ENGINEERING CHANGE NOTICE

Page 1 of 3

1. ECN 637767

Proj. ECN

2. ECN Category (mark one)
Supplemental ☐
Direct Revision ☒
Change ECN ☐
Temporary ☐
Standby ☐
Supersedure ☐
Cancel/Void ☐

3. Originator's Name, Organization, MSIN, and Telephone No.
W. S. Edwards, 33120, G1-11, 376-2522

4. USQ Required? ☐ Yes ☒ No

5. Date 12/19/96

6. Project Title/No./Work Order No. LF037

7. Bldg./Sys./Fac. No. NA

8. Approval Designator SQ

9. Document Numbers Changed by this ECN (includes sheet no. and rev.)
WHC-SD-TP-PDC-030, Rev. 3

10. Related ECN No(s). NA

11. Related PO No. NA

12a. Modification Work
☐ Yes (fill out Blk. 12b)
☒ No (NA Blks. 12b, 12c, 12d)

12b. Work Package No. NA

12c. Modification Work Complete NA
Design Authority/Cog. Engineer Signature & Date

12d. Restored to Original Condition (Temp. or Standby ECN only) NA
Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? ☐ Yes ☒ No

1. The maximum temperature requirement for the MCO shell under normal and accident conditions (Section 2.5.5) was changed to a requirement to keep the interior of the MCO cool enough to prevent a runaway uranium-water corrosion reaction.

2. The radiological source term was updated.

3. The puncture bar in the puncture accident was clarified to be located on a typical Hanford Site surface.

4. The thermal source term was updated to reflect current assumptions.

5. The contact dose rate requirement was revised to reflect typical onsite transportation limits.

See Continuation Sheet

14a. Justification (mark one)

Criteria Change ☒
Design Improvement ☐
Environmental ☐
Facility Deactivation ☐
As-Found ☐
Facilitate Const ☐
Const. Error/Omission ☐
Design Error/Omission ☐

14b. Justification Details

1. This requirement was eliminated in the cask specification because it was superseded by events. The MCO shell temperature requirement was based on limits for when the cask came to steady-state conditions. Due to the increase in gas generation rates from what were predicted at the start of the project, steady-state conditions will never be

See Continuation Sheet

15. Distribution (include name, MSIN, and no. of copies)

W. S. Edwards	G1-11, 1	SS Shiraga	G1-11, 1
J. G. Field	G1-11, 1	Central Files	A3-88, 1
C. R. Hoover	G1-11, 1	Document Processing Center	A3-94, 1
A. T. Kee	R3-86, 1	HNF-SD-TP-PDC-030 File	G1-11, 1
C. R. Hoover	G1-11, 1		
A. T. Kee	R3-86, 1		
D. W. McNally	G1-11, 1		

RELEASE STAMP

JAN 30 1997
DATE:
HANFORD RELEASE
STA: 37
ID 22

A-7900-013-2 (05/96) GEF095

ENGINEERING CHANGE NOTICE

Page 2 of 3

1. ECN (use no. from pg. 1)
637767

16. Design Verification Required
[X] Yes
[] No

17. Cost Impact

	ENGINEERING		CONSTRUCTION	
Additional	[NA] $	Additional	[NA] $
Savings	[NA] $	Savings	[NA] $

18. Schedule Impact (days)
Improvement [NA]
Delay [NA]

19. 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 13. Enter the affected document number in Block 20.

SDD/DD []
Functional Design Criteria []
Operating Specification []
Criticality Specification []
Conceptual Design Report []
Equipment Spec. []
Const. Spec. []
Procurement Spec. []
Vendor Information []
OM Manual []
FSAR/SAR []
Safety Equipment List []
Radiation Work Permit []
Environmental Impact Statement []
Environmental Report []
Environmental Permit []

Seismic/Stress Analysis []
Stress/Design Report []
Interface Control Drawing []
Calibration Procedure []
Installation Procedure []
Maintenance Procedure []
Engineering Procedure []
Operating Instruction []
Operating Procedure []
Operational Safety Requirement []
IEFD Drawing []
Cell Arrangement Drawing []
Essential Material Specification []
Fac. Proc. Samp. Schedule []
Inspection Plan []
Inventory Adjustment Request []

Tank Calibration Manual []
Health Physics Procedure []
Spares Multiple Unit Listing []
Test Procedures/Specification []
Component Index []
ASME Coded Item []
Human Factor Consideration []
Computer Software []
Electric Circuit Schedule []
ICRS Procedure []
Process Control Manual/Plan []
Process Flow Chart []
Purchase Requisition []
Tickler File []
NA [X]
[]

20. 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

21. Approvals

	Signature	Date
Design Authority AT Kee		1/21/97
Cog. Eng. WS Edwards	WS Edwards	12/19/96
Cog. Mgr. JG Field	for Field	12/19/96
QA CR Hoover		12/19/96
Safety DW McNally	DW McNally	12/20/96
Environ.		
Other RW Rasmussen		1/16/97

	Signature	Date
Design Agent WS Edwards	WS Edwards	12/19/96
PE		
QA		
Safety		
Design		
Environ.		
Other		

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

1/29/97

ADDITIONAL

ENGINEERING CHANGE NOTICE CONTINUATION SHEET

Page 3 of 3

ECN 637767

Date 12/19/96

No. 13b. Continued

6. A paragraph was added to the accident conditions section (5.1.2) that describes the failure threshold development process, which involves analysis of the final design.

No. 14b. Continued

1. Continued

approached, so the old temperature requirement is outdated. Now, the MCO temperature requirement is to keep gas generation rates from causing an overpressurization event during transfer.

2. More current radiological source term information has become available and should be used.

3. This clarifies that the puncture drop occurs on the same concrete surface used for the drop accidents.

4. The current assumptions involve 835 W of decay heat and a temperature- and surface-area-dependent chemical reaction source term (mainly from uranium corrosion).

5. The contact surface dose rate limit is being revised to reflect Hanford Site limits. The previous limit was based on operational restrictions.

6. That paragraph will also explain very clearly that the accident conditions listed in the PDC were based on a preliminary risk analysis that looked at estimated worst-case accidents for the cask, not the actual failure thresholds of the final design (like the SARP does).

Packaging Design Criteria for the MCO Cask

W. S. Edwards
Rust Federal Services of Hanford Inc., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 637767 UC: 513
Org Code: 33120 Charge Code: LF037
B&R Code: 35EW31354 Total Pages: 60

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.

