERATIONS

3.1 ORIGINATING SITE--K BASINS

The loading of the MCO and packaging shall take place either underwater or above the water in either of the loadout pits of the K East and K West Basins (Figure 3). This facility is limited in space and lifting capabilities. The MCO may be placed into the MCO cask prior to the loading of the reracked fuel baskets into the MCO. The fuel baskets shall be prepared, as necessary, for the conditioning process prior to being loaded into the MCO. Further conditioning of the fuel, such as vacuum drying, may take place with the MCO in the cask. The package shall be mounted on the transfer vehicle before leaving the basin. The exterior package contamination limits must be met, as shown in Table 7, prior to transportation. Prior to reuse of the cask, the cask internal cavity shall be decontaminated to less than 100 times the removable contamination limits set forth in Table 7. Figure 4 provides a sketch of the K East and K West loading areas, which are identical. Limited modifications of the loading area may be necessary to improve the fuel-loading and package-handling capabilities of the facility.

Table 7. External Cask Contamination Limits.

Contaminant	Maximum permissible limits	
	Removable, dpm/100 cm ²	Fixed + removable, dpm/100 cm ²
U-natural, U-235, U-238 and associate decay products	1,000 alpha	5,000 alpha
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-129	20	500
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-125, I-126, I-131, I-133	200	1,000
Beta-gamma emitters except Sr-90 and other noted above. Includes mixed fission products containing Sr-90.	1,000 beta-gamma	5,000 beta-gamma
Tritium organic compounds, surfaces contaminated by HT, HTO, and metal tritide aerosols	10,000	10,000

Source: HSRM-1, 1994, Hanford Site Radiological Control Manual. Table 2-2, Summary of Contamination Values.

3.2 DESTINATION SITE--CSB

Off-loading of the package shall take place at the CSB (Figure 5) in the 200 East Area. This activity shall involve the removal of the MCO from the package. The MCO will be staged at the CSB, possibly undergo further conditioning in a separate conditioning facility, and then be returned for storage in the CSB. The packaging shall also be decontaminated to Table 7 limits and inspected, as needed, before transport back to the K Basins.

Figure 3. K Basin Layout.

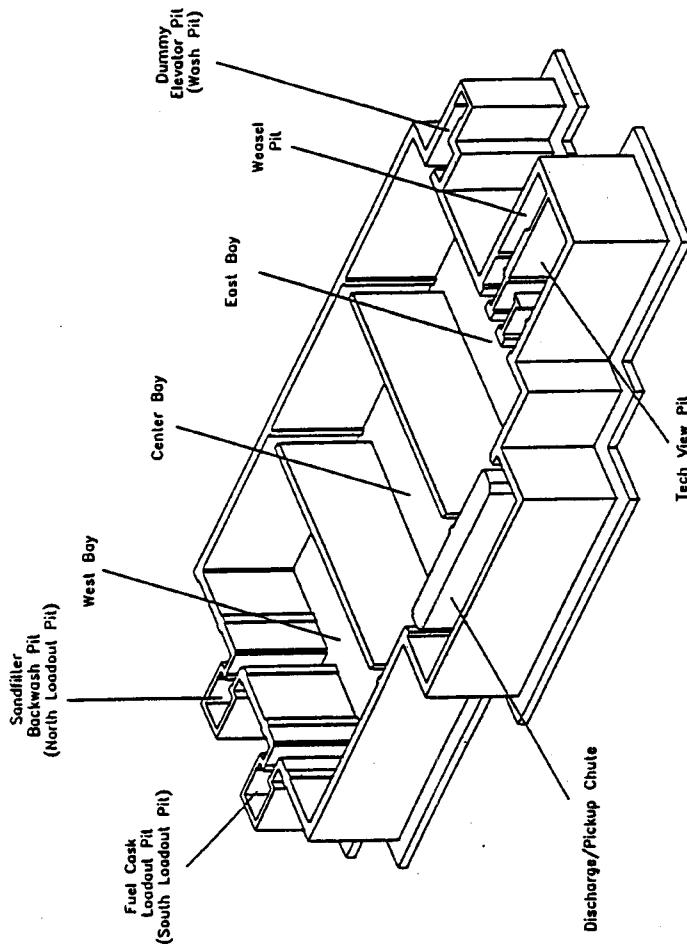


Figure 4. K Basin East and West Loadout Area.

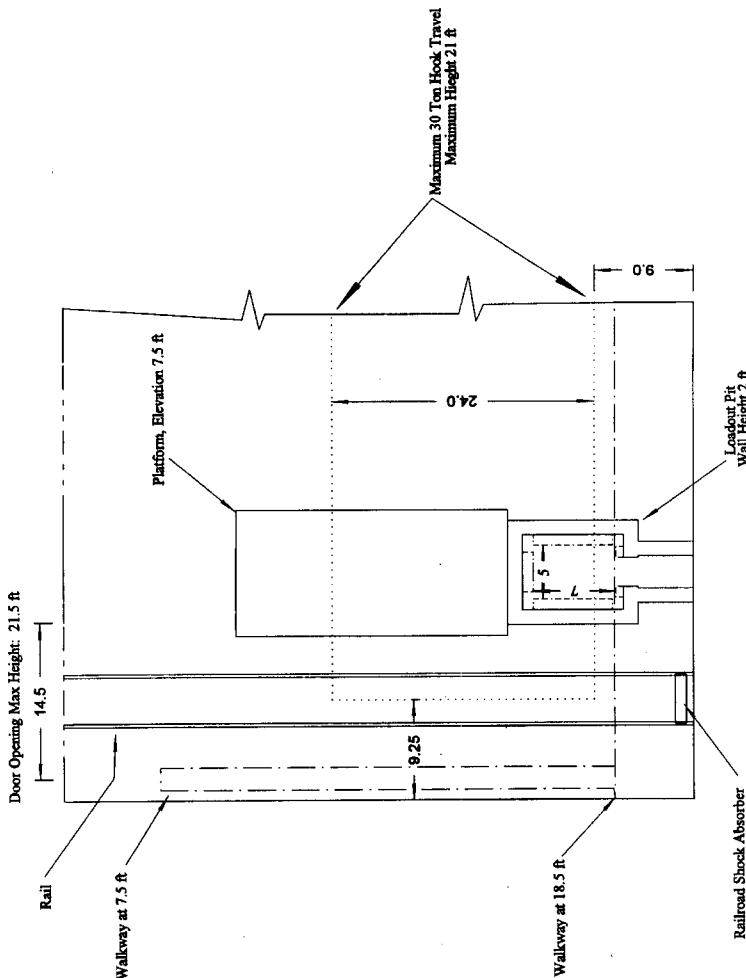
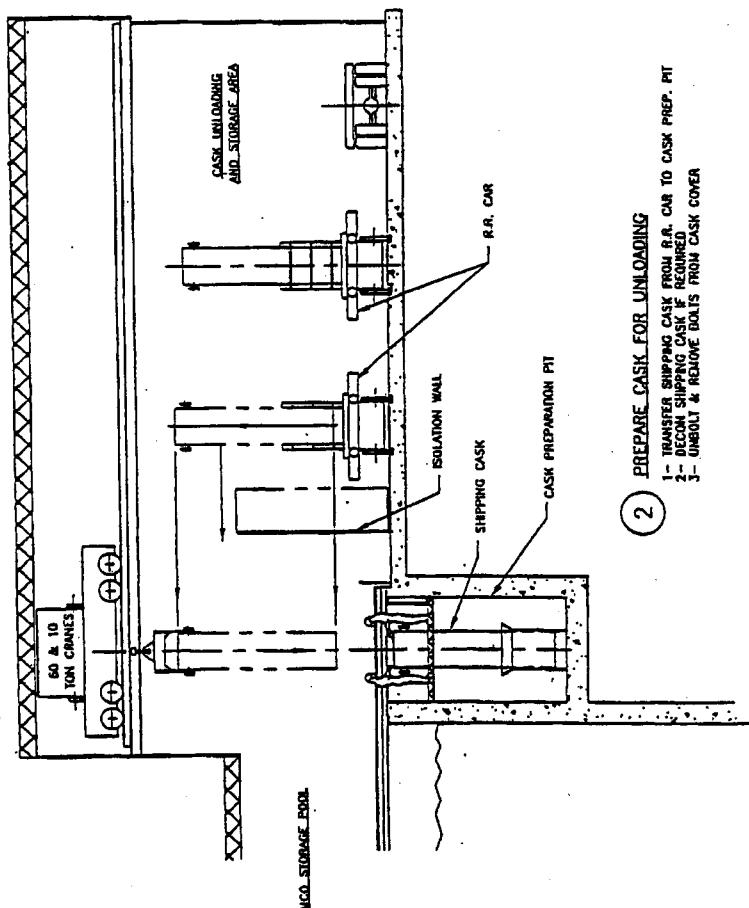


Figure 5. Canister Storage Building Loadout Area.



4.0 PACKAGING/TRANSPORT SYSTEM DESIGN

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, HRCQ of fissile radioactive material in the form of irradiated fuel assemblies. A SARP shall be written to demonstrate the safety of the transfer through a combination of cask performance and administrative controls as per the *Report on Equivalent Safety for Onsite Packaging and Transportation* (WHC 1994). The SARP will include the evaluation of the packaging system to provide containment, shielding, and subcriticality for the payload during normal (Section 5.1.1) and accident conditions (Section 5.1.2). The packaging and transportation shall be performed in accordance with WHC-CM-2-14, *Hazardous Material Shipping and Packaging Manual*. Approval of the SARP provides authorization for onsite transport.

4.2 PACKAGING DESIGN CRITERIA

The packaging shall be designed as a reusable system capable of being loaded and unloaded both in air and underwater. The MCO cask shall be capable of carrying at least one MCO. The design of the MCO cask shall be such that the MCO is capable of being loaded with irradiated fuel elements in baskets before or after the MCO is placed in the inner cavity of the cask. The MCO cask design shall be such that the MCO may be welded after being loaded into the packaging cavity. The cask may be top and/or bottom loaded. The cask design shall allow draining of water from the cask cavity prior to transport.

Package performance requirements during normal and accident transport conditions will be verified through analysis, or a combination of analytical and test methods, for a bounding case scenario. The results shall demonstrate that any material release falls within the dose consequence limits of Section 5.1.2.1.

4.2.1 Packaging Materials

The structural containment boundary materials for the packaging 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 requirements of Regulatory Guide 7.11 (NRC 1991a) or Regulatory Guide 7.12 (NRC 1991b), as applicable. There shall be an equivalent wall thickness (all wall materials) of at least 7.62-cm (3-in.) steel, based on puncture resistance thresholds.

All materials, including lead (if required for shielding purposes), shall be American Society of Mechanical Engineers (ASME) or American Society for Testing and Materials (ASTM)-certified materials or other recognized national or industrial standards for materials other than steel or stainless steel. The materials shall be compatible with or provide adequate resistance to the

corrosive effects of materials (liquids, vapors, gases, and solids) that they will be in contact with throughout their life cycle (20 years). The materials shall also be selected to minimize chemical-galvanic reactions between payload components and the packaging.

4.2.2 Fabrication Methods

Fabrication criteria for a Category I packaging, as delineated in NUREG/CR-3854 (Fischer and Lai 1985), shall be followed. Fabrication of the packaging shall be performed in accordance with ASME (1992) Section III, as required by NUREG/CR-3854.

Welding criteria for a Category I packaging, as delineated in NUREG/CR-3019 (Monroe et al. 1984), shall be followed. All welds and weld joints shall be examined per ASME (1992) Section III. Welds shall be inspected in accordance with the examination methods of ASME (1992) Section V, except as modified by the requirements of Section III. Welders shall be qualified per ASME (1992) Section IX.

All welds shall be sufficiently smooth to enable easy decontamination. The design shall consider avoiding potential contamination traps to the greatest extent practicable. All containment welds shall be inspected per ASME Section III, Subsection NB, requirements.

Decontamination of all external surfaces will be required to meet Table 7 limits. Surface areas that may contact radioactive materials shall be designed for ease of decontamination.

All of the above requirements apply to the fabrication of the MCO and the MCO Cask. However, an exception from the above criteria may be taken for the MCO. Examination of the MCO closure weld may be limited to liquid penetrant or magnetic particle examination of the root and final passes if the MCO closure weld is designed as a partial penetration weld that does not take credit for the thickness of the root pass.

4.2.3 Packaging Dimensions

The dimensions for the internal cavity of the packaging must be sufficient to accommodate the MCO. The MCO concept maximum dimensions are 406 cm (160 in.) long by 61 cm (24 in.) in diameter.

The maximum dimensions for the packaging exterior shall be based on the handling limits of the K Basins and CSB, shown in Figures 4 and 5.

4.2.4 Maximum Gross Weight

The weight of a package fully loaded with reracked fuel, water, etc., shall not exceed 27,210 kg (30 tons). The package shall be configured to be handled with the K Basin crane. The maximum lifting capacity of this crane is 27,210 kg (30 tons).

4.2.5 Lifting and Tiedown Attachments

The lifting attachments for the packaging 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 compatible with the cranes in the K Basins loadout area, CSB cranes, and portable cranes to permit field lifting of the packaging.

If the tiedown attachments are a structural part of the packaging, they shall be designed to withstand a force of ten times the package weight in the forward and aft directions; five times the gross package weight in the lateral directions; and two times the package weight in the vertical directions without yielding.

4.2.6 Venting

The packaging design shall incorporate vents for sampling the cask cavity. Any vents that are incorporated in the design must be capable of being closed and leaktight during normal transport conditions. During and subsequent to accident conditions, the release of materials from the package, including the venting system, shall not exceed the limits set in Section 5.1.2.

4.2.7 Loading

The packaging shall be capable of being loaded underwater or in air. The packaging shall be capable of being top-loaded with an empty or full MCO or bottom-loaded with a full MCO.

4.2.8 Draining

The packaging shall be outfitted with a drain port and high port vent that will permit removal of liquids from the cask cavity with or without a fully loaded MCO loaded into the cask. The drain port and high port vent shall be capable of being opened and closed using remote handling equipment.

4.2.9 Water Circulation

The packaging shall be equipped with features that permit circulation of a minimum of 76 L/min (20 gpm), 50 °C (122 °F), water through the package/MCO annulus for the cold vacuum drying process. This feature shall provide a uniform water temperature flow around the MCO. The system shall provide double shut-off quick release interfaces to the inlet and outlet ports on the cask. The design shall include features that will retain the MCO in the packaging for all normal and off-normal pressures in the annulus.

4.2.10 Closure

Each packaging closure shall be securely closed with a positive fastening device that cannot be opened unintentionally. The cask closure shall be simple to install, leak testable, and reliable. The cask payload cavity shall be provided with the capability to be filled and purged with inert gas.

4.2.11 Containment

The MCO cask shall provide the transportation containment barrier for the payload, as described below. The MCO will provide one additional level of containment. The packaging shall be designed so that during normal transfer conditions (Section 5.1.1), the package remains leaktight, as demonstrated through testing and/or analysis. Linear-elastic analysis may be performed to demonstrate maintenance of the leakage rate after the normal transfer conditions. ASME (1992) Section III, Service Level A stress allowables shall be used for analytical acceptance.

The cask system shall also be designed such that, during accident conditions (Section 5.1.2) the package maintains a single confinement barrier for the MCO, as demonstrated by analysis and/or testing. Elastic-plastic analysis may be performed to demonstrate maintenance of confinement after the accident conditions. ASME (1992) Section III, Service Level D stress allowables shall be used for analytical acceptance. Energy absorbed by the package during the drop is accounted for based on elastic-plastic analysis. During the fire scenario, the MCO cask seals may deteriorate such that loss of the cask containment seal occurs.

4.2.12 Shielding

As low as reasonably achievable (ALARA) principles will be the limiting factor for the design dose rate of the package. The packaging and closures (lid, vent ports, leak test ports, etc.) shall be designed to ensure that they provide adequate shielding.

4.2.13 Maintenance

The packaging and ancillary components shall be designed to minimize maintenance or testing requirements. Features requiring maintenance shall be designed in accordance with ALARA principles using the guidance found in HSRCM-1, *Hanford Site Radiological Control Manual*.

4.2.14 Life Cycle

The packaging shall be capable of being reused a minimum of 1,000 times. The MCO is used only one time for transportation and is the long-term storage container. Additionally, the packaging shall have a minimum transport service life of 20 years. Design features of the packaging shall minimize maintenance, refurbishing, and decontamination procedures required for

packaging reuse. Features requiring refurbishment prior to reuse shall be designed in accordance with ALARA principles, as per HSRCM-1.

The SARP will provide the necessary requirements, such as inspections and part replacements, to allow for the safe and effective reuse of the cask.

4.3 TRANSPORT SYSTEM

4.3.1 General

The transport operation involves loading the irradiated fuel into the MCO and packaging at the 100 K East and West Basins, and securing the package to a transport vehicle before shipment of the fuel. Figure 4 provides a sketch of the 100 K East and West loading areas. Limited modifications to the K East and K West loading areas, which are identical, may be possible to facilitate loading and handling of the package.

Transport of the package is from the 100 K Area to the CSB in the 200 East Area for further conditioning and storage. The package will be transported by truck. The total loaded transport distance will be approximately 16.1 km (10 mi).

The transportation campaign shall use existing onsite transport vehicles, if possible. Modifications required for adaptation of the transport vehicle shall be minimized.

4.3.2 Truck Transport System

The package transportation system may use a specially equipped trailer capable of transporting a minimum of one package per shipment. This trailer shall be built to all applicable U.S. Department of Transportation standards and will be capable of being pulled by tractors presently available for use on the Hanford Site. The trailer shall be a National Highway Traffic Safety Administration-registered trailer and meet all requirements of the enhanced Commercial Vehicle Safety Alliance inspection. Additional standards for the trailer to ensure compatibility with the K Basins and CSB facilities are as follows.

- The maximum gross weight per axle for a fully loaded tractor/trailer combination shall not exceed 9,100 kg (20,000 lbs).
- The maximum width of the tractor/trailer combination shall not exceed 3.96 m (13 ft).
- Dimensions with the cask system attached in a horizontal or vertical configuration shall allow access to the interfacing facilities.
- The height of the trailer bed shall be limited so that the combined height of the cask, with tiedowns and impact limiters, if used, shall not exceed 6.15 m (20 ft 2 in.) when mounted to the trailer.

- The trailer shall be equipped with tiedown points sufficient to secure the cask in accordance with the requirements set forth in Section 4.4.

4.3.3 Additional Requirements

To prevent the trailer from tipping over during normal transport, the trailer shall be designed in accordance with ANSI Standard N14.30 (ANSI 1992), Section 5.1.2.1. 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% of the trailer track (center-to-center width of the trailer tire group).

4.4 TIEDOWN SYSTEM

An engineered tiedown system shall be used to secure the packaging system to the transport vehicle(s). The tiedown system shall meet the requirements and be designed per the International Atomic Energy Agency Safety Series 37 (IAEA 1990). The tiedown attachments for those requirements shall be capable of resisting the forces for road or rail, as described in Table 8.

Table 8. Load Factors for Tiedown Systems.

Mode	Longitudinal	Lateral	Vertical
Road	+ 2g	+/- 1g	3g down, 2g up

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 SYSTEM

5.1.1 Normal Conditions of Transport

For conditions normally incident to transport, the SARP 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 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. The ambient temperatures at the Hanford Site for the peak summer month are tabulated in Table 9.

Table 9. Hanford Air Temperature.

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

- Maximum heat generation rate of worst-case source from Section 2.2 plus maximum solar heat load (see Table 10) 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.

Table 10. Maximum Solar Radiation Received from the Sun (BTU/h-ft²).

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

Maximum normal operating outside surface temperature of the cask shall be less than 82 °C (180 °F) in maximum air temperature and in the shade.

- **Reduced External Pressure.** An external pressure of 24.5 kPa (3.5 psi) absolute.
- **Increased External Pressure.** An external pressure of 140 kPa (20 psi) absolute.
- **Internal Pressure.** An internal working pressure of 1,033 kPa (150 psig) unless otherwise specified.
- **Vibration.** Vibration normally incident to transport. The package shall be evaluated per ANSI N14.23 to demonstrate containment when exposed to normal vibration due to the transportation from the 100 K West and East Basins to the CSB in the 200 East Area by the selected transport vehicle. Tiedowns and holddown bolts shall also be evaluated for this scenario.
- **Free Drop.** The package shall be evaluated to demonstrate containment subsequent to a 0.3-m (1-ft) free drop onto an 8-in.-thick concrete surface with a concrete strength of 4,000 psi, a Soil Modulus of Elasticity of 28,000 psi, and Grade 60, No. 7 rebar spaced 12. in. apart with 2-in. cover, each way, each face. The package shall impact in an orientation expected to cause maximum damage. Secondary impact of the package (slapdown) does not have to be examined for this drop. During the free drop, the MCO shall not be exposed to greater than 100g's and shall maintain containment.
- **Water Spray.** The 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 one hour.
- **Penetration.** Impact of the hemispherical end of a vertical steel cylinder of 3.2-cm (1.25-in.) diameter and 6-kg (13-lb) mass, dropped from a height of 1 m (40 in.) onto the exposed surface of the package that is expected to be most vulnerable to puncture. The long axis of the cylinder must be perpendicular to the package surface.

5.1.1.1 Containment. The cask shall be designed, constructed, and prepared for shipment so that when subjected to normal conditions, the containment boundary shall remain leaktight in accordance with the ANSI 14.5 definition of "leaktight." If the package design incorporates a venting feature, the leakage rate evaluation shall be made with the vent(s) sealed.

For conditions normally incident to transport, the packaging shall be evaluated by analysis to meet the containment criteria listed above.

5.1.1.2 Shielding. For exclusive use normal conditions of transport, as described in Section 5.1.1, the maximum surface dose on the accessible surface of the package shall not exceed 200 mR/h. The dose rate 2 m (6.5 ft) from the

surface shall be limited to 10 mrem/h. The dose in any normally occupied space in the transfer vehicle shall be limited to 2 mrem/h or less.

5.1.1.3 Criticality. The package design shall also ensure that twice the number of packages will meet the following criteria.

The contents shall remain subcritical (k_{eff} less than 0.95, where 0.95 is the mean value plus two times the one standard deviation value [two standard deviations] with bias applied) for the packages during normal conditions of transport, as described in Section 5.1.1, also assuming the following.

- The most reactive credible configuration is consistent with the chemical and physical form of the allowed packaged material.
- There is clustering of packages and close reflection of the package array by water on all sides.

5.1.2 Accident Conditions

The report on equivalent safety (WHC 1994) provides a description of how a highly controlled transportation environment, such as that available on the Hanford Reservation, can contribute to the safety of a packaging system. H&R (1995) uses accident data from the Hanford Site and other controlled transportation environments to establish the worst-case credible accidents (frequency greater than 10^{-6} accidents/year) for the packaging system.

Based on the preliminary risk evaluation (Green 1996), the following worst-case accidents meet the equivalent safety-based design criteria. For purposes of onsite package evaluation, these events are assumed to occur nonsequentially. For design evaluation, these accidents shall be evaluated at an ambient temperature between -32°C (-27°F) and 47°C (115°F), whichever was more severe for the individual incident. Additionally, the packaging system will be evaluated carrying the worst-case payload, as described in Section 2.0.

