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71-9291

COLUMBIANA HI TECH LLC

Nuclear Manufacturing Excellence

August 27, 2013

Michele Sampson
Division of Spent Fuel Storage and Transportation
U.S. Nuclear Regulatory Commission
11555 Rockville Pike M/S 14 A 44
Rockville, MD 28052

CC: Document Control Desk. (Without Attachments)

RE: Application for Revision of NRC Certificate of Compliance No. 9291, Rev. 8, Docket Number 71-9291 for Model No. Liqui-Rad (LR) Transport Unit Package.

Ms. Sampson,

Columbiana Hi Tech, LLC request that NRC Certificate of Compliance No. 9291 be amended (revised) to make the Draw Pipe an optional component of the Liqui-RAD (LR) Transport Unit Package. This change is requested as transport vibrations may have an effect on some draw pipe components of the Liqui-RAD (LR) Transport Unit Package.

The revision level of the current SARP is revision 7. Attached, please find one copy of the consolidated Safety Analysis Report for Packaging (SARP), revision 8, for the Columbiana Hi Tech Liqui-Rad (LR) Transport Unit Package. Attachment "A" provides instructions for inserting the revised pages into revision 7 of the SARP. Attachment "B" provides a listing of the changes made along with an explanation for the modification. Attachment "C" provides the changed pages for the SARP.

Columbiana Hi Tech (CHT) strives to provide the highest quality packages to our customers, designed, fabricated and licensed to the latest standards. Should you have any questions concerning this request or this submittal, please feel free to contact CHT at your convenience.

Sincerely,

Robert E. Hypes
Vice President – Special Projects
Columbiana Hi Tech, LLC

Enclosures: "A": Instructions for updating revision 7 to revision 8.
"B": Explanation of changes to SARP.
"C": Revision 8 changed pages.

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ATTACHMENT A

Instructions for Updating Revision 7 to Revision 8:

Title page and Table of Contents:

Remove (Revision 7):	Add (Revision 8):
Title page	Title Page
Table of Contents Pg. i	Table of Contents Pg. i

Glossary of Terms:

Remove (Revision 7):	Add (Revision 8):
Glossary of Terms Pg. v	Glossary of Terms Pg. v
Glossary of Terms Pg. vi	Glossary of Terms Pg. vi

Section 1:

Remove (Revision 7):	Add (Revision 8):
1-3	1-3
1-7	1-7
Appendix 1.3.1 Drawing LR-SAR, Rev. 8 (Sht. 1)	Appendix 1.3.1 Drawing LR-SAR, Rev. 9 (Sht. 1)
Appendix 1.3.1 Drawing LR-SAR, Rev. 8 (Sht. 2)	Appendix 1.3.1 Drawing LR-SAR, Rev. 9 (Sht. 2)
Appendix 1.3.1 Drawing LR-SAR, Rev. 8 (Sht. 3)	Appendix 1.3.1 Drawing LR-SAR, Rev. 9 (Sht. 3)
Appendix 1.3.1 Drawing LR-SAR, Rev. 8 (Sht. 4)	Appendix 1.3.1 Drawing LR-SAR, Rev. 9 (Sht. 4)

Section 2:

Remove (Revision 7):	Add (Revision 8):
Table of Contents Pg. 2-i	Table of Contents Pg. 2-i
2-1	2-1
2-7	2-7
2-11	2-11
2-12	2-12

Section 3:

Remove (Revision 7):	Add (Revision 8):
No Changes	No Changes

Section 4:

Remove (Revision 7):	Add (Revision 8):
4-1	4-1

Section 5:

Remove (Revision 7):	Add (Revision 8):
No Changes	No Changes

Section 6:

Remove (Revision 7):	Add (Revision 8):
No Changes	No Changes

Section 7:

Remove (Revision 7):	Add (Revision 8):
No Changes	No Changes

Section 8:

Remove (Revision 7):	Add (Revision 8):
No Changes	No Changes

ATTACHMENT B - EXPLANATION OF CHANGES

Changed Page	Explanation of Changes Made
Title Page	This page was modified to reflect the current SAR revision level.
Table of Contents Page i	This page was modified to reflect that paragraphs 2.7 and 2.7.1 were moved from page 2-12, to page 2-11. This page was modified to reflect the current SAR revision level.
Glossary of Terms page v	Added to description of Primary lid to read: ".....This lid (excluding the portion inside the secondary wall) is a part of the containment boundary." <u>Reason</u>: To clarify/better define the Containment Boundary of the Primary Lid Moved "Outer Vessel" and Containment Vessel" descriptions to page vi of the glossary of terms. This page was modified to reflect the current SAR revision level.
Glossary of Terms page vi	Added to description of Containment Boundary to read: "The containment vessel, primary lid (excluding the portion inside the secondary wall) and secondary lid and seal." <u>Reason</u>: To clarify/better define the Containment Boundary. Added "Outer Vessel" and "Containment Vessel" descriptions to page vi of the Glossary of Terms. No changes were made to these descriptions. This page was modified to reflect the current SAR revision level.
1-3	Added to paragraph 1.2.1.6 containment to read: "....The containment vessel, primary lid (excluding the portion inside the secondary wall) and seal, and secondary lid and seal." <u>Reason:</u> To clarify/better define the Containment Boundary. This page was modified to reflect the current SAR revision Level.

Changed Page	Explanation of Changes Made
1-7 (Appendix 1.3.1 cover sheet)	This page was modified to reflect the current SAR revision level.
Appendix 1.3.1 Drawing LR-SAR Revision 9, Sheet 1 of 4	Removed redundant draw pipe to vessel gap dimension of 3/8" ± 1/8" shown in the sectional view of the Liqui-Rad Transport Unit. <u>Reason:</u> The draw pipe dimension is addressed on sheet 3 of drawing.
Appendix 1.3.1 Drawing LR-SAR Revision 9, Sheet 2 of 4	Sheet 2 of this drawing was modified to reflect latest drawing revision only. No changes were made to sheet 2 of 4
Appendix 1.3.1 Drawing LR-SAR Revision 9, Sheet 3 of 4	<u>Changed:</u> "Pipe 1" Ø Sch 80 SS" <u>to read:</u> "Draw Pipe 1" Ø Sch 80 SS" in the containment vessel section view. Revised draw pipe to vessel gap dimension <u>from:</u> "3/8" ± 1/8" <u>to read:</u> "1/4" min." in the containment vessel section view. Added 1/8" min. dimension to length of draw pipe shown in fill port detail "D" of drawing <u>Reason:</u> The draw pipe is optional in the revised design.
Appendix 1.3.1 Drawing LR-SAR Revision 9, Sheet 4 of 4	Sheet 4 of this was modified to reflect latest drawing revision only. No changes were made to sheet 4 of 4
2-i Table of Contents	This page was modified to reflect that paragraphs 2.7 and 2.7.1 moved from page 2-12, to page 2-11. This page was modified to reflect the current SAR revision level.
2-1	Added to paragraph 2.1.2 design criteria to read: "The containment boundary is defined as the containment vessel, the primary lid (excluding the portion inside the secondary wall) and seal, and the secondary lid and seal." <u>Reason:</u> To clarify/better define the containment boundary. This page was modified to reflect the current SAR revision level.

Changed Page	Explanation of Changes Made
2-7	Added to paragraph 2.6.5 Vibration to read: "Vibration due to normal transport conditions has no measurable effect on the LR, excluding optional component, e.g., draw pipe." <u>Reason:</u> Transport vibration may effect some optional draw pipe components. This page was modified to reflect the current SAR revision level.
2-11	This page was modified to add paragraphs 2.7 and 2.7.1 which were moved from page 2-12. The content (text) of these paragraphs has not been changed. This page was modified to reflect the current SAR revision level.
2-12	The following has been added to the end of paragraph 2.7.1 prototype testing: "The draw pipe is optional in the revised design, but the previous tested configuration with draw pipe is still valid and conservative since the weight of the previous tested configuration is slightly higher than the revised configuration, and hence no additional drop tests are required. The leak test is also unnecessary since the draw pipe is not part of containment boundary." <u>Reason:</u> The draw pipe is optional in the revised design. This page was modified to reflect the current SAR revision level.
4-1	Added to paragraph 4.1 Containment Boundary to read: "The containment boundary is defined as the containment vessel, primary lid (excluding the portion inside the secondary wall) and seal, and secondary lid and seal." <u>Reason:</u> To clarify/better define the containment boundary. This page was modified to reflect the current SAR revision level.