Printed in the United States of America. To obtain copies of this document, contact: WHC/BCS Document Control Services, P.O. Box 1970, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

JAN 30 1997
DATE:
HANFORD RELEASE
STA: 37
ID: 22

Chris Willingham 1-30-97
Release Approval Date

Release Stamp

Approved for Public Release

RECORD OF REVISION

(1) Document Number
WHC-SD-TP-PDC-030

Page 1

(2) Title
Packaging Design Criteria for the MCO Cask

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
1 RS	(7) Revisions throughout document to correlate with the procurement specification written for this cask system. Changes are administrative in content to support the design and fabrication of the packaging. A new dose consequence analysis is incorporated into Appendix A to account for the rerack fuel scenario. ECN 625287.	MD Clements M.D. Clements 12/28/95	JG Field 12/28/95
2	Revisions throughout document to update the neutron source term, to add a table describing the energy distribution of the (alpha,n) neutron source, to change the target for the normal condition of transport free drop from an unyielding surface to a more typical Hanford Site surface, to change cask contamination limits from DOT to Hanford Site limits, and to remove the requirement for volumetric inspection of the MCO closure weld. ECN 625363.	WS Edwards WS Edwards 3/29/96	JG Field 3/29/96
3 RS	Revisions throughout document to include discussion of and requirements for transfer of the MCO from the K Basins to the Cold Vacuum Drying Facility while filled with water. The radiological and gas generation source term was also updated to reflect the latest cask specification revision, descriptions of the current system and facilities were added, leak testing and containment requirements were clarified, criticality requirements were updated to reflect new Federal regulations, contamination limits were returned to DOT limits, and several other requirements were updated. ECN 630853.	WS Edwards WS Edwards 6/17/96	JG Field 6/17/96

RECORD OF REVISION	(1) Document Number HNF-SD-TP-PDC-030	Page 2

(2) Title
Packaging Design Criteria for the MCO Cask

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
	(7)		
4 RS	The maximum temperature requirement for the MCO shell under normal and accident conditions (Section 2.5.5) was changed to a requirement to keep the interior of the MCO cool enough to prevent a runaway uranium-water corrosion reaction. The radiological source term was updated. The puncture bar in the puncture accident was clarified to be located on a typical Hanford Site surface. The thermal source term was updated to reflect current assumptions. The contact dose rate requirement was revised to reflect typical onsite transportation limits. A paragraph was added to the accident conditions section (5.1.2) that describes the failure threshold development process, which involves analysis of the final design. ECN 637767.	WS Edwards WS Edwards 12/19/96	JG Field 12/19/96

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 6
  2.3 CHEMICAL CONSTITUENT SOURCE TERM 6
  2.4 GAS GENERATION 6
  2.5 THERMAL DESCRIPTION 8
    2.5.1 Thermal Source Term 8
    2.5.2 MCO Surface Emittance 8
    2.5.3 Payload and MCO Thermal Mass 8
    2.5.4 MCO Dimensions and Gross Weight 8
    2.5.5 Maximum MCO Temperature 8
  2.6 TRANSPORTATION CLASSIFICATION 8
  2.7 FISSILE CLASSIFICATION 9
  2.8 CONTENT RESTRICTIONS 9

3.0 FACILITY OPERATIONS 10
  3.1 ORIGINATING SITE--K BASINS 10
  3.2 INTERMEDIATE SITE--CVD FACILITY 10
  3.3 DESTINATION SITE--CSB 13

4.0 PACKAGING/TRANSPORT SYSTEM DESIGN 13
  4.1 GENERAL 13
  4.2 PACKAGING DESIGN CRITERIA 13
    4.2.1 Packaging Materials 13
    4.2.2 Fabrication Methods 15
    4.2.3 Packaging Dimensions 15
    4.2.4 Maximum Gross Weight 16
    4.2.5 Lifting and Tiedown Attachments 16
    4.2.6 Gas Generation and Venting 16
    4.2.7 Loading 16
    4.2.8 Draining 16
    4.2.9 Water Circulation 17
    4.2.10 Closure 17
    4.2.11 Containment 17
    4.2.12 Shielding 18
    4.2.13 Maintenance 18
    4.2.14 Life Cycle 18
  4.3 TRANSPORT SYSTEM 18
    4.3.1 General 18
    4.3.2 Truck Transport System 19
    4.3.3 Additional Requirements 19
  4.4 TIEDOWN SYSTEM 19

CONTENTS (cont.)

5.0 GENERAL REQUIREMENTS 20
  5.1 TRANSPORTATION SYSTEM 20
    5.1.1 Normal Conditions of Transfer 20
    5.1.2 Accident Conditions 23
  5.2 ALARA 26
  5.3 QA 26
    5.3.1 System Safety Class 27
  5.4 DESIGN FORMAT 27
  5.5 ENVIRONMENTAL COMPLIANCE 27
  5.6 MAINTENANCE 27
  5.7 SARP 27

6.0 REFERENCES 28

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 7
3 K Basin Layout 11
4 K Basin East and West Loadout Area 12
5 Canister Storage Building Loadout Area 14

LIST OF TABLES

1 Shielding Source Term 4
2 Dose Consequence Source Term 5
3 Criticality Source Term 6
4 Preliminary Dimensions and Weight of the MCO 9
5 External Cask Contamination Limits 10
6 Load Factors for Tiedown Systems 20
7 Hanford Air Temperature 21
8 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	*Code of Federal Regulations*
Ci	curie
CSB	Canister Storage Building
CVD	Cold Vacuum Drying
EDE	effective dose equivalent
g	gram
HRCQ	Highway Route Controlled Quantity
IAEA	International Atomic Energy Agency
in.	inch
kg	kilogram
km	kilometer
kPa	kilopascal
L/min	liters per minute
lb	pound
m	meter
MCO	Multicanister Overpack
mR/h	milliroentgen per hour
mrem/h	millirem 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

This page intentionally left blank.

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 approximately 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 Multicanister 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 Hanford contractors, including Quality Assurance and Safety, 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 top loaded into the MCO, which is located in the cask in the pool. The MCO shield plug/lid will be placed on the MCO, the package lifted out of the pool, the cask lid installed, and the package placed on its trailer for transfer to a Cold Vacuum Drying (CVD) Facility in the 100 K Area. Cold vacuum drying involves water circulation around the outside of the MCO and vacuum drying of the MCO. The MCO package will be transported from the K Basins to the CVD Facility with water covering the spent fuel inside the MCO. The MCO may be sealed either at the K Basins or the CVD Facility. After cold vacuum drying is complete, the MCO package will be transported to the CSB for further fuel conditioning and storage.

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 contains 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).

