2. ECN Category (mark one)
Supplemental [ ] Direct Revision [x] Change ECN [ ] Temporary [ ] Standby [ ] Supersede [ ] Cancel/ Void [ ]

3. Originator's Name, Organization, MSIN and Telephone No.
R. J. Smith HI-19 375-5080

4. USQ Required?
[ ] Yes [x] No

5. Date
06/21/00

6. Project Title/No./Work Order No.
Spent Nuclear Fuel Project, Shippingport Fuel

7. Bldg./Sys./Fac.
NA

8. Approval Designator
SQ

9. Document Numbers Changed by this ECN
HNF-SD-TP-PDC-030, Rev. 4

10. Related ECN No(s).
NA

11. Related PO No.
NA

12a. Modification Work
[ ] Yes (fill out Blk 12b)
[x] No (NA Blks. 12b, 12c, 12d)

12b. Work Package No.
NA

12c. Modification Work Complete
NA

12d. Restored to Original Condition
(Temp. or Standby ECN only)
NA

13a. Description of Change
1. The primary purpose of this Engineering Change Notice is to add criteria necessary to support the inclusion of the Shippingport fuel assembly and canister as an additional payload in the MCO Cask. This change affects most sections of the PDC, but it is most significant in Section 2.0, "Package Contents," and Section 3.0, "Facility Operations."

2. References are updated throughout the document to reflect the change from WHC manuals to FH procedures.

3. References to K Basin sludge have been removed throughout the document.

4. The source term for the N Reactor fuel in Section 2.2.1 is updated.

5. A new reference to Marlow (1997) soil properties has been added to several subsections within Section 5.0, "General Requirements."

6. The 5g hard set-down requirement in Section 5.1.1.1 has been eliminated.

7. Section 2.5.4, "MCO Dimensions and Gross Weight," has been eliminated.

8. Sections 5.2, "ALARA"; 5.4, "Design Format"; and 5.5, "Environmental Compliance," have been eliminated.

9. The Quality Assurance (Section 5.2) requirements have been updated.

13b. Design Baseline Document? [ ] Yes [x] No

14a. Justification (mark one)
Criteria Change [x] Design Improvement [ ] Environmental [ ] Facility Deactivation [ ]
As-found [ ] Facilitate Const [ ] Const. Error/Omission [ ] Design Error/Omission [ ]

14b. Justification Details
1. Project requires the use of the MCO Cask for shipment of Shippingport fuel assemblies from T Plant to CSB. Source term, canister, and operational criteria are necessary to support the next revision to the MCO Cask onsite SARP.

2. References are updated as required to reflect the new Hanford Site procedures since the change from WHC to FH, and to achieve consistency with references used in the current revision of the MCO SARP.

3. Sludge is not currently authorized payload in the MCO Cask.

4. The most current radiological specifications for the N Reactor fuel must be used, to maintain consistency with other safety basis documents.

5. The most current soil properties are specified, to maintain consistency with impact analyses presented in other safety basis documents.

6. The 5g hard set-down requirement is bounded by the normal conditions free-drop requirements.

7. Section 2.5.4 was redundant with other sections.

8. Because the designs, hardware, and operational specifications for the MCO Cask and internals already exist, Sections 5.2, 5.4, and 5.5 are not needed. Of note, new FH manuals and HNF-PROs have replaced the WHC procedures specified by these sections.

9. QA manual requirements needed to be updated to FH requirements, and terminology (safety class vs. THI) required clarification.

Design verification of this change was performed, and the change(s) were found not to adversely impact the underlying safety bases and parameters of the package.

Verification performed by P. C. Ferrell.

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

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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.

### 21. Approvals

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DEPARTMENT OF ENERGY
Signature of a Control Number that tracks the Approval Signature
Packaging Design Criteria for the MCO Cask

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

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

Fluor Hanford
P.O. Box 1000
Richland, Washington

Approved for public release; further dissemination unlimited
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Document Type: DC
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B. D. Flanagan
Waste Management Federal Services, Inc., A Subsidiary of GTS Duratek

Date Published
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Printed in the United States of America
Key Words: Multi-canister Overpack, fuel elements, K Basins, Canister Storage Building, CSB, package, Shippingport, T Plant, N Reactor, 327 Laboratory

Abstract: Approximately 2,100 metric tons of unprocessed, irradiated, nuclear fuel elements are presently stored in the K Basins (including approximately 700 additional elements from the Plutonium-Uranium Extraction Plant, N Reactor, and 327 Laboratory). 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. 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 Multi-canister Overpacks. Concurrent with the K Basin cleanup, 72 Shippingport Pressurized Water Reactor Core 2 fuel assemblies will be transported from T Plant to the CSB to provide space at T Plant for K Basin sludge canisters
**Packaging Design Criteria for the MCO Cask**

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<td>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 re-rack fuel scenario. ECN 625287.</td>
<td>HD Clements 12/28/95 1/29/95</td>
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<td>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.</td>
<td>WS Edwards 3/24/96 3/29/96</td>
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<td>3</td>
<td>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.</td>
<td>WS Edwards 6/17/96 6/19/96</td>
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### CHANGE CONTROL RECORD

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<td>4</td>
<td>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.</td>
<td>WS Edwards Judy Field</td>
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<td>5</td>
<td>Adds criteria necessary to support the inclusion of the Shippingport fuel assembly and canister as an additional payload in the MCO cask, primarily affecting Sections 2.0 and 3.0. Updates references from WHC manuals to FH procedures. Removes references to K Basin sludge. Updates source term for N Reactor fuel. Adds new reference to Marlow (1997) soil properties within Section 5.0. Eliminates the 5g hard set-down requirement in Section 5.1.1.1. Eliminates sections on &quot;MCO Dimensions and Gross Weight,&quot; &quot;ALARA,&quot; &quot;Design Format,&quot; and &quot;Environmental Compliance.&quot; Updates QA requirements in Section 5.2. ECN 656499.</td>
<td>BD Flanagan DW Bergmann</td>
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<td>ANSI</td>
<td>American National Standards Institute</td>
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<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
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<tr>
<td>BPVC</td>
<td>Boiler and Pressure Vessel Code</td>
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<tr>
<td>Btu/h-ft²</td>
<td>British thermal units per hour-square foot</td>
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<tr>
<td>Ci/MCO</td>
<td>curies per Multi-canister Overpack</td>
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<td>Ci/MTU</td>
<td>curies per metric ton of uranium</td>
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<td>cm</td>
<td>centimeter</td>
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<td>CSB</td>
<td>Canister Storage Building</td>
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<td>CVD</td>
<td>cold vacuum drying</td>
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<td>dpm/cm²</td>
<td>disintegrations per minute per square centimeter</td>
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<td>μCi/cm²</td>
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<td>psig</td>
<td>pounds per square inch, gauge</td>
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<td>standard cubic centimeters per second</td>
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PACKAGING DESIGN CRITERIA FOR
THE MCO CASK

1.0 INTRODUCTION

1.1 BACKGROUND

Approximately 2,100 metric tons of unprocessed, irradiated nuclear fuel elements are presently stored in the K Basins (including approximately 700 additional elements from the Plutonium-Uranium Extraction Plant, 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. Concurrent with the K Basin cleanup, 72 Shippingport Pressurized Water Reactor (PWR) Core 2 fuel assemblies will be transported from T Plant to the CSB to provide space at T Plant for K Basin sludge canisters. The current plan calls for the initiation of fuel transport by November 2000.

1.2 PURPOSE

The purpose of this packaging design criteria (PDC) is to provide criteria for the design, fabrication, safety analysis, and use of a packaging system to transport large quantities of irradiated nuclear fuel elements from the K Basins positioned in Multi-canister Overpacks (MCO), within the boundaries of the Hanford Site. Similarly, this PDC will also provide the criteria for the onsite transport of Shippingport fuel in the MCO Cask, utilizing the Shippingport Spent Fuel Canister (SSFC) in place of the MCO. 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 onsite Safety Analysis Report for Packaging (SARP). 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 a Safety Review Board of Fluor Project Hanford contractors, including Quality Assurance and Safety.

1.3 SYSTEM DESCRIPTION AND DEFINITIONS

This PDC defines the requirements for the MCO cask and conveyance. The MCO cask provides the containment and shielding for the transportation of the spent fuel payload. Criticality control is maintained by the configuration of the MCO and internal baskets for the K Basin fuel or by the fissile quantity and low enrichment of the payload itself for the Shippingport fuel. For the purposes of this PDC, the following definitions apply.
MCO Cask: The packaging used to transport spent fuel to the CSB, either in an MCO or SSFC.

Packaging: The MCO cask without its payload.

