

LANL-B Package Certification Test Plan

AREVA Federal Services LLC

under contract to

Los Alamos National Security, LLC

March 31, 2011



Introductions

▶ AREVA Federal Services LLC (AFS)

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- ◆ Phil Noss, Licensing Manager
- ◆ Rick Migliore, Shielding Engineer

▶ Global Threat Reduction Initiative (GTRI, NA-21, NNSA)

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- ◆ Pete Tensmeyer, Deputy Director North and South America Threat Reduction
- ◆ Abigail Cuthbertson, Federal Project Manager, OSRP
- ◆ John Zarling, Staff, NNSA
- ◆ Darcy Campbell, Staff, NNSA

▶ Los Alamos National Laboratory (LANL OSRP)

- ◆ Julia Whitworth, OSRP Program Manager
- ◆ Dwaine Brown, Staff Lead for Type B Container Development
- ◆ Mike Pearson, Senior Technical Advisor
- ◆ Randolph B. Vaughn, Project Manager for Type B Container Development

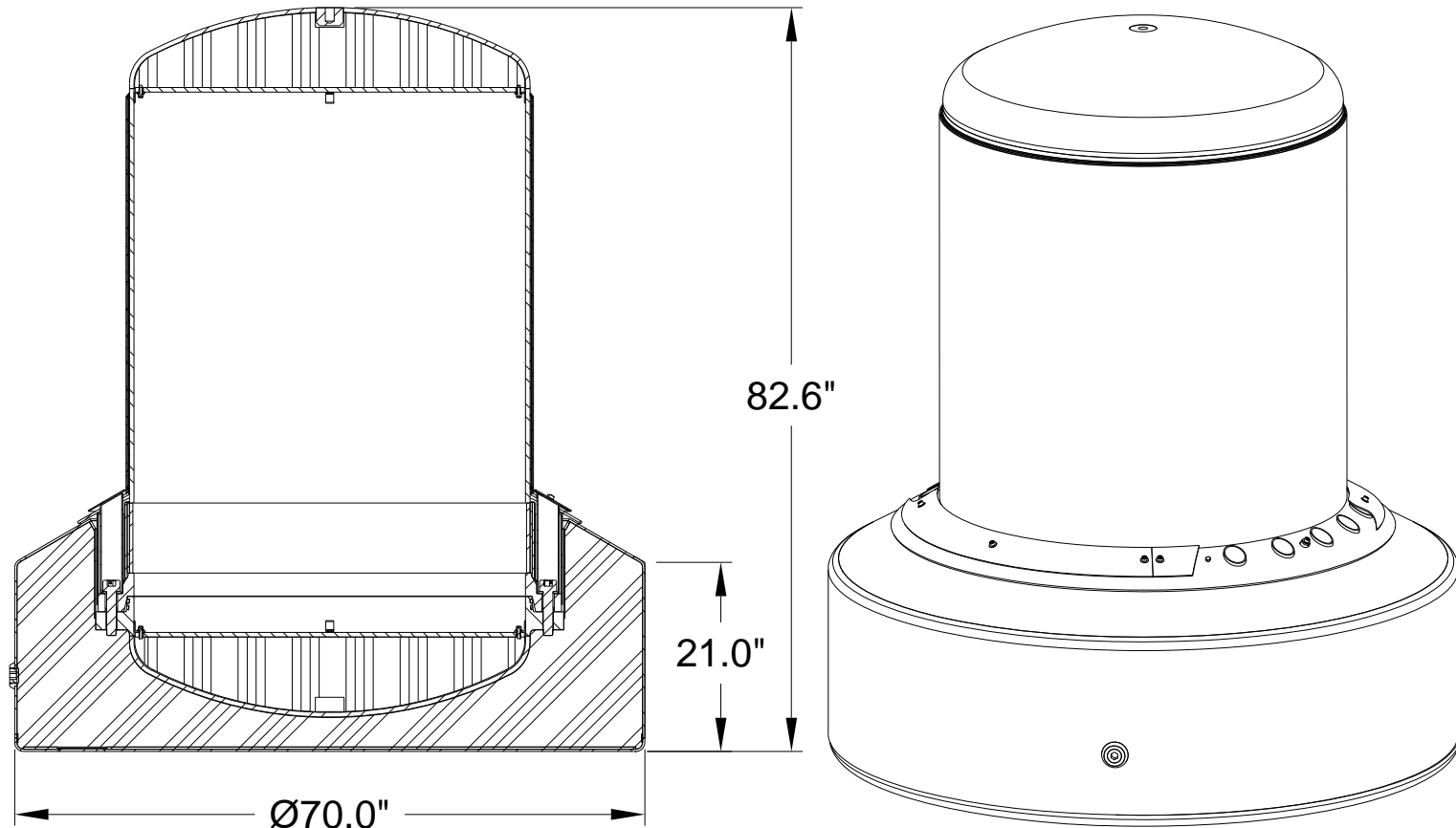
Meeting Objectives

- ▶ **Review of the LANL-B Packaging**
- ▶ **Discuss Certification Test Plan**
- ▶ **NRC Staff feedback**

Package Design Summary

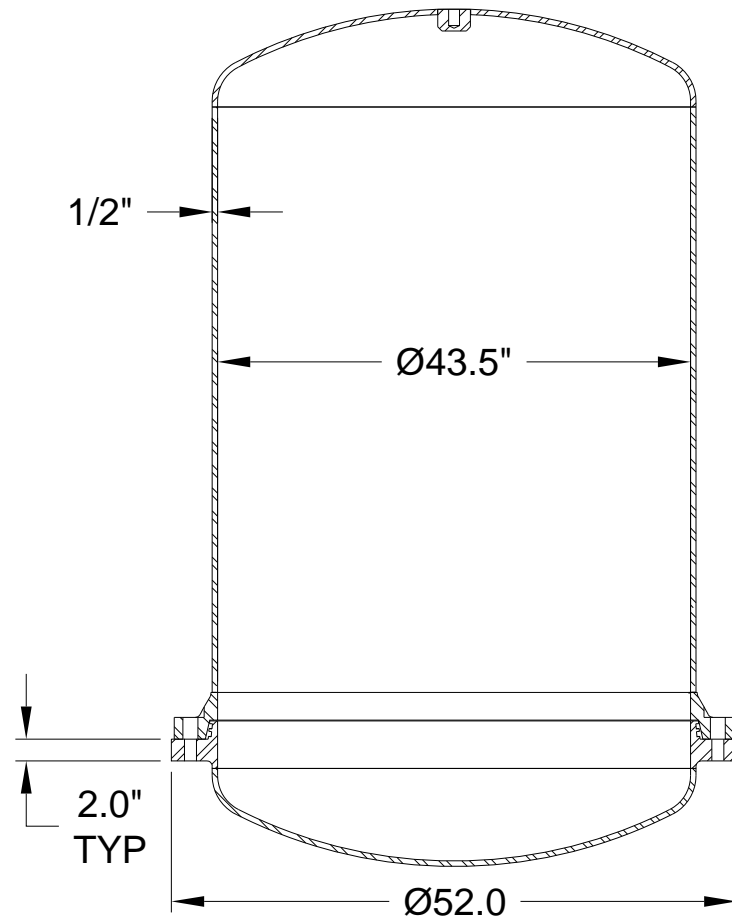
- ▶ **Type B**
- ▶ **Leaktight containment of shielded sources (LTSS or devices) ($<1.0 \times 10^{-7}$ std-cc/sec, air) for both NCT and HAC**
- ▶ **For transport by truck, rail, ship, and air**
- ▶ **10,000 lb licensed maximum weight; approx. 4,870 lb empty**
- ▶ **Two payload types**
 - ◆ **Long Term Storage Shield (LTSS), a lead shield developed by IAEA**
 - ◆ **Intact devices (i.e., teletherapy heads or industrial irradiators) containing their sources ('shielded devices')**

Package Design Summary



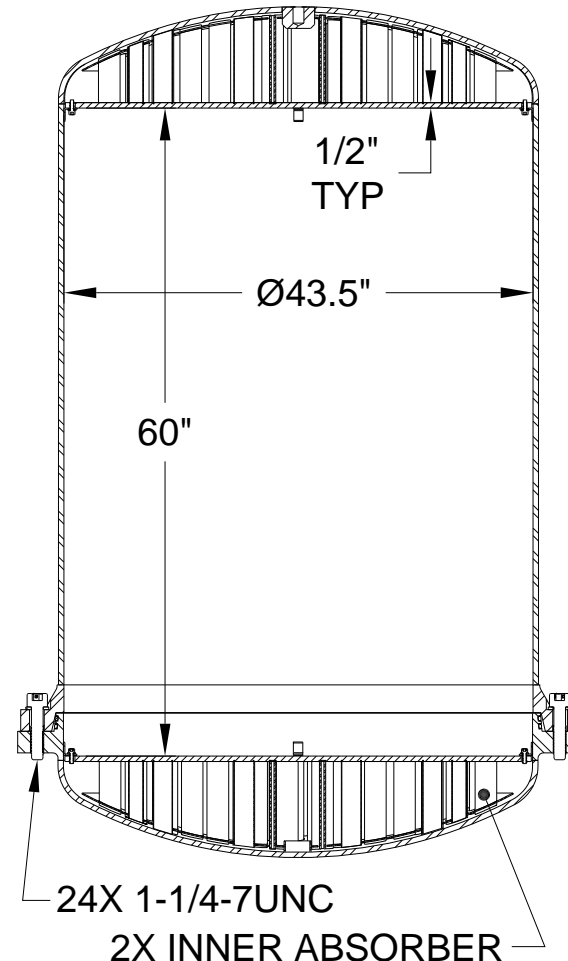
LANL-B Packaging Description

- ▶ **Containment boundary consists of a vertical cylinder with torispherical ends**
- ▶ **Massive closure joint near lower end**
- ▶ **Inner diameter 43.5 inches**
- ▶ **Thickness 1/2 inch**
- ▶ **Material: Type 304 austenitic stainless steel**

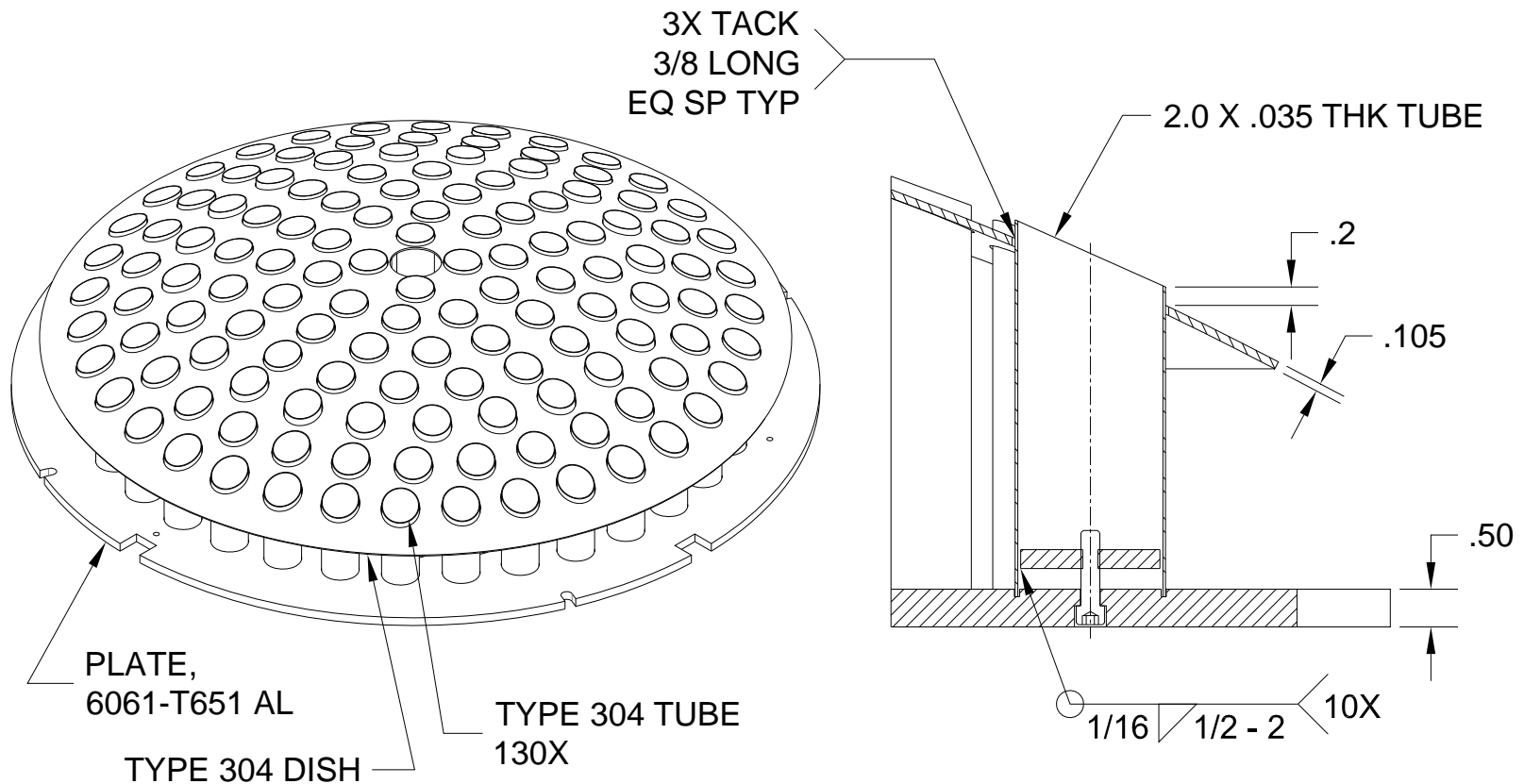


LANL-B Packaging Description

- ▶ At each end, crushing tube energy absorbers (with 1/2-inch thick aluminum plates to distribute load) creates flat ended cavity 60 inches long
- ▶ 24, 1-1/4 inch diameter closure bolts made from ASTM A320 L43 & hardened washers



