# LANL-B Package Certification Test Plan

AREVA Federal Services LLC

under contract to

Los Alamos National Security, LLC

March 31, 2011

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# Introductions

- **AREVA Federal Services LLC (AFS)**
  - Ron Burnham, LANL-B Project Manager
  - Phil Noss, Licensing Manager
  - Rick Migliore, Shielding Engineer
- **Global Threat Reduction Initiative (GTRI, NA-21, NNSA)**
  - Ioanna Iliopulos, Director North and South America Threat Reduction
  - 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’)



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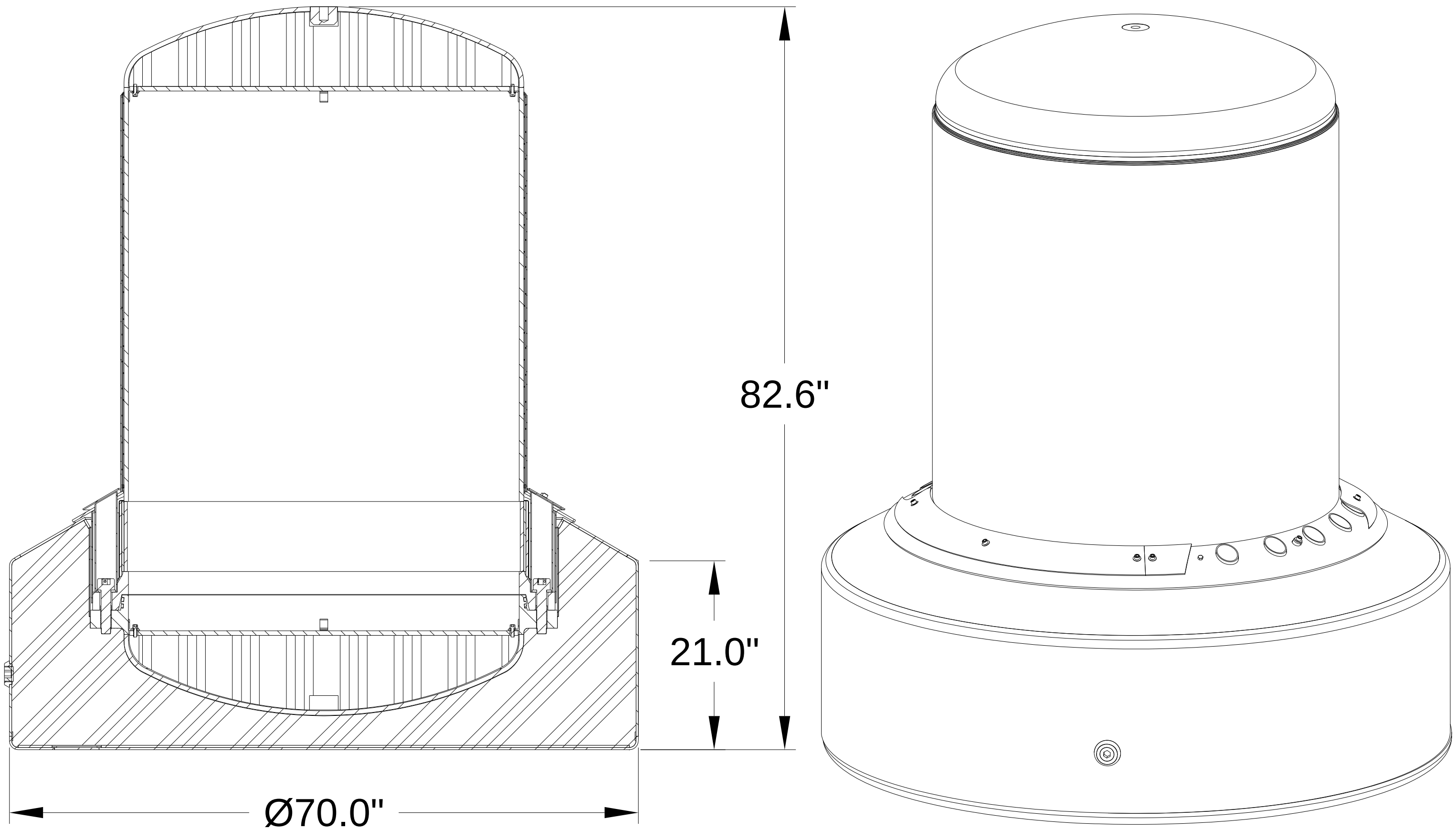
# Package Design Summary