<u>Attachment C</u>

(Revision 8, Changed Pages)

Consolidated safety analysis report for the model no. Liqui-Rad (LR) Transport Unit Package, Revision 8.

(1 copy)

Safety Analysis Report For Packaging (SARP)

For the

LIQUI-RAD TRANSPORT UNIT

(Revision 8, August 2013)

Submitted by:

Columbiana Hi Tech
1802 Fairfax Road
Greensboro, North Carolina 27407

TABLE OF CONTENTS

Glossary of Terms

Ceramic Fiber Blanket	Insulation material used in the side walls of the packaging (ESP specification ESP-CFI-1).
Ceramic Fiber Board	Insulation material used in outer lid of the packaging (ESP Specification ESP-CFI-1).
Framing system	The rectangular frame constructed of steel angle and bar that is used to support the cylindrical vessel.
Leak tight	Free from leaks as defined by ANSI N14.5-1997.
Load port	The valve and fittings that are located on the primary lid and allow filling of the containment vessel.
LR	The Liqui-Rad Packaging.
MVE Valve	The valve located in the Manual Vent Enclosure.
MVE	Manual Vent Enclosure – valve provided in the enclosure contained in the outer lid that contains a leak detection valve used as an overcheck of the containment boundary integrity
Outer Lid	The lid that secures the outer vessel. This lid is not a part of the containment boundary.
Foam Insulation	Insulation material used around the heads of the containment vessel (ESP specifications ESP-FP-2).
Primary lid	The primary lid for the containment vessel. This lid (excluding the portion inside the secondary wall) is a part of the containment boundary.
Secondary lid	The lid that is located between the primary lid and the outer lid and provides an enclosure for the load port.
Studding outlet	The annular steel block that is welded to the upper head of the containment vessel and provides a means of securing the primary lid to the containment vessel.
UN	Uranyl Nitrate.

Glossary of Terms, con't.

Outer Vessel	The rectangular prism that conspires the exterior steel wells of the packaging.
Containment Vessel	The cylindrical vessel that contains the payload.
MVE Lid	The 9" x 6" lid over the MVE.
Annulus Area	The air space outside of the containment boundary but inside the insulated outer vessel.
O-ring	A doughnut shaped gasket made of Viton or silicone rubber that is compressed between the lid and the base to provide a sealed closure.
Containment Boundary	The containment vessel, primary lid (excluding the portion inside the secondary wall) and secondary lid and seal.

1.2.1.2 Lifting and Tie down Devices

The LR may be lifted either by means of four shackles attached to the top angle frame or by forklift tines placed under the unit's reinforced bottom. The LR may be bolted to a conveyance and further secured by strapping over the top of the LR. After loading of the package, shackles shall be secured to the top angle with nylon tie to prevent shackle from being used as tie down. Package shall be stenciled "SHACKLE NOT FOR TIE DOWN". The packaging and cargo weights and volumes are provided in Table 1-1.

1.2.1.3 Shielding

Shielding is not required for the contents of the LR Transport Unit. For further discussion of shielding requirements, see Section 5.

1.2.1.4 Pressure Relief Systems

The LR uses only one type of pressure relief device: a plastic plug, designed to melt away between 300° and 400° F during a fire event to release any gases generated by the insulation due to the high temperature. This device vents the annulus between the containment vessel and outer shell only; it does not penetrate the containment boundary. Pressure relief of the containment vessel is unnecessary, since the contents do not present a pressure buildup during Normal or Hypothetical Accident Conditions. See Sections 2, 3, 4, and 7 for information with respect to internal pressure.

1.2.1.5 Closures

The containment vessel is secured by bolting the 5/8" thick primary lid to the vessel with sixteen 5/8" diameter studs and nuts. The primary lid is sealed with a double O-ring. The secondary lid is sealed using twelve 5/8" diameter bolts and nuts or, as a design option, the secondary lid flange is threaded and the secondary lid is secured to it using twelve (12) 5/8" diameter bolts and a double O-ring. A valve, enclosed in the sealed annulus space between the primary lid and secondary lid, is used in conjunction with a threaded (plugged) quick disconnect fitting for filling and discharge functions. The outer lid is secured with twelve 5/8" studs and nuts and is sealed using a ¼" thick gasket. The MVE lid is secured by four 5/8" bolts and nuts. All seals are silicone rubber or Viton and are rated for continuous service up to 400°F.