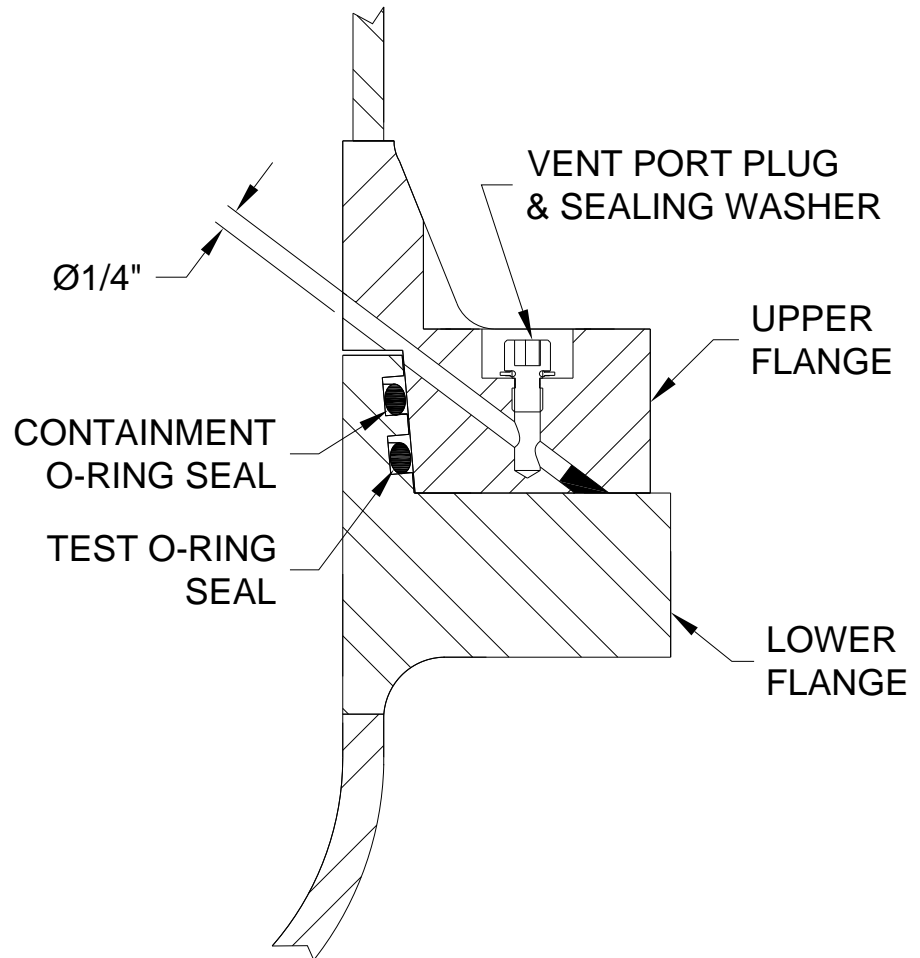
LANL-B Packaging Description



Internal absorber – top and bottom

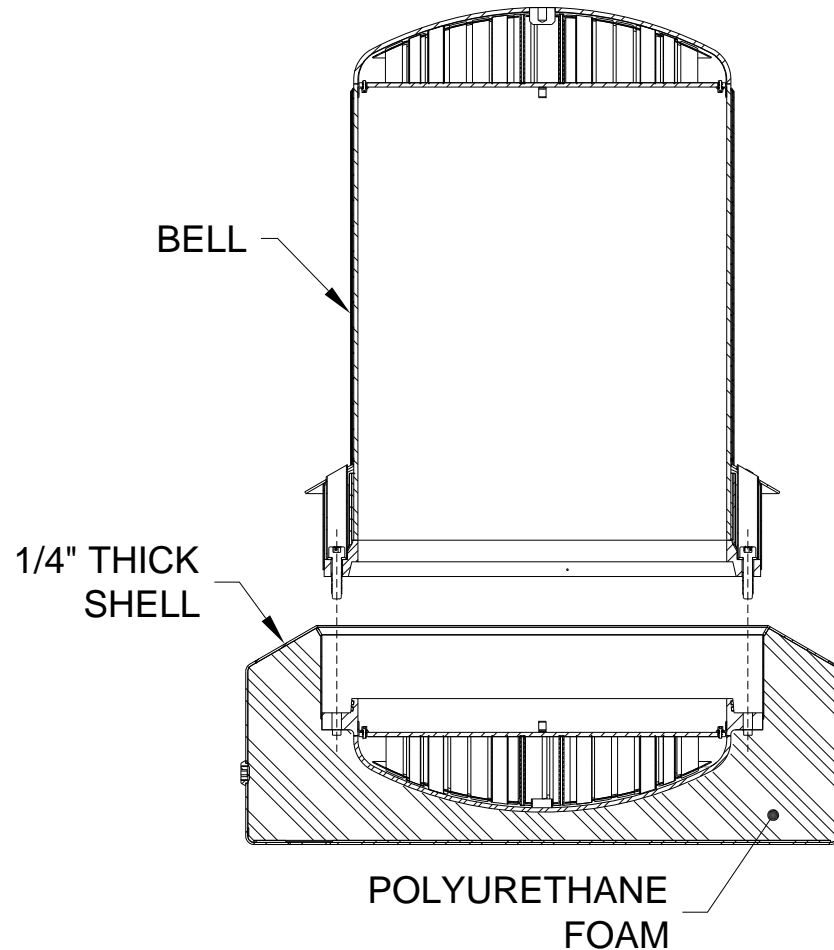
LANL-B Packaging Description

- ▶ **Containment seal and test seal $\frac{3}{8}$ -inch diameter butyl rubber on 5° tapered bore**
- ▶ **Seal material made from Rainier Rubber R-0405-70**
- ▶ **Vent port and seal test port located on bolt circle, with brass port plugs, and sealing washers using same butyl elastomer**



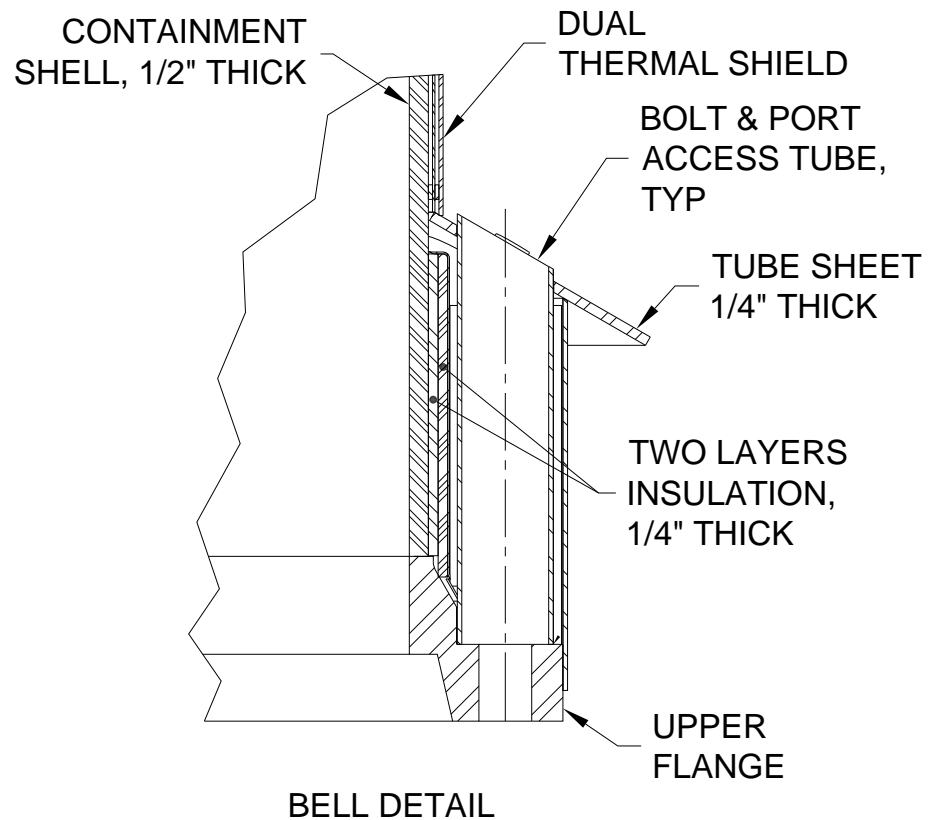
LANL-B Packaging Description

- ▶ **Single impact limiter on bottom protects from direct impact on flange, provides fire protection**
- ▶ **Impact limiter is integral to lower head**
- ▶ **Polyurethane foam, 15 lb/ft³**
- ▶ **IL shell is 1/4 inch thick, maximum use of rolled corners and full-thickness welds**



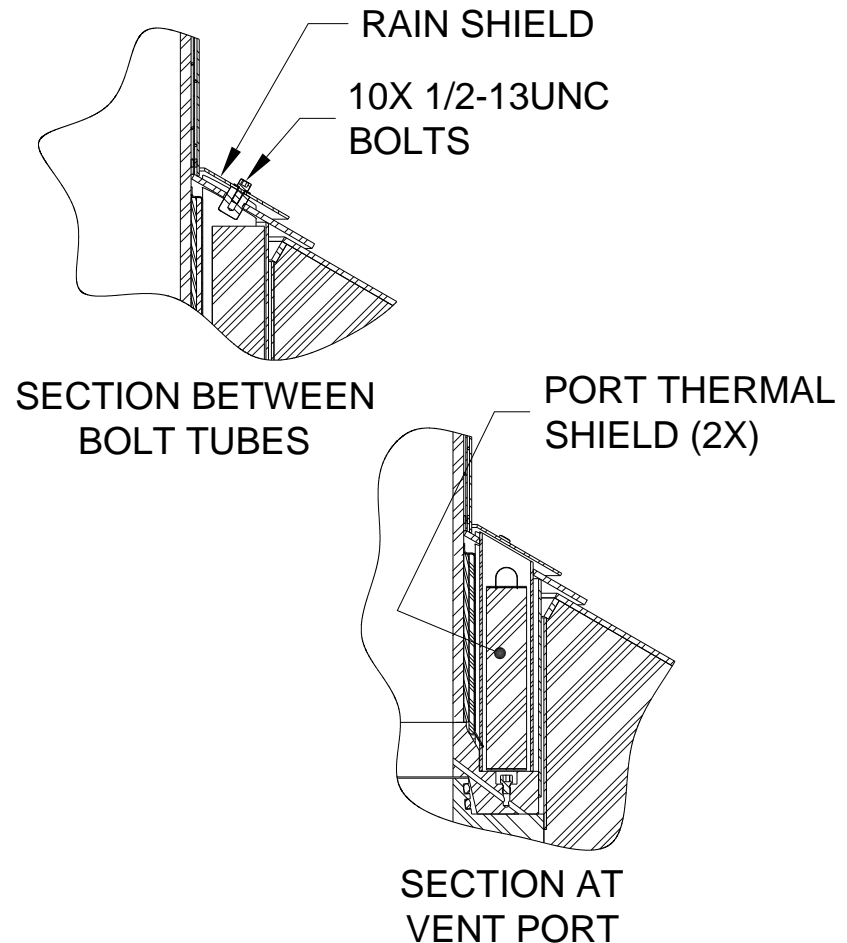
LANL-B Packaging Description

- ▶ Upper component (“bell”) has 2-1/4” I.D. tubes for access to closure bolts and ports
- ▶ Two layers of 1/4-inch insulation reduce heat input to lower bell
- ▶ Tube sheet (1/4-inch thick) holds tubes securely and improves puncture protection
- ▶ Dual thermal shield covers cylindrical outer surface



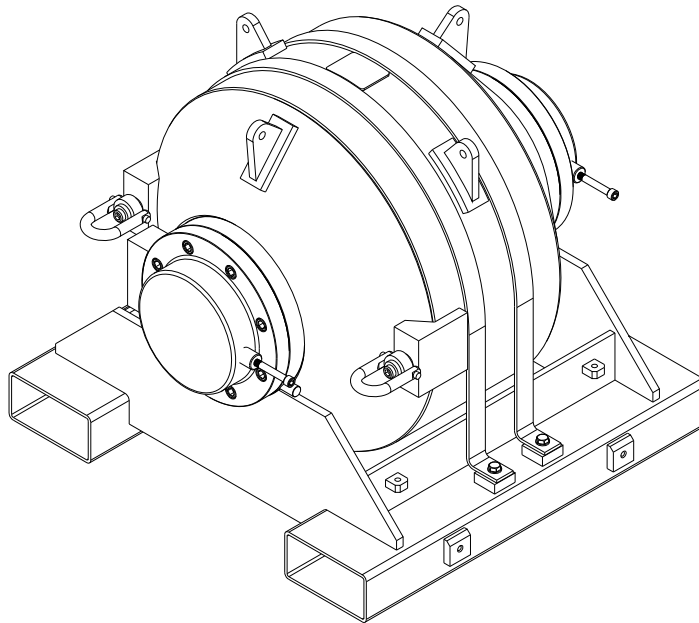
LANL-B Packaging Description

- ▶ Rain shield keeps bolt and port tubes dry and also serves as fire shield
- ▶ Rain shield attached using 10, 1/2-13 UNC bolts
- ▶ Port thermal shields used in vent and test port tubes
- ▶ Port thermal shields retained by rain shield

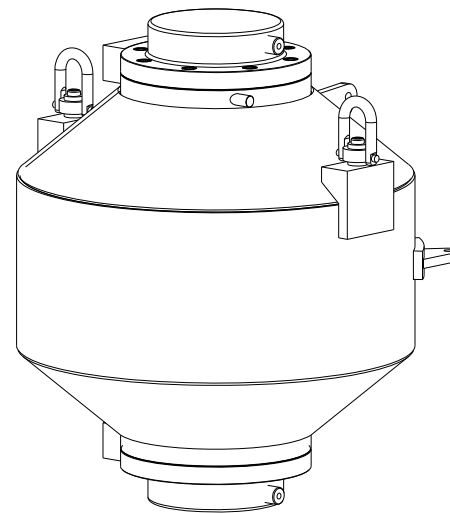


Payloads

► LTSS



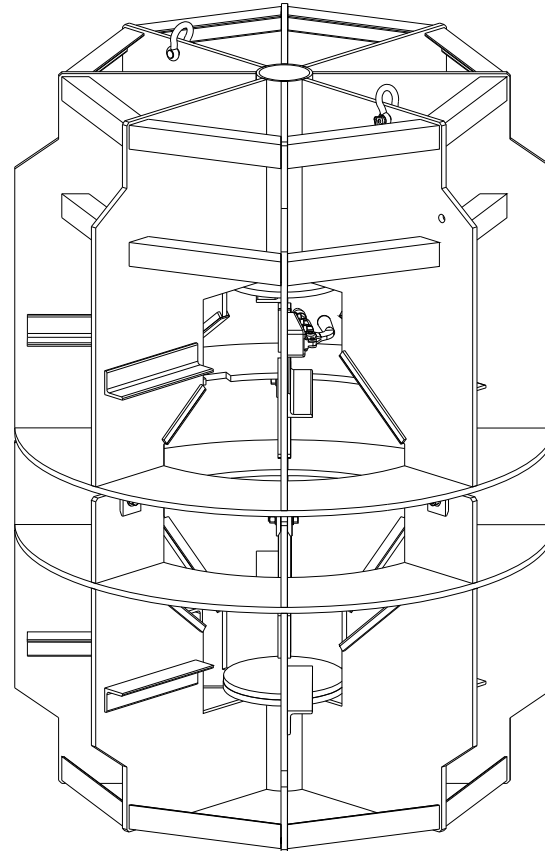
AS STORED



AS TRANSPORTED

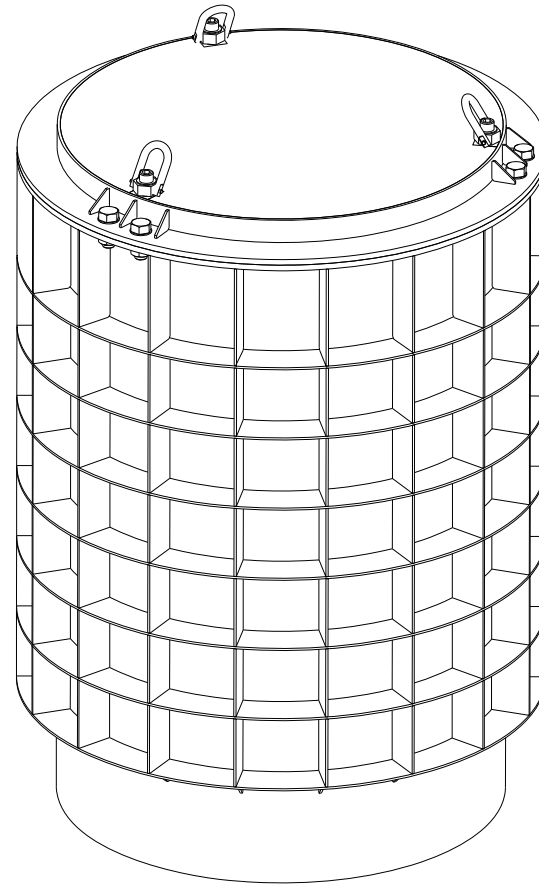
Payloads

- ▶ **LTSS lodgment fits with minimal clearance inside package cavity**
- ▶ **Aluminum weldment with upper and lower halves joined by bolts or pins**
- ▶ **Secures LTSS for transport**
- ▶ **LTSS max weight: 4,650 lb**
- ▶ **Max. gross weight of lodgment: 5,130 lb**



Payloads

- ▶ **Inner Container (IC) fits with minimal clearance inside package cavity**
- ▶ **Type 304 SS reinforced shell weldment with bolted lid**
- ▶ **Inner cavity is 36" dia by 53" long**
- ▶ **Secures device for transport using blocking and bracing**
- ▶ **Max. device weight: 3,500 lb**
- ▶ **Max. gross weight: 5,130 lb**



Certification Strategy

- ▶ **Demonstrate adequacy of package, LTSS lodgment, and IC design primarily by full scale test**
- ▶ **Certification Test Unit (CTU) will be leaktight after a worst-case series of free drop and puncture events**
- ▶ **Three full scale prototypic CTUs will be used**
- ▶ **Structural damage to package will be accounted for in thermal analysis**
- ▶ **Structural dynamics finite element model will be benchmarked by test results for use in orientations not tested**

Certification Strategy

- ▶ **Each test will consist of sequence:**
 - ◆ **NCT, 4-ft free drop**
 - ◆ **HAC, 30-ft free drop (in same orientation)**
 - ◆ **HAC, 40-in puncture (in same or different orientation, cumulative with free drop damage)**
- ▶ **Active accelerometers will be used for free drops**
- ▶ **Polyurethane foam impact limiter will be chilled or heated as required for free drops**
- ▶ **Puncture drops at prevailing temperature**
- ▶ **Design pressure = 25 psig, resulting stress is small**
 - ◆ **Pressure in test will be ambient**
- ▶ **Fire by analysis**