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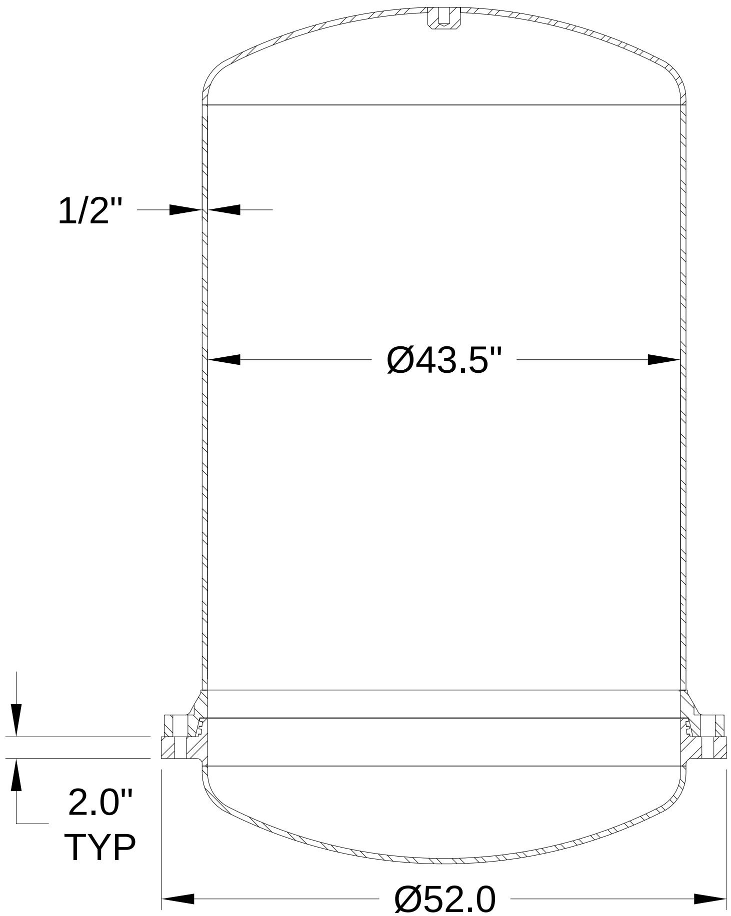
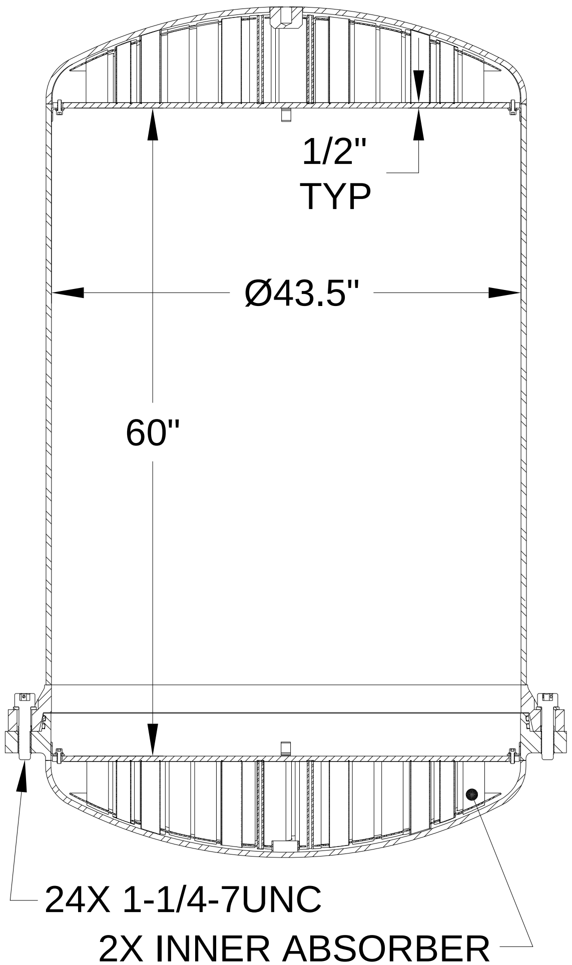
# LANL-B Packaging Description

- Containment boundary consists of a vertical cylinder with torispherical ends
- Massive closure joint near lower end
- Inner diameter 43.5 inches
- Thickness ½ inch
- