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Ref: AFS–13–0156

August 19, 2013

ATTN: Document Control Desk
Director, Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555–0001

SUBJECT: TRUPACT–III Amendment Request, Docket No. 71–9305, SAR Revision 15

AREVA Federal Services LLC (AFS) hereby submits Revision 15 of the Safety Analysis Report for the TRUPACT–III packaging, Docket No. 71-9305. This revision seeks approval for two additional methods of fabricating or repairing the debris shield holder (a 4-mm thick, 15-mm long extension of the shear lip of the closure lid). The two additional methods of fabrication utilize welding to attach the holder to the shear lip. The existing method includes the holder as integral with the shear lip. All three methods are considered equivalent and are now shown on sheet 14 of the SAR drawing as Options 1, 2, and 3 (where Option 2 is the existing method). The packaging description in Chapter 1 of the SAR has been revised accordingly. A justification for the optional methods, demonstrating no change to the safety of the packaging, is provided in Section 2.12.6.3 of the SAR.

Included with this letter is one paper copy of the revised pages and SAR drawings and one CD containing the entire SAR, Revision 15, in PDF file format. The CD is contained within an envelope labeled, "TRUPACT–III Docket 71–9305 Electronic Copy of Documents".

AFS appreciates the NRC's timely response to this matter, and requests that this revision be approved and the revised TRUPACT–III Certificate of Conformance be issued by October 31, 2013.

Should you have any questions regarding this submittal, please contact me at (253) 552–1321 or via E–mail (phil.noss@areva.com).

Very Truly Yours,
AREVA Federal Services LLC

Phil Noss

Phil Noss
Licensing Manager

cc: Huda Akhavannik, NRC (including six paper copies and one CD)
Robert Watkins, AFS Project Manager
Todd Sellmer, Nuclear Waste Partnership

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Contents of Electronic Media

This submission is composed of both paper copies and an electronic copy. The electronic copy is contained within an envelope labeled, "TRUPACT–III Docket 71–9305 Electronic Copy of Documents". The envelope contains one disc as follows:

Title	Media Type:	Contents
TRUPACT–III SAR	CD–R	One file of the complete text of the submittal: TRUPACT–III SAR, Complete, Rev. 15.pdf (26,624 kb) (580 pages)

Delete and Insert Instructions
for
Updating TRUPACT–III Safety Analysis Report
Docket Number 71–9305

SAR Section	Delete Rev. 14	Insert Rev. 15
Cover and Spine	Cover Page and Spine	Cover Page and Spine
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General Arrangement Drawings	51199–SAR, Rev. 14	51199–SAR, Rev. 15
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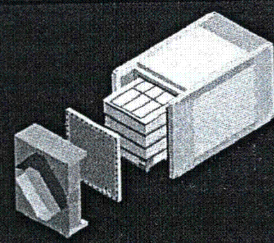
TRUPACT-III

Revision 15
July 2013

Safety Analysis Report



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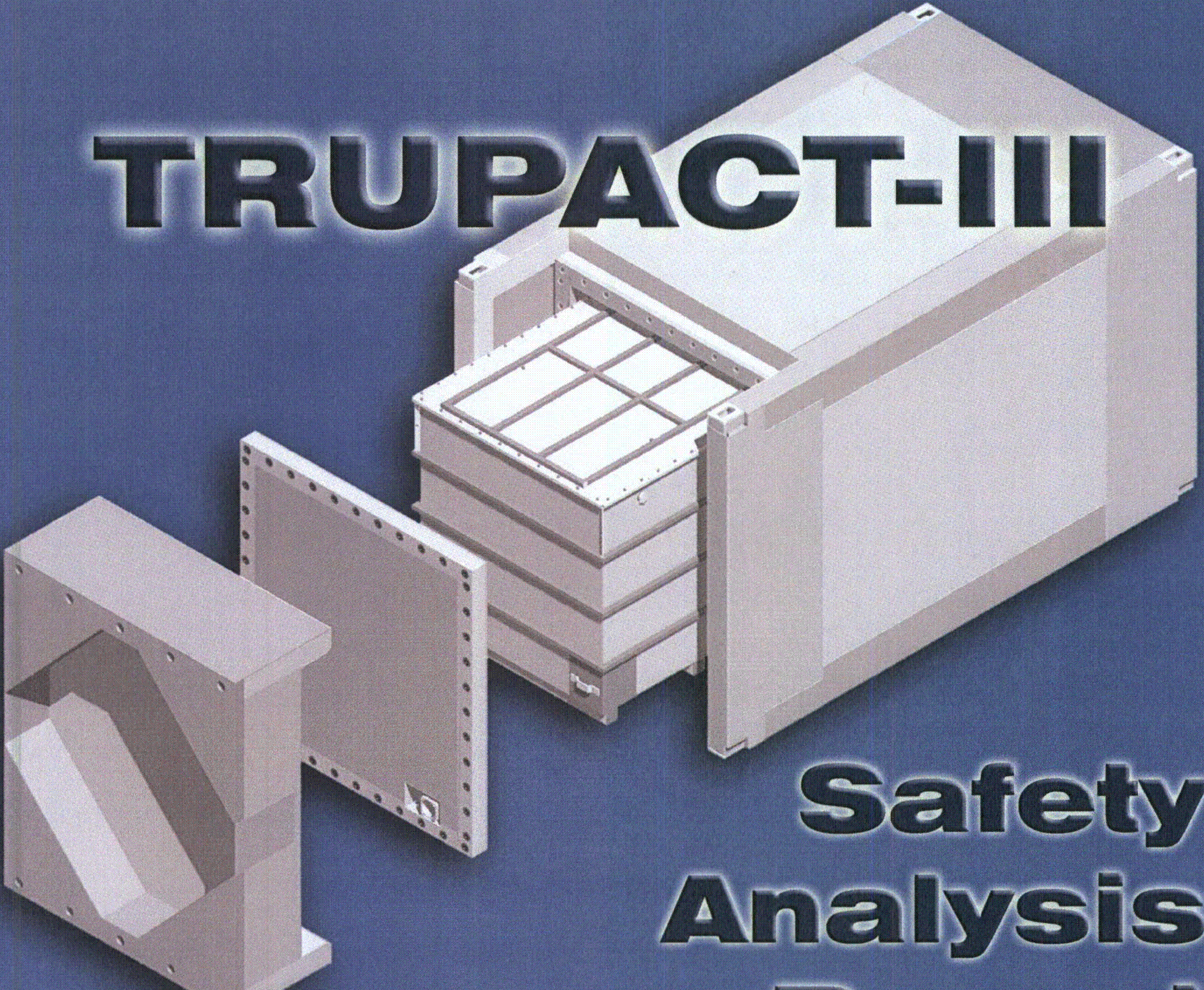

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1.2 Package Description

This section presents a basic description of the TRUPACT–III package. General arrangement drawings of the TRUPACT–III packaging are presented in Appendix 1.3.1, *Packaging General Arrangement Drawings*. Payload assembly details are presented in the TRUPACT–III TRAMPAC[1].