Package: The MCO cask with its payload.

Payload: Either an MCO with N Reactor spent fuel from the K Basins or an SSFC with Shippingport spent fuel from T Plant.

MCO: Multi-canister Overpack for the conditioning, transport, and storage of spent fuel from the K Basins.

SSFC: Shippingport Spent Fuel Canister for the conditioning, transport, and storage of Shippingport spent fuel from T Plant.

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 or Shippingport spent fuel within the constraints of the project baseline. The project requires that the spent nuclear fuel be moved in MCOs or SSFCs, respectively. The only onsite packaging system that may be compatible is the three-well-railcar system, which is geometrically incompatible with the payload. Also, the rail system at Hanford is shut down. Therefore, a packaging and transportation system was developed to 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 or SSFC that contains irradiated fuel elements or assemblies. MCOs and SSFCs are 61 cm (24-in. [outside diameter]) stainless steel pipe approximately 406 cm (160 in.) long, with the K Basin fuel elements in stacked baskets or Shippingport fuel assemblies with the SSFC insert inside.

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. The approximate weight of a fully loaded MCO will be 9,353 kg (20,620 lb) wet or 8,831 kg (19,470 lb) dry. The approximate weight of an empty (no baskets or fuel) MCO is 1,579 kg (3,480 lb) dry.
Figure 1. Multicanister Overpack Configuration.
2.1.2 SSFCs

The SSFC will serve as a long-term storage vessel for the irradiated Shippingport PWR Core 2 fuel elements, as well as the processing vessel during conditioning processes. The SSFC payload configuration is shown in Figure 2. The SSFC will be loaded and vacuum dried at T Plant prior to shipment to the CSB. The approximate maximum weight of a fully loaded SSFC will be 4,084 kg (9,004 lb) dry. The approximate SSFC empty weight (no insert or fuel) will be 1,564 kg (3,448 lb).

2.2 RADIOLOGICAL DESCRIPTION

The following describes the radiological source term for the MCO and SSFC payloads.

2.2.1 N Reactor Fuel

The N Reactor irradiated fuel (Figure 3) currently located at the K Basins 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 heat generation/dose consequence and shielding source terms have been defined and are given in Tables 1 and 2. A detailed description of the source term is provided in HNF-SD-SNF-TI-009, 105-K Basin Material Design Basis Feed Description for Spent Nuclear Fuel Project Facilities, Volume 1, Fuel (Packer 1999). Fuel has been stored at the K Basins for approximately 8 to 30 years. The decay date selected for presenting radionuclide inventories and bounds is May 31, 1998. This date is consistent with Packer 1999 and HNF-SD-SNF-SARR-005, Multi-Canister Overpack Topical Report (Lorenz et al. 2000).

The heat generation source term was selected by determining the fuel lot capable of generating the most heat within an MCO loaded with 6.34 MTU of Mark IV fuel. The dose consequence source term has the highest heat generation on a per-assembly basis (Packer 1999). This source term is shown in Table 1.

The shielding source term was selected on the basis of the fuel having the highest $^{137}$Cs content, because it is the major gamma contributor. The fuel with the highest $^{137}$Cs content is Mark IV fuel with a $^{240}$Pu content of 15.74% when discharged from the reactor. For conservatism, the shielding source term is defined as 16% $^{239}$Pu Mark IV fuel that has been aged 13.5 years to May 31, 1998. This source term is shown in Table 2.

Unirradiated Mark IA and Mark IV fuel is used as the basis for the criticality source term. Mark IA fuel has two uranium enrichments, 0.95% and 1.25% $^{235}$U. The Mark IV fuel has one enrichment, 0.95% $^{235}$U. Further details concerning the fuel criticality source term is described in HNF-SD-SNF-CSER-005, Criticality Safety Evaluation Report for the Multi-Canister Overpack (Kessler 2000).
Figure 2. Shippingport Spent Fuel Canister Configuration.
Figure 3. N Reactor Fuel Assembly.
Table 1. Dose Consequence and Heat Generation Source Term for a Multi-canister Overpack (MCO).

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Activity (Ci/MTU)</th>
<th>Activity (Ci/MCO)</th>
<th>Isotope</th>
<th>Activity (Ci/MTU)</th>
<th>Activity (Ci/MCO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^3$H</td>
<td>2.61 E+01</td>
<td>1.65 E+02</td>
<td>$^{129}$I</td>
<td>5.16 E-03</td>
<td>3.27 E-02</td>
</tr>
<tr>
<td>$^{14}$C</td>
<td>5.53 E-01</td>
<td>3.51 E+00</td>
<td>$^{134}$Cs</td>
<td>6.47 E+00</td>
<td>4.10 E+01</td>
</tr>
<tr>
<td>$^{55}$Fe</td>
<td>5.41 E-01</td>
<td>3.43 E+00</td>
<td>$^{133}$Cs</td>
<td>6.04 E-02</td>
<td>3.83 E-01</td>
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<tr>
<td>$^{60}$Co</td>
<td>2.09 E+00</td>
<td>1.33 E+01</td>
<td>$^{137}$Cs</td>
<td>9.66 E+03</td>
<td>6.12 E+04</td>
</tr>
<tr>
<td>$^{59}$Ni</td>
<td>3.18 E-02</td>
<td>2.02 E-01</td>
<td>$^{137m}$Ba</td>
<td>9.14 E+03</td>
<td>5.79 E+04</td>
</tr>
<tr>
<td>$^{60}$Ni</td>
<td>3.47 E+00</td>
<td>2.20 E+01</td>
<td>$^{144}$Ce</td>
<td>7.91 E-04</td>
<td>5.01 E-03</td>
</tr>
<tr>
<td>$^{79}$Se</td>
<td>6.54 E-02</td>
<td>4.15 E-01</td>
<td>$^{144}$Pr</td>
<td>7.82 E-04</td>
<td>4.96 E-03</td>
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<tr>
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<td>2.35 E+03</td>
<td>$^{144m}$Pr</td>
<td>9.48 E-06</td>
<td>6.01 E-05</td>
</tr>
<tr>
<td>$^{90}$Sr</td>
<td>6.93 E+03</td>
<td>4.39 E+04</td>
<td>$^{147}$Pm</td>
<td>1.09 E+02</td>
<td>6.91 E+02</td>
</tr>
<tr>
<td>$^{90}$Y</td>
<td>6.93 E+03</td>
<td>4.39 E+04</td>
<td>$^{151}$Sm</td>
<td>1.02 E+02</td>
<td>6.47 E+02</td>
</tr>
<tr>
<td>$^{92}$Zr</td>
<td>2.95 E-01</td>
<td>1.87 E+00</td>
<td>$^{152}$Eu</td>
<td>8.45 E-01</td>
<td>5.36 E+00</td>
</tr>
<tr>
<td>$^{93}$mNb</td>
<td>1.93 E-01</td>
<td>1.22 E+00</td>
<td>$^{150}$Eu</td>
<td>1.13 E+02</td>
<td>7.16 E+02</td>
</tr>
<tr>
<td>$^{99}$Tc</td>
<td>2.19 E+00</td>
<td>1.39 E+01</td>
<td>$^{155}$Eu</td>
<td>1.06 E+01</td>
<td>6.72 E+01</td>
</tr>
<tr>
<td>$^{106}$Ru</td>
<td>2.56 E-02</td>
<td>1.62 E+01</td>
<td>$^{155}$Gd</td>
<td>5.19 E+10</td>
<td>3.29 E+09</td>
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<td>$^{106}$Rh</td>
<td>2.56 E-02</td>
<td>1.62 E+01</td>
<td>$^{234}$U</td>
<td>3.84 E-01</td>
<td>2.43 E+00</td>
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<tr>
<td>$^{107}$Pd</td>
<td>1.56 E-02</td>
<td>9.89 E-02</td>
<td>$^{235}$U</td>
<td>1.27 E+02</td>
<td>8.05 E-02</td>
</tr>
<tr>
<td>$^{110}$Ag</td>
<td>7.17 E-10</td>
<td>4.55 E-09</td>
<td>$^{236}$U</td>
<td>7.16 E-02</td>
<td>4.54 E-01</td>
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<tr>
<td>$^{110m}$Ag</td>
<td>5.39 E-08</td>
<td>3.42 E-07</td>
<td>$^{238}$U</td>
<td>3.31 E-01</td>
<td>2.10 E+00</td>
</tr>
<tr>
<td>$^{113}$mCd</td>
<td>2.78 E+00</td>
<td>1.76 E+01</td>
<td>$^{237}$Np</td>
<td>4.66 E-02</td>
<td>2.95 E-01</td>
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<tr>
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<td>8.43 E+02</td>
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<td>8.62 E-19</td>
<td>$^{239}$Pu</td>
<td>1.73 E+02</td>
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<td>1.37 E+02</td>
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<td>8.71 E+02</td>
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<td>$^{241}$Am</td>
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<td>$^{242}$Am</td>
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<td>8.18 E-01</td>
<td>$^{242m}$Am</td>
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<td>2.36 E+00</td>
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<td>9.51 E-21</td>
<td>$^{243}$Am</td>
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<td>$^{242}$Cm</td>
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<td>1.37 E-18</td>
<td>$^{244}$Cm</td>
<td>4.47 E+00</td>
<td>2.83 E+01</td>
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</table>

MTU = Metric ton of uranium.
Totals  | 4.11 E+04        | 2.61 E+05         |
Table 2. Shielding Source for a Multi-canister Overpack (MCO).

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Activity (Ci/MTU)</th>
<th>Activity (Ci/MCO)</th>
<th>Activity (Ci/MTU)</th>
<th>Activity (Ci/MCO)</th>
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<td>$^{134}$Cs</td>
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<td>1.13 E+04</td>
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<td>1.92 E-01</td>
<td>$^{137m}$Ba</td>
<td>1.07 E+04</td>
</tr>
<tr>
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<td>1.75 E+00</td>
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<td>$^{144}$Pr</td>
<td>1.73 E+00</td>
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<td>$^{144m}$Pr</td>
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<td>5.95 E+01</td>
<td>$^{236}$U</td>
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<td>$^{239}$Np</td>
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<td>1.98 E-03</td>
<td>$^{238}$Pu</td>
<td>1.28 E+02</td>
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</tr>
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<td>7.54 E-10</td>
<td>$^{244}$Cm</td>
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</tr>
</tbody>
</table>

MTU = Metric ton of uranium.

Totals: 5.07 E+04, 3.22 E+05
2.2.2 Shippingport Fuel

Shippingport PWR Core 2 fuel blanket assemblies (Figure 4) were shipped to Hanford during 1978 and 1979 and have been stored underwater since that time in the T Plant 221-T Canyon. There are 72 assemblies, which will be shipped four at a time in the SSFC, for a total of 18 shipments from T Plant to the CSB. The assemblies are 142.3 in. long and have a 7.5-in.-square cross-section. Each assembly consists of an extended fuel cluster, and top and bottom extension brackets. The fuel cluster was clad with Zircaloy-4, and the extension brackets were fabricated of Type 304 stainless steel. Each assembly weighs approximately 1,180 lb.

The fuel cluster consists of two identical natural uranium oxide (UO₂) fuel plate subassemblies that are welded together to form a square structure with two Zircaloy-4 cluster extensions welded to the ends of the subassemblies. Each subassembly consists of 30 compartmented fuel plates and two Zircaloy-4 end plates welded together to form parallel coolant channels. The fuel plate design includes many small fuel wafers surrounded by a Zircaloy-4 grid to provide adequate structural strength. The wafers have a pyrolytic carbon coating which prevented the zirconium from reacting chemically with the uranium oxide.

Table 3 provides the activity, in curies, of selected radionuclides in a Shippingport assembly. Table 4 provides the actinide masses, in grams, in a Shippingport assembly. Further information regarding source term development and results is available in HNF-SD-SNF-TI-061, Shippingport Pressurized Water Reactor Core 2 Blanket Assemblies Source Term Calculations Using ORIGEN 2 (Wittekind 1999b). Details of neutron and gamma spectra at different locations on the assembly is available in HNF-SD-SNF-TI-062, Shippingport Pressurized Water Reactor Core 2 Blanket Assemblies in Multi-Canister Overpack Shielding Calculations Using MCNP (Wittekind 1999a).
Figure 4. Shippingport Pressurized Water Reactor Core 2 Blanket Fuel Assembly.
### Table 3. Activity of Selected Radionuclides in Shippingport Core 2 Blanket Assembly.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Fuel exposure during reactor irradiation&lt;sup&gt;a&lt;/sup&gt;</th>
<th>13,800 MWd/MTU</th>
<th>24,600 MWd/MTU</th>
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<td></td>
<td>1 Jan 2001</td>
<td>1 Jan 2004</td>
<td>1 Jan 2001</td>
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<td>2.106 E+01</td>
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<td>7.089 E-01</td>
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<td>1.078 E+01</td>
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<td>1.958 E+00</td>
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<td>1.799 E+02</td>
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<td>2.046 E-01</td>
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<td>&lt;sup&gt;134&lt;/sup&gt;Cs</td>
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<td>2.179 E-01</td>
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<tr>
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<td>4.574 E+03</td>
<td>9.263 E+03</td>
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<td>&lt;sup&gt;137m&lt;/sup&gt;Ba</td>
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<td>4.327 E+03</td>
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<tr>
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<td>3.182 E+00</td>
<td>9.995 E+00</td>
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<td>&lt;sup&gt;151&lt;/sup&gt;Sm</td>
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<td>7.146 E+01</td>
<td>2.584 E+02</td>
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<tr>
<td>&lt;sup&gt;155&lt;/sup&gt;Eu</td>
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<td>7.815 E+00</td>
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<td>&lt;sup&gt;238&lt;/sup&gt;Pu</td>
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<td>7.416 E+02</td>
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<tr>
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<td>6.713 E+01</td>
<td>7.124 E+01</td>
</tr>
<tr>
<td>&lt;sup&gt;240&lt;/sup&gt;Pu</td>
<td>8.300 E+01</td>
<td>8.299 E+01</td>
<td>1.222 E+02</td>
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<tr>
<td>&lt;sup&gt;241&lt;/sup&gt;Pu</td>
<td>6.499 E+03</td>
<td>5.625 E+03</td>
<td>9.098 E+03</td>
</tr>
<tr>
<td>&lt;sup&gt;241&lt;/sup&gt;Am</td>
<td>6.840 E+02</td>
<td>7.097 E+02</td>
<td>9.274 E+02</td>
</tr>
<tr>
<td>&lt;sup&gt;244&lt;/sup&gt;Cm</td>
<td>5.616 E+01</td>
<td>5.007 E+01</td>
<td>5.633 E+02</td>
</tr>
<tr>
<td>Total&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2.267 E+04</td>
<td>2.077 E+04</td>
<td>3.876 E+04</td>
</tr>
<tr>
<td>Decay Heat&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.149 E+01</td>
<td>7.886 E+01</td>
<td>1.577 E+02</td>
</tr>
</tbody>
</table>

<sup>a</sup>Units are curies per assembly, except decay heat, which is watts per assembly. Nuclides with activity below 1 Ci per assembly are not listed.

<sup>b</sup>Totals include effect of all radionuclides in one assembly with extensions.

MWd/MTU = megawatt-days per metric ton of uranium.
Table 4. Actinide Masses in Shippingport Core 2 Blanket Assembly.

<table>
<thead>
<tr>
<th>Nuclide (grams)</th>
<th>Fuel exposure during reactor irradiation(^a)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13,800 MWd/MTU</td>
<td>24,600 MWd/MTU</td>
<td>13,800 MWd/MTU</td>
<td>24,600 MWd/MTU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decay date</td>
<td>Decay date</td>
<td>Decay date</td>
<td>Decay date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Jan 2001</td>
<td>1 Jan 2004</td>
<td>1 Jan 2001</td>
<td>1 Jan 2004</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{235})U</td>
<td>555.9</td>
<td>555.9</td>
<td>247.0</td>
<td>247.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{236})U</td>
<td>179.0</td>
<td>179.0</td>
<td>214.4</td>
<td>214.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{238})U</td>
<td>219,700</td>
<td>219,700</td>
<td>216,500</td>
<td>216,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{237})Np</td>
<td>35.97</td>
<td>35.97</td>
<td>57.70</td>
<td>59.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{239})Pu</td>
<td>1,080</td>
<td>1,080</td>
<td>1,146</td>
<td>1,146</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{240})Pu</td>
<td>364.1</td>
<td>364.1</td>
<td>535.9</td>
<td>536.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{241})Pu</td>
<td>63.06</td>
<td>54.58</td>
<td>88.28</td>
<td>76.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{241})Am</td>
<td>193.5</td>
<td>199.2</td>
<td>270.1</td>
<td>280.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total(^b)</td>
<td>2.223 E+05</td>
<td>2.223 E+05</td>
<td>2.194 E+05</td>
<td>2.194 E+05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Units are grams per assembly. Actinides with mass below 50 g per assembly are not listed.

\(^b\)Totals include all actinides in one assembly.

MWd/MTU = megawatt-days per metric ton of uranium.