1.2.1.6 Containment

The containment boundary is defined by the containment vessel, primary lid (excluding the portion inside the secondary wall) and seal, and secondary lid and seal. The containment vessel has ¼" thick stainless steel walls and ¼" thick ASME flanged and dished heads and is designed to provide leak tight conditions. Post-fabrication the containment boundary is demonstrated to be leak-tight (per ANSI N14.5-1997's definition, leakage rate less than 1E-07 ref-cc/sec). Pre-shipment and periodic maintenance testing of the containment boundary assures that the containment boundary maintains a working leakage rate less than the maximum allowable rates specified by 10CFR71.51 as specified in Section 4. Leak test are performed as specified in Sections 7 and 8.

Appendix 1.3.1

Drawing Number LR-SAR, Sheets 1, 2, 3, & 4 for the Liqui-Rad Transport Unit

Security-Related Information
Figure Withheld Under 10 CFR 2.390

Rev. No.	Change	Date	By
9	REMOVED REDUNDANT DRAIN PIPE TO VESSEL CAP	8/23/13	RF
8	ADDED OPT. TO SHACKLES (ISO. VIEW)	6/1/11	CLC
7	NO CHANGES THIS PAGE	2/16/06	CLC
6	NO CHANGES THIS PAGE	2/16/06	CLC
5	NO CHANGES THIS PAGE	2/16/06	CLC
4	NO CHANGES THIS PAGE	2/16/06	CLC
3	ADDED OPT. TO MANUAL VENT ENCLOS. LID	8/4/05	CLC
2	CHANGED ACETATE TO PLASTIC & NEW LOGO	8/12/02	DAC
1	ADDED WELD SYMBOLS, DETAILS & NOTES	6/22/01	APM

REVISIONS

COLUMBIANA HI TECH

LIQUI—RAD
TRANSPORT UNIT

LR—SAR

Security-Related Information
Figure Withheld Under 10 CFR 2.390

Rev. No.	Change	Date	By
9	NO CHANGES THIS PAGE	5/23/13	RF
8	CHANGED LABEL TO MARK, ADDED (MM)	8/1/11	CLC
7	NO CHANGES THIS PAGE	2/16/06	CLC
6	NO CHANGES THIS PAGE	2/16/06	CLC
5	NO CHANGES THIS PAGE	2/16/06	CLC
4	ADDED OPTIONAL TO MANUAL VENT ENCLOSURE	8/4/05	CLC
3	ADDED 3/8" FOR MHC LID THICKNESS	9/03/02	GAC
2	CHANGED TO CHT LOGO	4/19/02	GAC
1	ADDED WELD SYMBOLS, DETAILS & NOTES	6/22/01	ARM

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LIQUI—RAD
TRANSPORT UNIT

Drawing Number: LR—SAR

Security-Related Information
Figure Withheld Under 10 CFR 2.390

Rev. No.	Change	Date	By
9	REVISED DRAW PIPE LENGTH REQUIREMENTS	8/23/13	RF
8	CHANGED LABEL TO MARK, ADDED (MIN) IF HANDLE PRESENT	8/1/11	CLC
7	NO CHANGES THIS PAGE	2/18/06	CLC
6	CORRECTED TITLE BLOCK	8/4/05	CLC
5	ADDED A STRESS GROOVE TO THE ELBOW	11/01/02	GAC
4	[illegible]	7/17/02	GAC
3	CHANGED TO CHT LOGO	8/18/02	GAC
2	ADDED TEST PORT DETAILS	5/16/02	ARM
1	ADDED WELD SYMBOLS, DETAILS & NOTES	6/22/01	ARM