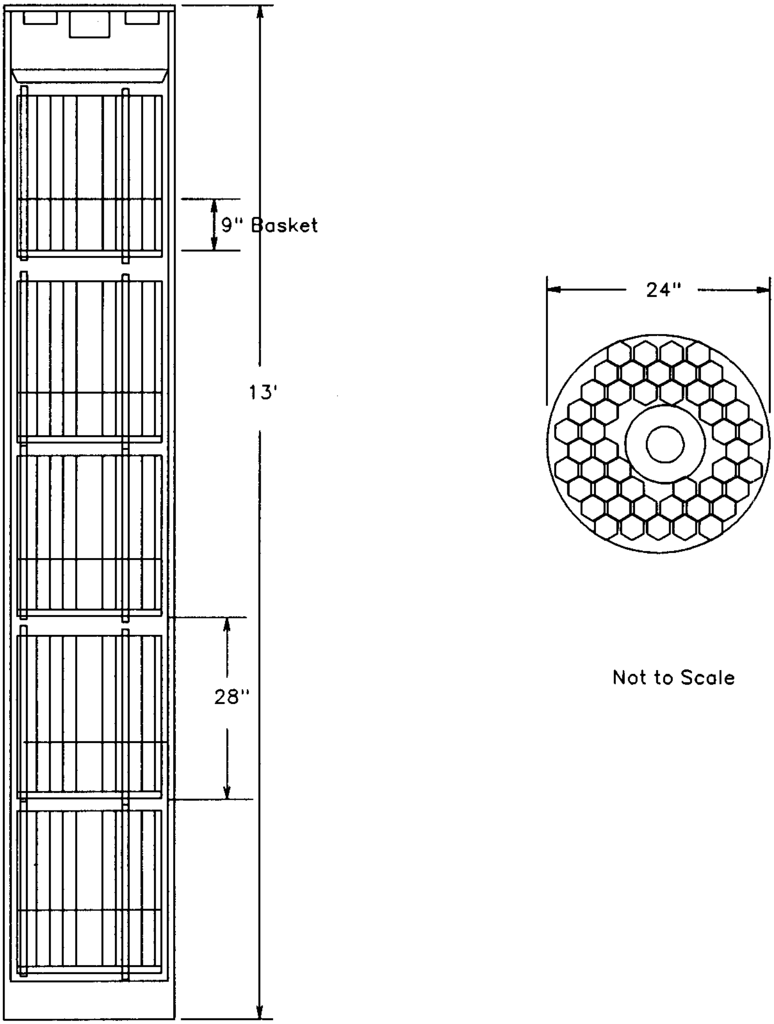
2.1.1 MCOs

The MCO will serve as a long-term storage vessel for the irradiated fuel elements, as well as the processing vessel during conditioning processes. The MCO payload configuration is shown in Figure 1. The MCO will be filled with water during transfer from the K Basins to the CVD Facility, but 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. Bounding worst-case shielding, dose consequence, and criticality source terms have been defined and are given in Tables 1, 2, and 3.

Figure 1. MCO Preliminary Design Description.



Not to Scale

Table 1. Shielding Source Term.

Isotope	Activity (Ci/MTU)	Activity (Ci/MCO)
^{3}H	4.11 E+01	2.6 E+02
^{14}C	5.27 E-01	3.3 E+00
^{55}Fe	5.85 E+00	3.7 E+01
^{60}Co	6.62 E+00	4.2 E+01
^{59}Ni	3.03 E-02	1.9 E-01
^{63}Ni	3.55 E+00	2.3 E+01
^{79}Se	6.23 E-02	3.9 E-01
^{85}Kr	6.38 E+02	4.0 E+03
^{90}Sr	8.27 E+03	5.2 E+04
^{90}Y	8.27 E+03	5.2 E+04
^{93}Zr	2.83 E-01	1.8 E+00
^{95}Zr	2.16 E-17	1.4 E-16
^{93m}Nb	1.35 E-01	8.6 E-01
^{95}Nb	4.78 E-17	3.0 E-16
^{95m}Nb	1.60 E-19	1.0 E-18
^{99}Tc	2.08 E+00	1.3 E+01
^{106}Ru	1.25 E+01	7.9 E+01
^{106}Rh	1.25 E+01	7.9 E+01
^{107}Pd	1.44 E-02	9.1 E-02
^{110}Ag	6.31 E-06	4.0 E-05
^{110m}Ag	4.73 E-04	3.0 E-03
^{113m}Cd	4.04 E+00	2.6 E+01
^{113m}In	6.42 E-11	4.1 E-10
^{113}Sn	6.42 E-11	4.1 E-10
^{119m}Sn	7.14 E-04	4.5 E-03
^{121m}Sn	6.74 E-02	4.3 E-01
^{123}Sn	9.12 E-09	5.8 E-08
^{126}Sn	1.22 E-01	7.7 E-01
^{125}Sb	1.09 E+02	6.9 E+02
^{126}Sb	1.71 E-02	1.1 E-01
^{126m}Sb	1.22 E-01	7.7 E-01
^{123m}Te	2.85 E-13	1.8 E-12
^{125m}Te	2.66 E+01	1.7 E+02
^{127}Te	3.04 E-10	1.9 E-09
^{127m}Te	3.10 E-10	2.0 E-09
^{129}I	4.88 E-03	3.1 E-02
^{134}Cs	1.23 E+02	7.8 E+02
^{135}Cs	5.77 E-02	3.7 E-01
^{137}Cs	1.14 E+04	7.2 E+04
^{137m}Ba	1.08 E+04	6.8 E+04
^{144}Ce	2.53 E+00	1.6 E+01
^{144}Pr	2.50 E+00	1.6 E+01
^{144m}Pr	3.03 E-02	1.9 E-01
^{147}Pm	1.18 E+03	7.5 E+03
^{151}Sm	1.08 E+02	6.8 E+02
^{152}Eu	1.24 E+00	7.9 E+00
^{154}Eu	2.08 E+02	1.3 E+03
^{155}Eu	3.63 E+01	2.3 E+02
^{153}Gd	6.04 E-06	3.8 E-05
^{160}Tb	9.46 E-19	6.0 E-18
^{234}U	3.92 E-01	2.5 E+00
^{235}U	1.31 E-02	8.3 E-02
^{236}U	7.12 E-02	4.5 E-01
^{238}U	3.35 E-01	2.1 E+00
^{237}Np	4.42 E-02	2.8 E-01
^{238}Pu	1.28 E+02	8.1 E+02
^{239}Pu	1.68 E+02	1.1 E+03
^{240}Pu	1.28 E+02	8.1 E+02
^{241}Pu	9.62 E+03	6.1 E+04
^{242}Pu	7.46 E-02	4.7 E-01
^{241}Am	2.85 E+02	1.8 E+03
^{242}Am	3.20 E-01	2.0 E+00
^{242m}Am	3.22 E-01	2.0 E+00
^{243}Am	2.22 E-01	1.4 E+00
^{242}Cm	2.65 E-01	1.7 E+00
^{244}Cm	4.69 E+00	3.0 E+01
Total	5.15 E+04	3.3 E+05

MCO = Multiple Canister Overpack.
MTU = Metric tons of uranium.

Table 2. Dose Consequence Source Term.