2.3 CHEMICAL CONSTITUENT SOURCE TERM

With the exception of hydrogen (discussed in Section 2.4) and inerting gas (e.g., helium), no other non-radioactive hazardous materials will be shipped in the MCO cask. For the K Basin payload, the MCO containing irradiated fuel will remain water-filled during transfer from the K Basins to the CVD Facility. There will be approximately 530 kg of water in the MCO during this transfer when all baskets within the MCO are filled with fuel. The reracked fuel will be vacuum dried within the MCO prior to transfer to the CSB. For the Shippingport payload, the SSFC will be shipped dry as all vacuum drying activities will be conducted at T Plant prior to shipment.

2.4 GAS GENERATION

Gas will be produced in the MCO by the N Reactor fuel 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 and to maintain flammable gas volumes below the lower flammability limit, under normal and accident conditions.
SSFCs will be vacuum dried at T Plant in accordance with HNF-3043, *Performance Specification Fuel Drying and Canister Inerting System for Shippingport Pressurized Water Reactor (PWR) Core 2 Blanket Fuel Assemblies Stored Within Shippingport Spent Fuel Canisters* (Johnson 2000a). No residual water will be permitted in the SSFC and there are no other reactive substances. The only source of gas generation may be via fission gas release within the cladding. Of note, no cladding breaches have been identified, based on monitoring of the T Plant basin water. SNF-5133, *Shippingport Spent Fuel Canister Design Report Project W-518* (Johnson 2000b), states that even with a conservative assumption of 100% fission gas release at the maximum postulated temperature, that the resulting pressure is well within the design limits of the SSFC. A shipping window will not be required for the SSFC.

### 2.5 THERMAL DESCRIPTION

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

#### 2.5.1 Thermal Source Term

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

#### 2.5.2 Surface Emittance

For the purpose of calculating radiant heat transfer between the MCO or SSFC and the packaging system, the surface emittance of the MCO or SSFC surfaces shall be assumed to be 0.30. The N-Reactor or Shippingport fuel assembly surfaces shall have an assumed surface emittance of 0.60.

#### 2.5.3 Payload 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 or SSFC shell may be included.
2.5.4 Maximum 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.

The SSFC shall be fully functional at temperature conditions up to 132 °C (270 °F) as specified in Johnson (2000b).

2.6 TRANSPORTATION CLASSIFICATION

For onsite transportation purposes, the irradiated fuel payload of the packaging is considered Type B, highway route controlled quantity, fissile, spent fuel. The transport will be administratively controlled based on the potential dose consequences associated with the payload.

2.7 FISSILE CLASSIFICATION

The payload shall be classified as fissile material for transportation. The maximum fissile content per MCO cask is 60,036 g for the worst-case Mark IV fuel rerack scenario. This content will also bound the SSFC payload. A criticality analysis will be performed for the MCO to determine the criticality transport index of the shipment in the SARP. Per Kessler (2000) it is assumed that the SSFC payload will not require criticality analysis due to its fissile quantity and low enrichment. For the purposes of the SARP, the criticality transport index shall be established.

2.8 CONTENT RESTRICTIONS

The MCO cask payload shall be limited to either nuclear fuel elements cleaned and placed in baskets that have been loaded into an MCO or complete Shippingport assemblies placed into the SSFC with the SSFC insert. In the case of the MCO, rubblized fuel elements will be allowed within the SARP-determined criticality limits.

3.0 FACILITY OPERATIONS

3.1 ORIGINATING SITE FOR N REACTOR FUEL IN AN MCO--K BASINS

Loading of the MCO and packaging shall take place in the loadout pits of the K East and K West Basins (Figure 5). 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.
Figure 5. K Basin Layout.
into the MCO. 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 6 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.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Maximum permissible limits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beta-gamma emitting radionuclides</strong>: all radionuclides with half-lives</td>
<td></td>
</tr>
<tr>
<td>less than ten days; natural uranium; natural thorium; uranium-235,</td>
<td>$10^{-5}$</td>
</tr>
<tr>
<td>uranium-238; thorium-232; thorium-228 and thorium-230 when contained in</td>
<td>22</td>
</tr>
<tr>
<td>ores or physical concentrates</td>
<td></td>
</tr>
<tr>
<td><strong>All other alpha emitting radionuclides</strong></td>
<td>$10^{-6}$</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
</tr>
</tbody>
</table>

**3.2 ORIGINATING SITE FOR SHIPPINGPORT FUEL IN AN SSFC--T PLANT**

At T Plant, Shippingport fuel is loaded dry by lifting the fuel from the 222-T Cell 4 pool storage racks, and letting it dry prior to placing it into the SSFC. At the time of loading, the SSFC with insert is in place within the MCO cask on the transporter. Four fuel assemblies are loaded in the SSFC, each separated by the four cells of the SSFC insert. Following loading, a shield plug is installed to shield and seal the SSFC. Using the process port, a vacuum is drawn to aid in the final drying of the fuel. This step is followed by a backfill of the SSFC with inert gas, leak test, and final securement of the cask lid. 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.

**3.3 INTERMEDIATE SITE FOR N REACTOR FUEL IN AN MCO--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 is a separate facility in the 100 K Area. 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. The MCO will then be drained of water and vacuum dried. The cask lid will be installed before final shipment to the CSB.
Figure 6. K Basin East and West Loadout Area.
3.4 DESTINATION SITE FOR MCO AND SSFC PAYLOADS--CSB

Off-loading of the package shall take place at the CSB (Figure 7) in the 200 East Area. This activity shall involve the removal of the MCO or SSFC from the package. The packaging shall also be decontaminated to Table 5 limits and inspected, as needed, before transport back to the K Basins or T Plant.

Figure 7. Canister Storage Building Loadout Area.
4.0 PACKAGING/TRANSPORT SYSTEM DESIGN

4.1 GENERAL

The packaging shall be approved for use within the boundaries of the Hanford Site. It will be authorized to transfer Type B, highway route controlled quantity of fissile radioactive material in the form of irradiated fuel assemblies. An onsite 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 (Mercado 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 HNF-PRO-154, Responsibilities and Procedures for All Hazardous Material Shipments. Approval of the SARP provides authorization for onsite transport.

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 or one SSFC. The MCO cask design shall be such that the MCO or SSFC 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 Criteria for Shipping Containers (Fischer and Lai 1985). The materials of construction shall meet the fracture toughness requirements of Regulatory Guide 7.11, Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask containment Vessels With a Maximum Wall Thickness of 4 Inches (NRC 1991a), or Regulatory Guide 7.12, 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 (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 Boiler and Pressure Vessel Code (BPVC), Section III, Subsection NB (ASME 1995a), as required by NUREG/CR-3854 (Fischer and Lai 1985).

Welding criteria for a Category I packaging, as delineated in NUREG/CR-3019, Recommended Welding Criteria for Use in the Fabrication of Shipping Containers for Radioactive Materials (Monroe et al. 1984), shall be followed. All welds and weld joints shall be examined per ASME (1995a). Welds shall be inspected in accordance with the examination methods of ASME BPVC, Section V (1995b), except as modified by the requirements of (ASME 1995a). Welders shall be qualified per ASME BPVC, Section IX (1995c).

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 (1995a), 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 or SSFC. The MCO and SSFC nominal 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, CVD, T Plant, and CSB.

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 (Information Notice 84-72, Clarification of Conditions for Waste Shipments Subject to Hydrogen Gas Generation [NRC 1984]). If hydrogen concentration in the MCO cask 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 or SSFC.

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 or SSFC 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 water through the package/payload annulus for the vacuum drying process at the CVD Facility.

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 CSB (via the CVD Facility), or T Plant to CSB, the package prevents leakage from exceeding Section 5.1.1.2 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 (1995a) 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 or SSFC, as demonstrated by analysis and/or testing. The MCO cask containment seals shall be capable of maintaining containment following a 6-minute fire. Elastic-plastic analysis may be performed to demonstrate maintenance of confinement after the accident conditions. ASME (1995a) 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.

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

4.2.12 Shielding

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 as-low-as-reasonably-achievable 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. An MCO or SSFC 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.

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 6 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 vacuum drying will be by truck/trailer. The maximum total loaded transfer distance will be approximately 0.8 km (0.5 mi). CVD Facility operations include completely draining the MCO of water, vacuum drying the fuel, final closure of the MCO, and reinstalling the cask lid.

Transport of the package from the 100 K Area to the CSB in the 200 East Area for storage will be by truck/trailer. The total loaded transport distance will be approximately 16 km (10 mi).

