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Washington TRU Solutions LLC

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April 19, 2010

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

Subject: SUPPLEMENTAL INFORMATION REGARDING APPLICATION FOR REVISION 5 OF THE RH-TRU 72-B SHIPPING PACKAGE, DOCKET NO. 71-9212

References:
1. Letter from T. E. Sellmer to Document Control Desk, dated February 12, 2010, subject: Revision 5 of the RH-TRU 72-B Shipping Package Application, Docket No. 71-9212
2. Letter from E. Brenner (NRC) to T. E. Sellmer, dated April 1, 2010, subject: Application for Revision to Certificate of Compliance No. 9212 for the Model No. RH-TRU 72-B Packaging, Docket No. 71-9212 – Supplemental Information Needed

Dear Sir or Madam:

Washington TRU Solutions LLC, on behalf of the U.S. Department of Energy, hereby submits supplemental information regarding the application for Revision 5 of the Certificate of Compliance for the RH-TRU 72-B Packaging, U.S. Nuclear Regulatory Commission (NRC) Docket No. 71-9212 (Reference 1). This information is provided in response to the request for supplemental information (Reference 2).

The supplemental information provided consists of the following:

- Response to Requests for Supplemental Information (RSI) and Observations Related to the Proposed RH-TRU 72-B Amendment
- A CDROM containing the SINDA/Thermal Desktop input and output files for the neutron shielded canister thermal analyses
- Neutron Shielded Canister Drop Test Procedure – 30' Height, JSP-7953-01, Revision 1, August 2009.

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Washington TRU Solutions LLC

If you have any questions regarding this submittal, please contact Mr. B. A. Day of my staff at (575) 234-7414.

Sincerely,

Todd Sellmer

T. E. Sellmer, Manager
Packaging Integration

TES:clm

Enclosures

cc: M. Brown (CBFO)
J. Rhoades (CBFO
C. Staab (NRC)

RESPONSE TO

REQUESTS FOR SUPPLEMENTAL INFORMATION (RSI) AND OBSERVATIONS

RELATED TO THE PROPOSED RH-TRU 72-B AMENDMENT

Structural

RSI-1: Provide justification for the continued applicability and the use of computer codes CASKDROP, SCANS, and SLAPDOWN. Also provide discussions of deviations from the guidelines delineated in ISG-21 "Use of Computational Modeling Software."

The applicant has used computer codes CASKDROP, SCANS, and SLAPDOWN, to demonstrate the adequacy of the impact limiters of the package during the regulatory drop evaluations under NCT and HAC of transportation. The applicant has not justified deviations from staff's guidance provided in ISG-21. Include in the explanations why more accurate and current computer codes, such as LS-DYNA, was not used to demonstrate the adequacy of the impact limiters of the package during the regulatory drop evaluations under NCT and HAC of transportation.

This information is required by the staff to verify the compliance with 10 CFR 71.71 and 10 CFR 71.73 regulations.

RSI-1 Response:

The continued applicability and use of computer codes CASKDROP, SLAPDOWN and SCANS within the RH-TRU 72-B SAR is appropriate and justifiable. The dominant basis for this conclusion is the fact that these analytic tools were specifically correlated with the results obtained from testing of prototypic RH-TRU 72-B impact limiters. With this key fact as a starting point, a specific response to Structural RSI-1 is provided as follows.

First, it is noted that all uses of, and references to, CASKDROP, SLAPDOWN and SCANS within the RH-TRU 72-B SAR occurred prior to the currently approved (Revision 4) version. The current (Revision 5) amendment proposes no changes to the design and certification bases established by the use of those codes. In addition, it is noted that the ISG-21 guidance document referred to in Structural RSI-1 had not yet been written at the time CASKDROP, SLAPDOWN and SCANS were being used to establish the original RH-TRU 72-B design and certification bases. Nevertheless, in order to respond to this RSI, the original use of these three codes has been revisited. It was concluded that continued reliance on the codes is valid and appropriate. It was also concluded that when taken collectively, documentation contained in RH-TRU 72-B SAR Appendices 2.10.2, 2.10.3, 2.10.4 and 2.10.7 is consistent with the spirit and intent of the guidance now provided in ISG-21. The need for a more rigorous evaluation of these codes against the provisions of ISG-21 would seem to be greatly minimized given the existence of directly applicable test data and the very good agreement that was reached between the analytic and test results.

As a high level summary, and as discussed in Section 2.10.2.1.1 of RH-TRU 72-B SAR

Appendix 2.10.2, CASKDROP is the tool used to establish force deflection relationships for the RH-TRU 72-B cask impact limiters. The force deflection results from CASKDROP are then used as input to SLAPDOWN, which, as discussed in Section 2.10.2.2 of RH-TRU 72-B SAR Appendix 2.10.2, is the tool used to establish the rigid body response of the RH-TRU 72-B to free drop conditions. Also as discussed within Section 2.10.2.2, it is noted that the SCANS code was only used to further confirm the SLAPDOWN code. A direct comparison of results obtained from these two independently developed tools is provided in Table 2.10.2-6 of RH-TRU 72-B SAR Appendix 2.10.2. As shown, agreement was excellent, thus inherently validating the rigid body response predictive capabilities of both SLAPDOWN and SCANS.

Most significantly, the analytic results obtained from the collective use of CASKDROP and SLAPDOWN were correlated with results obtained from half-scale, static and dynamic tests of prototypic RH-TRU 72-B impact limiters and their attachment devices. In the case of the dynamic testing, a mock-up of the cask body that accurately simulated RH-TRU 72-B mass and geometry was utilized. As documented in RH-TRU 72-B SAR Appendices 2.10.3 and 2.10.7, application of a single adjustment factor to the strength of the polyurethane foam used within the RH-TRU 72-B impact limiters led to analytic results that closely agreed with, or were somewhat conservative with respect to, observed test results. In particular, Figures 2.10.7-4, 2.10.7-7 and 2.10.7-11 and Table 2.10.7-12 of Appendix 2.10.7 are representative of the close agreement reached between analyses and tests. Where differences do exist, the analytic results are conservative as further discussed within the text of Appendix 2.10.7. This documented close agreement between analyses and tests is considered sufficient to justify continued reliance on the CASKDROP and SLAPDOWN tools. Although other tools such as LS-DYNA could have been employed for analysis of the RH-TRU 72-B (even if their use included correlation with, and adjustment for, observed test results), their ultimate agreement with the test data would not likely be better than the very close agreement that was obtained using CASKDROP and SLAPDOWN.

RSI-2: Provide reference JSP-7953-01, Revision 1, August 2009, and describe the applicability of the reference to the information contained in Chapter 2 of the SAR

JSP-7953-01 has been referenced at various places throughout Chapter 2 of the SAR.

This information is required by the staff to verify compliance with 10 CFR 71.31.

RSI-2 Response:

The JSP-7953-01 procedure is provided as an attachment to this document.

The referenced JSP-7953-01, Revision 1, August 2009, is not referenced in Chapter 2 of the RH-TRU 72-B SAR directly. Rather, Chapter 2 of the RH-TRU 72-B SAR specifies that neutron shielded canister structural evaluations are provided in Appendix 5.1, *Description of the Neutron Shielded Canister*, of the RH-TRU Payload Appendices (RPA). Appendix 5.1 of the RPA references Petersen Engineering Report 7953-R-027, Revision 0, November 2009, for details regarding the 30-foot drop testing of the neutron shielded canister in a test fixture that simulated the RH-TRU 72-B interface boundary conditions and g-loads. The 7953-R-027 report then references the JSP-7953-01 test procedure that delineated the 30-foot drop test conditions and requirements. The applicability of the JSP-7953-01 procedure to Chapter 2 of the RH-TRU 72-B SAR is as defined in Section 5.1.3 of Appendix 5.1 of the RPA. Note that the 30-foot drop testing of the neutron shielded canister was simply to ascertain the response of the canister and internal shielding to HAC. Because the gross weight of the neutron shielded canister is less than the fixed or removable lid canister previously analyzed, and due to the fact that interface boundary conditions between the packaging and payload are unchanged, the structural design basis for the RH-TRU 72-B packaging is not affected by the addition of the neutron shielded canister as an authorized payload container.

Thermal

RSI-1: Provide justification that the neutron-emitting RH waste does not generate pressures beyond the maximum allowable pressure.

The neutron-emitting RH waste necessitated the need for the shielded canister design. There was no discussion or analysis that indicated the neutron-emitting RH waste is bounded by the calculation found on pages 3.4-7 and 3.4-8, RH-TRU 72-B SAR, Rev. 5, February 2010.

This information is needed for staff to perform a technical review, per NUREG-1609, Section 3.5.4.2.

RSI-1 Response:

As discussed in Appendix 5.1, *Description of Neutron Shielded Canister,* of the RH-TRU Payload Appendices (RPA), the neutron-emitting RH waste is bounded by the calculation found on pages 3.4-7 and 3.4-8, RH-TRU 72-B SAR, Rev. 5, February 2010. As summarized in Section 5.1.4.1, *Thermal Evaluation for Normal Conditions of Transport*, of Appendix 5.1 of the RPA, the temperature levels achieved under normal conditions of transport demonstrate that all of the component temperatures for the NS15 and NS30 canister configurations are within their respective limits. Further, the computed temperatures for the RH-TRU 72-B packaging components are essentially the same as those predicted in the RH-TRU 72-B SAR for similar ambient conditions. Due to the insignificant temperature difference and the analysis assumption crediting only void space exterior to the canister, the bounding pressure analysis and wattages presented in Section 3.4.4.3, *Maximum Pressure for Normal Conditions of Transport*, of the RH-TRU 72-B SAR are applicable to the NS15 and NS30 canister configurations. RH-TRU 72-B SAR Section 3.0 (page 3.1-1) refers to Appendix 5.1 of the RPA for a description of the neutron shielded canister thermal evaluation.

RSI-2: Provide the procedures in the SAR that ensure the selection of waste will not generate decay heat and pressures beyond the allowable values.

Procedures are not found in the SAR to ensure that the waste placed within the package will not generate decay heat and pressure beyond the allowable values.

This information is needed for staff to perform a technical review, per NUREG-1609, Section 3.5.4.2.

RSI-2 Response:

As stated in RH-TRU 72-B SAR Section 1.0, *General Information*, all details relating to payload and payload preparation for shipment in a RH-TRU 72-B package are presented in the *Remote-Handled Transuranic Waste Authorized Methods for Payload Control (RH-TRAMPAC)*. The RH-TRAMPAC specifies the payload requirements and the associated allowable compliance methods for the RH-TRU 72-B packaging. All users of the RH-TRU 72-B shall comply with all payload requirements outlined in the RH-TRAMPAC. RH-TRAMPAC Section 5.0, *Gas Generation Requirements*, specifies the following two separate and distinct gas generation limits for RH-TRU 72-B payloads:

- The hydrogen generated shall be limited to a molar quantity that would be no more than 5% by volume of the innermost layer of confinement if present at standard temperature and pressure. Compliance with 5% hydrogen must be demonstrated for each payload container by meeting either a decay heat limit or flammable gas generation rate limit.

- The gases generated in the payload shall be controlled to maintain the pressure within the RH-TRU 72-B inner vessel cavity below the acceptable design pressure.

All payload containers to be transported in the RH-TRU 72-B must meet the RH-TRAMPAC requirements ensuring the waste placed within the package will not generate decay heat and pressure beyond the allowable values.

RSI-3: Provide the CDROM containing the SINDA/Thermal Desktop input and output files that are necessary for analysis.

The files listed on page 33 of 52, Thermal Analysis of RH Shielded Canisters in RH-TRU 72-B Cask, Section 7.2, should be provided.

This information is needed for staff to perform a technical review, per NUREG-1609, Section 3.5.3.1.

RSI-3 Response:

A CDROM containing the SINDA/Thermal Desktop input and output files for the neutron shielded canister thermal analyses is provided as an attachment to this document.

RSI-4: Provide the heat transfer coefficient calculations that are used in the thermal analyses.

Page 36 of 52, Thermal Analysis of RH Shielded Canisters in RH-TRU 72-B Cask, Section 7.4, states that heat transfer coefficients were not calculated as a function of local conditions. How were the heat transfer coefficients calculated, if not based on local conditions (e.g., local surface temperatures are not known *a priori*)? What is the certainty that the coefficients are conservative? Heat transfer coefficient calculations for the models should be provided (NCT, HAC, etc.).

This information is needed for staff to perform a technical review, per NUREG-1609, Section 3.5.3.1.