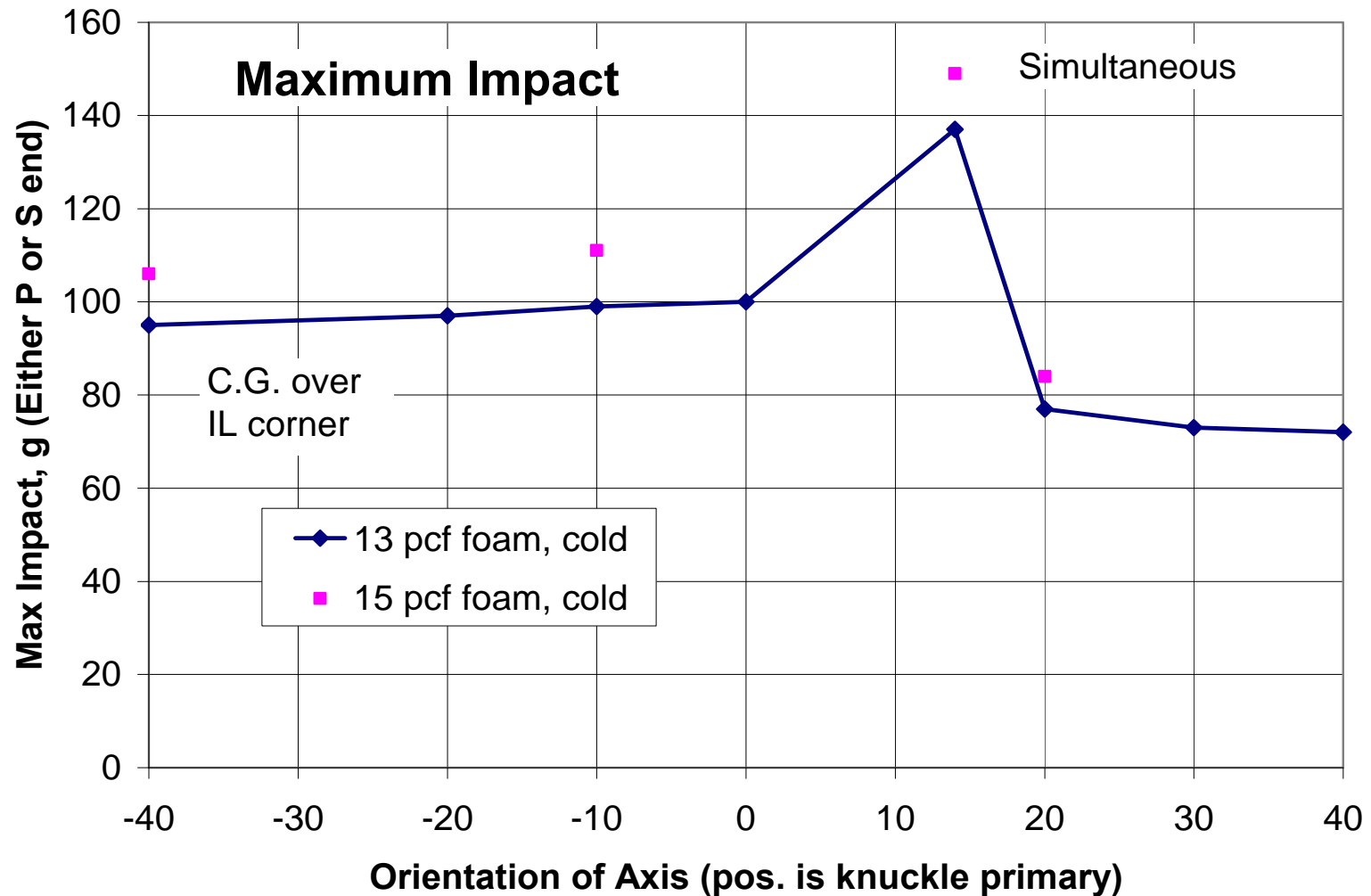
Significant Damage Scenarios

- ▶ **Closure joint**
 - ◆ Excessive loading of the closure bolts
 - ◆ Puncture deformation of closure joint
 - ◆ Deformation from the payload
 - ◆ Excessive fire temperatures due to excessive damage of impact limiter or bolt tube region
- ▶ **Containment boundary – excessive material strain**
- ▶ **Lodgment or IC – failure to control payload**
- ▶ **LTSS – damage to shielding ability by interaction with lodgment**
- ▶ **Shielded device – damage to shielding or movement of source**

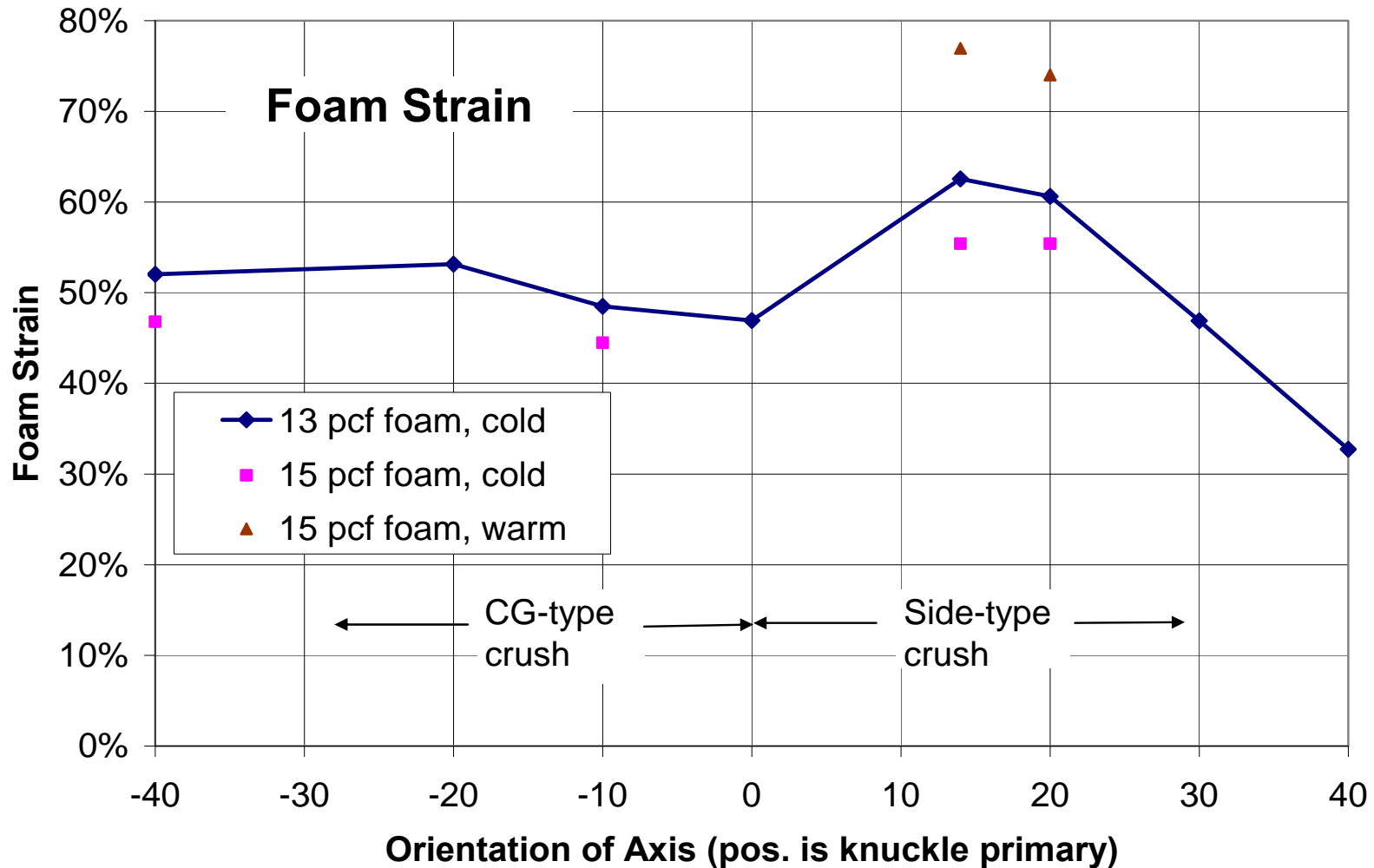
Analysis Results Guidance

- ▶ **LS-Dyna model used to compare package behavior in different orientations**
- ▶ **Model results can be used to identify worst-case orientations**
- ▶ **Model is prototypic with minor exceptions:**
 - ◆ **Most runs use 13 lb/ft³ foam density; prototype is 15 lb/ft³**
 - ◆ **All runs use early version of lodgment**
- ▶ **These differences do not have a significant effect on comparative results (and will be corrected in application)**