The transport operation for the SSFC payload is similar to that discussed above for the MCO, minus the intermediate shipment to the CVD Facility. Vacuum drying of the SSFC will take place at the originating site (T Plant), followed by direct transport to the CSB. The maximum total loaded transfer distance will be approximately 8 km (5 mi).

4.3.2 Truck Transport System

The transportation system shall use a specially equipped trailer capable of transporting 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 Site 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 lb).
- The maximum width of the tractor/trailer combination shall not exceed 3.05 m (10 ft).
- Dimensions with the cask system attached in a 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 tie-downs and lifting device shall not exceed 5.50 m (18 ft) when mounted to the trailer.
- The trailer shall be equipped with tie-down 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 American National Standards Institute (ANSI) Standard N14.30, *American National Standard for Radioactive Materials—Design, Fabrication, and Maintenance of Semi-Trailers Employed in the Transport of Weight-Concentrated Radioactive Loads* (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 tie-down system shall be used to secure the packaging system to the transport vehicle(s). The tie-down system shall meet the requirements and be designed per the International Atomic Energy Agency (IAEA) Safety Series 37, *Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material* (IAEA 1990). The tie-down attachments for those requirements shall be capable of resisting the forces for road as shown in Table 6.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Longitudinal</th>
<th>Lateral</th>
<th>Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>+2g</td>
<td>+/- 1g</td>
<td>3g down, 2g up</td>
</tr>
</tbody>
</table>

Table 6. Load Factors for Tiedown Systems.
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

For the MCO payload, 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 is not be sealed (i.e. it is vented to the cask interior through a HEPA filter system) 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 vacuum drying process.

For the SSFC payload, there is only one transportation phase, consisting of the direct transport of the MCO cask from T Plant to the CSB. The SSFC will be sealed and vacuum dried prior to transport.

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.

- **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, *Environmental Conditions for On-Site Hazardous Materials Packages* (Fadeff 1992). The ambient temperatures at the Hanford Site for the peak summer month are shown in Table 7.
Table 7. Hanford Air Temperature.

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature (°C)</th>
<th>Time</th>
<th>Temperature (°C)</th>
<th>Time</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 a.m.</td>
<td>82</td>
<td>8 a.m.</td>
<td>85</td>
<td>4 p.m.</td>
<td>115</td>
</tr>
<tr>
<td>2 a.m.</td>
<td>78</td>
<td>10 a.m.</td>
<td>97</td>
<td>6 p.m.</td>
<td>113</td>
</tr>
<tr>
<td>4 a.m.</td>
<td>75</td>
<td>12 p.m.</td>
<td>103</td>
<td>8 p.m.</td>
<td>100</td>
</tr>
<tr>
<td>6 a.m.</td>
<td>74</td>
<td>2 p.m.</td>
<td>111</td>
<td>10 p.m.</td>
<td>89</td>
</tr>
</tbody>
</table>

- 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)

Table 8. Maximum Solar Radiation Received From the Sun (Btu/h-ft²).

<table>
<thead>
<tr>
<th>Time</th>
<th>Vertical surfaces facing</th>
<th>Horizontal surface facing up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>NE</td>
</tr>
<tr>
<td>4 a.m.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6 a.m.</td>
<td>57</td>
<td>192</td>
</tr>
<tr>
<td>8 a.m.</td>
<td>35</td>
<td>173</td>
</tr>
<tr>
<td>10 a.m.</td>
<td>42</td>
<td>56</td>
</tr>
<tr>
<td>12 noon</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>2 p.m.</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>4 p.m.</td>
<td>35</td>
<td>32</td>
</tr>
<tr>
<td>6 p.m.</td>
<td>57</td>
<td>17</td>
</tr>
<tr>
<td>8 p.m.</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- Minimum air temperature of -33 °C (-27 °F) plus maximum heat generation rate from worst-case source in Section 2.2
- Minimum air temperature of -33 °C (-27 °F) and zero heat generation rate.
- Maximum accessible outside surface temperature of the 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 absolute (3.5 psia).

- **Increased External Pressure.** An external pressure of 140 kPa absolute (20 psia).

- **Maximum Internal Pressure.** An internal working pressure of 1,033 kPa gauge (150 psig) unless otherwise specified.

- **Vibration.** Vibration normally incident to transport. The package shall be evaluated per ANSI N14.23 (ANSI 1987) to demonstrate containment when exposed to normal vibration due to the onsite transfers defined in Section 4.3.1 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 Free Drop.** The package shall be evaluated to demonstrate containment subsequent to a 0.3 m (1-ft) free drop onto a 20 cm (8-in.-) thick concrete surface with a concrete strength of 4,000 psi, Grade 60, No. 7 rebar spaced 30 cm (12 in.) apart with 5 cm (2-in.) cover, each way, each face, and soil properties in accordance with *On the Effects of Soil Constitutive Parameters on Impact-Induced Cask Accelerations* (Marlow 1997). The package shall impact in an orientation expected to cause maximum damage. Secondary impact of the package (slapdown) does not have to be examined for this drop.

**5.1.1.2 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/s). 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.

**5.1.1.3 Shielding.** The general surface dose on the accessible surface of the package shall not exceed 2 mSv/h (200 mrem/h). The maximum surface dose at any radiation hot spot on the package shall not exceed 10 mSv/h (1000 mrem/h). The dose rate 2 m (6.5 ft) from the surface...
shall be limited to 0.1 mSv/h (10 mrem/h). The dose in any normally occupied space in the transfer vehicle shall be limited to 0.02 mSv/h (2 mrem/h) or less.

5.1.1.4 Criticality. The package design shall ensure that the package will meet the following criteria.

- The contents shall remain subcritical (\( k_{\text{eff}} \) 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 an array of packages (an array five times “\( N \)” as specified in 10 CFR 71, “Packaging and Transportation of Radioactive Material,” 71.59, “Standards for arrays of fissile material 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 (Mercado 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 (WHC-SD-TP-RPT-022, Radiological Risk Evaluation for Risk-Based Design Criteria for the Multiple Container Overpack Packaging [Green 1996]) and the operational restrictions predicted for the transfer. The risk analysis in the SARP will evaluate failure thresholds of the cask design and use Hanford Site accident rates to show the package meets risk acceptance criteria.

Based on 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 relative to the specific analysis being performed; e.g., containment, shielding, criticality. Payload source terms are provided in Section 2.0.

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 6 m (21 ft) onto a 20 cm (8-in.-) thick concrete surface with a concrete strength of 4,000 psi, Grade 60, No. 7 rebar spaced 30 cm (12 in.) apart with 5 cm (2-in.) cover, each way, each face, and soil properties in accordance with Marlow (1997). The package shall impact in an orientation expected to cause maximum damage.

- **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 soil properties in accordance with Marlow (1997). Acceptance to this requirement is that there is no loss of shielding to the extent shown below in Section 5.1.2.4.

- **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. 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, or T Plant 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 9 m (30 ft) onto a 20.3 cm (8-in.-) thick concrete surface with a concrete strength of 4,000 psi, Grade 60, No. 7 rebar spaced 30 cm (12 in.) apart with 5 cm (2-in.) cover, each way, each face, and soil properties in accordance with Marlow (1997). The package shall impact in an orientation expected to cause maximum damage.

• 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 soil properties in accordance with Marlow (1997). Acceptance to this requirement is that there is no loss of shielding to the extent shown below in Section 5.1.2.4.

• 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. 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 473 L/min (125 gal/min). Flow at this maximum flow rate shall be assumed to occur for a maximum of 45 minutes. If needed, additional quenching water flow can be assumed for an additional period of 100 minutes at a maximum flow rate of 189 L/min (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 containment function and meet the dose consequence criteria of Mercado (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 \( (k_{\text{eff}} < 0.95) \), 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.

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 Section 5.1.2. The radiological risk evaluation for the SARP will evaluate credible accident scenarios to meet Mercado (1994).

5.2 QUALITY ASSURANCE

The quality assurance (QA) program requirements for activities such as design, procurement, fabrication, inspection, testing, maintenance, and documentation of the MCO casks and their components shall be in accordance with the applicable portions of HNF-MP-599, Quality Assurance Program Description (as implemented via Fluor Project Hanford procedures); SNF-4948, Spent Nuclear Fuel Project Quality Assurance Program Plan (Nicol 1999); 49 CFR 173, “Shippers—General Requirements for Shipments and Packagings”; and 10 CFR 71, Subpart H, “Quality Assurance.”

The QA plan for the packagings shall use a graded approach. The Transportation Hazard Indicator (THI) of the system and the Hazard Impacts (HI) of individual components of the packaging system shall be defined. The application of the THI/HI system is documented in HNF-PRO-154. QA requirements shall be developed for the procurement, fabrication, and inspection of the package based on the assigned THI/HI designations for the package system and its components.
5.2.1 Transportation Hazard Indicator

In 1995, a transportation safety class of the proposed MCO package with a worst-case payload was determined by a dose consequence evaluation, which is 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 K Basins.