Isotope	Activity (Ci/MTU)	Activity (Ci/MCO)
^{3}H	2.67 E+01	1.7 E+02
^{14}C	5.53 E-01	3.5 E+00
^{55}Fe	6.05 E-01	3.8 E+00
^{60}Co	2.21 E+00	1.4 E+01
^{59}Ni	3.18 E-02	2.0 E-01
^{63}Ni	3.48 E+00	2.2 E+01
^{79}Se	6.54 E-02	4.1 E-01
^{85}Kr	3.80 E+02	2.4 E+03
^{90}Sr	7.00 E+03	4.4 E+04
^{90}Y	7.00 E+03	4.4 E+04
^{93}Zr	2.95 E-01	1.9 E+00
^{93m}Nb	1.91 E-01	1.2 E+00
^{99}Tc	2.19 E+00	1.4 E+01
^{106}Ru	3.41 E-02	2.2 E-01
^{106}Rh	3.41 E-02	2.2 E-01
^{107}Pd	1.56 E-02	9.9 E-02
^{110}Ag	1.09 E-09	6.9 E-09
^{110m}Ag	8.20 E-08	5.2 E-07
^{113m}Cd	2.83 E+00	1.8 E+01
^{113m}In	3.38 E-19	2.1 E-18
^{113}Sn	3.37 E-19	2.1 E-18
^{119m}Sn	9.42 E-08	6.0 E-07
^{121m}Sn	6.31 E-02	4.0 E-01
^{123}Sn	3.85 E-16	2.4 E-15
^{126}Sn	1.29 E-01	8.2 E-01
^{125}Sb	1.31 E+01	8.3 E+01
^{126}Sb	1.81 E-02	1.1 E-01
^{126m}Sb	1.29 E-01	8.2 E-01
^{123m}Te	3.60 E-21	2.3 E-20
^{125m}Te	3.20 E+00	2.0 E+01
^{127}Te	5.54 E-19	3.5 E-18
^{127m}Te	5.66 E-19	3.6 E-18
^{129}I	5.16 E-03	3.3 E-02
^{134}Cs	7.42 E+00	4.7 E+01
^{135}Cs	6.04 E-02	3.8 E-01
^{137}Cs	9.74 E+03	6.2 E+04
^{137m}Ba	9.22 E+03	5.8 E+04
^{144}Ce	1.15 E-03	7.3 E-03
^{144}Pr	1.13 E-03	7.2 E-03
^{144m}Pr	1.37 E-05	8.7 E-05
^{147}Pm	1.22 E+02	7.7 E+02
^{151}Sm	1.02 E+02	6.5 E+02
^{152}Eu	8.62 E-01	5.5 E+00
^{154}Eu	1.16 E+02	7.4 E+02
^{155}Eu	1.12 E+01	7.1 E+01
^{153}Gd	8.00 E-10	5.1 E-09
^{234}U	3.84 E-01	2.4 E+00
^{235}U	1.27 E-02	8.1 E-02
^{236}U	7.16 E-02	4.5 E-01
^{238}U	3.31 E-01	2.1 E+00
^{237}Np	4.66 E-02	3.0 E-01
^{238}Pu	1.34 E+02	8.5 E+02
^{239}Pu	1.73 E+02	1.1 E+03
^{240}Pu	1.37 E+02	8.7 E+02
^{241}Pu	6.96 E+03	4.4 E+04
^{242}Pu	8.71 E-02	5.5 E-01
^{241}Am	4.29 E+02	2.7 E+03
^{242}Am	3.72 E-01	2.4 E+00
^{242m}Am	3.73 E-01	2.4 E+00
^{243}Am	2.78 E-01	1.8 E+00
^{242}Cm	3.08 E-01	2.0 E+00
^{244}Cm	4.54 E+00	2.9 E+01
Total	4.16 E+04	2.6 E+05

MCO = Multiple Canister Overpack.
MTU = Metric tons of uranium.

Table 3. Criticality Source Term.*

Isotope	Mass (g/MCO)	Activity (Ci/MCO)
^{234}U	4.44 E+02	2.77 E-01
^{235}U	6.00 E+04	1.30 E-01
^{236}U	2.54 E+03	1.64 E-02
^{238}U	6.28 E+06	2.11 E+00
Total	6.34 E+06	2.53 E+00

MCO = Multiple Canister Overpack.
*Mark IV fuel initial composition.

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 purposes (see Table 1), 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). The dose consequence source term (see Table 2) is from N Reactor Mark IV fuel with 16.72% ^{240}Pu when discharged from the reactor on February 20, 1979, and decayed to December 1997. The criticality source term (see Table 3) shows the isotopic inventory for 6.34 metric tons of uranium of unirradiated Mark IV fuel with an enrichment of 0.947%.

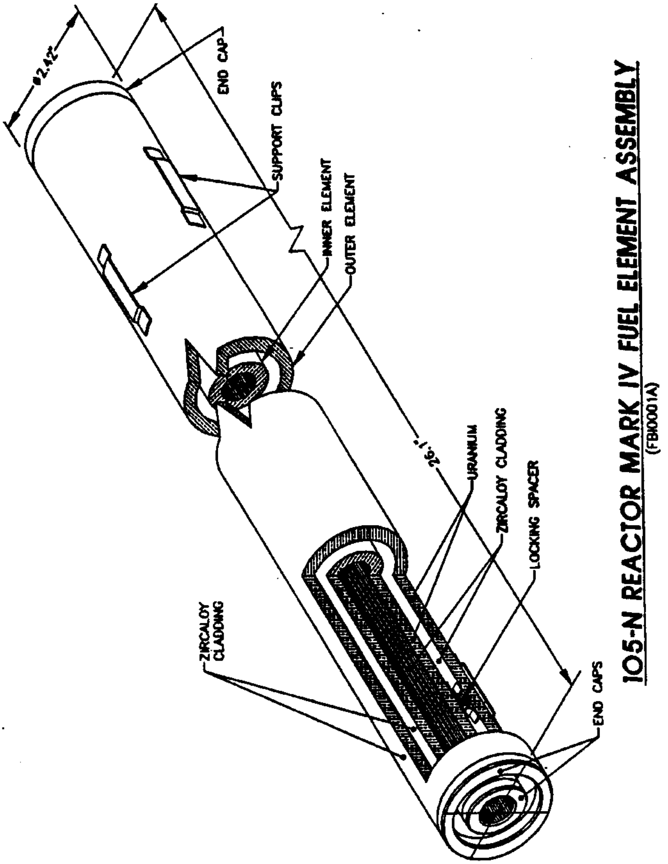
2.3 CHEMICAL CONSTITUENT SOURCE TERM

The MCO containing irradiated fuel may remain water-filled during transfer from the K Basins to the CVD Facility. There would be approximately 552 kg of water in the MCO during this transfer when all baskets within the MCO are filled with fuel. The reracked fuel will be cold vacuum dried within the MCO prior to transfer to the CSB.

2.4 GAS GENERATION

Gas will be produced in the MCO by three methods: uranium corrosion, radiolysis, and fission gas release from the spent fuel. Uranium corrosion and radiolysis produce hydrogen from the reaction of water with exposed uranium from damaged fuel. For both legs of transfer, the MCO will be backfilled with an inert gas, such as helium, argon, or nitrogen, to minimize oxygen present, which will preclude a hydrogen burn or formation of an explosive gas mixture. A shipping window for both legs of transfer will be established to preclude overpressurization of the package from the uranium corrosion reaction.

Figure 2. N Reactor Fuel Assembly.



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

The thermal source term for the fuel will be based on the properties of the fuel and sludge loaded into the MCO, as well as the chemical reaction rate between any water in the MCO and the fuel.

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 0.30.

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 transfer 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 4.

2.5.5 Maximum MCO Temperature

The maximum temperature allowed for the MCO shall be low enough to prevent a runaway uranium corrosion reaction from occurring during normal and accident conditions.

2.6 TRANSPORTATION CLASSIFICATION

For onsite 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.

Table 4. 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
Water weight	1,215 lb
MCO empty, no shield plug	1,900 lb
Weight of five loaded Mark IV fuel baskets	15,685 lb
MCO Shield Plug weight	1,360 lb

MCO = Multiple Canister Overpack.
*Top 8 in. has a 25.25-in. diameter.

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 criticality transport index of the shipment in the SARP. For the purposes of this PDC, the criticality transport index is assumed to be 100 ("N" = 0.5).

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. As stated in the *Bounding Particulate Contents of a Multi-Canister Overpack* (Pajunen 1996), each MCO will contain no more than 300 kg of sludge.

3.0 FACILITY OPERATIONS

3.1 ORIGINATING SITE--K BASINS

Loading of the MCO and packaging shall take place in the loadout pits of the K East and K West Basins (Figure 3). This facility is limited in space and lifting capabilities. The MCO is 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 5, prior to transportation. Prior to reuse of the cask, the cask internal cavity shall be decontaminated to less than 100 times the contamination limits set forth in Table 5. 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. The cask lid shall be installed before the package leaves the K Basins.

Table 5. External Cask Contamination Limits.