1.2.1 Packaging

The TRUPACT–III packaging is comprised of a body, a closure lid, and an overpack cover, as shown in Figure 1.1-1. The components may be briefly described as follows:

- The body is in the form of a rectangular box. It is comprised of the containment structural assembly (CSA, a rigid rectangular weldment) and an integral energy–absorbing overpack structure.
- The closure lid is a flat, rigid weldment having a construction similar to that of the CSA body, and when bolted in place, completes the CSA.
- The overpack cover is the only separable part of the overpack structure, and allows access to the closure lid and the vent/test ports.

The CSA (body plus bolted closure lid) is the rigid weldment that contains, supports, and reinforces the containment boundary. The containment boundary consists of:

- the inner stainless steel sheets of the CSA body (four sides plus the closed end),
- the closure lid inner sheet,
- the inner O–ring seal located in the flange of the closure lid,
- the vent port insert located in the closure lid,
- the vent port insert inner O–ring seal.

The body, closure lid, and overpack cover are fully described in the following subsections. All detail and sheet references in the following text refer to the drawings presented in Appendix 1.3.1, *Packaging General Arrangement Drawings*. Except for fasteners and some incidental parts as noted, all steel components are made from UNS S31803 duplex stainless steel.

1.2.1.1 Body

The body of the TRUPACT–III packaging is a rectangular box, open on one end. It consists of the body portion of the CSA with an integral overpack structure.

The CSA is a rigid stainless steel weldment consisting of sandwich panels which form the flat walls, as shown in Section BC–BC on Sheet 19. The wall sections are made of inner and outer, 8–mm thick sheets, connected by V–stiffeners of 4–mm thickness. The total wall section thickness of the CSA body is 140 mm. The V–stiffeners are connected to the outside surface of the inner sheets using continuous fillet welds. The outer sheets are connected to the V–stiffeners

[1] U.S. Department of Energy (DOE), *TRUPACT–III TRU Waste Authorized Methods for Payload Control (TRUPACT–III TRAMPAC)*, U.S. Department of Energy, Carlsbad Field Office, Carlsbad, New Mexico.

using either plug welds (on the four sides of the box) or continuous slot welds (on the closed end wall). The walls and V–stiffeners are joined at the edges of the box using diagonal sheets of 10–mm thickness as shown in Detail AX on Sheet 20. The CSA body flange is a rigid box beam structure having 15–mm inner and outer plates and a 25–mm seal face plate thickness, as shown in Detail BE on Sheet 21. The rear plate of the box beam is 10–mm in thickness. The threaded bolting bosses for the closure bolts and closure lid alignment pins pass through the box beam and are welded to both the outer plate and the rear plate. Optionally, alloy steel thread inserts may be used in the bolting bosses. By means of several 10–mm diameter holes in the diagonal corner plates and through other openings, all cavities between the inner (containment) and outer sheets of the CSA are interconnected. When evacuated of air and backfilled with helium, these cavities present a fully enveloping blanket of helium for use during leakage rate testing of the containment boundary. All containment boundary welds are radiograph inspected per Flag Note 15 and liquid penetrant inspected per Flag Note 16 on Sheet 1. All other CSA body welds are liquid penetrant inspected per Flag Note 16 on Sheet 1. The internal cavity dimensions are: 1,840 mm wide, 2,000 mm tall, and 2,790 mm long.

A debris shield receptacle is located on each side of the CSA inner cavity near the opening as shown on Sheet 4. The receptacle is a 26–mm × 38–mm cross section bar made of Type 304L or UNS S31803 duplex stainless steel with a 15–mm wide by approximately 20–mm deep groove cut along its length, as shown on Sheet 19. The groove interfaces with the debris shield insert, described in Section 1.2.1.2, *Closure Lid*. Guide bars are attached to the CSA inner cavity (as shown in Section F–F on Sheet 5 and Section H–H on Sheet 7), having a cross section of 25 mm × 76 mm, and running between the closed end of the CSA and the back edge of the debris shield receptacle. Three guide bars also run across the closed end of the CSA. The guide bars, made of ASTM Type 304/304L stainless steel, are located to correspond to the bumpers of the SLB2 payload container. There are three bars on each side of the cavity and on the closed end, and two on the top. Both the debris shield receptacle and guide bars are attached to the CSA containment sheets using a combination of groove welds and fillet welds.

Two 100–mm × 50–mm × 6–mm austenitic stainless steel channels are installed on the floor of the cavity, and continuously welded to the bottom containment stainless steel sheet. Austenitic stainless steel guide tracks are installed and continuously welded to the channels. Two M24 × 3 threaded bosses made from ASTM Type 304L stainless steel are welded to the channels to provide an anchorage for internal arrangements such as a roller floor, as shown in Detail AD on Sheet 21.

The overpack structure fully envelops the CSA body, and is designed to provide energy absorption, puncture resistance, and thermal insulation for the containment seals. Energy absorption is accomplished by the crushing of four different densities of polyurethane foam and by deformation of the outer sheets of the overpack structure, having a thickness of 6– or 8–mm. Puncture resistance is afforded by adjacent layers of balsa wood, stainless steel, and polyurethane foam. Thermal protection is provided by layers of stainless steel, foam, and calcium silicate insulation.

The overpack structure surrounding the CSA body is shown in Section F–F on Sheet 5 and Section G–G on Sheet 6. On the top and bottom walls, the thickness of the structure is 185 mm; on the vertical side walls, 190 mm; and in the octagonal recess on the closed end, the thickness is 201 mm. The overpack structure on the end (outside the octagonal recess) extends 610 mm beyond the CSA weldment, and the total length of the end overpack structure is 838 mm. At the open end of the body, two structures extend beyond the CSA flange face that envelops both sides of the overpack cover.

These structures, known as "cheeks", contain energy absorbing foam and thermal insulation. The cheeks extend 748 mm beyond the CSA flange face, and the total length of the cheek structure is 870 mm. The overall length of the Body assembly, which is equal to the overall length of the assembled packaging, is 4,288 mm. The external width is 2,500 mm, and the external height is 2,650 mm.