The transportation safety class dose consequence evaluation was performed for 270 N Reactor fuel elements in the rerack basket scenario, and indicated that the maximum inhalation dose to an onsite receptor is 240,000 rem effective dose equivalent, and the maximum inhalation dose to an offsite receptor is 120 rem effective dose equivalent. Therefore, at the time this analysis was conducted in 1995 for 270 reracked elements, the packaging constituted a Safety Class 1 system per WHC-SD-TP-RPT-001, Report on Equivalent Safety for Transportation and Packaging of Radioactive Materials (Mercado 1994), and WHC-CM-4-46, Nonreactor Facility Safety Analysis Manual.

Since the 1995 safety class evaluation, the THI system has been implemented by HNF-PRO-154. The THI is assigned to represent the relative safety significance of an onsite packaging system. This indicator is assigned based on the hazard of the authorized contents of the packaging system. A THI of 1 represents the highest safety significance and greatest content hazard; a THI of 4 represents the least safety significance and least content hazard. Per the existing Appendix A evaluation for the K Basin fuel, the results correlate to a THI of 1. QA requirements for the procurement, fabrication, and inspection of the package and its components shall be based on the THI designation.

5.3 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.

5.4 SARP

An onsite 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. Multiple payloads (as specified in Section 2.0) will be evaluated as necessary to establish the bounding case for each analysis. For example, the K Basin fuel payload will bound the containment analysis whereas the Shippingport assemblies will bound the shielding analysis. 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 located in Appendix B.

6.0 REFERENCES


HNF-MP-599, Quality Assurance Program Description, Fluor Hanford, Richland, Washington.


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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-barreled 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>
<thead>
<tr>
<th>Isotope</th>
<th>Curies per MTU</th>
<th>Curies per single assembly</th>
<th>Curies per MCO-270 assemblies</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{2}$H</td>
<td>38.8</td>
<td>0.91</td>
<td>246</td>
</tr>
<tr>
<td>$^{55}$Fe</td>
<td>6.8</td>
<td>0.16</td>
<td>43</td>
</tr>
<tr>
<td>$^{60}$Co</td>
<td>6.5</td>
<td>0.15</td>
<td>41</td>
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<td>$^{85}$Kr</td>
<td>611.5</td>
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<tr>
<td>$^{90}$Sr</td>
<td>7,893.6</td>
<td>185.35</td>
<td>50,045</td>
</tr>
<tr>
<td>$^{90}$Y</td>
<td>7,893.6</td>
<td>185.35</td>
<td>50,045</td>
</tr>
<tr>
<td>$^{106}$Ru</td>
<td>11.5</td>
<td>0.27</td>
<td>73</td>
</tr>
<tr>
<td>$^{106}$Rh</td>
<td>11.5</td>
<td>0.27</td>
<td>73</td>
</tr>
<tr>
<td>$^{124}$Sb</td>
<td>99.1</td>
<td>2.33</td>
<td>628</td>
</tr>
<tr>
<td>$^{135m}$Te</td>
<td>24.1</td>
<td>0.57</td>
<td>153</td>
</tr>
<tr>
<td>$^{134}$Cs</td>
<td>115.0</td>
<td>2.70</td>
<td>729</td>
</tr>
<tr>
<td>$^{137}$Cs</td>
<td>10,735.4</td>
<td>252.08</td>
<td>68,062</td>
</tr>
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<td>$^{135m}$Ba</td>
<td>10,162.8</td>
<td>238.64</td>
<td>64,432</td>
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</table>

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Curies per MTU</th>
<th>Curies per single assembly</th>
<th>Curies per MCO-270 assemblies</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{144}$Ce</td>
<td>2.5</td>
<td>0.06</td>
<td>16</td>
</tr>
<tr>
<td>$^{144}$Pr</td>
<td>2.5</td>
<td>0.06</td>
<td>16</td>
</tr>
<tr>
<td>$^{147}$Pm</td>
<td>1084.4</td>
<td>25.5</td>
<td>6875</td>
</tr>
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<td>$^{151}$Sm</td>
<td>102.7</td>
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<td>651</td>
</tr>
<tr>
<td>$^{154}$Eu</td>
<td>215.1</td>
<td>5.05</td>
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</tr>
<tr>
<td>$^{155}$Eu</td>
<td>16.4</td>
<td>0.39</td>
<td>104</td>
</tr>
<tr>
<td>$^{238}$Pu</td>
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<td>$^{241}$Pu</td>
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<td>57,953</td>
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<td>$^{241}$Am</td>
<td>269.7</td>
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<td>1710</td>
</tr>
<tr>
<td>$^{244}$Cm</td>
<td>3.9</td>
<td>0.09</td>
<td>25</td>
</tr>
</tbody>
</table>

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 $5.0 \times 10^{-3}$ (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 $5 \times 10^{-3}$ 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 $1 \times 10^{-2}$ (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 shown in Table 2.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Ci/Cask</th>
<th>Isotope</th>
<th>Ci/Cask</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{7}\text{H}$</td>
<td>2.5E+2</td>
<td>$^{144}\text{Ce}$</td>
<td>8.0E-2</td>
</tr>
<tr>
<td>$^{55}\text{Fe}$</td>
<td>2.2E-1</td>
<td>$^{144}\text{Pr}$</td>
<td>8.0E-2</td>
</tr>
<tr>
<td>$^{60}\text{Co}$</td>
<td>5.1</td>
<td>$^{147}\text{Pm}$</td>
<td>7.7E+1</td>
</tr>
<tr>
<td>$^{85}\text{Kr}$</td>
<td>3.9E+3</td>
<td>$^{154}\text{Sm}$</td>
<td>3.3</td>
</tr>
<tr>
<td>$^{90}\text{Sr}$</td>
<td>2.5E+2</td>
<td>$^{156}\text{Eu}$</td>
<td>6.1</td>
</tr>
<tr>
<td>$^{90}\text{Y}$</td>
<td>2.5E+2</td>
<td>$^{158}\text{Pm}$</td>
<td>1.1</td>
</tr>
<tr>
<td>$^{106}\text{Ru}$</td>
<td>7.3E-1</td>
<td>$^{238}\text{Pu}$</td>
<td>4.7</td>
</tr>
<tr>
<td>$^{106}\text{Rh}$</td>
<td>3.7E-1</td>
<td>$^{239}\text{Pu}$</td>
<td>4.8</td>
</tr>
<tr>
<td>$^{125}\text{Sb}$</td>
<td>3.1</td>
<td>$^{240}\text{Pu}$</td>
<td>3.6</td>
</tr>
<tr>
<td>$^{128}\text{Te}$</td>
<td>1.5</td>
<td>$^{241}\text{Pu}$</td>
<td>2.9E+2</td>
</tr>
<tr>
<td>$^{134}\text{Cs}$</td>
<td>6.6E+1</td>
<td>$^{241}\text{Am}$</td>
<td>8.7</td>
</tr>
<tr>
<td>$^{137}\text{Cs}$</td>
<td>6.1E+3</td>
<td>$^{244}\text{Cm}$</td>
<td>1.3</td>
</tr>
<tr>
<td>$^{137}\text{Ba}$</td>
<td>3.2E+2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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/m³, which is
associated with a receptor at 150 m in the northwest direction from the 100 K Area. The calculated values of $X/Q$ are given in Table 3 for the onsite and offsite receptors.

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

<table>
<thead>
<tr>
<th>Receptor</th>
<th>$/Q$ (s/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onsite (100 m E)</td>
<td>7.32 E-02</td>
</tr>
<tr>
<td>Near riverbank$^1$ (150 m NW)</td>
<td>1.54 E-02</td>
</tr>
<tr>
<td>Offsite (11.7 km W)$^2$</td>
<td>3.70 E-05</td>
</tr>
</tbody>
</table>

$^1$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.