RSI-4 Response:

Section 7.4 of the *Thermal Analysis of RH Shielded Canisters in RH-TRU 72-B Cask* refers to the general capabilities of the codes and the fact that complex algorithms could be incorporated within the thermal model to compute such things as the heat transfer convection coefficients (natural and forced) as a function of local conditions. However, as discussed in Section 7.4.2 of the calculation, since the heat transfer across the various gaps within the NS15 and NS30 shielded canisters and between the canisters and the inner shell of the cask is computed assuming only conduction and radiation across the various gaps, the use of these complex algorithms was not necessary. Instead, the conduction portion of this heat transfer is computed using the standard material conductor algorithm within Thermal Desktop based on the temperature dependent thermal conductivity properties of the fill gas, the surface areas, local temperatures, and the effective gap between the surfaces. The values of the resultant conductors are continuously updated as the model is iterated to its steady-state or transient solution. Conservatism of the computed conductors is assured by using well established thermal properties for the gas and the nominal cold dimensions of the gaps.

As discussed in Section 7.4.1 of the *Thermal Analysis of RH Shielded Canisters in RH-TRU 72-B Cask*, the heat transfer within the RH-TRU 72-B packaging and between the package's exterior surfaces and the ambient are described in the RH-TRU 72-B SAR. As documented in RH-TRU 72-B SAR Appendix 3.6.1, *Thermal Model Details*, the natural and forced convection coefficients are determined from the local Nusselt number based on local air temperature (average of the local external package surface temperature and the ambient temperature) and the package surface area. The Nusselt number is calculated as a function of the Grashof and Prandtl numbers.

RSI-5: Provide the validation reference that shows the validity of using a mixture of lumped-parameter and 'solids' modeling.

A combined 'lumped-parameter' and 'solids' modeling approach is new for this package. Page 39 of 52, Thermal Analysis of RH Shielded Canisters in RH-TRU 72-B Cask, Section 7.5, indicates that an evaluation was conducted on the NS15 and NS30 shielded insert containers. This reference should be provided.

This information is needed for staff to perform a technical review, per NUREG-1609, Section 3.5.3.1.

RSI-5 Response:

To clarify the text in Section 7.5 of the *Thermal Analysis of RH Shielded Canisters in RH-TRU 72-B Cask*, the validation performed was to rerun the original RH-TRU 72-B SAR thermal models (i.e., lumped-parameter SINDA '85 thermal model files) within the current version of the SINDA/FLUINT code to confirm that no significant difference in predicted temperature between the old and new versions of the code was observed. Table 7-1 provides a summary of results for the baseline HAC thermal models that show reasonably consistent results between the two code versions. Once this fact was established, then it could be concluded that any subsequent changes to the package temperatures were solely the result of the model changes for the revised payload definition and not due to computational differences between the code versions.

There is no real difference between using a 'lumped-parameter' versus a 'solids' modeling approach to thermally represent a component, assuming that in each case the same model resolution is obtained. Both modeling approaches have been validated as part of the general QA V&V (validation and verification) procedures for the Thermal Desktop and SINDA/FLUINT codes. As such, the general validity of combining 'lumped-parameter' and 'solids' modeling approaches within a single model requires no verification. The principle reason for combining modeling approaches for this application was simply to take advantage of the current code version's capability to internalize the calculation of the thermal mass and thermal conductors for the new NS15 and NS30 shielded canister payloads based on their respective geometry and material properties versus having to separately document these calculations as would be the case with the development of a lumped-parameter model. The solids modeling approach also offered the added advantage of being able to graphically depict the temperature distribution within the NS15 and NS30 shielded canister payloads.

While the combined 'lumped-parameter' and 'solids' modeling approach may be 'new' for this package, it has been used in a number of other thermal models for nuclear applications. Specifically, the recently approved amendment for the HalfPACT Shielded Container used an identical modeling approach to simulate the addition of a new payload definition within an existing lumped-parameter representation of the HalfPACT packaging.

Observation-1: Per NUREG-1609, the thermal evaluation period of one year is used to calculate Maximum Normal Operating Pressure (MNOP). Provide justifications for using 60 days to calculate MNOP.

Observation -1 Response:

As discussed in RH-TRU 72-B SAR Section 3.4.4.3 (page 3.4-7), the use of a 60-day shipping period in the calculation of MNOP is consistent with 10 CFR §71.41(c). As specified in 10 CFR §71.41(c), RH-TRU 72-B SAR Section 3.4.4.3 shows that the "...controls proposed to be exercised by the shipper are demonstrated to be adequate to provide equivalent safety of the shipment." This use of the 60-day shipping period is consistent with the analysis presented in Appendix 2.3, *Shipping Period – General Case*, of the RPA, which shows that the maximum normal shipping period will be less than 60 days by a large margin of safety. As described in Appendix 2.3 of the RPA, routine monitoring of shipments includes the use of the TRANSCOM system (state-of-the-art satellite tracking system) at the Waste Isolation Pilot Plant, which provides continuous tracking of shipments from the shipping site to its destination.

This use of the 60-day shipping period to calculate the MNOP was approved as part of the previous RH-TRU 72-B SAR revision (RH-TRU 72-B SAR, Revision 4, June 2006).

Containment

RSI-1: Provide information on the sensitivity and accuracy of the pressure rise test based on the actual volume (not the assumed volume), test pressures, and temperatures over the course of the test.

In regards to pages 7.4.1-1 and 7.4.1-2, Section 7.4.1.1, the sensitivity and accuracy of the pressure rise test should be provided based on the actual volume (not the assumed volume), test pressures, and expected temperatures over the course of the test.

This information is needed for staff to perform a technical review, per NUREG-1609, Section 4.5.5.

RSI-1 Response:

Pressure Rise Leak Testing is considered especially accurate when applied to constant, small volume systems such as those associated with the various test annuli for the RH-TRU 72-B (i.e., the outer cask (OC) seal test port or gas sampling port, or the inner vessel (IV) seal test port, gas sampling port, or helium backfill port).

As reflected in Appendix A.5.2.3 of ANSI N14.5 – 1997, the Gas Pressure Rise Test method has a sensitivity of 10^{-5} atmospheric-cc/second. Additionally, as shown in Table A.1 of ANSI N14.5 – 1997, the Gas Pressure Rise Test sensitivity is inversely proportional to the test volume. Based on the test volumes that would be encountered for the seal region annuli of the RH-TRU 72-B (40 cubic centimeters being the largest at the OC seal test port) the Gas Pressure Rise Test method is considered especially well suited for implementation as a pre-shipment leakage rate test method in accordance with Section 7.6 of ANSI N14.5 – 1997.

As generally shown in Equations 71 and/or 72 on page 201 of the American Society for Nondestructive Testing Handbook, Volume 1, "*Leak Testing*", the sensitivity of a pressure rise leak test can be calculated using the following formula:

$$Q = (P_2 - P_1) \times \frac{V}{t}$$

Where:

Q = leak rate sensitivity in torr • cubic centimeters per second

P_1 = initial pressure in torr

P_2 = final pressure in torr

V = volume of test item in cubic centimeters

t = test time in seconds

Per Section 7.6 of ANSI N14.5 – 1997, which requires "no detectable leakage when tested to a sensitivity of 10^{-3} ref·cm^3/s", the sensitivity of the Pressure Rise Leak Test for the RH-TRU 72-B in accordance with Section 7.4.1 of the RH-TRU 72-B SAR shall be better than or equal to 10^{-3} ref·cm^3/s. The resolution of the pressure transducer, evacuated test volume, and time duration of test are variables that are considered and/or controlled to ensure the requisite minimum test sensitivity is achieved. For example, applying the above formula to the OC seal test port annulus along with a minimum initial test pressure, measurable pressure increase due to resolution of the pressure transducer, maximum test annulus volume, and prescribed test time gives a test sensitivity that would comply with the ANSI requirement as follows:

P_1 = 0.02 torr (minimum initial test pressure)

P_2 = 0.03 torr (measurable 0.01 torr pressure increase)

V = 40 cm^3 (maximum test annulus volume)

t = 10 seconds (prescribed test time)

$$Q = (0.03 - 0.02) \times \frac{40}{10} = 0.040\ \frac{torr \cdot cm^3}{sec} = 5.263(10)^{-5}\ \frac{std \cdot cm^3}{sec}$$

Since the pressure rise leak test on the RH-TRU 72-B is performed on a small, constant volume system with a relatively short test time, temperature variations during the test are considered inconsequential and are not used. The accuracy of the pressure rise leak test is dependent upon the accuracy of the pressure measuring device being implemented in the test. In accordance with Appendix A.5.2.4 of ANSI N14.5-1997, the pressure transducer implemented has a less than 1% full-scale accuracy.

As defined in Section 7.4.1.2.1 of the RH-TRU 72-B SAR, connection of the test apparatus to the test volume (i.e., the outer cask (OC) seal test port or gas sampling port, or the inner vessel (IV) seal test port, gas sampling port or helium backfill port) ensures that the required actual (not assumed) test parameters for pressure and volume are determined and recorded.

Criticality

Observation 1: Table 6.1-2, Case A, should be updated with the numbers from the new analysis of the shielded canisters. The new fissile mass limits should also be included.

Observation 1 Response:

A criticality analysis for neutron shielded canisters was not explicitly performed as delineated in Section 5.1.6 of Appendix 5.1 of the RH-TRU Payload Appendices (RPA). The neutron shielded canisters are authorized for payload contents that are not compacted and that contain less than 1% beryllium (i.e., Case A), and are further restricted to the subcritical mass limits for compacted waste with less than 1% beryllium (i.e., Case C). The neutron shielded canisters are restricted to the Case C limits to conservatively account for the reactivity-increasing effects of the poly shield insert. Table 6.1-2, Case A, in the RH-TRU 72-B SAR was not updated because no new Case A analysis was performed for the neutron shielded canisters. However, Section 3.1.1 of the RH-TRAMPAC was revised to clearly delineate the subcritical mass limits for canisters with and without neutron shielding.

Observation 2: The applicant did not discuss the effect of non-fissile neutron emitters in the criticality analysis.

Observation 2 Response:

Pu-239 was used as the baseline fissile and/or non-fissile but neutron-emitting radionuclide in the previously submitted and approved criticality analyses. Table 5.1-1 of the RH-TRAMPAC defines the fissile-gram-equivalent Pu-239 conversion factors utilized to account for all neutron emitters. Note that Section 3.1.2 of the RH-TRAMPAC has a section entitled "Calculation of the Pu-239 FGE or U-235 FEM and Compliance Evaluation" that references the source of the conversions via the ANSI/ANS standards.

Shielding

RSI-1: Include doses resulting from loads reconfiguring under NCT to the maximum credible extent and a justification of that extent.

Provide similar tables to Tables 5.5.5-1, 5.5.6-1, and 5.5.6-2, in the current revision of the SAR, for the requested amendment. Provide an analysis of NCT and HAC doses for the RH-TRU 72-B with the NS15 and NS30 shielded canisters. Because HAC based limits do not usually bound NCT limits, it is important to ensure that the loads will not reconfigure under NCTs (shaking, speed bumps, potholes, etc.) and result in dose rates higher than allowed under 10 CFR 71.47(b). Include in this analysis a justification, beyond that contained in SAR Section 5.5.3, that neutron emitting isotopes are bounded by the limits in RH-TRAMPAC Table 3.2-2.

This information is needed for staff to proceed with a technical review to confirm that the package design meets 10 CFR 71.47(b).

RSI-1 Response:

For the RH-TRU 72-B package, compliance with 10 CFR 71.47(b) and 71.43(f) for NCT has historically been achieved through the use of preshipment radiological surveys of the package along with credit for its robust shielding components. The use of dose rate measurements at the time of shipment is appropriate for the general and controlled self-shielding payload cases (Chapter 5 of the RH-TRU 72-B SAR) because damage to the RH-TRU 72-B package under a 1-foot NCT drop condition is negligible, with no damage to the shielding components of the payload canister or packaging.

Similarly, the neutron shielded canister dose rate compliance methodology (Appendix 5.1 of the RH-TRU Payload Appendices [RPA]) proposes NCT dose rate compliance via preshipment radiological surveys. The logic is consistent with the previously approved approach because NCT damage to the RH-TRU 72-B package and neutron shielded canister shielding components is negligible under 1-foot NCT drop conditions. To conservatively quantify that NCT conditions would not result in a significant increase in dose rates, one could apply the HAC damage and source term reconfiguration results documented in Section 5.1.5 of Appendix 5.1 of the RPA to bound the NCT dose rate increase as shown below.

Section 5.1.5 of Appendix 5.1 of the RPA documents that 0.23% of the source term was released beyond the neutron shielded canister polyethylene shield insert as a result of multiple 30-foot HAC drops. Negligible damage to the canister shield insert was observed such that dents and wall-thinning was less than the ¼-inch scratch and gouge criteria. The amount of neutron attenuation provided by the NS15 neutron shielded canister (nominal wall thickness of 3.387 inches) can be estimated by comparing the calculated dose rates due to a 1 neutron per second point source for the NS15 neutron shielded canister (Table 8 of AREVA 01937.01.M005-03) with the non-shielded canister general case (Table 5.4-5 of the RH-TRU 72-B SAR) for Cm-244. The neutron dose rate attenuation for Cm-244 due to greater than 3 inches of polyethylene in the sidewall of the NS15 is given by the ratio of the calculated dose rates of shielded (1.22E-07 mrem/hr) and non-shielded (8.05E-07 mrem/hr) canister designs, resulting in a dose rate reduction of 6.6 times. If 0.23% of the source term were to conservatively be released outside of the neutron shield insert during an NCT event, then the preshipment dose rate would be increased as a function of the material attenuation and released source term as follows:

$$D_{NCT} = D_{PRE} \times [(1 - RF) + (ATT \times RF)]$$

where

ATT = neutron attenuation factor of NS15 poly shield = 6.6

RF = conservative NCT release fraction = 0.0023

D_{PRE} = dose rate measured during preshipment radiological survey (mrem/hr)

D_{NCT} = dose rate after bounding NCT event (mrem/hr)

so

$$\frac{D_{NCT}}{D_{PRE}} = (1 - .0023) + (6.6 \times .0023)$$

$$\frac{D_{NCT}}{D_{PRE}} = 1.0129$$

Therefore, a conservative estimate of dose rate increase for NCT conditions applied to a neutron shielded canister is approximately a 1.29% increase and not significant.

Appendices 5.5.5 and 5.5.6 of the RH-TRU 72-B SAR were approved in Revision 3 to justify the use of a higher HAC activity allowable for the Controlled Self-Shielding Payload Case where the calculations demonstrate that compliance with the NCT limits ensure compliance with the HAC dose rate limit. The calculations presented in Tables 5.5.5-1, 5.5.6-1, and 5.5.6-2 of the RH-TRU 72-B SAR were developed and utilized to compare the best-case NCT configuration to the worst-case HAC reconfiguration and show that the NCT limits were bounding. The analyses were not intended to establish activity limits applicable to either NCT or HAC conditions, but rather to demonstrate that NCT surveys ensure HAC dose rate compliance for all payloads with a limited loss in self-shielding and/or reconfiguration under HAC conditions.

Table 3.2-2 of the RH-TRAMPAC (same as Table 5.1-5 of Appendix 5.1 of the RPA) provides the activity limits required to ensure compliance with the HAC dose rate limit when transporting NS30 and NS15 neutron shielded canisters. The conservative assumptions employed in the HAC shielding analyses summarized in Section 5.1.5 of Appendix 5.1 of the RPA ensure that HAC dose rate requirements will be met through the application of HAC activity limits for the radionuclides authorized and listed in Table 3.2-2 of the RH-TRAMPAC. Appendices 5.5.3 and 5.5.4 of the RH-TRU 72-B SAR were approved in Revision 3 of the SAR only to define a methodology for establishing conservative activity limits for previously unanalyzed gamma and/or neutron emitting radionuclides in small quantities (<10% total contribution). The appendices only provide for new radionuclide screening and do not justify that established HAC activity limits are bounding. The fact that established HAC activity limits are bounding is due to the application of appropriately conservative assumptions in the HAC shielding analyses for both shielded and unshielded canister payloads.

Observation 1: The SAR should be updated with the new analysis, and a table containing the new HAC activity limits for the various radionuclides should be added.

Observation 1 Response:

The RH-TRU 72-B SAR Revision 5 amendment request incorporates the neutron shielded canister in a manner that parallels the addition of the shielded container incorporated in the recently approved HalfPACT SAR Revision 5. The logic for the organization of technical data was previously discussed with the NRC during the HalfPACT amendment process and agreed upon to summarize the structural, thermal, shielding, and criticality design basis of the package with respect to the new safety significant payload container in Appendix 4.5, *Description of Shielded Container*, of the CH-TRU Payload Appendices. Supporting calculation packages were to be included in the transmittal to provide the additional detail. Table 5.1-5 of Appendix 5.1 of the RPA contains the new HAC activity limits for radionuclides shipped in the neutron shielded canister and is provided by reference in Chapter 5 of the RH-TRU 72-B SAR.

Observation 2: The density of lead and stainless steel used in the shielding analysis is slightly higher than that from the SCALE Standard Composition Library, but is still within the range of normal lead values. There is a discrepancy in the densities in Table 5.3-1 versus those in Table 5.5.5-2 and 5.5.5-3.

Observation 2 Response:

The densities listed in Table 5.3-1 are those originally and consistently applied to the point-kernel gamma component of all shielding calculations (see MathCAD listing in Appendix 5.5.1 of the RH-TRU 72-B SAR). It is acknowledged that the densities utilized for the neutron component of the MCNP shielding calculations for unshielded canisters are inconsistent with the Table 5.3-1 values. Chapter 5 of the RH-TRU 72-B SAR shall be revised to correctly acknowledge that the neutron component of the shielding analyses utilized a slightly higher stainless steel density (8.02 vs 8.0128 g/cc) and a slightly lower lead density (11.34 vs 11.35 g/cc) listed in Table 5.3-1 and justify that this discrepancy is insignificant in that the stainless steel and lead provide essentially zero attenuation of neutrons.

The only shielding analyses that are new and/or revised with this application are for the neutron shielded canister (AREVA 01937.01.M005-03), where the density values listed in Table 5.3-1 of the RH-TRU 72-B SAR are consistent with those in Table 6 of AREVA 01937.01.M005-03 and consistently used in both the gamma and neutron shielding calculations.

Observation 3: When the mass attenuation coefficients were extracted from ANSI/ANS 6.4.3-1991 they were rounded. The direction of rounding was not always conservative.

Observation 3 Response:

The standard rounding (i.e., ≥5 round up, <5 round down) of ANSI/ANS 6.4.3-1991 mass attenuation coefficients was originally performed for data entry and tabular reporting convenience with the rounded values utilized in all previously approved RH-TRU 72-B shielding analyses and associated SAR revisions. If the shielding calculations were repeated using the non-rounded ANS mass attenuation coefficients, a maximally over-predicted (non-conservative) activity allowable of approximately 0.5% and a maximally under-predicted (conservative) activity allowable of approximately 1.5% would result. In concert with the extremely conservative use of iron build-up factors for the composite lead/steel shield and other geometric conservatisms incorporated into the RH-TRU 72-B gamma shielding analyses, the rounding of mass attenuation coefficients does not significantly affect or otherwise compromise the currently reported results.

Observation 4: The applicant did not discuss the method used to identify "source matrices not bounded by the UO_2 assumption," or if such wastes were actually transported.

Observation 4 Response:

Section 3.2.2 of the RH-TRAMPAC delineates the methods of compliance and verification for radiation dose rate requirements. Reference to Appendix 5.5.3 of the RH-TRU 72-B SAR requires the use of the neutron screening methodology to establish revised (more restrictive) activity limits for neutron radionuclides whose target matrix is not bounded by the uranium oxide assumption for alpha-n production. Typically, and to date, the uranium oxide target matrix has been bounding for the RH-TRU materials shipped, but the RH-TRAMPAC still requires that matrices producing a larger alpha-n component of the source term not be shipped unless the methodology of Appendix 5.5.3 of the RH-TRU 72-B SAR is employed to establish the revised activity limits.

Observation 5: Justify using 30% polyethylene and 70% water as a moderator and reflector results in a bounding dose rate from neutron multiplication. No justification was provided that this is a bounding composition.

Observation 5 Response:

The poly/water ratio utilized in the criticality analysis at the time this subcritical multiplication factor was determined (Revision 3 of the RH-TRU 72-B SAR) was 30/70 poly/water. Since that time, the criticality analyses were revised in the general case to utilize a 25/75 poly/water mixture, and a compacted waste case was added with a 100% poly assumption. Repeating the subcritical multiplication factor calculation using the same methodology but with a 100% poly assumption would yield a larger value for the subcritical multiplication. However, the original calculation using highly idealized assumptions resulted in a subcritical multiplication factor of 2.7, which is already significantly higher than expected from the waste. Note that the subcritical neutron multiplication calculation used the softest-energy neutron emitter (U-238) to maximize the multiplication effect, and the point source was modeled in the center of an idealized fissile sphere. The actual waste is not nearly so well ordered.

If the calculation is repeated with 100% poly, 245 FGE Pu-239 (consistent with Case C), and H/Pu = 900, the subcritical multiplication factor increases to 3.1. While this is slightly greater than the value of 2.7 that was used, this additional level of conservatism is not warranted because the 2.7 value is already unrealistically large.

Observation 6: The applicant's shielding analysis used the point source approximation and did not consider line sources. However, if the extent of the source is large compared to the distance from the detector then the point source approximation can be non-conservative.

Observation 6 Response:

The point source is placed at the location of puncture damage to minimize the shielding. A line source longer than the diameter of the puncture location would experience full gamma shielding thickness over part of its length, whereas a point source would only experience the reduced gamma shield thickness. The average distance from the source to the detector would also be greater for a line source, and the effective shielding thickness would be thicker because the particles would traverse the shield at an angle. Scoping calculations were performed for line neutron sources with lengths of 6, 12, and 72 inches for comparison with a point source. The 6-inch line source resulted in essentially the same 1 m dose rates as the point source. The 12-inch line source resulted in lower dose rates, and the 72-inch line source resulted in significantly lower dose rates. Therefore, it is conservative to model a point source.

Neutron Shielded Canister
Drop Test Procedure – 30' Height

Department(s) affected:

- ☐ All Departments
- ☒ Quality Assurance/Quality Control
- ☒ Design Engineering
- ☒ Process Planning
- ☐ Purchasing
- ☐ Project Management
- ☐ Facilities/Maintenance
- ☐ Information Technologies
- ☒ Production
- ☒ Shipping & Receiving
- ☐ Estimating, Sales & Marketing
- ☐ Administration & Accounting
- ☐ Human Resources
- ☒ Safety
- ☐ Field Services

Rev No.	Date	Description	Written By	Approved by	QA Approval
0	8/14/09	New Procedure	Bart Anderson		
1	8/31/09	Incorporated Comments	Bart Anderson	Tom Burklund	Keith [illegible]

1.0 SCOPE

1.1 This procedure provides requirements for performance and documentation of a set of 30' free drop tests in accordance with the *Regulatory Hypothetical Accident Condition Test Plan for the Neutron Shielded Canister Rev. 3, August 2009.* The following drop tests, when performed in accordance with this procedure shall demonstrate compliance to SOW for the NS30 Neutron Shielded Canister Type B Testing PO 411566 Rev. 2, August 2009.

2.0 APPLICABLE DOCUMENTS

2.1 Statement of Work for the NS30 Neutron Shielded Canister Type B Testing – Rev 2, August 2009.
2.2 Regulatory Hypothetical Accident Condition Test Plan for the Neutron Shielded Canister – Rev 3, August 2009.
2.2 ASME Section V – Nondestructive Examination.

3.0 EQUIPMENT LIST

Note: Record all measuring and testing equipment calibration information on DATA SHEET 1.2 – Calibration Records. Calibrated equipment indicated by an asterisk ("*") below.

3.1 Grove Mobile Crane RT855B.
3.2 Man-lift and necessary fall protection harness for operator.
3.3 2 - Soft Lifting Straps rated for a minimum of 8000 lb. lift capacity.
3.4 2 - Shackles Rated for a minimum of 4000 lb. each.
3.5 Quick Release Lift-hook with release cable rated for a working load of 50,000 lb.
3.6 Plumb-bob and string with a visible mark at 30 foot overall length.
3.7 Duct Tape (securing thermocouple wires, accelerometer cables and plumb-bob).
3.8 Digital Level.
3.9 Tape Measure, 35 Foot Steel Rule.
3.10 Torque Wrench set at 80 lb-ft with appropriate socket for test fixture end cap bolts. *
3.11 Video Camera.
3.12 Digital Camera.
3.13 Strip Chart Recorder/Data Logger. *
3.14 PPE clothing for cold and hot temperature conditions.
3.15 Sand Tubes, Sand (Ballast).
3.16 Drum Handling Bags.
3.17 Hand Held Temperature Probe. *
3.18 Scale rated at 4000 lbs. *
3.19 Stop Watch.
3.20 High Speed Grinder/Die Grinder with Abrasive Cut-off Wheel.
3.21 Broom (for cleaning test pad surface).
3.22 2 sets of 2-Leg Hoist Chains rated for a minimum of 8000 lb. lift capacity.
3.23 RLC (Pintle Cap) Lifting Fixture

4.0 TEST PREPARATIONS

4.1 Part Acceptance

Prior to performance of the following drop tests, verification shall be made that the assemblies comply with their respective drawing requirements. Assemblies that do not comply with these requirements will be documented on an internal Non-Conformance Report (NCR) and dispositioned appropriately. Any documentation created for disposition shall be attached to the Test Report.