- **Puncture.** The worst-case credible puncture incident is equivalent to a free drop of the packaging 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 mounted on an essentially unyielding, horizontal surface. 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 package, but not less than 20 cm (8 in.) long. Acceptance to this requirement is that there is no loss of shielding to the extent shown below in Section 5.1.2.2.
- **Impact.** The worst-case credible impact for the packaging system may be simulated by a free drop of 30 ft onto an 8-in.-thick concrete surface with a concrete strength of 4,000 psi, a Soil Modulus of Elasticity of 28,000 psi, and Grade 60, No. 7 rebar spaced 12 in. apart with 2-in. cover, each way, each face. The package shall

impact in an orientation expected to cause maximum damage. The MCO shall not be exposed to greater than 100g's during this drop scenario.

- **Thermal.** Exposure of the packaging system for not less than 30 minutes to a 800 °C (1,475 °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. The package can be assumed to be cooled after the fire. Any active cooling system for the packaging shall be assumed to be inoperative during the fire.

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 125 gal/min. Flow at this maximum flow rate shall be assumed to occur for a minimum 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 50 gal/min. Assume a water temperature of 29 °C (85 °F) for this procedure.

5.1.2.1 Containment. During and subsequent to all credible or probable accident events, as described in Section 5.1.2, the packaging system shall maintain confinement of the MCO (not allow the MCO to be released from the cask) and not allow a significant release of radioactive material to the environment (release the fuel elements from the cask and MCO). A radiological risk evaluation will support the credible accident scenarios.

5.1.2.2 Shielding. Subsequent to all credible or probable accident events, as described in Section 5.1.2, the dose 1 m (3.3 ft) from the surface of the packaging system shall not exceed 1 rem/h. Due to the fire event, there shall be no net loss of lead shielding, if lead is used. The lead may melt, but cannot be lost.

5.1.2.3 Criticality. Subsequent to all credible or probable accident events, as described in Section 5.1.2, the packaging system shall be evaluated for one package to meet the following criteria.

The contents shall remain subcritical (k_{eff} less than 0.95, as defined in Section 5.1.1.3) for the packaging system during and subsequent to an accident condition, also assuming the following.

- The fissile material is in the most reactive credible configuration consistent with the chemical form and damaged condition of the package and payload.
- There is optimum interspersed aqueous moderation.
- There is clustering of packages and close reflection of the package array by water on all sides.

5.1.2.4 Risk Evaluation. The preliminary risk evaluation was performed to establish the equivalent safety-based design criteria. This assessment was

used to develop the design criteria stated in 5.1.2. A radiological risk evaluation will be developed for the SARP and will evaluate credible accident scenarios to meet the onsite transportation safety criteria.

5.2 ALARA

The design features of the packages shall be consistent with the requirements of *WHC Occupational ALARA Program* (WHC 1995), for the Hanford Site. 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. Cost benefit analyses should be performed, as needed, to determine the best balance between exposure and economical design.

The contamination limits, as directed by HSRM-1, Article 423.2 (see Table 7), will be met prior to transport of the packaging.

5.3 QA

The QA program requirements for activities such as design, procurement, fabrication, inspection, testing, component handling, and documentation of the fuel casks and their components shall be equivalent to 10 CFR 71, Subpart H, and WHC-CM-4-2, *Quality Assurance Manual*.

To establish a QA plan for the packagings, a graded approach shall be 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 WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*. The criteria for transportation safety class evaluations are documented in WHC-SD-TP-RPT-001 (WHC 1994). QA requirements shall be developed for the procurement, fabrication, and inspection of the package based on the assigned transportation safety class of the package.

5.3.1 System Safety Class

The transportation safety class of the packages with a worst-case payload was determined by a dose consequence study, documented in Appendix A. This study assumed a total failure of the canister 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 irradiated fuel, the worst-case release location is within the 100 K Area, just outside the Basins.

The transportation safety class dose consequence study (Appendix A), performed for 270 elements in the rerack basket scenario, indicates that the maximum inhalation dose to an onsite receptor is 240,000 rem effective dose equivalent (EDE), and the maximum inhalation dose to an offsite receptor is 120 rem EDE. Therefore, for 270 reracked elements, the packaging constitutes a Safety Class 1 system per WHC-SD-TP-RPT-001 (WHC 1994) and WHC-CM-4-46.

For transportation packages with HRCQ material and a Safety Class 1, ASME (1992) Section III shall be used as guidelines for the design.

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, *Standard Engineering Practices*.

5.5 ENVIRONMENTAL COMPLIANCE

Actions and conditions for the protection of the environment during transport of the packaging shall comply with the requirements of WHC-CM-7-5, *Environmental Compliance*.

5.6 MAINTENANCE

Maintenance, as required and specified in the SARP, shall be performed on the packaging to ensure packaging integrity is maintained. Ease and minimization of maintenance shall be considered in the design of the packaging. 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 SARP

A SARP 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 QA criteria will be included in the SARP, ensuring that operation, transport, and storage of the package meets the requirements of this PDC. The onsite SARP table of contents is found in Appendix B.

6.0 REFERENCES

10 CFR 71, 1994, "Packaging and Transportation of Radioactive Material," *Code of Federal Regulations*, as amended.

49 CFR 173, 1994, "Shippers--General Requirements for Shipments and Packagings," *Code of Federal Regulations*, as amended.

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

Fischer, L. E., and W. Lai, 1985, *Fabrication Criteria for Shipping Containers*, NUREG/CR-3854 (under Lawrence Livermore National Laboratory contract to the U.S. Nuclear Regulatory Commission), U.S. Nuclear Regulatory Commission, Washington, D.C.

Green, J. R., 1996, *Radiological Risk Evaluation for Risk-Based Design Criteria of the Multiple Container Overpack Packaging*, WHC-SD-TP-RPT-022, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX A**SAFETY CLASSIFICATION FOR THE K BASIN CASK**

C. H. Huang
December 5, 1995

1.0 INTRODUCTION

Approximately 2,100 metric tons of unprocessed, irradiated nuclear fuel presently are stored in the K Basins. To clean up this nuclear spent fuel in the K Basins, the fuel must be transported from the 100 K Basin Area to a Canister Storage Building (CSB) in the 200 East area. The shipping transport operation involves loading the irradiated fuel into the Multiple Canister Overpack (MCO) cask assembly at the 100 K Basin Area. The cask may be transported by either truck or train.

A transportation accident resulting in a fire is postulated.

In this document, the onsite and offsite doses were calculated to determine the safety classification for the system (the K Basin cask) or components associated with the cask transport operations.

2.0 PURPOSE

The purpose of this document is to provide the safety classification for a packaging and transportation system (the K Basin cask) to transport spent nuclear fuel within the boundary of the Hanford Site.

3.0 SCOPE OF ANALYSIS

This safety class analysis addresses the transportation of the K Basin cask. In this analysis, only a bounding accident scenario will be analyzed.

4.0 SOURCE TERM

The worst-case source term for N Reactor fuel was specified by the customer.

In addition to the N fuel elements, a portion of the N Reactor fuel in both basins to be transported in the packaging system also is in the form of small fuel particles and radioactive corrosion products.

The fuel that is being stored in the K Basins is stored in double barrelled canisters that contain up to 14 N Reactor fuel assemblies. The fuel is removed from these canisters and placed in baskets inside of the MCO. A maximum of 270 assemblies will be placed in these baskets.

4.1 RADIOACTIVE INVENTORY

The inventory in the baskets is contained within the MCO. The MCO acts as the primary container vessel. Table 1 shows the anticipated activity per unit mass, per assembly, and per cask. The cask contains a total of 270 assemblies.