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

3.2 INTERMEDIATE SITE--CVD FACILITY

Draining of the water from the MCO, vacuum drying of the MCO, and sealing the MCO lid/shield plug onto the MCO will occur at the CVD Facility. The CVD Facility may be located in the K Basins facilities or within a separate building in the 100 K Area. If a CVD Facility is built away from the K Basins, the package will arrive at the CVD Facility on the trailer. The CVD Facility will perform all operations while the package is on the trailer. While at the CVD Facility, the MCO cask lid will be removed, and the MCO lid/shield plug will be sealed onto the MCO, if it was not sealed before it left the K Basins. The MCO will then be drained of water and vacuum dried. The cask lid will be installed before final shipment to the CSB.

Figure 3. K Basin Layout.

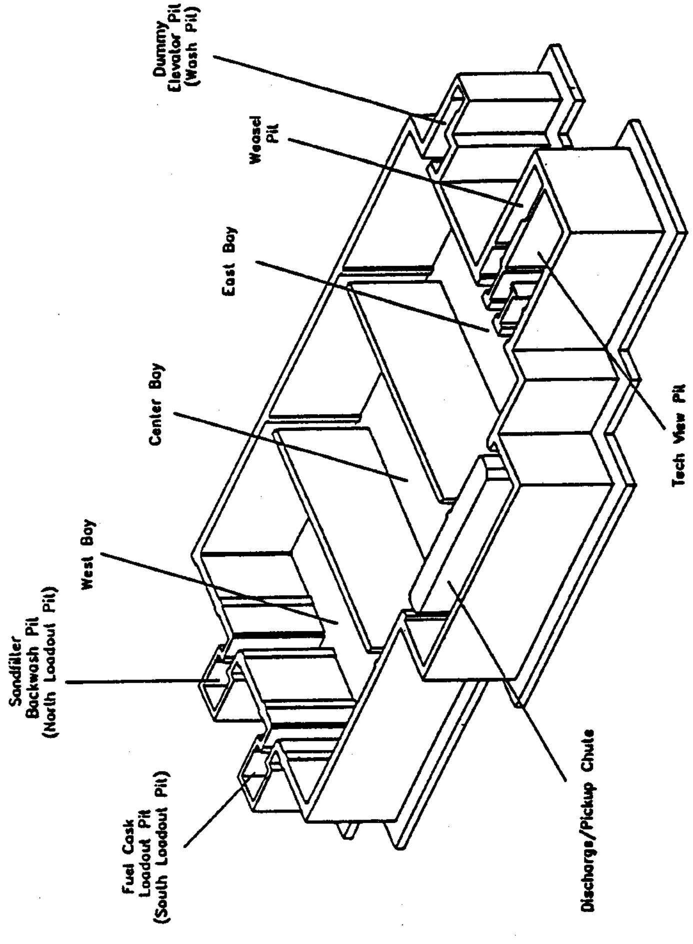
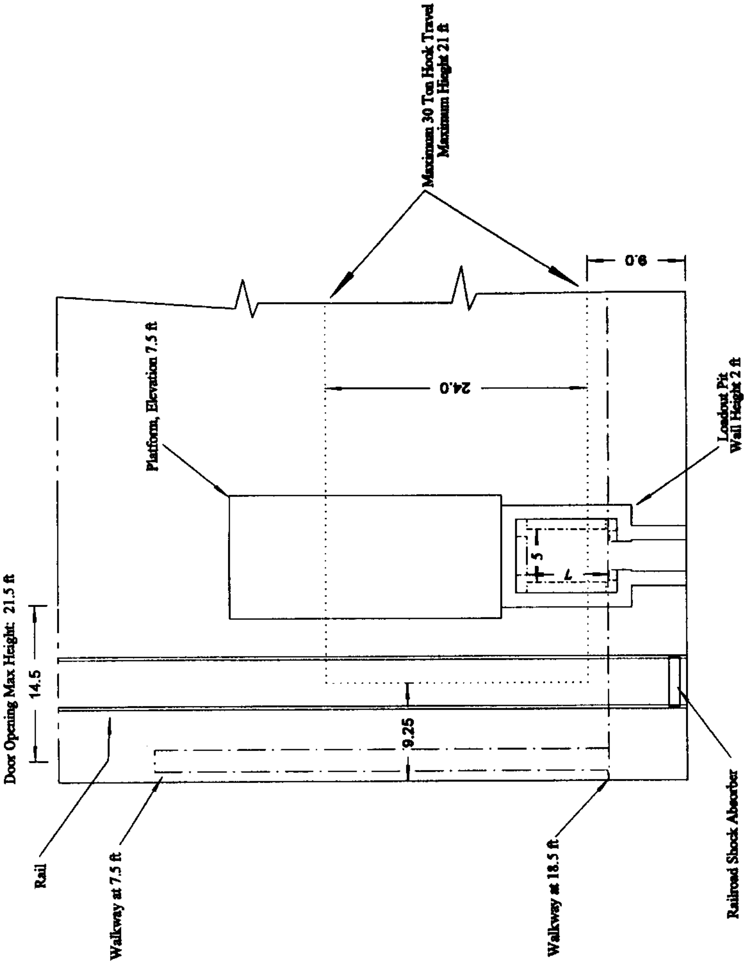


Figure 4. K Basin East and West Loadout Area.



3.3 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 packaging shall also be decontaminated to Table 5 limits and inspected, as needed, before transport back to the K Basins.

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 (Section 5.1.2) conditions. 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.

The packaging shall be designed to meet all Hanford Site "Master Safety Rules" referenced in WHC-CM-1-10, *Safety Manual*. The packaging shall also be designed to meet Occupational Safety and Health Administration standards per 29 CFR 1910 during normal operations, including loading, transport, unloading, and decontamination.

4.2 PACKAGING DESIGN CRITERIA

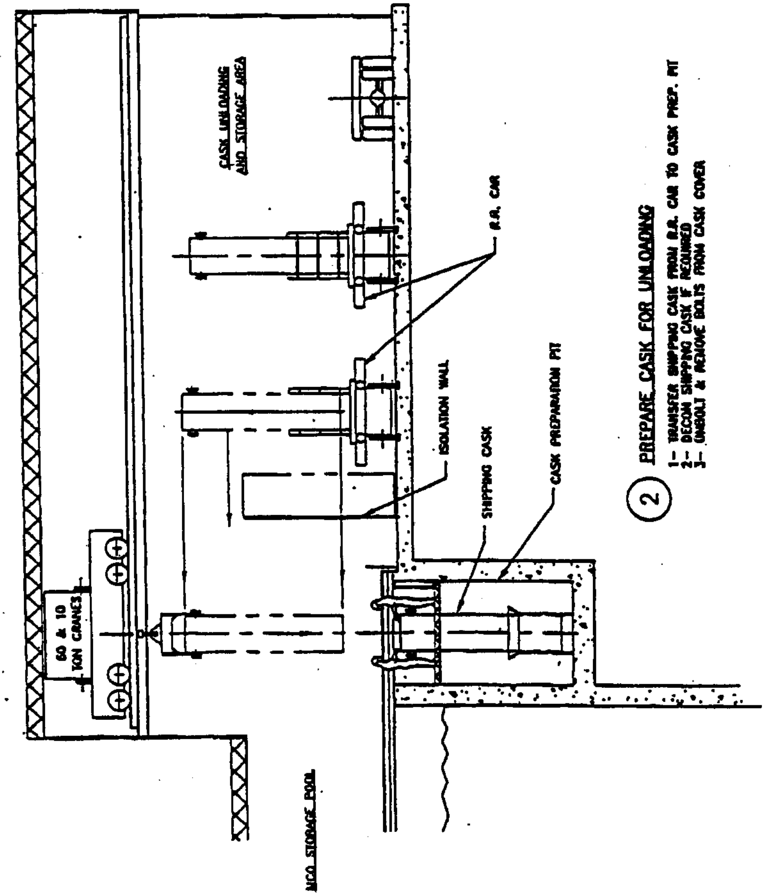
The MCO cask shall be designed as a reusable system capable of being loaded and unloaded both in air and underwater. The MCO cask shall be capable of carrying one MCO. The MCO cask design shall be such that the MCO may be sealed after being loaded into the packaging cavity. The cask will be top loaded. The cask design shall allow draining of water from the cask cavity prior to or after transport.