4.2 Component Weights and Marking

4.2.1 Weigh and indelibly mark as indicated the following test components:

- neutron shielded canister test fixture body assembly (i.e., all test fixture components minus the end limiter assemblies and the end cap plate and associated cap screws and washers),
- neutron shielded canister test fixture end limiter assemblies; mark one "End Limiter #1" and the other "End Limiter #2",
- neutron shielded canister test fixture end cap plate and associated cap screws and washers
- empty NS30 neutron shielded canisters; mark one "NS30 #1" and the other "NS30 #2", and
- 30-gallon payload drums; mark sequentially as "Payload Drum #1", "Payload Drum #2", ..., "Payload Drum #6".

4.2.2 Record measured weights and determine calculated weights using DATA SHEET 1.1 – Component Weights. Adjust amount of sand ballast in payload drums to ensure the loaded NS30 neutron shielded canisters meet the specified weight requirements.

4.3 Installation of instrumentation

4.3.1 Drill and tap the mounting hole for a thermocouple into the NS30 body pipes per Figure 1 (1 ea. cold and 1 ea. hot). Install a surface temperature sensor on the outer circumference of each of the body pipes (internal sensor) at their axial midlines. This is to include 5' of thermocouple wire to be able to run out to the datalogger equipment during thermal conditioning.

4.3.2 Drill a hole through each of the RLC bodies per figure 2. This hole will be used for running the internal sensor thermocouple lead wires through. Hole size may be increased to accommodate larger diameter thermocouple leads if necessary.

4.3.3 Drill and tap the mounting hole for a thermocouple into the RH-TRU 72-B Cask RLC per figure 2. Install a surface temperature sensor and thermocouple wires to each of the RH-TRU 72-B Cask RLC steel canister bodies per manufacturers instructions (external sensor).

4.3.4 Install 4 ea. Accelerometer Instrument Mounts per WTS drawing 165-F-039-W1.

4.4 "X" Hour Determination Test (Dry Run)

4.4.1 Review all steps of section 4.4 (walk-through) and make certain that all necessary equipment is in place to ensure that the determination test will happen without interruption.

4.4.2 Locate the mobile crane in position with the outriggers extended and lowered to the point of lifting the tires off of the ground and the chassis leveled. Extend the boom to the height necessary to achieve 30' under the initial point of impact.

4.4.3 Lower the hoist to a point where it just clears the test pad and ensure that it is directly above the desired point of impact.

4.4.4 Attach the quick release lift hook. Connect the release mechanism cable to the auxiliary hoist and engage to ensure that it works properly. Remove the release mechanism cable from the auxiliary hoist.

4.4.5 Clean the drop test pad and ensure that the test area is cordoned off.

4.4.6 Load the NS30 Neutron Shielded Canister Assembly into the RLC Assembly taking care to route the thermocouple lead wire through a co-located penetration in the steel canister body. Load Payload Drum #1, #2, and #3 into NS30 #1 using the drum handling bags, install the HDPE top end cap (including a 1 in. stock thickness CDX grade plywood spacer disc to achieve a 0.50 to 0.55 in. gap), and install and rotate the removable lid canister lid to the locked orientation ensuring spring plunger engagement.

4.4.7 Place the NS30 #1 test article into the temperature conditioning chamber. Route the thermocouple lead wires (internal and external) through a co-located penetration in the temperature conditioning chamber.

4.4.8 Close and seal the temperature conditioning chamber lid.

4.4.9 Record start time of the test.

Note: Even though this dry run will be done at ambient temperature, the operator will use the same protective clothing as if the test article was at final conditioning temperature.

Start Time:____________

4.4.10 Open the temperature conditioning chamber lid, remove the NS30 #1 test unit from the temperature conditioning chamber, detach the external temperature sensor, secure and protect the internal temperature sensor lead wire, and install the NS30 #1 test article into the neutron shielded canister text fixture in the end drop orientation (see Figure 3).

4.4.11 Install the end impact limiter #1 and associated washers and hex head cap screws, tightening the cap screws to 80 ± 10 lb-ft torque each. Prior to Step 4.4.10, install and secure the impact accelerometer on a neutron shielded canister test fixture mounting stud, following manufacturer's instructions, ensuring the acceleration measurement axis is aligned with the drop orientation. Provide appropriate strain relief and routing for the accelerometer data cables to prevent damage during the drop test.

4.4.12 Clean the drop pad.

4.4.13 Relocate the loaded neutron shielded canister test fixture to the drop pad location.

4.4.14 Rig the neutron shielded canister test fixture vertically, utilizing the lift lugs as shown in Figure 3.

4.4.15 Connect the accelerometer data cables to the data acquisition equipment.

4.4.16 Hoist the test fixture up 3' from the pad. Attach a 30' long plumb-bob and string line to the underside (impact point) of the test fixture using duct tape.

4.4.17 Verify that the test fixture is rigged within 2° of vertical.

4.4.18 Hoist the test fixture such that the initially impacting point is 30 feet (+3/-0 inches) above the target surface. The plumb-bob should be sitting just above the surface of the drop pad. Verify that the test fixture is centered over the drop pad.

4.4.19 Using a man-lift and 35 foot tape measure, verify that the test fixture is 30 feet (+3/-0 inches) above the target surface and then remove the plumb-bob from the underside of the test fixture.

Note: DO NOT CONNECT THE RELEASE MECHANISM CABLE TO THE AUXILIARY HOIST.

4.4.20 Verify positioning of the video cameras, start videotaping, start accelerometer data acquisition.

4.4.21 Call out for "**ALL CLEAR**".

4.4.22 Stop the timer and record the stop time. Add 5 minutes for pre-drop verification of paperwork. Multiply by 110% as a time buffer. This is the final "X" Hour time that all drop testing needs to meet from the time the temperature conditioning is completed until the actual drop is completed.

Stop Time:________.

"X" Hour = (Stop Time:________ - Start Time________ + 5 min) x 110% = ________minutes.

4.4.23 Lower the test fixture to the ground.

4.4.24 Loosen the cap screws and remove the cap screws, washers and the end impact limiter #1.

4.4.25 Remove the NS30 #1 test unit from the test fixture.

4.5 Temperature Conditioning Test #1 – Cold Cycle

Note: The Cold conditioned testing will use NS30 Neutron Shielded Canister Assembly #1. This canister assembly is the one that has been modified with the V-groove failure points.

4.5.1 Load the NS30 Neutron Shielded Canister Assembly #1 into the RLC Assembly taking care to route the thermocouple lead wire through a co-located penetration in the steel canister body. Load Payload Drum #1, #2, and #3 into NS30 #1, install the HDPE top end cap (including a 1 in. stock thickness CDX grade plywood spacer disc to achieve a 0.50 to 0.55 in. gap), and install and rotate the removable lid canister lid to the locked orientation ensuring spring plunger engagement.

4.5.2 Place the NS30 #1 test article into the temperature conditioning chamber. Route the thermocouple lead wires of both the internal and external sensors through a co-located penetration in the temperature conditioning chamber and connect to a temperature datalogger.

4.5.3 Close and seal the conditioning chamber lid and ensure the portable temperature conditioning unit is connected via insulated ducting to the temperature conditioning chamber, noting the time, date, and ambient air temperature on DATA SHEET 2.1. Initiate the conditioning process.

4.5.4 Monitor the temperature sensors by logging the temperature at 30 minute intervals or utilizing a temperature strip chart recorder and continue the conditioning process until both sensors stabilize at a temperature less than -30 °F (+ 0°/-10°).

4.5.5 Note the time, date, and ambient air temperature on DATA SHEET 2.1, and then discontinue the conditioning process.

4.5.6 Open the temperature conditioning chamber lid, avoiding direct solar exposure of the test article (perform inside a building underneath a bridge crane), and continue to monitor the temperature sensors by logging the temperature at 10 minute intervals for 'X' hours.

Note: 'X' hours is established (per 4.4.17) as the maximum time allowed between completion of the temperature conditioning process and the initiation of the drop test sequence.

4.5.7 If after 'X' hours the internal temperature sensor has a temperature reading greater than -20 °F, then repeat steps 4.5.3-4.5.7 with a temperature set-point in step 4.5.4 that is 10 °F less than the previous iteration.

4.5.8 Once the post-conditioning internal temperature (step 4.5.7) is less than -20 °F at the end of the 'X' hour monitoring period, record the value of this final iteration to be used as the draw down temperature for all cold drop tests.

4.6 Temperature Conditioning Test #2 – Hot Cycle

Note: This Conditioning Test is to be run only after <u>ALL</u> Cold Cycle drop testing has been completed.

4.6.1 Load the NS30 Neutron Shielded Canister Assembly #2 into the RLC Assembly taking care to route the thermocouple lead wire through a co-located penetration in the steel canister body. Load Payload Drum #4, #5, and #6 into NS30 #2 using drum handling bags, install the HDPE top end cap (including a 1 in. stock thickness CDX grade plywood spacer disc to achieve a 0.50 to 0.55 in. gap), and install and rotate the removable lid canister lid to the locked orientation ensuring spring plunger engagement.

4.6.2 Place the NS30 #2 test article into the temperature conditioning chamber. Route the thermocouple lead wires of both the internal and external sensors through a co-located penetration in the temperature conditioning chamber and connect to a temperature datalogger.

4.6.3 Close and seal the conditioning chamber lid and ensure the portable temperature conditioning unit is connected via insulated ducting to the temperature conditioning chamber, noting the time, date, and ambient air temperature on DATA SHEET 2.4. Initiate the conditioning process.

4.6.4 Monitor the temperature sensors by logging the temperature at 30 minute intervals or utilizing a temperature strip chart recorder and continue the conditioning process until both sensors stabilize at a temperature greater than 160 °F (+10°/-0°).

4.6.5 Note the time, date, and ambient air temperature on DATA SHEET 2.4, and then discontinue the conditioning process.

4.6.6 Open the temperature conditioning chamber lid, avoiding direct solar exposure of the test article, and continue to monitor the temperature sensors by logging the temperature at 10 minute intervals for 'X' hours. Note: 'X' hours is to be established as the maximum time allowed between completion of the temperature conditioning process and the initiation of the drop test sequence.

4.6.7 If after 'X' hours the internal temperature sensor has a temperature reading less than 150 °F, then repeat steps 4.6.3-4.6.7 with a temperature set-point in step 4.6.4 that is 10 °F higher than the previous iteration.

4.6.8 Once the post-conditioning internal temperature (step 4.6.7) is greater than 150 °F at the end of the 'X' hour monitoring period, record the value of this final iteration to be used as the heat-up temperature for all hot drop tests.

5.0 Free Drop Tests

Conduct a total of four 30-foot free drop tests of two NS30 neutron shielded canisters at temperature extremes as follows:

Cold Drop Tests:

- Test #1 – cold end drop of NS30 Neutron Shielded Canister Assembly #1 at -20 °F.
- Test #2 – cold side drop of NS30 Neutron Shielded Canister Assembly #1 at -20 °F.

Hot Drop Tests:

- Test #3 – hot end drop of NS30 Neutron Shielded Canister Assembly #2 at 150 °F.
- Test #4 – hot side drop of NS30 Neutron Shielded Canister Assembly #2 at 150 °F.

All loading and closure operations for all test components shall be in accordance with this test plan and all associated test article design drawings or manufacturer's instructions, and operations manuals, if applicable.

5.1 Cold End Drop Test

5.1.1 Review all steps of section 5.1 (walk-through) and make certain that all necessary equipment is in place to ensure that the test will happen within the established "X" hour requirements.

5.1.2 If not already in place, locate the mobile crane in position with the outriggers extended and lowered to the point of lifting the tires off of the ground and the chassis leveled. Extend the boom to the height necessary to achieve 30' under the initial point of impact. Verify that the quick release lift hook is installed.

5.1.3 Connect the release mechanism cable to the auxiliary hoist and engage to ensure that it works properly. Remove the release mechanism cable from the auxiliary hoist.

5.1.4 Clean the drop test pad surface and ensure test area is cordoned off.

5.1.5 Place the NS30 #1 test article into the temperature conditioning chamber and attach a temperature sensor to the steel canister body (external sensor). Route the thermocouple lead wires of both the internal and external sensors through a co-located penetration in the temperature conditioning chamber and connect to a temperature datalogger or temperature stripchart recorder.