Table 1. Worst-Case Source Term for N Reactor Fuel.
(provided by the customer)

Isotope	Curies per MTU	Curies per single assembly	Curies per MCO-270 assemblies	Isotope	Curies per MTU	Curies per single assembly	Curies per MCO-270 assemblies
³ H	38.8	0.91	246	¹⁴⁴ Ce	2.5	0.06	16
⁵⁵ Fe	6.8	0.16	43	¹⁴⁴ Pr	2.5	0.06	16
⁶⁰ Co	160.9	3.78	1020	¹⁴⁷ Pm	2,423.2	56.9	15,363
⁸⁵ Kr	611.5	14.36	3,877	¹⁵¹ Sm	102.7	2.41	651
⁹⁰ Sr	7,893.2	185.34	50,043	¹⁵⁴ Eu	192.3	4.51	1219
⁹⁰ Y	7,893.2	185.34	50,043	¹⁵⁵ Eu	33.4	0.79	212
¹⁰⁶ Ru	11.5	0.27	73	²³⁸ Pu	147.3	3.46	934
¹⁰⁶ Rh	11.5	0.27	73	²³⁹ Pu	152.1	3.57	964
¹²⁵ Sb	99.1	2.33	628	²⁴⁰ Pu	115	2.70	729
^{125m} Te	24.1	0.57	153	²⁴¹ Pu	9,139.9	214.62	57,947
¹³⁴ Cs	115	2.70	729	²⁴¹ Am	272.9	6.41	1730
¹³⁷ Cs	10,734.9	252.07	68,059	²⁴⁴ Cm	39.9	0.94	253
^{137m} Ba	10,162.3	238.63	64,429				

MCO = Multiple canister overpack.

MTU = Metric ton of uranium.

5.0 ACCIDENT SCENARIOS/INITIATING EVENTS

The bounding condition considered for the accident scenario is a fire accident.

The possible cause of fire accidents is that the truck fuel could catch fire due to traffic accidents.

In the accident postulated, all of the fuel in the MCO is assumed to be exposed and surrounded by fire.

5.1 RELEASE FRACTION

An airborne release fraction (ARF) of 5.0×10^{-3} (DOE 1994, pp. 4-37) is used to calculate the doses at the onsite and offsite receptor locations for the fire scenario. This release fraction was taken from DOE (1994) and is associated with oxidation of uranium. The 5×10^{-3} was selected because it is the most conservative value. This release fraction is applied to all radionuclides present, except for cesium, ruthenium, and tellurium, which are considered semivolatile. The release fraction for ruthenium and tellurium was taken to be 1×10^{-2} (DOE 1992, p. A-9). The release fraction for cesium was taken to be 0.09 (DOE 1994). The release fraction for krypton and tritium was taken to be 1.0 (DOE 1992, p. A-9).

The quantity of airborne radioactive material released from the fire is therefore equal to the activity of each radionuclide listed in Table 1 times the release fraction.

The worst-case source term for N Reactor fuel, adjusting for the airborne release fraction, is given in Table 2.

Table 2. Worst-Case Source Term for N Reactor Fuel.

Isotope	Ci/Cask	Isotope	Ci/Cask
^3H	2.5E+2	^{144}Ce	8.0E-2
^{55}Fe	2.2E-1	^{144}Pr	8.0E-2
^{60}Co	5.1	^{147}Pm	7.7E+1
^{85}Kr	3.9E+3	^{151}Sm	3.3
^{90}Sr	2.5E+2	^{154}Eu	6.1
^{90}Y	2.5E+2	^{155}Eu	1.1
^{106}Ru	7.3E-1	^{238}Pu	4.7
^{106}Rh	3.7E-1	^{239}Pu	4.8
^{125}Sb	3.1	^{240}Pu	3.6
^{125m}Te	1.5	^{241}Pu	2.9E+2
^{134}Cs	6.6E+1	^{241}Am	8.7
^{137}Cs	6.1E+3	^{244}Cm	1.3
^{137m}Ba	3.2E+2		

6.0 METHODOLOGIES AND ASSUMPTIONS

Acute maximum individual ground-level release doses for the onsite and offsite receptors were calculated using the computer code GENII version 1.485 (Napier et al. 1988).

6.1 CODE DOCUMENTATION

- GENII version 1.485 (12/3/90)
- GENII Default Parameter Values (28-Mar-90 RAP)
- Radionuclide Master Library (7/23/93 PDR)
- PNL Food Transfer Factor Library (7/19/93)
- External Dose Factor Library (8-May-90-RAP)
- Internal Dose Increments, PNL Solubilities (7/23/93 PDR)
- Joint Frequency Data: 100 Area, 10 m, Pasquill A-G (1983-1991 Average). The worst dose consequences would occur in the 100 Area.

GENII input files are attached in Appendix A.

7.0 RESULTS

The safety class for the K Basin cask transporting N Reactor fuel assemblies was determined in accordance with the guidance provided in WHC-CM-4-46, 9.0, Rev. 0, "Assigning Safety Classes to Systems, Components and Structures." In the case of radioactive materials, the failure of a system or component that could result in an offsite public exposure in excess of 500 mrem effective dose equivalent is classified as Safety Class 1. The guidance for making a safety class determination for a facility or a system indicates that the safety classification is based upon the determination of consequences of potential accidents without the mitigation provided by engineered or administrative barriers. In addition, the entire inventories of hazardous materials allowed in the facility or the system are assumed to be present.

Atmospheric dispersion factor, X/Qs, for the onsite and offsite receptors were taken from Savino (1995). The onsite receptor is located 100 m from the source; the offsite receptor is 11,730 m west of the K Basins (current site boundary). For the proposed site boundary (see footnotes in Table 3), the maximum offsite receptor X/Q value is 1.54E-02 s/m³, which is associated with a receptor at 150 m in the northwest direction from the 100 K Area. The calculated values of X/Q are given in Table 3 for the onsite and offsite receptors.

Table 3. The Values of X/Q for the Onsite, Near Riverbank, and Offsite Receptors in the Worst Sector.

Receptor	/Q (s/m ³)
Onsite (100 m E)	7.32 E-02
Near riverbank ¹ (150 NW)	1.54 E-02
Offsite (11.7 km W) ²	3.70 E-05

¹The proposed site boundary distance is the minimum distance from the area boundary of interest (i.e., 100 K or 200 East Area) to the proposed site boundary. The proposed site boundary assumes the site is bounded by Highway 240 on the west and the near riverbank on the north and east.

²The current site boundary distance is the minimum distance from the area boundary of interest (i.e., 100 K or 200 East Area) to the existing site boundary.

The values of X/Q, as shown in Table 3, are used as input data into the GENII code for dose calculations. The calculated doses for the onsite and offsite receptors are given in Table 4.

Table 4. The Calculated Doses for the Onsite, Near Riverbank, and Offsite Receptors.

Receptor	Effective dose equivalent (rem)
Onsite (100 m E)	2.4 E+05
Near riverbank ¹ (150 m NW)	4.9 E+04
Offsite (11.7 km W) ²	1.2 E+02

As shown in Table 4, the exposures to the public at a near riverbank receptor and an offsite receptor are 4.9×10^4 and 1.2×10^2 rem, respectively, which exceed the 500 mrem threshold limit for Safety Class 1. Therefore, the K Basin cask loaded with N reactor fuel is classified as Safety Class 1.