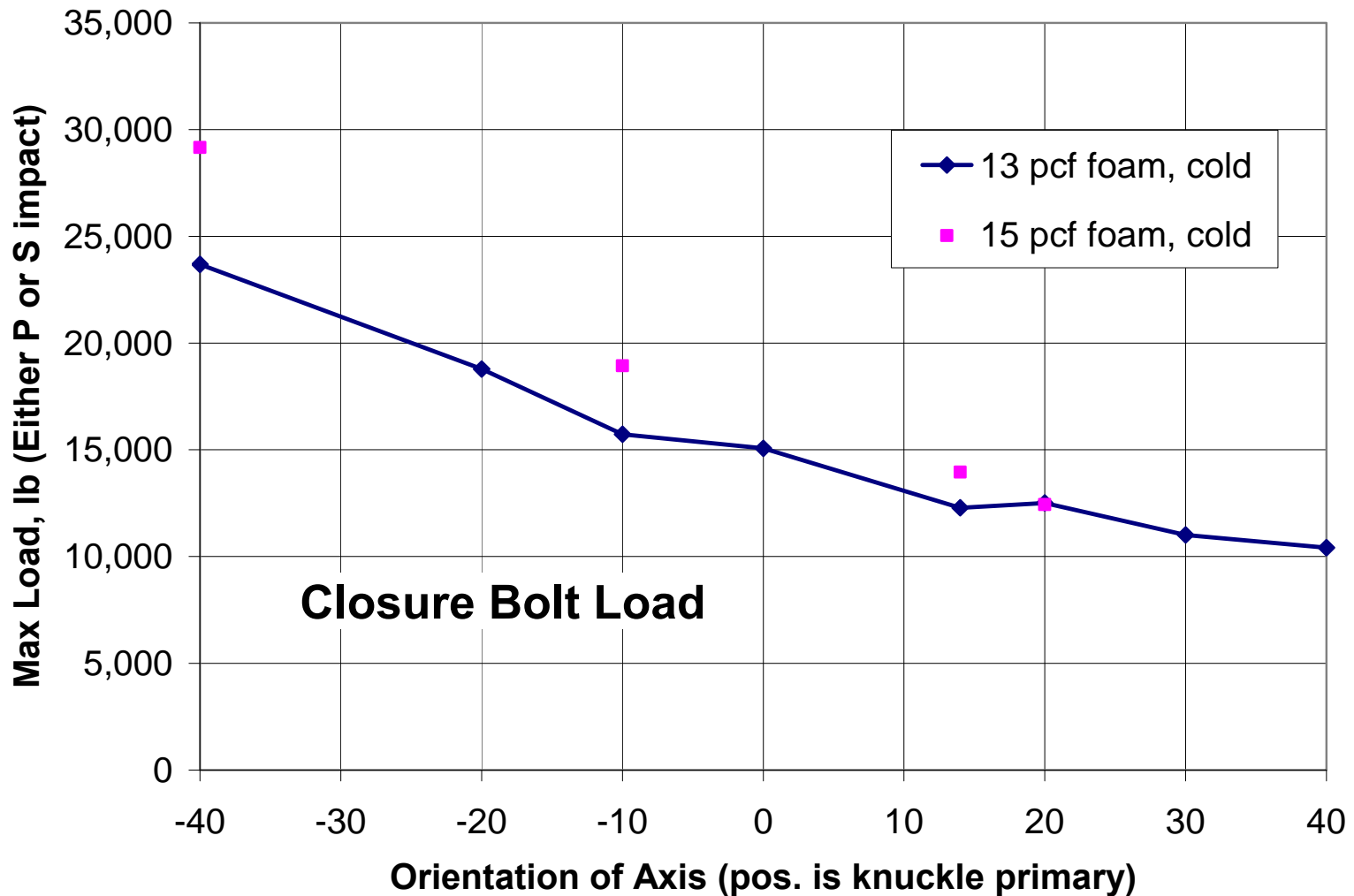
Analysis Results Guidance



Analysis Results Guidance

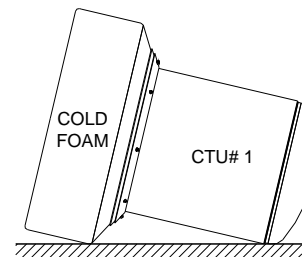
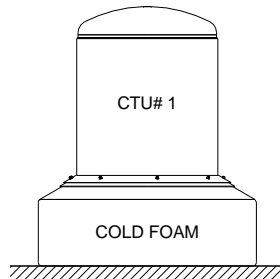


Analysis Results Guidance



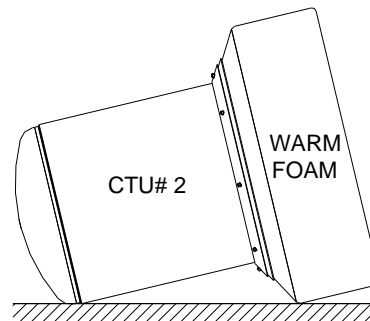
Discussion of Free Drops

- ▶ **The largest impact is vertical, bottom-down (cold)**
 - ◆ Greatest challenge to impact limiter attachment to lower flange
 - ◆ Greatest challenge to energy absorbing tubes
 - ◆ Greatest challenge to lodgment or IC along vertical axis
- ▶ **Second largest impact is the simultaneous side drop (cold)**
 - ◆ Knuckle and impact limiter hit simultaneously
 - ◆ Slapdowns show significantly lower impact
 - ◆ Greatest challenge to lodgment or IC perpendicular to axis
- ▶ **Consequently, these two orientations will be tested**



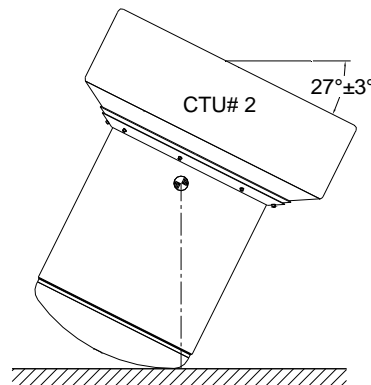
Discussion of Free Drops

- ▶ **The greatest foam strain occurs in simultaneous side drop (warm)**
 - ◆ **Non-bounding impact**
 - ◆ **Maximum foam crush near the flange**
 - ◆ **May represent the worst thermal damage case in HAC fire**
- ▶ **Consequently, this orientation will be tested**



Discussion of Free Drops

- ▶ Since no impact limiter is used on the top end, the containment boundary will need to deform in a head-first drop
- ▶ CG-over-knuckle orientation provides greatest material strain
 - ◆ Non-bounding impact
 - ◆ No impact limiter involvement
 - ◆ Combined with puncture, represents greatest plastic strain in containment boundary
- ▶ Consequently, this orientation will be tested

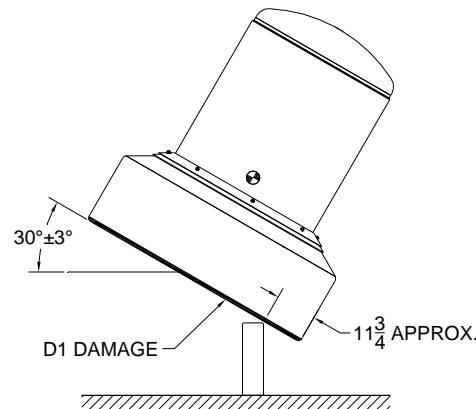


Discussion of Free Drops

- ▶ From the model results, the CG-over-lower corner (impact limiter corner) represents the greatest closure bolt loads
- ▶ Since the bolts and surrounding flange region remain elastic, the model can be relied upon with good confidence
- ▶ The maximum bolt load will be calculated using the benchmarked LS-dyna model and bolt stresses compared to elastic allowables
- ▶ Consequently, this orientation will be evaluated by analysis
- ▶ Other orientations evaluated by analysis in SAR:
 - ◆ Vertical top-down
 - ◆ Slapdowns
 - ◆ Do not have bounding impacts, foam strain, or bolt loadings

Discussion of Punctures

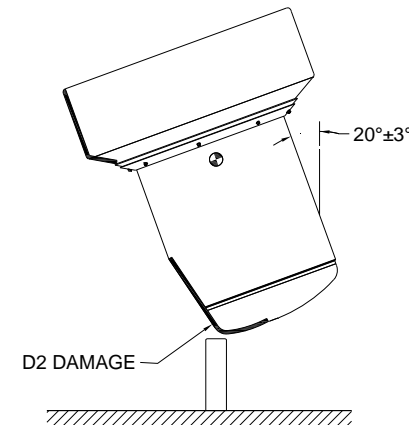
- ▶ Puncture drops will occur on prior free drop damage
- ▶ Predicted free drop damage has been evaluated to determine the worst-case puncture drop that could be applied
- ▶ On bottom-down free drop damage
 - ◆ Risk of perforation of impact limiter shell and loss of foam
 - ◆ Could expose lower head to fire



Discussion of Punctures

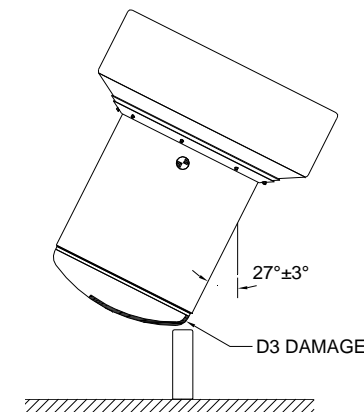
► On side free drop damage to knuckle

- ◆ Could damage containment boundary
- ◆ Most damage occurs if puncture is through CG



► On CG-over-knuckle free drop damage

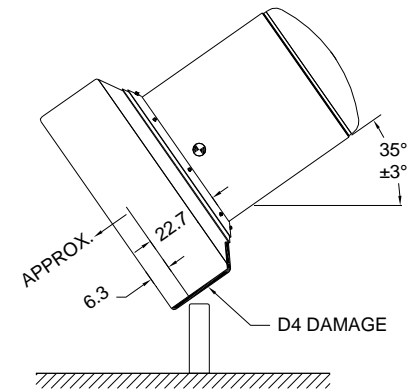
- ◆ Could damage containment boundary
- ◆ Puncture through CG in same orientation as free drop



Discussion of Punctures

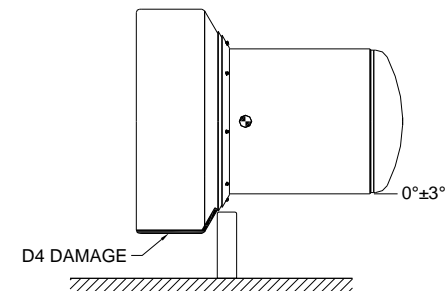
► On warm side free drop damage to impact limiter

- ◆ Oblique will maximize possibility of perforation, and direct puncture through CG
- ◆ Puncture occurs on minimum foam thickness near flange



► On warm side free drop damage to upper bolt tube region

- ◆ Aims at tube sheet/rain shield area, near CG, avoids support from impact limiter
- ◆ Could deform flange area or expose vent port to fire