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LIQUI—RAD
TRANSPORT UNIT

DRAWING NUMBER
LR—SAR

Security-Related Information
Figure Withheld Under 10 CFR 2.390

Rev. No.	Change	Date	By
9	NO CHANGES THIS PAGE	8/23/13	PF
8	UPDATED NOTES 4, 5, 7, 10, 12 & 13	8/1/11	CLC
7	CORRECTED TITLE BLOCK	8/4/05	CLC
6	ADDED GLT TO VITON	11/01/02	GAC
5	REVISED NOTE 4 AND 15	9/03/02	GAC
4	UPDATED NOTES AND CSP-C1-2 TO REV.1	7/26/02	GAC
3	UPDATED NOTES & NEW LOGO	6/12/02	GAC
2	UPDATED NOTES	8/30/01	ARM
1	ADDED WELD SYMBOLS, DCALS & NOTES	8/23/01	ARM

• REVISIONS •

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LIQUI—RAD
TRANSPORT UNIT

DRAWING NUMBER
LR—SAR

SECTION TWO
STRUCTURAL EVALUATION

TABLE OF CONTENTS

2 STRUCTURAL EVALUATION

2.1 Structural Design

2.1.1 Discussion

The LR is a cylindrical package set in a rectangular angle frame having a foot print of 56" x 56" and a height of 73". The loaded package maximum gross weight of the LR is provided in Table 1-1. Table 1-2 provides a list of the materials of construction. A comprehensive description of the packaging is provided in Section 1.2, and drawings are provided in Appendix 1.3.1. The primary structural components of the packaging are the inner and outer vessels and the angle frame. The insulation functions structurally as an impact limiter. Positive closure of the packaging is provided using stainless steel bolts/studs at each of the lids.

2.1.2 Design Criteria

The LR is designed to meet all of the performance requirements of 10CFR71, Subpart E for Type B fissile materials. The containment boundary is defined as the containment vessel, the primary lid (excluding the portion inside the secondary wall) and seal, and the secondary lid and seal. While the package is not stamped as an ASME pressure vessel, the containment vessel is constructed in accordance with ASME Pressure Vessel Code (Section VIII) procedures, calculations, and design criteria, with a maximum internal design pressure of 50 psig and a maximum external design pressure of 30 psig. The LR is designed to allow transport of UN solution in a safe manner under Normal and Hypothetical Accident Conditions. Table 2-1 provides a summary of the structural evaluation, design criteria, and results of the evaluation.

The LR is manufactured under a quality assurance program that meets the requirements of 10CFR71, Subpart H. All welding is completed by ASME Section IX-qualified welders using acceptable welding procedures.

2.2 Weights and Centers of Gravity

The weights and centers of gravity of the LR Transport Unit and its contents are tabulated in Table 2-1. Based on properties of the materials of construction and the maximum contents, the center of gravity was determined to be located 36.59 inches from the absolute base (including the legs) of the package along a vertical axis in the physical center of the package (See Appendix 2.10.1)

2.3 Mechanical Properties of Materials

The mechanical material properties used in the structural evaluation are provided in Tables 2-2 and 2-3. Metal samples were subjected to Charpy "V" impact test at +100°F, 67-74°F and -20°F to evaluate the effects of temperature on the material properties. Foam insulation samples were tested for compressive strength at +100°F, 67-74°F and -20°F to evaluate any temperature effects on the foam's compressive strength. The result of these tests can be found in Appendix 2.10.2.

packaging remain nominal at these temperatures. Effects from heat due to normal conditions of transport are described in Section 3.3. Under normal conditions, the temperature of the contents does not exceed 179°F (82°C).

2.6.2 Cold

An ambient temperature of -40°F with no insolation and no decay heat results in a package with a uniform temperature of -40°F. An ambient temperature of -40°F will not have an adverse effect on the LR, since temperatures in this range do not materially affect the ductility of the steel in the package. Charpy impact test results are provided in Appendix 2.10.2.

At temperatures below 0°C, the contents of the package freeze. Because the contents are largely water, expansion occurs with the phase change. The 33-gallon ullage provided is sufficient for expansion of the contents and allows additional space for the air in the head space to avoid pressurization above the 50 psig design pressure rating. The compression of the closure on the O-ring assures that normal thermal effects do not produce leaks.

2.6.3 Reduced External Pressure

The internal pressure of a filled containment vessel ranges from 14.7 to 32 psia (see Section 3). A reduced external pressure of 3.5 psia results in a maximum differential pressure of 28.5 psi. This pressure is well within the 50 psig internal design pressure of the LR.