5.1.6 Close and seal the conditioning chamber lid and ensure the portable temperature conditioning unit is connected via insulated ducting to the temperature conditioning chamber, noting the time, date, and ambient air temperature on DATA SHEET 2.1 – Test #1, 30-Foot End Drop (Cold). Initiate the conditioning process.

5.1.7 Monitor the temperature sensors by utilizing the datalogger or a temperature strip chart recorder and continue the conditioning process until both sensors stabilize at the temperature established in the temperature conditioning test #1- Cold Cycle.

5.1.8 Note the time, date, and ambient air temperature on DATA SHEET 2.1 – Test #1, 30-Foot End Drop (Cold) and then discontinue the conditioning process.

5.1.9 Open the temperature conditioning chamber lid, remove the NS30 #1 test unit from the temperature conditioning chamber, detach the external temperature sensor, secure and protect the internal temperature sensor lead wire, and install the NS30 #1 test article into the neutron shielded canister text fixture in the end drop orientation (see Figure 3).

5.1.10 Install the end impact limiter #1 and associated washers and hex head cap screws, tightening the cap screws to 80 ± 10 lb-ft torque each. Prior to Step 5.1.12, install and secure two impact accelerometers on the neutron shielded canister test fixture instrument mounts, near the impact point, following manufacturer's instructions, ensuring the acceleration measurement axis is aligned with the drop orientation. Provide appropriate strain relief and routing for the accelerometer data cables to prevent damage during the drop test.

5.1.11 Relocate the loaded neutron shielded canister test fixture to the drop pad location.

5.1.12 Rig the neutron shielded canister test fixture vertically, utilizing the lift lugs as shown in Figure 3.

5.1.13 Connect the accelerometer data cables to the data acquisition equipment.

5.1.14 Hoist the test fixture up 3' from the test pad surface. Attach a 30' long plumb-bob and string line to the underside (impact point) of the test fixture using duct tape.

5.1.15 Verify that the test fixture is rigged within 2° of vertical.

5.1.16 Hoist the test fixture such that the initial impact point is 30 feet (+3/-0 inches) above the target surface. The plumb-bob should be sitting just above the drop pad surface. Verify that the test fixture is centered over the drop pad.

5.1.17 Using a man-lift, remove the plumb-bob and string from the test fixture and then connect the release mechanism cable to the auxiliary hoist.

5.1.18 Verify that all test preparations have been completed and data recorded as delineated in DATA SHEET 2.1 – Test #1, 30-Foot End Drop (Cold).

5.1.19 Verify positioning of the video cameras, start videotaping, start accelerometer data acquisition.

5.1.20 Call out for **"ALL CLEAR"**.

5.1.21 Drop the test fixture.

5.1.22 Discontinue accelerometer data acquisition, secure the acceleration versus time data traces, and remove the accelerometers from the instrument mounts. Record damage to the impact zone on DATA SHEET 2.1 – Test #1, 30-Foot End Drop Test (Cold) and measure and record the residual height of the end impact limiter.

5.2 Post Cold End Drop Test Disassembly

5.2.1 Take special care during the post-test disassembly process not to cause deformations and/or damage that could interfere with test related results.

5.2.2 Remove the end impact limiter #1 and associated washers and hex head cap screws and remove the NS30 #1 test article from the test fixture.

5.2.3 Photo-document all test related/induced deformations and results with respect to the exterior of the NS30 #1 test article. If possible, use a high-contrast rule or tape measure to depict scale in each photograph, including the NS30 test article number for reference.

5.2.4 Record damage to the NS30 #1 test article exterior on DATA SHEET 2.1 – Test #1, 30-Foot End Drop Test (Cold).

5.3 Cold Side Drop Testing

5.3.1 Review all steps of section 5.3 (walk-through) and make certain that all necessary equipment is in place to ensure that the test will happen within the established "X" hour requirements.

5.3.2 If not already in place, locate the mobile crane in position with the outriggers extended and lowered to the point of lifting the tires off of the ground and the chassis leveled. Extend the boom to the height necessary to achieve 30' under the initial point of impact. Verify that the quick release lift hook is installed.

5.3.3 Connect the release mechanism cable to the auxiliary hoist and engage to ensure that it works properly. Remove the release mechanism cable from the auxiliary hoist.

5.3.4 Clean the drop test pad and ensure test area is cordoned off.

5.3.5 Place the NS30 #1 test article into the temperature conditioning chamber and attach a temperature sensor to the steel canister body (external sensor). Unsecure the internal temperature sensor lead wire and route the thermocouple lead wires of both the internal and external sensors through a co-located penetration in the temperature conditioning chamber and connect to a temperature datalogger or temperature stripchart recorder.

5.3.6 Close and seal the conditioning chamber lid and ensure the portable temperature conditioning unit is connected via insulated ducting to the temperature conditioning chamber, noting the time, date, and ambient air temperature in DATA SHEET 2.2 – Test #2, 30-Foot Side Drop (Cold). Initiate the conditioning process.

5.3.7 Monitor the temperature sensors by utilizing the datalogger or a temperature strip chart recorder and continue the conditioning process until both sensors stabilize at the temperature established in the temperature conditioning test #1- Cold Cycle.

Note: If the internal temperature sensor was damaged during the cold end drop test, alternatively monitor the external temperature sensor only, noting the time delay in the cold end drop test preparation for the internal sensor to stabilize with the external temperature sensor. The conditioning time shall be extended beyond the time required for the external sensor to reach the desired set-point by a period of time equal to the time delay for stabilization in the cold end drop conditioning process.

5.3.8 Note the time, date, and ambient air temperature on DATA SHEET 2.2 – Test #2, 30-Foot Side Drop (Cold) and then discontinue the conditioning process.

5.3.9 Open the temperature conditioning chamber lid, remove the NS30 #1 test unit from the temperature conditioning chamber, detach the external temperature sensor, secure and protect the internal temperature sensor lead wire, and install the NS30 #1 test article into the neutron shielded canister text fixture in the side drop orientation (see Figure 4).

5.3.10 Install the end cap plate and associated washers and hex head cap screws, tightening the cap screws to 80 ± 10 lb-ft torque each. Prior to Step 5.3.12, install and secure two impact accelerometers on the neutron shielded canister test fixture instrument mounts, near the impact point, following manufacturer's instructions, ensuring the acceleration measurement axis is aligned with the drop orientation. Provide appropriate strain relief and routing for the accelerometer data cables to prevent damage during the drop test.

5.3.11 Relocate the loaded neutron shielded canister test fixture to the drop pad location.

5.3.12 Rig the neutron shielded canister test fixture horizontally, utilizing the lift lugs as shown in Figure 4.

5.3.13 Connect the accelerometer data cables to the data acquisition equipment.

5.3.14 Hoist the test fixture up 3' from the test pad surface. Attach a 30' long plumb-bob and string line to the underside (impact point) of the test fixture using duct tape.

5.3.15 Verify that the test fixture is rigged within 2° of horizontal.

5.3.16 Hoist the test fixture such that the initially impacting point is 30 feet (+3/-0 inches) above the target surface. The plumb-bob should be sitting just above the drop pad surface. Verify that the test fixture is centered over the drop pad.

5.3.17 Using a man-lift, remove the plumb-bob and string from the test fixture and then connect the release mechanism cable to the auxiliary hoist.

5.3.18 Verify that all test preparations have been completed and data recorded as delineated in DATA SHEET 2.2 – Test #2, 30-Foot Side Drop (Cold).

5.3.19 Verify positioning of the video cameras, start videotaping, start accelerometer data acquisition.

5.3.20 Call out for **"ALL CLEAR"**.

5.3.21 Drop the test fixture.

5.3.22 Discontinue accelerometer data acquisition, secure the acceleration versus time data traces, and remove the accelerometers from the instrument mounts. Record damage to the impact zone on DATA SHEET 2.2 – Test #2, 30-Foot Side Drop (Cold) and measure and record the residual height (inside radius to outside radius at the impact zone) of each side impact limiter.

5.4 Post Cold Side Drop Test Disassembly

5.4.1 Take special care during the post-test disassembly process not to cause deformations and/or damage that could interfere with test related results.

5.4.2 Remove the end cap plate and associated washers and hex head cap screws and remove the NS30 #1 test article from the test fixture.

5.4.3 Photo-document all test related/induced deformations and results with respect to the exterior of the NS30 #1 test article. If possible, use a high-contrast rule or tape measure to depict scale in each photograph, including the NS30 test article number for reference.

5.4.4 Record damage to the NS30 #1 test article exterior on DATA SHEET 2.2 – Test #2, 30-Foot Side Drop (Cold).

5.5 Post Cold Drop Test Disassembly

5.5.1 Take special care during the post-test disassembly process not to cause deformations and/or damage that could interfere with test related results.

5.5.2 With the NS30 #1 test article in a vertical (top end up) orientation, disassemble the removable lid canister by utilizing an abrasive cutting wheel to circumferentially sever the canister body from the body flange near the original circumferential girth weld. Remove the removable lid canister lid assembly and body flange to permit inspection of the top end cap assembly to body interface. Similarly, cut three equally spaced viewing windows out of the removable lid canister body near the body flat head original circumferential girth weld.

5.5.3 Photo-document all test related/induced deformations and results with respect to the top end cap assembly and bottom end cap assembly to body interfaces. If possible, use a high-contrast rule or tape measure to depict scale in each photograph, including the NS30 test article number for reference. Note the presence (or lack thereof) of any payload sand exterior to the shield insert assembly. If present, collect and obtain the weight of the sand.

5.5.4 Fully disassemble and remove the top end cap, body pipe, payload containers, and bottom end cap to permit inspection of all shield insert assembly components.

5.5.5 Photo-document all test related/induced local deformations (including scratches and gouges that exceed ¼ in. depth) and results with respect to the top end cap, bottom end cap, and body. If possible, use a high-contrast rule or tape measure to depict scale in each photograph, including the NS30 test article number for reference.

5.5.6 Record results of inspections on DATA SHEET 2.3 – Tests #1 & #2, 30-Foot Drops (Cold).

5.6 Hot End Drop Testing

5.6.1 Review all steps of section 5.6 (walk-through) and make certain that all necessary equipment is in place to ensure that the test will happen within the established "X" hour requirements.

5.6.2 If not already in place, locate the mobile crane in position with the outriggers extended and lowered to the point of lifting the tires off of the ground and the chassis leveled. Extend the boom to the height necessary to achieve 30' under the initial point of impact. Verify that the quick release lift hook is installed.

5.6.3 Connect the release mechanism cable to the auxiliary hoist and engage to ensure that it works properly. Remove the release mechanism cable from the auxiliary hoist.

5.6.4 Clean the drop test pad and ensure test area is cordoned off.

5.6.5 Place the NS30 #2 test article into the temperature conditioning chamber and attach a temperature sensor to the steel canister body (external sensor). Route the thermocouple lead wires of both the internal and external sensors through a co-located penetration in the temperature conditioning chamber and connect to a temperature datalogger or temperature strip chart recorder.

5.6.6 Close and seal the conditioning chamber lid and ensure the portable temperature conditioning unit is connected via insulated ducting to the temperature conditioning chamber, noting the time, date, and ambient air temperature on DATA SHEET 2.4 – Test #3, 30-Foot End Drop (Hot). Initiate the conditioning process.

5.6.7 Monitor the temperature sensors by utilizing the datalogger or a temperature strip chart recorder and continue the conditioning process until both sensors stabilize at the temperature established in the temperature conditioning test #2- Hot Cycle.

5.6.8 Note the time, date, and ambient air temperature on DATA SHEET 2.4 – Test #3, 30-Foot End Drop (Hot), and then discontinue the conditioning process.

5.6.9 Open the temperature conditioning chamber lid, remove the NS30 #2 test unit from the temperature conditioning chamber, detach the external temperature sensor, secure and protect the internal temperature sensor lead wire, and install the NS30 #2 test article into the neutron shielded canister text fixture in the end drop orientation (see Figure 3).

5.6.10 Install the end impact limiter #2 and associated washers and hex head cap screws, tightening the cap screws to 80 ± 10 lb-ft torque each. Prior to Step 5.6.12, install and secure two impact accelerometers on the neutron shielded canister test fixture instrument mounts, near the impact point, following manufacturer's instructions, ensuring the acceleration measurement axis is aligned with the drop orientation. Provide appropriate strain relief and routing for the accelerometer data cables to prevent damage during the drop test.

5.6.11 Relocate the loaded neutron shielded canister test fixture to the drop pad location.

5.6.12 Rig the neutron shielded canister test fixture vertically, utilizing the lift lugs as shown in Figure 3.

5.6.13 Connect the accelerometer data cables to the data acquisition equipment.

5.6.14 Hoist the test fixture up 3' from the test pad surface. Attach a 30' long plumb-bob and string line to the underside (impact point) of the test fixture using duct tape.