Package performance requirements will be verified through analysis, or a combination of analytical and test methods, for bounding case scenarios within the SARP.

4.2.1 Packaging Materials

The structural containment boundary materials for the packaging shall comply with material requirements identified in NUREG/CR-3854, *Fabrication*

Figure 5. Canister Storage Building Loadout Area.



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.

All materials shall be American Society of Mechanical Engineers (ASME) or American Society for Testing and Materials (ASTM)-certified materials or other national or industrial standards for materials other than steel or stainless steel that have been approved by the design authority. 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 MCO Cask shall be performed in accordance with ASME (1995) 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 (1995) Section III. Welds shall be inspected in accordance with the examination methods of ASME (1995) Section V, except as modified by the requirements of Section III. Welders shall be qualified per ASME (1995) 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 5 limits. Surface areas that may contact radioactive materials shall be designed for ease of decontamination.

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, with a shield plug that is 64.14 cm (25.25 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 60,000 lb (27,210 kg). The package shall be configured to be handled with the K Basin crane. The maximum lifting capacity of this crane is 30 tons (27,210 kg).

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 Gas Generation and Venting

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.

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 made 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.

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 packaging shall be designed so that during normal transfer conditions from the K Basins to the CVD Facility (Section 5.1.1.1), the package prevents leakage from exceeding Section 5.1.1.3 requirements, 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 (1995) Section III, Service Level A stress allowables shall be used for analytical acceptance.

The packaging shall be designed so that during normal transfer conditions from the CVD Facility to the CSB (Section 5.1.1.2), 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 (1995) 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) a single confinement barrier is maintained 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 (1995) 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.

The cask shall be designed so that it is leakage rate testable once loaded.

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, as defined by Sections 5.1.1.4 and 5.1.2.4.

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 WHC-SD-GN-DGS-30011, *Radiological Design Guide* (Evans 1994).

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 WHC-SD-GN-DGS-30011.

The SARP will address the necessary maintenance 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, installing the lid, 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 necessary to facilitate loading and handling of the package.

Transfer of the package from the K Basins to the CVD Facility in the 100 K Area for cold vacuum drying will be by truck/trailer. The maximum total loaded transfer distance will be approximately 0.8 km (0.5 mi). If not sealed at the K Basins, the MCO lid will be sealed to the MCO once at the CVD Facility. Other CVD Facility operations include completely draining the MCO of water, vacuum drying the fuel, and reinstalling the cask lid.

Transport of the package from the 100 K Area to the CSB in the 200 East Area for further conditioning and storage will be by truck/trailer. The total loaded transport distance will be approximately 16 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 transportation system may use a specially equipped trailer capable of transporting a minimum of one package per shipment. This trailer shall meet all applicable U.S. Department of Transportation standards and 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. Specific 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). That 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 (IAEA) Safety Series 37 (IAEA 1990). The tiedown attachments for those requirements shall be capable of resisting the forces for road, as described in Table 6.

Table 6. Load Factors for Tiedown Systems.

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

There are two distinct phases of transportation of the MCO cask package. The first phase is transfer from the K Basins to the CVD Facility with an MCO loaded with fuel and filled with water. The MCO lid may or may not be sealed onto the MCO during this phase. The second phase is transfer from the CVD Facility to the CSB with a sealed MCO loaded with fuel, but almost empty of water due to the cold vacuum drying process. This section address both distinct phases of transfer.

5.1.1 Normal Conditions of Transfer

For conditions normally incident to transfer, the SARP shall evaluate the packaging design for its ability to maintain containment, shielding, and nuclear criticality control when subjected to the following conditions. This section lists normal conditions of transfer for transfer of the package from K Basins to the CVD Facility and from the CVD Facility to the CSB. Conditions unique to the transfer of the package from the K Basins to the CVD Facility are identified in Sections 5.1.1.1, while conditions unique to the transfer of the package from the CVD Facility to the CSB are identified in Section 5.1.1.2.

- **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. Hanford Site environmental conditions are derived from WHC-SD-TP-RPT-004 (Fadeff 1992). The ambient temperatures at the Hanford Site for the peak summer month are tabulated in Table 7.

Table 7. Hanford Air Temperature.

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

- Maximum heat generation rate of worst-case source from Section 2.2 plus maximum solar heat load (see Table 8) 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 8. Maximum Solar Radiation Received from the Sun (BTU/h-ft^2).

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

Maximum accessible outside surface temperature of the cask shall be less than 85 °C (185 °F) in 100 °F 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.
- **Maximum 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 transfer from the 100 K West and East Basins to the CVD Facility and from the CVD Facility to the CSB in the 200 East Area by the selected transport vehicle. Tiedowns and hold-down bolts shall also be evaluated for this scenario.

- **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.

- **Package Remains on Trailer.** The package shall be evaluated to demonstrate that the package is not separated from the trailer when subjected to the conditions described in Section 4.4.

5.1.1.1 Normal Conditions of Transfer From K Basins to CVD Facility. The normal conditions of transfer that are unique for the transfer of the MCO cask from the K Basins to the CVD Facility are listed below. All conditions listed previously in Section 5.1.1 apply to this transfer, as well as the following.

Flat-Bottom Drop. The package shall be evaluated to demonstrate containment subsequent to a hard set-down defined by a drop flat onto the bottom of the package that causes a 5*g* impact to the package.

5.1.1.2 Normal Conditions of Transfer From CVD Facility to CSB. The normal conditions of transfer that are unique for transfer of the MCO cask from the CVD Facility to the CSB are listed below. All conditions listed previously in Section 5.1.1 apply to this transfer, as well as the following.

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, Grade 60, No. 7 rebar spaced 12. in. apart with 2-in. cover, each way, each face, and a Soil Modulus of Elasticity of 28,000 psi. 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 100*g*'s and shall maintain containment.

5.1.1.3 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" (leakage less than 10^{-7} std cc/sec). 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 transfer, the packaging shall be evaluated by analysis to meet the containment criteria listed above.

5.1.1.4 Shielding. The general surface dose on the accessible surface of the package shall not exceed 200 mrem/h. The maximum surface dose at any radiation hot spot on the package shall not exceed 1000 mrem/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.

5.1.1.5 Criticality. The package design shall ensure that the package 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 transfer, 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.
  - Moderation by water to the most reactive credible extent
  - Close reflection of the containment system by water on all sides or such greater reflection of the containment system as may additionally be provided by the surrounding material of the packaging.
- The package design shall also ensure that three packages stacked together in any arrangement with close full reflection on all sides of the stack by water will remain subcritical (as defined above).