The puncture–resistant system of components occupies the central 2,574 mm of the package sides, top, and bottom, and the octagonal recess at the closed end. Starting adjacent to the CSA weldment, the system consists of a 109 – 120–mm thick layer of nominally 0.10 kg/dm^3 polyurethane foam, a puncture resistant plate made from stainless steel, a 60–mm thick layer of nominally 0.12 kg/dm^3 balsa wood, and an outer sheet made from 6–mm thick stainless steel. The puncture–resistant plate is 10–mm thick on the sides, top, and bottom, and 15–mm thick on the closed end. The puncture–resistant plates are fastened to the surrounding structures using pop rivets. As shown in Detail E on Sheet 4, the end faces of the top and bottom overpack structure by the open end each contain five threaded bosses (total of ten) for the attachment of the overpack cover. The threads are M36 × 4 and may optionally feature alloy steel thread inserts. As shown in Section C–C of Sheet 4, a single alignment pin is located between two bolt holes in the top row, used to aid in alignment during installation of the overpack cover.

As shown in Section H–H on Sheet 7, with further detail given in Detail K, the four edges of the overpack in the central 2,574 mm length between the end structures are protected by a chevron–shaped region filled with blocks of 0.29 kg/dm^3 polyurethane foam and enveloped by a 6–mm thick stainless steel sheet.

The end overpack region (228 mm overlapping the end of the CSA weldment and extending 610 mm beyond the end of the CSA for a total length of 838 mm) is composed of nominally 0.48 kg/dm^3 and 0.16 kg/dm^3 polyurethane foam. The heavier density foam is used for protection in corner drops, and is placed as shown in Section J–J on sheet 8. The lighter density foam is used primarily on the end face as shown in Section AU–AU on sheet 8. A puncture–resistant plate of 6–mm thickness separates the two densities of foam. Other views of the end overpack structure are shown in Partial Sections AR–AR and AS–AS on Sheet 9.

At the open end of the body, the cheek structures have a construction similar to the corresponding regions of the closed end overpack. An added feature in the cheeks is a 30–mm thick sheet of calcium silicate thermal insulation placed next to the CSA body flange. The insulation is protected by enveloping stainless steel plates of 16–mm thickness. The cheek is shown in Partial Sections AN–AN and AP–AP on Sheet 9. All welds pertaining to the overpack structure are liquid penetrant inspected per Flag Note 17 on Sheet 1.

A modified International Organization for Standardization (ISO) lifting corner fitting is incorporated into each corner of the body. These ISO fittings provide the handling interface for lifting the TRUPACT–III package from its conveyance and on–site movement for loading/unloading operations. Since these fittings are only designed for lifting and off–road movement of the package, the ISO fittings are disabled during transport to prevent their use as a potential tie–down device.

The payload cavity length is 2752 ± 3 mm. This tight tolerance is achieved in one of three ways: a) reducing the thickness of the three guide bars which run transversely across the closed end of the payload cavity, b) attaching hard plastic plates to the three guide bars, or c) a combination of guide bar thickness reduction and addition of plastic plates. The vertical locations of the transverse guide bars correspond to the bumpers on each end of the SLB2. For a minimum length SLB2 of 107.38 inches, or 2,727 mm, the maximum axial free space between the package cavity and the SLB2 is 28 mm. A minimum clearance between the SLB2 and the closure lid inner surface of 2 mm will be assured at the time of package closure (see Section 7.1.4, *Loading the Payload into the TRUPACT–III Package*).

To prevent pressurization of the overpack structure in the event of the HAC fire, the outer sheets feature a total of (36) 1–inch NPT fusible plastic plugs. All external surfaces of the body assembly except the external bottom surface, surfaces covered by the overpack cover, and the ISO corner fittings, are coated with a low–halogen white paint. The external bottom surface may be painted as an option.

1.2.1.2 Closure Lid

The closure lid, shown on Sheets 13 and 14, is a rigid stainless steel weldment that completes the CSA. It consists of inner and outer, 12–mm thick sheets, connected by V–stiffeners of 4–mm thickness. The total thickness of the weldment is 148 mm (not including the shear lip), the width is 2,108 mm, and the height is 2,280 mm. The V–stiffeners are attached to the outside of the inner (containment) sheet using continuous fillet welds. The outer sheets are connected to the V–stiffeners using continuous slot welds (similar in kind to the corresponding welds on the closed end).

Around the outside of the lid is located a rigid box beam flange which mates with the flange on the CSA body. As shown in Detail Y on Sheet 14, the inner (seal side) plate of the flange is 20–mm thick. The opposite side of the flange is also 20–mm in thickness. The remaining two plates of the flange are of 16–mm thickness. Bolt tubes of 10–mm radial thickness are welded at each end to the inner and outer flange plates, and which carry the closure bolt loads through the thickness of the lid. A shear lip runs on all four sides of the lid and engages the opening of the CSA body. It has a shear thickness of 20 mm and a bearing width of 10 mm. All containment boundary welds are radiograph inspected per Flag Note 15 and liquid penetrant inspected per Flag Note 16 on Sheet 1. All other closure lid welds are liquid penetrant inspected per Flag Note 16 on Sheet 1. As with the CSA body, all cavities within the closure lid are interconnected. When evacuated of air and backfilled with helium, these cavities present a fully enveloping blanket of helium for use during leakage rate testing of the containment boundary. Access to these cavities (including those between the inner and outer sheets of the CSA body) is provided by small ports in the lower right–hand corner of the lid and CSA body flanges, as shown in Section Z–Z on Sheet 15.

Extending inward from the shear lip inner surface (as shown in Figure 1.1-7) is the debris shield holder, which is 4 mm thick and 15 mm long. It may be welded to, or be integral with the shear lip. The debris shield insert, shown on Sheet 4, has a U–shaped cross–section and is made of silicone foam rubber. It is attached to both sides of the holder using double–sided tape. The insert mates with the receptacle described in Section 1.2.1.1, *Body,* to form the completed debris shield, as shown on Sheet 4. Each of the four shear lips features two, 5/16–inch (7.9 mm) diameter filters made from porous polyethylene. These filtered passages prevent a pressure differential across the debris shield and permit helium to reach the containment O–ring seal during leakage rate testing.

In the lower right–hand corner on the exterior surface, a 200–mm × 320–mm recess is located, which contains the vent port and the seal test port, as shown in Section Z–Z on Sheet 15. The seal test port communicates with the cavity between the containment and test O–ring seals in the closure lid and is used during leakage rate or pressure rise testing. The vent port (a containment boundary penetration) is 50–mm in diameter. It is closed by an aluminum bronze insert and sealed by a butyl

O–ring seal. A test O–ring seal is also located in the vent port insert. The insert is retained in position using an aluminum bronze, M120 × 6 threaded retaining ring, which in turn is locked in place using an aluminum bronze locking ring. In the region of the 200 mm × 320 mm recess, the closure lid inner plate is 40–mm in thickness (20–mm elsewhere).