2.6.4 Increased External Pressure

The internal pressure of a filled containment vessel ranges from 14.7 to 32 psia (see Section 3). An increased external pressure of 20 psia results in a maximum differential pressure of 12 psi. This pressure is well within the 30 psig external design pressure of the LR. The increased external pressure of 20 psia is bounded by the immersion pressure evaluated in Section 2.7.4 for the outer vessel. The factor of safety calculated for immersion is 1.73.

2.6.5 Vibration

Vibration due to normal transport conditions has no measurable effect on the LR, excluding optional component, e.g., draw pipe. All closures are tightly bolted (75 ft/lbs. +10/-0) to prevent loosening due to vibration. The insulation does not settle or compact appreciably due to vibration, nor does vibration cause the contents to settle.

2.6.6 Water Spray

A one-hour water spray simulating rainfall at a rate of 2 in/hr will have no effect on the LR, as the outer vessel is impervious to water and is designed to withstand exterior pressure loads much higher than those applied by the water spray. The stainless steel containment vessel is sealed with a double O-ring designed to prevent water inleakage during normal transportation; therefore, the exterior water spray has no effect on the containment vessel or contents. Because it is clear that it would have no effect on the package or contents, the water spray test was not conducted during the battery of drop and fire test.

2.6.7 Free Drop

The LR was subjected to HAC drop testing as specified by 10CFR71 and the conditions and results of the test are provided in Appendix 2.10.4. When subjected to a free drop from a evaluation of the critical general buckling load for the uprights. The slenderness ratio for the frame uprights is:

$$L/r = 64\ 3/4'' / 0.39'' = 166.$$

Where L is the length of the upright and r is the least radius of gyration of the section. Thus the uprights behave as a long column and the Euler formula is used to determine the critical general buckling stress:

$$\sigma_{critical} = n\, \pi^2\, E / (L/r)^2 = 41{,}550 \text{ psi.}$$

where

$\sigma_{critical}$	is the critical general buckling stress
n	is the end constant for both ends fixed, 4
E	is the modulus of elasticity, 29E6 psi
L/r	is the slenderness ratio, 166.

Assuming the entire load is carried by the four frame uprights, the stress due to the 5x compression load is:

$$28{,}460 \text{ lb} / 4\ (0.94 \text{ in}^2) = 7{,}569 \text{ psi}$$

The factor of safety against failure of the frame uprights due to general buckling is:

$$\text{F.S.} = 41{,}550 \text{ psi} / 7{,}569 \text{ psi} = 5.5.$$

2.6.10 Penetration

Puncture drop tests conducted as part of the hypothetical accident testing (see Appendix 2.10.4) showed that minimal damage was done to the package's integrity as a result of these severe tests. Because the more severe hypothetical accident testing did not produce appreciable damage to the package, it is reasonable to assume that the much lighter impact of a 13 pound rod as described in 10CFR71 has a negligible effect on the LR's ability to provide containment of the package contents.

2.6.11 Conclusion

Analytical evaluation and extrapolation of the results of hypothetical accident tests show that packaging remains intact under all normal conditions. The containment vessel provides absolute containment during all normal condition events; therefore, the LR meets the requirements for Normal Conditions of Transport.

2.7 Hypothetical Accident Conditions

2.7.1 Prototype Testing

A full-scale LR prototype containing a simulated load was subjected to the sequence of drop, puncture and fire tests of the hypothetical accident conditions of 10CFR71.73. The prototype was fabricated to the drawings provided in Appendix 1.3.1, using the procedures described throughout this SARP. A detailed report of the LR Compliance Test Program is provided in Appendix 2.10.4.