5.6.15 Verify that the test fixture is rigged within 2° of vertical.

5.6.16 Hoist the test fixture such that the initially impacting point is 30 feet (+3/-0 inches) above the target surface. The plumb-bob should be sitting just above the drop pad surface. Verify that the test fixture is centered over the drop pad.

5.6.17 Using a man-lift, remove the plumb-bob and string from the test fixture and then connect the release mechanism cable to the auxiliary hoist.

5.6.18 Verify that all test preparations have been completed and data recorded as delineated in DATA SHEET 2.4 – Test #3, 30-Foot End Drop (Hot).

5.6.19 Verify positioning of the video cameras, start videotaping, start accelerometer data acquisition

5.6.20 Call out for **"ALL CLEAR"**.

5.6.21 Drop the test fixture.

5.6.22 Discontinue accelerometer data acquisition, secure the acceleration versus time data traces, and remove the accelerometers from the instrument mounts. Record damage to the impact zone on DATA SHEET 2.4 – Test #3, 30-Foot End Drop (Hot), and measure and record the residual height of the end impact limiter.

5.7 Post Hot End Drop Test Disassembly

5.7.1 Take special care during the post-test disassembly process not to cause deformations and/or damage that could interfere with test related results.

5.7.2 Remove the end impact limiter #2 and associated washers and hex head cap screws and remove the NS30 #2 test article from the test fixture.

5.7.3 Photo-document all test related/induced deformations and results with respect to the exterior of the NS30 #2 test article. If possible, use a high-contrast rule or tape measure to depict scale in each photograph, including the NS30 test article number for reference.

5.7.4 Record damage to the NS30 #2 test article exterior on DATA SHEET 2.4 – Test #3, 30-Foot End Drop (Hot).

5.8 Hot Side Drop Testing

5.8.1 Review all steps of section 5.8 (walk-through) and make certain that all necessary equipment is in place to ensure that the test will happen within the established "X" hour requirements.

5.8.2 If not already in place, locate the mobile crane in position with the outriggers extended and lowered to the point of lifting the tires off of the ground and the chassis leveled. Extend the boom to the height necessary to achieve 30' under the initial point of impact. Verify that the quick release lift hook is installed.

5.8.3 Connect the release mechanism cable to the auxiliary hoist and engage to ensure that it works properly. Remove the release mechanism cable from the auxiliary hoist.

5.8.4 Clean the drop test pad and ensure test area is cordoned off.

5.8.5 Place the NS30 #2 test article into the temperature conditioning chamber and attach a temperature sensor to the steel canister body (external sensor). Unsecure the internal temperature sensor lead wire and route the thermocouple lead wires of both the internal and external sensors through a co-located penetration in the temperature conditioning chamber and connect to a temperature datalogger or temperature strip chart recorder.

5.8.6 Close and seal the conditioning chamber lid and ensure the portable temperature conditioning unit is connected via insulated ducting to the temperature conditioning chamber, noting the time, date, and ambient air temperature on DATA SHEET 2.5 – Test #4, 30-Foot Side Drop (Hot). Initiate the conditioning process.

5.8.7 Monitor the temperature sensors by utilizing the datalogger or a temperature strip chart recorder and continue the conditioning process until both sensors stabilize at the temperature established in the temperature conditioning test #2- Hot Cycle.

Note: If the internal temperature sensor was damaged during the hot end drop test, alternatively monitor the external temperature sensor only, noting the time delay in the hot end drop test preparation for the internal sensor to stabilize with the external temperature sensor. The conditioning time shall be extended beyond the time required for the external sensor to reach the desired set-point by a period of time equal to the time delay for stabilization in the hot end drop conditioning process.

5.8.8 Note the time, date, and ambient air temperature on DATA SHEET 2.5 – Test #4, 30-Foot Side Drop (Hot) and then discontinue the conditioning process.

5.8.9 Open the temperature conditioning chamber lid, remove the NS30 #2 test unit from the temperature conditioning chamber, detach the external temperature sensor, secure and protect the internal temperature sensor lead wire, and install the NS30 #2 test article into the neutron shielded canister text fixture in the side drop orientation (see Figure 4).

5.8.10 Install the end cap plate and associated washers and hex head cap screws, tightening the cap screws to 80 ± 10 lb-ft torque each. Prior to Step 5.8.12, install and secure two impact accelerometers on the neutron shielded canister test fixture instrument mounts, near the impact point, following manufacturer's instructions, ensuring the acceleration measurement axis is aligned with the drop orientation. Provide appropriate strain relief and routing for the accelerometer data cables to prevent damage during the drop test.

Note: accelerometer locations should be on the side opposite the previous cold side drop.

5.8.11 Relocate the loaded neutron shielded canister test fixture to the drop pad location.

5.8.12 Rig the neutron shielded canister test fixture horizontally, utilizing the lift lugs as shown in Figure 4, in an orientation that is 180° from the previous cold side drop.

5.8.13 Connect the accelerometer data cables to the data acquisition equipment.

5.8.14 Hoist the test fixture up 3' from the test pad surface. Attach a 30' long plumb-bob and string line to the underside (impact point) of the test fixture using duct tape.

5.8.15 Verify that the test fixture is rigged within 2° of horizontal.

5.8.16 Hoist the test fixture such that the initially impacting point is 30 feet (+3/-0 inches) above the target surface. The plumb-bob should be sitting just above the drop pad surface. Verify that the test fixture is centered over the drop pad.

5.8.17 Using a man-lift, remove the plumb-bob and string from the test fixture and then connect the release mechanism cable to the auxiliary hoist.

5.8.18 Verify that all test preparations have been completed and data recorded as delineated in DATA SHEET 2.5 – Test #4, 30-Foot Side Drop (Hot).

5.8.19 Verify positioning of the video cameras, start videotaping, start accelerometer data acquisition.

5.8.20 Call out for **"ALL CLEAR"**.

5.8.21 Drop the test fixture.

5.8.22 Discontinue accelerometer data acquisition, secure the acceleration versus time data traces, and remove the accelerometers from the instrument mounts. Record damage to the impact zone on DATA SHEET 2.5 – Test #4, 30-Foot Side Drop (Hot) and measure and record the residual height (inside radius to outside radius at the impact zone) of each side impact limiter.

5.9 Post Hot Side Drop Test Disassembly

5.9.1 Take special care during the post-test disassembly process not to cause deformations and/or damage that could interfere with test related results.

5.9.2 Remove the end cap plate and associated washers and hex head cap screws and remove the NS30 #2 test article from the test fixture.

5.9.3 Photo-document all test related/induced deformations and results with respect to the exterior of the NS30 #2 test article. If possible, use a high-contrast rule or tape measure to depict scale in each photograph, including the NS30 test article number for reference.

5.9.4 Record damage to the NS30 #2 test article exterior on DATA SHEET 2.5 – Test #4, 30-Foot Side Drop (Hot).

5.10 Post Hot Drop Test Disassembly

5.10.1 Take special care during the post-test disassembly process not to cause deformations and/or damage that could interfere with test related results.

5.10.2 With the NS30 #2 test article in a vertical (top end up) orientation, disassemble the removable lid canister by utilizing an abrasive cutting wheel to circumferentially sever the canister body from the body flange near the original circumferential girth weld. Remove the removable lid canister lid assembly and body flange to permit inspection of the top end cap assembly to body interface. Similarly, cut three equally spaced viewing windows out of the removable lid canister body near the body flat head original circumferential girth weld.

5.10.3 Photo-document all test related/induced deformations and results with respect to the top end cap assembly and bottom end cap assembly to body interfaces. If possible, use a high-contrast rule or tape measure to depict scale in each photograph, including the NS30 test article number for reference. Note the presence (or lack thereof) of any payload sand exterior to the shield insert assembly. If present, collect and obtain the weight of the sand.

5.10.4 Fully disassemble and remove the top end cap, body pipe, payload containers, and bottom end cap to permit inspection of all shield insert assembly components.

5.10.5 Photo-document all test related/induced local deformations (including scratches and gouges that exceed ¼ in. depth) and results with respect to the top end cap, bottom end cap, and body. If possible, use a high-contrast rule or tape measure to depict scale in each photograph, including the NS30 test article number for reference.

5.10.6 Record results of inspections on DATA SHEET 2.6 – Test #3 and 4, 30-Foot Drops (Hot).

6.0 Additional Requirements

6.1 Documentation Requirements.

6.1.1 Prior to each of the drop test sequences, a determination will be made of documentation and inspection requirements in addition to those described in the individual test procedures. These requirements will be determined based on input from TRU Solutions and Petersen Inc. personnel involved in the set-up, performance, and observation of the tests.

6.1.2 These additional requirements shall include video or digital photography of significant testing sequences, dimensional inspections, or other requirements. All additional requirements will be clearly described and documented on the Test Report.

6.1.3 As directed by the WTS Test Engineer, deviations from this test procedure may be determined necessary, and directed during the course of testing. Any deviations shall be fully documented with concurrence from Petersen Inc. Quality Assurance and Engineering representatives.

7.0 Quality Assurance Requirements

7.1 Petersen Quality Assurance shall maintain surveillance of testing activities as necessary to assure ongoing compliance.

7.1.1 This surveillance will be maintained through actual witnessing of the test and/or review of production travelers or test data.

7.2 Personnel performing this test in accordance with this procedure shall receive training in the proper application to the test procedures described in this document.

7.3 Any nonconformance to the requirements and instructions stated in this procedure shall be handled within the Petersen Inc. standard Nonconforming Material Control system.

7.4 Records documenting performance of this procedure will be maintained in a retrievable state for the amount of time specified by the governing contract.