The closure lid is attached to the body by (44) M36 × 205 mm bolts that are tightened to 1,600 N–m (lubricated) torque. The bolts are made from ASTM A320, L43 alloy steel and are cadmium plated. Washers are used with the closure bolts, made of ASTM A564, Grade 630, Condition H1025 (17–4 PH) material. The sealing flange of the closure lid contains two dovetail grooves to retain the butyl rubber containment and test O–rings, each of which is nominally of 12–mm cross–sectional diameter. At each corner of the closure lid, the containment seal groove changes direction using a 50–mm radius, while the test O–ring groove utilizes a 74–mm radius. Both containment O–ring seals (i.e., the inner seal on the vent port and the inner seal of the closure lid) are made from Rainier Rubber R–0405–70 material, meeting the requirements of Section 8.1.5.3, *Butyl Rubber O–rings*.

Lifting of the closure lid is performed using two standard lifting eyes that are threaded into M36 threaded bosses installed on the top surface. During transport, these lifting points are covered by the overpack cover, making them inoperable.

One M36 threaded hole is located near the middle of each side of the lid (total of four holes). These holes are used if needed to separate the closure lid from the body. Two holes for the closure lid guide pins (attached to the CSA body flange) are located immediately above the horizontal centerline. As an option, thread inserts may be installed in all internal threads of the closure lid.

1.2.1.3 Overpack Cover

The overpack cover has a design very similar to that of the overpack structure on the closed end. When installed, the overpack cover fits between the cheeks on the body and completely envelops the closure lid and CSA body flange. It is designed to provide energy absorption, puncture resistance for the closure lid, and thermal insulation for the containment seals, and is depicted on Sheets 16 through 18.

The overpack cover of the TRUPACT–III packaging consists of a rectangular stainless steel sheet structure encasing an impact–absorbing and thermal insulation materials structure. Similar to the body closed end overpack structure, the central area of the overpack cover consists of a nominally 393–mm deep octagonal recess. The recess consists of a 6–mm cover sheet, a 60–mm thick balsa wood sheet, a 15–mm thick puncture–resistant stainless steel sheet, and a 120–mm thickness of 0.10 kg/dm^3 polyurethane foam, adjacent to a 6–mm thick inner cover sheet. Outside the recess, the overpack cover features 272 mm long, upper and lower flanges which envelop the CSA body flange. The remainder of the 870–mm total thickness is taken up by a 42–mm thick layer of calcium silicate insulation, a 16–mm thick stainless steel protective plate, a 382–mm thickness of 0.48 kg/dm^3 polyurethane foam, a 6–mm thick puncture–resistant plate, a 140–mm thickness of 0.16 kg/dm^3 polyurethane foam, and an outer 8–mm thick steel sheet. The calcium silicate thermal insulation and the 16–mm thick protective stainless steel sheet include a region that covers the vent test ports as shown in Section AF–AF on Sheet 17. The upper and lower flanges feature 30–mm thick thermal insulation (corresponding to the thermal insulation in the body cheeks), protected by 16–mm thick stainless steel plates.

The overpack cover is attached to the body by ten, M36 × 60 mm bolts that are tightened to 1,600 N–m (lubricated) torque. The bolts are made from ASTM A320, Type L43 alloy steel and are cadmium plated. The bolts (five each along the top and bottom edges) are installed through thin–wall, ASTM Type 304L stainless steel access tubes that are located on the top and bottom edges. The bolts thread into 70–mm diameter stainless steel threaded bosses that are welded in the exterior stainless steel sheet of the body. Two of the access tubes (lower left and lower right) are configured to accept a tamper–indicating seal. On the inside surface, short, 3½–inch diameter cylindrical depressions are located around the perimeter to provide receptacles for the heads of the closure lid bolts. A 44–mm wide and 84–mm tall opening located on the top flange of the overpack cover interfaces with the guide pin installed in the mating flange of the body assembly.

Lifting of the overpack cover is performed using two standard lifting eyes that are threaded into M36 threaded bosses installed on the top surface. These threaded bosses are made inoperable during transport to prevent their use as a tie–down device and to prevent the collection of water. As an option, a thread insert may be installed in these internal threads. On one side of the overpack cover (protected by a side cheek), is located a recess in which a pressure relief valve is installed, and which will prevent an excessive pressure differential from developing inside the overpack cover shell. To prevent pressurization of the overpack cover in the event of the HAC fire, the outer face sheet features a total of (8) 1–inch NPT fusible plastic plugs.

The overpack cover has nominal external dimensions of 2,108–mm wide, 2,650–mm high, and 870–mm thick. All overpack cover welds are liquid penetrant inspected per Flag Note 17 on Sheet 1. All surfaces of the overpack cover that form the outside surface when installed on the TRUPACT–III, except the external bottom surface, are coated with a low–halogen white paint. The external bottom surface may be painted as an option.

1.2.1.4 Gross Weight

The gross shipping weight of a TRUPACT–III package is 25,000 kg (55,116 lbs) maximum. A summary of overall component weights is shown in Table 2.1-2 and discussed in Section 2.1.3, *Weights and Centers of Gravity*.

1.2.1.5 Neutron Moderation and Absorption

The TRUPACT–III package does not require specific design features to provide neutron moderation and absorption for criticality control. Fissile materials in the payload are limited to amounts that ensure safely subcritical packages for both NCT and HAC. The fissile material limits for a single TRUPACT–III package are based on an optimally moderated and reflected fissile material. The structural materials in the TRUPACT–III packaging are sufficient to maintain reactivity between the fissile materials in an infinite array of damaged TRUPACT–III packages at an acceptable level. Further discussion of neutron moderation and absorption is provided in Chapter 6.0, *Criticality Evaluation.*

1.2.1.6 Receptacles, Valves, Testing, and Sampling Ports

There are no receptacles used on the TRUPACT–III packaging. However, a vent port, a seal test port, and a body helium fill port access port are located in the closure lid as described in Section 1.2.1.2, *Closure Lid.* The vent port provides access to the payload cavity for sampling or venting the payload cavity during unloading operations. The vent port, in conjunction with the seal test port, is also used to perform leakage rate testing of the inner containment O–ring seal to verify proper assembly of the TRUPACT–III package prior to shipment. The vent port and the seal test port are accessed through a recess located in the lower right corner of the closure lid. The body helium fill port access port is accessible on the surface of the closure lid, near the recess. All ports are inaccessible when the overpack cover is installed.

1.2.1.7 Heat Dissipation

The TRUPACT–III package design capacity is 80 thermal watts maximum. The TRUPACT–III package dissipates this low internal heat load entirely by passive heat transfer for both NCT and HAC. The TRUPACT–III packaging does not utilize any coolants. To improve the insolation resistance for NCT, the external surfaces of the packaging are painted with a low–halogen white paint. No other features or special devices are needed or utilized to enhance the dissipation of heat. Features are included in the design to enhance thermal performance in the HAC thermal event. These features include the use of a high temperature insulating material (calcium silicate insulating board) and polyurethane foam in the body and overpack cover. A more detailed discussion of the package thermal characteristics is provided in Chapter 3.0, *Thermal Evaluation.*

1.2.1.8 Lifting and Tie–down Devices

Lifting of the TRUPACT–III package is via the ISO fittings at each upper corner. Under excessive load, the ISO corner fittings are designed to fail in shear prior to compromising the structure of the packaging. The ISO corner fittings are covered during transport and rendered inoperable to preclude their use as a tie–down device.

The closure lid and the overpack cover are lifted via two M36 lifting eyes. These lifting points are designed for lifting only their respective component, and therefore, are covered during transport and rendered inoperable to preclude their use as a tie–down device.

There are no tie–down devices on the TRUPACT–III package. The TRUPACT–III package is secured to the transport vehicle (semi–trailer or rail car) by straps or a tie–down frame that is positioned over the top of the package.

A detailed discussion of lifting and tie–down designs, with corresponding structural analyses, is provided in Section 2.5, *Lifting and Tie–down Standards for All Packages.*

1.2.1.9 Pressure Relief System

There are no pressure relief systems included in the TRUPACT–III package design to relieve pressure from within the containment boundary. A pressure relief valve is utilized in the overpack cover to prevent a significant gage pressure from occurring within the overpack cover outer shell. In addition, fire–consumable, plastic vent plugs are employed on the exterior surface of the body and overpack cover.

1.2.1.10 Shielding

Due to the nature of the contact–handled transuranic (CH–TRU) payloads, no biological shielding is necessary or provided by the TRUPACT–III packaging.

1.2.2 Contents

The TRUPACT–III packaging is designed to transport contact–handled transuranic (CH–TRU) waste and other authorized payloads that do not exceed 10^5 A_2 quantities, as defined in the TRUPACT–III TRAMPAC. All users of the TRUPACT–III package shall comply with all payload requirements outlined in the TRUPACT–III TRAMPAC, using one or more of the methods described in that document.

1.2.3 Special Requirements for Plutonium

The TRUPACT–III package may contain plutonium in excess of 0.74 Tbq (20 Ci), which is in solid or solidified form.

1.2.4 Operational Features

The TRUPACT–III package is not operationally complex. All operational features are readily apparent from an inspection of the drawings provided in Appendix 1.3.1, *Packaging General Arrangement Drawings*, and the previous discussions presented in Section 1.2.1, *Packaging*. Operational procedures and instructions for loading, unloading, and preparing an empty TRUPACT–III package for transport are provided in Chapter 7.0, *Operating Procedures*.

1.3.1 Packaging General Arrangement Drawings

This section presents the TRUPACT–III packaging general arrangement drawing[1], consisting of 21 sheets entitled, *TRUPACT–III Packaging SAR Drawing*, Drawing Number 51199–SAR, Rev. 15.

Within the packaging general arrangement drawing, dimensions important to the packaging's safety are dimensioned and toleranced (e.g., sealing regions on the seal flanges). All other dimensions are provided as a reference dimension, and are toleranced in accordance with the general tolerance block.

[1] The TRUPACT–III packaging general arrangement drawing utilizes the uniform standard practices of ASME Y14.5M–1994, *Dimensioning and Tolerancing*, American National Standards Institute, Inc. (ANSI).

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51199-SAR | 1 | 15

Security-Related Information
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Tacoma, WA 98402

TRUPACT-III PACKAGING
SAR DRAWING

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SCALE: NONE	WT. N/A
REV: 15	SHEET 1 OF 21
DWG SIZE: D	DWG NO. 51199-SAR

Security-Related Information
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REV: 15	SHEET 2 of 21
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	CADFILE: 51199SAR0215.DWG

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Security-Related Information
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CADFILE: 51199SAR1015.DWG

Security-Related Information
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Figure Withheld Under 10 CFR 2.390

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DWG SIZE D	DWG NO. 51199-SAR	

Security-Related Information
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51199-SAR 16 15

Security-Related Information
Figure Withheld Under 10 CFR 2.390

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DWG SIZE D	DWG NO. 51199-SAR	
	CADFILE: 51199SAR1615.DWG	

Security-Related Information
Figure Withheld Under 10 CFR 2.390

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DWG SIZE D	DWG NO. 51199-SAR	
	CADFILE: 51199SAR1715.DWG	

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CADFILE: 51199SAR2115.DWG

7. The debris shield seal holder located on the closure lid shear lip may be made utilizing three different configurations, as shown on Drawing 51199-SAR, Sheet 14, Zone A-1/5:
    - Optional Configuration 1 was utilized for CTU-2 in which the holder was made from A240/A479 Type 304/304L material in a welded configuration. The shear lip height was 10 mm. This configuration may be used for initial fabrication or repair. UNS S31803 material may also be used for configuration 1.
    - Optional Configuration 2 utilizes a non-welded configuration in which the holder is integral with the shear lip which is made from UNS S31803 material. The shear lip height is 14 mm. This is justified since the use of a stronger material in a non-welded configuration, with a taller shear lip (greater contact area) is conservative vis-à-vis the test.
    - Optional Configuration 3 utilizes a holder made from UNS S31803 material which is welded to the top of the shear lip. This is justified since the final configuration, which uses a full-thickness weld, is structurally the same as Configuration 2. This configuration may be used for initial fabrication or repair.
8. The guide bars which are located on the inside walls of the payload cavity were located approximately 13 mm below the location shown on the SAR drawings. In spite of this, the square tube bumpers on the SLB2 properly interfaced with the guide bars during the test.
9. The bolting bosses in the body flange included 35 mm diameter × 40 mm deep holes on the back side (towards the inside of the flange). These holes had no effect on test results.
10. Several nonconformances were encountered during fabrication of the CTU. All are recorded in the data package for the CTU, and were dispositioned according to the Quality Assurance program and approved by AFS. The nonconformances were very minor in nature and did not have a significant effect on the performance of the CTU during testing. The most significant nonconformances are noted in the following list.
    - The CSA body face flange thickness for the CTU ranged from 27 – 31 mm, compared to the specified thickness of 20 – 30 mm. This difference is negligible.
    - The 28.5 mm thick lifting plate on each ISO corner was to be welded to the 8 mm thick side plate using an 8 mm groove weld from the outside only. The actual components featured an additional 6 mm fillet backing weld on the inside of the ISO corner weldment. This had a negligible effect on the strength of the ISO corner component.
    - Due to welding-related distortion, the outside surface of the CSA top, bottom, and side surfaces were out–of–flat by 8 mm, which required the addition of small pieces of 8–mm plate to bridge the gap between the square frame containing the overpack cover bolt bosses on the front end to the CSA body.
    - The 3–piece polyurethane glued foam assembly in the right front cheek broke at the glue line, and was installed without repair of the joint. This had no effect on the test results, since the right cheek was not deformed by any of the tests.
    - To prevent out-gassing from behind the debris shield receptacle (which would lead to a high background reading in the payload cavity and interfere with the ability to perform the metallic containment boundary leakage rate testing), epoxy material was applied at various places to the receptacle attachment welds and inside the receptacle

opening where the receptacle component was thinned or locally penetrated during machining of the opening. This localized use of epoxy had no effect on debris shield performance or on any other test results.