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Effective dose equivalent (rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onsite (100 m E)</td>
<td>2.4 E+05</td>
</tr>
<tr>
<td>Near riverbank$^1$ (150 m NW)</td>
<td>4.9 E+04</td>
</tr>
<tr>
<td>Offsite (11.7 km W)$^2$</td>
<td>1.2 E+02</td>
</tr>
</tbody>
</table>

As shown in Table 4, the exposures to the public at a near riverbank receptor and an offsite receptor are $4.9 \times 10^4$ and $1.2 \times 10^2$ 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


APPENDIX

GENII INPUT FILES

#~ Program GENII Input File #~
Title: PROJECT K BASIN ACUTE ONSITE INDIVIDUAL DOSES RELEASE

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

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

Use when | Release Terms------ | Basic Concentrations------ |
--------- |---------------------|-----------------------------|
<p>| transport selected | near-field scenario, optionally |
|----------- |---------------------|-----------------------------|
| Release | Surface Buried | Surface Deep | Ground Surface |
| Radionuclide | Air | Water | Waste | Air | Soil | Water | Water |
| /yr | /yr | /m3 | /m3 | /unit | /m3 | /L | /L |
| H | 3 | 2.5E+2 |
| FE55 | 2.2E-1 |
| CO60 | 5.1 |
| KB85 | 3.9E+3 |
| SR90 | 2.6E+2 |
| Y | 90 | 2.6E+2 |
| RU106 | 7.3E-1 |
| SB125 | 3.1 |
| TI125M | 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 | 4.6 |</p>
<table>
<thead>
<tr>
<th>Radio-</th>
<th>Plant Product Water Food</th>
<th>nuclide</th>
<th>kg/kg/L/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM241</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM244</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I-...D erived Concentrations-----I</td>
<td>Use when measured values are known</td>
<td>Release Terres. Animal Drink Aquatic</td>
</tr>
</tbody>
</table>

**TIME**

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

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

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

**NEAR-FIELD SCENARIOS**

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

**TRANSPORT**

**AIR TRANSPORT**

- Option: 1-Use ch/Q or PM value
- Select MI dist & dir
- Specify MI dist & dir
- Ch/Q or PM value
- MI sector index (1=5)
- MI distance from release point (m)
- Use jf data, (T/F) else ch/Q grid

**SURFACE WATER TRANSPORT**

- Mixing ratio model: 0-use value, 1-river, 2-lake
- Mixing ratio, dimensionless
- Average river flow rate for: MIXFLG=0 (m³/s), MIXFLG=1.2 (m³/s)
- Transit time to irrigation withdrawal location (hr)
- If mixing ratio model > 0:
- Rate of effluent discharge to receiving water body (m³/s)
- Offshore distance to the water intake (m)
- Average water depth in surface water body (m)
Average river width (m), MIXFLG=1 only

Depth of effluent discharge point to surface water (m), lake only

Waste form/package half life, (yr)

Waste thickness, (m)

Depth of soil overburden, m

---BIOTIC TRANSPORT OF BURIED SOURCE------------------------SECTION 4------

Consider during inventory decay/buildup period (T/F)?

Consider during intake period (T/F)? 1-Arid non agricultural

Pre-Intake site condition..............| 2-Humid non agricultural

3-Agricultural

---EXTERNAL EXPOSURE--------------------------------SECTION 5------

Exposure time:

<table>
<thead>
<tr>
<th>Residential irrigation:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plume (hr)</td>
<td>T Consider: (T/F)</td>
</tr>
<tr>
<td>Soil contamination (hr)</td>
<td>0</td>
</tr>
<tr>
<td>Swimming (hr)</td>
<td>2</td>
</tr>
<tr>
<td>Boating (hr)</td>
<td>0</td>
</tr>
<tr>
<td>Shoreline activities (hr)</td>
<td>0</td>
</tr>
</tbody>
</table>

Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)

Transit time for release to reach aquatic recreation (hr)

1.0 Average fraction of time submerged in acute cloud (hr/person hr)

---INHALATION----------------------------------------SECTION 6------

8766.0 Hours of exposure to contamination per year

0 No resus- 1-Use Mass Loading 2-Use Ansraugh model

Mass loading factor (g/m³) Top soil available (cm)

---INGESTION POPULATION-------------------------------SECTION 7------

Atmospheric production definition (select option):

0-Use food-weighted chiQ.(food-secm³). enter value on this line
1-Use population-weighted chiQ
2-Use uniform production
3-Use chiQ and production grids (PRODUCTION will be overridden)

Population ingesting aquatic foods, 0 defaults to total (person)

Population ingesting drinking water, 0 defaults to total (person)

Consider dose from food exported out of region (default=F)

---AQUATIC FOODS / DRINKING WATER INGESTION---------SECTION 8------

Salt water? (default is fresh)

USE DRINKING WATER

<table>
<thead>
<tr>
<th>USE</th>
<th>PROD.</th>
<th>CONSUMPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>T/F</td>
<td>TYPE</td>
<td>kg/yr</td>
</tr>
<tr>
<td>F</td>
<td>FISH</td>
<td>0.00</td>
</tr>
<tr>
<td>F</td>
<td>MOLLUS</td>
<td>0.00</td>
</tr>
<tr>
<td>F</td>
<td>CRUSTA</td>
<td>0.00</td>
</tr>
<tr>
<td>F</td>
<td>PLANTS</td>
<td>0.00</td>
</tr>
</tbody>
</table>

---TERRESTRIAL FOOD INGESTION-------------------------SECTION 9------

USE |

<table>
<thead>
<tr>
<th>USE</th>
<th>IRRIGATION</th>
<th>PROD.</th>
<th>CONSUMPTION</th>
</tr>
</thead>
</table>

A-9
### Food Time Rate Yield Uction Holdup Rate

<table>
<thead>
<tr>
<th>Food Type</th>
<th>Time</th>
<th>Rate</th>
<th>Yield</th>
<th>Uction</th>
<th>Holdup</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>F LEAF V</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F ROOT V</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F FRUIT</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F GRAIN</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### Animal Production Consumption

<table>
<thead>
<tr>
<th>Human Food Production</th>
<th>Drink</th>
<th>Stored Feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Consumption Prods</td>
<td>Water</td>
<td>Diet</td>
</tr>
<tr>
<td>Food Type</td>
<td>Rate</td>
<td>Uction</td>
</tr>
<tr>
<td>-----------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>F BEEF</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F POULTR</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F MILK</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F EGG</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

---

**Fresh Forage**

- BEEF: 0.00 0.0 0.0 0.0 0.0 0.0 0.0 0.0
- MILK: 0.00 0.0 0.0 0.0 0.0 0.0 0.0 0.0

---

---ANIMAL PRODUCTION CONSUMPTION----SECTION 10---

---HUMAN--- TOTAL DRINK STORED FEED---

<table>
<thead>
<tr>
<th>Use</th>
<th>CONSUMPTION Prod.</th>
<th>WATER</th>
<th>Diet</th>
<th>Irrigation</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Type</td>
<td>Rate</td>
<td>Uction</td>
<td>Contamn</td>
<td>Fract.</td>
<td>Time</td>
</tr>
<tr>
<td>-----------</td>
<td>------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>F BEEF</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F POULTR</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F MILK</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F EGG</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

---FRESH FORAGE---

- BEEF: 0.00 0.0 0.0 0.0 0.0 0.0 0.0 0.0
- MILK: 0.00 0.0 0.0 0.0 0.0 0.0 0.0 0.0
### Program GENII Input File

**Title:** PROJECT K BASIN ACUTE OFFSITE INDIVIDUAL DOSES RELEASE

**OPTIONS**

- Default
- Near-field scenario? (Far-field)
- Population dose? (Individual)
- Acute release? (Chronic)
- Maximum Individual data set used

**TRANSPORT OPTIONS**

- Air Transport
- Surface Water Transport
- Biotic Transport (near-field)
- Waste Form Degradation (near)
- Surface Buried
- Surface Deep
- Ground
- Surface Water
- Waste
- Air
- Soil
- Soil
- Water

**REPORT OPTIONS**

- Drinking water ingestion
- Aquatic foods ingestion
- Terrestrial foods ingestion
- Animal product ingestion
- Inadvertent soil ingestion

**INVENTORY**

- Inventory input activity units: (1-pCi 2-μCi 3-mCi 4-Ci 5-Bq)
- Equilibrium question goes here

<table>
<thead>
<tr>
<th>Release Term</th>
<th>Basic Concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near-field scenario, optionally</td>
<td></td>
</tr>
<tr>
<td>Radio-nuclide</td>
<td>/yr /yr /m³</td>
</tr>
</tbody>
</table>

| 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 |
| R106 | 7.3E-1 |
| SB125 | 3.1 |
| TE125M | 1.5 |
| CS134 | 6.6E+1 |
| CS137 | 6.1E+3 |
| CE144 | 8.0E-2 |
| FR144 | 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
HNF-SD-TP-PDC-030, Rev. 5

--- Release | Terres. Animal Drink Aquatic Radio- | Plant Product Water Food |
nuclide | /kg /kg /L /kg |

---

TIME 

1. Intake ends after (yr)
2. 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
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. "Ch/Q or PM value" | 0 Stack radius (m)
0. MI sector index (1=5) | 0 Effluent temp. (°C)
0. MI distance from release point (m) | 0 Building x-section (m²)
0. Use jf data. (T/F) else ch/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 (m³/sec)
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

---

A-12
Biotic Transport of Buried Source

Consider during inventory decay/buildup period (T/F)?
Consider during intake period (T/F)?