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.

The conditions that follow are based on estimated worst-case accidents. These were developed based on the preliminary risk evaluation (Green 1996) and the operational restrictions predicted for the transfer. The SARP will analyze the cask design to determine actual failure thresholds of the package. The risk analysis in the SARP will evaluate those failure thresholds and use Hanford Site accident rates to show the package meets risk acceptance criteria.

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 46 °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.

This section lists accident conditions for transfer of the package from the K Basins to the CVD Facility and from the CVD Facility to the CSB. Accident conditions unique to the transfer of the package from the K Basins to the CVD Facility are identified in Section 5.1.2.1, while conditions unique to the transfer of the package from the CVD Facility to the CSB are identified in Section 5.1.2.2.

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. 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. The puncture bar is mounted on a 20-cm- (8-in.-) thick concrete horizontal surface with a concrete strength of 4,000 psi, Grade 60, No. 7 rebar spaced 30 cm (12 in.) apart with a 5-cm (2-in.) cover, each way, each face, and a Soil Modulus of Elasticity of 193,053 kPa (28,000 psi). Acceptance to this requirement is that there is no loss of shielding to the extent shown below in Section 5.1.2.2.

5.1.2.1 Accident Conditions for Transfer From K Basins to CVD Facility. The accident conditions that are unique for the transfer of the package from the K Basins to the CVD Facility are listed below. All conditions listed previously in Section 5.1.2 also apply to this transfer.

- **Impact**. The worst-case failure threshold evaluation for the packaging system will be a free drop of 21 ft onto an 8-in.-thick concrete surface with a concrete strength of 4,000 psi, Grade 60, No. 7 rebar spaced 12 in. apart with 2-in. cover, each way, each face, and a Soil Modulus of Elasticity of 28,000 psi. The package shall impact in an orientation expected to cause maximum damage.

- **Thermal**. The worst-case fire that the packaging system can be exposed to is a 15 minute, 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 preliminary risk evaluation (Green 1996) determined that evaluation of this thermal accident against the criteria of Section 5.1.2.3 would satisfy onsite transportation criteria. The SARP will also evaluate other less severe thermal accidents to ensure the criteria of Section 5.1.2.3 are satisfied.

  Active cooling of the package following the 15-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 maximum of 45 minutes. If needed, additional quenching water flow can be assumed for an additional period of 100 minutes at a maximum flow rate of 50 gal/min. Assume a water temperature of 29 °C (85 °F) for this procedure.

5.1.2.2 Accident Conditions for Transfer From CVD Facility to CSB. The following are accident conditions that are unique for transfer of the MCO cask from the CVD Facility to the CSB. All conditions listed previously in Section 5.1.2 also apply to this transfer.

- **Impact.** The worst-case failure threshold evaluation for the packaging system will be a free drop of 30 ft onto an 8-in.-thick concrete surface with a concrete strength of 4,000 psi, Grade 60, No. 7 rebar spaced 12 in. apart with 2-in. cover, each way, each face, and a Soil Modulus of Elasticity of 28,000 psi. The package shall impact in an orientation expected to cause maximum damage. The MCO shall not be exposed to greater than 100*g*'s during this drop scenario.

- **Thermal.** The worst-case fire that the packaging system can be exposed to during the transfer from the CVD Facility to the CSB is a 30 minute, 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. The preliminary risk evaluation (Green 1996) determined that evaluation of this thermal accident against the criteria of Section 5.1.2.3 would satisfy onsite transportation criteria. The SARP will also evaluate other less severe thermal accidents to ensure the criteria of Section 5.1.2.3 are satisfied.

  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 maximum of 45 minutes. If needed, additional quenching water flow can be assumed for an additional period of 100 minutes at a maximum flow rate of 50 gal/min. Assume a water temperature of 29 °C (85 °F) for this procedure.

5.1.2.3 Containment. During and subsequent to all credible or probable accident events, as described in Section 5.1.2, the packaging system shall provide the confinement function and meet the dose consequence criteria of the *Report on Equivalent Safety for Transportation of Radioactive Materials* (WHC 1994) for any release of radioactive material. A radiological risk evaluation will support the credible accident scenarios.

5.1.2.4 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.

5.1.2.5 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 5.1.1.5) 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.

5.1.2.6 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 (Mercado 1994).

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 49 CFR 173.443 (see Table 5), 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 MCO casks and their components shall be equivalent to the applicable portions of 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 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.

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, 1996, "Packaging and Transportation of Radioactive Material," *Code of Federal Regulations*, as amended.

29 CFR 1910, 1996, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

49 CFR 173, 1996, "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.

Evans, R. A., 1994, *Radiological Design Guide*, WHC-SD-GN-DGS-30011, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Fadeff, J. G., 1992, *Environmental Conditions for On-Site Hazardous Materials Packages*, WHC-SD-TP-RPT-004, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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.

H&R, 1995, *Recommended Onsite Transportation Risk Management Methodology*, 522-1, H&R Technical Associates, Inc., Oak Ridge, Tennessee.

HSRCM-1, 1994, *Hanford Site Radiological Control Manual*, Pacific Northwest Laboratory, Richland, Washington.

IAEA, 1990, *Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material*, Safety Series 37, 3rd Edition, International Atomic Energy Agency, Vienna, Austria.

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

NRC, 1991a, *Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches*, Regulatory Guide 7.11, U.S. Nuclear Regulatory Commission, Washington, D.C.

NRC, 1991b, *Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Wall Thickness Greater Than 4 Inches, But Not Exceeding 12 Inches*, Regulatory Guide 7.12, U.S. Nuclear Regulatory Commission, Washington, D.C.

NRC, 1984, *NRC IE Information Notice 84-72*, September 10, U.S. Nuclear Regulatory Commission, Washington, D.C.

Pajunen, 1996, *Bounding Particulate Contents of a Multi-Canister Overpack*, WHC-SD-SNF-TI-023, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Schwarz, R. A., 1995, *Neutron and Photon Baseline Source Terms for K-Basin Shielding*, Internal Memo 8M730-LLC-95-011R1, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-1-10, *Safety Manual*, Westinghouse Hanford Company, Richland, Washington.

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

WHC-CM-4-2, *Quality Assurance Manual*, Westinghouse Hanford Company, Richland, Washington.

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

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

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

WHC, 1995, *WHC Occupational ALARA Program*, WHC-IP-1043, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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

This page intentionally left blank.

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	6.5	0.15	41	^{147}Pm	1084.4	25.5	6875
^{85}Kr	611.5	14.36	3,877	^{151}Sm	102.7	2.41	651
^{90}Sr	7,893.6	185.35	50,045	^{154}Eu	215.1	5.05	1364
^{90}Y	7,893.6	185.35	50,045	^{155}Eu	16.4	0.39	104
^{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	115.0	2.70	729
^{125m}Te	24.1	0.57	153	^{241}Pu	9,140.9	214.64	57,953
^{134}Cs	115.0	2.70	729	^{241}Am	269.7	6.33	1710
^{137}Cs	10,735.4	252.08	68,062	^{244}Cm	3.9	0.09	25
^{137m}Ba	10,162.8	238.64	64,432				

MCO = Multiple Canister Overpack.
MTU = Metric tons of uranium.

5.0 ACCIDENT SCENARIOS/INITIATING EVENTS

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

The possible cause of a fire accident 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 x 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 x 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 x 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
^{3}H	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 the appendix.