- The bars from which the debris shield receptacle were machined did not match up properly at the four corners. The resulting gaps were filled using epoxy.
- Due to welding-related distortion, the width between the front cheeks on the CTU where they weld to the CSA measured 2105 mm on the top versus the specified width of 2120 ±10 mm (which applies at the attachment of the cheeks to the CSA). To permit assembly of the overpack cover between the cheeks, the width of the overpack cover was locally reduced by a total of approximately 10 mm. This change was made only to the lips of the overpack cover (a region 272 mm long, measured from the bolting flange). The resulting lateral fit up gaps between the overpack cover and the cheek inside dimension were measured and are recorded in Table 2.12.6-4.
- The CTU utilized 15 mm plate thickness for the puncture resistant plates in the rear octagon (item 19, see sheet 5, zone C-1 of drawing 51199-SAR in Section 1.3.1, *Packaging General Arrangement Drawings*) and in the overpack cover (item 19, see sheet 17, zone C-3). In addition, the CTU utilized 15 mm plate thickness for the inner and outer body flange plates (item 19, see sheet 21, zone C/D-5). The list of materials on sheet 1 of the drawing shows that 16 mm thickness material (item 23) may optionally be used in place of item 19. This potential increase in thickness (nominally only 6.7%) is structurally conservative and will have a negligible effect on the outcome of any test. In the body flange position, the resulting small increase in stiffness effectively reduces deformations that might occur during a HAC event. In the puncture-resistant plate positions, a slightly greater resistance to puncture will result. Thus, the potential substitution of a 16 mm thickness for 15 mm plates is acceptable.
- The CTU used a nominal 40 mm thick plate in the vent port region of the closure lid. The plate can vary from 37 to 52 mm in thickness. This variation in thickness, primarily to the plus-side, will not affect the leaktight performance of the closure lid or of the vent port.
- The CTU was fabricated using a drawing that limited the opening width of the closure lid main O-ring grooves (designated P1 and P2), at the narrow part of the dovetail shape, to a maximum of 11.30 mm. Drawing 51199-SAR, sheet 13, and associated flag note 52, identifies that the O-ring groove may be up to 11.35 mm wide. The difference in width, equal to 0.05 mm (0.002 inch), does not affect the depth of the O-ring groove or the location of the sides of the groove. The only effect is on the outer opening, which serves to retain the O-ring when the lid is removed. The small increase in width will not materially affect the ability of the dovetail shape to retain the O-ring, and has no effect on the performance of the O-ring in service.
- The CTU was fabricated using a drawing which specified the dimensions of the rectangular groove located between the main O-ring grooves on the closure lid of 1 ±0.2 mm × 4 ±0.2 mm (applying block tolerances). The only purpose of the groove is to allow for sensing helium during leakage rate testing of the main containment O-ring seal. For this function, such tight control of the tolerance is not necessary. Drawing 51199-SAR, sheet 13, zone

C-2/3, shows a dimension of 1 ±0.2 mm × 4 ±0.4 mm for this rectangular groove. This difference will have no effect on the stated function of the groove.

Prior to any certification testing, the CTU was subject to acceptance testing, including a lifting load test, an internal pressure (1.5 times MNOP) test, and leakage rate tests of the containment boundary.

The test payload included a prototypic roller floor, pallet, and SLB2, shown in Figure 2.12.6-3. The SLB2 was loaded with a quantity of square-ended, two-inch and four-inch diameter aluminum bars. Approximately one quart of debris was added to the payload cavity of the CTU (outside the SLB2). The debris was composed of crushed concrete and fine grinding grit found in the fabrication shop, and was poured into the cavity just before the final installation of the closure lid. It was placed primarily in the gap between the lower front debris shield receptacle bar and the roller floor, and between the two side walls and the roller floor nearest the opening. The debris is shown on white paper in Figure 2.12.6-9 and shown in the CTU cavity in Figure 2.12.6-10. Weights are detailed in Table 2.12.6-1. The gross weight of CTU-2 was 25,154 kg, slightly more than the maximum gross weight of the TRUPACT–III package of 25,000 kg.

2.12.6.4 Instrumentation

2.12.6.4.1 Accelerometers

Four single axis piezoresistive accelerometers were utilized to record the free drop impact. Accelerometers were not used for the puncture drop tests. The accelerometers were attached to solid stainless steel blocks that were attached by screws and epoxy to the outer sheet on the body at the locations shown in Figure 2.12.6-1. Data was recorded and conditioned by a calibrated stand-alone Spectral Dynamics data acquisition system. A Fast Fourier Transform (FFT) of the raw data was performed to determine the appropriate cutoff, or filtering frequency. The accelerometer data was filtered using a six-pole Butterworth filter with the cutoff set at 200 Hz.

2.12.6.4.2 Thermocouples

Type K thermocouples were installed as shown in Figure 2.12.6-2 to measure the temperature of the polyurethane foam in the critical region near the impact event on the lower left corner of the CTU. The data was monitored during the chilling period, and continued until impact.

2.12.6.5 Initial Test Conditions

2.12.6.5.1 Internal Pressure

Since internal pressure has the effect of increasing the stress on the containment boundary, the CTU was pressurized to an internal pressure of 170 kPa at a temperature of -4 °C, which conservatively exceeded the design pressure of 172 kPa at 21 °C. Since resistance to puncture is not significantly affected by internal pressure, the CTU was not pressurized for the puncture tests. Since the pressure is only an initial condition, monitoring the pressure was not performed.

2.12.6.5.2 Temperature

As discussed in Section 2.7.1.1.3, *Free Drop Test on CTU-2*, the maximum damage from the c.g.-over-corner free drop will occur at the minimum regulatory temperature condition of -29 °C. The actual temperature of the energy-absorbing material in free drop test LD91 is recorded in Section 2.12.6.7.1, *Free Drop, CG-Over-Corner, Overpack Cover Down, HAC (LD91).* Prevailing temperature was used for all puncture drop tests.

2.12.6.6 Certification Tests Performed

The evaluation and selection of tests to be performed for certification testing is discussed in Section 2.7.1, *Free Drop*, and Section 2.7.3, *Puncture*. One HAC free drop and two puncture drops were performed, as summarized in Table 2.12.6-2. The free drop is designated LD91 and is shown schematically in Figure 2.12.6-4. The punctures are designated LP91 and LP92, and shown schematically in Figure 2.12.6-5 and Figure 2.12.6-6, respectively.

2.12.6.7 Test Results

After each of the tests, a vacuum was placed between the closure lid seals as an approximate confirmation of the sealing integrity of the containment seal, using the special test port on the CTU side. The vacuum achieved in each case is recorded in the sections below. For the puncture tests, the internal pressure was bled off to a value nominally equal to atmospheric.

Prior to performing any tests, helium leakage rate tests were performed on the containment metallic boundary, the main O-ring seal, and the sampling/vent port plug O-ring seal according to an approved procedure. Photos of certification testing are provided in Figure 2.12.6-7 to Figure 2.12.6-20.

2.12.6.7.1 Free Drop, CG-Over-Corner, Overpack Cover Down, HAC (Test LD91)

Test LD91 was a free drop from a conservative height of 9.2 m, with the CTU axis oriented approximately 47° to the ground, striking the lower left corner of the package as shown in Figure 2.12.6-4. The center of gravity of the package was over the point of initial impact. The average temperature of thermocouples T1, T2, and T7 was -33.6 °C. These temperatures represent both shallow and deep readings in the corner of the package. The ambient temperature was 5.6 °C. Accelerations were obtained from gages A1 through A4. The raw signals were filtered at 200 Hz, and the resulting acceleration plots are shown in Section 2.12.6.9, *Acceleration Time History Plots*. The shapes of the accelerometer curves were not consistent with each other, nor (with one exception) were the recorded peaks as high as expected. The resulting curve which best fit the expectation based on the high speed video and on the results obtained from CTU-1 was accelerometer A1. This was also the highest acceleration. The impact was therefore considered to be best characterized by the A1 result, and the results of A2 – A4 were not used. The accelerometers were mounted with their measuring axis parallel to the package axis; the resulting acceleration perpendicular to the ground was found using:

$$A1_{\perp} = \frac{A1}{\cos(43)} = 80.8g$$

where A1 is the filtered accelerometer peak value from the table below, and the axial direction is oriented at an angle of 90° – 47° = 43° to the vertical as defined in Figure 2.12.6-4.

A1	A2	A3	A4	$A1_{\perp}$
59.1	(25.8)	(37.1)	(33.7)	**80.8**

The impact caused a triangular flat region having dimensions of 737 mm along the overpack cover, 864 mm along the bottom, and 787 mm along the left side of the CTU. The damage to the overpack cover included a gap of up to 70 mm at the center between the cheek and the overpack cover left edge, see Figure 2.12.6-12. The gap exposed some foam, but narrowed to nearly zero a short distance from the surface. No significant weld seam failures were noted from this test. A hard vacuum of below 200 millitorr was obtained between the closure lid seals as a preliminary confirmation of leak tightness. Photos of the damage are shown in Figure 2.12.6-11 and Figure 2.12.6-12.

2.12.6.7.2 Puncture Drop On CG-over-Corner Damage (Test LP91)

The drop height for this test was one meter. The ambient temperature for this test was 15 °C and the package surface temperature was 19 °C. The CTU was rigged as shown in Figure 2.12.6-5. The bar was 762 mm long (above the baseplate). The puncture bar struck on the overpack cover portion of the prior c.g.-over-corner free drop (LD91) damage. The depth of puncture, measured to the center of the damage hole in an axial direction from the undeformed surface of the overpack cover, was 146 mm. The damage loosened the entire lower quadrant of the overpack cover outer sheet and a significant portion of the low density (0.16 kg/dm^3) foam fell out. The bar corner partially sheared into the 6-mm thick puncture resistant plate located between the low density and high density (0.48 kg/dm^3) foam by an amount of 38 mm. However, little of the high density foam was exposed and essentially none was lost. A hard vacuum of 224 millitorr was obtained between the closure lid seals as a preliminary confirmation of leak tightness. The puncture bar remained intact after the impact. A photograph of the damage is shown in Figure 2.12.6-13.

2.12.6.7.3 Puncture Drop On CTU Bottom (Test LP92)

The drop height for this test was one meter. The ambient temperature for this test was 12 °C, and the package surface temperature was 15 °C. The bar was 965 mm long (above the baseplate). The puncture bar struck as shown in Figure 2.12.6-6, with the edge of the bar placed approximately 476 mm from the closed outer end of the package, with the package inclined 40° from the horizontal. The bar penetrated the outer skin and impacted the CSA outer structural sheet, creating a crack in the weld between the structural sheet and the rear diagonal corner stiffener of the CSA, and in some of the adjacent plug welds which connect the outer structural sheet to the V-stiffener nearest the impact. This condition required weld repairs in order to support helium leakage rate testing of the containment boundary structure. (The CSA outer wall structure must be capable of retaining the helium test gas for the containment boundary leakage rate test to be performed.) However, there was no evidence of any dent or bulge in the CSA inner (containment) sheet at the puncture site. In addition, the containment boundary was leaktight as discussed in Section 2.12.6.8.1, *Leakage Rate Tests*. A hard vacuum of below 250 millitorr was obtained between the closure lid seals as a preliminary confirmation of leak tightness. The puncture bar remained intact after the impact. The damage is shown in Figure 2.12.6-14 and Figure 2.12.6-15. Figure 2.12.6-15 shows the cracked outer structural sheet weld.

2.12.6.8 Leakage Rate Tests and Post-Test Measurements

2.12.6.8.1 Leakage Rate Tests

Post-test leakage rate testing of the containment boundary was performed using helium tracer gas and a mass spectrometer leak detector (MSLD). The leaktight criterion was 2.2×10^{-8} Pa-m^3/s, He. All tests were successful. Testing result details are provided in Table 2.12.6-3. The testing consisted of three elements:

- Closure lid containment O-ring seal
- Vent port containment O-ring seal
- Metallic portion of the containment boundary

2.12.6.8.1.1 Closure Lid and Vent Port Containment O-ring Seals

The closure lid and vent/test port containment seals were both tested by connecting a MSLD to the space between the containment seal and the test seal and then filling the payload cavity with helium. Testing was performed at the prevailing ambient temperature of the fabrication shop. This test was equivalent to a test at the minimum regulatory temperature of -20 °F due to the intentionally low O-ring compression used in the CTU. As shown in Section 2.12.6.3, *Test Unit Configuration*, the room-temperature compression of the closure lid containment O-ring in the CTU was 25.8%, and the minimum room-temperature compression in a prototypic unit is 27.8%. The reduction in compression in the seal at a temperature of -29 °C (caused by thermal contraction of the rubber) may be inferred to be approximately 1%, based on the calculation performed in Section 2.12.2.6, *Test Results*, for a temperature of -40 °C. Therefore, a prototypic unit at a temperature of -29 °C would have a minimum compression of 27.8 – 1 = 26.8%, which is 1% greater than the compression in the CTU at the test temperature. Therefore testing the CTU at room temperature was conservative. The leakage rate of both containment seals was acceptable as shown in Table 2.12.6-3.