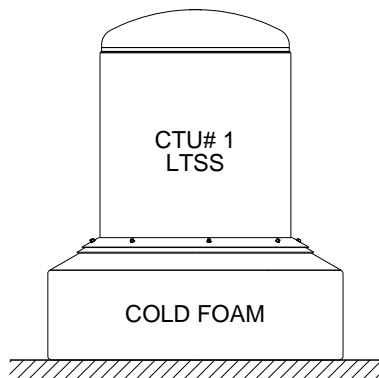


Discussion of Punctures

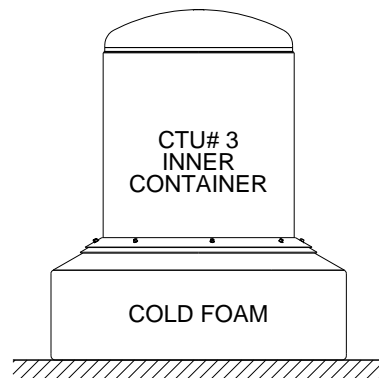
► Puncture on the package side

- ◆ According to Bechtel Power Corporation Topical Report BC-TOP-9A, *Design of Structures for Missile Impact*:
- ◆ the required wall thickness to prevent perforation is 0.25 inches
- ◆ The containment wall is twice that thick (0.50 inches), and is not subject to free drop damage due to its recessed location
- ◆ Puncture will be tested on head and knuckle of same thickness
- ◆ Therefore, a puncture on the wall does not need to be performed