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/m^3, 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

[1] The 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.

[2] The 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 x 10^4 and 1.2 x 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

DOE, 1992, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, DOE-STD-1027-92, U.S. Department of Energy, Washington, D.C.

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

Hartmann, I., J. Nagy, and M. Jacobson, 1951, *The Explosive Characteristics of Ti, Zr, Th, U and Their Hydrides*, U.S. Bureau of Mines Report 4835.

Napier, B. A., et al., 1988, *GENII - The Hanford Environmental Radiation Dosimetry Software System*, PNL-6484, Pacific Northwest Laboratory, Richland, Washington.

Peacock, H. B., 1992, *Pyrophoricity of Uranium*, WSRC-TR-92-106, Savannah River Laboratory, Aiken, South Carolina.

Savino, A. V., 1995, *Preliminary Dose Consequence Study for the Hanford Interarea Protective Package Overpack (HIPPO)*, 8M400-AVS-95-007, Draft, Westinghouse Hanford Company, Richland, Washington.

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

APPENDIX

GENII INPUT FILES

```
######################### Program GENII Input File ########### 8 Jul 88 ####
Title: PROJECT K BASIN ACUTE ONSITE INDIVIDUAL DOSES RELEASE
      \GENII\KBASINR.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   Water  |
     nuclide |/yr    /yr     /m3     |/m3    /unit   /m3     /L      /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-  |Plant   Product Water   Food   |
     nuclide |/kg     /kg     /L      /kg    |
     --------|------- ------- ------- -------|
```

```
TIME ######################################################################

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

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

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

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

TRANSPORT #################################################################

           ====AIR TRANSPORT===================================SECTION 1=====
                   0-Calculate PM             ¦0         Release type (0-3)
1          Option: 1-Use chi/Q or PM value    ¦F         Stack release (T/F)
                   2-Select MI dist & dir     ¦0         Stack height (m)
                   3-Specify MI dist & dir    ¦0         Stack flow (m3/sec)
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 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
            1-Use population-weighted chi/Q
            2-Use uniform production
            3-Use chi/Q and production grids (PRODUCTION will be overridden)
0         Population ingesting aquatic foods, 0 defaults to total (person)
0         Population ingesting drinking water, 0 defaults to total (person)
F         Consider dose from food exported out of region (default=F)

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

F         Salt water? (default is fresh)

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

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

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

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

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

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

```
######################### Program GENII Input File ########### 8 Jul 88 ####
Title: PROJECT K BASIN ACUTE OFFSITE INDIVIDUAL DOSES RELESAE
     \GENII\KBASNRFR.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   Water  |
     nuclide |/yr     /yr     /m3    |/m3     /unit   /m3     /L      /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-  |Plant   Product Water   Food   |
     nuclide |/kg     /kg     /L      /kg    |
     --------|------- ------- ------- -------|

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

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

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

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

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

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

TRANSPORT ###################################################################

           ====AIR TRANSPORT===================================SECTION 1=====
                   0-Calculate PM            |0         Release type (0-3)
1          Option: 1-Use chi/Q or PM value   |F         Stack release (T/F)
                   2-Select MI dist & dir    |0         Stack height (m)
                   3-Specify MI dist & dir   |0         Stack flow (m3/sec)
1.54E-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
                                                 | 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
             1-Use population-weighted chi/Q
             2-Use uniform production
             3-Use chi/Q and production grids (PRODUCTION will be overridden)
0          Population ingesting aquatic foods, 0 defaults to total (person)
```

```
0         Population ingesting drinking water, 0 defaults to total (person)
F         Consider dose from food exported out of region (default=F)

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

F         Salt water? (default is fresh)

          USE        TRAN-  PROD-    -CONSUMPTION- |
          ?   FOOD   SIT    UCTION   HOLDUP   RATE |
          T/F TYPE   hr     kg/yr    da      kg/yr |      DRINKING WATER
          --- ------ -----  -------  ------  ----- |------------------------
          F   FISH    0.00  0.0E+00   0.00     0.0 | 0      Source(see above)
          F   MOLLUS  0.00  0.0E+00   0.00     0.0 | T      Treatment? T/F
          F   CRUSTA  0.00  0.0E+00   0.00     0.0 | 0      Hldup/transit(da)
          F   PLANTS  0.00  0.0E+00   0.00     0.0 | 0      Consumpton(L/yr)

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

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

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

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

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

```
######################### Program GENII Input File ###########  8 Jul 88 ####
Title: PROJECT K BASIN ACUTE OFFSITE INDIVIDUAL DOSES RELESAE
       \GENII\KBASNFR.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   Water  |
     nuclide |/yr    /yr     /m3     |/m3    /unit   /m3     /L      /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-  |Plant   Product Water   Food   |
     nuclide |/kg     /kg     /L      /kg    |
     --------|------- ------- ------- -------|

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

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

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

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

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

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

TRANSPORT ##################################################################

           ====AIR TRANSPORT===================================SECTION 1=====
                   0-Calculate PM               |0        Release type (0-3)
1          Option: 1-Use chi/Q or PM value      |F        Stack release (T/F)
                   2-Select MI dist & dir       |0        Stack height (m)
                   3-Specify MI dist & dir      |0        Stack flow (m3/sec)
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
             1-Use population-weighted chi/Q
             2-Use uniform production
             3-Use chi/Q and production grids (PRODUCTION will be overridden)
0          Population ingesting aquatic foods, 0 defaults to total (person)
```

```
0          Population ingesting drinking water, 0 defaults to total (person)
F          Consider dose from food exported out of region (default=F)

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

F          Salt water? (default is fresh)

           USE        TRAN-  PROD-    -CONSUMPTION- |
           ?   FOOD   SIT    UCTION   HOLDUP   RATE |
           T/F TYPE   hr     kg/yr    da      kg/yr |      DRINKING WATER
           --- ------ -----  -------  ------  ----- |------------------------
           F   FISH    0.00  0.0E+00   0.00    0.0  | 0      Source(see above)
           F   MOLLUS  0.00  0.0E+00   0.00    0.0  | T      Treatment? T/F
           F   CRUSTA  0.00  0.0E+00   0.00    0.0  | 0      Hldup/transit(da)
           F   PLANTS  0.00  0.0E+00   0.00    0.0  | 0      Consumpton(L/yr)

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

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

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

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

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

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 6/6/95
HEDOP-Approved Reviewer (Printed Name and Signature) 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.
☒	☐	☐	Software output consistent with input and with results reported in document reviewed.
☒	☐	~~☒~~ BEH	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.

Brit E. Hey — 6/1/95

Reviewer (Printed Name and Signature) — Date

This page intentionally left blank.

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	From	Page 1 of 1
Distribution	Packaging Engineering	Date 12/19/96
Project Title/Work Order Packaging Design Criteria for the MCO Cask (HNF-SD-TP-PDC-030)		EDT No. NA ECN No. 637767

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
W. S. Edwards	G1-12	X			
J. G. Field	G1-11	X			
C. R. Hoover	G1-11	X			
A. T. Kee	R3-86	X			
D. W. McNally	G1-11	X			
R. W. Rasmussen	R3-86	X			
S. S. Shiraga	G1-11	X			
Central Files	A3-88	X			
Document Processing Center	A3-94	X			
HNF-SD-TP-PDC-030 File	G1-11	X			