Regulatory Hypothetical Accident Condition Type B Testing for the HalfPACT Shielded Container Payloads

Prepared by:

Nuclear Waste Partnership
An Amentum-led partnership with BWXT and Orano

Prepared for:

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		Signature	Date
Document Preparer	S. A. Porter	Digitally signed by STEVEN PORTER (Affiliate) Date: 2021.01.05 17:18:37 -08'00'	01/05/2021
Independent Reviewers	D. C. Staber	DANIEL STABER (Affiliate) Digitally signed by DANIEL STABER (Affiliate) Date: 2021.01.05 19:13:07 -07'00'	01/05/2021
	R. S. Burns	Digitally signed by ROBERT BURNS (Affiliate) Date: 2021.01.06 11:24:13 -07'00'	01/06/2021
Cognizant Manager	T. E. Sellmer	TODD SELLMER (Affiliate) Digitally signed by TODD SELLMER (Affiliate) Date: 2021.01.06 13:08:57 -07'00'	01/06/2021
Quality Assurance	D. S. Tanner	DAVID TANNER (Affiliate) Digitally signed by DAVID TANNER (Affiliate) Date: 2021.01.06 12:21:20 -07'00'	01/06/2021

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0	All	New issue.

1.0 INTRODUCTION

1.1 Objective

Shielded containers containing specific transuranic waste forms with unshielded dose rates exceeding contact-handled limits are planned to be transported within HalfPACT packages. This report documents 30-foot free drop tests per the regulatory Hypothetical Accident Conditions (HAC) described in 10 CFR §71.73 [1] to support the licensing activities for the shielded container payload configurations.

Shielded containers were assembled onto a heavy-duty pallet and installed, including dunnage assemblies, within a HalfPACT inner containment vessel (ICV). Each loaded ICV was subjected to two 30-foot free drops onto a flat, essentially unyielding, horizontal surface. The ICV was dropped such that it impacted the target surface in a position to maximize shielded container damage. The HalfPACT outer containment assembly (OCA), with its energy absorbing polyurethane foam, was conservatively omitted from the tests. At the conclusion of the second 30-foot free drop, each shielded container was removed from the ICV and subjected to gamma scan testing to verify shielding integrity, and visually scanned for the presence of fluorescein dye to verify confinement integrity.

All tests were documented via video and still photography to provide a visual record of events.

1.2 Background

Type B HAC 30-foot drop testing of the original shielded container assembly (SCA) design, now referred to as the SC-30G1, was performed in 2007 [2]. This report details identical Type B HAC drop testing for evaluating four new shielded container designs: the SC-30G2, SC-30G3, SC-55G1, and SC-55G2. All shielded container designs were optimized to fit within the HalfPACT package's payload cavity and weight limitations [3], with the following table summarizing the overall configuration for the original design and each of the four new designs.

Shielded Container Design	Payload Drum Size	Maximum Shielded Container Weight	Number Shipped per HalfPACT Package
SC-30G1 (SCA)	30-gallon	2,260	3
SC-30G2	30-gallon	3,160	2
SC-30G3	30-gallon	6,300	1
SC-55G1	55-gallon	3,410	2
SC-55G2	55-gallon	6,500	1

In addition to the Type B HAC tests, the original SC-30G1 design was required to demonstrate compliance with Type A tests for container robustness by dropping an unprotected (bare) shielded container 4-feet onto an essentially unyielding surface in an orientation that causes the worst damage. To demonstrate this requirement, two SC-30G1 Type A test units were fabricated so that 4-foot drops at four different orientations could be performed: a bottom-oriented vertical end drop and a center-of-gravity-over-corner drop on one, and a top-oriented near-vertical drop and horizontal side drop on the other. Comparison of the ensuing damage to the SC-30G1s from the unprotected 4-foot drop tests versus the protected (via dunnage within an ICV) HAC 30-foot drop tests showed the Type A 4-foot drop tests resulted in greater damage to the SC-30G1 than from the Type B 30-foot drop tests; regardless, all Type A and Type B test requirements were successfully met.

Similar in size and weight, and the quantity that may be shipped within a HalfPACT package, the SC-30G2 and SC-55G1 designs were grouped for comparison. Accordingly, the SC-30G3 and SC-55G2 designs were also grouped for comparison. As discussed in subsequent sections, the SC-55G1 and SC-30G3 designs were chosen as bounding over the SC-30G2 and SC-55G2 designs, respectively, and Type B HAC 30-foot drop testing was performed for qualifying each of those two designs. Type A testing was also performed for all four new designs, and Type A test results were utilized for qualifying the SC-30G2 and SC-55G2 designs based on their Type A test performance. Thus, this test program leveraged the results of SC-30G1 Type B and Type A testing, and the comparative results of SC-30G3 and SC-55G1 Type B and Type A testing, to qualify both the SC-30G2 and SC-55G2 designs by comparison, and correspondingly demonstrate that all four new designs met the HAC 30-foot drop requirements delineated in 10 CFR §71.73.

2.0 REFERENCES

1. Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), Packaging and Transportation of Radioactive Materials, 01-01-20 Edition.
2. *Regulatory Hypothetical Accident Condition Type B Testing for the HalfPACT Shielded Container Payload*, WP 08-PT.15, Rev. 0, Washington TRU Solutions, December 2007.
3. U.S. Department of Energy (DOE), *Safety Analysis Report for the HalfPACT Shipping Package*, USNRC Certificate of Compliance 71-9279, U.S. Department of Energy, Carlsbad Field Office, Carlsbad, New Mexico.
4. MIL-HDBK-5J, Metallic Materials and Elements for Aerospace Vehicle Structures, Department of Defense Handbook, 31 January 2003.
5. U.S. Department of Energy (DOE), *Safety Analysis Report for the RH-TRU 72-B Waste Shipping Package*, USNRC Certificate of Compliance 71-9212, U.S. Department of Energy, Carlsbad Field Office, Carlsbad, New Mexico.
6. U.S. Department of Energy (DOE), *Safety Analysis Report for the TRUPACT-II Shipping Package*, USNRC Certificate of Compliance 71-9218, U.S. Department of Energy, Carlsbad Field Office, Carlsbad, New Mexico.
7. NWP Drawing 163-010, *SC-30G2 Shielded Container SAR Drawing*, Rev. 0, Nuclear Waste Partnership, Carlsbad, New Mexico.
8. NWP Drawing 163-011, *SC-30G3 Shielded Container SAR Drawing*, Rev. 0, Nuclear Waste Partnership, Carlsbad, New Mexico.
9. NWP Drawing 163-012, *SC-55G1 Shielded Container SAR Drawing*, Rev. 0, Nuclear Waste Partnership, Carlsbad, New Mexico.
10. NWP Drawing 163-013, *SC-55G2 Shielded Container SAR Drawing*, Rev. 0, Nuclear Waste Partnership, Carlsbad, New Mexico.

3.0 TESTING RESPONSIBILITIES

Nuclear Waste Partnership (NWP) was responsible for the overall test program, including directing testing activities, as follows:

- Preparing and approving the fabrication drawings for the shielded containers, pallet, and various dunnage designs, and test planning,
- Providing a TRUPACT-II ICV, with aluminum honeycomb end spacers, to Premier Technology, Inc., for modification to reflect the configuration of a HalfPACT ICV,
- Providing a HalfPACT ICV for testing,
- Providing engineering support during fabrication,
- Providing photometrics (still photography and video) and data instrumentation during the testing process,
- Providing engineering oversight during the testing process,
- Providing 10 CFR 71, Subpart H, quality assurance oversight during fabrication, test procedure development, testing, pre- and post-test shielding integrity testing, and dimensional inspections, and
- Preparing this test report.

Premier Technology, Inc., was responsible for fabricating and testing the shielded container configurations, as follows:

- Preparing detailed test procedures that included test preparation, pre- and post-drop shield integrity tests of each shielded container, free drop test details, and post-drop test documentation,
- Fabricating shielded container prototypes (see Section 4.1, *Shielded Containers*), payload drums (see Section 4.2, *Simulated Payloads*) and payload support components (see Section 4.3, *Payload Support Components*), in accordance with approved drawings and procurement documentation,
- Modifying the TRUPACT-II ICV to shorten it to a HalfPACT ICV configuration, and stiffening the ICV bottoms on both the modified TRUPACT-II ICV and a HalfPACT ICV, and installing test lifting and handling attachments,
- Providing facility personnel and equipment for the testing process,
- Preparing a drop test pad with a mass of approximately 470 tons and dimensions as follows: 32 feet long by 25 feet-10 inches wide by 7 feet-6 inches deep, with a 2-inch thick by 8-foot by 12-foot steel plate securely anchored to the surface,
- Performing drop testing, pre- and post-test shielding integrity testing, and disassembly as, directed by NWP, and
- Providing the necessary measuring and test equipment for documenting fabrication, testing, and pre- and post-test measurements.

4.0 TEST ARTICLE DESCRIPTION

4.1 Shielded Containers

4.1.1 SC-30G2 Shielded Container

As illustrated in Figure 4-1, the SC-30G2 is an approximately 24½-inch diameter, 36⅝-inch tall, lead-shielded payload container that is designed to overpack a 30-gallon inner drum; it weighs approximately 2,610 pounds empty and has a maximum gross weight limit of 3,160 pounds. The SC-30G2 consists of a twin-shelled, carbon steel cylindrical structure and a lid. Nominally, 1.44 inches of lead shielding is contained between 0.30-inch thick inner and outer shells. The shells are connected to an upper flange and a 3.00-inch thick steel base. The base integrates a 21.50-inch diameter, 0.50-inch thick lower lead plate, and a 20.00-inch diameter, 0.70-inch thick upper lead plate. The 3.89-inch thick steel lid integrates a 19.50-inch diameter, 0.75-inch thick lead plate, and a 4.00-inch diameter, 0.25-inch thick lead disk that is aligned under the vent port feature. The lid also includes a silicone rubber gasket, alloy steel closure bolts, penetrations for lifting features, and alignment pins to facilitate remote lid installation.

4.1.2 SC-30G3 Shielded Container

As illustrated in Figure 4-2, the SC-30G3 is an approximately 28-inch diameter, 42¼-inch tall, lead-shielded payload container that is designed to overpack a 30-gallon inner drum; it weighs approximately 5,750 pounds empty and has a maximum gross weight limit of 6,300 pounds. The SC-30G3 consists of a twin-shelled, carbon steel cylindrical structure and a lid. Nominally, 2.80 inches of lead shielding is contained between 0.50-inch thick inner and outer shells. The shells are connected to an upper flange and a 5.75-inch thick steel base. The base integrates a 23.00-inch diameter, 0.75-inch thick lower lead plate, and a 20.00-inch diameter, 1.75-inch thick upper lead plate. The 6.79-inch thick steel lid integrates a 19.00-inch diameter, 2.25-inch thick lead plate, and a 23.00-inch outside diameter, 17.75-inch inside diameter, 0.75-inch thick lead ring. The lid also includes a silicone rubber gasket, alloy steel closure bolts, penetrations for lifting features, and alignment pins to facilitate remote lid installation.

4.1.3 SC-55G1 Shielded Container

As illustrated in Figure 4-3, the SC-55G1 is an approximately 29⅜-inch diameter, 40½-inch tall, solid steel payload container that is designed to overpack a 55-gallon inner drum; it weighs approximately 2,810 pounds empty and has a maximum gross weight limit of 3,410 pounds. The SC-55G1 consists of a carbon steel cylindrical structure and a lid. The 2.20-inch thick sidewall is connected to a 2.35-inch thick steel base. The 2.40-inch thick steel lid integrates a 4.00-inch diameter, 0.25-inch thick lead disk that is aligned under the vent port feature. The lid also includes a silicone rubber gasket, alloy steel closure bolts, penetrations for lifting features, and alignment pins to facilitate remote lid installation.

4.1.4 SC-55G2 Shielded Container

As illustrated in Figure 4-4, the SC-55G2 is an approximately 31-inch diameter, 45¾-inch tall, lead-shielded payload container that is designed to overpack a 55-gallon inner drum; it weighs approximately 5,900 pounds empty and has a maximum gross weight limit of 6,500 pounds. The

SC-55G2 consists of a twin-shelled, carbon steel cylindrical structure and a lid. Nominally, 2.02 inches of lead shielding is contained between 0.50-inch thick inner and outer shells. The shells are connected to an upper flange and a 4.25-inch thick steel base. The base integrates a 27.00-inch diameter, 0.75-inch thick lower lead plate, and a 24.50-inch diameter, 1.00-inch thick upper lead plate. The 5.76-inch thick steel lid integrates a 23.75-inch diameter, 1.50-inch thick lead plate, and a 26.63-inch outside diameter, 21.63-inch inside diameter, 0.50-inch thick lead ring. The lid also includes a silicone rubber gasket, alloy steel closure bolts, penetrations for lifting features, and alignment pins to facilitate remote lid installation.

4.2 Simulated Payloads

The 30-gallon drum payloads were fitted with a slotted 6-inch diameter, 27-inch long PVC pipe filled with concrete, as shown in Figure 4-5. A 1/2-inch diameter rebar embedment was used as a provision for handling the loaded 30-gallon drum.

The 55-gallon drum payloads were fitted with a slotted 16-inch diameter, 32¾-inch long PVC pipe filled with concrete, as shown in Figure 4-6. A 1/2-inch diameter rebar embedment was used as a provision for handling the loaded 55-gallon drum.

4.3 Payload Support Components

4.3.1 SC-30G2 Payload Assembly

With reference to Figure 4-7, the SC-30G2 payload assembly is comprised of a heavy-duty pallet, a slip sheet, two SC-30G2s, a radial dunnage assembly, and an axial dunnage assembly positioned atop the radial dunnage assembly. The SC-30G2 payload assembly is sized and configured to fit within a HalfPACT package.

4.3.2 SC-30G3 Payload Assembly

With reference to Figure 4-8, the SC-30G3 payload assembly is comprised of a heavy-duty pallet, one SC-30G3 with two end caps, and surrounding lower and upper lateral dunnage assemblies. The SC-30G3 payload assembly is sized and configured to fit within a HalfPACT package.

4.3.3 SC-55G1 Payload Assembly

With reference to Figure 4-9, the SC-55G1 payload assembly is comprised of a heavy-duty pallet, a slip sheet, two SC-55G1s, and a surrounding radial dunnage assembly. The SC-55G1 payload assembly is sized and configured to fit within a HalfPACT package.

4.3.4 SC-55G2 Payload Assembly

With reference to Figure 4-10, the SC-55G2 payload assembly is comprised of a heavy-duty pallet, one SC-55G2, and surrounding lower and upper lateral dunnage assemblies. The SC-55G2 payload assembly is sized and configured to fit within a HalfPACT package.

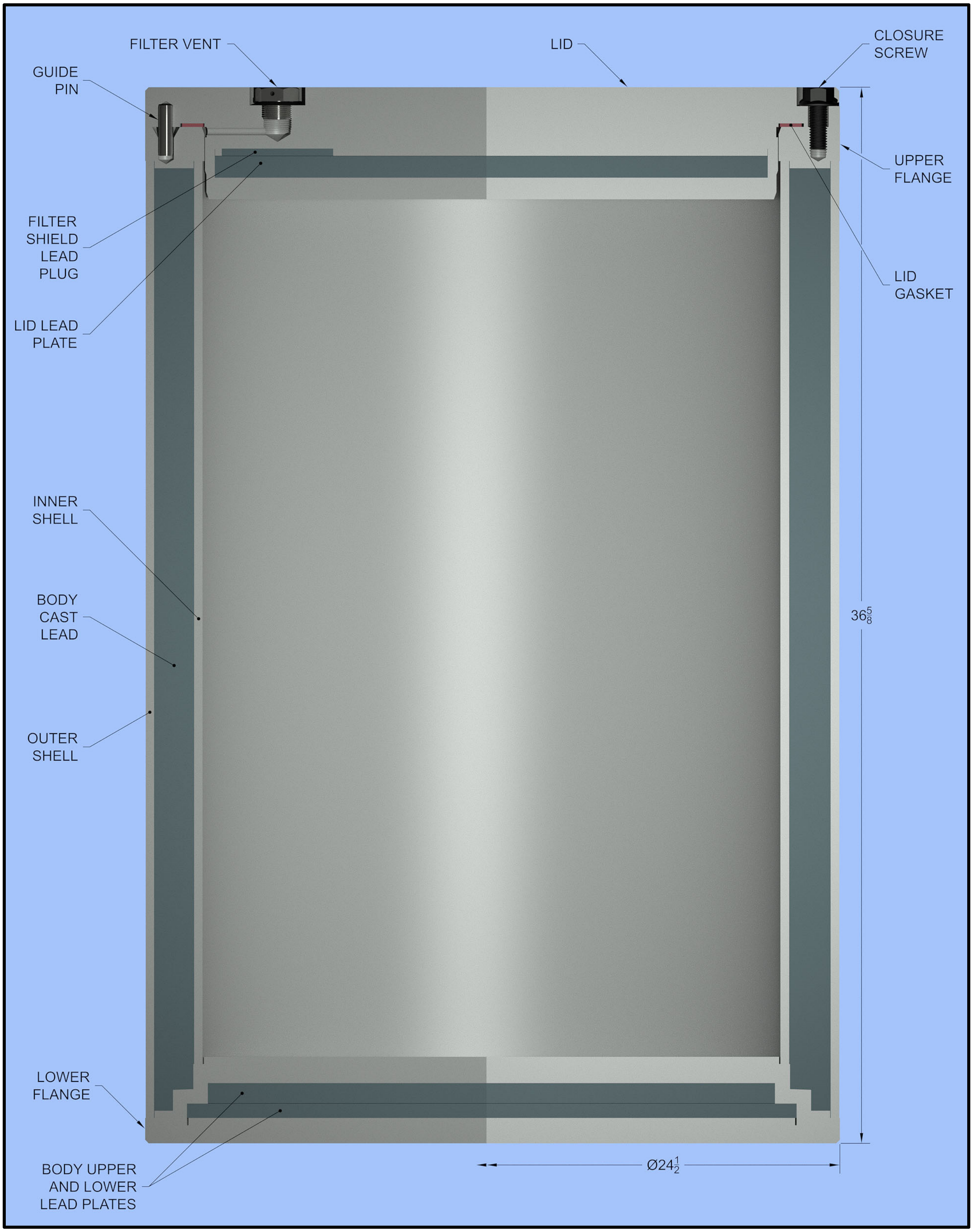

Figure 4-1 – SC-30G2 Shielded Container (shown without Payload Drum)

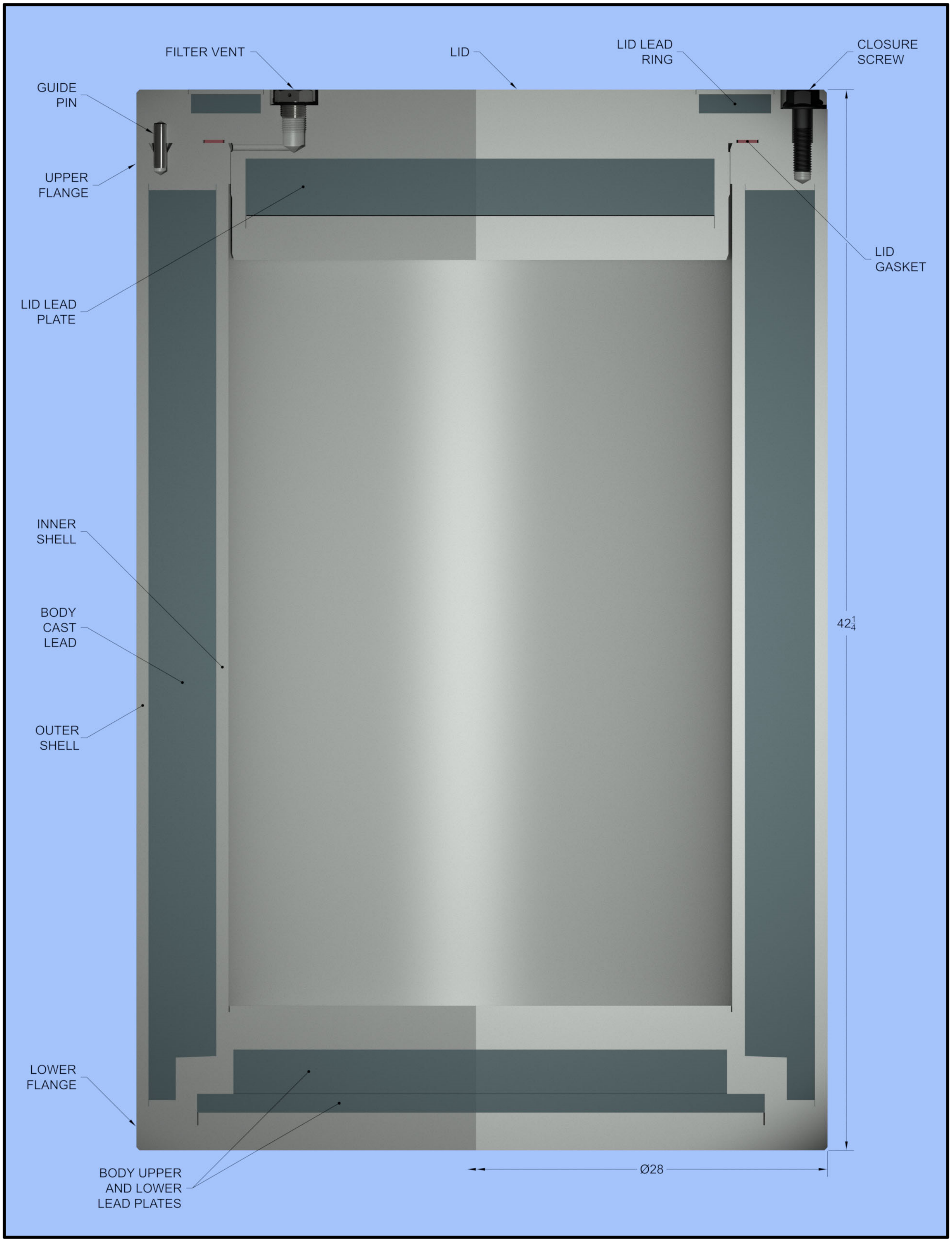

Figure 4-2 – SC-30G3 Shielded Container (shown without Payload Drum)

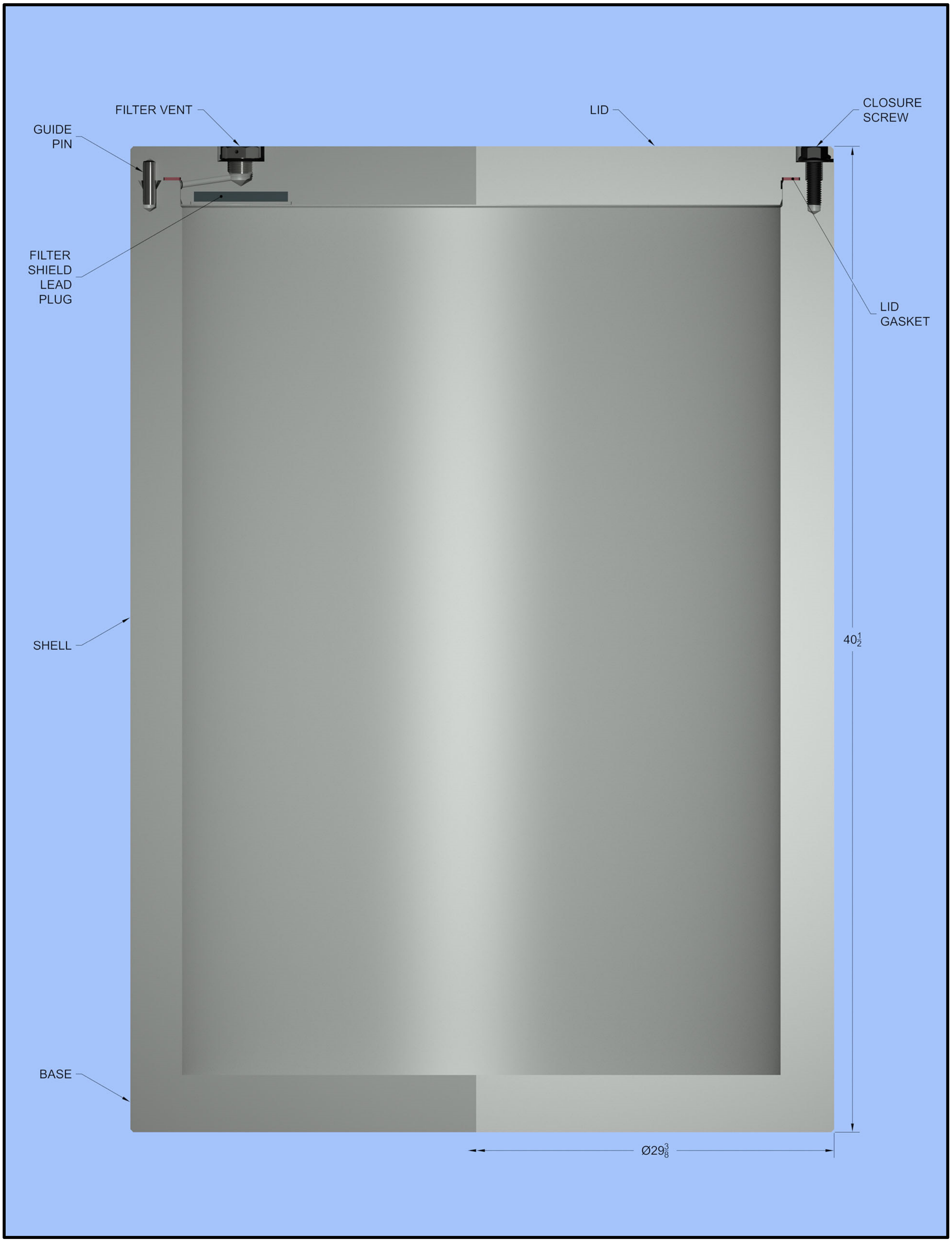

Figure 4-3 – SC-55G1 Shielded Container (shown without Payload Drum)

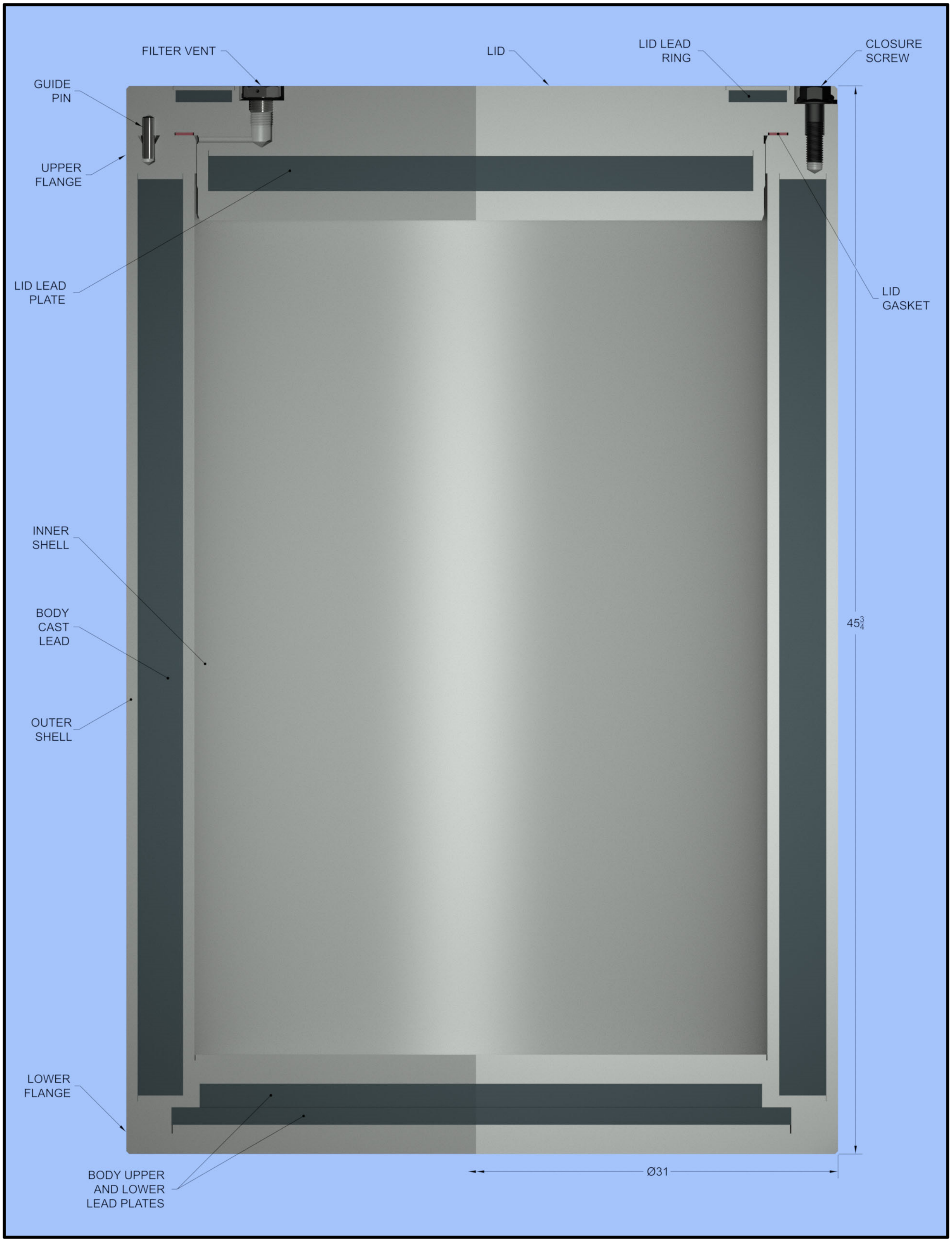

Figure 4-4 – SC-55G2 Shielded Container (shown without Payload Drum)

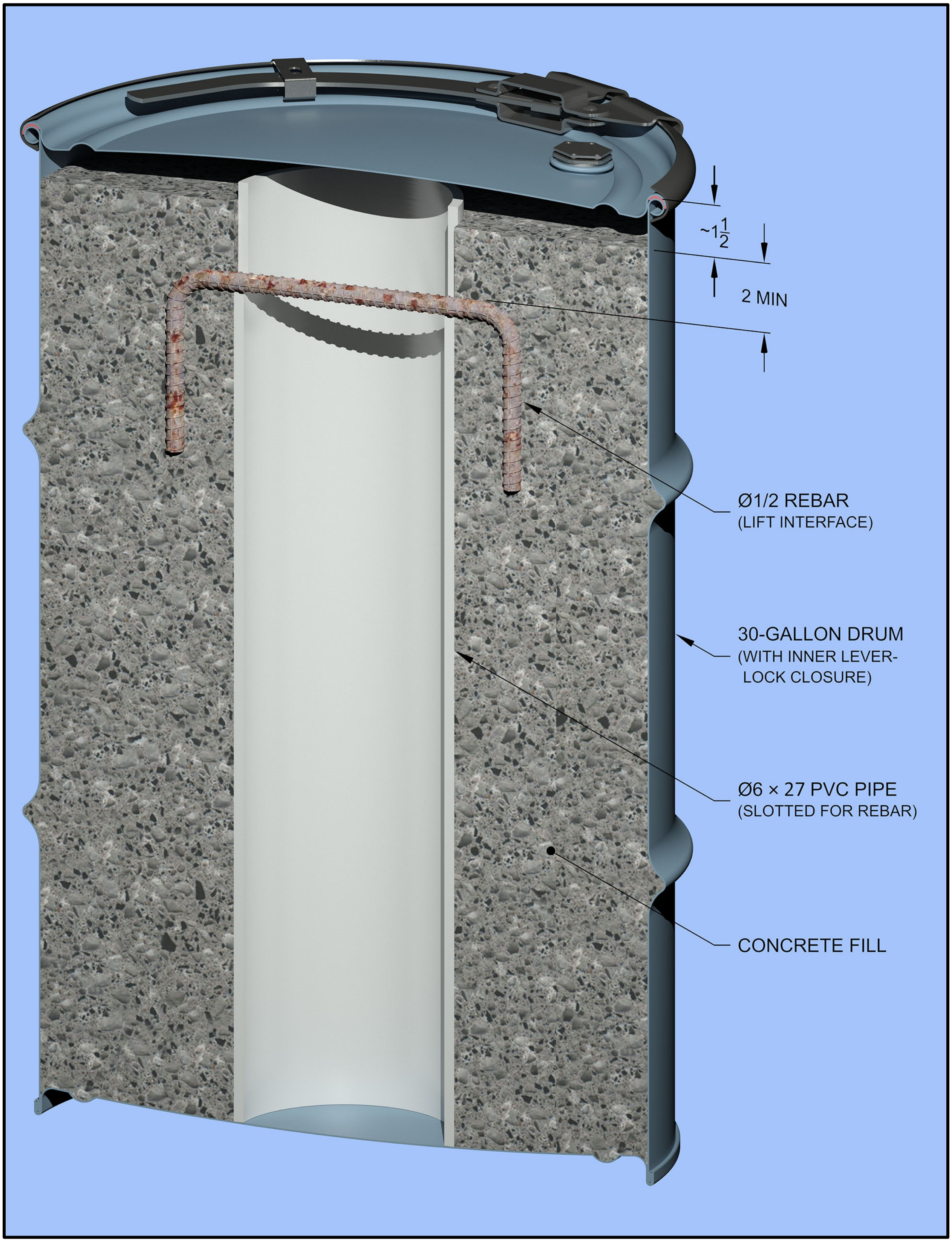

Figure 4-5 – 30-Gallon Payload Drum with Concrete Ballast

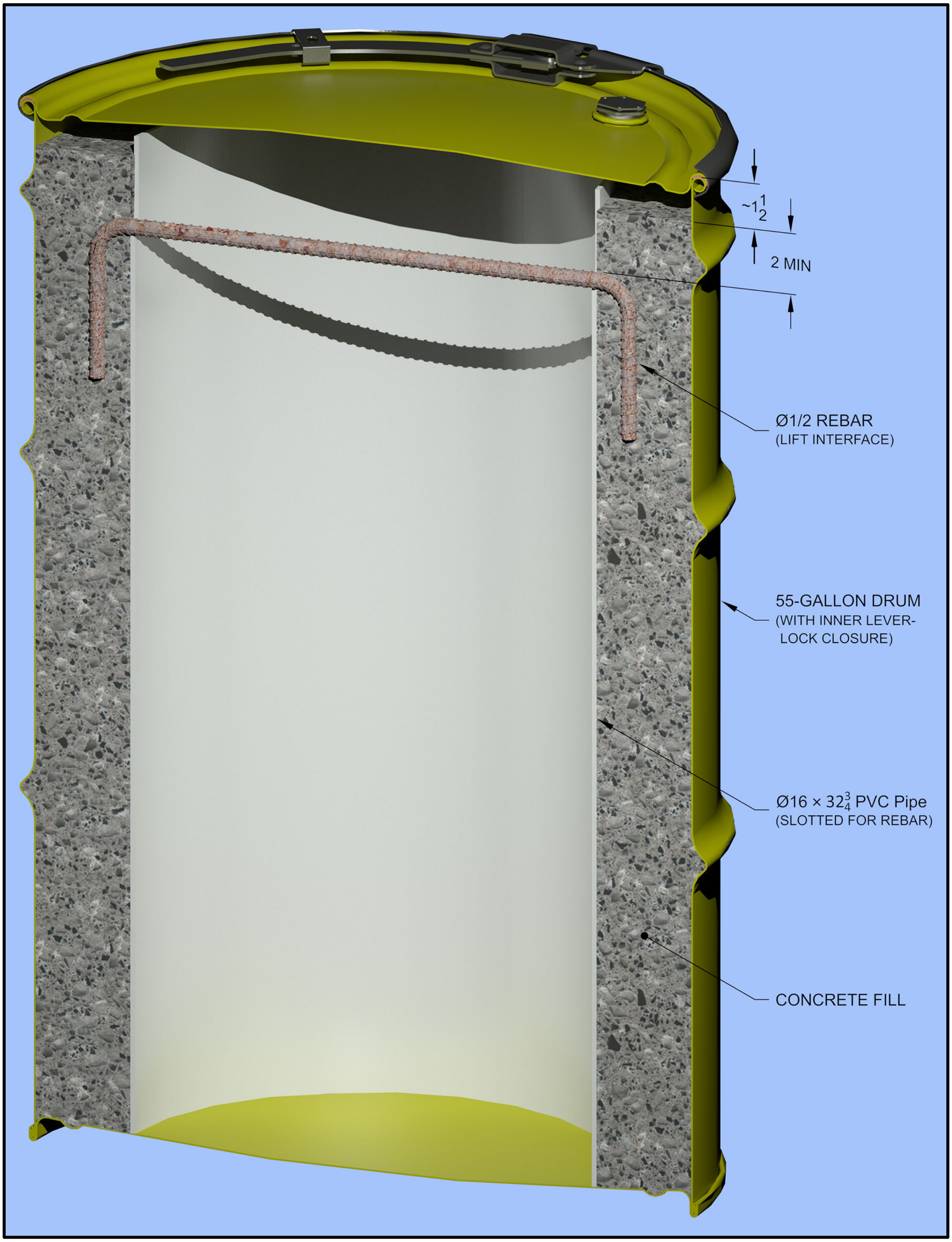

Figure 4-6 – 55-Gallon Payload Drum with Concrete Ballast

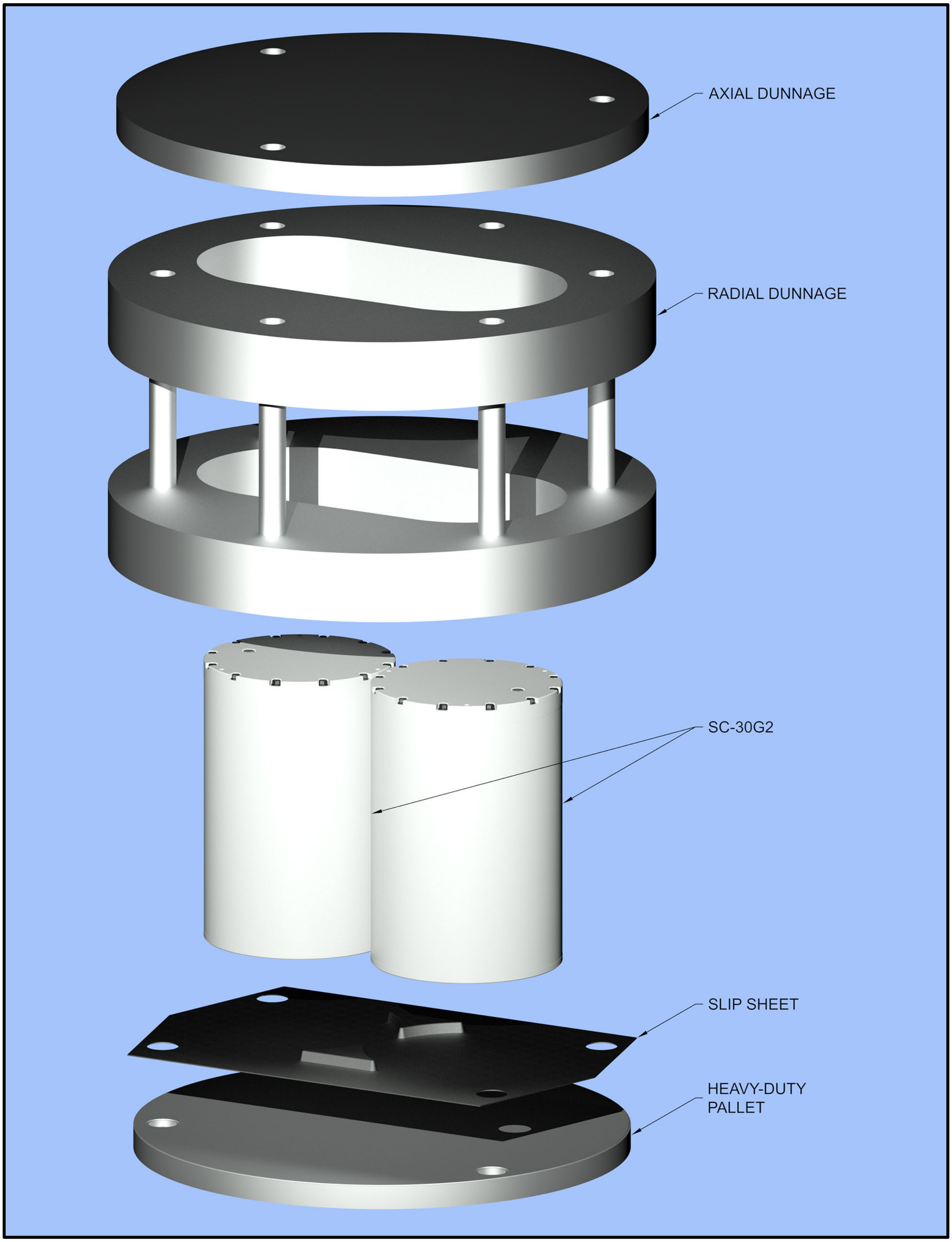

Figure 4-7 – SC-30G2 Payload Assembly

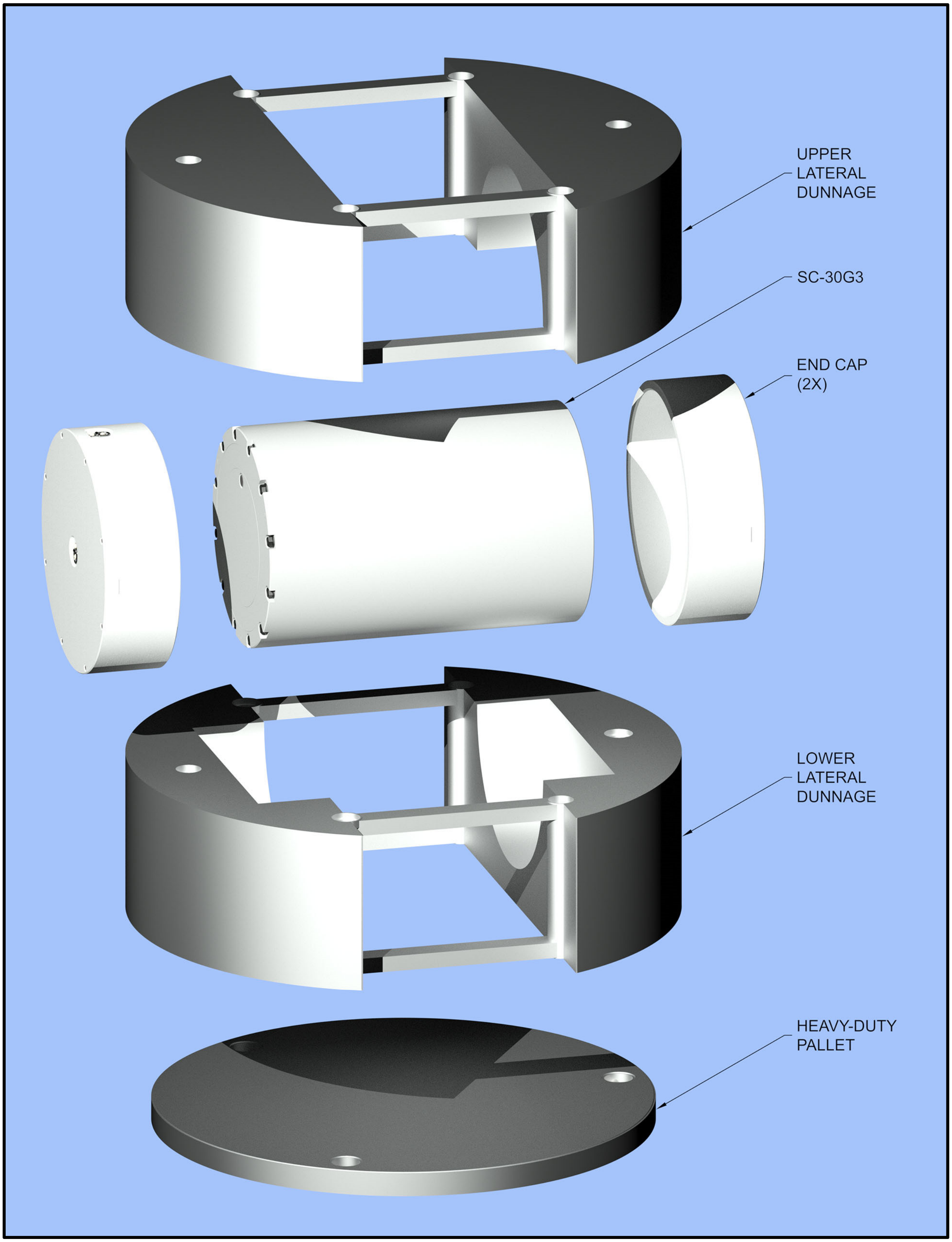

Figure 4-8 – SC-30G3 Payload Assembly

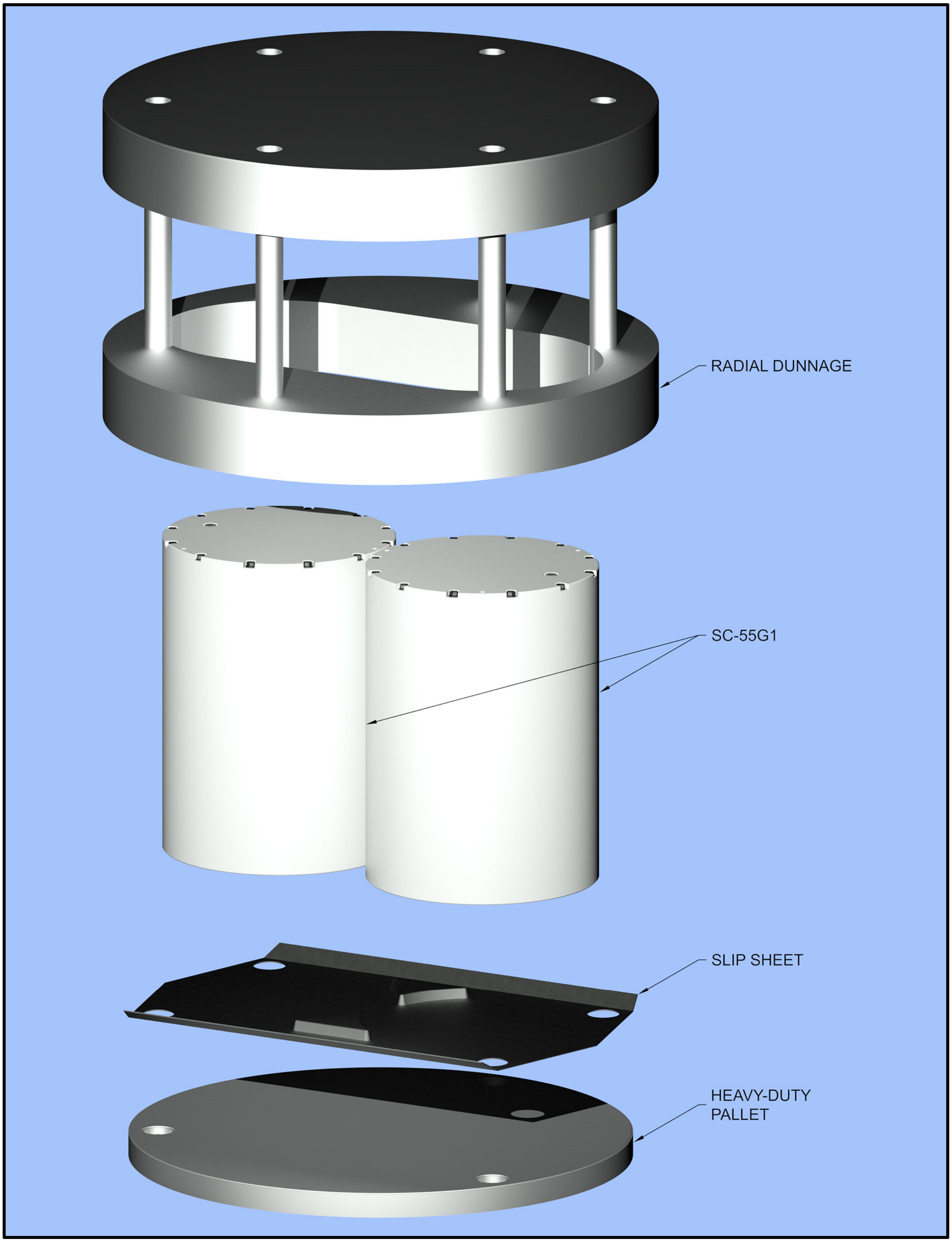

Figure 4-9 – SC-55G1 Payload Assembly

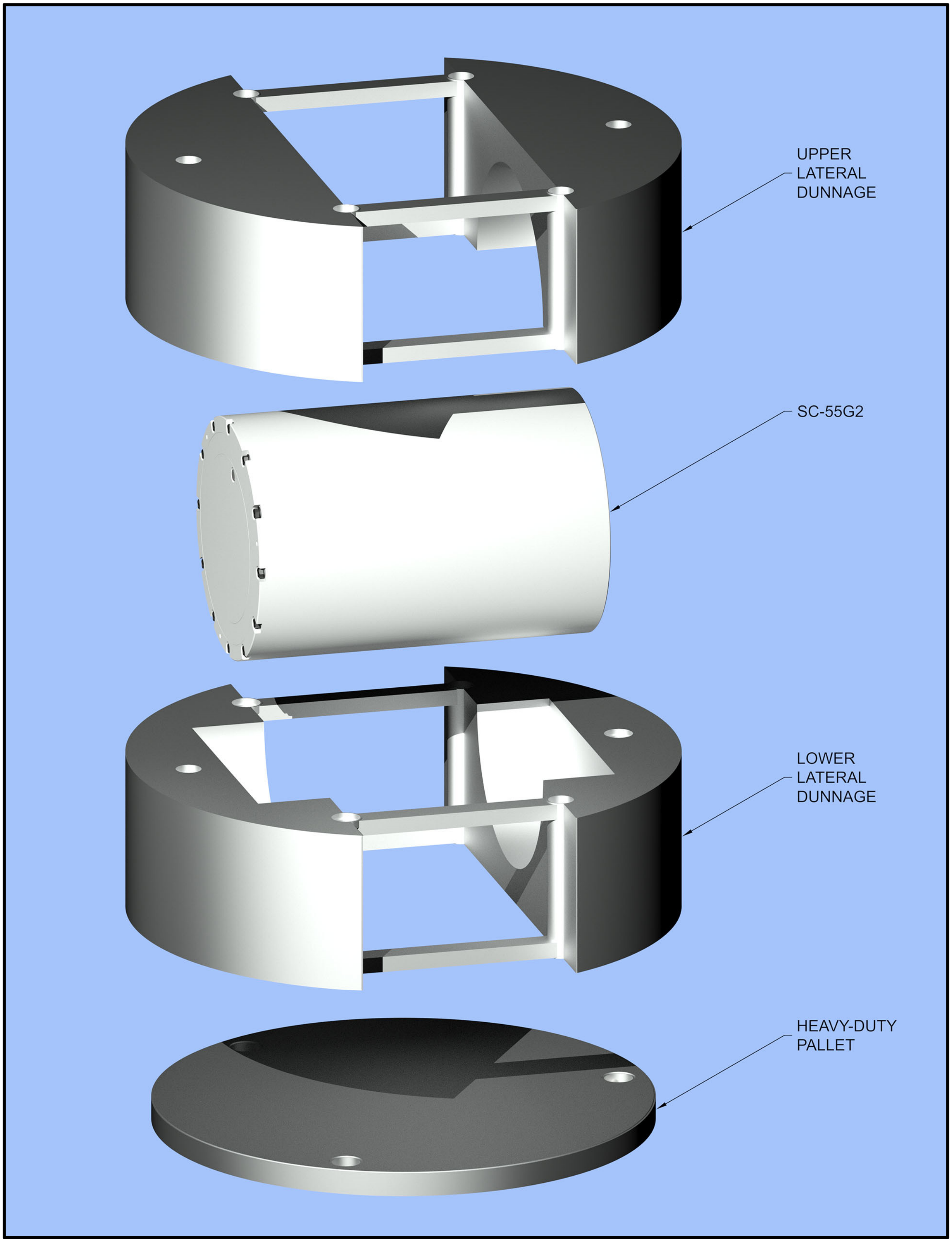

Figure 4-10 – SC-55G2 Payload Assembly

4.4 HalfPACT Inner Containment Vessel (ICV)

Testing utilized two HalfPACT ICVs, one cut down from a TRUPACT-II ICV and the other a prototypic HalfPACT ICV. Upper and lower aluminum honeycomb spacers were used in each assembly.

Eight radial stiffeners and a single circumferential ring stiffener were added to stiffen the ICV bottom for the bottom end drop (see Figure 4-11 and Figure 4-12). The quantity of stiffeners was designed to produce impact forces equal to or greater than the maximum measured during TRUPACT-II testing (see Section 5.2.1, *End Drop*, for a relevant discussion). This stiffener design is identical to what was previously used for HAC testing of the SC-30G1 [2].

Lifting attachments and appropriate rigging hardware were installed as necessary to allow handling and control of orientation of the ICV for each drop test.

Figure 4-11 – HalfPACT ICV Bottom Reinforcement Configuration

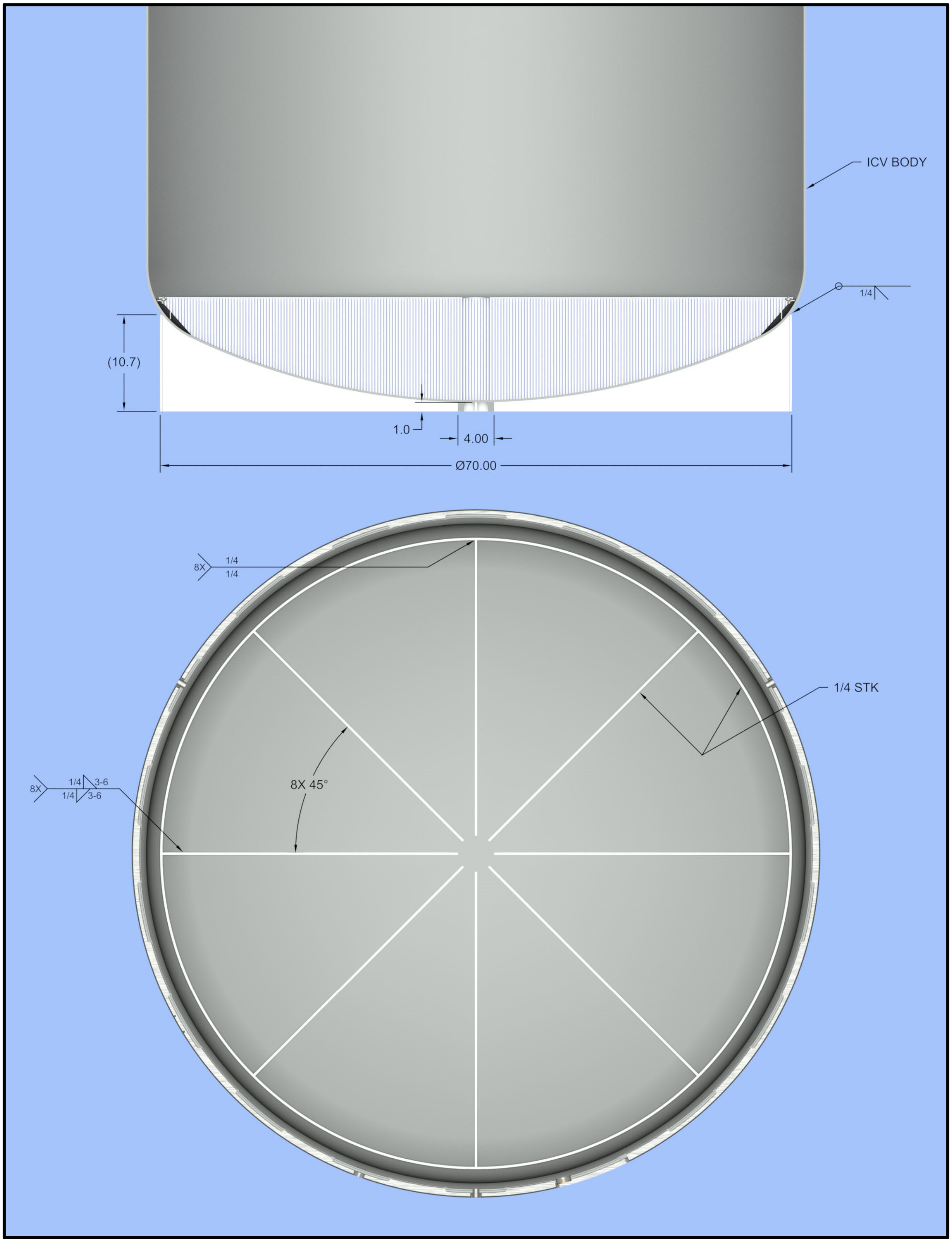

Figure 4-12 – HalfPACT ICV Bottom Reinforcement Details

5.0 TECHNICAL BASIS FOR THE TESTS

The following subsections supply the technical basis for the chosen free drop test orientations and initial conditions (temperature and pressure). As shown, performance capabilities are adequately demonstrated by ambient temperature, free drop testing of the bottom end and side drop orientations. Other drop test orientations are shown to have less significance than end and side, and observed ambient temperature performance was such that conservative analytic extrapolations to temperature extremes (hot and cold) coupled with the inherent strength of the relatively robust shielded container design readily demonstrate acceptable performance at those extremes.

Key test observations (see Section 6.0, *Test Results*) that support the conclusions presented herein and allow for use of conservative analytic extrapolations to temperature extremes are as follows:

1. Two SC-55G1s and one SC-30G3 were conservatively subjected to cumulative HAC drop damage (both end and side drop orientations) rather than using previously undamaged units for each test.

2. Post-test visual inspection of the interior and exterior surfaces of the three shielded containers indicated no apparent global or localized deformation or damage to the shielded containers. The solid, concrete-filled rolling hoops in the 30-gallon test payload drums left no visible deformation of the shielded container's inner shell, even though these drums were loaded to exceed the SC-55G1 and SC-30G3 gross weights (see Table 6-1 and Table 6-2, respectively). Visible damage was limited to localized flattening (~2 inches long) of the two SC-55G1 outer shells that were in contact during drop testing.

3. Post-test visual inspection of the HalfPACT ICV shell at its interface with payload dunnage components revealed no localized deformations that could in any way compromise containment integrity.

4. Subsequent to the performance of end and side drop testing, the flour/fluorescein mixture placed within each shielded container was 100% retained throughout the testing. Prior to and following drop testing, each shielded container was positioned within a dark enclosure having less than 5 foot-candles of measured ambient white light, the exterior spritzed with water, and visually inspected using an ultraviolet light source with a peak wave length of 365 nm and a minimum intensity of 1,200 $\mu W/cm^2$ at a 15-inch minimum distance to confirm confinement integrity by the absence of the fluorescing dye.

5. Pre- and post-test shielding integrity tests coupled with destructive disassembling of selected shielded container sidewalls showed no evidence of lead slump or changes of any significance to the shielding capabilities of the design. Post-test visual inspection of the shielded container wall cut-outs revealed some localized shell deformation resulting from some of the Type A drop tests, but the magnitudes were very limited and of no structural significance; measurable lead shielding thinning/reduction was well within acceptable limits or determined to be non-prototypic test anomalies generated by test rigging.

5.1 Justification for the Tested Configurations

Two tested payload assembly configurations were chosen to demonstrate that the damage to the tested shielded container designs bounds the untested shielded container designs, and that damage inflicted by the shielded containers to the HalfPACT transportation package is insufficient to compromise the previously established 7,600-pound payload capacity of the HalfPACT package and associated full compliance with all the regulatory performance requirements of 10 CFR 71 [1]. Both of the two tested payload assembly configurations are described below.

5.1.1 SC-30G2 Payload Assembly vs. SC-55G1 Payload Assembly

With reference to Figure 4-1 and Figure 4-3, respectively, the size and weight of the SC-30G2 and SC-55G1 shielded containers allow two (2) to be transported within a HalfPACT package, i.e., either two SC-30G2 shielded containers or two SC-55G1 shielded containers. From a size and weight perspective, however, the SC-30G2 (Ø24½ × 36⅝ nominally; 3,160-lb maximum) is smaller than the SC-55G1 (Ø29⅜ × 40½ nominally; 3,410-lb maximum). More importantly, with reference to Figure 5-1, the larger diameter and height of the SC-55G1 compared to the SC-30G2 results in approximately half the available protective thickness in the radial dunnage for attenuating the shielded containers' kinetic energy associated with a side drop impact. From an axial standpoint, a bottom-down impact is identical between the two designs, with the heavy-duty pallet used to distribute impact forces from the shielded containers into the lower aluminum honeycomb spacer. Similarly, a top-down impact of the two SC-30G2s is distributed into the axial dunnage that correspondingly distributes forces into the upper aluminum honeycomb spacer. The SC-55G1 design does not include axial dunnage, but the thick top plate on the radial dunnage performs the same function as the axial dunnage of distributing forces into the upper aluminum honeycomb spacer. Since the SC-55G1 payload assembly bounds the SC-30G2 payload assembly, the SC-30G2 payload assembly does not need to be tested.

5.1.2 SC-30G3 Payload Assembly vs. SC-55G2 Payload Assembly

With reference to Figure 4-2 and Figure 4-4, respectively, the size and weight of the SC-30G3 and SC-55G2 shielded containers allow only one (1) to be transported within a HalfPACT package. From a size and weight perspective, however, the SC-30G3 (Ø28 × 42¼ nominally; 6,300-lb maximum; 6,460 pounds with its two end caps) is smaller than the SC-55G2 (Ø31 × 45¾ nominally; 6,500-lb maximum). However, with reference to Figure 5-2, the SC-30G3, with its HDPE end caps, is essentially the same size and weight as the SC-55G2, has a slightly smaller bearing area with the lateral dunnage, and has the same minimum lateral dunnage minimum foam thickness. Given that the HDPE end caps provide additional radial and axial clearances between the SC-30G3 shielded container and the lateral dunnage resulting in a slightly smaller bearing (and crush) area, and the SC-30G3 design has a greater lead sidewall thickness for the same steel shell thicknesses as for the SC-55G2 design, testing with the SC-30G3 payload assembly would bound the SC-55G2 payload assembly. Since the SC-30G3 payload assembly bounds the SC-55G2 payload assembly, the SC-55G2 payload assembly does not need to be tested.

5.2 Justification for Testing Only End and Side Orientations

The radial dunnage assembly, in conjunction with the aluminum honeycomb spacers at each end of the ICV and, if applicable, axial dunnage assembly, is designed to distribute forces to the ICV and independently absorb 100% of the payload energy associated with the 30-foot side and end drops, respectively. Other orientations (i.e., corner drop) will partially crush both the radial and axial energy-absorbing components, but each to a lesser degree than what will occur for the side and end drop orientations. Thus, any combination of energy distribution between the side and end drop orientations will result in a lesser case compared to each of these two orientations, and drop testing can be limited to the bounding side and end drop orientations.

By using bare ICVs, drop testing will conservatively ignore the presence of the foam-filled, impact-attenuating OCA. Drop testing is not a test of the ICV's performance, but rather is intended to address performance of the shielded containers and dunnage. The two test configurations are illustrated in Figure 5-3 for the SC-55G1 payload assembly and Figure 5-4 for the SC-30G3 payload assembly.

5.2.1 End Drop

The end drop is performed using an unprotected HalfPACT ICV that is conservatively stiffened at its lower end (see Figure 4-11 and Figure 4-12). Stiffening of the lower head results in a higher overall system deceleration than if testing had instead included the impact attenuating HalfPACT OCA. Per Section 2.10.3.5.2.2 of the HalfPACT SAR [3] for the bottom end drop scenario, the cold impact deceleration acting on the HalfPACT packaging would be 409*g* if the OCA were present. As shown below, the reinforced ICV bottom will result in an end drop acceleration approximately 50% higher than measured during HalfPACT certification testing resulting in a conservative test configuration.

<u>ICV Bottom Reinforcement Acceleration</u>

The ICV bottom is reinforced with eight, 1/4-inch thick × 32¾-inch long radial stiffeners and one, 1/4-inch thick × 70-inch outside diameter ring stiffener; therefore, the total effective impact area, $A_i = ¼[8(32¾) + \pi(70 – 1/4)] = 120.3$ in^2. The Series 300 stainless steel stiffener's flow stress, σ_f, is the average of the minimum yield strength, $\sigma_y = 30{,}000$ psi, and minimum ultimate strength, $\sigma_u = 75{,}000$ psi, is $\sigma_f = ½(30{,}000 + 75{,}000) = 52{,}500$ psi. The minimum force, F_s, to flow the Series 300 stainless steel stiffeners is:

$$F_s = (A_i)(\sigma_f) = (120.3)(52{,}500) = 6{,}315{,}750 \text{ lb}$$

Per Table 6-1 in Section 6.1.1, *SC-55G1 Component Weights*, and Table 6-2 in Section 6.2.1, *SC-30G3 Component Weights*, the HalfPACT ICV test assembly weights, W, are 10,033 and 9,868 pounds, respectively, resulting in a minimum ICV acceleration, η, of:

$$\eta = \frac{F_s}{W} = \frac{6{,}315{,}750}{10{,}033} = 629g$$

<u>ICV Aluminum Honeycomb Spacer Acceleration</u>

The approximate outside diameter of the bottom aluminum honeycomb spacer, D = 70 inches, and its maximum bare compressive crush strength, $\sigma_c = 391$ psi; the corresponding crush area, $A_c = (\pi/4)D^2 = (\pi/4)(70)^2 = 3{,}848.5$ in^2. Thus, the maximum force to crush the aluminum honeycomb spacer, F_a, is:

$$F_a = (A_c)(\sigma_c) = (3{,}848.5)(391) = 1{,}504{,}764 \text{ lb}$$

Given a maximum HalfPACT payload assembly weight, W_p= 7,600 pounds, results in a maximum acceleration, η, to the bounding HalfPACT payload assembly of:

$$\eta = \frac{F_a}{W_p} = \frac{1{,}504{,}764}{7{,}600} = 198g$$

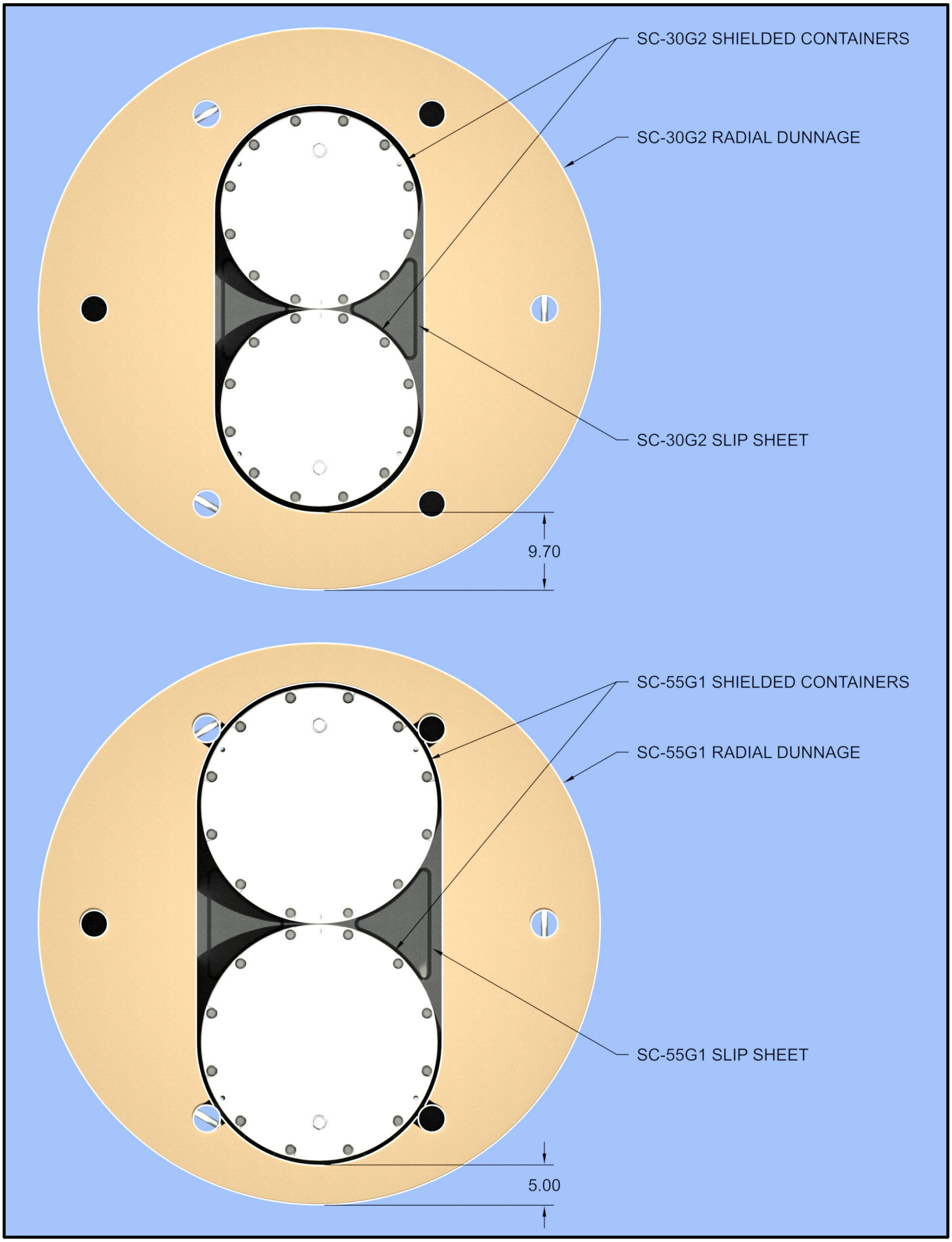

Figure 5-1 – Configuration for SC-30G2 vs. SC-55G1 Shielded Containers

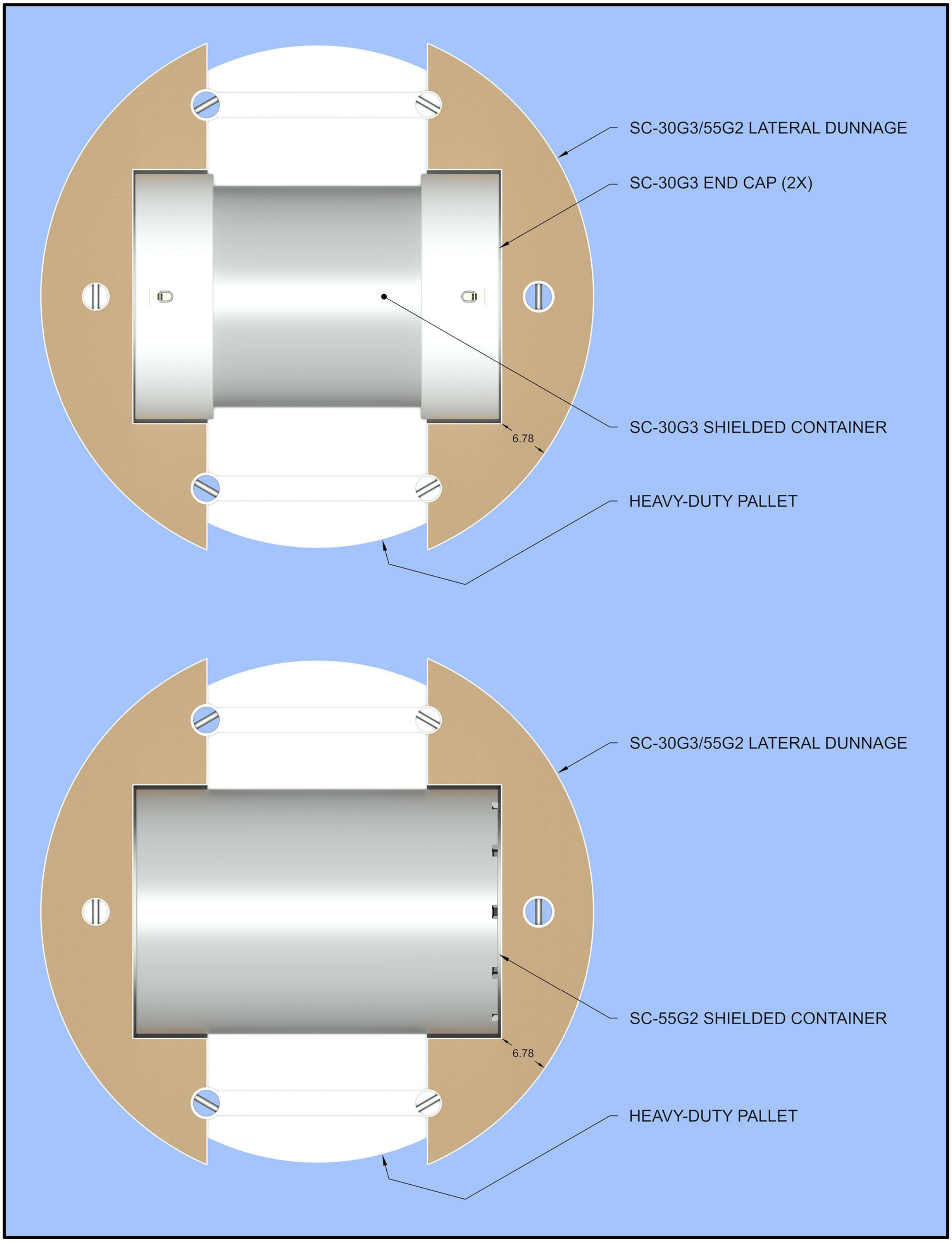

Figure 5-2 – Configuration for SC-30G3 vs. SC-55G2 Shielded Containers

Therefore, crush of the aluminum honeycomb spacer results in a lesser case, and the bottom-end drop orientation remains the bounding case.

Top-Down OCA Domed Head Impact Acceleration

A top-down end drop orientation will have the additional 200-pound mass of the heavy-duty pallet axially loading the shielded containers. However, the greater deformability of the OCA top's spherical crown will result in a substantially lower acceleration to the payload and, therefore, is a lesser case. Specifically, the average top-down end drop acceleration may be determined by the ratio of the drop height to the package deformation, as follows.

For a free drop of height, h, acted upon by gravitational acceleration, *g*, the velocity, ν_i, at the instant of package impact is:

$$(\nu_i)^2 = 2g(h + \delta)$$

Given that initial velocity, ν_o, the average deceleration, η, over a distance equal to the deformation, δ, may also be determined from the same equation:

$$(\nu_o)^2 = 2\eta\delta$$

Setting the gravitational acceleration equal to unity (i.e., free-fall), the velocities equal, $\nu_i = \nu_o$, and solving for the *average* deceleration, η, results in:

$$(\nu_i)^2 = (\nu_o)^2 \;\Rightarrow\; 2g(h+\delta) = 2\eta\delta \;\Rightarrow \eta = \frac{2g(h+\delta)}{2\delta} = \frac{h+\delta}{\delta}$$

Thus, assuming linear deceleration, the peak deceleration, η_{max}, is twice the average:

$$\eta_{max} = \frac{2(h+\delta)}{\delta}$$

HalfPACT certification testing did not include a top-down free drop; instead, results from TRUPACT-II certification testing will be used. Per Section 2.10.3.7.1.4, *CTU-1 Free Drop No. 4*, of the TRUPACT-II SAR [6], a top-down drop resulted in a 3⅞-inch measured axial deformation of the OCA domed head due to the 30-foot (360-inch) drop. Thus, the maximum acceleration, $\eta_{max} = 2h/\delta = 2(360 + 3⅞)/3⅞ = 188g$, an amount less than half the maximum bottom-down acceleration of 409*g* discussed previously. Therefore, the added mass due to the payload pallet results in a lesser case, and the bottom-end drop orientation remains the bounding case.

As stated earlier, the cold impact deceleration acting on the HalfPACT packaging per Section 2.10.3.5.2.2 of the HalfPACT SAR [3] for the bottom end drop scenario would be 409*g* if the OCA were present. The corresponding ICV shell compressive stress, per that same section, is a relatively modest 12,305 psi. With reference to Figure 6-5 and Figure 6-25, given the circumferentially uniform and permanent deformation that occurred just above the stiffeners at the lower end of the ICV shell in the end drop tests (absent in all prior TRUPACT-II and HalfPACT testing that included an OCA), it is clear that stiffening of the ICV for the shielded container testing conservatively bounded the overall system deceleration.

The response of the shielded containers themselves is therefore dictated by the behavior of the lower aluminum honeycomb spacer and, to a lesser extent, flexure of the adjacent heavy-duty pallet. Furthermore, the pallet's open bottom provides a significantly smaller footprint onto the aluminum honeycomb spacer compared to the much large footprint of the axial dunnage used with the SC-30G2s or the thick upper plate on the radial dunnage used with the SC-55G1s; thus, damage to the honeycomb spacers will be significantly greater for the bottom-down orientation. Finally, although the overall system deceleration for a top-down drop that is well less than for the bottom-down drop), the shielded containers will experience greater loads in a bottom-down drop rather than a top-down drop; nevertheless, for end drop test purposes, one SC-55G1 was inverted with its lid pointing downward conservatively simulating the effects of a top-down drop on a shielded container. The SC-30G3 encased within the lateral dunnage is not directionally sensitive from a drop standpoint, but for reasons just stated the bottom-down orientation will be more damaging to the honeycomb spacers than a top-down orientation.

For an ambient temperature of 64 ºF for SC-55G1 end drop testing, the SC-55G1s were measured to have a permanent axial offset of 5.92 inches relative to the ICV lower seal flange (see Section 6.1.2.3, *SC-55G1 Post-Drop Test Disassembly*. With the available kinetic energy, E, from the various payload components having a combined weight, W = 7,600 pounds, falling from a height, h = 360 inches, a nominal crush strength, σ_{cr} = 120 psi, for the aluminum honeycomb material (see Table 2.3-3 in the HalfPACT SAR [3]), and the impact area, $A = (\pi/4)(63.5)^2 = 3{,}167\ in^2$ for the heavy-duty pallet assembly with an outer diameter, D = 63.5 inches, the impact acceleration, η, acting on the 7,600 pounds of payload components for an end drop test at ambient temperature is:

$$\eta = \frac{\sigma_{cr} A}{W} = 50.0g$$

As a check, the estimated deformation of the aluminum honeycomb spacer, δ, may be estimated by balancing the kinetic energy of the drop, $E_k = W(h + \delta)$, with the strain energy absorbed by the aluminum honeycomb material, $E_s = \sigma_{cr} A\delta$, or:

$$E_k = E_s \ \Rightarrow \ W(h+\delta) = \sigma_{cr} A\delta \ \Rightarrow \ \delta = \frac{Wh}{A\sigma_{cr} - W} = 7.35 \text{ in}$$

Note that, although greater than the post-drop test axial offset of 5.92 inches, this deformation is reasonable since it ignores kinetic energy absorbed by elastic and plastic deformation of the heavy-duty pallet (see Figure 6-11). Impact accelerations at temperature extremes will be proportional to the strength of the aluminum at those temperature extremes, with the force that is able to develop in the axial dunnage assembly again being limited to the force that can be supported by the honeycomb end spacer itself.

5.2.2 Side Drop

The side drop is also conservatively performed using an unprotected HalfPACT ICV (i.e., without the energy absorbing HalfPACT OCA). The radial dunnage assembly for the SC-30G2 and SC-55G1 designs, and lateral dunnage for the SC-30G3 and SC-55G2 designs, must absorb all of the drop induced kinetic energy of the shielded containers. To maximize damage to the radial dunnage assembly and maximize the load acting on a single shielded container for the SC-55G1 side drop test, the SC-55G1s were oriented as shown in Figure 6-6; this orientation placed both a single shielded container and the least amount of radial dunnage thickness directly in line with the impact point. To maximize damage to the lateral dunnage assembly, the SC-30G3 was oriented as shown in Figure 6-26; this orientation placed the least amount of lateral dunnage thickness directly in line with the impact point.

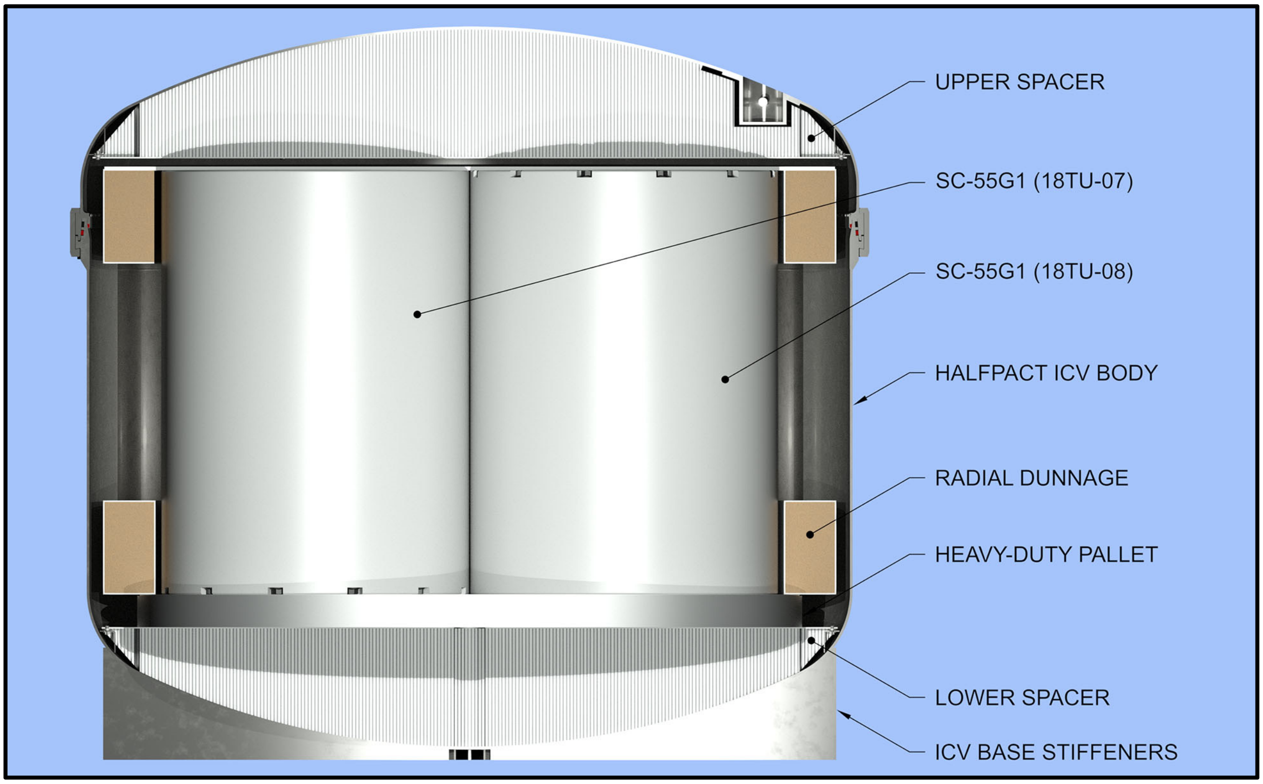

Figure 5-3 – SC-55G1 Payload Assembly in a HalfPACT ICV

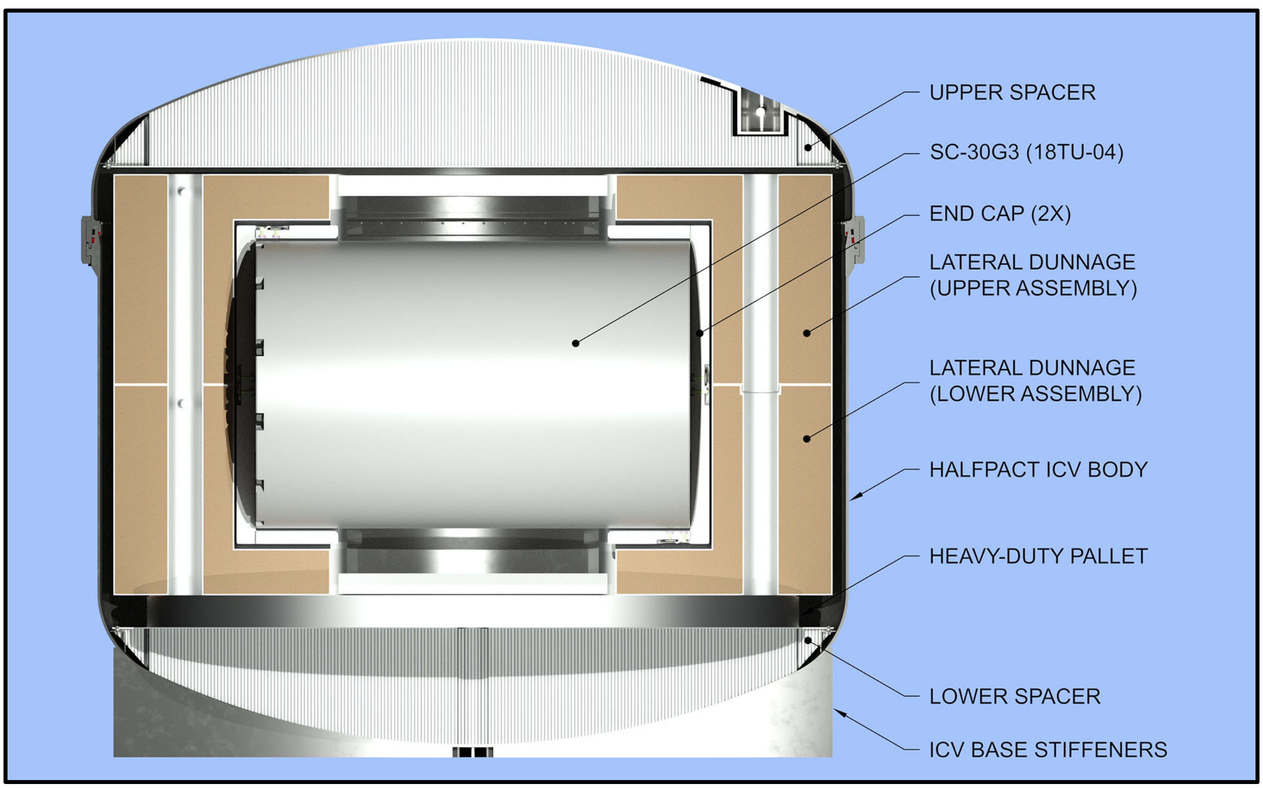

Figure 5-4 – SC-30G3 Payload Assembly in a HalfPACT ICV

Unlike for the case of end drop where the aluminum honeycomb end spacer and heavy-duty pallet have been shown to be of little importance, for side drop the strength and temperature sensitivity of the radial dunnage (and lateral dunnage) foam is a primary contributor to system response. The impact of temperature variations on maximum deformation of the radial dunnage (and lateral dunnage) assembly and on the structural response of the shielded containers is addressed in Section 5.3, *Temperature*, below. Other data used in that section includes the observed crush of the HalfPACT OCA (3¾ inches) in a 30-foot side drop (see Table 2.10.3-3 of the HalfPACT SAR [3]).

5.3 Temperature

As indicated above and in Section 6.0, *Test Results*, below, the end and side drop tests were performed at ambient temperatures ranging from 64 ºF to 81 ºF. The significance of cold (-20 ºF) and hot (160 ºF bounding maximum for all payload components of interest) temperature extremes are addressed as follows.

5.3.1 Cold

5.3.1.1 End Drop

As established in Section 5.2.1, *End Drop*, for an end (axially oriented) drop, the aluminum honeycomb spacer material is the crushable medium of interest. Considering that crush of the aluminum honeycomb material is a buckling defined process, and that buckling is directly proportional to the material's elastic modulus and/or yield strength, the expected increase in acceleration at cold (-20 ºF) conditions versus ambient conditions is no more than 5% considering a wide range of aluminum grades (see Figures 3.2.1.1.1(d), 3.2.1.1.4, 3.2.3.1.4, 3.5.1.1.4 and 3.6.2.2.1(b) of MIL-HDBK-5J [4]). With steel and lead yield strengths exhibiting similar, if not slightly greater, strength increases over this same temperature range (e.g., see Table 2.3-2 of the RH-TRU 72-B SAR [5] for representative lead properties), the cold drop response of the shielded containers will not be substantially different than the ambient temperature drop response.

Therefore, based on a room temperature axial acceleration of 50.0*g* from Section 5.2.1, *End Drop*, the maximum cold case acceleration would remain relatively modest at 1.05 × 50.0*g* = 52.5*g*, with the slight increase in acceleration readily offset by the corresponding increases in shielded container lead and steel strengths.

5.3.1.2 Side Drop

With reference to Section 6.1.2.3, *SC-55G1 Post-Drop Test Disassembly*, the SC-55G1 radial dunnage compressed approximately 2½ inches for an ambient condition side drop. A similar, but somewhat larger OCA crush distance of 3¾ inches was observed for the side drop testing of a HalfPACT package. As such, for the specific side drop orientation of the radial dunnage that was tested, the shielded containers would experience greater impact decelerations than would the overall HalfPACT package system.

To be conservative, it can be assumed that the maximum side drop deceleration that can ever be imposed on a shielded container corresponds to the maximum possible SC-55G1 deceleration resulting from the 2½-inch side crush. Given the cylindrical geometry of the SC-55G1 radial dunnage, its force-deflection relationship can be bounded on the low end by an assumed constant force resistance, and on the high end by an assumed linearly varying force-deflection relationship. Given these two extremes, a bounding impact deceleration can be established as follows.

For a constant resistance force, E = W(h + δ) = Fδ = Wηδ, where W is the system weight (lb), F is the force magnitude (lb), the drop height, h = 360 inches, the maximum deflection, and δ = 2.5 inches. Simplifying, the lower-bound impact acceleration, η, is:

$$\eta = \frac{h+\delta}{\delta} = \frac{360+2.5}{2.5} = 145g$$

For a linearly increasing resistance force, E = W(h + δ) = (F_{max}/2)δ = (Wη_{max}/2)δ, or equivalently, η_{max} = 2(h + δ)/δ, where W is the system weight (lb), F_{max} is the peak force reached at the maximum deflection, δ = 2.5 inches, and the upper bound impact acceleration, η_{max}, is:

$$\eta_{max} = \frac{2(h+\delta)}{\delta} = \frac{2(360+2.5)}{2.5} = 290g$$

Assuming each shielded container design is a simply supported beam that ignores the stiffening effects of the lead between the inner and outer shells, the unit bending stress in the shells, σ, is:

$$\sigma = \frac{Mc}{I}$$

where the maximum bending moment, M = $wL^2/8$, very conservatively assuming a uniformly distributed load, w = W/L; a total weight, W; a length, L; a distance to the outer surface, c; and a composite moment of inertial for the inner and outer shells, I, of:

$$I = \frac{\pi}{64}\left\{\left[\left(D_i + 2t_i\right)^4 - D_i^4\right] + \left[D_o^4 - \left(D_o - 2t_o\right)^4\right]\right\}$$

with an inside diameter of the inner shell, D_i; a thickness of the inner shell, t_i; an outside diameter of the outer shell, D_o; and a thickness of the outer shell, t_o. The following table summarizes the unit bending stress for each of the four shielded container designs.

Model [Reference]	W (lb)	L (in)	M (in-lb)	D_i (in)	t_i (in)	D_o (in)	t_o (in)	I (in^4)	c (in)	σ (psi/*g*)
SC-30G2 [7]	3,160	36.625	14,467	20.375	0.300	24.500	0.300	2,711	12.250	65.4
SC-30G3 [8]	6,300	42.260	33,280	20.410	0.500	28.000	0.500	5,881	14.000	79.2
SC-55G1 [9]	3,410	40.500	17,263	25.000	2.200	29.400	—	17,499	14.700	14.5
SC-55G2 [10]	6,500	45.750	37,172	31.000	0.500	24.960	0.500	9,013	12.480	51.5

Using the maximum estimated side drop acceleration of 194*g* from above, the corresponding worst-case maximum stress is in the SC-30G3 outer shell, $\sigma_{max} = \sigma\eta_{max}$ = (79.2 psi/*g*)(290*g*) = 22,968 psi. Given the ASTM A516, Grade 70, carbon steel shell's minimum room temperature yield strength of 38,000 psi, and given the conservatism of the above analysis, it may be readily concluded that all shielded container designs will withstand a cold side drop with no significant deformations occurring to their structure.

5.3.2 Hot

5.3.2.1 End Drop

Considering the same MIL-HDBK-5J [4] figures referenced in Section 5.3.1.1, *End Drop*, the decrease in aluminum honeycomb strength for a temperature change from 70 ºF to 160 ºF is again very limited. From those figures, a 5% change is appropriate. As such, in a hot condition end drop, the 5.92-inch offset of the shielded containers relative to the ICV lower seal flange, as measured for the ambient condition drop, can be increased to 1.05 × 5.92 = 6.22 inches. This represents a bounding hot condition crush distance that can be utilized in the HAC shielding evaluation.

Relative to impact accelerations, the 5% decrease in aluminum honeycomb strength at hot versus ambient temperatures can be expected to reduce ambient temperature impacts by 5% from 50.0*g* to 47.5*g*. However, since lead strength will reduce by more than 5% for a temperature increase from 70 ºF to 160 ºF, it is necessary to address the response of the lead in a hot end drop. This can be conservatively done by assuming the surrounding steel shells will not provide any support to the lead column and, therefore, that the lead column must support its own inertia. From 30-foot free drop testing and associated post-drop shielding integrity testing and confirmatory sectioning of one of the shielded containers, ambient temperature drop testing has been shown to result in no significant lead slump. The following calculation demonstrates that the lack of lead slump observed for ambient temperature drop conditions is physically reasonable, and that the increase in slump in going from ambient to hot (160 ºF) conditions is a maximum of 0.112 – 0.079 = 0.033 inches. This minor additional slump, which occurs outboard of the ends of the shielded container payload cavity, is of no significance to the shielding performance of the container and the HalfPACT package.

With reference to Figure 2.3-6 of the RH-TRU 72-B SAR [5], at an ambient test temperature of 77 ºF and at hot (160 ºF) conditions, the corresponding compressive stress strain curves for lead can be approximated as follows:

Strain (%)	Stress (psi) at Temperature	
	77 ºF	160 ºF
0.0	300	200
0.3	—	500
0.5	700	—
1.0	900	750

With a lead column height, h = 39.000 inches, for the SC-55G2 (largest design) and a lead density, $\rho = 0.41$ lb/in^3, the stress, σ, in the lead under an applied acceleration, η, will vary linearly along the length of the lead column and at any location, x (with x being 0.0 at the top of the lead column), becomes:

$$\sigma = \rho\eta x$$

The following table summarizes the resultant stress and strain in the lead versus lead column position, x, for an ambient acceleration, η_a, of 50.0*g* and a hot acceleration η_h, of 47.5*g*.

Lead position, x (inches, from top of column)	50.0*g* at 77 ºF		47.5*g* at 160 ºF	
	Stress (psi)	Strain (%)	Stress (psi)	Strain (%)
0.000	0	0.000	0	0.000
10.270	—	—	200	0.000
14.634	300	0.000	—	—
25.674	—	—	500	0.300
34.146	700	0.500	—	—
39.000	800	0.749	760	1.027

The resultant shortening (or slump) of the unsupported lead column for the ambient condition case becomes:

$$\Delta L = (34.146 - 14.634)(0.00500)/2 + (39.000 - 34.146)(0.00749 + 0.00500)/2 = 0.079 \text{ inches}$$

The resultant shortening (or slump) of the unsupported lead column for the hot condition case becomes:

$$\Delta L = (25.674 - 10.270)(0.00300)/2 + (39.000 - 25.674)(0.01027 + 0.00300)/2 = 0.112 \text{ inches}$$

5.3.2.2 Side Drop

For the hot side drop case, the bounding deceleration established for side drop in Section 5.3.1.2, *Side Drop*, of 290*g* can again be conservatively employed. At 290*g*, from Section 5.3.1.2, *Side Drop*, the side drop induced stress in the worst-case SC-30G3 outer shell is 290 × 79.2 = 22,968 psi, which remains well below the yield strength of the ASTM A516, Grade 70, shell at 160 ºF.

To conservatively bound the maximum crush of the radial dunnage assembly at hot conditions, the observed ambient condition crush of 2½ inches must first be multiplied by a factor of 4/3, to account for the reduction in foam strength when going from 70 ºF to 160 ºF. Per Section 2.10.3.5.1.2 of the TRUPACT-II SAR [6], foam strength reduces to approximately 75% of its room temperature strength for this temperature change. With crush volume being inversely proportional to foam crush strength, the crush volume at hot conditions becomes 1/0.75 = 4/3 times the ambient temperature crush volume. The extrapolated crush of the radial dunnage for hot conditions therefore becomes 2½ × 4/3 = 3.33 inches. With an initial foam thickness calculated from the shielded container SAR drawing of 5.00 inches, approximately 1.67 inches of uncrushed foam would still remain, which corresponds to a maximum foam strain of 67% (i.e., 3.33/5.00 = 0.67). This represents a bounding hot condition radial dunnage strain.

5.4 Pressure

Except for investigating the potential for any adverse payload to ICV interactions, the 30-foot free drop tests were not intended to address ICV performance, hence, it was not necessary to include internal pressure within the ICV. The ICV was assembled with O-ring seals installed and a vacuum down to 10 inches of mercury was applied to facilitate locking ring actuation; the vacuum was still present following completion of all drop testing. The effect of a 50 psig external pressure on the foam-filled dunnage assemblies and lead-filled shielded container outer shell assemblies, however, is of little significance that did not warrant testing within a pressurized ICV.

6.0 TEST RESULTS

6.1 SC-55G1 Shielded Container Tests

6.1.1 SC-55G1 Component Weights

Component weights are summarized in Table 6-1. Testing with payload drums exceeding 630 pounds within each SC-55G1 was conservative and resulted in a total gross weight of each loaded SC-55G1 that exceeded its 3,410-pound weight limit. Additionally, the gross weight of all payload assembly components exceeded the 7,600-pound maximum authorized content weight limit for the HalfPACT package.

Table 6-1 – SC-55G1 Component Weights (lb)

Component	Subassembly Weight	Assembly Weight
ICV Lid	779	
ICV Body	1,399	
Upper Spacer	91	
Lower Spacer	75	
ICV Assembly		*2,344*
SC-55G1 18-TU07	2,808	
Payload Drum 1	634	
SC-55G1 18-TU08	2,813	
Payload Drum 2	632	
Heavy-Duty Pallet	168	
Radial Dunnage	634	
Payload Assembly		*7,689*
Total Tested Weight		***10,033***

6.1.2 SC-55G1 Free Drop Tests

Based on the justification provided in Section 5.2, *Justification for Testing Only End and Side Orientations*, two 30-foot free drop tests were performed: 1) a vertical end drop and, 2) a horizontal side drop.

Fluorescein dye powder was mixed with dry flour and placed within each SC-55G1 as a means for determining whether payload container confinement integrity was compromised (see Figure 6-1). Fluorescein dye, when activated by water, fluoresces yellow-green in both the ultraviolet and visible light spectrum.

The SC-55G1s were plastic stretch-wrapped after positioning on the heavy-duty pallet (see Figure 6-2).

Figure 6-1 – Installing and Cutting the Fluorescein Dye Bags

Figure 6-2 – Stretch-Wrapped SC-55G1s

6.1.2.1 SC-55G1 Vertical End Drop Preparation and Test

The following list summarizes the end drop test parameters:

- tightened all SC-55G1 lid closure screws to 170 ±15 lb-ft torque at final assembly
- installed one SC-55G1 (18TU-08) in a normal transport orientation (i.e., lid oriented upward), and the other SC-55G1 (18TU-07) in an inverted orientation (i.e., lid oriented downward); see Figure 6-2 and Figure 6-3
- verified the vertical angle as 0º ±2º; see Figure 6-4
- verified the free drop height as 30 feet, +3/-0 inches
- measured the temperature to be 64 ºF at the time of the end drop test
- conducted the drop test at 8:07 a.m. on 08/04/2020; see Figure 6-4
- witnessed a small rebound of approximately 3½ inches during the impact event
- measured a 3/4-inch radial bulge near the bottom of the ICV assembly; see Figure 6-5

6.1.2.2 SC-55G1 Horizontal Side Drop Test Preparation and Test

The following list summarizes the side drop test parameters:

- oriented to locate a SC-55G1 (18TU-08) at the lowest position (see Figure 6-6) that is aligned with the minimum thickness of radial dunnage foam in the plane of impact
- verified the horizontal angle as 0º ±2º
- verified the free drop height as 30 feet, +3/-0 inches
- measured the temperature to be 69 ºF at the time of the side drop test
- conducted the drop test at 9:03 a.m. on 08/04/2020; see Figure 6-7
- witnessed a small rebound of approximately 7½ inches during the impact event
- measured a 32-inch wide flattening of the ICV locking ring, corresponding to an external crush depth of approximately 3½ inches, and a 24-inch side flattening of the ICV lower torispherical head, corresponding to an external crush depth of approximately 2 inches; in comparison, from the HalfPACT SAR for CTU Test 2 [3], the measured permanent deformation were flats 37 inches wide at the OCA top and bottom, corresponding to a crush depth of approximately 3¾ inches; see Figure 6-8

6.1.2.3 SC-55G1 Post-Drop Test Disassembly

The following summarizes the end drop results:

- measured the average pre-test axial height of 4.77 inches from the top of the ICV body seal flange to the top of the SC-55G1s (see Figure 6-9 for the relative position of components)
- measured the average post-test axial height of -1.09 inches from the top of the ICV body seal flange to the top of the SC-55G1s (see Figure 6-10 for the relative position of components)
- measured axial deformation of the ICV body of 1/16 inch
- calculated axial movement of the SC-55G1s of 4.77 – (-1.09) + 0.06 = 5.92 inches

- observed significant damage to the heavy-duty pallet and lower aluminum honeycomb spacer (see Figure 6-11 and Figure 6-12) indicating that the majority of the payload's kinetic energy went into deforming these components; the heavy-duty pallet had damage consisting mostly of weld cracks and structural bending/twisting

The following summarizes the side drop results:

- observed dissimilar performance between the upper and lower regions of the radial dunnage due to an approximately 6-inch downward axial offset of the two SC-55G1s from the HAC end drop test resulting in a very conservative HAC side drop test; see Figure 6-13 and Figure 6-14
- pre-test radial dunnage thickness of 5 inches through the impact plane
- measured post-test radial dunnage average thickness of approximately 2½ inches through the impact plane; see Figure 6-15 and Figure 6-16
- calculated radial deformation of the radial dunnage of 5 – 2½ = 2½ inches; note that this deformation was grossly conservative because the SC-55G1s were shifted almost 6 inches out of axial alignment with the radial dunnage from damage caused by the preceding end drop; with a planned 9-inch axial engagement on each foam-filled region of the radial dunnage, the loss of 6 inches of axial engagement resulted in fully 1/3 of the polyurethane foam available to attenuate the side drop event not used; had the SC-55G1s fully engaged the radial dunnage, the estimated crush depth would have been closer to 2 inches total

The following summarizes general results:

- observed no significant deformation of or damage to the SC-55G1 exteriors (see Figure 6-17 and Figure 6-18), and observed no visible damage to the interiors
- observed no significant deformation of, or damage to, the ICV attributable to interaction with the payload components; see Figure 6-19 and Figure 6-20 (flattening of the ICV sidewall that is visible in Figure 6-20 is due to external impact damage, i.e., interaction with the drop pad)
- observed no fluorescein dye on the exterior of both SC-55G1s indicating that confinement integrity was maintained; see Figure 6-21 and Figure 6-22

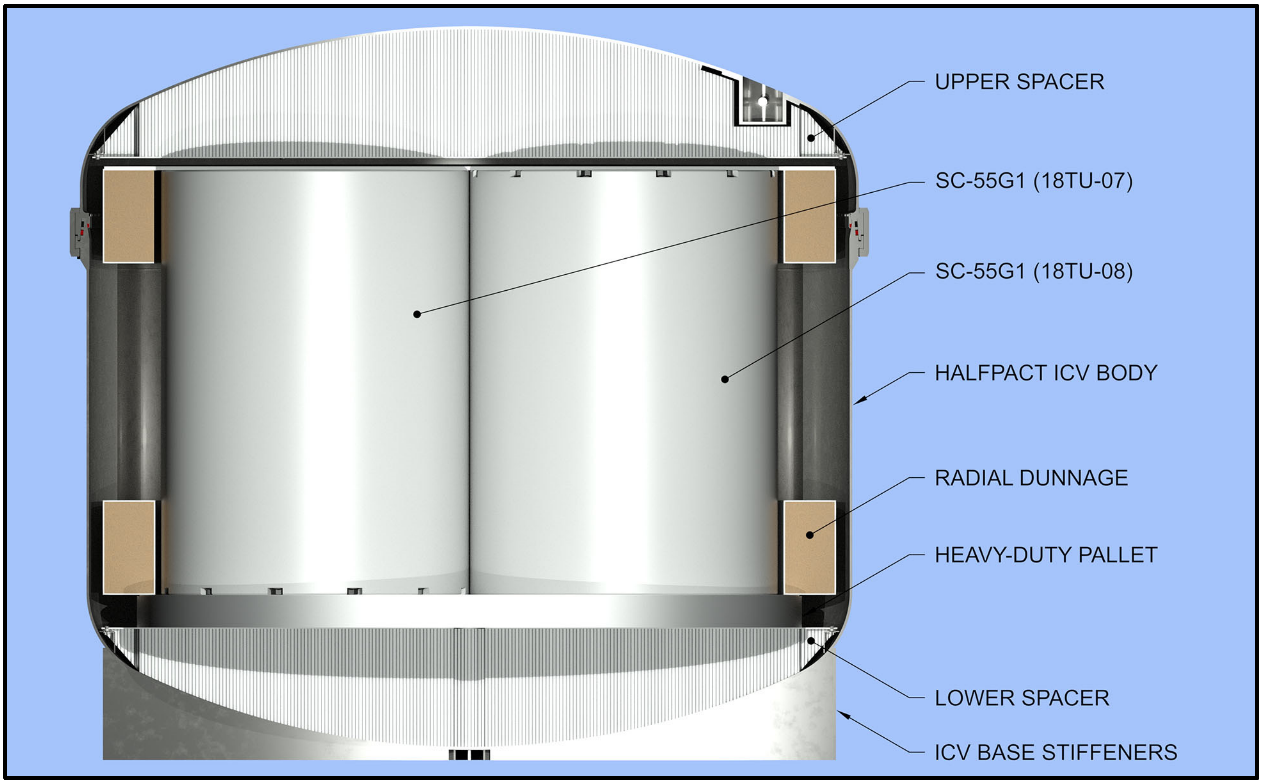

Figure 6-3 – SC-55G1 End Drop Configuration

Figure 6-4 – SC-55G1 30-foot End Drop

Figure 6-5 – SC-55G1 End Drop Hoop Damage to the ICV Shell

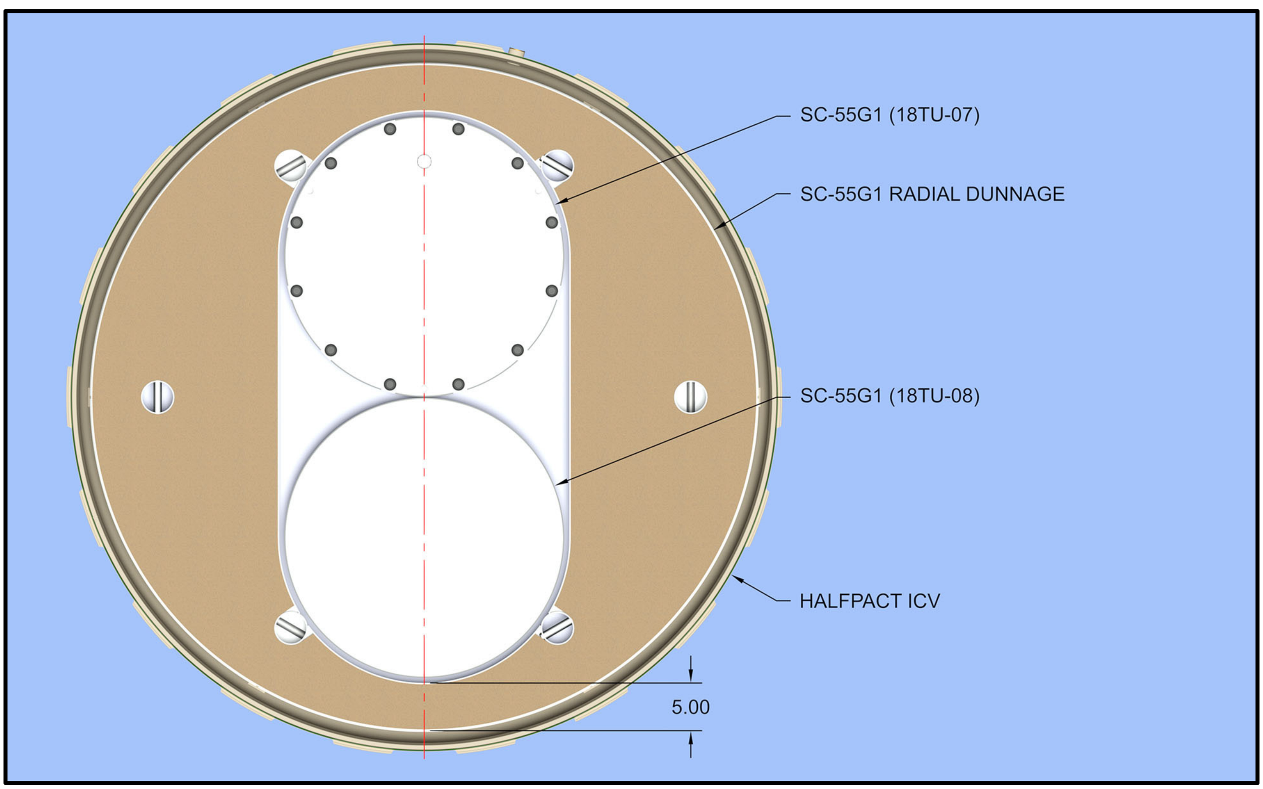

Figure 6-6 – SC-55G1 Side Drop Configuration

Figure 6-7 – SC-55G1 30-foot Side Drop

Figure 6-8 – SC-55G1 Side Drop Radial Flattening of the ICV Shell

Figure 6-9 – Pre-End Drop Relative Position of SC-55G1s

Figure 6-10 – Post-End Drop Relative Position of SC-55G1s

Figure 6-11 – Deformed Heavy-Duty Pallet and Lower Spacer

Figure 6-12 – Deformed Lower Spacer (Bottom-View)

Figure 6-13 – SC-55G1 Radial Dunnage Side Drop Damage

Figure 6-14 – SC-55G1 Radial Dunnage Upper-End Side Drop Damage

Figure 6-15 – SC-55G1 Radial Dunnage Lower-End Residual Thickness

Figure 6-16 – SC-55G1 Radial Dunnage Upper-End Residual Thickness

Figure 6-17 – SC-55G1 18TU-08 Superficial Sidewall Damage (Lower in Side Drop)

Figure 6-18 – SC-55G1 18TU-07 Superficial Sidewall Damage (Upper in Side Drop)

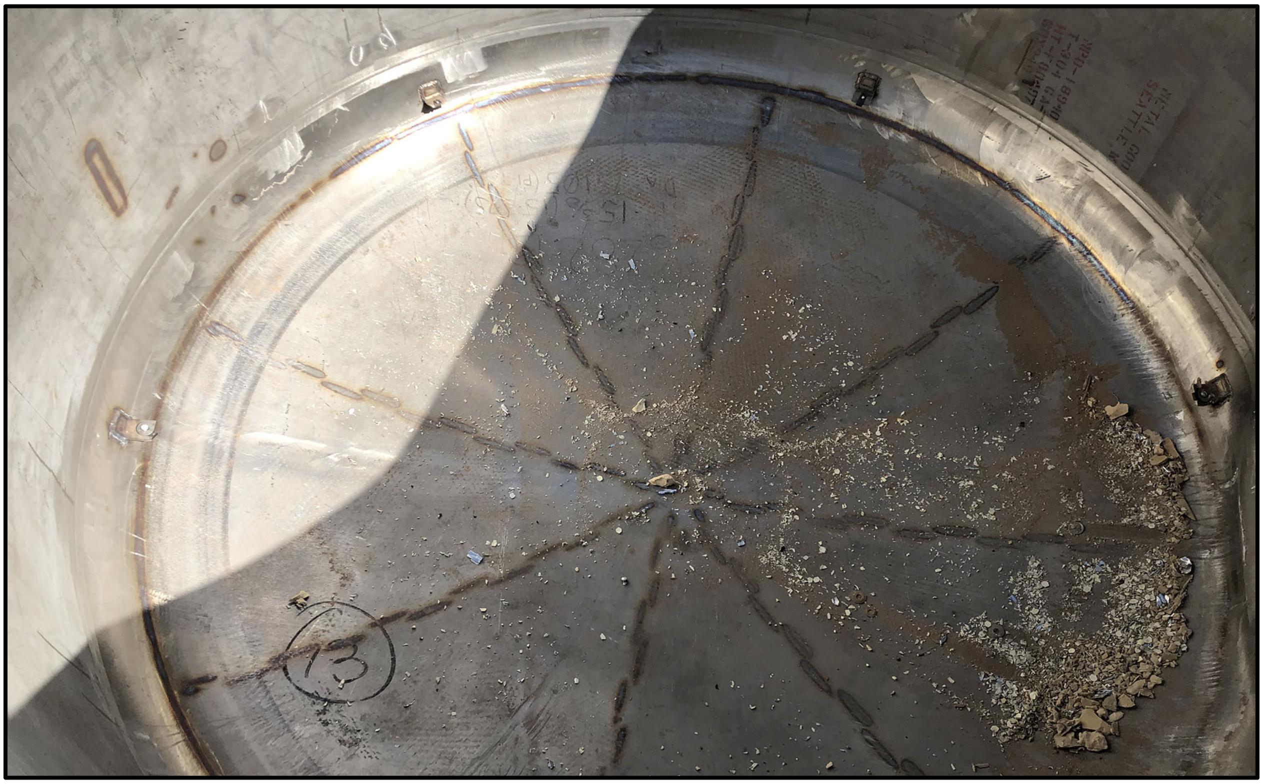

Figure 6-19 – SC-55G1 ICV with No Visible End Drop Interaction from SC-55G1s

Figure 6-20 – SC-55G1 ICV with No Visible Side Drop Interaction from SC-55G1s

Figure 6-21 – Fluorescein Dye inside the SC-55G1 Body

Figure 6-22 – Fluorescein Dye under the SC-55G1 Lid

6.2 SC-30G3 Shielded Container Tests

6.2.1 SC-30G3 Component Weights

Component weights are summarized in Table 6-2. Testing with payload drums exceeding 550 pounds within the SC-30G3 was conservative and resulted in a total gross weight of the loaded SC-30G3 that exceeded its 6,300-pound weight limit. Regardless, the gross weight of all payload assembly components approached, but did not exceed the 7,600-pound maximum authorized content weight limit for the HalfPACT package due to the below-maximum weight of the dunnage components and pallet.

Table 6-2 – SC-30G3 Component Weights (lb)

Component	Subassembly Weight	Assembly Weight
ICV Lid	795	
ICV Body	1,405	
Upper Spacer	91	
Lower Spacer	82	
ICV Assembly		*2,373*
SC-30G3 18TU-04	5,685	
Payload Drum	625	
Heavy-Duty Pallet	168	
Upper Lateral Dunnage	420	
Lower Lateral Dunnage	434	
End Caps	163	
Payload Assembly		*7,495*
Total Tested Weight		***9,868***

6.2.2 SC-30G3 Free Drop Tests

Based on the justification provided in Section 5.2, *Justification for Testing Only End and Side Orientations*, two 30-foot free drop tests were performed: 1) a vertical end drop and, 2) a horizontal side drop.

As with SC-55G1 testing, fluorescein dye powder was mixed with dry flour and placed within the SC-30G3 as a means for determining whether confinement integrity was compromised.

6.2.2.1 SC-30G3 Vertical End Drop Preparation and Test

The following list summarizes the end drop test parameters:

- tightened all SC-30G3 lid closure screws to 280 ±20 lb-ft torque at final assembly
- installed a SC-30G3 (18TU-04), with end caps, into the lateral dunnage; see Figure 6-23 and Figure 6-24
- verified the vertical angle as 0º ±2º
- verified the free drop height as 30 feet, +3/-0 inches
- measured the temperature to be 81 ºF at the time of the end drop test

- conducted the drop test at 10:20 a.m. on 08/04/2020
- witnessed a modest rebound of approximately 13½ inches during the impact event
- measured a 1-inch radial bulge near the bottom of the ICV assembly; see Figure 6-25

6.2.2.2 SC-30G3 Horizontal Side Drop Test Preparation and Test

The following list summarizes the side drop test parameters:

- oriented at a circumferential angle of 34½º to locate the lateral dunnage's minimum thickness at the lowest position (see Figure 6-26)
- verified the horizontal angle as 0º ±2º
- verified the free drop height as 30 feet, +3/-0 inches
- measured the temperature to be 75 ºF at the time of the side drop test
- conducted the drop test at 10:57 a.m. on 08/04/2020
- witnessed a modest rebound of approximately 10½ inches during the impact event
- measured a 38-inch wide flattening of the ICV locking ring, corresponding to an external crush depth of approximately 5 inches, and a 24-inch side flattening of the ICV lower torispherical head, corresponding to an external crush depth of approximately 2 inches; in comparison, from the HalfPACT SAR for CTU Test 2 [3], the measured permanent deformation were flats 37 inches wide at the OCA top and bottom, corresponding to a crush depth of approximately 3¾ inches; see Figure 6-27

6.2.2.3 SC-30G3 Post-Drop Test Disassembly

The following list summarizes the end drop results:

- measured the average pre-test axial height of 5.53 inches from the top of the ICV body seal flange to the top of the lateral dunnage (see Figure 6-28)
- measured the average post-test axial height of 4.13 inches from the top of the ICV body seal flange to the top of the lateral dunnage (see Figure 6-29)
- calculated axial deformation of the lateral dunnage of 5.53 – 4.13 = 1.40 inches
- measured the average pre-test axial height of 2.13 inches from the top of the ICV body seal flange to the highest point on the side of the SC-30G3
- measured the average post-test axial height of 5.44 inches from the top of the ICV body seal flange to the highest point on the side of the SC-30G3
- calculated axial movement of the SC-30G3 of 5.44 – 2.13 = 3.31 inches; see Figure 6-32
- measured axial deformation of the ICV body of 1/16 inch
- observed moderate damage to the heavy-duty pallet and lower aluminum honeycomb spacer (see Figure 6-30 and Figure 6-31) indicating that the majority of the payload's kinetic energy went into deforming these components; the heavy-duty pallet had damage consisting mostly of weld cracks and structural bending/twisting

The following list summarizes the side drop results:

- pre-test lateral dunnage inside corner thickness of 6.78 inches through the impact plane
- measured post-test lateral dunnage inside corner thickness of approximately 5.90 inches through the impact plane; see Figure 6-33
- calculated deformation of the lateral dunnage inside corner of 6.78 – 5.90 = 0.88 inches

The following summarizes general results:

- observed no significant deformation of or damage to the SC-30G3 exterior (see Figure 6-34), and observed no visible damage to the interior (see Figure 6-35 and Figure 6-36)
- observed minor scuffing of the lateral end caps; see Figure 6-37
- observed no significant deformation of, or damage to, the ICV attributable to interaction with the payload components
- observed no fluorescein dye on the exterior of both SC-55G1s indicating that confinement integrity was maintained; see Figure 6-38 and Figure 6-39
- shielding integrity testing indicated no significant change in shielding capabilities of the design (see Section 6.3, *SC-30G3 Shielding Integrity Testing*, Section 7.1.2, *SC-30G2 Type B HAC Evaluation*, and Section 7.1.3, *SC-55G2 Type B HAC Evaluation*)

Figure 6-23 – SC-30G3 with End Caps Loaded into Lateral Dunnage

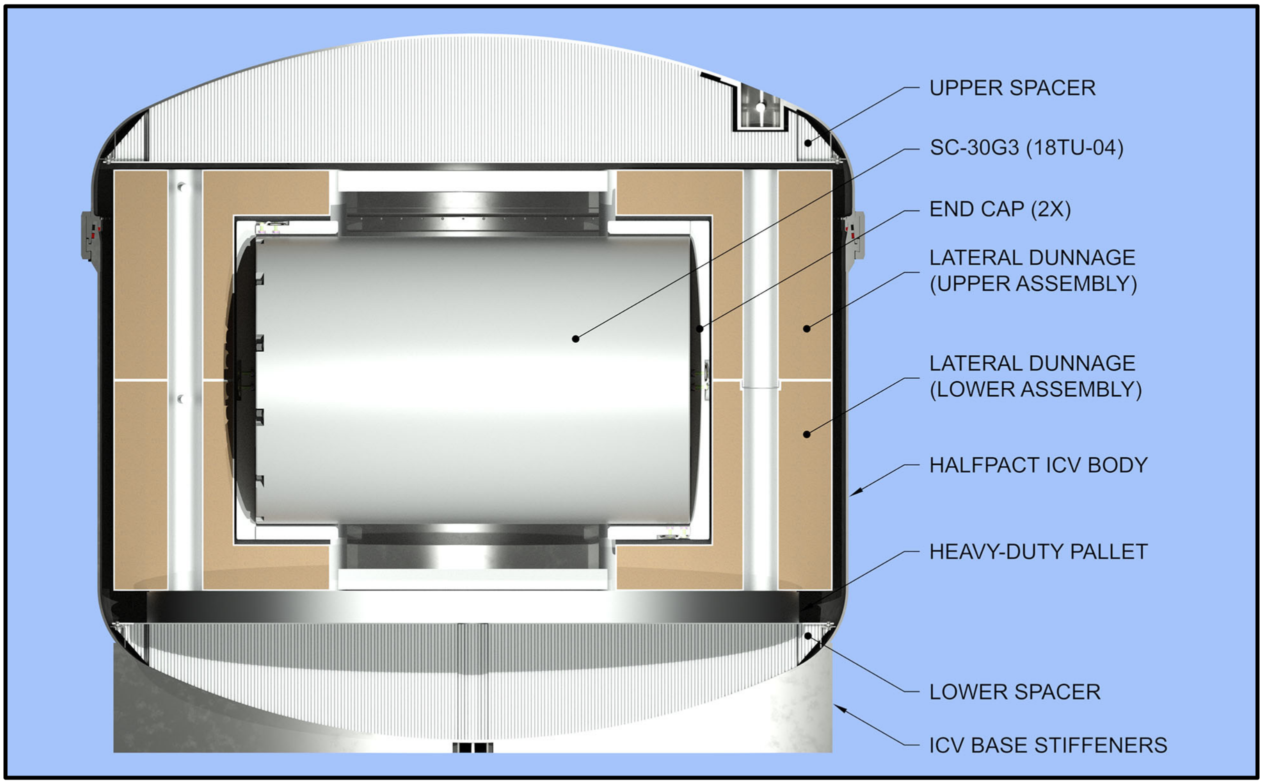

Figure 6-24 – SC-30G3 End Drop Configuration

Figure 6-25 – SC-30G3 End Drop Hoop Damage to the ICV Shell

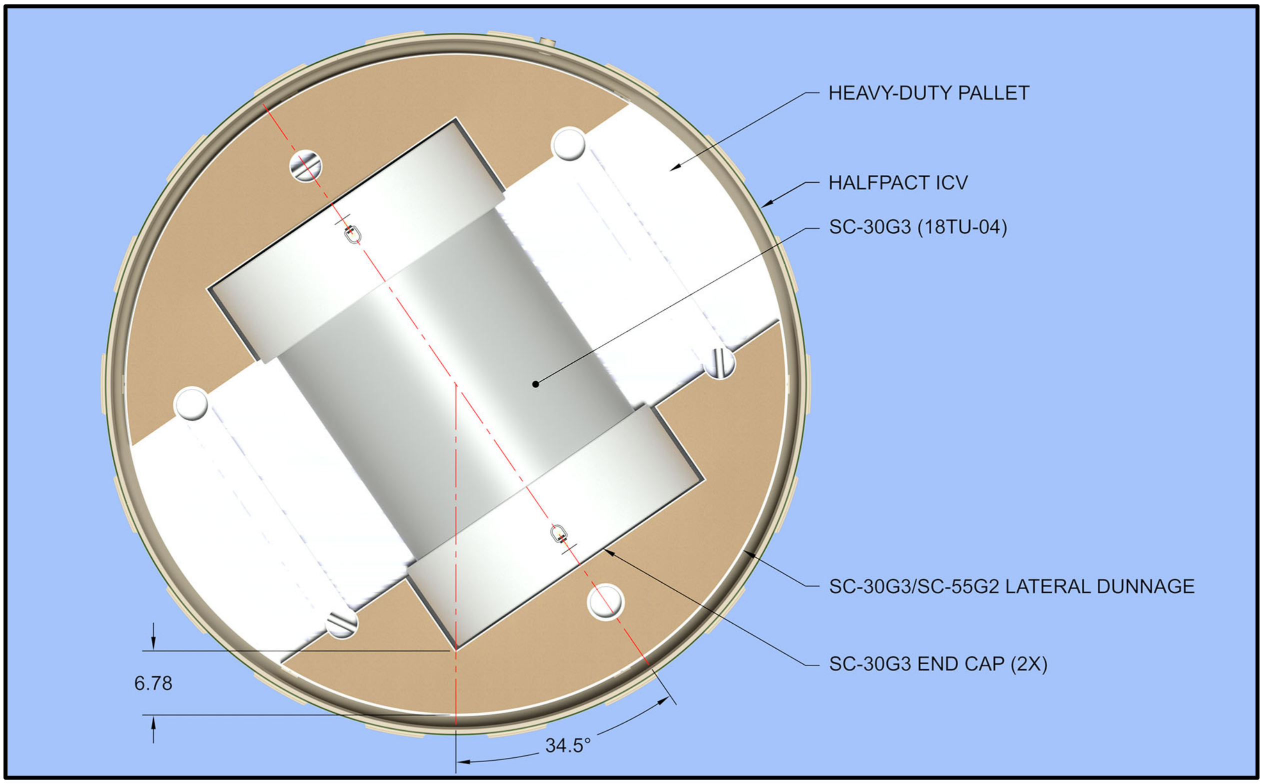

Figure 6-26 – SC-30G3 Side Drop Configuration

Figure 6-27 – SC-30G3 Side Drop Radial Flattening of the ICV Shell

Figure 6-28 – Pre-End Drop Relative Position of the SC-30G3 Lateral Dunnage

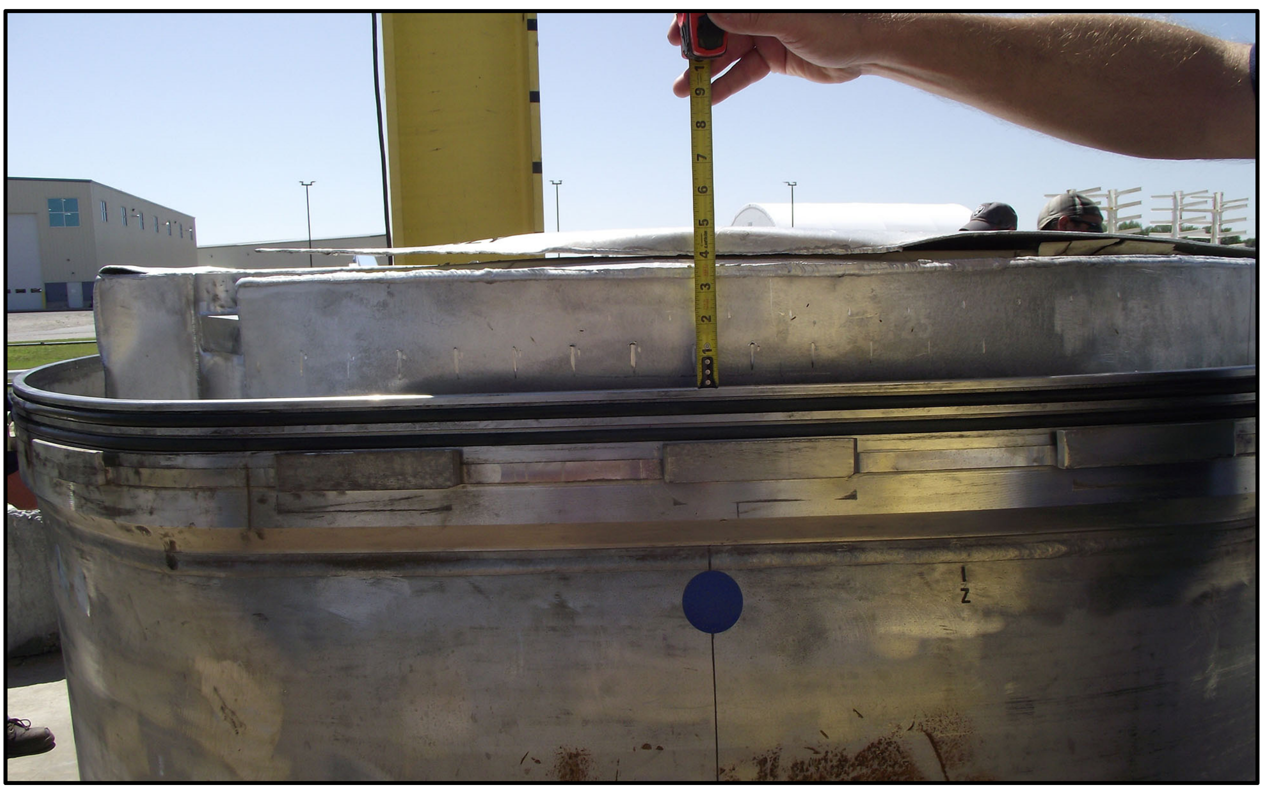

Figure 6-29 – Post-End Drop Relative Position of the SC-30G3 Lateral Dunnage

Figure 6-30 – SC-30G3 Deformed Heavy-Duty Pallet

Figure 6-31 – SC-30G3 Deformed Lower Spacer

Figure 6-32 – SC-30G3 Lateral Dunnage End Drop Damage

Figure 6-33 – SC-30G3 Lateral Dunnage Side Drop Damage

Figure 6-34 – SC-30G3 18TU-04 Superficial Sidewall Damage

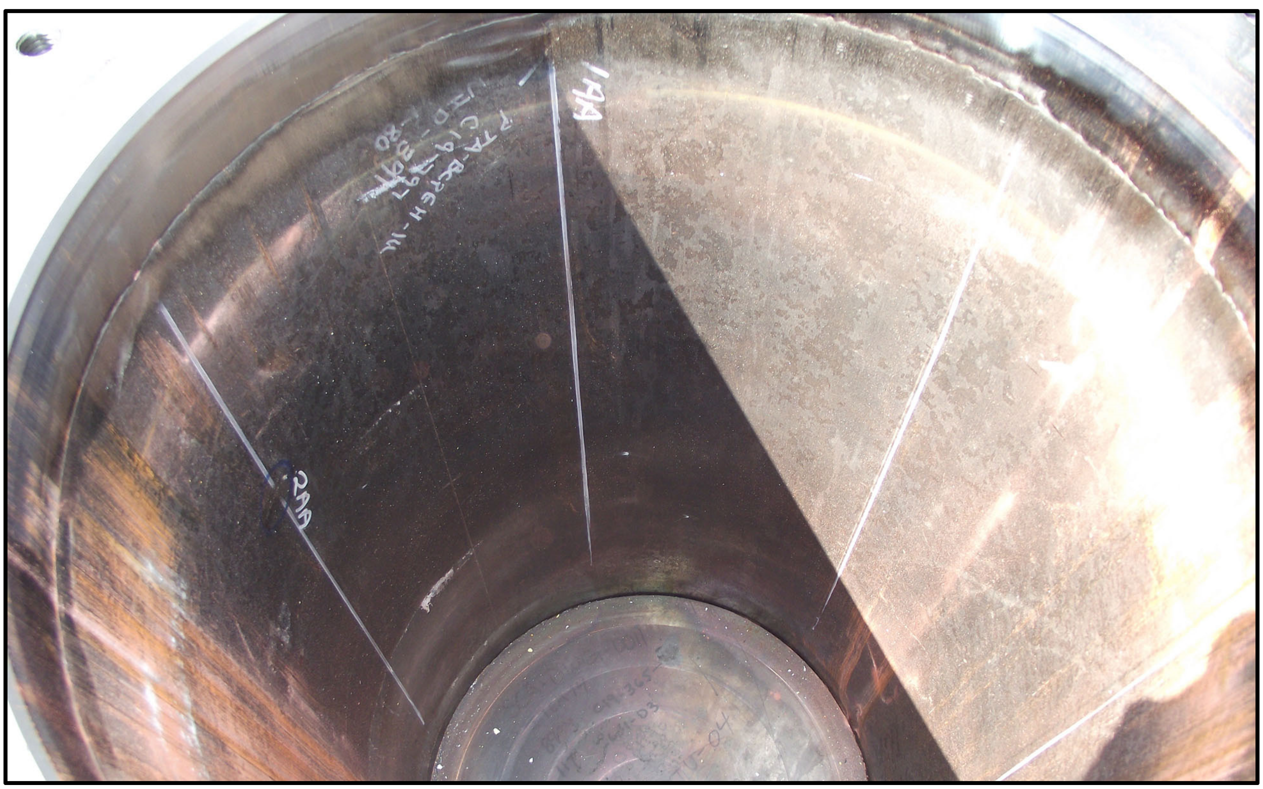

Figure 6-35 – SC-30G3 Interior 1

Figure 6-36 – SC-30G3 Interior 2

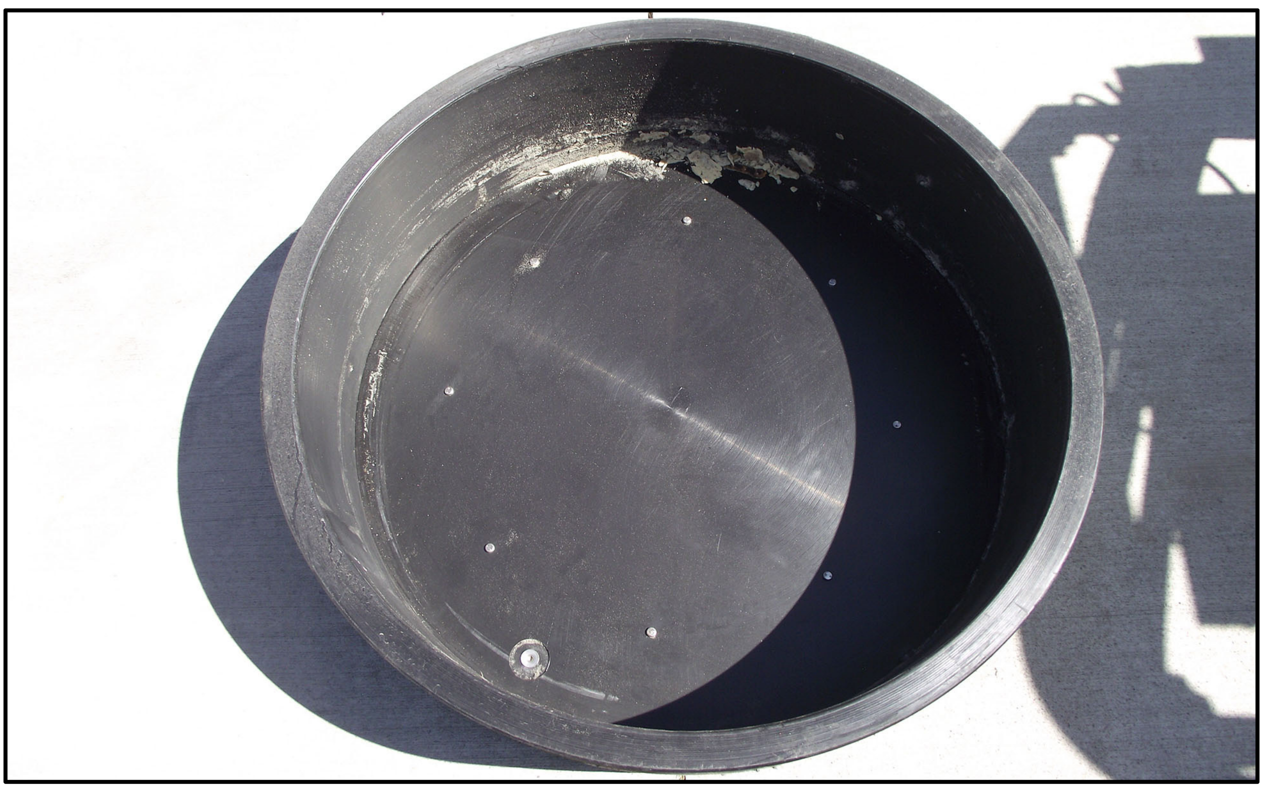

Figure 6-37 – SC-30G3 18TU-04 Lateral End Cap Localized Damage

Figure 6-38 – Fluorescein Dye inside the SC-30G3 Body

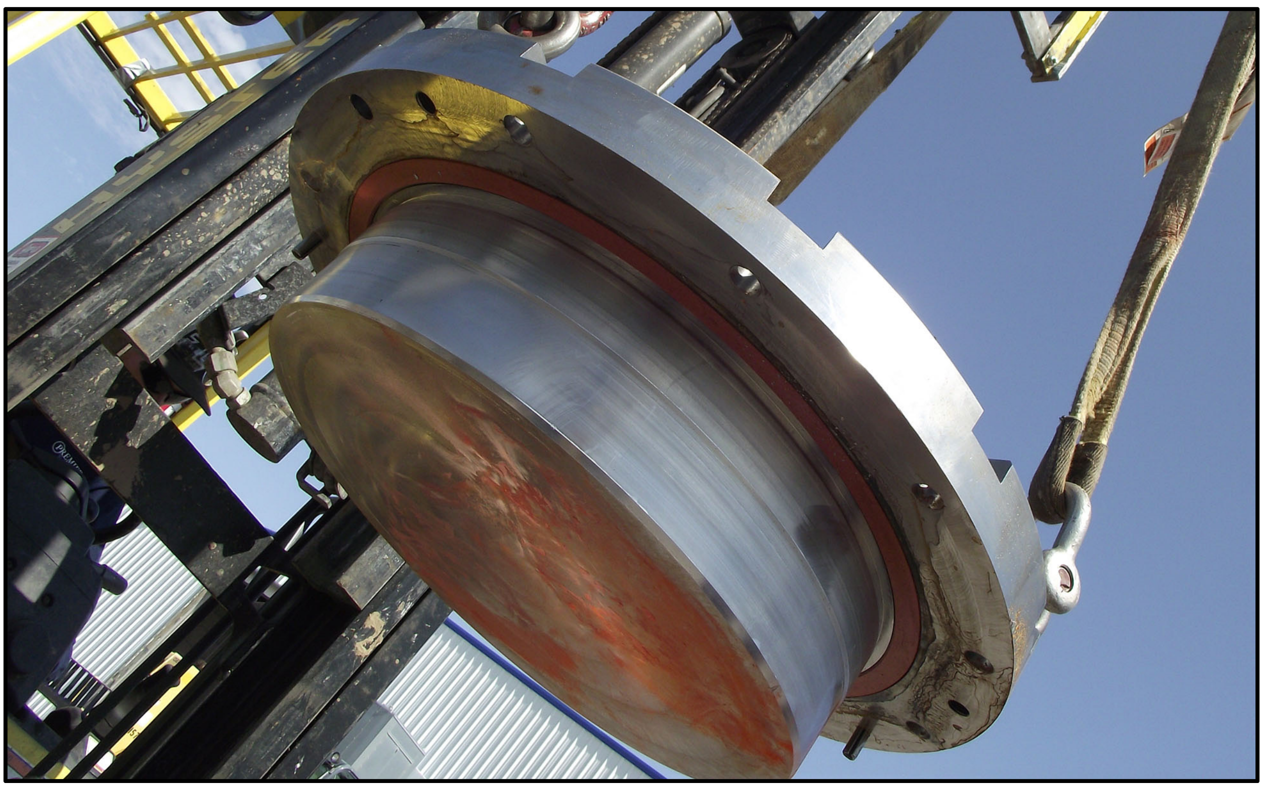

Figure 6-39 – Fluorescein Dye under the SC-30G3 Lid

6.3 SC-30G3 Shielding Integrity Testing

Pre- and post-drop shielding integrity testing of SC-30G3 18TU-04 involved the use of a Ludlum Model 3000 survey meter in conjunction with a Ludlum 44-10 two-inch diameter, sodium-iodide scintillator. A 39.5-curie Iridium-192 source was used for the pre-drop survey, and a 29.8-curie Iridium-192 source was used for the post-drop survey; the pre- and post-drop survey comparison was done by normalizing the results based on source strength.

As shown in Figure 6-40 and Figure 6-42, a gridded overlay was used to facilitate measurement repeatability at the defined grid locations. The zero circumferential position was established at the outer shell's longitudinal seam weld and the zero axial position was set at the elevation of the inner surface of the base. Each axial row consisted of 60 sets of circumferential readings (A – BH), with 21 total axial rows (1.5 – 31.5). Survey measurements taken below the 1.5 level and above the 30.0 level are inconsistent and therefore ignored for three reasons:

1. The calibration standard was configured with prototypic sidewall steel shell and lead thicknesses; prototypic slant-wall calibration standards for the lower and upper flange regions, due to their complexity, were not used.
2. Unlike the post-drop test survey measurements, the lower flange lead plates were not present for the pre-drop test survey measurements, but were present for the post-drop test survey measurements. During the pre-test survey measurements, supplemental external shielding was necessary at the container's bottom flange due to the lead base plates not having yet been installed. The containers were placed on a 2-inch thick lead plate and the bottom flange was wrapped with lead sheet to facilitate this extra shielding. This configuration was repeated for the post-test survey measurements in an effort to achieve a direct comparison. The use of this lead wrap required hand-held measurements of the lowest elevation (1.5) for each container.
3. The test lid was not prototypic because it did not include the lead/steel composition of the designed lid. The gamma scan lid consisted of a circular steel plate with a hole through the center. Varying thicknesses of lead plates (ranging from 0 to 4½ inches) were added to the inside of the lid to represent the lead for each design. Space between the container shell and inside lead was present due to the lid steel plate being used for each different design. Scatter due to the configuration of the test lid/container interface was observed which affected readings of the top few rows.

The purpose of the shielding integrity testing was to evaluate any potential reduction in shielding effectiveness of the steel and lead composite body shielding resulting from the HAC drop tests. A shielding effectiveness change map was generated for each of the units by calculating the percent difference in measured dose rate at each grid location for the pre- and post-drop readings with a 20% change threshold selected to prompt further evaluation. Figure 6-41 illustrates the pre-and post-drop test percent difference in measured dose rate for SC-30G3 18TU-04. As can be seen in Figure 6-41, a few locations at the lower axial and upper axial elevations show a percent difference that nears a 20% increase or reduction in shielding effectiveness, with all remaining grid locations indicating no appreciable change resulting from the drop events. Therefore, shielding integrity testing indicates that no demonstrable change in shielding occurred resulting from HAC drop testing.

To supplement the shield integrity testing and validate the above conclusions, saw-cuts were made through SC-30G3 18TU-04. Due to the size limitation of the saw, the test unit was first cut in half axially, and then each half cut in half longitudinally (see Figure 6-43). The primary longitudinal cut was made through the C-AH circumferential location where the maximum decrease of 18.4% was indicated at the upper flange region (see Figure 6-44, Figure 6-45, Figure 6-46, and Figure 6-47), and a secondary longitudinal cut was made between the AD/AE circumferential locations where a decrease of 14.0% was indicated near the lower flange region (see Figure 6-48 and Figure 6-49). As can be seen in these figures, lead slump did not occur at either end. However, as shown in Figure 6-46 and Figure 6-48, a measureable 0.084-inch axial gap is visible at the upper step in the lower flange that is attributable to the lead pour process control (termed a "cold shut", i.e., premature lead solidification near the vent/fill port during the lead pour process). Regardless, the deep-set ends of the sidewall lead column, both at the lower-flange and upper flange regions, make small axial gaps inconsequential. A detailed MCNP shielding model of the SC-30G3 was used to determine the effect of axial gaps present at the ends of the sidewall lead column. Using the baseline design radionuclide Cesium-137 in a uniformly distributed source geometry, an MCNP evaluation determined that the lower and upper flange axial gaps would have to exceed 0.35 and 0.20 inches, respectively, before the SC-30G3 surface dose at the axial gaps would become dominant; however, the effect of these axial gaps on dose rates at the HalfPACT package surface and 2-meters from the surface would be negligible.

With reference to Figure 6-40, Table 6-3 presents lead thickness measurements taken at locations along the length of the three axial slices and compare reasonably well with the pre-lead pour minimum lead gap requirement of 2.75 inches. As shown, post-drop test lead thicknesses significantly exceed the 2.48-inch thickness assumed for the HAC shielding analyses in all locations. Further, it is observed that the small variations in lead thickness observed along the length and at varying circumferential positions identified post-test most likely reflect the state of the lead at pre-test conditions as opposed to changes resulting from free drop testing. In any event, the observed variations in gamma scan readings taken at the ends of the shielded container before and after free drop are of no significance relative to the shielding capabilities of the design.

Table 6-3 – SC-30G3 18TU-04 Sidewall Lead Thickness Measurements

Axial Elevation	Sidewall Lead Thickness (in)		
	Cut Edge C	Cut Edge AH	Cut Edge AD/AE
33.0	2.78	2.77	2.78
31.5	2.78	2.77	2.78
30.0	2.77	2.77	2.78
28.5	2.77	2.77	2.80
27.0	2.75	2.77	2.80
25.5	2.76	2.78	2.80
24.0	2.76	2.78	2.80
22.5	2.76	2.77	2.81
21.0	2.77	2.78	2.79
19.5	2.75	2.78	2.79
18.0	2.75	2.78	2.78
16.5	2.75	2.79	2.75
15.0	2.75	2.79	2.76
13.5	2.75	2.78	2.76
12.0	2.76	2.77	2.74
10.5	2.76	2.75	2.73
9.0	2.76	2.75	2.73
7.5	2.76	2.77	2.73
6.0	2.76	2.80	2.73
4.5	2.76	2.80	2.73
3.0	2.76	2.82	2.71
1.5	2.77	2.79	2.78

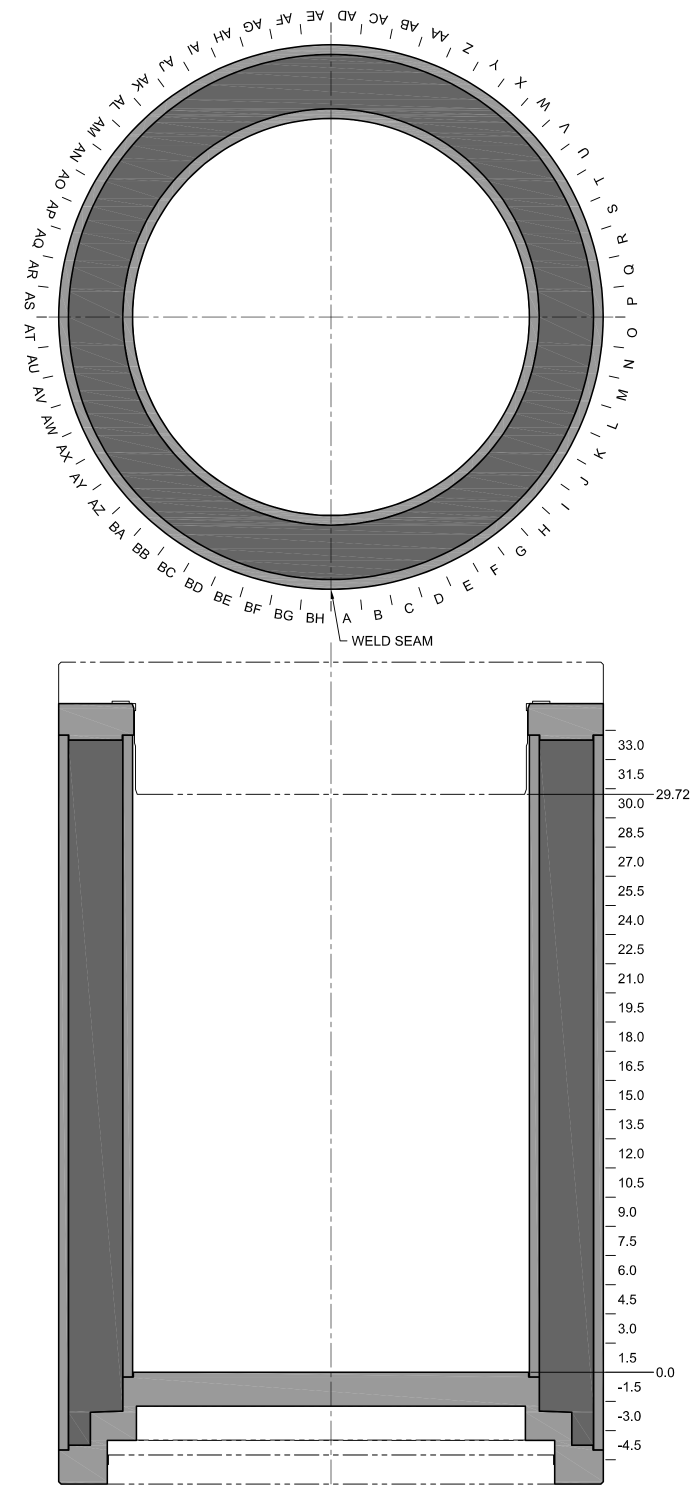

Figure 6-40 – Circumferential and Axial Scan Grid Map

SC-30G3 TU18-04 (HAC) Post Drop Shielding Evaluation; a Negative Number Indicates a Loss of Shielding																						
		Axial Elevation																				
		1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5	27.0	28.5	30.0	31.5
Circumferential Grid Identifier A		2.9%	3.9%	3.2%	1.8%	1.1%	0.0%	1.2%	1.5%	2.1%	0.7%	0.3%	0.2%	-0.2%	-0.6%	0.9%	-0.2%	0.2%	-1.2%	-4.8%	-2.4%	6.1%
B		4.6%	3.1%	2.7%	1.0%	0.3%	0.9%	0.4%	1.6%	0.9%	0.3%	0.3%	0.6%	1.4%	1.1%	1.4%	1.4%	1.3%	1.1%	2.6%	-9.2%	4.6%
C	CUT	10.0%	3.8%	2.6%	3.7%	3.3%	1.3%	0.9%	1.0%	1.4%	0.7%	1.0%	-0.3%	-1.6%	0.2%	1.8%	3.7%	1.4%	-3.0%	-6.1%	-18.4%	4.9%
D		6.9%	3.1%	1.7%	3.6%	2.0%	-0.1%	1.9%	0.8%	1.4%	0.0%	-0.5%	-0.8%	1.1%	-0.2%	1.3%	1.4%	0.0%	0.4%	0.6%	-7.4%	-0.8%
E		9.5%	1.7%	-0.3%	1.3%	4.9%	-0.4%	0.7%	-0.9%	-0.5%	0.0%	1.0%	-0.9%	-1.8%	-1.5%	0.1%	2.8%	0.4%	-1.7%	-5.7%	-10.2%	3.5%
F		2.9%	2.4%	0.8%	3.2%	1.7%	1.1%	0.8%	0.6%	0.1%	-0.1%	-0.5%	-1.6%	-0.7%	0.2%	1.2%	1.0%	-0.4%	-0.1%	0.7%	-5.4%	-2.9%
G		3.4%	3.2%	1.5%	3.0%	1.4%	-1.4%	-3.3%	-4.5%	-3.5%	-1.1%	-0.6%	-1.5%	-2.5%	-1.1%	-0.2%	-0.1%	-0.1%	-2.0%	-1.7%	-1.1%	-2.6%
H		-1.4%	3.0%	-5.2%	-0.7%	-1.6%	-0.9%	-1.0%	-0.6%	-0.9%	-2.0%	-1.9%	0.1%	0.4%	0.7%	0.4%	1.0%	1.1%	0.0%	1.7%	-1.0%	-6.5%
I		0.9%	1.4%	0.2%	-0.7%	-0.4%	-1.7%	-3.9%	-4.2%	-1.7%	1.6%	0.0%	-1.9%	-1.6%	-0.9%	-0.7%	-0.1%	-0.4%	-0.3%	-1.7%	-4.4%	-13.8%
J		1.8%	-0.1%	-0.4%	-0.7%	-0.9%	-1.2%	0.0%	-2.3%	-1.9%	-2.7%	-2.9%	-1.3%	-0.8%	0.6%	1.3%	-0.1%	0.5%	2.2%	1.5%	-2.1%	2.4%
K		0.8%	1.4%	-1.3%	0.2%	0.0%	-0.3%	-2.5%	-9.4%	-11.9%	-8.3%	1.7%	-0.3%	-0.6%	0.4%	0.8%	-0.2%	0.2%	-1.0%	-0.5%	-2.3%	1.2%
L		3.1%	0.2%	0.7%	-0.6%	-0.2%	-1.7%	-1.4%	-0.3%	1.2%	1.3%	-0.4%	-0.2%	0.1%	0.4%	-0.3%	0.6%	0.1%	-0.2%	1.6%	-1.8%	-10.0%
M		5.3%	0.7%	1.7%	1.2%	1.3%	-0.2%	1.3%	-1.3%	-4.3%	-2.7%	0.2%	0.4%	-2.3%	-0.8%	-0.2%	0.8%	0.8%	-1.7%	-1.7%	-2.6%	-4.2%
N		-1.5%	-0.9%	0.5%	0.3%	-0.3%	-0.3%	-2.4%	-2.2%	-0.7%	-0.2%	0.7%	0.7%	0.1%	0.2%	1.2%	0.5%	0.7%	0.8%	0.1%	0.6%	-1.8%
O		2.5%	0.6%	1.4%	1.4%	0.7%	-0.5%	0.3%	-0.1%	-1.2%	-1.5%	-0.1%	-0.1%	-0.9%	-0.8%	-0.7%	0.5%	1.8%	-2.0%	-3.3%	-4.2%	3.8%
P		5.8%	-5.4%	7.2%	7.9%	-0.9%	-0.4%	0.2%	4.0%	8.9%	8.9%	0.0%	3.3%	0.4%	0.3%	0.1%	0.6%	-0.5%	-2.5%	1.3%	-3.3%	-3.2%
Q		12.2%	0.6%	0.3%	0.5%	0.9%	0.6%	-2.3%	-0.8%	-0.8%	-0.5%	0.8%	-0.5%	-0.8%	-1.0%	0.1%	0.5%	1.0%	-3.4%	-2.0%	-5.7%	2.2%
R		0.5%	-6.9%	-1.7%	-1.3%	-1.4%	-2.8%	-1.0%	-0.4%	-0.1%	-0.9%	-1.6%	-1.2%	-0.9%	0.6%	-0.9%	-0.3%	-0.6%	-1.4%	1.1%	-2.5%	4.0%
S		-2.2%	-0.2%	0.0%	-1.0%	0.4%	-0.6%	-0.1%	0.3%	-0.2%	-0.2%	0.2%	-0.6%	-1.0%	-1.2%	-0.5%	0.9%	2.3%	-1.1%	-2.9%	-1.7%	1.5%
T		-3.1%	-1.9%	-0.9%	-1.1%	-2.6%	0.8%	-0.1%	-1.0%	-1.1%	-0.8%	-0.9%	-0.1%	2.0%	3.3%	1.4%	1.2%	-0.9%	-2.6%	0.3%	1.7%	-2.6%
U		-6.6%	-0.4%	2.3%	2.6%	-2.3%	-0.6%	-0.6%	0.2%	0.5%	0.8%	3.1%	0.8%	-2.6%	-2.2%	-1.6%	-1.0%	0.3%	-2.0%	-2.3%	-1.6%	-5.0%
V		-5.6%	-3.6%	-1.2%	-3.5%	-4.8%	-3.1%	1.1%	-0.8%	-1.6%	-1.2%	-1.2%	-1.0%	-2.5%	-1.7%	-1.0%	2.4%	0.4%	-0.5%	1.5%	0.3%	4.5%
W		-7.0%	-0.8%	0.0%	1.2%	-0.7%	0.0%	-2.5%	-2.3%	-0.2%	-0.2%	-0.6%	0.0%	0.0%	-1.1%	-3.3%	-1.2%	0.6%	-1.5%	-0.6%	-4.0%	-10.4%
X		-5.0%	-3.2%	-1.1%	0.2%	-0.8%	-2.2%	-1.0%	-0.1%	0.4%	0.2%	0.2%	0.3%	-1.5%	-2.7%	-2.3%	-0.5%	-0.9%	-1.6%	-0.6%	-1.1%	-8.8%
Y		-3.1%	0.8%	-0.6%	-0.6%	0.7%	-2.1%	-1.3%	-1.4%	-0.3%	-0.6%	0.1%	0.5%	0.7%	-0.8%	-1.6%	-0.2%	1.1%	0.2%	-1.1%	0.2%	0.4%
Z		-5.8%	-3.3%	-1.1%	-0.6%	-0.6%	-2.6%	-1.7%	-0.1%	1.9%	2.2%	2.1%	1.8%	0.3%	1.2%	1.4%	1.9%	1.6%	0.5%	2.0%	0.5%	3.5%
AA		-5.8%	0.8%	-1.4%	0.0%	3.7%	2.2%	-2.4%	-4.5%	-0.6%	-1.4%	-3.6%	0.7%	1.7%	-1.6%	-1.1%	4.8%	3.1%	1.7%	-2.1%	-0.4%	-2.3%
AB		-2.3%	-1.4%	0.5%	1.7%	1.3%	1.7%	1.5%	1.7%	1.7%	1.2%	1.7%	1.2%	0.2%	0.8%	1.8%	0.1%	0.6%	1.4%	1.8%	2.9%	-6.3%
AC		-4.9%	-1.7%	-0.1%	-1.1%	-0.9%	-0.6%	0.2%	-0.2%	0.2%	-0.8%	-1.4%	-0.2%	0.4%	-0.6%	1.1%	0.6%	-0.8%	0.0%	-1.2%	4.1%	-3.0%
AD	CUT	-11.5%	-3.2%	0.3%	0.2%	-0.6%	-1.3%	-2.4%	-1.2%	-1.7%	-1.6%	-1.1%	-1.1%	-3.4%	-0.9%	-2.0%	-1.0%	-2.4%	-0.7%	0.2%	2.2%	-8.7%
AE	CUT	-14.0%	-0.2%	3.3%	-1.2%	-2.3%	-3.2%	-4.5%	-3.7%	-1.5%	-1.0%	-1.0%	-1.7%	-0.7%	-0.7%	1.4%	0.2%	1.4%	1.1%	-0.3%	0.9%	-2.6%
AF		-12.3%	-7.8%	-5.2%	-0.8%	-2.6%	-3.5%	-5.1%	-3.9%	0.2%	0.7%	-1.0%	-2.0%	-1.6%	-1.7%	-1.4%	-1.2%	-0.8%	-0.2%	-0.4%	2.8%	-2.8%
AG		-8.5%	0.9%	-0.9%	-0.8%	-2.1%	-2.9%	-2.0%	-2.8%	-2.7%	-1.3%	-0.7%	-2.6%	-2.4%	-3.2%	1.0%	-0.3%	-0.1%	-0.2%	-0.6%	-2.8%	0.8%
AH	CUT	-11.0%	-5.2%	-5.1%	-4.5%	-3.1%	-1.3%	1.3%	-1.6%	-0.2%	0.0%	0.6%	-1.0%	-3.9%	-4.1%	-3.1%	-1.5%	-1.3%	-1.1%	0.1%	3.6%	-2.0%
AI		-10.2%	-1.1%	-1.5%	-0.3%	-1.9%	-1.1%	-1.7%	-1.0%	-0.8%	0.3%	0.0%	-0.3%	-1.7%	-1.3%	-2.7%	-0.2%	-1.2%	-1.5%	-3.0%	-0.5%	-2.3%
AJ		-12.8%	-6.0%	-4.0%	-2.1%	-2.0%	-2.6%	-0.9%	-1.3%	-0.9%	-1.7%	-2.0%	-0.3%	-2.2%	-3.4%	-3.1%	-1.0%	-1.6%	-0.9%	0.5%	1.8%	6.6%
AK		-9.8%	0.3%	-0.3%	-1.4%	0.4%	-0.5%	0.2%	0.5%	0.1%	0.3%	-0.6%	-1.5%	-0.9%	-0.7%	-1.0%	0.3%	-0.5%	-1.8%	-4.5%	4.2%	2.2%
AL		-10.3%	-5.0%	-1.7%	-3.0%	-2.5%	-2.0%	-0.4%	-1.4%	-1.2%	-1.3%	-0.6%	-0.7%	-1.1%	-1.6%	0.3%	-0.6%	-0.5%	-1.9%	0.0%	3.1%	1.0%
AM		-10.0%	-0.9%	-0.4%	1.5%	0.3%	0.0%	1.1%	0.3%	0.4%	-0.1%	0.2%	0.6%	0.5%	-0.1%	0.3%	-0.1%	1.0%	-0.5%	-2.3%	3.5%	4.1%
AN		-8.9%	-4.3%	-2.1%	-1.6%	-2.3%	-0.8%	0.0%	-1.4%	-1.7%	-0.7%	-0.8%	-1.2%	-1.3%	-0.7%	0.0%	0.0%	-0.5%	-0.2%	0.4%	5.2%	5.2%
AO		-8.4%	-0.4%	-0.3%	0.6%	0.2%	0.1%	0.1%	-0.1%	0.6%	0.1%	-0.5%	0.7%	0.2%	-1.2%	-1.4%	-0.9%	0.2%	-0.6%	-1.6%	6.2%	11.6%
AP		-9.0%	-6.0%	-1.3%	-0.6%	-0.6%	-1.8%	-1.2%	-0.1%	-1.5%	-0.8%	-0.1%	-0.7%	-1.9%	-1.2%	0.7%	0.1%	0.2%	-0.4%	0.5%	9.5%	6.0%
AQ		-7.9%	0.3%	1.9%	3.0%	3.1%	1.1%	-0.1%	0.0%	1.2%	2.0%	1.2%	0.7%	-0.7%	-2.2%	-2.0%	-0.7%	-0.7%	-0.3%	-1.7%	3.8%	7.9%
AR		-8.8%	-3.2%	0.9%	3.0%	0.0%	-0.3%	2.0%	0.8%	-5.1%	-1.9%	-1.5%	-1.3%	-0.6%	-0.5%	-0.7%	-0.2%	-0.6%	0.5%	0.5%	3.8%	6.8%
AS		-10.4%	-0.4%	0.0%	-0.6%	-0.5%	-0.6%	-0.1%	0.3%	-0.2%	-1.7%	-2.5%	-2.3%	-1.5%	-1.5%	-1.0%	-1.0%	-0.7%	-0.8%	-3.1%	1.6%	13.9%
AT		-8.0%	-5.6%	-3.6%	-0.2%	-1.4%	-0.9%	-1.3%	-4.4%	-2.7%	-2.6%	-1.5%	-0.5%	-0.9%	-1.6%	-0.4%	-1.6%	-0.9%	-1.5%	0.0%	1.4%	12.9%
AU		-9.0%	-1.0%	-0.7%	-1.7%	-1.4%	-1.4%	-0.4%	0.2%	-1.1%	-1.6%	-2.7%	-2.0%	-1.5%	-2.2%	-0.6%	-1.4%	-0.7%	0.0%	-2.9%	0.1%	14.3%
AV		-5.5%	-2.2%	-2.9%	-0.3%	-1.7%	-2.6%	-1.4%	-1.6%	-2.2%	-0.8%	-1.4%	-1.5%	-0.4%	-1.1%	-0.7%	-2.2%	-1.8%	-2.0%	-1.8%	0.5%	11.2%
AW		-2.7%	-1.7%	0.3%	1.7%	-0.2%	-1.2%	-2.4%	-1.9%	-2.5%	-1.6%	-1.5%	-0.7%	-1.1%	-2.2%	-1.4%	-0.6%	-1.0%	-0.8%	-3.3%	-4.9%	10.1%
AX		-7.0%	-3.3%	-4.3%	-3.8%	-1.3%	-0.5%	-1.2%	0.3%	0.1%	-0.6%	-1.7%	-2.2%	-2.5%	-0.7%	0.1%	-0.6%	-1.4%	-1.0%	-2.3%	-1.8%	15.0%
AY		-5.2%	1.7%	1.3%	-1.0%	-1.4%	-2.4%	-2.5%	-1.3%	-1.1%	-0.5%	-1.2%	-0.9%	-1.4%	-1.7%	-2.5%	-1.9%	-1.9%	-0.8%	-1.7%	-14.7%	13.2%
AZ		-7.7%	-2.6%	-7.4%	-12.6%	-5.0%	-3.1%	0.3%	0.9%	1.2%	-0.8%	-0.8%	-0.8%	-1.7%	-1.2%	-1.2%	-0.8%	-0.7%	-1.5%	-1.3%	-2.9%	18.4%
BA		-1.8%	1.6%	1.8%	0.3%	-0.3%	10.5%	-0.6%	-1.3%	-1.7%	-2.3%	-2.6%	-1.3%	-0.9%	0.2%	-0.6%	0.1%	-1.3%	-1.3%	-2.4%	-3.0%	9.7%
BB		-3.2%	0.5%	-3.1%	-1.5%	-1.2%	-3.7%	-2.4%	-0.6%	-0.9%	-1.0%	-0.4%	0.0%	-1.8%	-2.1%	-2.5%	-1.1%	-1.0%	-0.7%	0.3%	-0.2%	9.1%
BC		0.1%	3.4%	2.3%	1.9%	1.8%	0.1%	-0.2%	-0.7%	-1.3%	-0.3%	0.5%	0.4%	0.2%	-0.6%	-2.0%	-0.7%	-1.5%	-1.8%	-3.2%	-1.8%	7.0%
BD		2.0%	1.3%	1.8%	2.5%	1.3%	0.9%	0.3%	-1.5%	-0.8%	0.2%	0.9%	0.1%	0.0%	0.0%	-1.4%	-1.9%	-1.9%	-1.5%	-1.0%	-2.2%	15.0%
BE		0.6%	4.2%	0.0%	0.4%	2.7%	2.1%	1.0%	1.2%	1.3%	1.2%	0.9%	0.1%	0.4%	-1.0%	-0.3%	-1.1%	-0.8%	-1.5%	-3.4%	-4.6%	18.8%
BF		-1.5%	-1.4%	-3.1%	-0.4%	0.9%	0.8%	-0.5%	-0.4%	0.6%	-1.1%	0.3%	0.0%	0.1%	0.4%	0.2%	-1.2%	-1.6%	-0.8%	-1.5%	-1.2%	12.8%
BG		0.1%	2.3%	-1.2%	-1.8%	-1.9%	-0.6%	-0.7%	-0.1%	-1.1%	-0.1%	-0.9%	-1.3%	-1.7%	-1.9%	-0.9%	-1.6%	-1.5%	-2.7%	-4.1%	-4.8%	10.5%
BH		-4.3%	-3.2%	-5.1%	-5.8%	-1.9%	2.2%	-3.1%	-2.8%	-3.6%	-3.2%	-2.9%	-2.4%	-1.9%	-2.7%	-1.6%	-1.9%	-1.8%	-2.1%	-4.6%	-4.1%	4.9%
MAX		12.2%	3.9%	7.2%	7.9%	4.9%	2.2%	2.0%	4.0%	8.9%	8.9%	3.1%	3.3%	2.0%	3.3%	1.8%	4.8%	3.1%	2.2%	2.6%	9.5%	18.4%
MIN		-14.0%	-7.8%	-7.4%	-12.6%	-5.0%	-3.5%	-5.1%	-9.4%	-11.9%	-8.3%	-3.6%	-2.6%	-3.9%	-4.1%	-3.3%	-2.2%	-2.4%	-3.4%	-6.1%	-18.4%	-13.8%
AVG		-3.6%	-1.1%	-0.4%	-0.1%	-0.4%	-0.9%	-0.8%	-1.0%	-0.6%	-0.5%	-0.5%	-0.5%	-0.9%	-0.9%	-0.4%	0.1%	0.0%	-0.7%	-1.0%	-1.1%	3.1%

Figure 6-41 – SC-30G3 Pre-Drop/Post-Drop Dose Rate Change Comparison

Figure 6-42 – SC-30G3 Gamma Scan Configuration

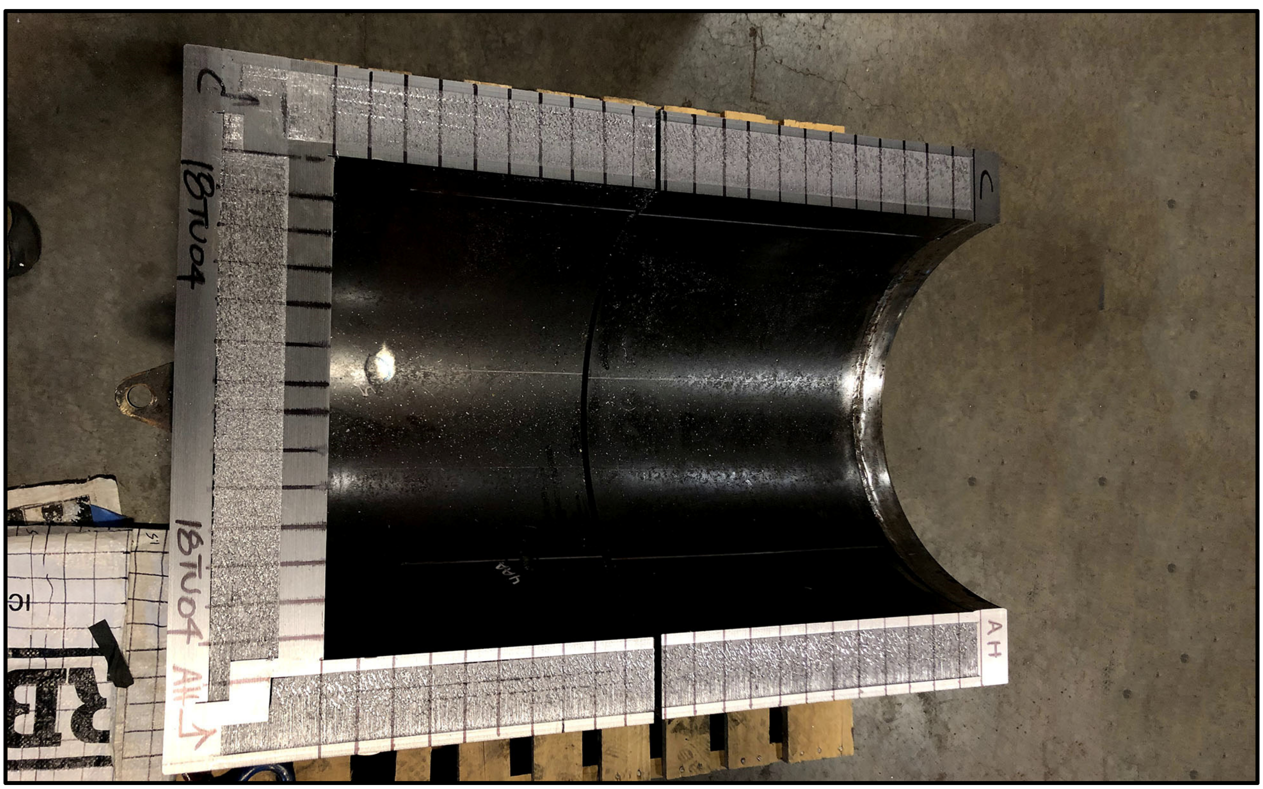

Figure 6-43 – SC-30G3 18TU-04 Destructive Disassembly Overview

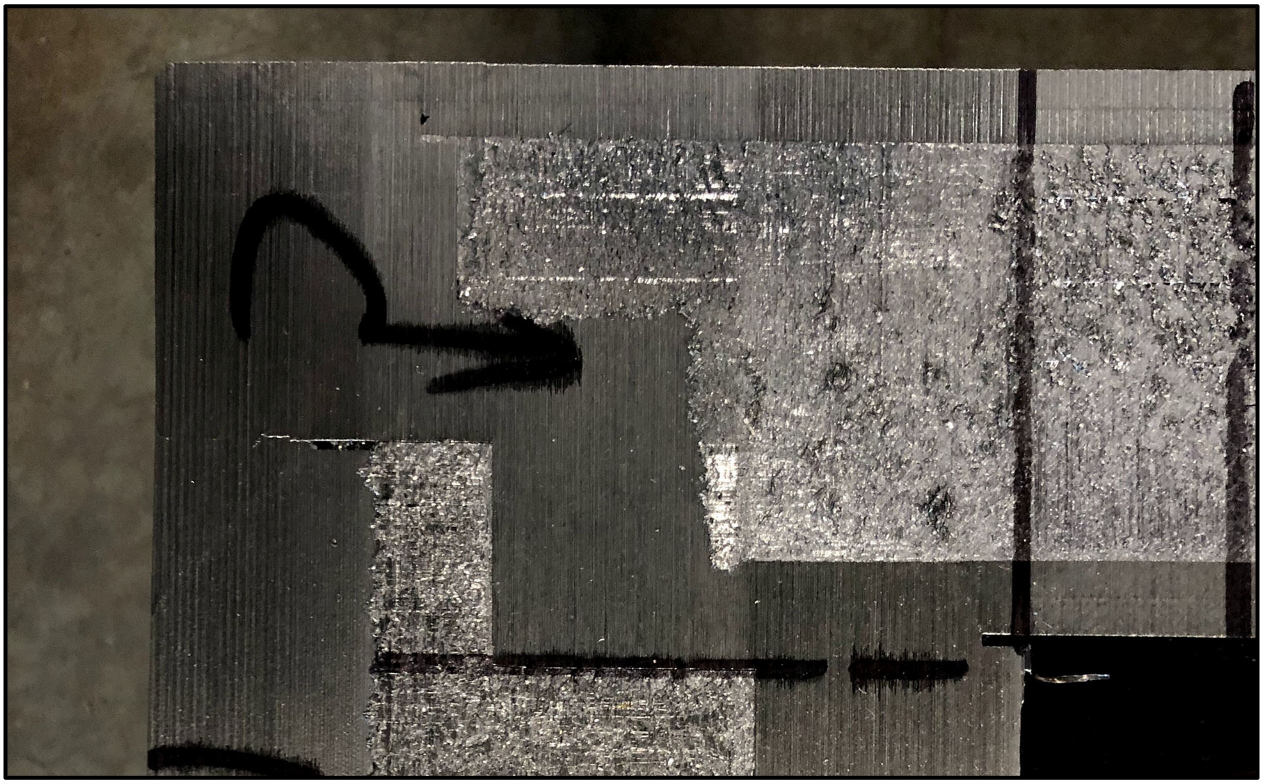

Figure 6-44 – SC-30G3 18TU-04 Destructive Disassembly Cut C at Lower Flange

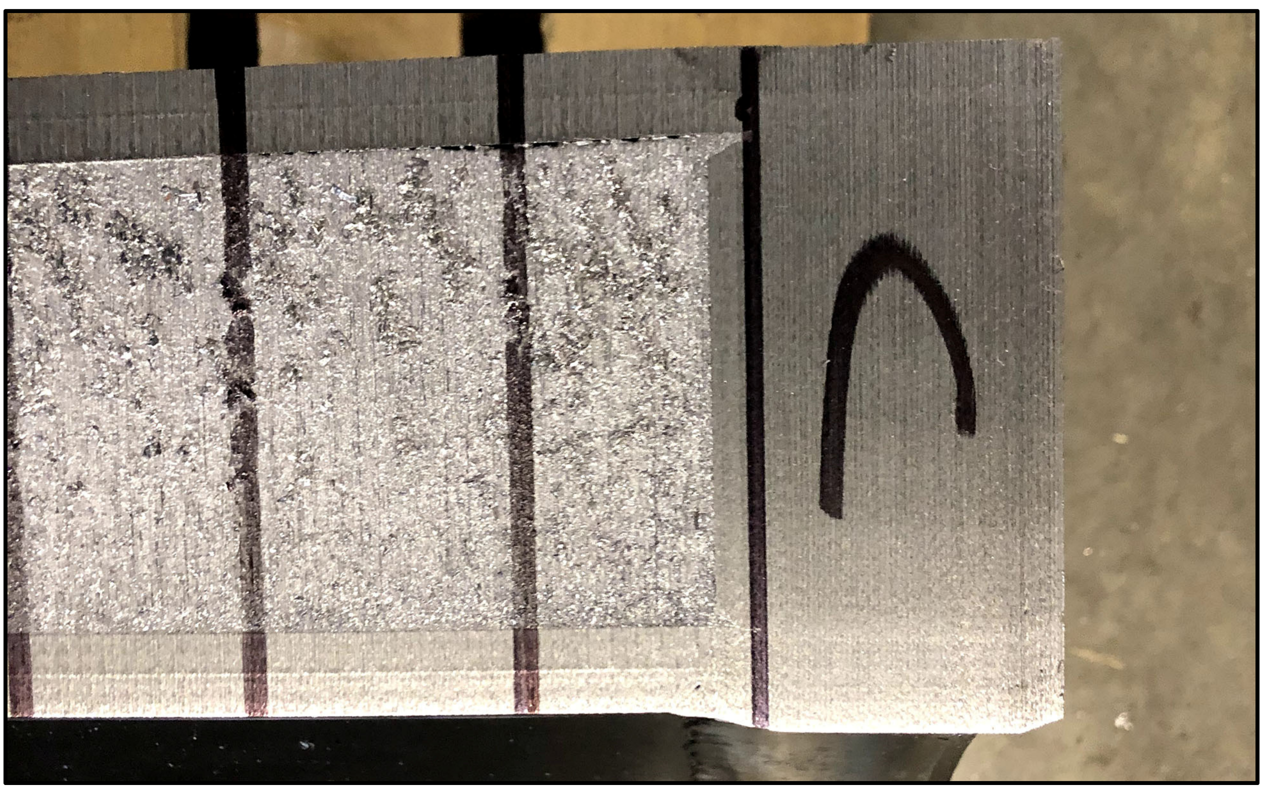

Figure 6-45 – SC-30G3 18TU-04 Destructive Disassembly Cut C at Upper Flange

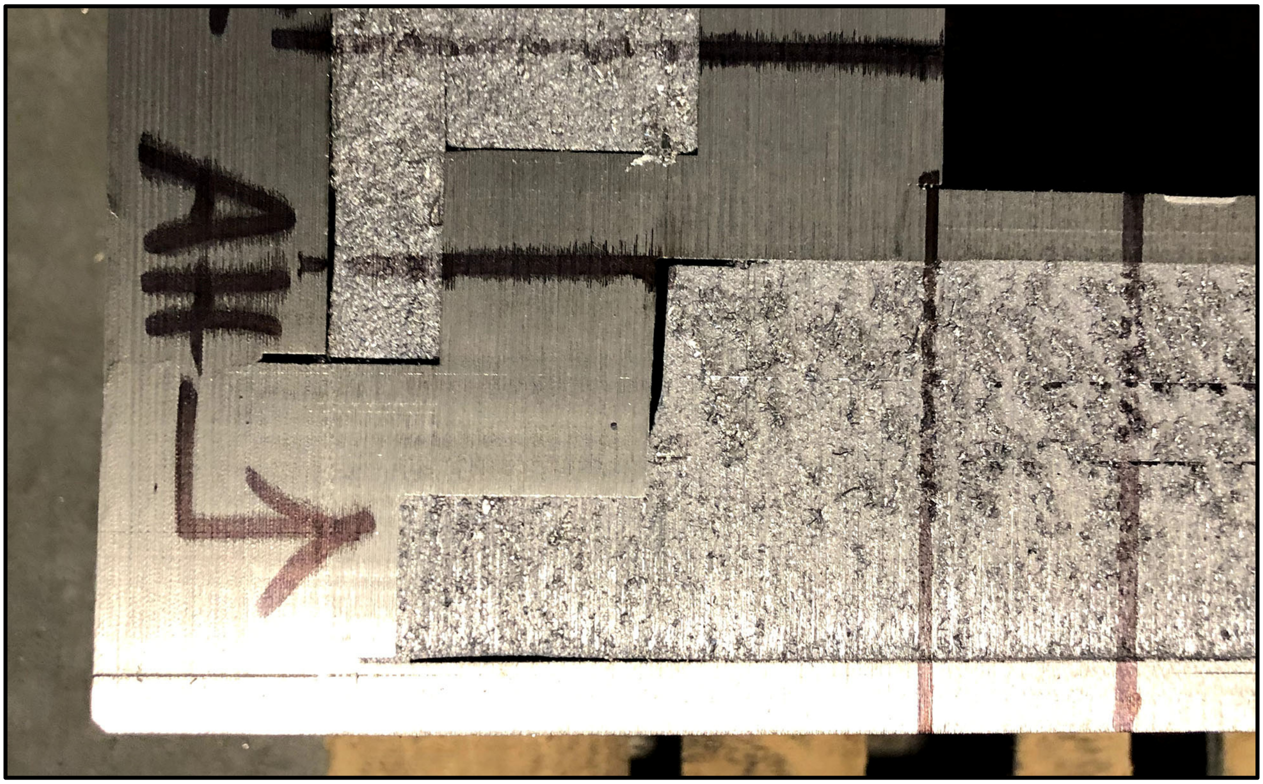

Figure 6-46 – SC-30G3 18TU-04 Destructive Disassembly Cut AH at Lower Flange

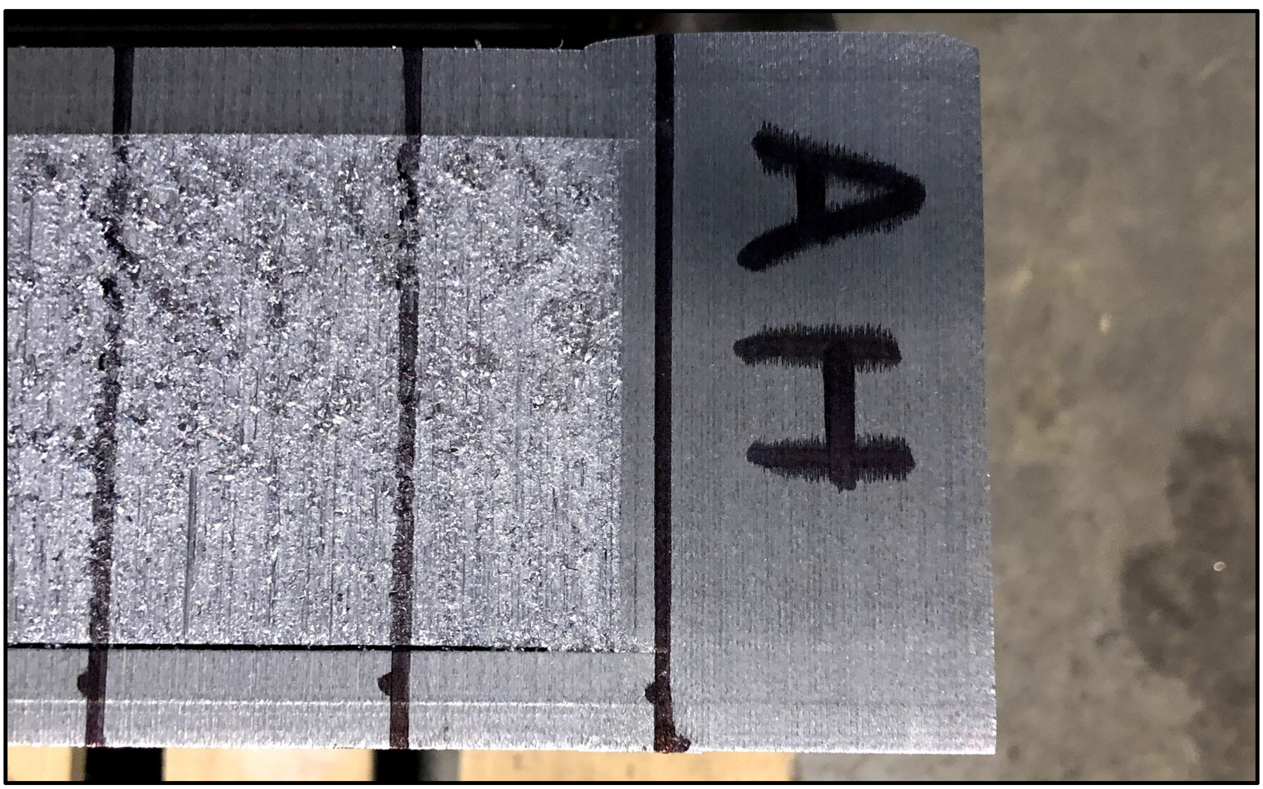

Figure 6-47 – SC-30G3 18TU-04 Destructive Disassembly Cut AH at Upper Flange

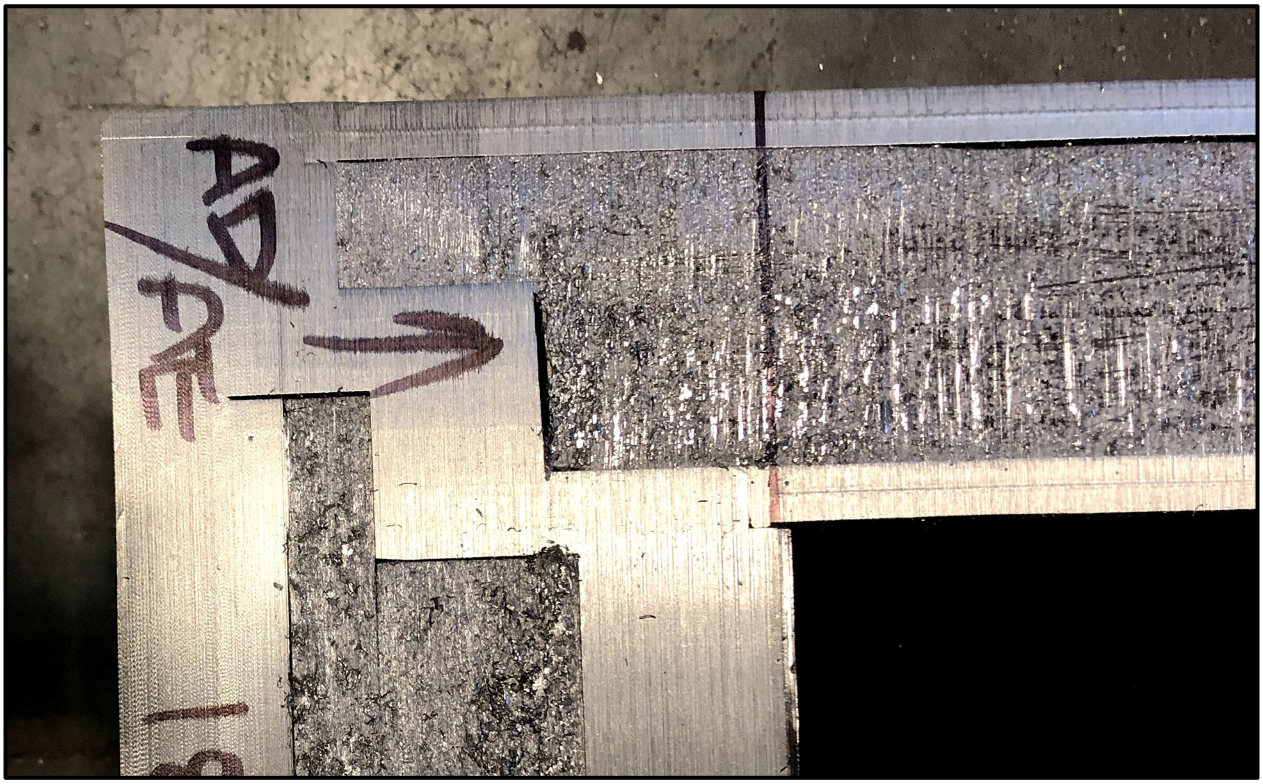

Figure 6-48 – SC-30G3 18TU-04 Destructive Disassembly Cut AD/AE at Lower Flange

Figure 6-49 – SC-30G3 18TU-04 Destructive Disassembly Cut AD/AE at Upper Flange

7.0 SC-30G2 AND SC-55G2 SHIELDED CONTAINERS

7.1 Methodology for Qualification

As stated in Section 5.1, *Justification for the Tested Configurations*, Type B HAC drop tests were not performed for the SC-30G2 and SC-55G2 designs. Rather, the Type B HAC drop test performance results for the SC-55G1 and SC-30G3 designs, their protective dunnages, heavy-duty pallet, and ICV aluminum honeycomb end spacers, in conjunction with the robustness tests as a result of unprotected (bare) 4-foot free drops will be used as the basis for demonstrating Type B HAC compliance for the SC-30G2 and SC-55G2 designs.

As with the Type B HAC tests, fluorescein dye powder was mixed with dry flour and placed within each SC-30G2 and SC-55G2 test unit as a means for determining whether confinement integrity was compromised. Fluorescein dye, when activated by water, fluoresces yellow-green in both the ultraviolet and visible light spectrum.

7.1.1 SC-30G3 Impact Acceleration Comparison

The SC-30G3 will be used for direct comparison of 30-foot protected versus 4-foot unprotected bottom and side drops. Informally, an information-only uniaxial accelerometer was installed on SC-30G3 18TU-04 (the test unit used for Type B HAC drop testing). The measured acceleration of 18TU-04 was 186*g* for the HAC end drop (which was a side-oriented drop for the SC-30G3), and the measured acceleration of 18TU-04 was 160*g* for the HAC side drop (which was a center-of-gravity over corner drop for the SC-30G3). The corresponding measured side drop acceleration of SC-30G3 18TU-03 for the 4-foot drop exceeded 500*g* (the range limit of the accelerometer), and the measured center-of-gravity over corner drop acceleration of SC-30G3 18TU-05 for the 4-foot drop was 338*g*. In both cases, the unprotected 4-foot free drop accelerations were more than twice the protected (via dunnage, pallet, and ICV end spacers) 30-foot free drop accelerations for the Type B HAC tests. Therefore, test results from the 4-foot drop tests may be considered bounding for the SC-30G2 and SC-55G2 Type B HAC evaluations.

7.1.2 SC-30G2 Type B HAC Evaluation

7.1.2.1 Confinement Integrity Testing

Two SC-30G2 test units, 18TU-01 and 18TU-02, were subjected to a series of 4-foot drop tests. 18TU-01 was dropped in two orientations: a center-of-gravity over bottom corner drop and a bottom-down vertical end drop. 18TU-02 was also dropped in two orientations: a 10º near-vertical top-down drop and horizontal side drop. As shown in Figure 7-1 and Figure 7-2, vertical end drop damage to SC-30G2 18TU-01 was modest. Side drop damage to SC-30G2 18TU-02, as shown in Figure 7-3 and Figure 7-4, was a localized 2-inch wide, 0.034-inch deep flat along the length of the container. In contrast, with reference to Figure 6-17 and Figure 6-18, damage to SC-55G1 18TU-07 and 18TU-08 from the HAC drop testing shows significantly less localized damage thereby confirming the conservatism of using results from the unprotected 4-foot drop tests of the SC-30G2s.

Subsequent ultraviolet scanning revealed no fluorescein dye on the SC-30G2 18TU-01 and 18TU-02 exteriors indicating that confinement integrity was maintained.

Figure 7-1 – SC-30G2 18TU-01 Vertical End Drop

Figure 7-2 – SC-30G2 18TU-01 Vertical End Drop Damage

Figure 7-3 – SC-30G2 18TU-02 Horizontal Side Drop Base-End Damage

Figure 7-4 – SC-30G2 18TU-02 Horizontal Side Drop Lid-End Damage

7.1.2.2 Shielding Integrity Testing

As previously discussed in Section 6.3, *SC-30G3 Shielding Integrity Testing*, pre- and post-drop shielding integrity testing involved the use of a Ludlum Model 3000 survey meter in conjunction with a Ludlum 44-10 two-inch diameter, sodium-iodide scintillator. A 0.0026-curie Cobalt-60 source was used for the pre-drop survey, and a 0.0024-curie Cobalt-60 source was used for the post-drop survey; the pre- and post-drop survey comparison was done by normalizing the results based on source strength.

As depicted in Figure 6-42 and Figure 7-5, a gridded overlay was used to facilitate measurement repeatability at the defined grid locations. The zero circumferential position was established at the outer shell's longitudinal seam weld and the zero axial position was set at the elevation of the inner surface of the base. Each axial row consisted of 52 sets of circumferential readings (A – AZ), with 20 total axial rows (1.5 – 30.0). Therefore, for the reasons stated earlier, survey measurements taken below the 1.5 level and above the 30.0 level are inconsistent and correspondingly ignored.

The purpose of the shielding integrity testing was to evaluate any potential reduction in shielding effectiveness of the steel and lead composite body shielding resulting from the bare 4-foot drop tests that bound the 30-foot drop tests within the HalfPACT package. A shielding effectiveness change map was generated for each of the units by calculating the percent difference in measured dose rate at each grid location for the pre- and post-drop readings with a 20% change threshold selected to prompt further evaluation. Figure 7-6 and Figure 7-7 illustrate the pre-and post-drop test percent difference in measured dose rate for SC-30G2 18TU-01 and 18TU-02, respectively. As can be seen in Figure 7-6 and Figure 7-7, a few locations at the lower axial and upper axial elevations show a percent difference that nears a 20% increase or reduction in shielding effectiveness, with all remaining grid locations indicating no appreciable change resulting from the drop events. Therefore, shielding integrity testing indicates that no demonstrable change in shielding occurred resulting from HAC drop testing.

To supplement the shield integrity testing and validate the above conclusions, saw-cuts were made through SC-30G2 18TU-01 and 18TU-02. Due to the size limitation of the saw, the test unit was first cut in half axially, and then each half cut in half longitudinally (see Figure 7-8 for 18TU-01 and Figure 7-13 for 18TU-02).

With respect to 18TU-01, a single longitudinal cut was made through the A-AA circumferential location (see Figure 7-9, Figure 7-10, Figure 7-11, and Figure 7-12). As can be seen in these figures, lead slump did not occur at either end, even though 18TU-01 was subjected to the most severe vertical end drop.

With respect to 18TU-02, a primary longitudinal cut was made between the T/U-AT/AU circumferential location which corresponds to the impact point for the 10º near-vertical top-down drop and horizontal side drop (see Figure 7-14, Figure 7-15, Figure 7-16, Figure 7-17, and Figure 7-18), and a secondary longitudinal cut was made through the A-AA circumferential location where a decrease of 17.0% was indicated near the upper flange region (see Figure 7-19 and Figure 7-20). As shown in Figure 7-14 and Figure 7-16, a measureable 0.10-inch axial gap is visible at the upper step and a 0.06-inch axial gap at the lower step of the lower flange region that may be attributed to a cold shut during the lead pour process. This conclusion, and not lead slump, is appropriate because lead slump did not occur for 18TU-01 with its significantly more severe vertical end drop. Regardless, the deep-set ends of the sidewall lead column, both at the lower-flange and upper flange regions, make small axial gaps inconsequential. A detailed MCNP shielding model of the SC-30G2 was used to determine the effect of axial gaps present at the ends of the sidewall lead column. Using the baseline design radionuclide Cesium-137 in a uniformly distributed source geometry, an MCNP evaluation determined that the lower and upper flange axial gaps would have to exceed 0.32 and 0.16 inches, respectively, before the SC-30G2 surface dose at the axial gaps would become dominant; however, the effect of these axial gaps on dose rates at the HalfPACT package surface and 2-meters from the surface would be negligible.

With reference to Figure 7-5, Table 7-1 presents lead thickness measurements taken at locations along the length of the two axial slices for 18TU-01 and three axial slices for 18TU-02. As shown, post-drop test lead thicknesses significantly exceed the 1.26-inch thickness assumed for the HAC shielding analyses in all locations.

Table 7-1 – SC-30G2 18TU-01 and 18TU-02 Sidewall Lead Thickness Measurements

	Sidewall Lead Thickness (in)				
	SC-30G2 18TU-01		SC-30G2 18TU-02		
Axial Elevation	Cut A	Cut AA	Cut T/U	Cut AT/AU	Cut A
30.0	1.44	1.45	1.41	1.44	1.52
28.5	1.44	1.45	1.41	1.43	1.52
27.0	1.44	1.45	1.40	1.43	1.52
25.5	1.43	1.45	1.40	1.43	1.52
24.0	1.43	1.44	1.40	1.43	1.53
22.5	1.43	1.44	1.40	1.43	1.53
21.0	1.43	1.44	1.42	1.43	1.53
19.5	1.43	1.43	1.41	1.43	1.53
18.0	1.42	1.43	1.43	1.43	1.53
16.5	1.42	1.43	1.43	1.43	1.53
15.0	1.43	1.43	1.41	1.42	1.53
13.5	1.43	1.43	1.41	1.42	1.53
12.0	1.43	1.42	1.41	1.40	1.53
10.5	1.43	1.42	1.40	1.35	1.53
9.0	1.43	1.43	1.40	1.41	1.53
7.5	1.43	1.43	1.40	1.41	1.53
6.0	1.44	1.43	1.40	1.40	1.53
4.5	1.44	1.43	1.40	1.40	1.53
3.0	1.44	1.43	1.40	1.40	1.53
1.5	1.44	1.43	1.40	1.40	1.53

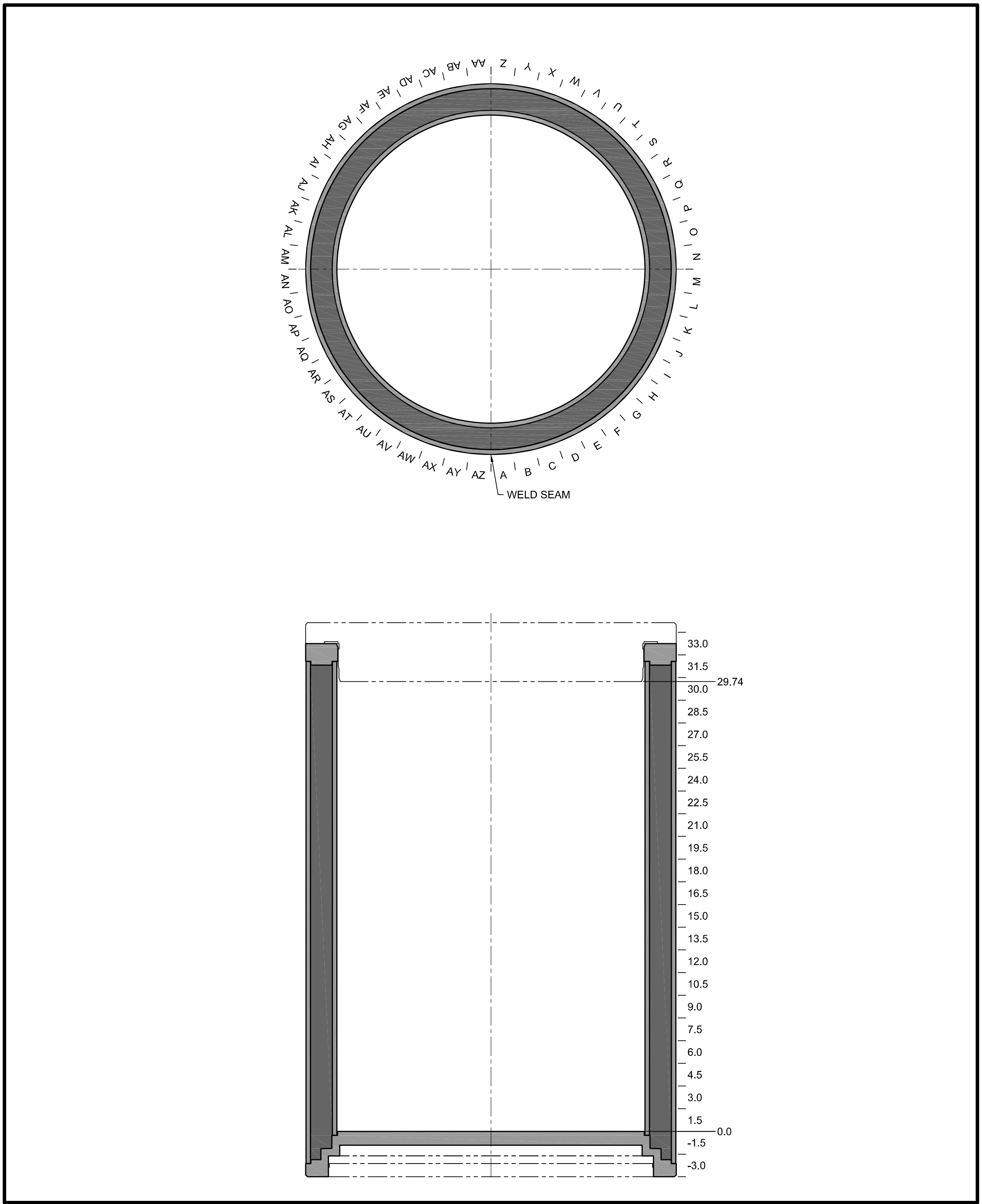

Figure 7-5 – SC-30G2 Circumferential and Axial Scan Grid Map

SC-30G2 TU18-01 Post Drop Shielding Evaluation; a Negative Number Indicates a Loss of Shielding																					
		Axial Elevation																			
Circumferential Grid Identifier		1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5	27.0	28.5	30.0
A	CUT	13.8%	4.7%	4.0%	3.3%	2.7%	3.3%	2.6%	2.6%	1.9%	2.5%	2.4%	2.4%	1.2%	1.9%	1.9%	0.7%	0.6%	-0.8%	-3.7%	(1)
B		15.3%	4.6%	3.9%	2.5%	1.9%	1.8%	1.1%	1.1%	1.7%	1.0%	1.7%	1.7%	0.4%	0.4%	0.4%	1.0%	-1.0%	-0.4%	0.1%	(1)
C		15.3%	4.0%	3.9%	1.8%	2.5%	1.1%	3.1%	1.7%	3.0%	1.7%	1.7%	2.3%	1.7%	1.0%	1.6%	2.2%	1.5%	0.8%	-1.9%	(1)
D		16.1%	4.6%	3.7%	3.2%	2.5%	2.4%	1.7%	1.7%	2.3%	1.7%	0.3%	2.3%	0.3%	1.0%	1.0%	0.3%	-0.5%	0.1%	-2.6%	(1)
E		15.8%	5.3%	4.0%	1.9%	3.2%	3.2%	1.2%	1.8%	1.8%	1.8%	1.1%	2.4%	1.7%	2.4%	1.7%	2.3%	1.5%	0.0%	-2.0%	(1)
F		15.3%	5.4%	4.0%	4.0%	1.9%	1.9%	2.5%	2.5%	1.9%	2.5%	2.5%	1.7%	1.7%	1.1%	1.7%	1.7%	0.0%	0.1%	-1.4%	(1)
G		15.1%	4.9%	4.1%	2.7%	2.7%	2.0%	1.4%	1.4%	0.7%	2.6%	3.3%	2.5%	1.8%	3.1%	1.7%	1.7%	2.8%	0.0%	-1.4%	(1)
H		14.2%	3.5%	4.1%	2.1%	2.7%	2.2%	2.1%	2.1%	2.6%	2.0%	3.3%	1.2%	1.8%	2.4%	2.3%	0.9%	1.5%	1.1%	-0.8%	(1)
I		12.0%	3.5%	3.4%	2.7%	2.2%	1.6%	1.4%	1.9%	2.6%	2.5%	2.5%	1.8%	1.1%	2.4%	0.3%	1.6%	0.8%	0.5%	-1.4%	(1)
J		11.7%	4.1%	2.7%	1.4%	2.1%	1.4%	1.9%	1.9%	2.5%	1.8%	2.4%	0.4%	1.0%	1.0%	1.5%	0.8%	0.0%	0.5%	-2.1%	(1)
K		8.6%	5.3%	3.7%	3.2%	2.5%	1.8%	1.7%	2.4%	1.7%	2.3%	3.5%	2.3%	2.2%	1.4%	2.0%	1.9%	1.8%	1.0%	-1.6%	(1)
L		12.3%	4.4%	2.4%	2.4%	1.7%	1.7%	2.4%	1.7%	2.3%	2.9%	2.1%	1.6%	0.8%	1.3%	1.9%	0.5%	1.1%	1.0%	-2.8%	(1)
M		10.5%	3.6%	4.8%	3.0%	1.6%	1.5%	1.5%	2.1%	2.2%	0.9%	1.5%	2.7%	2.6%	0.7%	1.3%	1.9%	1.1%	-0.2%	-1.6%	(1)
N		13.5%	4.8%	3.5%	1.6%	2.2%	1.5%	2.8%	1.5%	0.9%	2.8%	2.1%	2.1%	0.7%	2.0%	1.9%	0.6%	0.5%	1.0%	-1.5%	(1)
O		13.3%	3.7%	4.2%	3.4%	1.6%	2.2%	2.1%	1.5%	1.6%	1.5%	1.5%	2.8%	2.1%	2.8%	2.1%	1.5%	0.8%	0.7%	-0.8%	(1)
P		8.7%	4.3%	4.2%	2.9%	3.4%	1.6%	1.6%	2.2%	1.0%	2.3%	1.6%	1.6%	2.2%	0.9%	1.5%	0.9%	-1.0%	0.1%	-2.5%	(1)
Q		8.7%	3.6%	3.6%	3.6%	2.4%	1.0%	2.2%	2.3%	1.7%	3.5%	2.4%	2.3%	1.6%	2.4%	1.7%	2.4%	1.7%	1.0%	-1.2%	(1)
R		11.7%	3.5%	4.1%	1.7%	3.6%	2.4%	2.4%	2.4%	2.4%	1.1%	1.7%	1.1%	1.1%	1.7%	1.8%	1.1%	0.5%	1.1%	0.8%	(1)
S		8.5%	4.8%	4.1%	3.5%	3.0%	3.0%	1.7%	1.7%	1.7%	1.7%	1.1%	1.2%	1.2%	0.6%	1.9%	1.3%	1.3%	1.2%	0.3%	(1)
T		8.5%	4.1%	4.1%	4.2%	3.0%	3.0%	3.0%	2.4%	2.4%	1.2%	1.2%	1.3%	2.0%	0.7%	0.8%	0.7%	-0.6%	1.9%	1.0%	(1)
U		5.4%	4.1%	3.5%	3.6%	3.1%	1.1%	1.1%	1.1%	1.2%	1.8%	0.6%	0.7%	0.7%	1.4%	0.8%	0.1%	0.1%	0.0%	-0.1%	(1)
V		7.4%	4.7%	2.4%	3.6%	2.4%	1.7%	1.1%	1.8%	1.2%	1.3%	1.3%	1.4%	0.8%	1.5%	0.9%	0.1%	0.1%	0.8%	0.6%	(1)
W		7.6%	4.1%	3.6%	4.6%	3.1%	2.4%	1.2%	0.6%	2.0%	0.6%	1.4%	0.8%	0.8%	0.9%	0.9%	1.5%	0.2%	-0.5%	0.0%	(1)
X		10.3%	4.7%	2.5%	2.6%	1.8%	1.1%	3.2%	1.9%	2.0%	1.4%	1.4%	0.8%	0.9%	0.9%	1.6%	0.9%	1.6%	0.9%	0.6%	(1)
Y		8.8%	4.2%	3.6%	3.3%	3.9%	1.1%	1.8%	0.6%	1.3%	1.3%	1.3%	0.7%	0.8%	-0.5%	1.5%	0.9%	1.5%	0.8%	-0.1%	(1)
Z		8.6%	4.3%	3.6%	2.5%	3.7%	3.9%	3.9%	2.6%	2.0%	2.6%	2.6%	1.4%	1.5%	3.5%	2.2%	4.1%	1.3%	1.9%	3.5%	(1)
AA	CUT	8.5%	4.3%	4.3%	2.4%	1.9%	2.5%	1.1%	1.8%	1.2%	1.3%	1.4%	1.3%	1.4%	1.4%	2.0%	1.3%	0.6%	1.1%	0.8%	(1)
AB		6.4%	4.4%	2.4%	1.8%	1.8%	1.8%	0.5%	1.9%	1.9%	1.3%	1.3%	0.6%	1.3%	0.6%	0.6%	1.3%	1.2%	1.0%	1.4%	(1)
AC		2.5%	5.6%	3.1%	3.6%	2.4%	1.7%	1.7%	1.7%	2.4%	2.3%	1.7%	1.7%	1.7%	2.4%	1.7%	2.4%	1.0%	0.8%	1.1%	(1)
AD		8.1%	4.3%	3.7%	3.1%	1.7%	1.0%	0.3%	1.7%	1.7%	0.3%	1.0%	1.7%	1.0%	1.0%	1.7%	1.0%	2.3%	1.3%	-0.2%	(1)
AE		6.1%	4.3%	3.7%	3.2%	3.7%	1.7%	0.3%	1.6%	2.3%	3.0%	2.3%	2.9%	2.2%	2.2%	1.6%	1.4%	1.4%	-0.1%	0.8%	(1)
AF		5.6%	3.5%	3.6%	3.1%	2.4%	2.3%	1.0%	2.2%	1.0%	3.5%	2.9%	2.1%	1.4%	0.8%	1.4%	1.3%	1.3%	1.0%	2.5%	(1)
AG		5.8%	4.1%	5.4%	3.0%	4.1%	3.4%	2.2%	2.8%	1.5%	1.5%	2.7%	1.9%	2.6%	1.9%	1.9%	2.5%	1.0%	-0.4%	1.8%	(1)
AH		7.1%	2.9%	4.7%	4.1%	3.4%	1.5%	2.1%	2.0%	1.4%	2.6%	2.0%	2.0%	1.3%	1.3%	1.3%	1.9%	1.1%	0.9%	2.2%	(1)
AI		5.3%	2.9%	2.8%	2.7%	2.0%	1.2%	2.5%	1.2%	1.9%	1.2%	1.8%	1.8%	1.2%	1.1%	1.1%	1.1%	0.4%	0.8%	-0.1%	(1)
AJ		8.7%	3.8%	3.2%	2.6%	3.1%	1.8%	1.8%	0.6%	1.8%	1.1%	1.7%	1.7%	1.7%	1.1%	0.5%	-0.2%	0.4%	2.0%	2.7%	(1)
AK		8.1%	3.7%	3.7%	2.5%	2.5%	2.4%	1.8%	1.1%	1.1%	0.5%	0.5%	1.0%	1.0%	0.5%	-0.2%	1.6%	1.0%	2.0%	1.0%	(1)
AL		7.9%	4.1%	3.5%	2.3%	1.7%	2.3%	0.5%	1.6%	0.5%	0.5%	0.5%	0.5%	-0.1%	0.5%	-0.8%	1.0%	1.0%	0.9%	3.8%	(1)
AM		9.6%	3.5%	2.3%	1.7%	1.7%	1.7%	2.3%	2.3%	2.3%	1.1%	1.1%	1.1%	1.8%	1.1%	0.5%	0.4%	-0.2%	1.5%	0.5%	(1)
AN		13.2%	4.7%	3.0%	2.4%	2.3%	2.4%	1.7%	1.7%	2.4%	1.8%	1.8%	1.8%	0.5%	-0.1%	1.2%	-0.1%	1.1%	0.3%	1.7%	(1)
AO		6.9%	3.6%	4.1%	3.0%	2.5%	2.3%	1.9%	1.9%	1.9%	2.5%	2.5%	1.3%	0.6%	0.0%	0.6%	-0.1%	-0.1%	-0.1%	-3.5%	(1)
AP		8.1%	4.2%	3.6%	2.5%	1.9%	2.5%	1.9%	0.6%	1.4%	1.4%	1.4%	1.4%	0.7%	-0.6%	0.1%	0.0%	0.7%	-1.3%	-0.5%	(1)
AQ		7.6%	3.7%	4.3%	3.2%	1.9%	1.3%	2.0%	1.4%	0.8%	1.5%	2.8%	2.1%	2.0%	2.2%	2.1%	1.4%	0.7%	-0.7%	0.4%	(1)
AR		5.8%	3.8%	3.2%	2.7%	2.2%	2.8%	2.1%	1.5%	2.3%	1.7%	1.7%	2.2%	0.9%	1.5%	2.1%	-0.4%	0.1%	0.5%	0.2%	(1)
AS		6.6%	3.8%	3.1%	2.6%	2.7%	1.4%	1.5%	1.5%	2.8%	2.2%	2.3%	1.6%	2.2%	1.5%	1.0%	-0.4%	0.2%	0.1%	-2.7%	(1)
AT		5.8%	3.7%	3.7%	2.7%	1.4%	2.1%	1.6%	2.2%	2.2%	2.3%	1.6%	1.7%	0.9%	2.2%	0.3%	0.3%	0.3%	-1.2%	-0.2%	(1)
AU		5.3%	3.2%	2.5%	3.2%	1.5%	0.9%	0.3%	2.2%	1.0%	1.6%	1.7%	1.7%	1.7%	1.0%	0.4%	-0.3%	1.0%	0.2%	-3.9%	(1)
AV		7.3%	3.2%	2.7%	2.2%	1.6%	1.6%	1.6%	1.0%	2.3%	1.6%	1.0%	1.7%	0.4%	0.3%	1.0%	-0.3%	1.0%	-1.1%	-1.4%	(1)
AW		6.3%	4.0%	3.3%	2.9%	0.9%	1.6%	2.3%	1.0%	2.3%	2.3%	1.7%	1.7%	0.4%	0.5%	1.1%	1.1%	1.1%	-0.3%	-3.1%	(1)
AX		6.3%	3.0%	3.5%	3.0%	2.4%	3.3%	0.5%	1.7%	1.0%	2.3%	1.1%	1.7%	-0.1%	-0.1%	0.6%	1.8%	-0.2%	1.7%	-2.5%	(1)
AY		5.8%	3.6%	3.6%	3.1%	1.7%	2.5%	1.2%	1.7%	1.7%	1.7%	2.3%	1.7%	1.7%	1.7%	0.5%	0.5%	0.6%	-0.1%	-4.3%	(1)
AZ		8.8%	3.7%	1.1%	2.5%	1.9%	3.3%	1.8%	1.8%	1.7%	1.0%	1.7%	0.5%	0.5%	0.5%	0.6%	0.0%	-0.8%	-0.8%	-3.7%	(1)
MAX		16.1%	5.6%	5.4%	4.6%	4.1%	3.9%	3.9%	2.8%	3.0%	3.5%	3.5%	2.9%	2.6%	3.5%	2.3%	4.1%	2.8%	2.0%	3.8%	
MIN		2.5%	2.9%	1.1%	1.4%	0.9%	0.9%	0.3%	0.6%	0.5%	0.3%	0.3%	0.4%	-0.1%	-0.6%	-0.8%	-0.4%	-1.0%	-1.3%	-4.3%	
AVG		9.2%	4.1%	3.5%	2.8%	2.4%	2.0%	1.8%	1.7%	1.8%	1.8%	1.8%	1.6%	1.3%	1.3%	1.2%	1.0%	0.7%	0.5%	-0.5%	

NOTES: (1) Data for the pre- and post-drop gamma scans was taken inconsistently and is therefore not comparable.

Figure 7-6 – SC-30G2 18TU-01 Pre-Drop/Post-Drop Dose Rate Change Comparison

SC-30G2B TU18-02 Post Drop Shielding Evaluation; a Negative Number Indicates a Loss of Shielding

Circumferential Grid Identifier		Axial Elevation 1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5	27.0	28.5	30.0
A	CUT	7.9%	-0.1%	1.2%	-0.3%	-0.3%	-1.0%	-1.8%	-1.0%	-1.0%	-1.6%	-1.0%	-2.4%	-1.0%	-1.0%	-1.0%	-0.2%	0.6%	-0.7%	0.1%	-17.0%
B		10.0%	4.6%	3.2%	3.1%	2.3%	1.6%	2.2%	2.3%	1.7%	1.7%	2.3%	2.3%	1.6%	2.3%	1.7%	2.5%	2.0%	2.0%	1.7%	-15.0%
C		8.4%	2.6%	1.2%	2.5%	1.1%	0.4%	0.4%	-0.9%	1.0%	1.0%	1.0%	1.6%	1.6%	1.0%	0.4%	-0.2%	1.2%	1.9%	0.1%	-9.6%
D		13.2%	0.8%	0.8%	-0.5%	0.1%	-0.6%	-1.3%	-1.2%	-1.9%	-0.6%	-1.2%	-0.6%	-1.9%	-1.2%	-1.8%	-0.5%	-1.1%	-1.1%	-2.9%	-10.5%
E		16.8%	1.4%	1.4%	-0.6%	0.0%	0.0%	-0.7%	-0.1%	0.6%	-0.7%	-1.4%	-0.7%	-0.7%	0.6%	-0.1%	-0.7%	-0.1%	-0.1%	0.0%	-8.3%
F		5.1%	2.0%	0.7%	0.0%	-0.7%	-0.7%	-0.6%	0.0%	-0.6%	-1.3%	-2.0%	-0.1%	-0.7%	-0.1%	-0.1%	-0.7%	-0.1%	-0.1%	-0.6%	-6.8%
G		4.3%	0.1%	0.7%	0.0%	-0.6%	0.0%	0.0%	1.2%	1.2%	0.0%	0.6%	-0.1%	-0.1%	0.4%	0.4%	0.4%	1.6%	0.4%	1.2%	-4.6%
H		5.0%	1.3%	0.7%	-0.7%	-0.7%	-0.6%	-0.7%	-1.9%	-1.9%	-0.7%	-0.1%	0.5%	-0.1%	-0.1%	0.4%	0.4%	-0.1%	0.4%	-3.2%	-9.0%
I		4.7%	-0.5%	1.3%	1.3%	0.0%	0.0%	0.0%	-0.6%	-1.2%	-1.2%	-0.7%	-0.7%	-0.7%	-0.7%	-0.1%	-0.1%	-0.1%	-0.1%	-0.7%	-2.4%
J		0.0%	0.6%	-0.1%	-0.6%	-0.6%	-0.6%	-0.5%	-1.8%	-0.6%	-0.5%	0.7%	-1.2%	-1.2%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%	-1.2%	-3.1%
K		-0.1%	1.8%	-0.1%	0.5%	0.7%	-0.7%	-0.6%	-0.5%	-1.2%	-0.6%	-1.2%	-1.8%	-0.6%	-1.9%	-0.6%	-0.7%	0.5%	-1.3%	-0.6%	-6.8%
L		6.4%	-0.1%	-0.1%	0.0%	-1.3%	-1.3%	-1.2%	-1.2%	-1.2%	-0.6%	-0.6%	-1.2%	-0.6%	-1.3%	-1.3%	-0.6%	0.0%	-0.6%	-1.8%	-6.0%
M		2.6%	-0.7%	0.5%	-1.3%	-1.3%	-0.7%	0.0%	-1.9%	-1.3%	-1.9%	-1.9%	-1.2%	-1.2%	-0.6%	-0.6%	0.0%	0.6%	-0.7%	0.6%	-7.6%
N		5.0%	1.7%	0.0%	0.0%	-0.5%	-1.2%	-1.2%	-1.2%	-1.2%	-1.2%	-1.8%	-1.8%	-0.6%	-0.5%	0.1%	-1.2%	-0.6%	-0.6%	-0.5%	-6.1%
O		4.4%	-1.8%	0.6%	0.1%	-1.2%	-1.8%	-1.2%	-1.8%	-1.8%	-1.2%	-1.8%	-1.8%	-1.2%	-1.2%	-1.8%	-1.2%	-0.6%	-0.6%	0.0%	-5.4%
P		8.4%	1.3%	-0.5%	-0.5%	-0.5%	-1.2%	-1.2%	-1.8%	-0.5%	-0.5%	-0.5%	-0.5%	-1.8%	-1.2%	-1.2%	-0.5%	0.0%	0.7%	-1.2%	-4.5%
Q		8.4%	-0.5%	0.2%	-0.5%	-0.5%	-1.8%	-1.2%	-1.2%	-1.2%	-2.5%	-1.2%	-0.6%	-1.8%	-0.6%	-1.2%	-1.3%	-1.2%	-0.6%	0.1%	-3.1%
R		12.9%	0.8%	0.2%	-0.4%	-1.1%	-1.2%	-1.2%	-1.8%	-0.6%	-1.9%	-1.9%	-1.3%	-0.7%	-1.9%	-1.9%	-1.9%	-2.5%	-1.2%	-1.8%	-5.3%
S		10.3%	1.0%	0.4%	-0.4%	-1.0%	-0.5%	-1.1%	0.1%	-0.6%	0.0%	-1.9%	-1.3%	-2.0%	-0.7%	-2.0%	-0.7%	-0.7%	-0.7%	-0.6%	-4.5%
T	CUT	6.7%	1.6%	0.4%	0.2%	0.2%	-0.5%	-0.5%	-0.5%	-0.6%	-1.2%	-0.6%	-0.1%	-0.7%	-0.1%	-0.7%	1.2%	0.0%	-1.2%	-0.5%	-11.3%
U	CUT	8.4%	-0.3%	-0.4%	-1.1%	-1.1%	-1.1%	-1.8%	-1.8%	-1.2%	-1.9%	-1.2%	-0.6%	-0.6%	-0.7%	-0.1%	-1.4%	-0.7%	-1.4%	0.1%	-1.5%
V		3.8%	0.9%	0.2%	-0.4%	0.1%	0.1%	-0.5%	-1.8%	-1.2%	-1.2%	-1.2%	-2.5%	-1.3%	-1.2%	0.1%	0.7%	0.7%	-0.5%	-1.0%	0.0%
W		5.5%	-0.4%	0.8%	0.8%	-0.5%	-0.5%	-1.2%	-1.2%	-1.2%	-0.6%	-0.5%	-0.6%	0.0%	-1.2%	0.7%	0.1%	0.7%	0.0%	2.6%	-0.1%
X		5.3%	2.4%	1.3%	-0.1%	-0.1%	-0.1%	-1.4%	-1.4%	-0.1%	1.2%	1.8%	-0.7%	0.6%	0.0%	-0.1%	0.6%	0.5%	0.6%	-1.2%	-0.9%
Y		12.8%	3.2%	2.0%	0.3%	-0.9%	0.4%	-0.2%	0.4%	0.4%	0.4%	-0.2%	-0.2%	-0.2%	-0.2%	0.4%	0.4%	1.0%	1.5%	1.0%	-4.2%
Z		5.4%	0.2%	0.2%	-0.9%	-0.8%	-0.2%	-0.8%	-0.8%	-0.2%	0.4%	-0.7%	-0.7%	-1.4%	-2.0%	0.5%	0.4%	1.0%	1.0%	0.4%	-1.4%
AA		1.1%	-0.2%	-0.1%	-0.1%	-0.6%	-1.2%	-0.5%	-1.2%	-1.2%	-1.2%	-1.8%	0.1%	-0.5%	-1.0%	-1.0%	0.2%	0.1%	-0.6%	0.0%	-1.8%
AB		7.8%	1.0%	1.2%	-0.6%	0.1%	-1.2%	-0.5%	-0.5%	-1.8%	-0.5%	-1.2%	-1.8%	0.2%	0.2%	0.1%	0.7%	0.0%	-0.7%	-2.0%	-3.2%
AC		9.7%	-0.7%	0.6%	0.0%	0.1%	-1.2%	-1.2%	-0.5%	-1.2%	-1.2%	-1.2%	0.1%	0.8%	-1.1%	-0.5%	-1.2%	-0.5%	0.1%	-0.6%	-2.4%
AD		7.5%	1.3%	0.6%	-0.5%	-0.5%	-0.5%	0.1%	-0.5%	-1.1%	-0.5%	-0.5%	0.1%	-0.5%	0.1%	0.8%	-0.5%	0.1%	-0.5%	-1.1%	-2.2%
AE		10.0%	0.2%	0.1%	0.1%	-0.5%	-1.2%	-0.5%	0.1%	0.1%	0.1%	-1.2%	0.1%	-0.5%	-0.5%	-0.5%	0.1%	0.1%	-0.5%	0.9%	-2.7%
AF		11.7%	1.4%	0.8%	0.1%	-0.5%	0.1%	-0.6%	-0.7%	-0.6%	-0.6%	0.1%	-0.6%	0.7%	0.1%	0.0%	-1.2%	-1.2%	-0.5%	-0.2%	-3.4%
AG		16.2%	2.7%	1.9%	-0.6%	0.0%	-1.3%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	0.5%	-0.1%	0.5%	-0.1%	0.5%	0.0%	0.1%	0.9%	-1.9%
AH		11.6%	1.9%	1.1%	0.5%	-0.1%	-0.1%	-0.1%	0.4%	-1.4%	-0.7%	-0.7%	0.4%	-0.7%	-0.7%	-1.3%	-1.3%	-0.6%	-0.5%	-0.9%	-6.4%
AI		10.6%	1.9%	1.8%	1.8%	-0.1%	-0.7%	-0.8%	-2.0%	-0.8%	-0.1%	-0.1%	-0.7%	-0.1%	-0.1%	-0.1%	0.1%	-0.5%	0.2%	0.3%	-12.2%
AJ		11.1%	2.3%	0.4%	0.4%	-0.1%	-0.1%	-1.4%	-1.4%	-0.7%	-0.1%	-0.7%	-0.7%	-0.7%	0.0%	-1.2%	-0.5%	-1.6%	0.4%	-0.2%	-18.5%
AK		11.4%	1.6%	2.2%	1.6%	-0.1%	-0.1%	-0.8%	-0.1%	0.5%	-0.7%	-0.7%	-0.1%	0.0%	0.7%	0.1%	0.1%	-0.5%	-1.0%	1.9%	-4.7%
AL		3.5%	1.5%	1.6%	1.0%	0.4%	-0.1%	-0.1%	-0.1%	-0.7%	0.6%	-0.6%	-1.2%	0.1%	0.1%	0.2%	1.5%	1.6%	0.4%	-0.9%	-2.5%
AM		2.8%	2.1%	1.5%	0.4%	-0.8%	0.4%	-0.7%	-0.1%	-0.1%	-0.7%	-1.2%	0.0%	-1.2%	0.1%	0.1%	0.2%	-0.3%	1.0%	1.8%	-3.2%
AN		7.6%	0.3%	0.4%	0.4%	0.5%	-0.1%	-1.3%	-0.7%	-1.3%	-0.6%	-0.6%	-1.2%	-0.5%	0.1%	0.8%	-0.4%	0.3%	1.0%	-0.7%	-4.0%
AO		5.3%	0.4%	0.3%	1.6%	-0.1%	-0.7%	-0.1%	-0.7%	-0.6%	-1.2%	-1.2%	-1.2%	-0.5%	-0.5%	-0.4%	-0.4%	0.3%	1.0%	2.4%	-5.6%
AP		13.8%	1.0%	0.4%	-5.2%	-0.7%	-1.9%	-1.9%	-0.5%	-0.4%	-1.1%	-1.0%	0.2%	-0.4%	-0.4%	0.3%	1.0%	0.4%	-0.8%	1.2%	-3.8%
AQ		8.7%	0.0%	1.2%	-0.6%	-1.2%	-0.5%	-1.8%	-1.8%	-1.0%	-0.3%	-0.3%	0.4%	0.4%	0.4%	1.1%	1.1%	1.8%	1.2%	1.9%	-1.4%
AR		4.6%	0.1%	0.8%	-0.5%	-0.5%	-1.7%	-2.4%	-0.4%	-1.6%	-0.2%	0.5%	0.5%	1.1%	0.5%	0.5%	1.1%	1.2%	-0.1%	-2.1%	-1.4%
AS		4.7%	2.0%	1.4%	0.8%	0.8%	-0.4%	-1.8%	-1.6%	0.5%	-0.2%	-0.2%	-0.9%	-0.2%	0.5%	-0.2%	0.5%	1.2%	1.2%	2.7%	-5.5%
AT	CUT	1.6%	0.1%	0.2%	0.8%	-0.3%	-0.4%	-5.2%	-3.0%	-1.5%	-0.2%	0.5%	-0.9%	-0.2%	-0.2%	-0.2%	1.1%	1.2%	-0.1%	0.7%	-7.1%
AU	CUT	0.1%	-1.1%	0.1%	0.1%	-1.2%	-2.5%	-8.0%	-5.9%	-2.3%	-1.6%	-1.6%	-1.6%	-0.9%	-2.3%	-2.3%	-0.2%	0.5%	1.9%	1.2%	-5.6%
AV		0.1%	0.8%	0.8%	-0.4%	-0.4%	-1.1%	-3.9%	-1.8%	0.4%	1.0%	-0.2%	0.4%	-0.2%	-1.0%	-1.6%	-0.2%	1.8%	1.2%	1.3%	-5.5%
AW		1.5%	0.9%	2.1%	1.5%	0.3%	-0.4%	-1.2%	-0.5%	1.0%	-0.2%	0.4%	-0.3%	0.3%	-1.0%	0.3%	0.3%	-0.2%	0.5%	0.0%	-3.9%
AX		4.1%	0.9%	-0.3%	0.3%	0.3%	0.2%	-1.1%	0.2%	-1.7%	-0.9%	-0.3%	-0.3%	-0.3%	1.0%	0.5%	-0.2%	-0.1%	0.1%	0.9%	-3.0%
AY		2.1%	1.2%	-0.1%	-0.8%	0.5%	-1.4%	-0.9%	-0.9%	-0.9%	-1.5%	-0.9%	-0.9%	-0.2%	-0.2%	-0.8%	-0.7%	-0.6%	-1.2%	-0.3%	-7.8%
AZ		6.2%	-1.2%	-1.2%	-1.3%	-2.8%	-2.8%	-3.4%	-2.7%	-2.0%	-2.7%	-2.0%	-2.6%	-2.0%	-2.0%	-2.6%	-2.5%	-2.4%	-2.9%	-2.1%	-8.5%
MAX		16.8%	4.6%	3.2%	3.1%	2.3%	1.6%	2.2%	2.3%	1.7%	1.7%	2.3%	2.3%	1.6%	2.3%	1.7%	2.5%	2.0%	2.0%	2.7%	0.0%
MIN		-0.1%	-1.8%	-1.2%	-5.2%	-2.8%	-2.8%	-8.0%	-5.9%	-2.3%	-2.7%	-2.0%	-2.6%	-2.0%	-2.3%	-2.6%	-2.5%	-2.5%	-2.9%	-3.2%	-18.5%
AVG		6.9%	0.9%	0.7%	0.0%	-0.3%	-0.7%	-1.1%	-1.0%	-0.7%	-0.7%	-0.7%	-0.6%	-0.5%	-0.4%	-0.3%	-0.1%	0.1%	0.0%	-0.1%	-5.0%

Figure 7-7 – SC-30G2 18TU-02 Pre-Drop/Post-Drop Dose Rate Change Comparison

Figure 7-8 – SC-30G2 18TU-01 Destructive Disassembly Overview

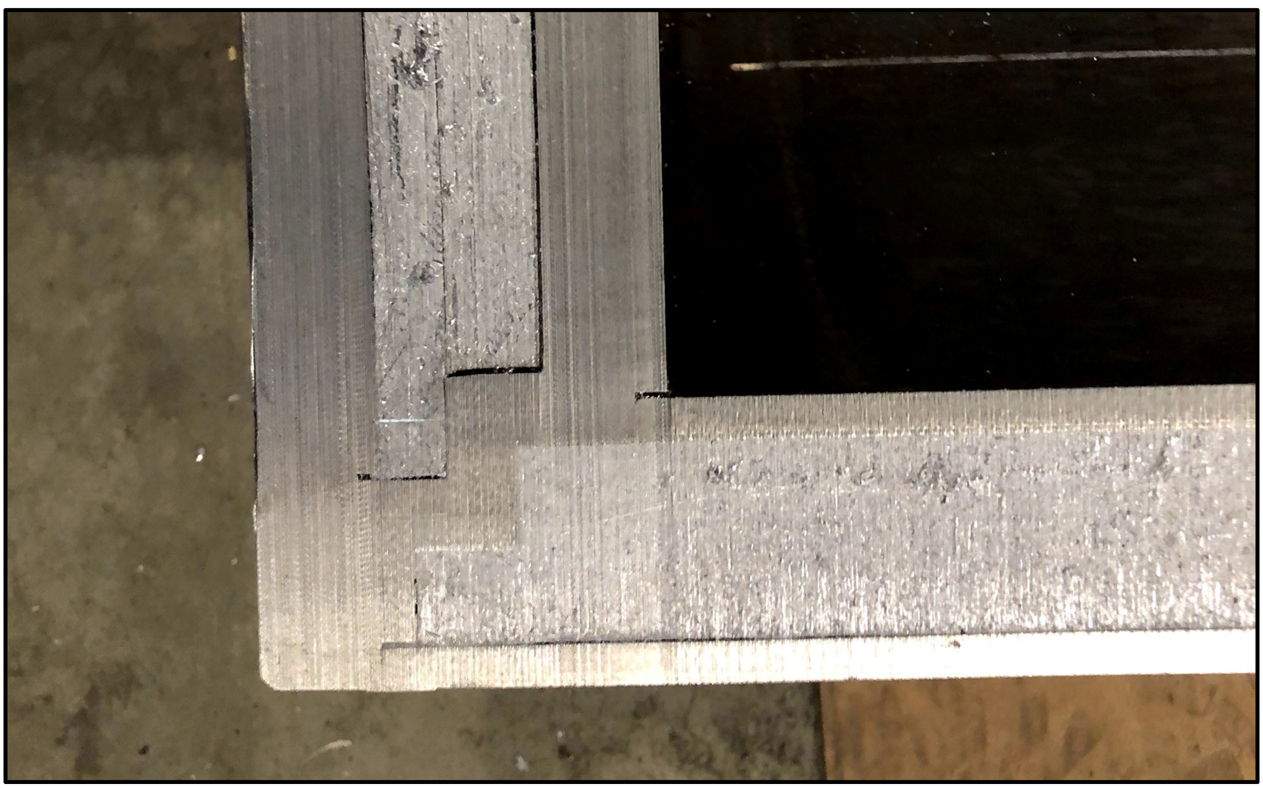

Figure 7-9 – SC-30G2 18TU-01 Destructive Disassembly Cut A at Lower Flange

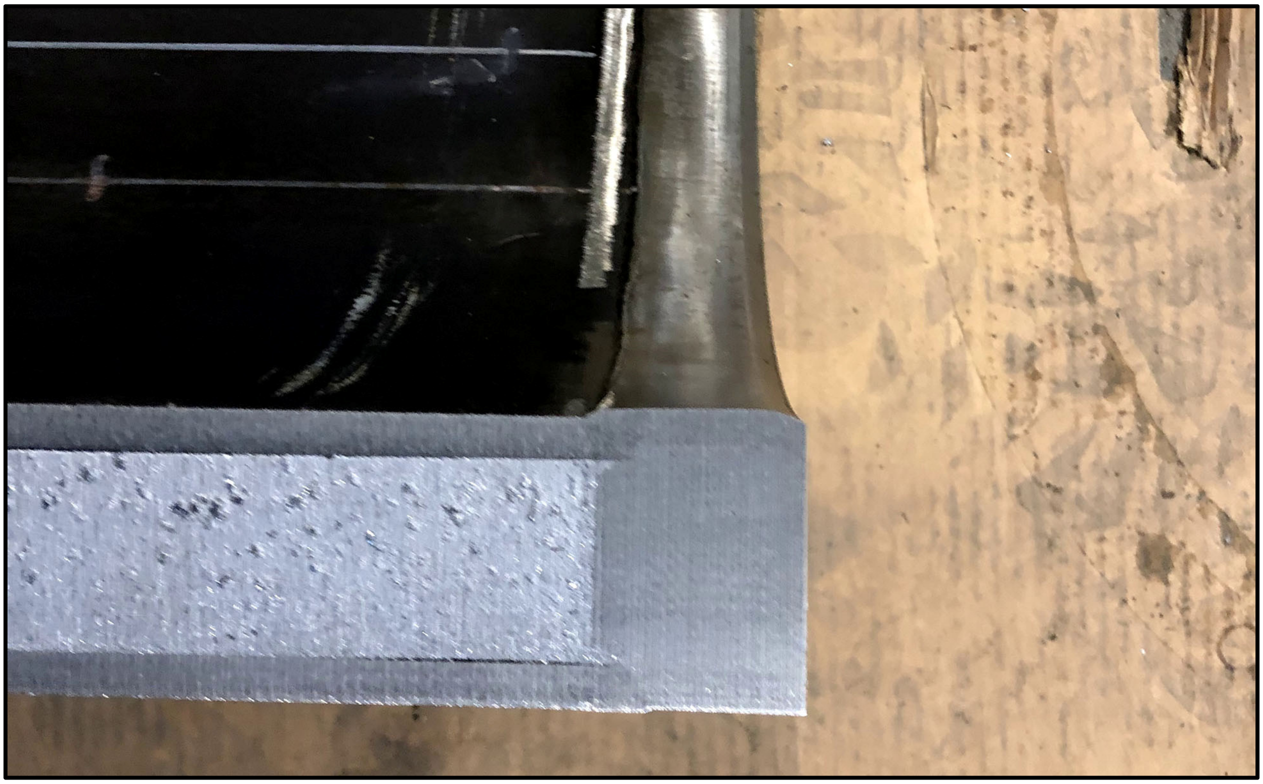

Figure 7-10 – SC-30G2 18TU-01 Destructive Disassembly Cut A at Upper Flange

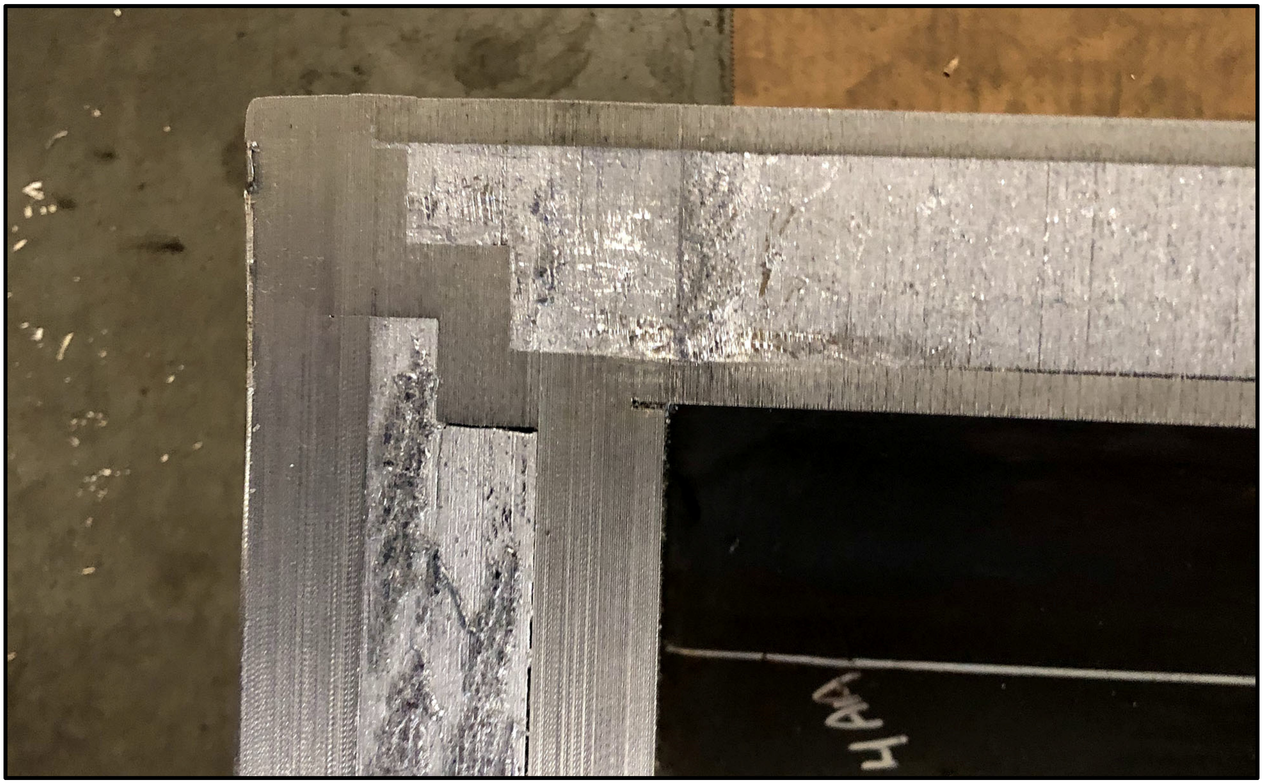

Figure 7-11 – SC-30G2 18TU-01 Destructive Disassembly Cut AA at Lower Flange

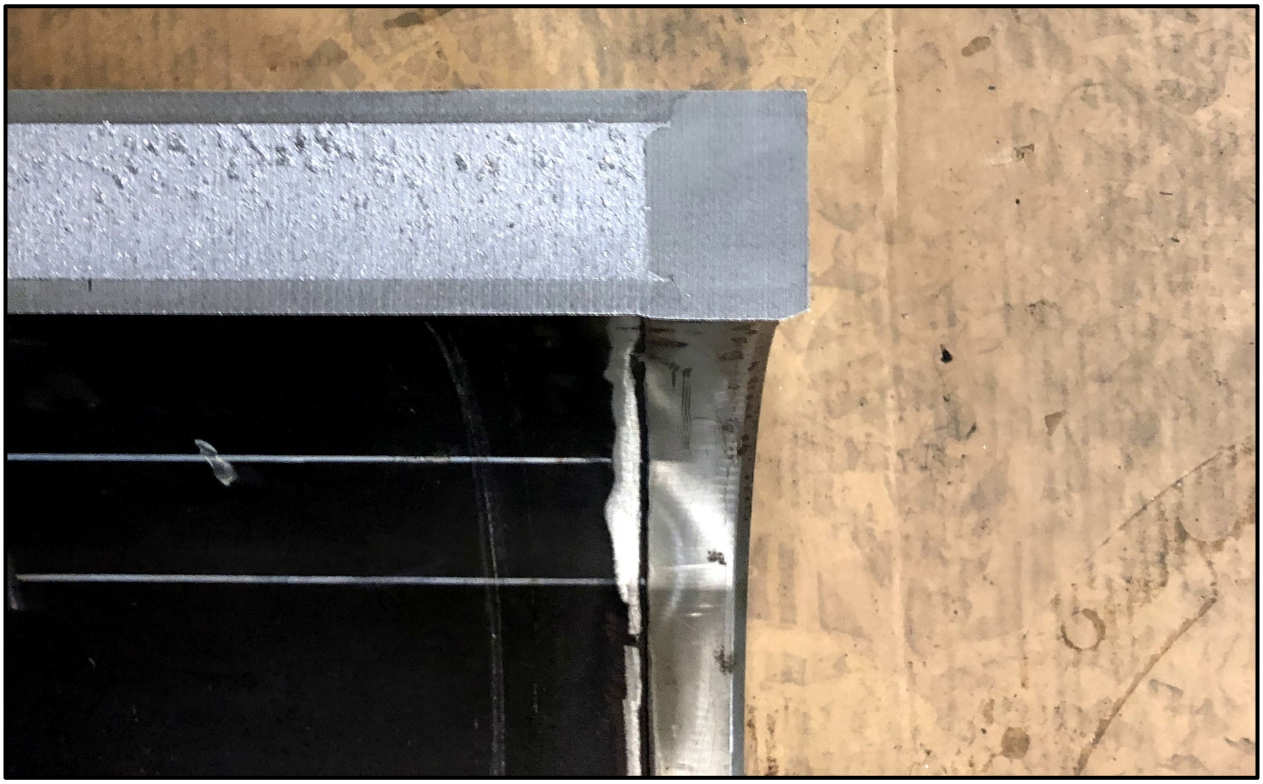

Figure 7-12 – SC-30G2 18TU-01 Destructive Disassembly Cut AA at Upper Flange

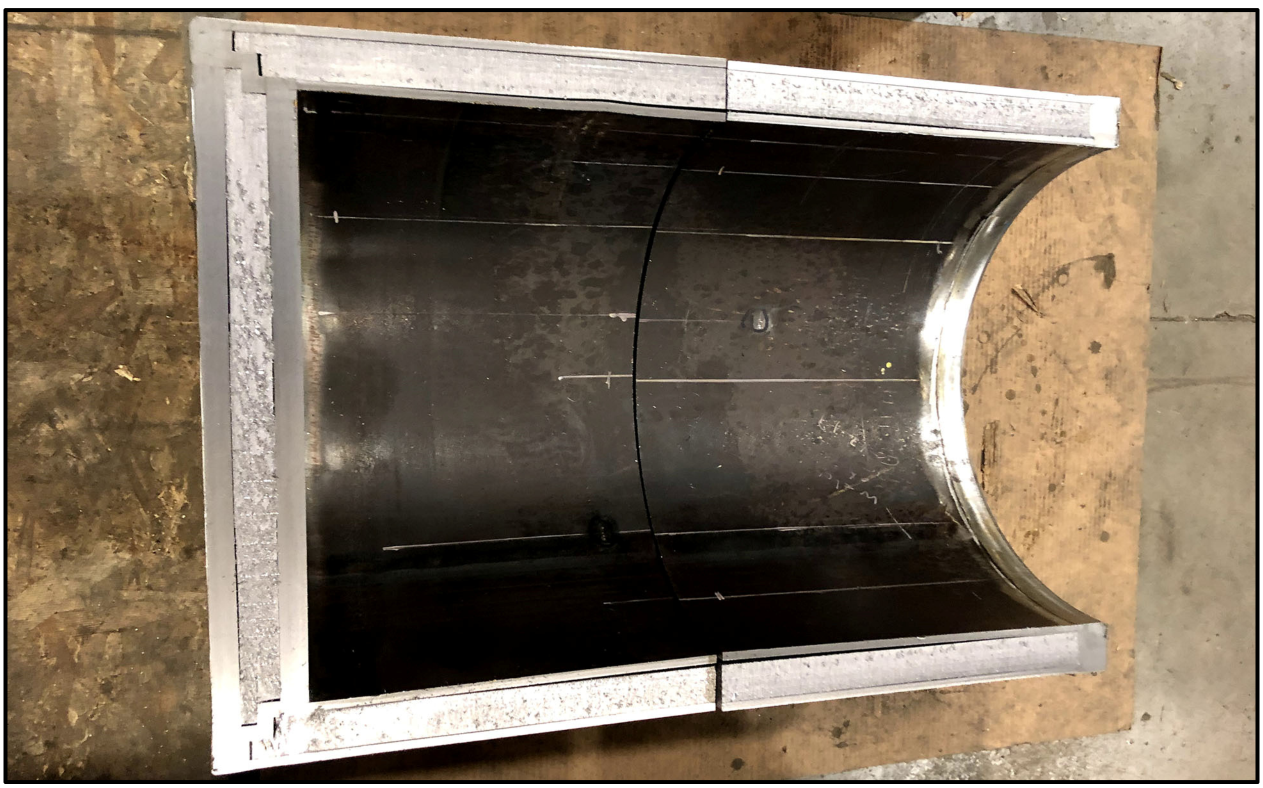

Figure 7-13 – SC-30G2 18TU-02 Destructive Disassembly Overview

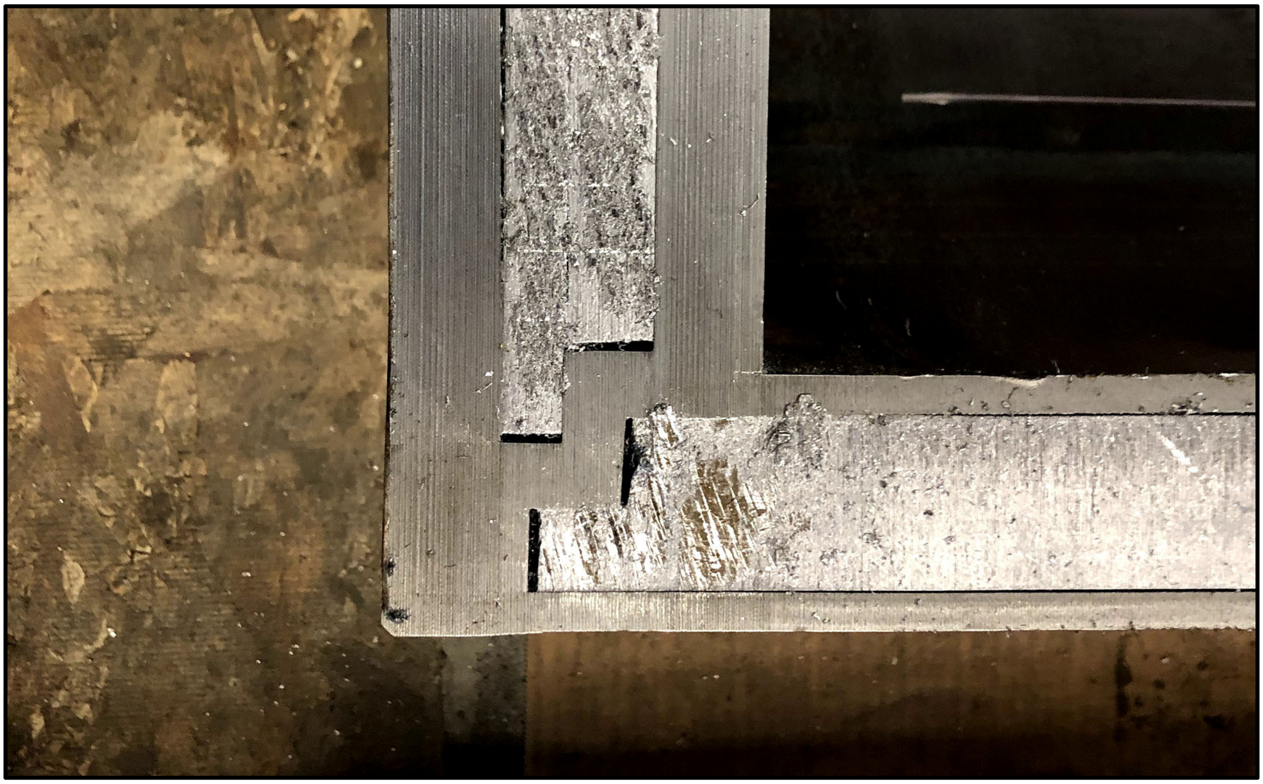

Figure 7-14 – SC-30G2 18TU-02 Destructive Disassembly Cut T/U at Lower Flange

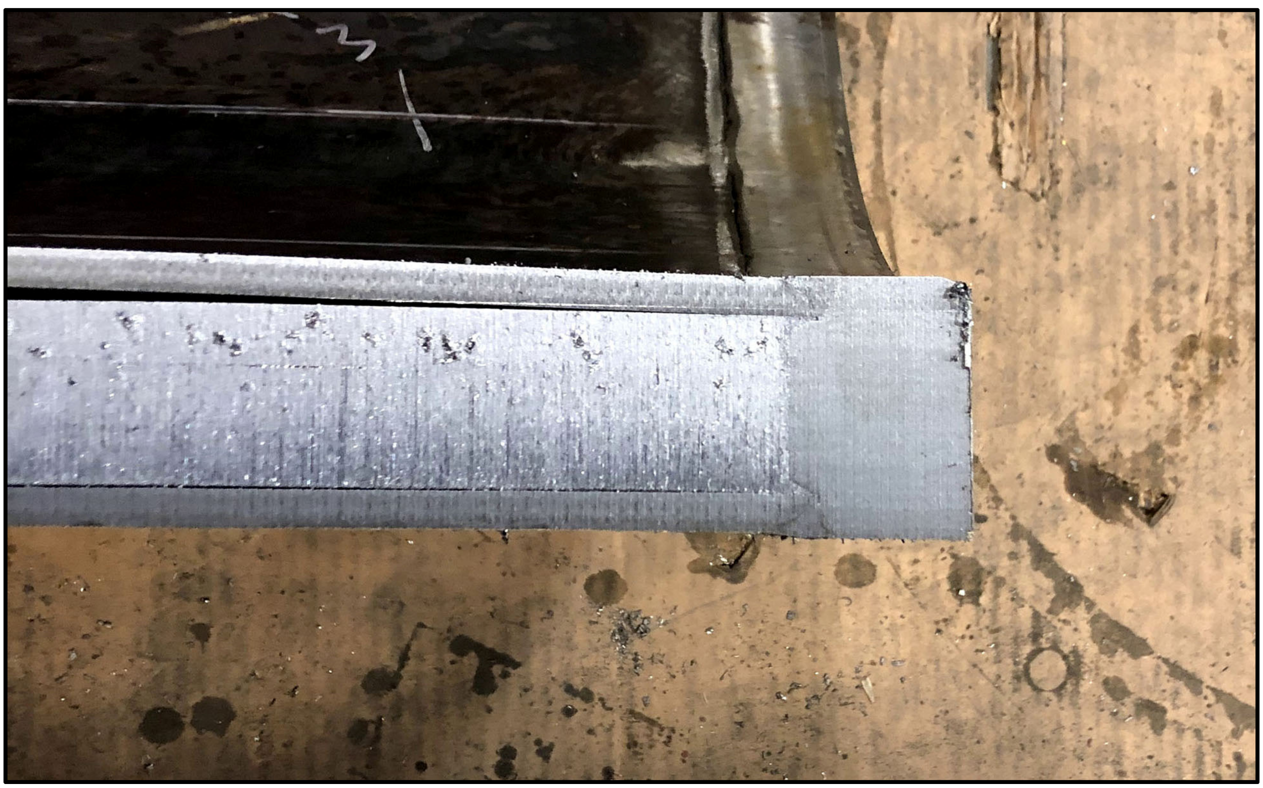

Figure 7-15 – SC-30G2 18TU-02 Destructive Disassembly Cut T/U at Upper Flange

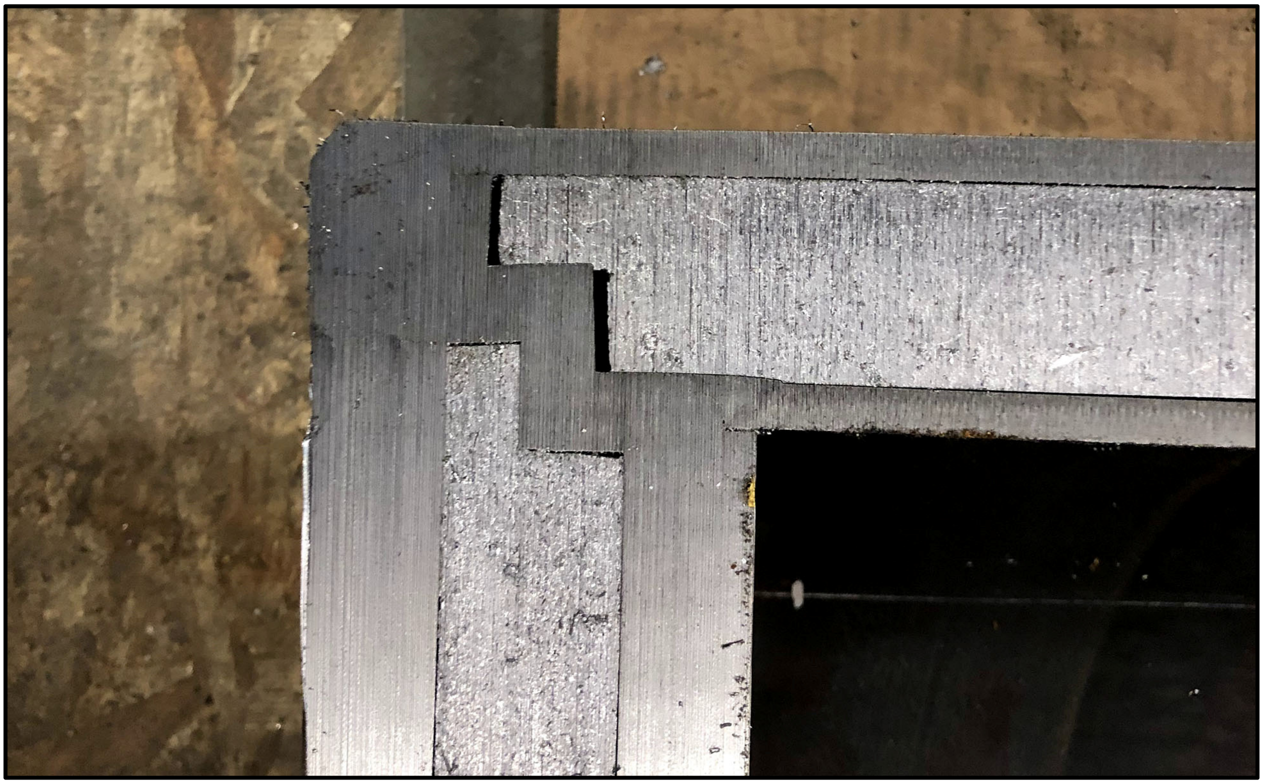

Figure 7-16 – SC-30G2 18TU-02 Destructive Disassembly Cut AT/AU at Lower Flange

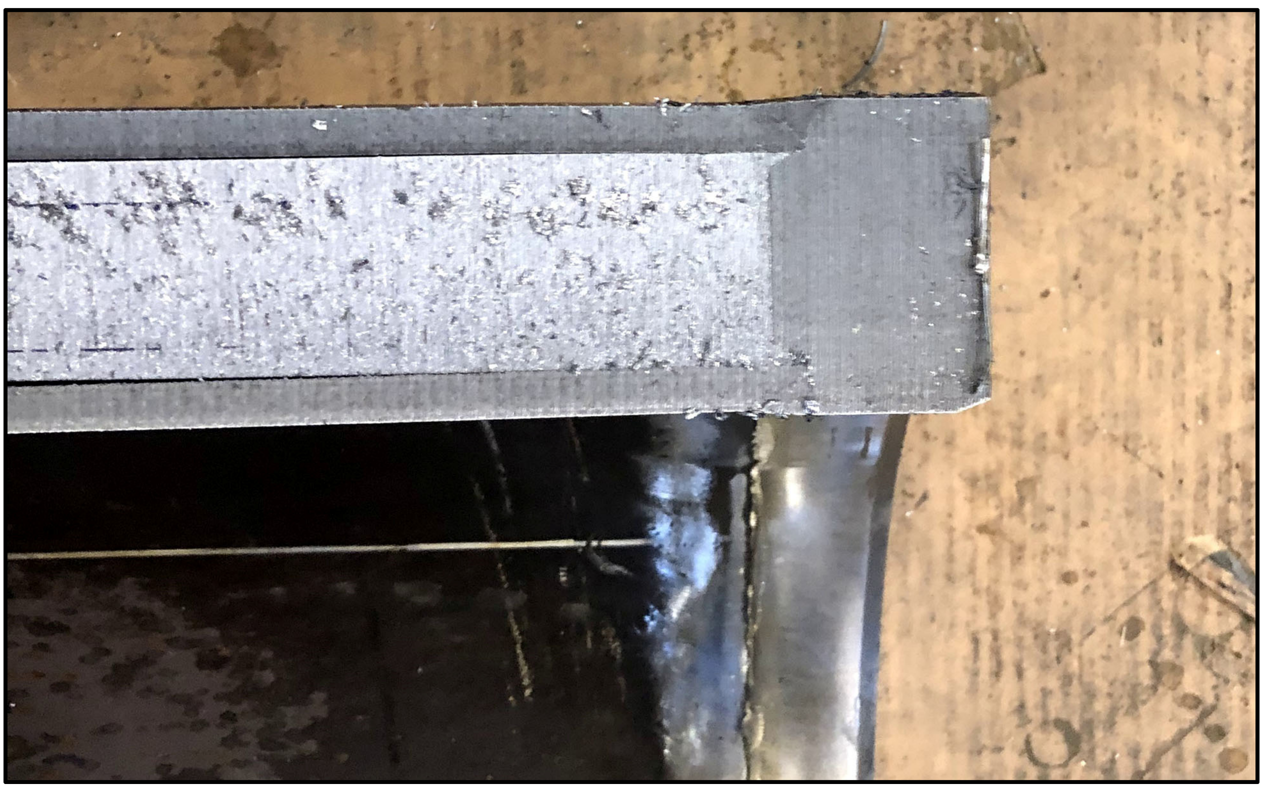

Figure 7-17 – SC-30G2 18TU-02 Destructive Disassembly Cut AT/AU at Upper Flange

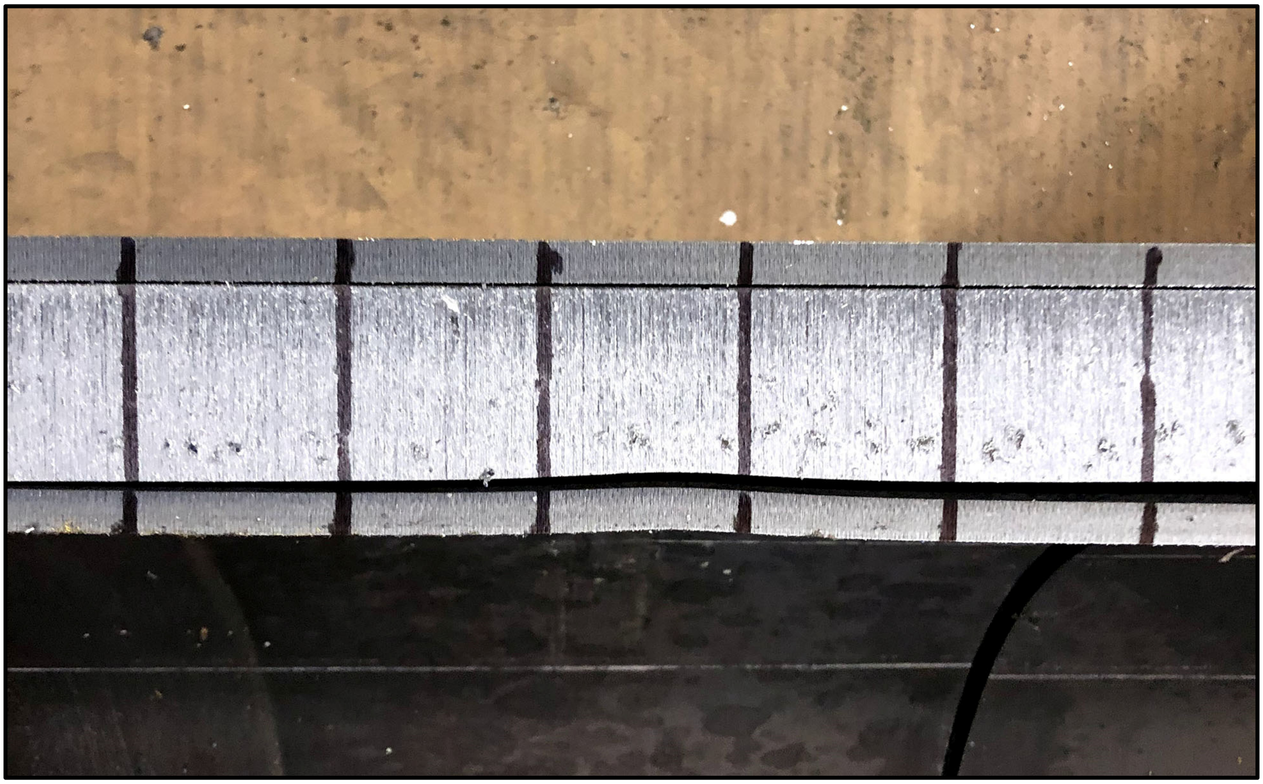

Figure 7-18 – SC-30G2 18TU-02 Destructive Disassembly Cut AT/AU at Axial Elevation 10.5

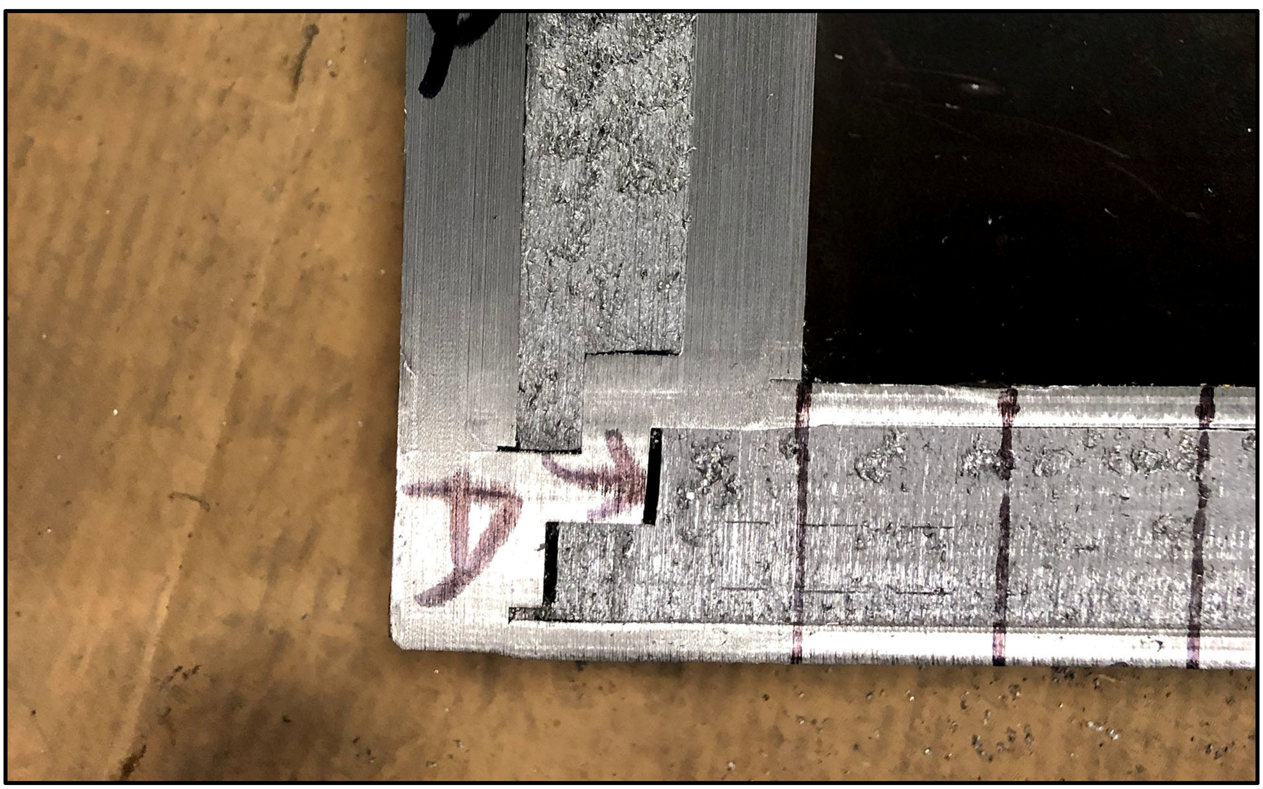

Figure 7-19 – SC-30G2 18TU-02 Destructive Disassembly Cut A at Lower Flange

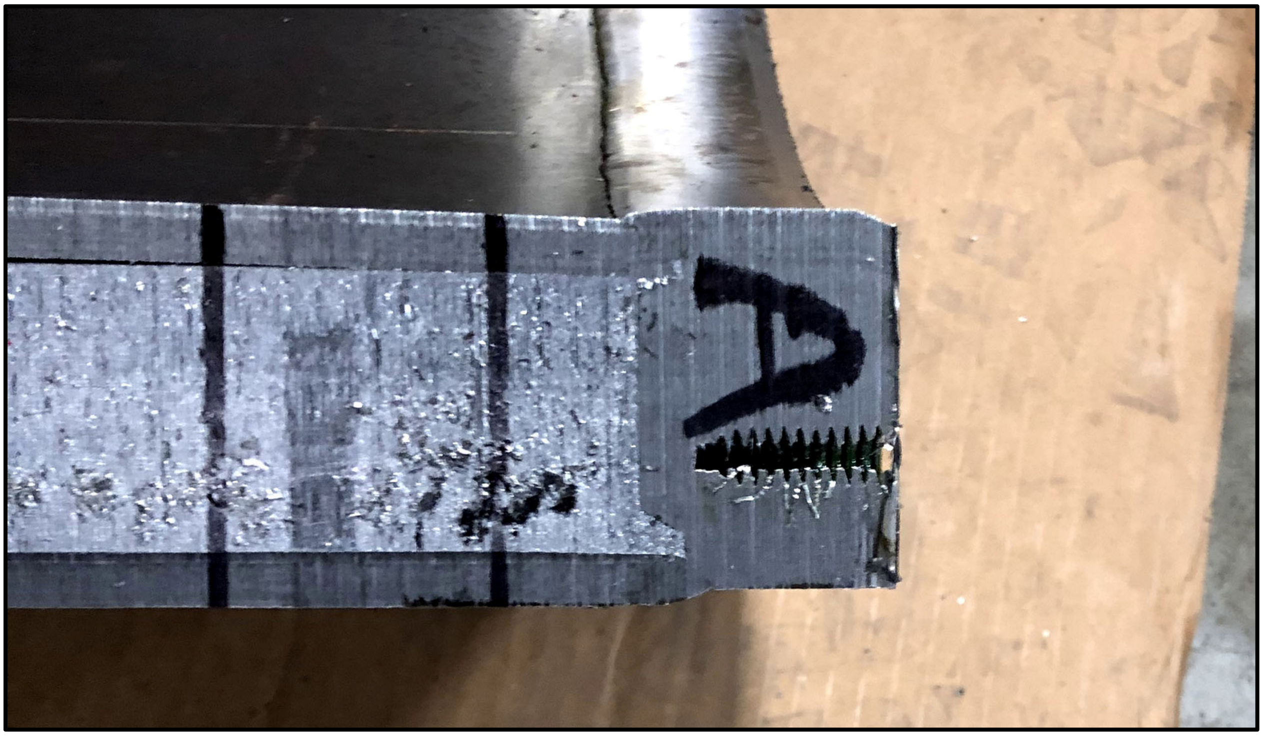

Figure 7-20 – SC-30G2 18TU-02 Destructive Disassembly Cut A at Lower Flange

With reference to Figure 7-18 and Table 7-1 for 18TU-02, axial location 10.5 at circumferential location AT/AU exhibits localized lead sidewall thinning to 1.35 inches due to horizontal side drop impact of the rigid concrete-filled rolling hoop of the payload drum, a condition that would not occur with the presence of the impact attenuating radial dunnage. Regardless, this post-drop test lead thicknesses still exceeds the 1.26-inch thickness assumed for the HAC shielding analyses in all locations. Further, it is observed that the small variations in lead thickness observed along the length and at varying circumferential positions identified post-test most likely reflect the state of the lead at pre-test conditions as opposed to changes resulting from free drop testing. In any event, the observed variations in gamma scan readings taken at the ends of the shielded container before and after free drop are of no significance relative to the shielding capabilities of the design.

7.1.3 SC-55G2 Type B HAC Evaluation

7.1.3.1 Confinement Integrity Testing

Two SC-55G2 test units, 18TU-09 and 18TU-10, were subjected to a series of 4-foot drop tests in an identical manner as conducted for the SC-30G2 design discussed in Section 7.1.2, *SC-30G2 Type B HAC Evaluation*. 18TU-09 was dropped in two orientations: a center-of-gravity over bottom corner drop and a bottom-down vertical end drop. 18TU-10 was also dropped in two orientations: a 10º near-vertical top-down drop and horizontal side drop. As shown in Figure 7-21 and Figure 7-22, vertical end drop damage to SC-55G2 18TU-09 was modest. Side drop damage to SC-55G2 18TU-10, as shown in Figure 7-23 and Figure 7-24, was a localized 3½-inch wide, 0.099-inch deep flat along the length of the container, a condition that would not occur with the presence of the impact attenuating lateral dunnage.

Figure 7-21 – SC-55G2 18TU-09 Vertical End Drop

Figure 7-22 – SC-55G2 18TU-09 Vertical End Drop Damage

Figure 7-23 – SC-55G2 18TU-10 Horizontal Side Drop Base-End Damage

Figure 7-24 – SC-55G2 18TU-10 Horizontal Side Drop Lid-End Damage

Subsequent ultraviolet scanning revealed no fluorescein dye on the SC-55G2 18TU-09 and 18TU-10 exteriors indicating that confinement integrity was maintained.

7.1.3.2 Shielding Integrity Testing

As previously discussed in Section 6.3, *SC-30G3 Shielding Integrity Testing*, pre- and post-drop shielding integrity testing involved the use of a Ludlum Model 3000 survey meter in conjunction with a Ludlum 44-10 two-inch diameter, sodium-iodide scintillator. A 3.6-curie Iridium-192 source was used for the pre-drop survey, and a 5.2-curie Iridium-192 source was used for the post-drop survey; the pre- and post-drop survey comparison was done by normalizing the results based on source strength.

As depicted in Figure 6-42 and Figure 7-25, a gridded overlay was used to facilitate measurement repeatability at the defined grid locations. The zero circumferential position was established at the outer shell's longitudinal seam weld and the zero axial position was set at the elevation of the inner surface of the base. Each axial row consisted of 65 sets of circumferential readings (A – BM), with 24 total axial rows (1.5 – 36.0). Therefore, for the reasons stated earlier, survey measurements taken below the 1.5 level and above the 36.0 level are inconsistent and correspondingly ignored.

The purpose of the shielding integrity testing was to evaluate any potential reduction in shielding effectiveness of the steel and lead composite body shielding resulting from the bare 4-foot drop tests that bound the 30-foot drop tests within the HalfPACT package. A shielding effectiveness change map was generated for each of the units by calculating the percent difference in measured dose rate at each grid location for the pre- and post-drop readings with a 20% change threshold selected to prompt further evaluation. Figure 7-26 and Figure 7-27 illustrate the pre-and post-drop test percent difference in measured dose rate for SC-55G2 18TU-09 and 18TU-10, respectively. As can be seen in Figure 7-26 and Figure 7-27, several locations at the lower axial and upper axial elevations show a percent difference that exceeds a 20% increase or reduction in shielding effectiveness that require further evaluation and are discussed further below, with all remaining grid locations indicating no appreciable change resulting from the drop events.

To supplement shield integrity testing results and determine the reasons for localized "hot spots" in the gamma scans for both test units, saw-cuts were made through SC-55G2 18TU-09 and 18TU-10. Due to the size limitation of the saw, the test unit was first cut in half axially, and then each half cut in half longitudinally (see Figure 7-28 for 18TU-09 and Figure 7-34 for 18TU-10).

With reference to Figure 7-25, Table 7-2 presents lead thickness measurements taken at locations along the length of the three axial slices for 18TU-09 and two axial slices for 18TU-10. As shown, post-drop test lead thicknesses significantly exceed the 1.78-inch thickness assumed for the HAC shielding analyses in all locations.

With respect to 18TU-09, a primary longitudinal saw-cut was made through the A-AG/AH circumferential location where a decrease of nearly 79% was indicated near the upper flange region (see Figure 7-29, Figure 7-30, Figure 7-31, and Figure 7-32), and a secondary longitudinal cut was made through the W/X circumferential location where a decrease of 22% was indicated near the lower flange region (see Figure 7-33). As shown in Figure 7-30 and Figure 7-33, a measured 0.318-inch axial gap is visible near the upper flange region at A, and a measured 0.193-inch axial gap is visible near the upper flange region at W/X; subsequent checking determined that the gap spans from AY to Z (i.e., approximately halfway around the circumference). It may be concluded that issues with the lead pour process again resulted in a cold shut during the lead pour process at the lead cavity base (since lead pouring is performed with the container inverted), and the void shifted from the lower flange region to the upper flange region during the vertical bottom-end drop event. A cold shut, and not lead slump, may be concluded for the following reasons:

1. A high-speed video recording of the vertical bottom-end drop event shows that the SC-55G1 18TU-09 impacted the target with nearly perfect vertical alignment; a large biased axial gap at the top of the lead column would have required a near-vertical impact orientation.
2. Lead slump, when it occurs, leaves a telltale bulging of the inner and/or outer shells near the bottom of the lead column; subsequent dimension inspections of the lead column thickness demonstrated that no bulging occurred (see Table 7-2).
3. Based on both unprotected 4-foot drop testing and protected 30-foot HAC drop testing, lead slump was not evident in either of the other (i.e., SC-30G2 or SC-30G3) designs.

The deep-set ends of the sidewall lead column at both the lower-flange and upper flange regions make small axial gaps inconsequential or, at least, having a much lesser effect. A detailed MCNP shielding model of the SC-55G2 was used to determine the effect of axial gaps present at the ends of the sidewall lead column. Using the baseline design radionuclide Cesium-137 in a uniformly distributed source geometry, an MCNP evaluation determined that the lower and upper flange axial gaps would have to exceed 0.25 and 0.17 inches, respectively, before the SC-55G2 surface dose at those axial gaps would become dominant; however, the effect of these axial gaps on dose rates at the HalfPACT package surface and 2-meters from the surface would be negligible.

Because high gamma scan dose rate readings occurred at an elevation more than 6 inches below the axial gap (i.e., the 31.5-inch elevation whereas the gap is located at the 37.5-inch elevation), and because the lead column thickness readings through these "hot spot" regions demonstrate no localized reduction in lead shield thickness (see Table 7-2), the conclusion is that these abnormally high readings are anomalous and without a clear understanding as to their cause. Although these anomalous high gamma scan readings have no apparent specific cause at this time, NWP believes that through additional analysis and review of the lead pouring process, along with additional rigorous lead pouring control process in our fabrication specification that is coupled with additional quality control hold points, the cause of these anomalies reflected in the post drop gamma scan of 18TU-09 will be eliminated and/or brought to within acceptable limits during the production of subsequent fabrication units.

With respect to SC-55G2 18TU-10, a single longitudinal cut was made between the AM/AN and E/F circumferential location which corresponds to the impact point for the 10º near-vertical top-down drop and horizontal side drop (see Figure 7-35, Figure 7-36, Figure 7-37, Figure 7-38, and Figure 7-39). With reference to Table 7-2 and Figure 7-39, the two "hot spots" shown in Figure 7-27 correspond to two separate occurrences of lifting rigging (i.e., shackles) becoming trapped beneath 18TU-10 during secondary impacts and are therefore assessed as atypical damage that would not normally occur had the rigging been omitted, as when configured for transport.

7.1.4 SC-30G2 and SC-55G2 Evaluation Summary

In summary, 4-foot drop testing of the SC-30G2 and SC-55G2 designs demonstrate their robust nature and ability to correspondingly perform acceptably for the Type B HAC regulatory 30-foot drop test events while maintaining confinement and shielding integrity.

Table 7-2 – SC-55G2 18TU-09 and 18TU-10 Sidewall Lead Thickness Measurements

Axial Elevation	Sidewall Lead Thickness (in)				
	SC-55G2 18TU-09			SC-55G2 18TU-10	
	Cut A	Cut AG/AH	Cut W/X	Cut AM/AN	Cut G
36.0	2.09	2.00	2.02	2.00	2.04
34.5	2.07	2.00	2.01	2.00	2.04
33.0	2.07	2.00	2.01	2.02	2.03
31.5	2.07	2.00	2.00	2.02	2.03
30.0	2.06	1.99	2.00	2.02	2.02
28.5	2.06	1.99	2.00	2.02	2.02
27.0	2.06	1.98	2.00	2.00	2.02
25.5	2.07	1.98	2.00	1.96	2.02
24.0	2.07	1.98	2.00	2.00	2.02
22.5	2.06	2.00	2.00	2.01	2.02
21.0	2.06	2.00	2.00	2.04	2.02
19.5	2.05	2.00	2.00	2.05	2.02
18.0	2.05	2.00	2.00	2.05	2.01
16.5	2.06	2.00	2.00	2.05	2.01
15.0	2.06	2.01	2.00	1.96	2.00
13.5	2.06	2.01	2.00	1.89	2.01
12.0	2.06	2.02	2.00	1.97	2.02
10.5	2.06	2.02	2.00	2.04	2.01
9.0	2.07	2.02	2.00	2.04	2.01
7.5	2.07	2.02	2.00	2.04	2.01
6.0	2.07	2.02	2.00	2.04	2.00
4.5	2.06	2.02	2.00	2.03	2.00
3.0	2.06	2.02	2.00	2.02	2.00
1.5	2.06	2.02	2.00	2.02	2.01

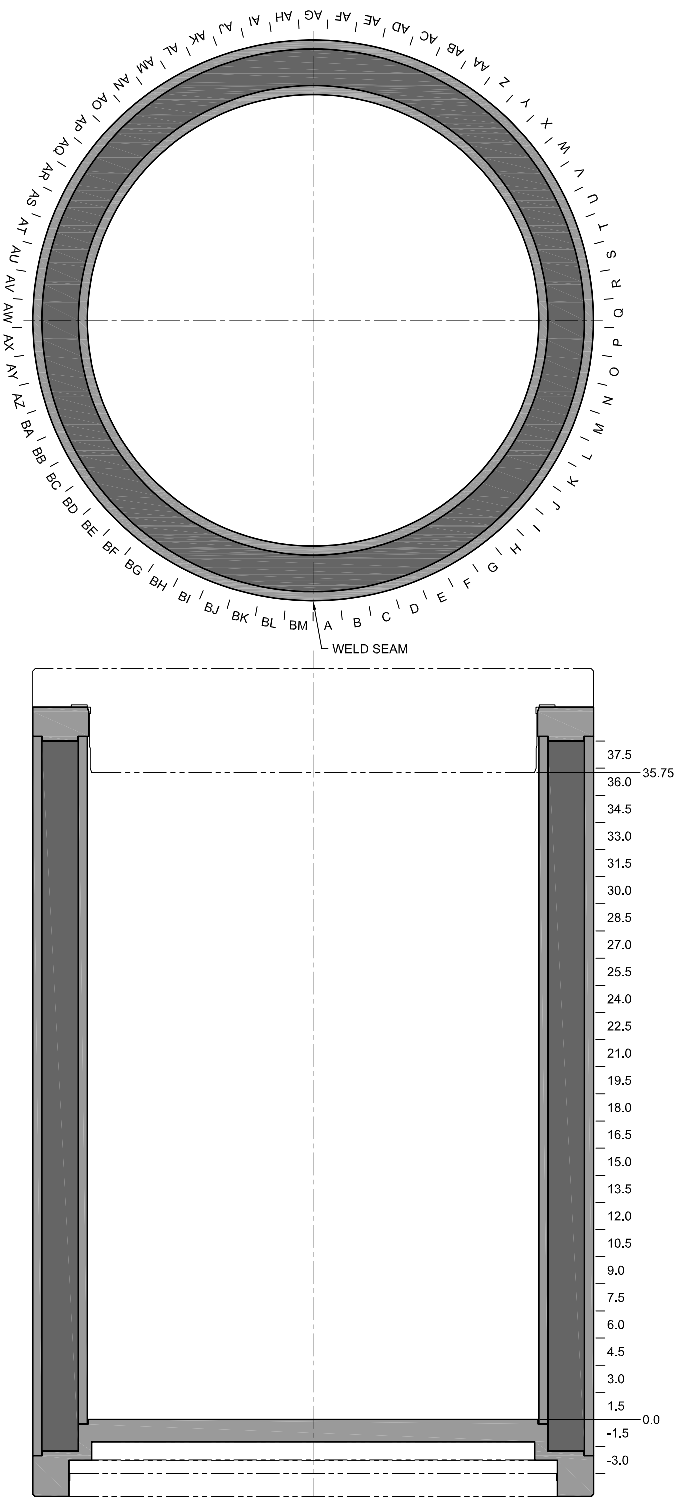

Figure 7-25 – SC-55G2 Circumferential and Axial Scan Grid Map

SC-55G2A TU18-09 Post Drop Shielding Evaluation; a Negative Number Indicates a Loss of Shielding																										
		Axial Elevation																								
Circumferential Grid Identifier		1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5	27.0	28.5	30.0	31.5	33.0	34.5	36.0
A	CUT	1.2%	10.0%	8.3%	6.2%	5.1%	4.9%	5.2%	4.7%	4.2%	3.0%	2.3%	1.2%	-0.3%	1.8%	0.5%	0.4%	-1.8%	-0.8%	-4.2%	-7.1%	-15.7%	-37.7%	-76.4%	-51.8%
B		5.9%	11.9%	10.8%	7.4%	7.4%	6.6%	5.5%	6.3%	4.4%	5.4%	5.4%	2.7%	0.6%	0.2%	-0.5%	-0.4%	-2.0%	-2.4%	-4.8%	-8.2%	-17.5%	-36.8%	-78.8%	-27.6%
C		6.5%	11.3%	11.4%	8.1%	9.4%	8.7%	8.0%	6.8%	6.1%	6.9%	5.9%	4.8%	4.0%	3.6%	3.6%	2.3%	1.3%	0.6%	-1.3%	-5.2%	-16.8%	-36.8%	-61.1%	-15.3%
D		9.3%	13.5%	9.5%	7.2%	7.2%	7.2%	6.7%	6.3%	5.8%	4.5%	4.3%	2.6%	1.8%	2.2%	0.8%	-0.5%	-0.2%	-1.6%	-4.2%	-6.2%	-13.1%	-32.7%	-54.6%	-20.1%
E		5.3%	13.0%	10.6%	9.4%	8.8%	8.8%	8.7%	7.4%	6.7%	6.7%	5.6%	5.3%	2.9%	2.2%	1.8%	1.8%	1.2%	-0.8%	-1.9%	-4.6%	-11.6%	-23.5%	-43.2%	-15.5%
F		6.0%	10.7%	10.4%	8.1%	8.1%	8.1%	6.1%	4.4%	4.3%	4.7%	4.7%	3.4%	1.8%	2.0%	1.3%	-0.1%	-0.1%	-0.7%	-3.5%	-5.1%	-12.3%	-25.6%	-39.0%	-11.6%
G		0.7%	10.2%	10.4%	8.0%	7.6%	7.6%	6.2%	5.5%	4.2%	4.2%	4.6%	4.6%	3.3%	2.9%	1.8%	0.9%	0.1%	0.4%	-1.3%	-3.8%	-9.5%	-18.0%	-30.8%	-9.0%
H		3.3%	10.2%	10.7%	8.9%	7.6%	7.3%	5.9%	3.8%	3.2%	3.9%	4.7%	3.4%	2.3%	1.9%	1.6%	0.2%	1.1%	-0.3%	-2.3%	-4.5%	-9.5%	-17.7%	-21.4%	-11.2%
I		0.0%	11.4%	9.6%	8.0%	8.2%	6.0%	4.9%	2.5%	2.5%	3.3%	5.6%	3.5%	2.0%	1.7%	0.9%	-0.1%	-0.1%	-0.5%	-2.3%	-4.1%	-8.4%	-14.8%	-17.7%	-13.8%
J		0.2%	6.8%	9.9%	9.2%	6.7%	4.6%	1.8%	1.5%	3.4%	4.8%	4.5%	2.7%	1.4%	0.3%	-0.5%	0.9%	-0.1%	-1.9%	-4.7%	-8.4%	-12.3%	-14.1%	-11.3%	-14.6%
K		-1.7%	6.2%	9.2%	8.7%	8.7%	7.5%	6.5%	3.3%	1.1%	4.0%	4.8%	4.8%	2.7%	1.4%	1.9%	0.5%	0.2%	-0.2%	-1.9%	-4.1%	-7.7%	-12.3%	-13.4%	-9.8%
L		3.1%	4.5%	9.6%	9.2%	7.8%	6.6%	3.0%	0.5%	-0.2%	2.3%	4.3%	4.1%	2.0%	2.0%	2.6%	0.8%	0.4%	0.1%	-1.3%	-3.4%	-9.1%	-13.4%	-14.1%	-4.0%
M		2.4%	4.2%	9.3%	7.9%	6.4%	4.5%	2.6%	1.5%	0.5%	2.3%	4.1%	3.7%	2.6%	2.3%	0.6%	0.2%	0.1%	-0.6%	-2.0%	-5.2%	-9.5%	-15.5%	-15.9%	-2.3%
N		0.8%	3.5%	8.2%	7.7%	7.0%	5.9%	4.1%	1.9%	1.2%	2.3%	3.0%	3.0%	2.4%	2.6%	1.9%	1.2%	0.2%	-0.6%	-1.0%	-4.1%	-8.7%	-14.8%	-16.7%	0.6%
O		-6.8%	2.7%	8.4%	7.9%	6.3%	5.5%	4.0%	2.6%	1.8%	3.3%	2.9%	2.9%	2.9%	2.6%	1.8%	0.5%	0.8%	-0.6%	-1.3%	-4.7%	-9.4%	-15.2%	-16.7%	-0.7%
P		-6.5%	6.6%	6.7%	6.4%	6.2%	5.7%	4.3%	2.9%	1.8%	2.9%	3.3%	2.6%	2.3%	2.3%	1.9%	0.9%	0.2%	-0.5%	-2.2%	-3.6%	-9.4%	-15.3%	-16.0%	-2.8%
Q		-10.1%	4.5%	6.8%	7.9%	7.0%	6.7%	5.3%	3.9%	2.9%	3.6%	3.6%	3.6%	3.0%	1.7%	2.3%	3.3%	1.3%	0.6%	-1.4%	-4.0%	-10.1%	-16.4%	-17.2%	-2.7%
R		-12.9%	4.0%	5.7%	7.0%	6.9%	6.5%	5.1%	4.5%	3.4%	2.0%	2.7%	3.1%	2.5%	2.8%	2.2%	1.5%	0.2%	-0.5%	-1.2%	-3.3%	-8.0%	-14.5%	-17.9%	-5.8%
S		-13.4%	2.9%	5.3%	7.5%	7.4%	6.0%	5.0%	4.9%	3.8%	3.1%	2.2%	3.2%	3.2%	2.6%	1.3%	1.7%	0.6%	0.0%	-1.0%	-3.8%	-7.4%	-13.8%	-16.3%	-4.5%
T		-15.6%	1.5%	4.4%	6.7%	6.0%	5.9%	5.2%	4.5%	3.8%	3.5%	2.2%	2.2%	1.9%	1.6%	1.2%	0.6%	0.6%	-0.4%	-1.7%	-2.8%	-8.7%	-14.1%	-15.6%	-1.5%
U		-12.0%	0.3%	4.1%	6.6%	5.7%	4.6%	3.9%	4.2%	3.5%	2.8%	1.9%	2.2%	0.9%	0.9%	1.2%	0.5%	-0.4%	-0.4%	-1.1%	-3.5%	-8.1%	-14.5%	-15.6%	-0.9%
V		-19.6%	-2.5%	3.2%	6.8%	6.1%	6.1%	4.5%	3.2%	2.5%	2.5%	1.9%	2.2%	0.9%	0.9%	1.2%	-0.4%	-0.1%	-1.4%	-1.1%	-4.2%	-8.1%	-13.0%	-13.4%	19.7%
W	CUT	-22.4%	-2.7%	2.8%	5.4%	5.3%	5.7%	5.5%	6.5%	4.3%	2.9%	3.2%	2.5%	2.2%	1.0%	1.0%	0.3%	0.6%	-0.1%	-0.7%	-1.1%	-2.1%	-3.4%	-6.6%	22.7%
X	CUT	-22.5%	-3.7%	1.5%	5.8%	6.1%	5.4%	4.5%	3.2%	3.2%	3.2%	2.3%	1.3%	0.7%	0.7%	0.0%	-0.4%	-1.0%	-1.0%	-2.7%	-4.1%	-7.3%	-10.9%	-10.9%	-2.7%
Y		-20.9%	-0.6%	1.0%	4.5%	4.1%	4.1%	2.7%	1.8%	2.1%	2.1%	1.1%	1.1%	0.2%	0.1%	-0.8%	-0.2%	-0.6%	-2.3%	-3.7%	-5.1%	-7.6%	-10.9%	-9.8%	-1.9%
Z		-19.0%	0.3%	3.3%	4.4%	4.7%	4.7%	3.0%	1.9%	1.9%	1.7%	0.7%	0.7%	0.7%	0.3%	-0.3%	-0.7%	-1.4%	-2.5%	-3.2%	-5.0%	-7.6%	-9.0%	-9.4%	0.9%
AA		7.4%	0.7%	3.5%	3.7%	3.9%	3.6%	2.5%	1.8%	1.8%	0.5%	1.1%	-0.6%	-0.6%	-0.9%	-2.0%	-0.6%	-1.7%	-2.4%	-4.9%	-5.7%	-8.3%	-9.7%	-7.2%	-0.4%
AB		13.2%	1.7%	4.1%	4.6%	4.3%	4.5%	3.8%	2.5%	2.7%	1.5%	1.5%	0.2%	1.1%	0.1%	-0.6%	-2.0%	-2.4%	-3.5%	-4.6%	-6.1%	-7.9%	-9.8%	-8.6%	-2.7%
AC		5.2%	3.4%	6.0%	5.5%	4.4%	4.9%	5.2%	4.0%	2.0%	2.0%	2.6%	2.6%	1.9%	1.6%	0.9%	0.2%	-0.8%	-1.6%	-4.0%	-5.1%	-7.6%	-8.4%	-5.5%	-0.5%
AD		-10.7%	5.2%	7.0%	5.7%	4.3%	2.9%	2.9%	2.5%	1.9%	1.5%	1.5%	1.8%	0.8%	0.1%	-0.8%	-2.2%	-2.2%	-3.9%	-4.6%	-5.7%	-7.1%	-7.5%	-6.0%	-3.6%
AE		-15.6%	5.1%	9.7%	8.6%	8.2%	8.8%	7.2%	6.7%	6.3%	5.1%	5.7%	5.1%	3.8%	3.4%	2.3%	2.5%	1.3%	1.6%	-0.2%	-0.5%	-2.4%	-3.6%	-1.3%	5.0%
AF		-24.0%	-7.2%	-1.0%	3.7%	3.8%	2.9%	1.0%	0.7%	0.1%	0.0%	-0.5%	-0.5%	-2.0%	-2.2%	-2.5%	-3.7%	4.6%	-4.1%	-4.1%	-5.3%	-1.8%	-5.6%	-4.5%	-4.8%
AG	CUT	-24.9%	-3.4%	-0.4%	0.1%	-1.3%	-1.3%	-1.8%	-3.8%	-2.5%	-2.8%	-3.4%	-3.8%	-5.1%	-4.4%	-4.8%	-5.8%	-6.1%	-6.4%	-7.1%	-7.8%	-8.2%	-7.2%	-4.1%	-3.2%
AH	CUT	-12.0%	-0.6%	2.5%	2.3%	1.8%	1.4%	0.4%	-0.4%	-0.1%	-0.7%	-1.1%	-1.7%	-1.6%	-3.0%	-3.4%	-3.4%	-3.5%	-3.5%	-4.9%	-5.3%	-6.0%	-6.0%	-3.5%	0.6%
AI		-13.3%	0.1%	2.9%	2.0%	0.9%	1.2%	0.5%	0.0%	-0.3%	-0.7%	-1.4%	-2.1%	-1.4%	-2.8%	-2.5%	-3.6%	-3.2%	-4.0%	-5.1%	-5.5%	-6.6%	-6.6%	-4.1%	0.8%
AJ		-11.5%	0.3%	2.0%	1.6%	1.1%	-0.4%	-0.1%	-1.6%	-1.6%	-0.9%	-2.0%	-2.0%	-2.8%	-2.8%	-3.5%	-3.2%	-4.2%	-5.3%	-5.8%	-6.5%	-7.2%	-6.2%	-4.7%	2.7%
AK		-12.9%	3.4%	4.7%	4.3%	2.4%	1.6%	0.5%	-0.2%	0.1%	-0.8%	-0.8%	-0.8%	-1.9%	-2.0%	-2.0%	-2.3%	-2.0%	-2.8%	-4.2%	-4.3%	-5.4%	-6.5%	-4.0%	3.4%
AL		-11.5%	4.7%	9.7%	3.6%	3.8%	2.3%	1.6%	1.2%	0.1%	0.1%	-0.4%	-0.8%	-1.5%	-1.6%	-0.9%	-2.8%	-3.5%	-2.8%	-4.2%	-5.4%	-5.8%	-6.2%	-4.8%	-1.1%
AM		-12.0%	5.1%	10.7%	4.2%	4.1%	3.0%	1.6%	1.8%	0.7%	0.0%	0.9%	-0.2%	-0.2%	-1.7%	-1.4%	-1.7%	-2.2%	-2.9%	-4.0%	-5.5%	-5.5%	-6.6%	-5.6%	-0.7%
AN		-10.6%	7.9%	10.2%	6.1%	3.9%	3.1%	2.4%	1.7%	0.6%	1.2%	0.5%	-0.3%	0.0%	-1.1%	-0.5%	-1.2%	-1.6%	-2.7%	-4.1%	-4.5%	-5.6%	-6.0%	-5.3%	-0.1%
AO		-8.9%	8.0%	8.8%	5.7%	4.3%	3.9%	1.8%	1.8%	1.5%	1.8%	1.4%	0.7%	-0.1%	-0.8%	-1.6%	-2.1%	-2.8%	-2.8%	-4.2%	-5.6%	-6.7%	-6.8%	-5.4%	-0.3%
AP		-12.9%	8.0%	8.1%	4.6%	3.6%	3.2%	2.7%	2.4%	1.3%	1.3%	1.6%	0.9%	0.9%	-0.2%	-0.6%	-2.1%	-2.8%	-3.2%	-4.3%	-5.0%	-6.4%	-7.1%	-6.4%	-1.6%
AQ		-8.9%	3.7%	8.5%	4.6%	4.2%	3.1%	3.4%	2.3%	1.9%	1.2%	0.9%	0.5%	-0.2%	0.1%	-0.7%	-1.1%	-1.8%	-3.5%	-4.5%	-6.3%	-7.1%	-7.8%	-6.7%	-3.8%
AR		-12.4%	4.4%	8.5%	5.3%	4.5%	4.1%	3.0%	2.3%	1.6%	1.1%	1.1%	0.8%	0.1%	-0.3%	0.6%	-0.8%	-2.1%	-3.2%	-4.2%	-4.6%	-7.4%	-7.8%	-6.8%	-2.1%
AS		-12.9%	5.0%	9.0%	5.7%	4.5%	3.8%	2.7%	3.4%	1.9%	1.5%	0.8%	1.4%	0.4%	0.0%	-0.7%	-0.1%	-1.1%	-2.2%	-4.3%	-6.0%	-8.1%	-9.5%	-7.5%	-2.4%
AT		-17.7%	6.7%	10.1%	4.8%	5.4%	5.1%	4.1%	3.3%	2.2%	2.1%	1.1%	1.3%	0.4%	0.6%	-0.4%	-0.8%	-0.6%	-2.6%	-4.3%	-5.4%	-7.8%	-8.5%	-7.8%	-2.4%
AU		-16.7%	8.5%	11.1%	6.6%	5.7%	4.9%	3.6%	2.7%	1.3%	0.9%	0.8%	0.0%	0.6%	-0.1%	-0.1%	-0.1%	-1.2%	-2.2%	-4.3%	-5.7%	-6.8%	-8.9%	-7.1%	-4.1%
AV		-14.3%	10.6%	11.1%	7.7%	6.8%	4.8%	4.6%	3.5%	2.4%	2.9%	1.5%	1.7%	1.3%	0.4%	1.2%	0.5%	-1.1%	-2.2%	-4.3%	-6.1%	-7.5%	-8.5%	-8.5%	-4.1%
AW		-17.2%	10.6%	10.9%	7.4%	6.7%	5.8%	4.8%	3.9%	2.5%	2.0%	1.0%	0.9%	1.1%	1.1%	0.1%	0.4%	-0.4%	-2.2%	-3.6%	-5.7%	-7.8%	-9.5%	-8.5%	-6.9%
AX		-11.5%	11.6%	12.9%	8.5%	6.7%	5.8%	5.0%	4.3%	3.2%	2.5%	2.1%	1.6%	1.5%	0.2%	0.8%	-0.4%	0.3%	-2.1%	-3.2%	-5.0%	-8.8%	-8.8%	-9.9%	-8.7%
AY		-13.4%	10.7%	12.5%	8.4%	7.2%	5.7%	4.9%	4.2%	3.1%	3.3%	2.9%	2.1%	1.1%	1.3%	0.3%	-0.4%	-1.5%	-1.6%	-3.0%	-4.1%	-8.5%	-10.9%	-10.3%	-9.2%
AZ		-14.8%	11.7%	13.4%	8.1%	6.9%	5.5%	5.4%	5.0%	3.3%	3.8%	2.7%	2.6%	1.6%	1.2%	0.2%	0.1%	-1.0%	-2.1%	-3.1%	-4.6%	-7.3%	-12.0%	-12.0%	-10.9%
BA		-11.1%	12.7%	14.2%	8.7%	6.7%	6.5%	5.4%	4.2%	3.9%	2.7%	2.0%	1.2%	1.5%	0.5%	0.4%	-0.1%	-0.8%	-1.2%	-4.3%	-6.0%	-10.0%	-12.6%	-13.9%	-8.9%
BB		-7.5%	12.2%	13.1%	7.9%	6.8%	4.7%	4.0%	3.9%	2.8%	2.4%	1.6%	1.5%	1.1%	-0.6%	0.0%	-1.5%	-1.5%	-2.2%	-4.3%	-7.3%	-10.3%	-16.2%	-18.8%	-8.0%
BC		-10.6%	13.9%	13.1%	6.9%	6.1%	5.0%	4.0%	3.3%	1.8%	2.4%	1.0%	0.5%	0.1%	-0.2%	-0.3%	-1.7%	-2.4%	-2.2%	-5.3%	-8.6%	-13.6%	-22.4%	-23.6%	-9.3%
BD		-8.3%	14.1%	13.1%	7.3%	6.1%	5.4%	4.7%	3.6%	2.1%	2.4%	1.3%	1.0%	0.9%	-0.1%	-0.2%	-1.0%	-1.1%	-2.8%	-4.6%	-8.6%	-13.9%	-25.4%	-30.2%	-10.6%
BE		-9.7%	11.3%	13.6%	8.4%	6.6%	5.1%	4.1%	3.7%	2.6%	1.2%	0.9%	1.1%	-0.3%	0.0%	0.3%	-0.8%	-0.9%	-3.7%	-6.1%	-7.6%	-15.0%	-27.1%	-36.9%	-13.3%
BF		-4.9%	11.1%	12.7%	8.8%	7.4%	6.0%	4.9%	3.8%	2.5%	1.8%	2.4%	0.6%	0.2%	-0.8%	-0.9%	-0.7%	-1.4%	-2.9%	-5.0%	-9.9%	-16.8%	-18.8%	-44.9%	-14.1%
BG		-2.3%	11.2%	12.0%	8.0%	7.2%	5.8%	5.1%	4.0%	2.9%	3.2%	1.5%	0.7%	0.3%	0.2%	-1.2%	-0.9%	-2.0%	-3.4%	-3.9%	-7.7%	-15.8%	-30.9%	-44.1%	-17.6%
BH		-1.3%	10.4%	11.9%	7.5%	6.8%	5.6%	5.2%	3.8%	3.0%	2.6%	2.2%	1.4%	1.3%	0.2%	-0.5%	-0.5%	-0.6%	-2.0%	-4.1%	-8.0%	-15.2%	-28.5%	-47.2%	-22.1%
BI		2.2%	10.1%	10.9%	6.7%	7.5%	7.2%	5.3%	4.1%	3.4%	2.9%	2.5%	2.1%	1.7%	0.7%	-0.1%	0.2%	-0.8%	-1.9%	-3.7%	-8.7%	-15.6%	-32.2%	-50.9%	-18.6%
BJ		-2.8%	10.4%	10.9%	6.4%	6.3%	5.5%	5.7%	4.2%	2.4%	2.7%	1.8%	1.1%	1.0%	1.0%	-0.7%	-0.7%	-2.1%	-3.2%	-5.3%	-8.7%	-15.7%	-34.1%	-58.3%	-23.8%
BK		4.3%	8.7%	10.6%	7.3%	7.8%	6.7%	4.8%	4.7%	3.9%	3.4%	2.3%	0.8%	0.1%	-0.9%	-0.9%	-0.9%	-2.0%	-3.0%	-4.1%	-7.8%	-16.2%	-31.0%	-58.0%	-33.0%
BL		3.0%	10.3%	8.5%	6.0%	5.9%	5.1%	4.6%	3.4%	2.6%	2.1%	1.7%	0.2%	0.2%	-0.2%	-2.0%	-1.2%	-3.8%	-3.8%	-6.4%	-9.2%	-17.2%	-34.0%	-64.3%	-37.9%
BM		0.7%	10.0%	9.3%	7.2%	6.7%	7.0%	5.8%	5.6%	5.5%	3.6%	2.5%	2.1%	-0.1%	-0.5%	-1.2%	-1.2%	-2.3%	-3.5%	-5.4%	-9.1%	-16.1%	-36.4%	-65.0%	-35.0%
MAX		13.2%	13.5%	13.4%	9.4%	9.4%	8.8%	8.7%	7.4%	6.7%	6.9%	5.9%	5.3%	4.0%	3.6%	3.6%	3.3%	4.6%	1.6%	-0.2%	-0.5%	-1.8%	-3.4%	-1.3%	22.7%
MIN		-24.9%	-7.2%	-1.0%	0.1%	-1.3%	-1.3%	-1.8%	-3.8%	-2.5%	-2.8%	-3.4%	-3.8%	-5.1%	-4.4%	-4.8%	-5.8%	-6.1%	-6.4%	-7.1%	-8.4%	-17.5%	-36.8%	-78.8%	-27.6%
AVG		-8.3%	5.1%	7.4%	6.2%	5.6%	4.9%	3.9%	3.0%	2.3%	2.3%	2.2%	1.7%	1.0%	0.6%	0.2%	-0.4%	-0.8%	-1.8%	-3.2%	-5.5%	-9.4%	-15.0%	-19.5%	-6.7%

Figure 7-26 – SC-55G2 18TU-09 Pre-Drop/Post-Drop Dose Rate Change Comparison

SC-55G2B TU18-10 Post Drop Shielding Evaluation; a Negative Number Indicates a Loss of Shielding