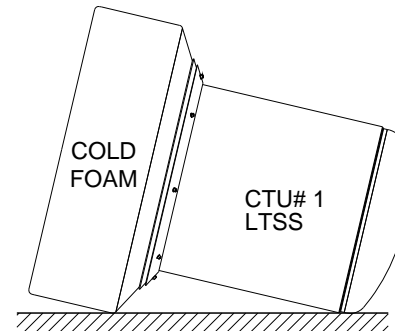
Free Drop Test Summary



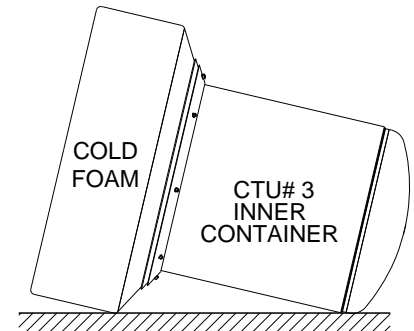
D1N & D1H



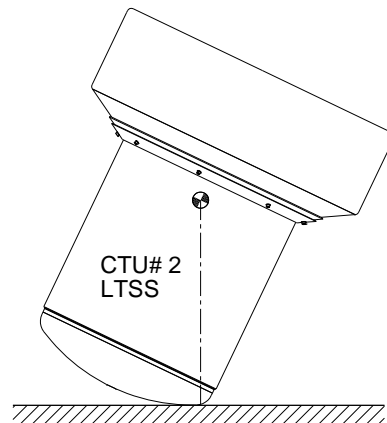
D5N & D5H



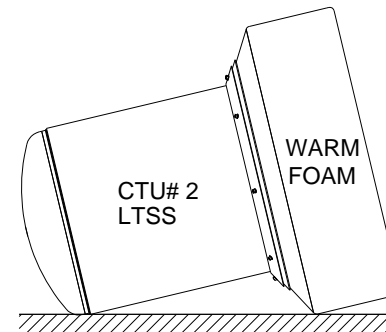
D2N & D2H



D6N & D6H

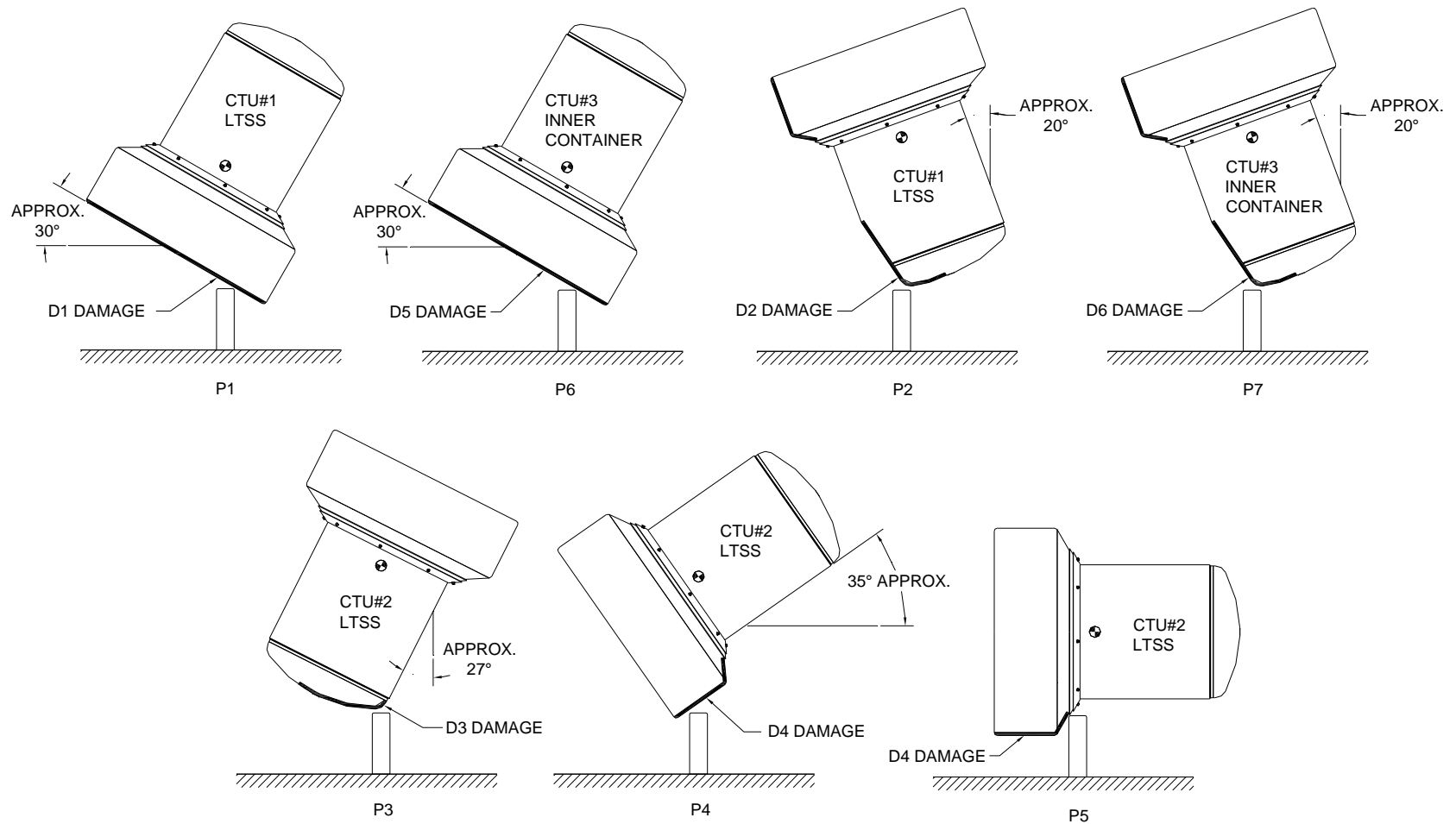


D3N & D3H



D4N & D4H

Puncture Drop Test Summary



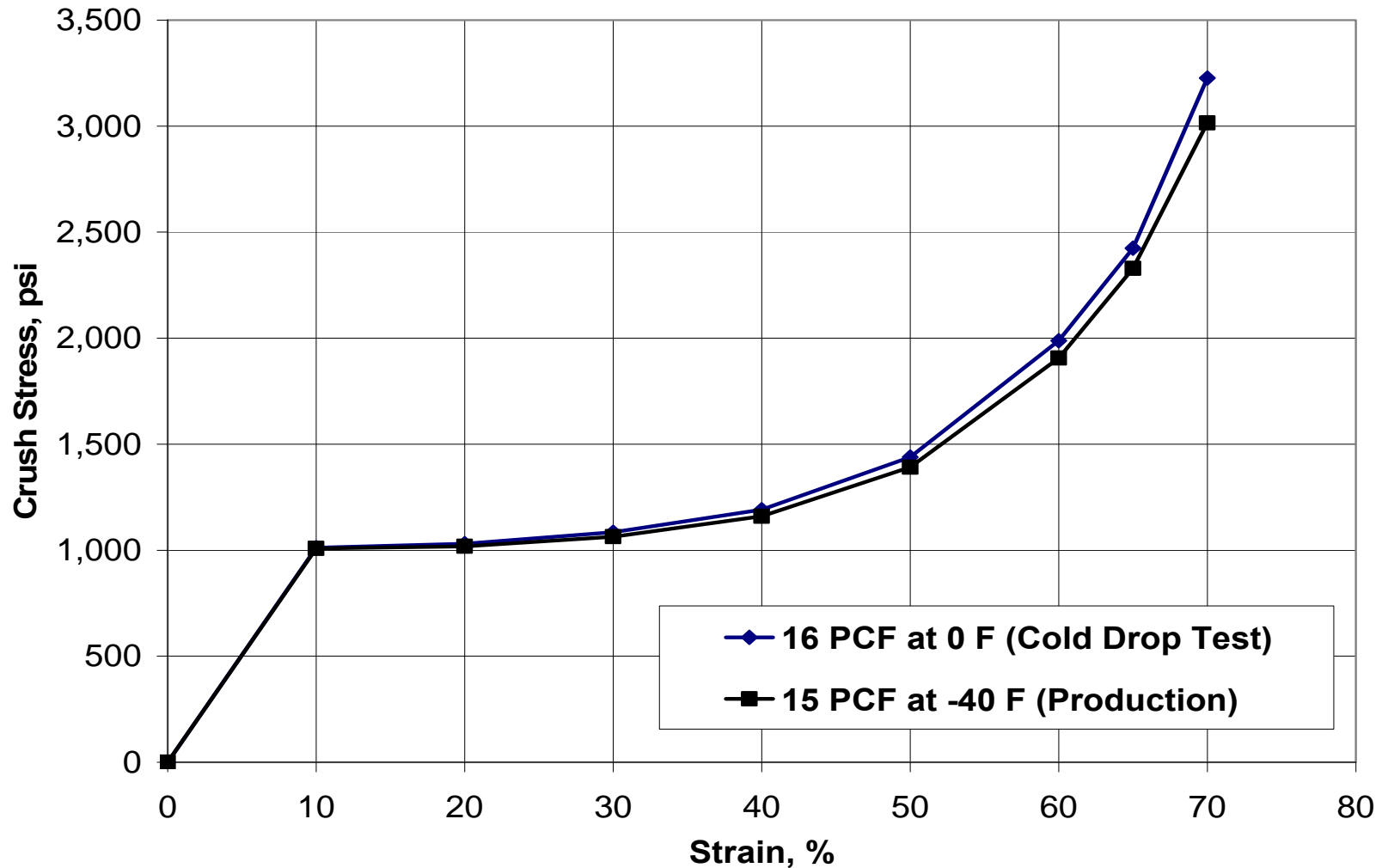
Acceptance Criteria

- ▶ **At conclusion of all drop and puncture testing, each CTU shall be leaktight per definition of ANSI N14.5**
- ▶ **Damage relevant to thermal performance shall be bounded by thermal analysis damage assumptions**
- ▶ **Any damage to the LTSS relevant to shielding performance shall be bounded by shielding analysis assumptions**
- ▶ **At conclusion of testing, the vent port thermal shield must be retained by the rain shield or by deformed structure**

CTU Configuration

- ▶ **CTUs are fully prototypic except for the following:**
 - ◆ **Foam density is adjusted to facilitate temperature extremes**
 - ◆ **Thermal shield is omitted**
- ▶ **Cold free drop tests will consider TS-R-1 requirement of -40 °F**
- ▶ **Obtaining foam temperature of -40 °F at test site is difficult and dangerous**
- ▶ **To facilitate the cold test, the polyurethane foam density is adjusted upward by 1 lb/ft³ and cooled to 0 °F**
- ▶ **Behavior of 16 lb/ft³ foam at 0 °F is essentially identical to behavior of 15 lb/ft³ foam at -40 °F – see plot**

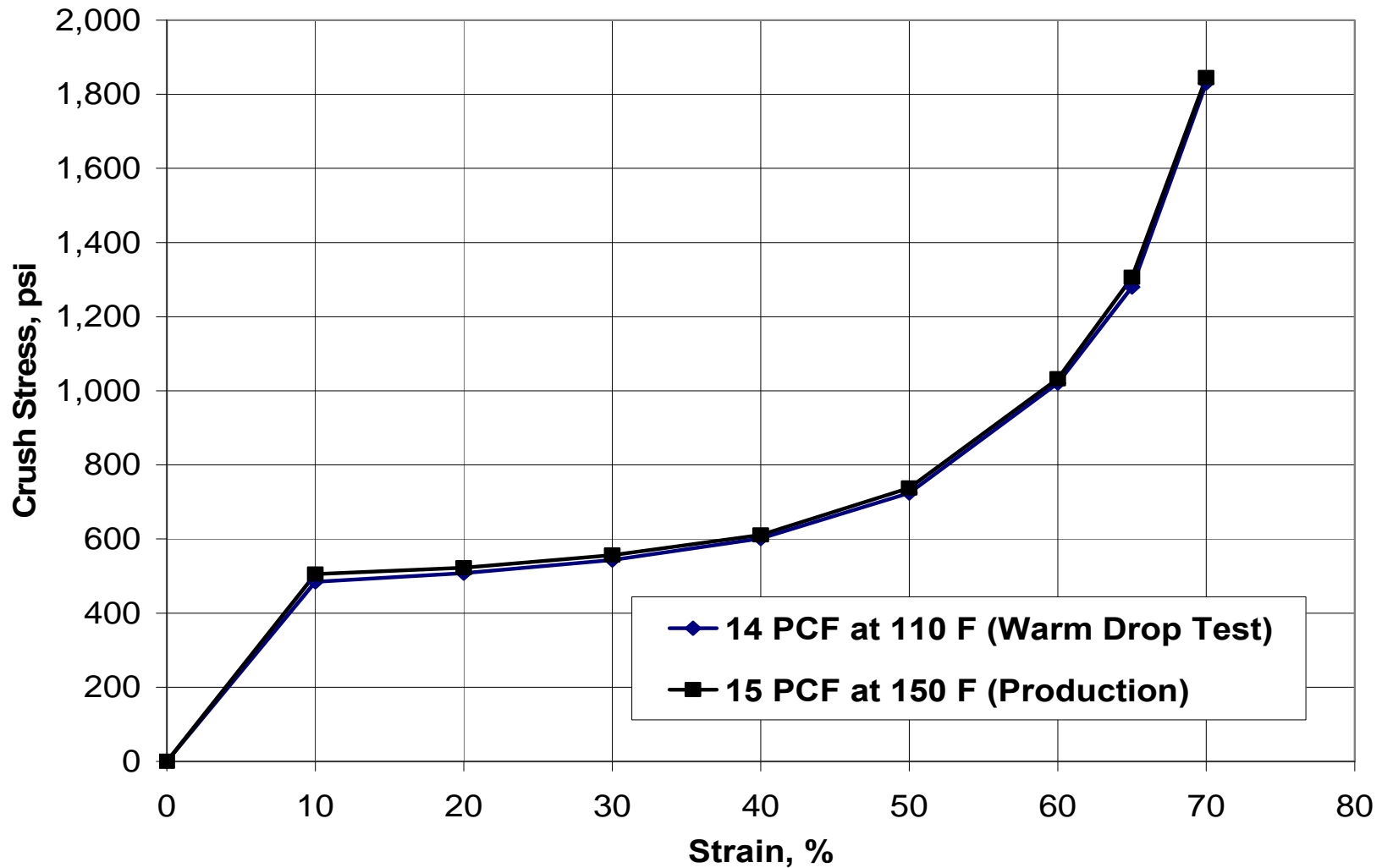
CTU Configuration



CTU Configuration

- ▶ The warm free drop test must be consistent with the NCT warm case foam temperature of 150 °F
- ▶ Obtaining foam temperature of 150 °F at test site is difficult and dangerous
- ▶ To facilitate the warm test, the polyurethane foam density is adjusted downward by 1 lb/ft³ and warmed to 110 °F
- ▶ Behavior of 14 lb/ft³ foam at 110 °F is essentially identical to behavior of 15 lb/ft³ foam at 150 °F – see plot

CTU Configuration



CTU Configuration

- ▶ Thermal shields consist of two thin layers of sheet steel (0.060" and 0.105") separated by two windings of 0.105" diameter wire
- ▶ Since their structural effect will be negligible and their absence is conservative, CTUs do not include thermal shields
- ▶ To make up for mass, a single wrap of 0.105" thick sheet is placed around the CTU in the same position using low strength intermittent attachment welds
- ▶ This sheet is non-structural weight only

Payload Configuration

- ▶ **LTSS will be prototypic regarding important structure**
 - ◆ Door hinges and internal magazine will be weight-simulated
 - ◆ Overall weight, lead weight, outer shell & structural load paths are prototypic
 - ◆ Damage affecting shielding function is not expected
- ▶ **Device inside IC test article will be simulated (dummy device)**
 - ◆ Devices are more robust than LTSS (less weight and thicker steel)
 - ◆ Devices will be blocked by wood or other dunnage material (more forgiving for local damage compared to lodgment of LTSS)
- ▶ **Consequently, the resulting LTSS test damage (if any – none expected) will be bounding for devices**



NRC Staff Comments & Suggestions