The test article consisted of the 263 gallon LR prototype, loaded with salt water and steel shot to simulate a typical payload. The total weight of the package tested was 5,692 lb (2582 kg). The orientations used for the drop tests were determined to be the most damaging based on preliminary drop tests and finite element modeling (see Appendix 2.10.5). Either polyurethane or phenolic foam may be used as structural insulation, and current specifications for the foam insulation differ from that used in the prototype testing. However, these changes do not impact the results of the test of performance of the package, for a full explanation see Appendix 2.10.6. Additionally, a closure design option and leak test port option for the Secondary Lid was not tested. Calculations are provided in Appendix 2.10.8 and Appendix 2.10.9 demonstrating that these design options are equivalent to the tested configuration, and based on the analytical results, additional performance testing with these design options is unnecessary. The draw pipe is optional in the revised design, but the previous tested configuration with draw pipe is still valid and conservative since the weight of the previous tested configuration is slightly higher than the revised configuration, and hence no additional drop test are necessary. The leak test is also unnecessary since the draw pipe is not part of containment boundary.

2.7.1.1 Prototype Drop Tests

All drop test were performed on the same 10' x 10' x 6' reinforced concrete target pad. A 1" thick steel plate is attached to the top of the target pad using J-bolts. The estimated weight of the target pad is approximately 95,000 pounds. A plywood panel, set behind the test pad, was painted with a 1 foot grid pattern to allow gross reference measurements. A quick release mechanism (a D-ring pin in mechanical jaws with pneumatic actuation) was used to release the prototype from the drop height without imparting rotational or translational motion to the prototype. For the puncture drop, a puncture ram was attached to the center of the test pad using eight bolts. The ram is a 6 inch diameter by 16 inch long right circular cylinder with radiused ends, fabricated from mild steel and welded to a 2 inch thick steel plate. The test were videotaped and photographed, and post-drop damage measurements were recorded after each drop.

2.7.1.1.1 Initial Conditions

In order to determine the worst-case initial temperature conditions for the drop tests, the performance characteristics of the primary LR fabrication materials were evaluated at various temperatures. Metal samples were subjected to Charpy "V" impact tests and ESP-PF-2 foam insulation samples were tested for compressive strength at +100°F, 67-74°F and -20°F (See Appendix 2.10.2). The physical characteristics of the foam samples remained essentially unaffected by the different temperatures; however, metal samples tested at the -20°F range exhibited reduced impact strength; therefore, test packages were maintained at a temperature below -20°F prior to testing. Additionally, polyurethane generally has a higher compressive strength at all temperatures than phenolic insulation; therefore, the use of phenolic foam insulation for the performance tests is conservative.

4 CONTAINMENT

4.1 Containment Boundary

The containment boundary is defined as the containment vessel, primary lid (excluding the portion inside the secondary wall) and seal, and secondary lid and seal.

4.1.1 Containment vessel

Although it is not stamped as such, the containment vessel is built in accordance with the ASME pressure vessel Code (Section VIII Division 1). The containment vessel's primary closures are at the primary and secondary lids. The primary lid is sealed using a double O-ring and is secured by sixteen 5/8" stainless steel studs and nuts. The primary lid includes a fill port consisting of a vent and pressurization valve and a stainless steel threaded (plugged) quick-disconnect fitting. The secondary lid assembly provides a sealed enclosure around the valving and fittings on the primary lid. The secondary lid is sealed using a double O-ring and is secured by twelve 5/8" stainless steel bolts and nuts.

4.1.2 Containment Penetrations

The LR containment vessel has no penetrations.

4.1.3 Seals and Welds

The containment vessel uses four circumferential welds: the joint between the lower head and the vessel body, the joint between the upper head and the vessel body, the joint between the upper head and the studding outlet, and the joint on the primary lid assembly. All welds are completed, inspected, tested, and maintained in accordance with Drawing Number LR-SAR, Sheets 1, 2, 3, & 4 for the Liqui-Rad Transport Unit (Appendix 1.3.1). Minimum requirements are specified in Sections 7 and 8 of this Safety Analysis Report.

Both the primary and secondary lids are sealed using a double O-ring rated for continuous use up to 400°F.

4.1.4 Closure

The containment vessel has two closures, one at the primary lid and one at the secondary lid. The primary lid is sealed using a double O-Ring and is secured by sixteen 5/8" stainless steel studs and nuts. The secondary lid is sealed using a double O-ring and is secured by twelve 5/8" stainless steel bolts and nuts. The closure torque required for each bolt or stud is 75 ft.-lbs. [+10-0].

4.2 Requirements for Normal Conditions of Transport

4.2.1 Containment of Radioactive Material

The package contents, as defined in Section 1.2.3, are assumed to be completely releasable in