8.0 REFERENCES

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APPENDIX A

GENII INPUT FILES

Program GENII Input File ##### 8 Jul 88 ####
 Title: PROJECT K BASIN ACUTE ONSITE INDIVIDUAL DOSES RELEASE
 \GENIIKBASINR.in

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
 T Report by radionuclide F Terrestrial foods ingestion 7,9
 T 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
nucleide	/yr	/yr	/m ³	/m ³	/unit	/m ³	/L

H 3	2.5E+2
FE55	2.2E-1
CO60	5.1
KR85	3.9E+3
SR90	2.5E+2
Y 90	2.5E+2
RU106	7.3E-1
SB125	3.1
TE125M	1.5
CS134	6.6E+1
CS137	6.1E+3
CE144	8.0E-2
PR144	8.0E-2
PM147	7.7E+1
SM151	3.3
EU154	6.1
EU155	1.1
PU238	4.7
PU239	4.8
PU240	3.6
PU241	2.9E+2
AM241	8.7
CM244	1.3

-----Derived Concentrations-----	
Use when	measured values are known
Release	Terres. Animal Drink Aquatic
Radio-nucleide	Plant Product Water Food

TIME

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

FAR-FIELD SCENARIOS (IF POPULATION DOSE) #####
 0 Definition option: 1-Use population grid in file POP.IN
 0 2-Use total entered on this line

NEAR-FIELD SCENARIOS

Prior to the beginning of the intake period: (yr)
 0 When was the inventory disposed? (Package degradation starts)
 0 When was LOIC? (Biotic transport starts)
 0 Fraction of roots in upper soil (top 15 cm)
 0 Fraction of roots in deep soil
 0 Manual redistribution: deep soil/surface soil dilution factor
 0 Source area for external dose modification factor (m²)

TRANSPORT

====AIR TRANSPORT=====SECTION 1====
 0-Calculate PM | 0 Release type (0-3)
 1 Option: 1-Use chi/Q or PM value | F Stack release (T/F)
 2-Select MI dist & dir | 0 Stack height (m)
 3-Specify MI dist & dir | 0 Stack flow (m³/sec)
 7.32E-2 Chi/Q or PM value | 0 Stack radius (m)
 0 MI sector index (1=S) | 0 Effluent temp. (C)
 0 MI distance from release point (m) | 0 Building x-section (m²)
 T Use if 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 withdrawal location (hr)
 If mixing ratio model > 0:
 0 Rate of effluent discharge to receiving water body (m³/s)
 0 Longshore distance from release point to usage location (m)
 0 Offshore distance to the water intake (m)
 0 Average water depth in surface water body (m)
 0 Average river width (m), MIXFLG=1 only
 0 Depth of effluent discharge point to surface water (m), lake only

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

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

EXPOSURE

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

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

Program GENII Input File ##### 8 Jul 88 #####
 Title: PROJECT K BASIN ACUTE OFFSITE INDIVIDUAL DOSES RELESAE
 \GENII\KBSNFR.in

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
 T Report by radionuclide F Terrestrial foods ingestion 7,9
 T 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-nuclide	/yr	Air /yr	Water /m ³	Waste /m ³	Air /m ³	Soil /unit	Water /L
H 3	2.5E+2						
FE55	2.2E-1						
CO60	5.1						
KR85	3.9E+3						
SR90	2.5E+2						
Y 90	2.5E+2						
RU106	7.3E-1						
SB125	3.1						
TE125M	1.5						
CS134	6.6E+1						
CS137	6.1E+3						
CE144	8.0E-2						
PR144	8.0E-2						
PM147	7.7E+1						
SM151	3.3						
EU154	6.1						
EU155	1.1						
PU238	4.7						
PU239	4.8						
PU240	3.6						
PU241	2.9E+2						
AM241	8.7						
CM244	1.3						
-----Derived Concentrations-----							
Use when	measured values are known						
Release		Terres.	Animal	Drink	Aquatic		
Radio-nuclide	/kg	Plant	Product	Water	Food		
			/kg	/L	/kg		

TIME #####

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

FAR-FIELD SCENARIOS (IF POPULATION DOSE)

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

NEAR-FIELD SCENARIOS

Prior to the beginning of the intake period: (yr)
 0 When was the inventory disposed? (Package degradation starts)
 0 When was LOIC? (Biotic transport starts)
 0 Fraction of roots in upper soil (top 15 cm)
 0 Fraction of roots in deep soil
 0 Manual redistribution: deep soil/surface soil dilution factor
 0 Source area for external dose modification factor (m2)

TRANSPORT

====AIR TRANSPORT===== SECTION 1=====
 1 Option: 0-Calculate PM 0 Release type (0-3)
 1 1-Use chi/Q or PM value F Stack release (T/F)
 1 2-Select MI dist & dir 0 Stack height (m)
 1 3-Specify MI dist & dir 0 Stack flow (m3/sec)
 1.54E-2 Chi/Q or PM value 0 Stack radius (m)
 0 MI sector index (1=S) 0 Effluent temp. (C)
 0 MI distance from release point (m) 0 Building x-section (m2)
 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 withdrawal location (hr)
 If mixing ratio model > 0:
 0 Rate of effluent discharge to receiving water body (m3/s)
 0 Longshore distance from release point to usage location (m)
 0 Offshore distance to the water intake (m)
 0 Average water depth in surface water body (m)
 0 Average river width (m), MIXFLG=1 only
 0 Depth of effluent discharge point to surface water (m), lake only

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

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

EXPOSURE

====EXTERNAL EXPOSURE===== SECTION 5=====
 Exposure time: Residential irrigation:
 0 Plume (hr) T Consider: (T/F)
 0 Soil contamination (hr) 0 Source: 1-ground water
 0 Swimming (hr) 2-surface water
 0 Boating (hr) 0 Application rate (in/yr)
 0 Shoreline activities (hr) 0 Duration (mo/yr)
 0 Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)
 0 Transit time for release to reach aquatic recreation (hr)
 1.0 Average fraction of time submerged 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
 0 1-Use population-weighted chi/Q
 0 2-Use uniform production
 0 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- DUCTION kg/yr	HOLDUP da	-CONSUMPTION- kg/yr	RATE kg/yr	D	DRINKING WATER
F	FISH	0.00	0.0E+00	0.00	0.0	0.0	0	Source(see above)
F	MOLLUS	0.00	0.0E+00	0.00	0.0	0.0	T	Treatment? T/F
F	CRUSTA	0.00	0.0E+00	0.00	0.0	0.0	0	Holdup/transit? 0
F	PLANTS	0.00	0.0E+00	0.00	0.0	0.0	0	Consumption(L/yr)

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

USE T/F	FOOD TYPE	GROW- da	--IRRIGATION--			YIELD kg/m ²	PROD- CTION kg/yr	--CONSUMPTION--		
			TIME * in/yr	RATE mo/yr	TIME mo/yr			HOLDUP da	RATE kg/yr	
F	LEAF	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0	
F	ROOT	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	

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

USE T/F	---HUMAN---		DRINK WATER CONTAM FRACT.	-STORED FEED-		STOR- AGE kg/m3 da
	TOTAL CONSUMPTION RATE			GROW RATE		
	FOOD TYPE	HOLDUP da		PROD kg/yr	IRRIGATION da	
F BEEF	0.0	0.0	0.00	0.00	0.0	0.00
F POULTR	0.0	0.0	0.00	0.00	0.0	0.00
F MILK	0.0	0.0	0.00	0.00	0.0	0.00
F EGG	0.0	0.0	0.00	0.00	0.0	0.00
-----FRESH FORAGE-----						
BEEF			0.00	0.0	0.0	0.00
MILK			0.00	0.0	0.0	0.00

####

Program GENII Input File ##### 8 Jul 88 #####
 Title: PROJECT K BASIN ACUTE OFFSITE INDIVIDUAL DOSES RELESAE
 \GENI1\K\BASNFR.in

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 Complete multiple sites

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
		F Drinking water ingestion	7,8
		F Aquatic foods ingestion	7,8
		F Terrestrial foods ingestion	7,9
		F Animal product ingestion	7,10
		F Inadvertent soil ingestion	

REPORT OPTIONS=====

T Report ADE only
 T Report by radionuclide
 T Report by exposure pathway
 F Debug report on screen

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-nuclide	/yr	/yr	/m ³	/m ³	/unit	/m ³	/L
H 3	2.5E+2						
FE55	2.2E-1						
CO60	5.1						
KR85	3.9E+3						
SR90	2.5E+2						
Y 90	2.5E+2						
RU106	7.3E-1						
SB125	3.1						
TE125M	1.5						
CS134	6.6E+1						
CS137	6.1E+3						
CE144	8.0E-2						
PR144	8.0E-2						
PM147	7.7E+1						
SM151	3.3						
EU154	6.1						
EU155	1.1						
PU238	4.7						
PU239	4.8						
PU240	3.6						
PU241	2.9E+2						
AM241	8.7						
CM244	1.3						