		Axial Elevation																							
Circumferential Grid Identifier		1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5	27.0	28.5	30.0	31.5	33.0	34.5	36.0
A		18.5%	-2.1%	-1.1%	-1.4%	-1.0%	-1.0%	-0.3%	0.0%	0.4%	0.0%	0.7%	0.4%	0.4%	1.0%	1.4%	1.4%	3.2%	2.6%	4.5%	4.6%	4.0%	5.6%	6.1%	5.5%
B		12.7%	-4.2%	-1.0%	-4.5%	-4.1%	-2.7%	-0.5%	-0.9%	-1.3%	-0.9%	-0.9%	-0.2%	-0.2%	0.2%	0.5%	1.5%	0.8%	1.3%	2.9%	3.0%	2.7%	3.3%	3.9%	4.9%
C		9.5%	-5.5%	-5.2%	-1.4%	-0.7%	0.4%	0.4%	0.3%	0.6%	0.6%	0.3%	0.6%	0.6%	0.6%	1.6%	1.9%	1.3%	3.1%	3.8%	3.4%	4.1%	5.6%	6.5%	6.4%
D		10.4%	-4.8%	-3.0%	-0.7%	-0.4%	-0.4%	1.6%	1.3%	1.6%	1.9%	1.9%	0.9%	1.6%	1.6%	1.6%	1.6%	1.4%	2.9%	3.3%	4.1%	4.1%	4.2%	5.4%	4.8%
E	CUT	10.1%	-3.7%	-5.7%	-0.1%	-0.1%	0.6%	1.0%	1.6%	1.6%	1.6%	1.6%	2.3%	1.3%	1.6%	1.7%	2.2%	2.2%	3.3%	4.1%	4.1%	5.0%	5.4%	5.8%	5.5%
F	CUT	9.7%	-3.7%	-6.5%	-0.2%	0.2%	0.9%	1.3%	1.6%	2.0%	1.6%	1.6%	2.0%	1.6%	1.4%	2.2%	3.2%	2.9%	3.9%	4.6%	4.3%	4.6%	6.7%	6.5%	5.0%
G		10.8%	-6.5%	-6.1%	0.2%	0.6%	1.3%	1.6%	1.6%	2.0%	2.0%	2.0%	2.0%	2.0%	2.7%	3.5%	3.8%	3.1%	3.5%	3.8%	3.8%	4.2%	6.3%	7.3%	7.1%
H		11.6%	-7.6%	-6.5%	0.6%	0.9%	1.4%	1.4%	1.1%	1.1%	2.4%	1.8%	2.4%	2.4%	2.5%	3.5%	3.2%	3.8%	3.5%	4.2%	4.2%	4.5%	6.5%	7.1%	8.2%
I		13.4%	-8.0%	-4.6%	1.9%	1.3%	1.6%	2.4%	1.7%	2.1%	2.2%	2.8%	2.8%	2.5%	2.5%	3.5%	3.5%	3.2%	4.2%	4.2%	4.5%	4.8%	7.1%	8.9%	9.5%
J		14.1%	1.0%	-5.4%	0.9%	1.6%	1.6%	2.4%	2.1%	2.4%	2.4%	2.4%	2.8%	2.5%	2.5%	2.9%	4.2%	4.2%	4.2%	4.2%	4.2%	5.8%	7.5%	8.8%	8.9%
K		15.4%	1.9%	0.2%	2.2%	2.2%	2.9%	3.3%	3.6%	3.3%	2.6%	4.0%	4.4%	4.1%	4.5%	4.5%	4.1%	4.7%	5.1%	5.1%	5.3%	5.3%	6.4%	8.7%	9.9%
L		16.2%	1.6%	1.1%	2.5%	2.6%	2.9%	2.2%	2.9%	2.2%	1.1%	1.9%	2.7%	3.7%	3.4%	4.7%	4.4%	4.7%	5.1%	5.1%	5.1%	5.3%	7.1%	9.6%	10.0%
M		16.2%	2.5%	1.4%	1.9%	2.1%	2.1%	2.1%	3.1%	2.1%	1.4%	3.4%	3.8%	4.2%	3.6%	4.5%	4.5%	4.5%	5.5%	5.9%	6.9%	6.6%	7.6%	9.3%	10.5%
N		15.1%	0.8%	0.3%	2.1%	2.8%	2.4%	2.1%	2.3%	2.0%	0.9%	2.0%	3.4%	3.5%	4.2%	4.1%	4.8%	5.1%	5.8%	6.2%	5.6%	5.9%	7.5%	9.8%	11.2%
O		11.3%	-2.8%	-1.9%	2.3%	1.3%	1.9%	1.9%	1.6%	0.5%	-0.6%	1.1%	2.6%	2.6%	3.7%	4.0%	4.0%	4.7%	4.5%	5.2%	6.4%	6.6%	6.8%	9.3%	11.1%
P		7.0%	-1.9%	-4.7%	-0.8%	-0.1%	0.2%	-0.2%	-1.5%	-1.3%	-4.0%	-1.2%	0.6%	1.3%	1.3%	0.6%	1.0%	0.4%	1.4%	2.5%	3.2%	2.9%	2.8%	6.4%	8.9%
Q		8.2%	-4.4%	-6.1%	-1.2%	-1.3%	0.0%	-0.6%	-1.3%	-2.1%	-4.8%	-2.4%	0.7%	1.4%	1.1%	-0.2%	-0.2%	0.2%	-0.1%	0.6%	2.0%	3.0%	3.3%	8.1%	6.8%
R		14.1%	-1.2%	-0.7%	0.8%	0.0%	0.6%	0.6%	-1.0%	-2.8%	-4.8%	-2.1%	0.0%	0.1%	1.5%	1.5%	0.9%	1.6%	2.6%	2.7%	3.7%	4.2%	5.0%	5.5%	6.6%
S		16.7%	0.1%	-0.4%	0.5%	1.1%	0.3%	-0.9%	-0.6%	-2.4%	-3.7%	-1.0%	1.4%	0.2%	0.5%	2.3%	2.6%	3.3%	4.0%	4.1%	3.7%	4.8%	5.6%	5.9%	5.9%
T		13.5%	0.9%	-2.0%	0.9%	0.2%	0.1%	-0.9%	-0.3%	-0.6%	-2.7%	-0.6%	1.1%	1.1%	1.6%	2.6%	3.6%	3.7%	3.7%	4.1%	4.7%	4.2%	4.7%	5.3%	5.9%
U		14.7%	-1.8%	-1.5%	0.8%	0.5%	-0.2%	0.4%	0.0%	-0.9%	-1.3%	0.1%	0.8%	1.5%	2.2%	2.6%	2.6%	3.3%	4.0%	3.7%	3.7%	3.5%	5.2%	6.4%	6.6%
V		8.2%	-1.6%	-6.2%	-0.3%	-0.3%	0.3%	0.0%	0.4%	0.4%	0.0%	0.5%	1.1%	0.9%	1.2%	1.9%	2.3%	2.7%	3.0%	2.1%	2.4%	2.5%	1.9%	3.4%	4.7%
W		7.3%	-0.9%	-6.9%	0.5%	0.8%	0.8%	-0.1%	0.3%	0.6%	1.3%	0.7%	1.4%	2.0%	1.4%	3.1%	4.1%	3.5%	3.3%	2.7%	3.6%	2.6%	3.0%	3.6%	5.8%
X		8.1%	-2.5%	-8.3%	0.1%	-0.5%	-0.2%	0.2%	-0.5%	0.5%	1.2%	1.2%	1.3%	2.3%	1.7%	2.4%	3.7%	3.5%	2.9%	4.2%	3.5%	3.6%	3.7%	4.5%	5.4%
Y		8.7%	-2.1%	-7.9%	0.0%	0.4%	0.7%	0.4%	0.8%	0.1%	0.5%	1.5%	1.6%	1.2%	2.2%	2.0%	3.2%	3.2%	2.5%	3.8%	3.1%	2.1%	2.9%	3.0%	3.6%
Z		7.5%	-1.8%	-6.9%	-0.3%	-0.2%	-0.2%	-0.1%	0.5%	0.2%	0.9%	0.3%	1.6%	0.7%	1.4%	2.6%	3.0%	2.7%	3.4%	3.8%	2.5%	2.3%	1.6%	2.8%	4.2%
AA		6.3%	-2.1%	-7.3%	-1.7%	-1.4%	-1.0%	-1.0%	-0.4%	-0.4%	0.3%	0.0%	-0.6%	-0.6%	-0.2%	-0.2%	1.1%	1.8%	2.5%	1.8%	1.8%	0.2%	0.9%	2.1%	1.6%
AB		7.7%	-2.3%	-7.6%	-1.7%	-1.0%	-2.0%	-1.9%	-1.6%	-1.6%	-0.5%	-0.2%	-0.5%	-0.5%	-0.2%	0.5%	1.1%	-0.1%	0.9%	0.9%	0.6%	-0.7%	0.4%	-0.2%	1.4%
AC		6.5%	-4.5%	-7.2%	-2.9%	-2.9%	-2.6%	-1.9%	-1.9%	-1.8%	-2.2%	-1.5%	-1.1%	-1.1%	-0.1%	0.2%	-0.8%	0.3%	0.3%	0.9%	1.2%	0.9%	-0.1%	0.4%	2.0%
AD		5.3%	-3.6%	-6.6%	-3.6%	-3.6%	-3.9%	-3.6%	-2.1%	-2.1%	-3.2%	-1.8%	-1.5%	-0.8%	-0.4%	-0.4%	-1.4%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.3%	0.8%	3.2%
AE		5.9%	-4.5%	-6.6%	-4.0%	-4.3%	-4.0%	-2.9%	-2.2%	-2.5%	-2.2%	-2.5%	-1.8%	-1.8%	-1.5%	-1.1%	-0.8%	-1.5%	0.3%	1.2%	0.5%	-0.8%	-1.0%	-0.5%	1.8%
AF		5.5%	-2.0%	-6.9%	-3.4%	-3.4%	-3.4%	-3.7%	-2.0%	-2.0%	-1.7%	-1.6%	-2.0%	-2.0%	-1.3%	-0.6%	0.7%	0.7%	1.4%	1.3%	0.9%	-0.2%	0.4%	1.5%	3.3%
AG		7.1%	-4.0%	-6.6%	-2.8%	-2.8%	-3.1%	-2.5%	-1.8%	-1.8%	-1.5%	-1.4%	-0.8%	-0.1%	-1.1%	-0.8%	0.5%	-0.1%	2.4%	2.3%	0.1%	-1.4%	0.4%	1.0%	2.5%
AH		13.9%	-4.9%	-6.9%	-3.4%	-2.7%	-2.1%	-3.7%	-2.7%	-2.0%	-1.4%	-1.7%	-1.7%	-1.7%	-2.1%	-0.8%	0.2%	-0.1%	0.5%	0.5%	-0.9%	-1.4%	-1.3%	-0.4%	1.0%
AI		12.9%	-2.0%	-2.8%	-0.8%	-0.9%	-0.9%	0.2%	0.5%	0.1%	-0.2%	0.5%	1.1%	0.0%	0.4%	0.4%	2.3%	1.1%	1.4%	1.6%	0.3%	-0.1%	0.6%	2.1%	1.6%
AJ		6.6%	1.4%	-0.2%	-0.2%	0.1%	-0.9%	-0.9%	0.1%	0.1%	0.1%	0.5%	-0.2%	-0.3%	-0.3%	0.1%	1.4%	2.3%	2.3%	0.6%	0.2%	-0.7%	0.5%	2.1%	2.5%
AK		8.7%	0.7%	-0.1%	-0.4%	0.3%	0.6%	1.0%	1.0%	0.6%	-0.4%	0.3%	0.3%	-0.2%	-1.2%	-1.3%	-3.5%	-3.6%	-1.8%	0.0%	-0.7%	-1.7%	-0.2%	0.1%	0.6%
AL		8.8%	-2.3%	-3.8%	0.0%	0.0%	0.7%	1.1%	-1.5%	-3.7%	-4.5%	-1.5%	1.3%	-0.2%	-0.2%	-3.5%	-12.1%	-19.0%	-10.7%	-1.8%	-0.8%	-2.1%	-1.0%	-1.0%	1.9%
AM	CUT	8.8%	-1.3%	-4.1%	0.0%	0.3%	0.6%	-0.5%	-7.4%	-18.3%	-16.9%	-4.9%	-0.6%	-0.6%	-1.3%	-4.2%	-14.3%	-25.4%	-13.1%	-1.9%	-1.5%	-1.2%	-2.2%	-0.7%	1.3%
AN	CUT	11.1%	1.5%	-3.5%	0.3%	0.3%	-0.5%	-2.3%	-14.7%	-31.4%	-27.6%	-8.2%	-1.3%	-1.3%	-0.4%	-1.8%	-6.1%	-11.4%	-6.8%	-1.6%	-1.2%	-1.3%	-2.3%	-0.9%	2.0%
AO		11.5%	-3.0%	-4.2%	0.3%	0.3%	0.6%	-1.3%	-8.2%	17.8%	21.0%	-5.0%	-1.0%	-0.4%	-0.4%	-0.1%	-0.8%	-1.2%	-0.2%	0.7%	-0.6%	-2.0%	-1.7%	-0.6%	1.6%
AP		9.6%	-0.9%	-6.0%	0.3%	-0.8%	0.5%	-0.2%	0.7%	-1.1%	-0.7%	1.1%	0.6%	-0.7%	-0.4%	0.2%	-0.2%	0.8%	1.0%	0.3%	-1.4%	-1.4%	-0.8%	-0.1%	1.6%
AQ		2.5%	-3.3%	-3.8%	0.3%	0.2%	0.8%	0.1%	1.8%	2.5%	2.5%	1.4%	0.0%	-0.4%	-0.8%	-0.1%	0.1%	-0.6%	-0.1%	-0.5%	-0.1%	-0.8%	-0.5%	-1.8%	-0.2%
AR		4.7%	-2.6%	-9.6%	-0.4%	-0.5%	0.5%	1.1%	-0.2%	0.8%	1.6%	1.1%	0.4%	-0.4%	-0.4%	-1.8%	0.7%	-0.4%	-0.1%	-0.1%	0.2%	0.8%	-0.3%	0.1%	0.6%
AS		4.6%	-4.1%	-6.0%	-1.5%	-0.5%	-0.5%	-0.2%	0.1%	0.1%	1.2%	1.4%	0.7%	0.6%	0.5%	0.5%	0.0%	0.9%	0.8%	0.5%	0.8%	1.2%	2.0%	0.4%	1.6%
AT		4.3%	-4.0%	-5.3%	-1.1%	-1.2%	-1.3%	0.1%	0.0%	0.0%	0.0%	0.2%	0.5%	-0.9%	-0.9%	-1.3%	-0.8%	-0.8%	-0.5%	-0.6%	0.0%	-0.3%	0.4%	0.4%	1.8%
AU		5.2%	-4.7%	-6.0%	-0.5%	0.2%	-0.9%	-0.7%	-1.0%	-0.3%	0.4%	0.2%	0.7%	0.7%	-0.7%	-0.1%	-0.5%	-0.5%	0.4%	0.9%	0.6%	0.2%	0.2%	1.5%	2.8%
AV		7.8%	-1.5%	-6.0%	-1.5%	-1.2%	-1.3%	-1.7%	-1.7%	-1.7%	0.3%	-0.2%	-1.3%	-1.7%	-0.8%	-0.8%	-2.5%	-1.3%	-1.0%	0.2%	-0.5%	-1.8%	-0.3%	-0.1%	1.7%
AW		7.4%	-3.3%	-6.7%	-1.2%	-1.0%	-1.0%	-2.4%	-2.1%	-1.5%	-1.2%	-1.6%	-2.0%	-1.4%	-2.1%	-1.5%	-1.5%	-1.0%	-0.4%	-0.5%	-0.6%	-1.2%	-0.6%	-0.1%	2.1%
AX		9.8%	-2.5%	-7.8%	-1.3%	-2.3%	-2.4%	-3.8%	-2.5%	-3.6%	-3.6%	-3.0%	-3.4%	-3.1%	-2.8%	-2.1%	-2.5%	-1.9%	-1.7%	-1.5%	-1.2%	-1.3%	-2.2%	-0.5%	1.5%
AY		9.5%	-4.6%	-8.5%	-2.3%	-2.0%	-3.1%	-2.4%	-2.8%	-3.2%	-2.9%	-2.3%	-2.0%	-3.0%	-2.0%	-1.4%	-1.2%	-1.9%	-0.7%	-1.1%	-1.8%	-2.4%	-1.8%	-0.1%	1.4%
AZ		11.3%	-2.8%	-9.2%	-2.3%	-3.4%	-3.4%	-3.8%	-3.4%	-3.8%	-3.1%	-2.1%	-2.5%	-2.6%	-2.3%	-2.3%	-2.4%	-2.8%	-1.9%	-2.2%	-2.3%	-2.0%	-1.4%	0.9%	1.7%
BA		11.9%	-3.5%	-8.5%	-2.9%	-2.0%	-3.1%	-3.8%	-2.4%	-2.4%	-2.1%	-1.1%	-2.2%	-1.9%	-1.3%	-1.4%	-1.8%	-1.2%	-1.2%	-1.5%	-1.5%	-0.6%	0.6%	1.0%	1.4%
BB		12.3%	-2.8%	-9.2%	-2.6%	-3.4%	-4.1%	-3.8%	-3.5%	-4.9%	-3.2%	-2.8%	-2.8%	-3.2%	-2.6%	-2.6%	-1.7%	-2.1%	-1.3%	-1.7%	-2.0%	0.5%	1.0%	1.0%	0.1%
BC		13.4%	-3.9%	-6.7%	-3.7%	-3.8%	-4.2%	-3.5%	-4.2%	-4.6%	-2.4%	-1.5%	-1.5%	-2.2%	-1.9%	-0.6%	-1.6%	-1.0%	-0.3%	0.0%	0.0%	1.8%	1.9%	1.0%	2.4%
BD		12.0%	-5.7%	-7.7%	-4.4%	-4.8%	-4.1%	-4.5%	-4.9%	-4.6%	-3.9%	-2.9%	-2.2%	-2.5%	-1.5%	-2.2%	-1.6%	-2.0%	-1.3%	0.0%	-1.0%	0.2%	-0.1%	-0.1%	1.4%
BE		14.9%	-4.5%	-10.4%	-3.6%	-4.4%	-4.8%	-4.1%	-3.1%	-2.4%	-2.4%	-3.5%	-2.4%	-2.1%	-1.5%	-1.2%	-1.2%	-1.6%	-1.6%	-0.6%	-1.3%	-0.3%	1.1%	1.4%	2.9%
BF		14.6%	-1.4%	-10.0%	-5.0%	-5.7%	-6.2%	-5.4%	-4.7%	-5.1%	-5.1%	-4.7%	-4.4%	-4.7%	-3.3%	-4.1%	-4.1%	-4.4%	-3.7%	-3.4%	-2.7%	-2.0%	-0.3%	-0.2%	1.6%
BG		8.0%	-1.2%	-6.1%	-4.1%	-5.3%	-4.6%	-2.4%	-2.8%	-3.1%	-3.5%	-3.9%	-3.1%	-2.0%	-1.4%	-1.4%	-1.0%	-2.0%	-0.7%	-1.4%	-0.4%	-0.8%	0.3%	1.4%	0.3%
BH		9.8%	0.8%	-5.3%	-4.0%	-4.8%	-3.3%	-3.7%	-3.4%	-3.0%	-3.1%	-3.1%	-2.3%	-1.9%	-1.3%	-1.3%	-1.7%	-1.0%	-0.9%	-0.5%	-0.9%	-0.7%	-1.0%	0.9%	1.5%
BI		10.6%	0.9%	-4.9%	-2.5%	-2.6%	-2.6%	-3.0%	-2.6%	-1.6%	-1.6%	-0.9%	-0.5%	-0.5%	0.2%	-0.2%	-0.2%	-0.2%	-0.2%	0.5%	0.5%	0.5%	0.2%	1.4%	3.6%
BJ		11.9%	2.9%	-3.3%	-3.7%	-4.0%	-3.0%	-2.2%	-1.5%	-1.6%	-1.6%	-1.3%	-0.5%	-0.9%	-1.2%	-0.5%	-0.9%	-0.9%	-0.5%	-0.5%	-0.2%	0.2%	0.7%	2.4%	2.5%
BK		11.9%	1.3%	-4.4%	-2.9%	-1.4%	-2.2%	-1.9%	-1.9%	-2.3%	-1.2%	-0.9%	-1.7%	-1.6%	-1.2%	-0.8%	-0.4%	-0.4%	-0.8%	0.0%	0.7%	0.7%	0.9%	3.7%	4.5%
BL		10.8%	-1.0%	-3.3%	-2.2%	-3.7%	-2.6%	-3.0%	-3.0%	-1.2%	-1.6%	-2.7%	-2.7%	-2.3%	-1.9%	0.0%	0.0%	0.4%	0.4%	1.2%	-0.6%	-0.2%	1.4%	2.3%	2.7%
BM		10.1%	-5.4%	-2.2%	-3.3%	-3.3%	-1.8%	-1.8%	-1.1%	-1.9%	-2.3%	-1.5%	-1.5%	-1.5%	-1.1%	0.0%	-0.7%	0.0%	-0.3%	0.2%	0.6%	0.7%	2.1%	1.8%	2.2%
MAX		18.5%	2.5%	1.4%	2.5%	2.8%	2.9%	3.3%	3.6%	17.8%	21.0%	4.0%	4.4%	4.2%	4.5%	4.7%	4.8%	5.1%	5.8%	6.2%	6.9%	6.6%	7.6%	9.8%	11.2%
MIN		2.5%	-8.0%	-9.6%	-4.5%	-4.3%	-4.0%	-3.8%	-14.7%	-31.4%	-27.6%	-8.2%	-3.4%	-3.1%	-2.8%	-4.2%	-14.3%	-25.4%	-13.1%	-2.2%	-2.3%	-2.4%	-2.3%	-1.8%	-0.2%
AVG		9.9%	-2.4%	-4.7%	-0.5%	-0.5%	-0.3%	-0.3%	-0.7%	-0.9%	-0.9%	-0.2%	0.5%	0.4%	0.6%	0.8%	0.6%	0.2%	1.2%	2.0%	1.3%	1.3%	1.9%	2.9%	3.9%

Figure 7-27 – SC-55G2 18TU-10 Pre-Drop/Post-Drop Dose Rate Change Comparison

Figure 7-28 – SC-55G2 18TU-09 Destructive Disassembly Overview

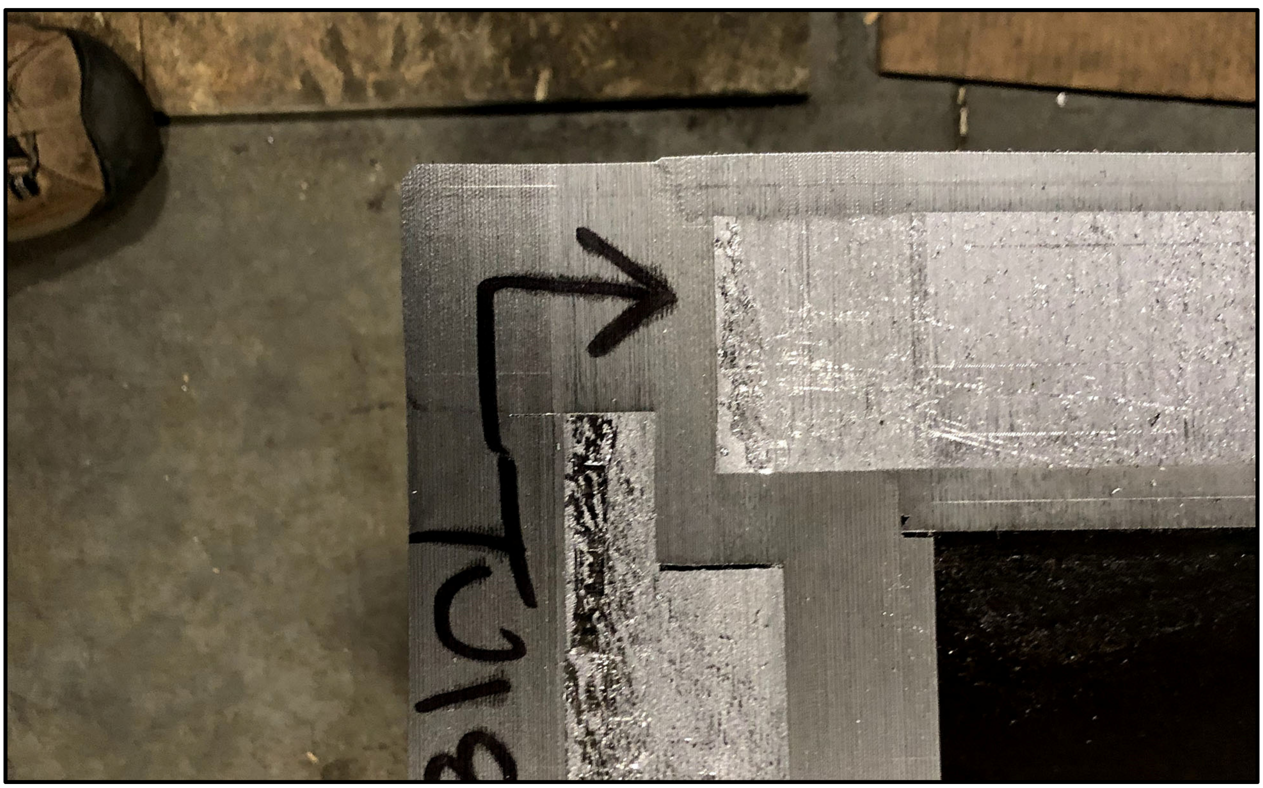

Figure 7-29 – SC-55G2 18TU-09 Destructive Disassembly Cut A at Lower Flange

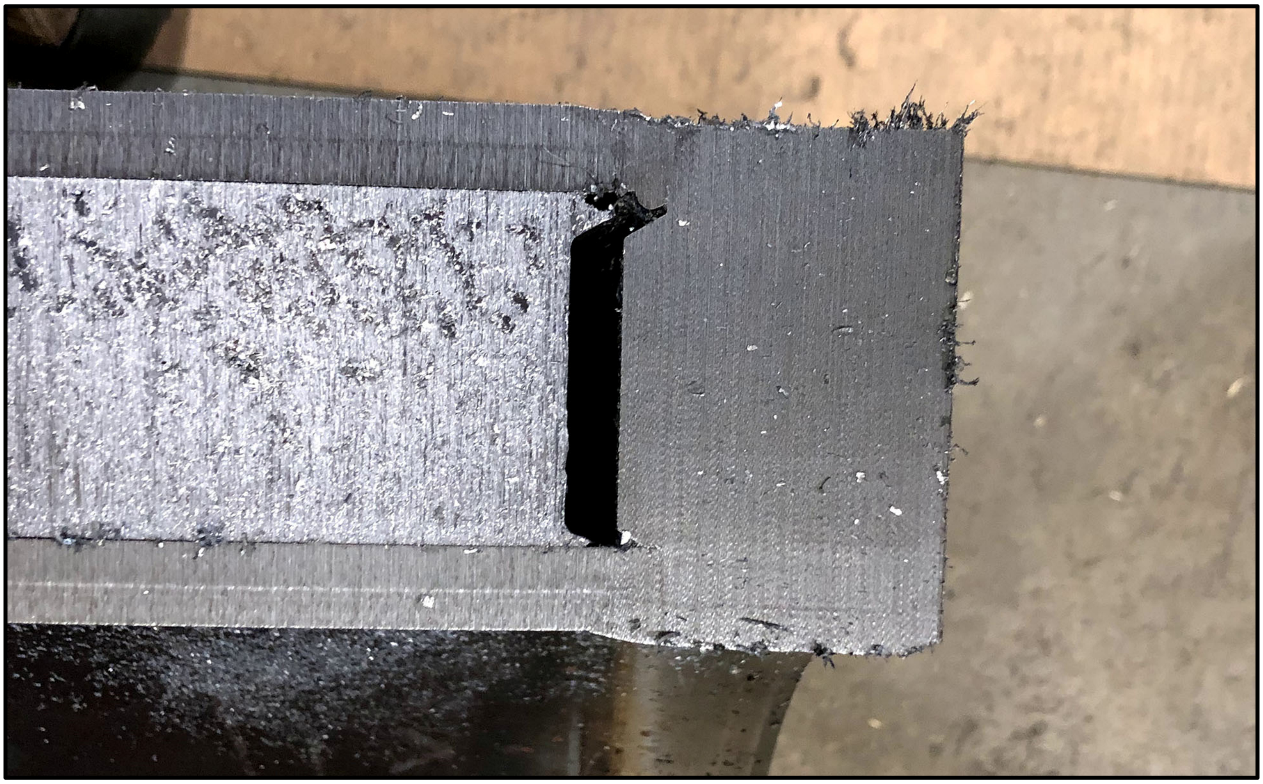

Figure 7-30 – SC-55G2 18TU-09 Destructive Disassembly Cut A at Upper Flange

Figure 7-31 – SC-55G2 18TU-09 Destructive Disassembly Cut AG/AH at Lower Flange

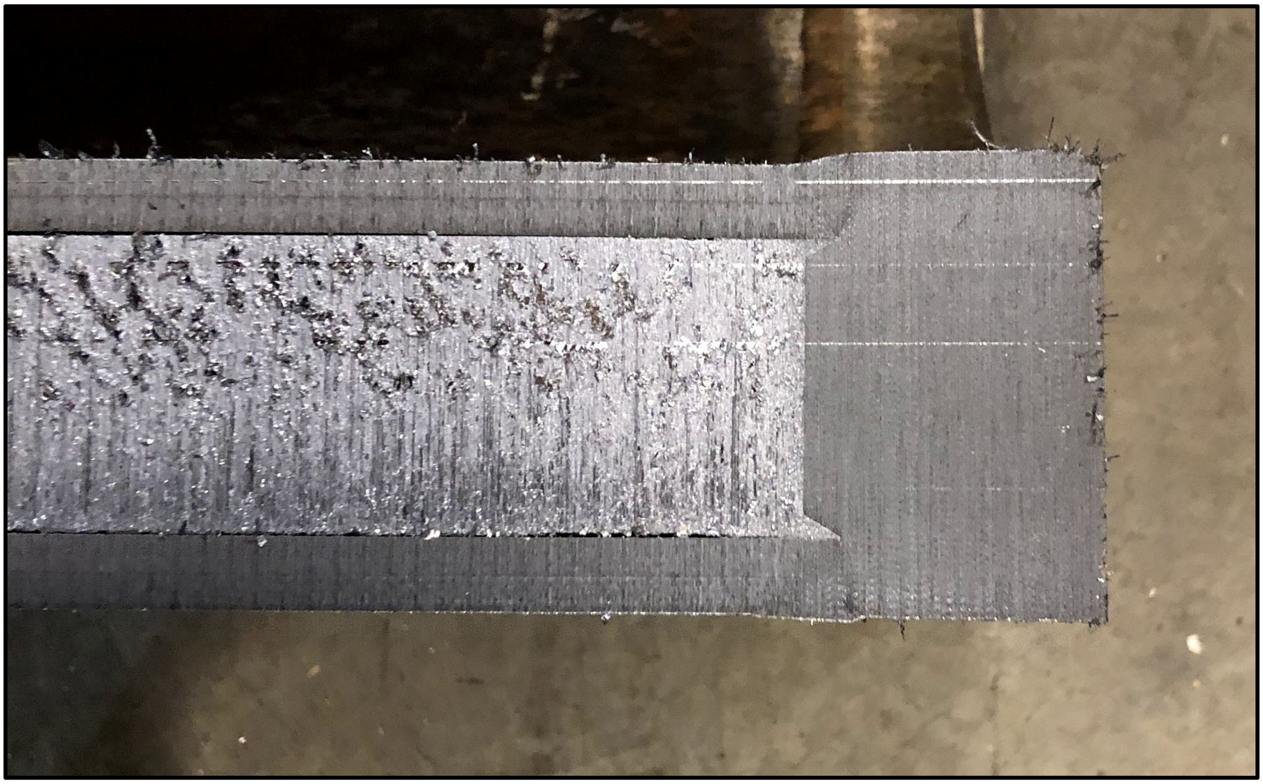

Figure 7-32 – SC-55G2 18TU-09 Destructive Disassembly Cut AG/AH at Upper Flange

Figure 7-33 – SC-55G2 18TU-09 Destructive Disassembly Cut W/X

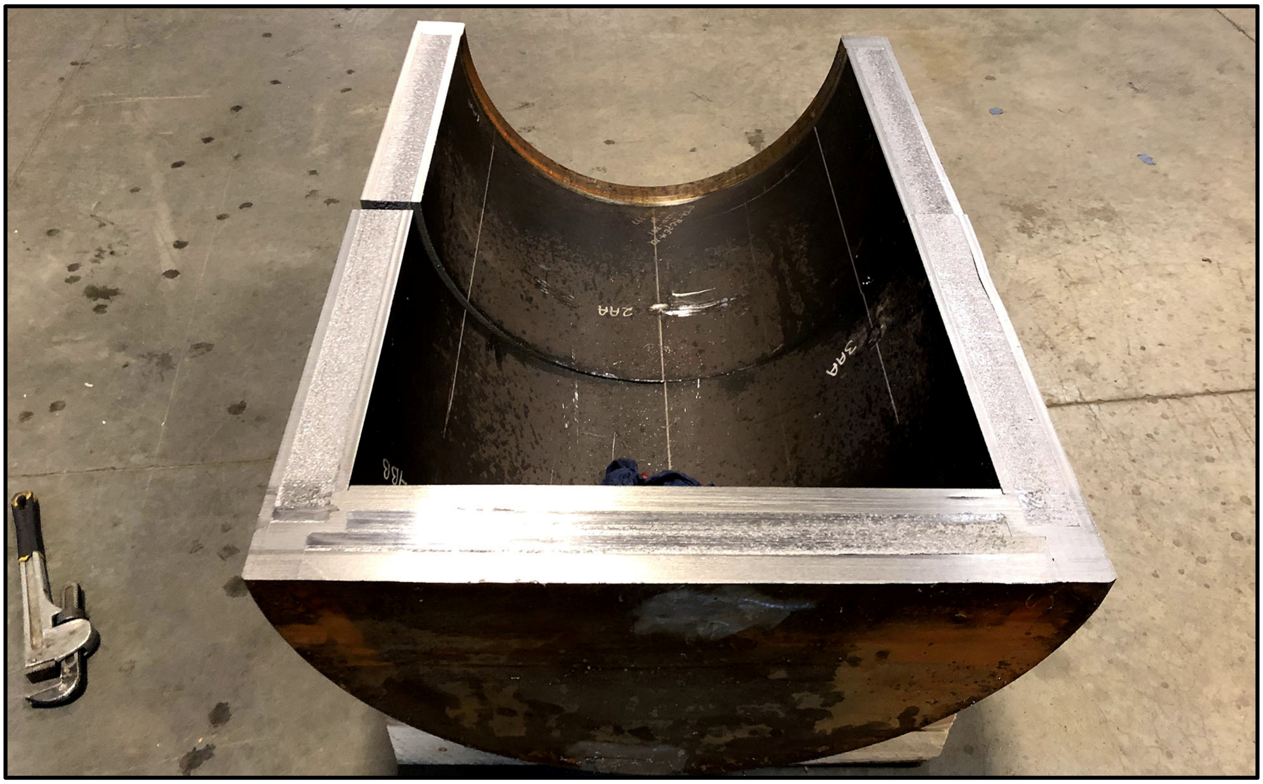

Figure 7-34 – SC-55G2 18TU-10 Destructive Disassembly Overview

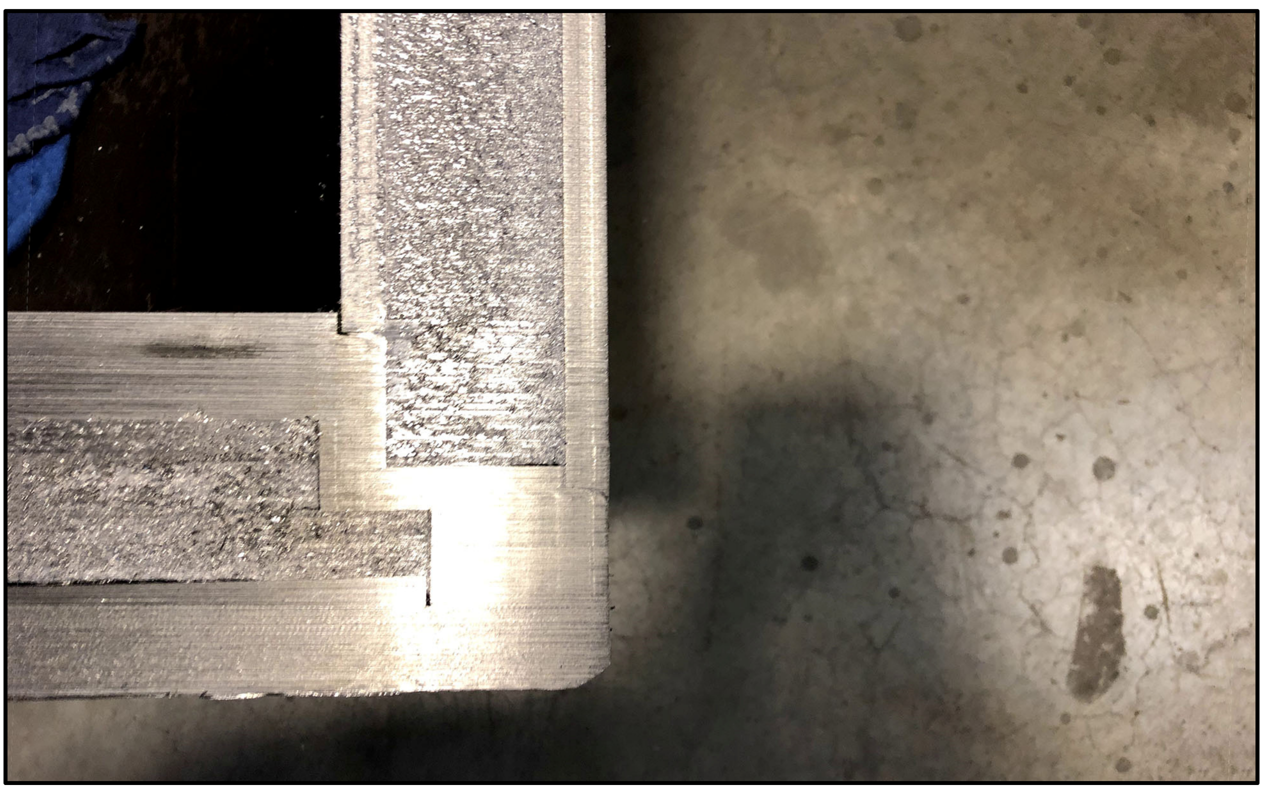

Figure 7-35 – SC-55G2 18TU-10 Destructive Disassembly Cut AM/AN at Lower Flange

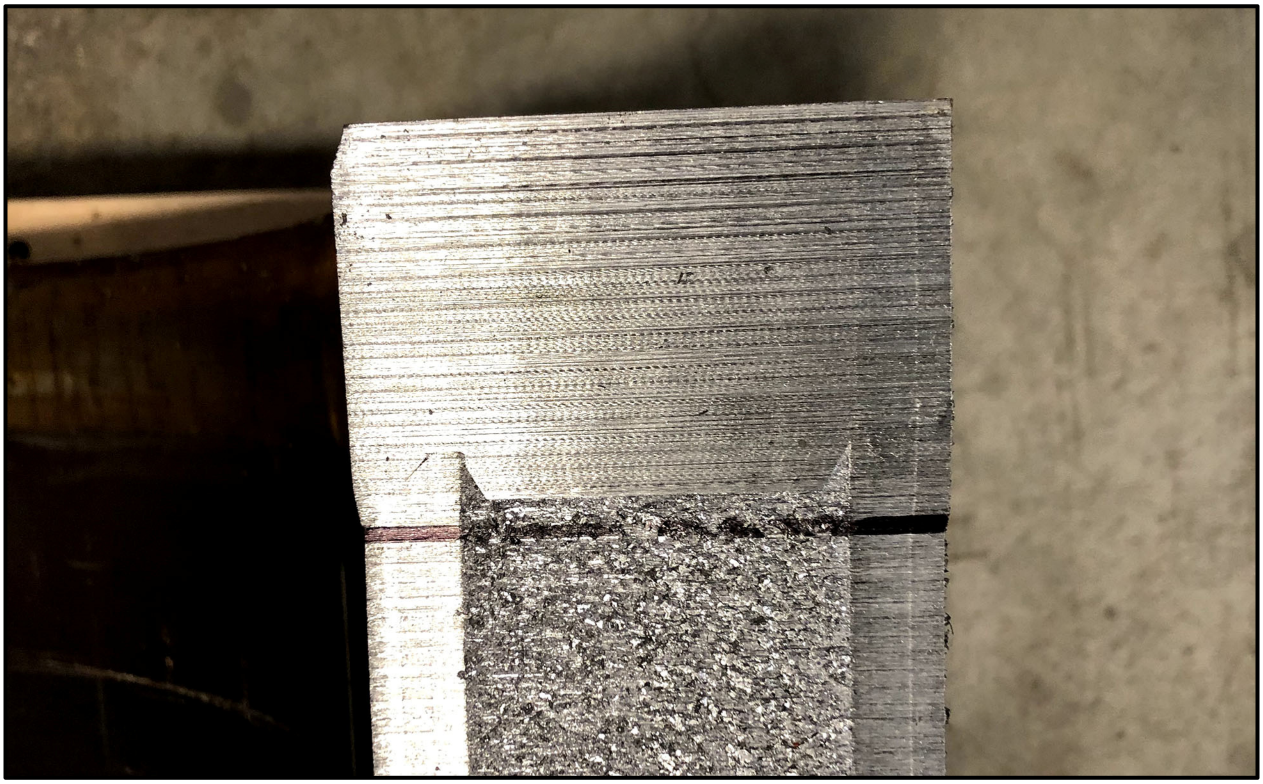

Figure 7-36 – SC-55G2 18TU-10 Destructive Disassembly Cut AM/AN at Upper Flange

Figure 7-37 – SC-55G2 18TU-10 Destructive Disassembly Cut E/F at Lower Flange

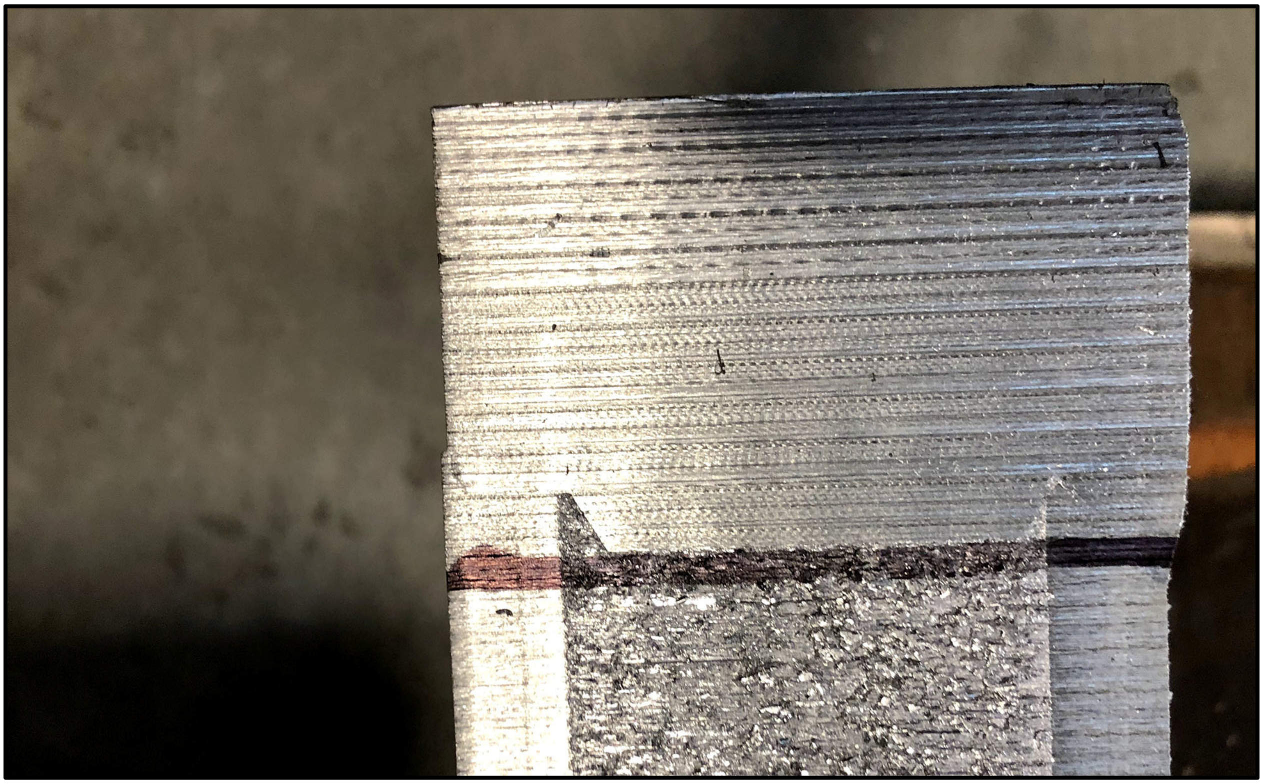

Figure 7-38 – SC-55G2 18TU-10 Destructive Disassembly Cut E/F at Upper Flange

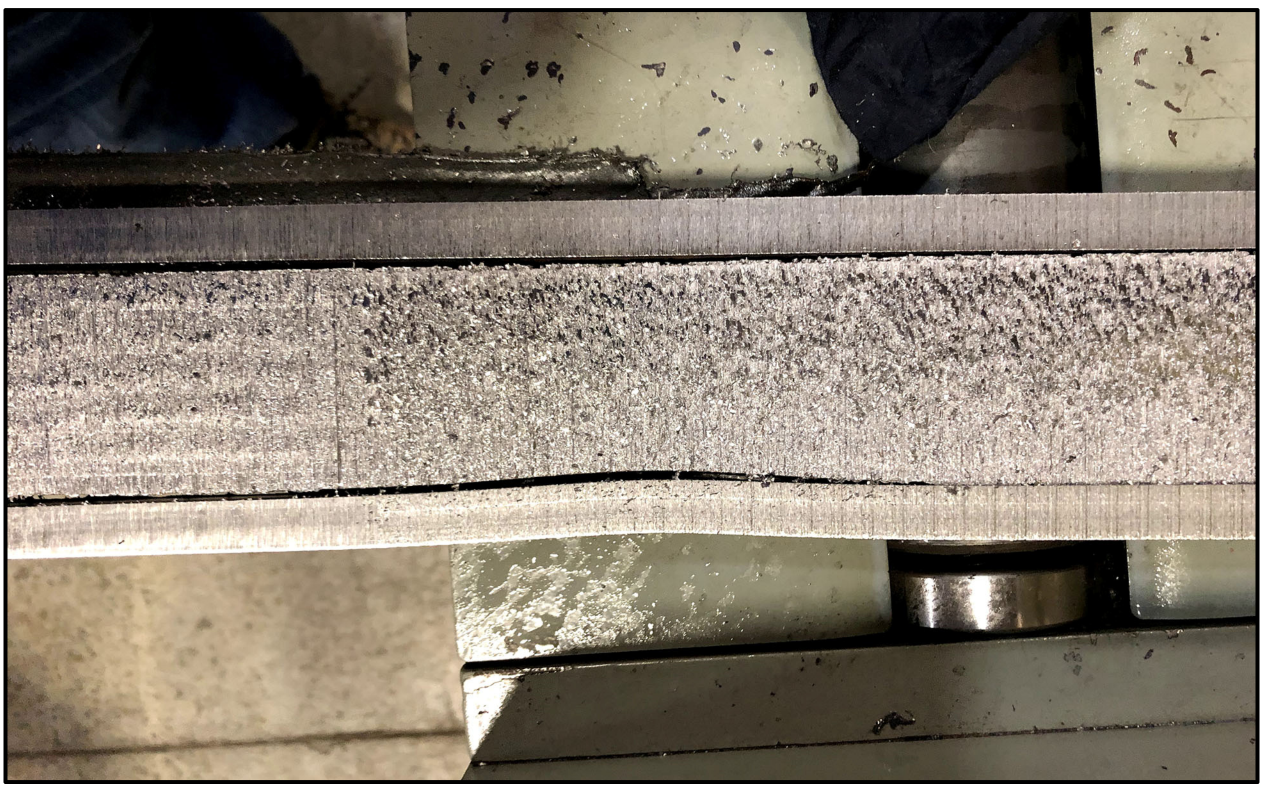

Figure 7-39 – SC-55G2 18TU-10 Destructive Disassembly Cut AM/AN at Axial Elevation 13.5