APPENDIX A – FIGURES

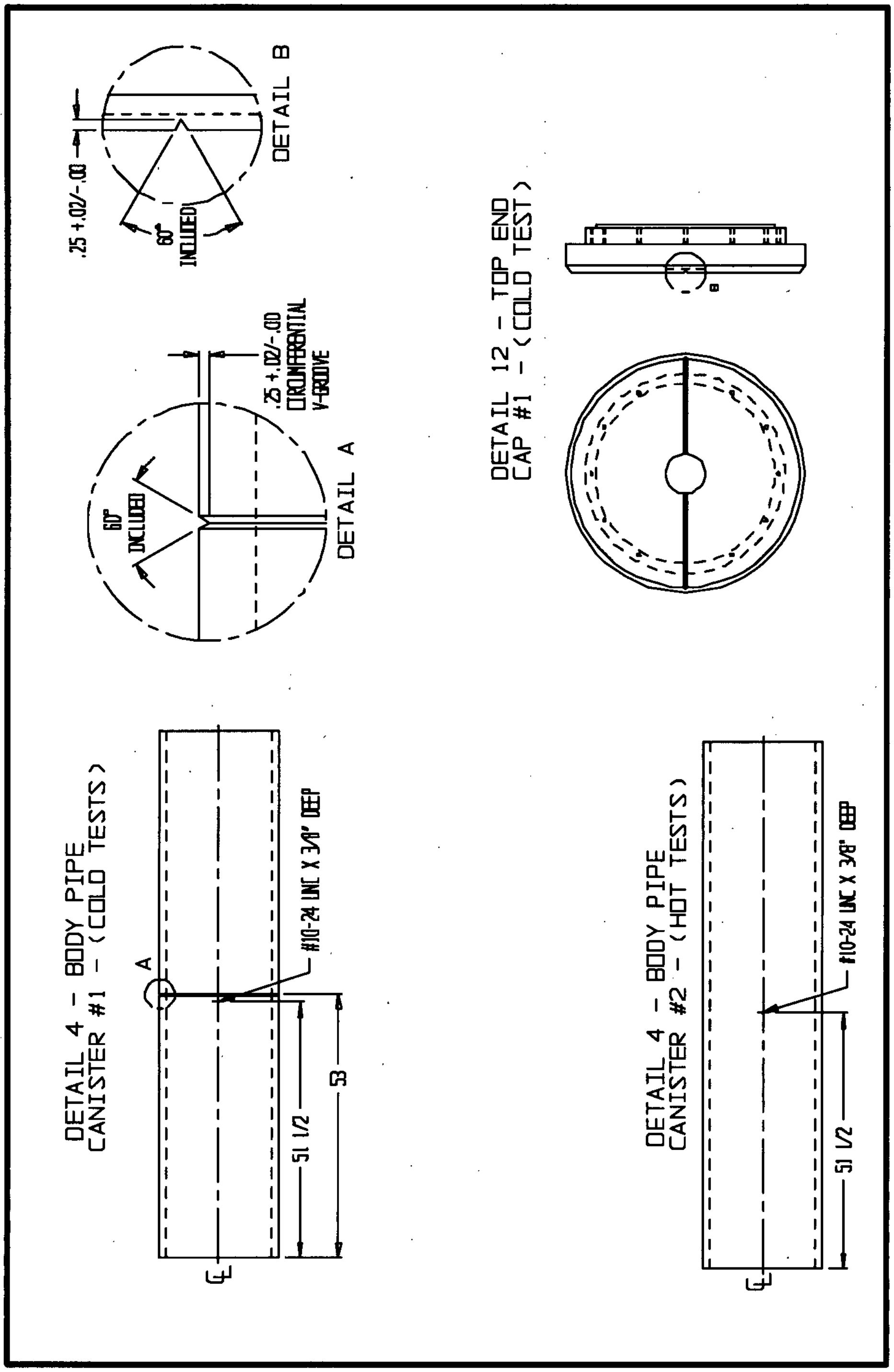

Figure 1 – NS30 Body Pipe (Detail 4) Testing Modifications

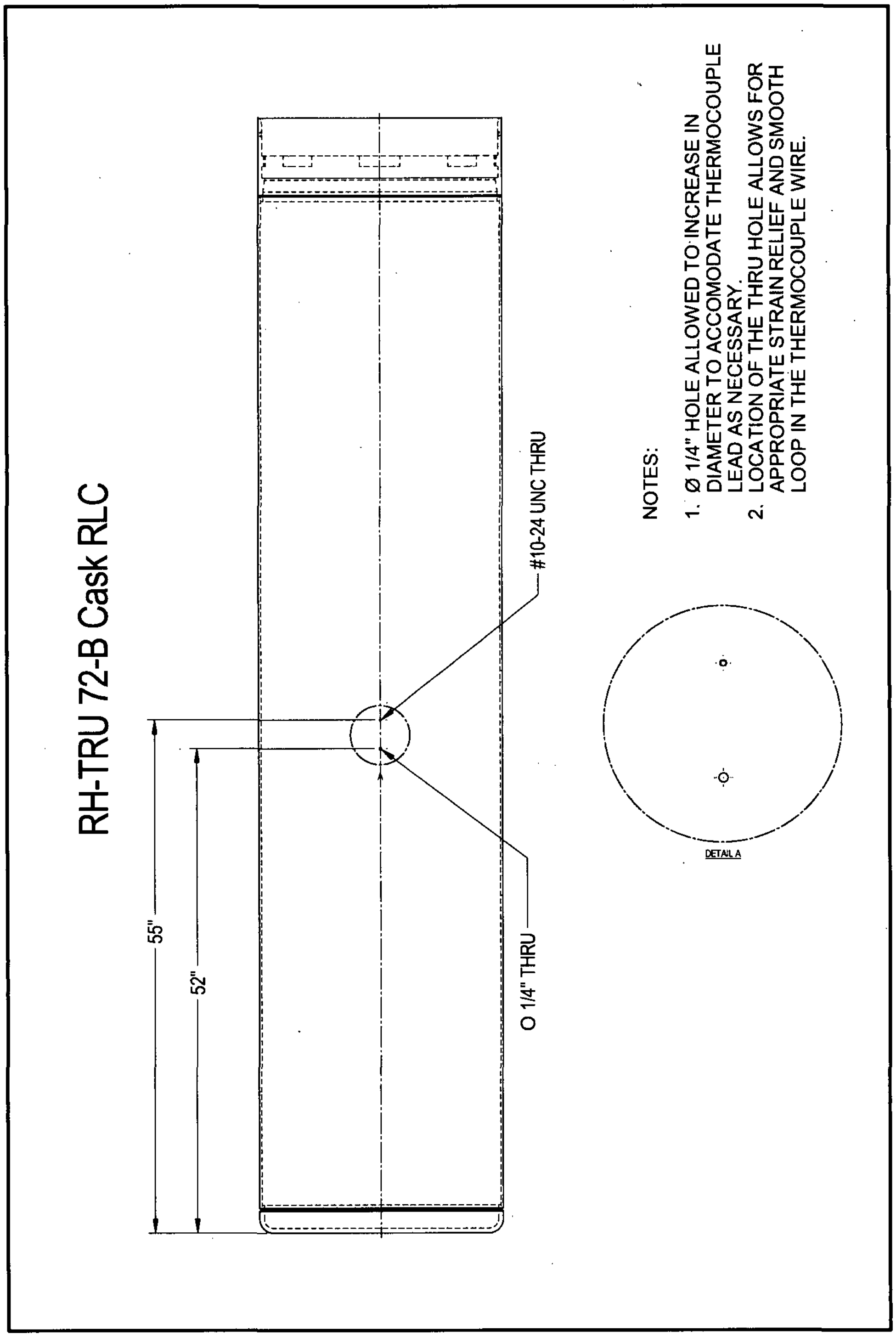

Figure 2 – Modification of RH-TRU 72-B Cask RLC for thermocouple routing.

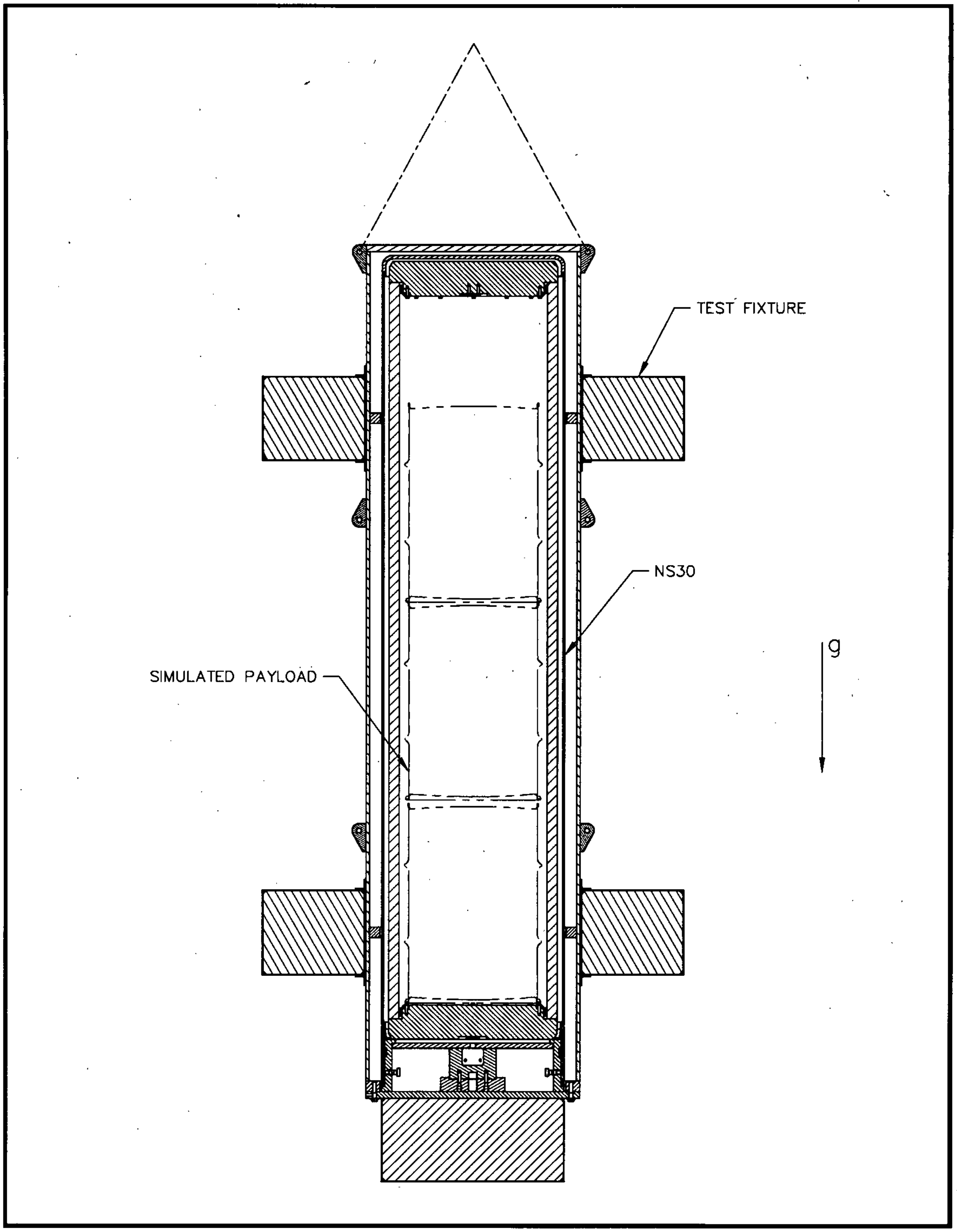

Figure 3 – End Drop Test Configuration

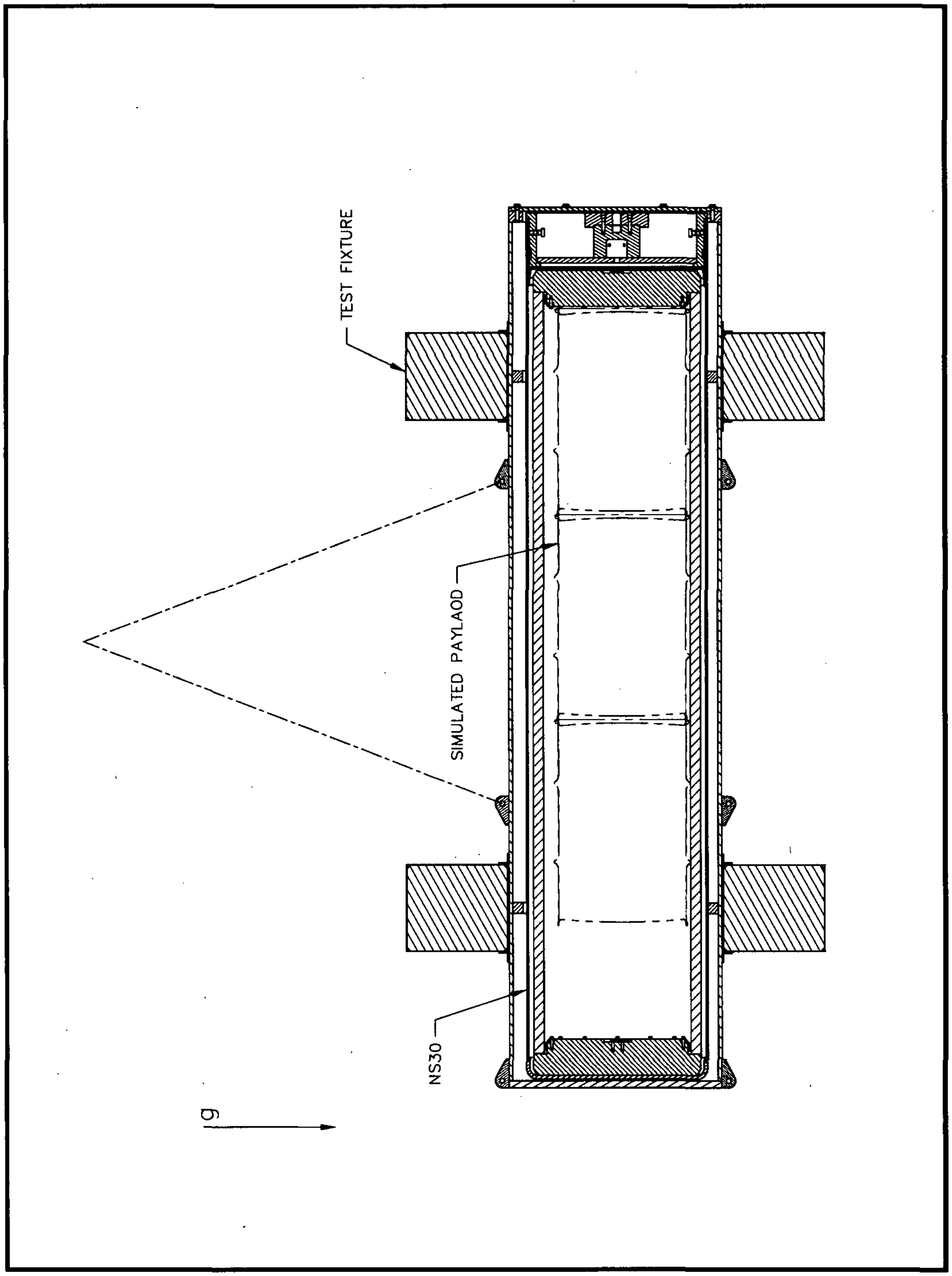

Figure 4 – Side Drop Test Configuration

APPENDIX B – DATA SHEETS

Component Weight Records:

- DATA SHEET 1.1 – Component Weights
- DATA SHEET 1.2 – Calibration Records

Free Drop Test Records:

- DATA SHEET 2.1 – Test #1, 30-Foot End Drop (Cold)
- DATA SHEET 2.2 – Test #2, 30-Foot Side Drop (Cold)
- DATA SHEET 2.3 – Test #1 & 2, 30-Foot Drops (Cold)
- DATA SHEET 2.4 – Test #3, 30-Foot End Drop (Hot)
- DATA SHEET 2.5 – Test #4, 30-Foot Side Drop (Hot)
- DATA SHEET 2.6 – Test #3 & 4, 30-Foot Drops (Hot)

DATA SHEET 1.1 – Component Weights

Neutron Shielded Canister Test Fixture Tare Weights (lb)

Body Assembly ①	End Limiter #1 ②	End Limiter #2 ③	End Cap Plate & Hardware ④
End Drop #1 Test Fixture ①+②=⑤	Side Drop #1 Test Fixture ①+④=⑥	End Drop #2 Test Fixture ①+③=⑦	Side Drop #2 Test Fixture ①+④=⑧

NS30 Neutron Shielded Canister Tare Weights (lb)

NS30 #1 ⑨	NS30 #2 ⑩

Payload Drum Weights (lb)

Payload Drum # 1 ❶	Payload Drum #2 ❷	Payload Drum # 3 ❸
Payload Drum # 4 ❹	Payload Drum #5 ❺	Payload Drum # 6 ❻

Loaded NS30 Neutron Shielded Canister Weights (lb)

NS30 #1 ⑨+❶+❷+❸=❼ (3,100 - 3,200 lb)	NS30 #2 ⑩+❹+❺+❻=❽ (3,100 - 3,200 lb)

Loaded Neutron Shielded Canister and Test Fixture Weights (lb)

End Drop #1 ⑤+❼	Side Drop #1 ⑥+❼	End Drop #2 ⑦+❽	Side Drop #2 ⑧+❽

Test Engineer and Witness Records

Test Engineer Signature	Printed Name	Date
Witness Signature	Printed Name	Date

DATA SHEET 1.2 – Calibration Records

Instrumentation Records

(If multiple load cells/scales are utilized, denote the corresponding component(s) that each load cell/scale was used to measure.)

Load Cell/Scale Description	*Petersen PF Number*	*Calibration Due Date*
Load Cell/Scale Description	*Petersen PF Number*	*Calibration Due Date*
Load Cell/Scale Description	*Petersen PF Number*	*Calibration Due Date*
Torque Wrench	*Petersen PF Number*	*Calibration Due Date*
Strip Chart Recorder	*Petersen PF Number*	*Calibration Due Date*
Hand Held Temperature Probe	*Petersen PF Number*	*Calibration Due Date*
Data Logger	*Serial Number*	*Calibration Due Date*
Thermocouple Lead #1	*Serial Number*	*Calibration Due Date*
Thermocouple Lead #2	*Serial Number*	*Calibration Due Date*
Accelerometer #1	*Serial Number*	*Calibration Due Date*
Accelerometer #2	*Serial Number*	*Calibration Due Date*
Other	*Serial Number*	*Calibration Due Date*
Other	*Serial Number*	*Calibration Due Date*
Other	*Serial Number*	*Calibration Due Date*

DATA SHEET 2.1 – Test #1, 30-Foot End Drop (Cold)

.... Pre-Test Records				
Conditioning Iteration #_____ Set Point _____(°F)	Date & Time (mm/dd/yy & hh:mm)	Ambient Temp. (°F)	Internal Sensor (°F)	External Sensor (°F)
Start Conditioning				
Start +30 min.				
Start +60 min.				
Start +90 min.				
Start +120 min.				
Start +150 min.				
Start +180 min.				
Start +210 min.				
Start +240 min.				
Start +270 min.				
Start +300 min.				
Start +330 min.				
Start +360 min.				
Start +390 min.				
Start +420 min.				
Start +450 min.				
Start +480 min.				
Start +510 min.				
Start +540 min.				
Start +570 min.				
Start +600 min.				
Note: If time to reach conditioning set-point is greater than +600 min., use supplemental pages as necessary to record sensor temperatures.				
Stop Conditioning				
Stop +10 min.				
Stop +20 min.				
Stop +30 min.				
Stop +40 min.				
Stop +50 min.				
Stop +60 min.				
Stop +70 min.				
Stop +80 min.				
Stop +90 min.				
Stop +100 min.				
Stop +110 min.				
Stop +120 min.				
Note: If additional conditioning iterations with lower set-point are required to achieve internal temperature < -20 °F at the end of the 'X' dwell period, use supplemental pages as necessary to record sensor temperatures.				

Final Conditioning Iteration Set Point ____(°F)	Date & Time (mm/dd/yy & hh:mm)	Ambient Temp. (°F)	Internal Sensor (°F)	External Sensor (°F)
Start Conditioning				
Start +30 min.				
Start +60 min.				
Start +90 min.				
Start +120 min.				
Start +150 min.				
Start +180 min.				
Start +210 min.				
Start +240 min.				
Start +270 min.				
Start +300 min.				
Start +330 min.				
Start +360 min.				
Start +390 min.				
Start +420 min.				
Start +450 min.				
Start +480 min.				
Start +510 min.				
Start +540 min.				
Start +570 min.				
Start +600 min.				
Note: If time to reach final conditioning set-point is greater than +600 min., use supplemental pages as necessary to record sensor temperatures.				
Stop Conditioning				

Datasheet 2.1 – Page 2

Test Records

Ambient Temperature (°F)

Test Date (mm/dd/yy) and Test Time (hh:mm)

Measured Drop Test Height (in.)

Measured Longitudinal Angle (0° = horizontal)

Post-Test Records

Record Residual Height of End Impact Limiter and Damage to the Test Article Exterior Using the Space Below

Record Additional Comments Below or on a Separate Page

Test Engineer and Witness Records

Test Engineer Signature	*Printed Name*	*Date*
Witness Signature	*Printed Name*	*Date*

Datasheet 2.1 – Page 3

DATA SHEET 2.2 – Test #2, 30-Foot Side Drop (Cold)

Final Conditioning Iteration Set Point _____(°F)	Date & Time (mm/dd/yy & hh:mm)	Ambient Temp. (°F)	Internal Sensor (°F)	External Sensor (°F)
Start Conditioning				
Start +30 min.				
Start +60 min.				
Start +90 min.				
Start +120 min.				
Start +150 min.				
Start +180 min.				
Start +210 min.				
Start +240 min.				
Start +270 min.				
Start +300 min.				
Start +330 min.				
Start +360 min.				
Start +390 min.				
Start +420 min.				
Start +450 min.				
Start +480 min.				
Start +510 min.				
Start +540 min.				
Start +570 min.				
Start +600 min.				
Note: If time to reach final conditioning set-point is greater than +600 min., use supplemental pages as necessary to record sensor temperatures.				
Stop Conditioning				

Datasheet 2.2 – Page 1

Test Records

Ambient Temperature (°F)

Test Date (mm/dd/yy) and Test Time (hh:mm)

Measured Drop Test Height (in.)

Measured Longitudinal Angle (0° = horizontal)

Post-Test Records

Record Residual Height of Side Impact Limiters and Damage to the Test Article Exterior Using the Space Below

Record Additional Comments Below or on a Separate Page

Test Engineer and Witness Records

Test Engineer Signature	Printed Name	Date
Witness Signature	Printed Name	Date

Datasheet 2.2 – Page 2

DATA SHEET 2.3 – Tests #1 & 2, 30-Foot Drops (Cold)

.... Post-Test Records	
Record Visible Damage of Top and Bottom End Cap Assembly to Body Interfaces Using the Space Below	*Record Additional Comments Below or on a Separate Page*
Record Visible Damage of Top End Cap, Bottom End Cap, and Body Using the Space Below	*Record Additional Comments Below or on a Separate Page*

.... Test Engineer and Witness Records ....

Test Engineer Signature	Printed Name	Date
Witness Signature	Printed Name	Date

DATA SHEET 2.4 – Test #3, 30-Foot End Drop (Hot)

.... Pre-Test Records				
Conditioning Iteration #_____ Set Point _____(°F)	Date & Time (mm/dd/yy & hh:mm)	Ambient Temp. (°F)	Internal Sensor (°F)	External Sensor (°F)
Start Conditioning				
Start +30 min.				
Start +60 min.				
Start +90 min.				
Start +120 min.				
Start +150 min.				
Start +180 min.				
Start +210 min.				
Start +240 min.				
Start +270 min.				
Start +300 min.				
Start +330 min.				
Start +360 min.				
Start +390 min.				
Start +420 min.				
Start +450 min.				
Start +480 min.				
Start +510 min.				
Start +540 min.				
Start +570 min.				
Start +600 min.				
Note: If time to reach conditioning set-point is greater than +600 min., use supplemental pages as necessary to record sensor temperatures.				
Stop Conditioning				
Stop +10 min.				
Stop +20 min.				
Stop +30 min.				
Stop +40 min.				
Stop +50 min.				
Stop +60 min.				
Stop +70 min.				
Stop +80 min.				
Stop +90 min.				
Stop +100 min.				
Stop +110 min.				
Stop +120 min.				
Note: If additional conditioning iterations with higher set-point are required to achieve internal temperature > 150 °F at the end of the 'X' dwell period, use supplemental pages as necessary to record sensor temperatures.				

Final Conditioning Iteration Set Point _____(°F)	Date & Time (mm/dd/yy & hh:mm)	Ambient Temp. (°F)	Internal Sensor (°F)	External Sensor (°F)
Start Conditioning				
Start +30 min.				
Start +60 min.				
Start +90 min.				
Start +120 min.				
Start +150 min.				
Start +180 min.				
Start +210 min.				
Start +240 min.				
Start +270 min.				
Start +300 min.				
Start +330 min.				
Start +360 min.				
Start +390 min.				
Start +420 min.				
Start +450 min.				
Start +480 min.				
Start +510 min.				
Start +540 min.				
Start +570 min.				
Start +600 min.				
Note: If time to reach final conditioning set-point is greater than +600 min., use supplemental pages as necessary to record sensor temperatures.				
Stop Conditioning				

Datasheet 2.4 – Page 2

Test Records

Ambient Temperature (°F)	*Test Date (mm/dd/yy) and Test Time (hh:mm)*
Measured Drop Test Height (in.)	*Measured Longitudinal Angle (0° = horizontal)*

Post-Test Records

Record Residual Height of End Impact Limiter and Damage to the Test Article Exterior Using the Space Below	*Record Additional Comments Below or on a Separate Page*

Test Engineer and Witness Records

Test Engineer Signature	*Printed Name*	*Date*
Witness Signature	*Printed Name*	*Date*

Datasheet 2.4 – Page 3

DATA SHEET 2.5 – Test #4, 30-Foot Side Drop (Hot)

Final Conditioning Iteration Set Point _____(°F)	Date & Time (mm/dd/yy & hh:mm)	Ambient Temp. (°F)	Internal Sensor (°F)	External Sensor (°F)
Start Conditioning				
Start +30 min.				
Start +60 min.				
Start +90 min.				
Start +120 min.				
Start +150 min.				
Start +180 min.				
Start +210 min.				
Start +240 min.				
Start +270 min.				
Start +300 min.				
Start +330 min.				
Start +360 min.				
Start +390 min.				
Start +420 min.				
Start +450 min.				
Start +480 min.				
Start +510 min.				
Start +540 min.				
Start +570 min.				
Start +600 min.				
Note: If time to reach final conditioning set-point is greater than +600 min., use supplemental pages as necessary to record sensor temperatures.				
Stop Conditioning				

Datasheet 2.5 – Page 1

Test Records	
Ambient Temperature (°F)	Test Date (mm/dd/yy) and Test Time (hh:mm)
Measured Drop Test Height (in.)	Measured Longitudinal Angle (0° = horizontal)
Post-Test Records	
Record Residual Height of Side Impact Limiters and Damage to the Test Article Exterior Using the Space Below	Record Additional Comments Below or on a Separate Page

Test Engineer and Witness Records		
Test Engineer Signature	Printed Name	Date
Witness Signature	Printed Name	Date

Datasheet 2.5 – Page 2

DATA SHEET 2.6 – Tests #3 & 4, 30-Foot Drops (Hot)

Post-Test Records	
Record Visible Damage of Top and Bottom End Cap Assembly to Body Interfaces Using the Space Below	*Record Additional Comments Below or on a Separate Page*
Record Visible Damage of Top End Cap, Bottom End Cap, and Body Using the Space Below	*Record Additional Comments Below or on a Separate Page*

Test Engineer and Witness Records

Test Engineer Signature	*Printed Name*	*Date*
Witness Signature	*Printed Name*	*Date*