----- -----Derived Concentrations-----					
Use when:	measured values are known				
Release	Terres.	Animal	Drink	Aquatic	
Radio-nuclide	/kg	/kg	/L	/kg	

TIME #####

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

FAR-FIELD SCENARIOS (IF POPULATION DOSE)

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

NEAR-FIELD SCENARIOS

Prior to the beginning of the intake period: (yr)
 0 When was the inventory disposed? (Package degradation starts)
 0 When was LOIC? (Biotic transport starts)
 0 Fraction of roots in upper soil (top 15 cm)
 0 Fraction of roots in deep soil
 0 Manual redistribution: deep soil/surface soil dilution factor
 0 Source area for external dose modification factor (m²)

TRANSPORT

====AIR TRANSPORT===== SECTION 1=====
 0-Calculate PM | 0 Release type (0-3)
 1 Option: 1-Use chi/Q or PM value | F Stack release (T/F)
 2-Select MI dist & dir | 0 Stack height (m)
 3-Specify MI dist & dir | 0 Stack flow (m³/sec)
 3.70E-5 Chi/Q or PM value | 0 Stack radius (m)
 0 MI sector index (1=S) | 0 Effluent temp. (C)
 0 MI distance from release point (m) | 0 Building x-section (m²)
 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 withdrawal location (hr)
 If mixing ratio model > 0:
 0 Rate of effluent discharge to receiving water body (m³/s)
 0 Longshore distance from release point to usage location (m)
 0 Offshore distance to the water intake (m)
 0 Average water depth in surface water body (m)
 0 Average river width (m), MIXFLG=1 only
 0 Depth of effluent discharge point to surface water (m), lake only

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

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

EXPOSURE

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

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

====INGESTION POPULATION===== SECTION 7=====
 0 Atmospheric production definition (select option):
 0 0-Use food-weighted chi/Q, (food-sec/m³), enter value on this line
 0 1-Use population-weighted chi/Q
 0 2-Use uniform production
 0 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- CTION kg/yr	-CONSUMPTION- HOLDUP da	RATE kg/yr	D	RINKING WATER
F	FISH	0.00	0.0E+00	0.00	0.0	0	Source(s see above)
F	MOLLUS	0.00	0.0E+00	0.00	0.0	0	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 da	--IRRIGATION--			PROD- CTION kg/yr	--CONSUMPTION--		
			TIME * in/yr	TIME mo/yr	YIELD kg/m ²		HOLDUP da	RATE kg/yr	
F	LEAF	0.00	0	0.0	0.0	0.0E+00	0.0	0.0	
F	ROOT	0.00	0	0.0	0.0	0.0E+00	0.0	0.0	
F	FRUIT	0.00	0	0.0	0.0	0.0E+00	0.0	0.0	
F	GRAIN	0.00	0	0.0	0.0	0.0E+00	0.0	0.0	

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

USE T/F	--HUMAN--		RATE kg/yr	HOLDUP da	TOTAL		WATER kg/yr	DIET FRACT.	DRINK		GROW		STORED FEED		YIELD kg/m ³	AGE da		
	FOOD TYPE	CONSUMPTION kg/yr			PROD- CTION	CONTAM kg/yr			FRAC- TION	TIME da	IRRIGATION S * in/yr	RATE mo/yr	TIME				IRRIGATION S * in/yr	
													WATER	DIET			TIME	IRRIGATION S * in/yr
F BEEF	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
F POULTR	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
F MILK	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
F EGG	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
-----FRESH FORAGE-----																		
BEEF									0.00	0.0	0.0	0.0	0.00	0.0				
MILK									0.00	0.0	0.0	0.0	0.00	0.0				

####

HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

Document Reviewed: "SAFETY CLASSIFICATION FOR THE K BASIN CASK."

Submitted by: C. H. HUANG
Date Submitted: June 1, 1995

Scope of Review: Entire Document

YES NO* N/A

- [] [] 1. A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
- [] [] 2. Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
- [] [] 3. HEDOP-approved code(s) were used.
- [] [] 4. Receptor locations were selected according to HEDOP recommendations.
- [] [] 5. All applicable environmental pathways and code options were included and are appropriate for the calculations.
- [] [] 6. Hanford site data were used.
- [] [] 7. Model adjustments external to the computer program were justified and performed correctly.
- [] [] 8. The analysis is consistent with HEDOP recommendations.
- [] [] 9. Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
- [] 10. Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.

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


D.A. Himes 
HEDOP-Approved Reviewer (Printed Name and Signature)

6/6/95
Date

COMMENTS (add additional signed and dated pages if necessary):

CHECKLIST FOR PEER REVIEW

Document Reviewed: C. H. Huang, "SAFETY CLASSIFICATION FOR THE K BASIN CASK," June 1, 1995.

Scope of Review: Entire Document

Yes No NA

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

[] [] Document approved.

Br. + E. He *AFS* *6/1/95*
Reviewer (Printed/Name and Signature) Date

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APPENDIX B
ONSITE SARP TABLE OF CONTENTS

PART A: DESCRIPTION AND OPERATIONS

- 1.0 INTRODUCTION
 - 1.1 GENERAL INFORMATION
 - 1.2 SYSTEM DESCRIPTION
 - 1.3 REVIEW AND UPDATE CYCLES
- 2.0 PACKAGING SYSTEM
 - 2.1 CONFIGURATION AND DIMENSIONS
 - 2.2 MATERIALS OF CONSTRUCTION
 - 2.3 MECHANICAL PROPERTIES OF MATERIALS
 - 2.4 DESIGN AND FABRICATION METHODS
 - 2.5 WEIGHTS AND CENTER OF GRAVITY
 - 2.6 CONTAINMENT BOUNDARY
 - 2.7 CAVITY SIZE
 - 2.8 HEAT DISSIPATION
 - 2.9 SHIELDING
 - 2.10 LIFTING DEVICES
 - 2.11 TIEDOWN DEVICES
- 3.0 PACKAGE CONTENTS
 - 3.1 GENERAL DESCRIPTION
 - 3.2 CONTENT RESTRICTIONS
 - 3.2.1 Content Matrix
 - 3.2.2 Radioactive Materials
 - 3.2.3 Nonradioactive Materials
- 4.0 TRANSPORT SYSTEM
 - 4.1 TRANSPORTER
 - 4.2 TIEDOWN SYSTEM
 - 4.3 SPECIAL TRANSFER REQUIREMENTS
- 5.0 ACCEPTANCE OF PACKAGING FOR USE
 - 5.1 NEW PACKAGING
 - 5.1.1 Acceptance Requirements
 - 5.1.2 Inspection and Testing
 - 5.1.3 Documentation
 - 5.2 PACKAGING FOR REUSE
 - 5.2.1 Acceptance Requirements
 - 5.2.2 Inspection and Testing
 - 5.2.3 Documentation
- 6.0 OPERATING REQUIREMENTS
 - 6.1 GENERAL REQUIREMENTS
 - 6.2 LOADING PACKAGE
 - 6.3 UNLOADING PACKAGE
 - 6.4 EMPTY PACKAGING

- 7.0 QUALITY ASSURANCE REQUIREMENTS
 - 7.1 INTRODUCTION
 - 7.2 GENERAL REQUIREMENTS
 - 7.3 ORGANIZATION
 - 7.4 QUALITY ASSURANCE PLAN AND ACTIVITIES
 - 7.4.1 Design Control
 - 7.4.2 Procurement Control
 - 7.4.3 Fabrication Control
 - 7.4.4 Control and Inspection of testing
 - 7.4.5 Maintenance Checks and Controls
 - 7.4.6 Records and Document Control
 - 7.5 SARP CONTROL SYSTEM
- 8.0 MAINTENANCE
 - 8.1 GENERAL REQUIREMENTS
 - 8.2 INSPECTION AND VERIFICATION SCHEDULES
 - 8.3 RECORDS AND DOCUMENTATION
- 9.0 APPENDIX
 - 9.1 DRAWINGS