2.12.6.8.1.2 Metallic Containment Boundary

The metallic portion of the containment boundary was tested by connecting a MSLD to the payload (interior) cavity and then replacing the air in the annulus between the containment and structural sheets of the CSA with helium. Helium could then pass through any openings in the containment boundary to the inside of the package, and register on the MSLD connected to the cavity. In order to achieve the required vacuum in the payload cavity to support the leakage rate test and to ensure there were no obstructions to any potential leak paths, the closure lid was removed, the contents were removed, and the payload cavity was thoroughly cleaned. The lid was then reinstalled and the bolts tightened to approximately 400 N-m, which was conservatively much less than the measured minimum residual torque for any bolt (see Section 2.12.6.8.2.1, *Overpack Cover and Closure Lid Observations*). Since the leakage rate tests of the closure lid O-ring and vent port seals had already been completed, removal of the closure lid had no effect on any test. Further, a leak in the metallic boundary, had one existed, would not be affected by the removal of the closure lid, of the contents, or by the cleaning. The leakage rate was acceptable as shown in Table 2.12.6-3.

2.12.6.8.2 CTU Measurements

Besides measurement of the damage reported above, various measurements were taken of the CTU during disassembly as discussed below.

2.12.6.8.2.1 Overpack Cover and Closure Lid Observations

The gaps between the overpack cover and the cheeks were measured in several locations before and after the test, and reported in Table 2.12.6-4. The results show that the cover moved away from the impact, and the total gap width decreased, as expected. It is concluded that the cover did not move very far as a result of the tests.

The lid moved slightly relative to the body as demonstrated by the scribe line offsets. On assembly, four scribe lines were made between the lid and body. After the test, the scribe lines were offset by 1.3 mm top left; 1.8 mm top right; 0.25 – 0.50 mm lower left; and 0 – 0.13 mm lower right. The lid appeared to have moved to the left, i.e, toward the c.g.-over-corner impact (test LD91).

It was noted that a 0.102 mm thick feeler gauge could not be inserted between the lid and body flanges (with one very limited exception) along the top and bottom flanges. The sides were not checked due to the presence of the cheeks. It is thus concluded that the closure lid flange was in clamped contact with the body flange. As noted in Section 2.12.6.8.2.2, *Observations with the Closure Lid Removed*, some galling of the flanges near the bolt holes testified to a high clamping force during the test.

None of the bolt heads had rotated, based on the location of the rotational index marks, and based on the residual torques. Residual torques were checked in the clockwise direction by applying a torque of 1,356 N-m to each bolt. No bolts rotated as a result of this torque application. Residual loosening torque was recorded as the largest counter-clockwise torque value obtained during removal of the bolts. Of note, all bolts were tested for loosening torque without significantly reducing the preload of any. Only after checking the residual loosening torque of all bolts were any bolts significantly loosened and removed. The residual loosening torques varied between a minimum of 1,112 N-m and a value greater than 1,356 N-m (which was the maximum capacity of the torque wrench used for this test). The average was 1,260 N-m, which is equal to $1{,}260/1{,}600\times100 = 79\%$ of the original tightening torque value of 1,600 N-m. Residual torques are given in Table 2.12.6-5.

There was some interference between the overpack cover cups and the closure bolt washers on about 61% of the bolts, from bolt no. 13 on the right side, down the right side, across the bottom, and up the left side as far as bolt no. 40[6]. Washer nos. 41 on the left side, up through no. 12 on the top, had no interference with the cups. The struck location was uniformly between 6:30 O'clock and 7:00 O'clock, which indicates that the overpack cover slid primarily upward and slightly to the right, away from the free drop impact. The washers showed no evidence of denting or imprinting from the bolt head or lid hole, and no out-of-flat deformation. Only a little scuffing/galling from use was evident. The greatest displacement of washers relative to the lid surface occurred centered on the lower left corner impact zone. For bolt no. 33 (lower left corner, adjacent to the impact), the washer displaced approximately 0.5 mm toward the upper right. However, none of the bolts were bent. Bolt nos. 31 through 35 showed no runout when checked using a V-block and dial indicator. None of the bolt heads were struck by the cups, only

[6] Bolt no. 1 is the leftmost bolt on the top side, and numbered clockwise.

some washers as stated. Typical evidence of interference between an overpack cover cup and a washer is shown in Figure 2.12.6-16.

2.12.6.8.2.2 Observations with the Closure Lid Removed

The debris shield was in good condition and protected the containment O-ring seal from contact with any of the debris which had been introduced into the payload cavity before testing. The only anomaly was that on the top side, the foam rubber component appeared to have caught an edge – apparently the edge of the receptacle – during lid assembly or removal and pulled away from the holder on the outside (nearest the flange). However, most of the silicone foam rubber in the affected sections was still compressed in the receptacle as designed, and the shield function was unaffected. There was a small pile of debris on the inside of the shield on the lid as shown in Figure 2.12.6-17, which functioned properly in preventing access of the debris to the containment seal.

The metallic portion of the containment boundary was in good condition. There was no evidence of any bulge in the inner containment wall at the site of puncture LP92. There was a little galling between the lid and body appearing next to some of the bolt holes, indicating good clamping force local to the bolts, as shown in Figure 2.12.6-18. There was also a narrow line of scuffing across the top flange. There were no deformations on the closure lid or in the body cavity due to contact with the SLB2 except for a dent in the debris shield receptacle on the left side at the elevation of the SLB2 lid as shown in Figure 2.12.6-19. This condition did not affect the function of the debris shield, since it locally increased the compression of the foam rubber shield.

Measurements of the payload cavity, shown in Table 2.12.6-6, demonstrate essentially no change to the cavity due to the test impacts. The small differences which were noted (up to two millimeters) are considered to be measurement anomalies, rather than evidence of permanent deformation. A view of the cavity with all of the contents removed is shown in Figure 2.12.6-20.

The SLB2, roller floor, and pallet were in very good condition after the test. The payload bars caused the panel walls of the SLB2 to bulge outward from the impact, and the lower of the three square tube bumpers were flattened on the front face and left side. (The level of the payload bars did not reach the middle or upper bumpers, and thus, they were not deformed.) One bar poked through the front panel of the SLB2 at the bottom. The roller floor and pallet were fully functional during removal of the SLB2 from the CTU.