Input Intake Site Condition...
1. Arid non agricultural
2. Humid non agricultural
3. Agricultural

Exposure

External Exposure

Exposure Time:
- Residence irrigation:
  - Plume (hr)
  - Soil contamination (hr)
  - Swimming (hr)
  - Boating (hr)
  - Shoreline activities (hr)
- Average fraction of time submerged in acute cloud (hr/person hr)

Inhalation

Hours of exposure to contamination per year:
- No resus-1 Use Mass Loading
- 2 Use Anspaugh model
- 3 Use uniform production
- 4 Use chi/Q and production grids (PRODUCTION will be overridden)
- 5 Population ingesting aquatic foods, 0 defaults to total (person)
- 6 Population ingesting drinking water, 0 defaults to total (person)
- 7 Consider dose from food exported out of region (default=F)

Note below:

Salt water? (default is fresh)

Aquatic Foods / Drinking Water Ingestion

Terrestrial Food Ingestion
<table>
<thead>
<tr>
<th>T/F</th>
<th>TYPE</th>
<th>kg/yr</th>
<th>da</th>
<th>kg/yr</th>
<th>FRACT.</th>
<th>TION</th>
<th>da</th>
<th>in/yr</th>
<th>mo/yr</th>
<th>kg/m³</th>
<th>da</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>BEEF</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
</tr>
<tr>
<td>F</td>
<td>POULTR</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
</tr>
<tr>
<td>F</td>
<td>MILK</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
</tr>
<tr>
<td>F</td>
<td>EGG</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
</tr>
</tbody>
</table>

---FRESH FORAGE---

| BEEF | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 0.0 |
| MILK | 0.00 | 0.0 | 0.0 | 0.0 | 0.00 | 0.0 |

---STORED FEED---

<table>
<thead>
<tr>
<th>TYPE</th>
<th>kg/yr</th>
<th>da</th>
<th>kg/yr</th>
<th>FRACT.</th>
<th>TION</th>
<th>da</th>
<th>in/yr</th>
<th>mo/yr</th>
<th>kg/m³</th>
<th>da</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEEF</td>
<td>0.00</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
</tr>
<tr>
<td>MILK</td>
<td>0.00</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
</tr>
</tbody>
</table>

---HUMAN---

<table>
<thead>
<tr>
<th>TOTAL</th>
<th>CONSUMPTION</th>
<th>PROD-</th>
<th>WATER</th>
<th>DIET</th>
<th>GROW</th>
<th>-IRRIGATION-</th>
<th>STOR-</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRINK</td>
<td>-------------</td>
<td>-------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td>USE</td>
<td>-------------</td>
<td>-------</td>
<td>-------</td>
<td>------</td>
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---ANIMAL PRODUCTION CONSUMPTION---

---SECTION 10---
Title: PROJECT K BASIN ACUTE OFFSITE INDIVIDUAL DOSES RELEASE

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, multiple sites

Maximum Individual data set used

TRANSPORT OPTIONS------------- Section
T Air Transport 1
F Finite plume, external 5
F Biotic Transport (near-field) 3.4
F Ground, external 5
F Waste Form Degradation (near) 3.4
F Recreation, external 5
T Inhalation uptake 5.6

REPORT OPTIONS------------------------
T Report AEDE only
F Drinking water ingestion 7.8
T Report by radionuclide
F Aquatic foods ingestion 7.8
T Report by exposure pathway
F Terrestrial foods ingestion 7.9
T Debug report on screen
F Animal product ingestion 7.10
F Inadvertent soil ingestion

INVENTORY -------------------------------
4 Inventory input activity units: (1-pCi 2-uCi 3-mCi 4-Ci 5-Rq)
0 Surface soil source units (1-m2 2-m3 3-kg)

Equilibrium question goes here

<p>| Radio- | Surface Buried | Surface Deep | Ground | Surface |</p>
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</table>

--- Derived Concentrations ---

Use when measured values are known
### 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  Option: 1-Use chl/Q or PM value
0  2-Select MI dist & dir
0  3-Specify MI dist & dir
0  3.70E-5
0  Chl/Q or PM value
0  MI sector index (1-9)
0  MI distance from release point (m)
0  Use JF data, (T/F) else chl/Q grid
0  Building x-section (m²)
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 (m³/s).
0  Transit time to irrigation withdrawal location (hr)
0  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)?
0 Pre-Intake site condition .................

EXPOSURE #--------------------------------------------------------------------

--- EXTERNAL EXPOSURE !=-MLEM==LEMQ=-SECTION 5 ==-----

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<td>Plume (hr)</td>
<td>T Consider: (T/F)</td>
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<tr>
<td>Soil contamination (hr)</td>
<td>Source: 1-ground water</td>
</tr>
<tr>
<td>Swimming (hr)</td>
<td>2-surface water</td>
</tr>
<tr>
<td>Boating (hr)</td>
<td>0 Application rate (in/yr)</td>
</tr>
<tr>
<td>Shoreline activities (hr)</td>
<td>0 Duration (mo/yr)</td>
</tr>
<tr>
<td>Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)</td>
<td></td>
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<tr>
<td>Transit time for release to reach aquatic recreation (hr)</td>
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</table>

--- INHALATION =-MLEM==LEMQ=-SECTION 6 ==-----

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

--- INGESTION POPULATION =-MLEM==LEMQ=-SECTION 7 ==-----

Atmospheric production definition (select option):
0 0-Use food-weighted chi/Q. (food-seclm3). 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 =-MLEM==LEMQ=-SECTION 8 ==-----

Salt water? (default is fresh)

--- TERRESTRIAL FOOD INGESTION =-MLEM==LEMQ=-SECTION 9 ==-----

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<th>TRAN-</th>
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<th>CONSUMPTION</th>
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<tr>
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<td>DRINKING WATER</td>
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A-17
### Animal Production Consumption

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<th>Use</th>
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<th>Diet Grow</th>
<th>Irrigation</th>
<th>Stored Feed</th>
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<td>? Food</td>
<td>Rate Holdup Action Contam.</td>
<td>Frac. Time</td>
<td>Rate</td>
<td>Time</td>
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<tr>
<td>T/F Type</td>
<td>kg/yr</td>
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<td>F</td>
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<td>---</td>
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<td><strong>F BEEF</strong></td>
<td>0.0</td>
<td>0.0</td>
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<tr>
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<td>0.0</td>
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<tr>
<td><strong>F EGG</strong></td>
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*-----------------------*  
**Fresh Forage**  

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---
HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

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

Submitted by: C. H. HUANG
Date Submitted: June 1, 1995
Scope of Review: Entire Document

YES NO* N/A

[ ] [ ] 1. A detailed technical review and approval of the
environmental transport and dose calculation portion of
the analysis has been performed and documented.

[ ] [ ] 2. Detailed technical review(s) and approval(s) of scenario
and release determinations have been performed and
documented.

[ ] [ ] 3. HEDOP-approved code(s) were used.

[ ] [ ] 4. Receptor locations were selected according to HEDOP
recommendations.

[ ] [ ] 5. All applicable environmental pathways and code options
were included and are appropriate for the calculations.

[ ] [ ] 6. Hanford site data were used.

[ ] [ ] 7. Model adjustments external to the computer program were
justified and performed correctly.

[ ] [ ] 8. The analysis is consistent with HEDOP recommendations.

[ ] [ ] 9. Supporting notes, calculations, comments, comment
resolutions, or other information is attached. (Use the
"Page 1 of X" page numbering format and sign and date
each added page.)

[ ] [ ] 10. Approval is granted on behalf of the Hanford
Environmental Dose Overview Panel.

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

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

Date

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

A-19
CHECKLIST FOR PEER REVIEW


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.

[ ] [ ] [ ] 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.

Reviewer (Printed/Name and Signature) 6/1/95

Date
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  9.3.1 K Basin to CBDF
  9.3.2 CVDF to CSB
  9.3.3 Fission Gases
9.4 PACKAGE PRESSURE
  9.4.1 K Basins to CVDF
  9.4.2 CVDF to CSB
9.5 REFERENCES

10.0 PACKAGE TIEDOWN SYSTEM EVALUATION
10.1 SYSTEM DESIGN
10.2 TIEDOWN LOADS
10.3 TIEDOWN EVALUATION
10.4 REFERENCES
10.5 APPENDIX: TIEDOWN ANALYSIS
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