PART B: PACKAGE EVALUATION

- 1.0 INTRODUCTION
 - 1.1 SAFETY EVALUATION METHODOLOGY
 - 1.2 EVALUATION SUMMARY AND CONCLUSIONS
 - 1.3 APPENDIX
- 2.0 CONTENTS EVALUATION
 - 2.1 CHARACTERIZATION
 - 2.2 RESTRICTIONS
 - 2.3 SIZE AND WEIGHT
 - 2.4 CONCLUSIONS
 - 2.5 APPENDIX
- 3.0 RADIOLOGICAL RISK EVALUATION
 - 3.1 INTRODUCTION
 - 3.2 RISK ACCEPTANCE CRITERIA
 - 3.3 DOSE CONSEQUENCE ANALYSIS
 - 3.4 PACKAGE FAILURE THRESHOLD ANALYSIS
 - 3.5 ACCIDENT FREQUENCY ASSESSMENT
 - 3.5.1 Approach
 - 3.5.2 Accident Sequence Event Tree Analysis
 - 3.6 RISK EVALUATION AND CONCLUSIONS
 - 3.7 APPENDIX

- 4.0 CONTAINMENT EVALUATION
 - 4.1 INTRODUCTION
 - 4.2 CONTAINMENT SOURCE SPECIFICATION
 - 4.3 NORMAL TRANSFER CONDITIONS
 - 4.3.1 Conditions to be Evaluated
 - 4.3.2 Containment Acceptance Criteria
 - 4.3.3 Containment Model
 - 4.3.4 Containment Calculations
 - 4.4 ACCIDENT CONDITIONS
 - 4.4.1 Conditions to be Evaluated
 - 4.4.2 Containment Acceptance Criteria
 - 4.4.3 Containment Model
 - 4.4.4 Containment Calculations
 - 4.5 CONTAINMENT EVALUATION AND CONCLUSIONS
 - 4.6 APPENDIX
- 5.0 SHIELDING EVALUATION
 - 5.1 INTRODUCTION
 - 5.2 DIRECT RADIATION SOURCE SPECIFICATION
 - 5.3 SUMMARY OF SHIELDING PROPERTIES OF MATERIALS
 - 5.4 NORMAL TRANSFER CONDITIONS
 - 5.4.1 Conditions to be Evaluated
 - 5.4.2 Acceptance Criteria
 - 5.4.3 Shielding Model
 - 5.4.4 Shielding Calculations
 - 5.5 ACCIDENT CONDITIONS
 - 5.5.1 Conditions to be Evaluated
 - 5.5.2 Acceptance Criteria
 - 5.5.3 Shielding Model
 - 5.5.4 Shielding Calculations
 - 5.6 SHIELDING EVALUATION AND CONCLUSIONS
 - 5.7 APPENDIX
- 6.0 CRITICALITY EVALUATION
 - 6.1 INTRODUCTION
 - 6.2 CRITICALITY SOURCE SPECIFICATION
 - 6.3 SUMMARY OF CRITICALITY PROPERTIES OF MATERIALS
 - 6.4 NORMAL TRANSFER CONDITIONS
 - 6.4.1 Conditions To Be Evaluated
 - 6.4.2 Acceptance Criteria
 - 6.4.3 Criticality Model
 - 6.4.4 Criticality Calculations
 - 6.5 ACCIDENT CONDITIONS
 - 6.5.1 Conditions To Be Evaluated
 - 6.5.2 Acceptance Criteria
 - 6.5.3 Criticality Model
 - 6.5.4 Criticality Calculations
 - 6.6 CRITICAL BENCHMARK EXPERIMENTS
 - 6.6.1 Benchmark Experiments and Applicability
 - 6.6.2 Details of Benchmark Calculations
 - 6.6.3 Results of Benchmark Calculations
 - 6.7 CRITICALITY EVALUATION AND CONCLUSIONS
 - 6.8 APPENDIX

7.0 STRUCTURAL EVALUATION**7.1 INTRODUCTION****7.2 STRUCTURAL EVALUATION OF PACKAGE**

- 7.2.1 Structural Design and Features
- 7.2.2 Mechanical Properties of Materials
- 7.2.3 Chemical and Galvanic Reactions
- 7.2.4 Size of Package and Cavity
- 7.2.5 Weights and Center of Gravity
- 7.2.6 Tamper-Indicating Feature
- 7.2.7 Positive Closure
- 7.2.8 Lifting and Tiedown Devices
- 7.2.9 Brittle Fracture

7.3 NORMAL TRANSFER CONDITIONS

- 7.3.1 Conditions to be Evaluated
- 7.3.2 Acceptance Criteria
- 7.3.3 Structural Model
- 7.3.4 Initial Conditions
 - 7.3.4.1 Environmental Heat Loading
 - 7.3.4.2 Maximum Thermal and Pressure Stresses
 - 7.3.4.3 Structural Evaluations and Conclusions

7.4 ACCIDENT CONDITIONS

- 7.4.1 Conditions to be Evaluated
- 7.4.2 Acceptance Criteria
- 7.4.3 Structural Model
- 7.4.4 Initial Conditions
 - 7.4.4.1 Environmental Heat Loading
 - 7.4.4.2 Maximum Thermal and Pressure Stresses
 - 7.4.4.3 Structural Evaluation and Conclusions

7.5 APPENDIX**8.0 THERMAL EVALUATION****8.1 INTRODUCTION****8.2 THERMAL SOURCE SPECIFICATION****8.3 SUMMARY OF THERMAL PROPERTIES OF MATERIALS****8.4 THERMAL EVALUATION FOR NORMAL TRANSFER CONDITIONS**

- 8.4.1 Conditions to be Evaluated
- 8.4.2 Acceptance Criteria
- 8.4.3 Thermal Model
- 8.4.4 Thermal Analysis
 - 8.4.4.1 Internal Temperatures
 - 8.4.4.2 Maximum Surface Temperatures

8.5 THERMAL EVALUATION FOR ACCIDENT CONDITIONS

- 8.5.1 Conditions to be Evaluated
- 8.5.2 Acceptance Criteria
- 8.5.3 Package Conditions and Environment
- 8.5.4 Thermal Model
- 8.5.5 Thermal Analysis
 - 8.5.5.1 Internal Temperatures
 - 8.5.5.2 Maximum Surface Temperatures

8.6 THERMAL EVALUATION AND CONCLUSIONS**8.7 APPENDIX**

9.0 PRESSURE AND GAS GENERATION EVALUATION

9.1 GAS GENERATION

9.2 PACKAGE PRESSURE

9.3 APPENDIX

10.0 PACKAGE TIEDOWN SYSTEM EVALUATION

10.1 SYSTEM DESIGN

10.2 ATTACHMENTS AND RATINGS

10.3 APPENDIX (CALCULATIONS)

DISTRIBUTION SHEET

To Distribution	From Packaging Engineering	Page 1 of 1 Date 03/28/96		
Project Title/Work Order				EDT No. N/A
Packaging Design Criteria for the MCO Cask (WHC-SD-TP-PDC-030)				ECN No. 625363
Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only
W. S. Edwards	G1-12	X		
J. G. Field	G1-11	X		
W. D. Gallo	R3-85	X		
J. R. Green	G1-11	X		
C. R. Hoover	G1-11	X		
A. T. Kee	R3-86	X		
D. W. McNally	G1-11	X		
T. D. Merkling	R3-09	X		
W. J. Schlauder	S7-84	X		
S. S. Shiraga	G1-11	X		
R. J. Smith	G1-11	X		
Central Files	A3-88	X		
WHC-SD-TP-PDC-030 File	G1-11	X		

C. E. McDonald

EB46 X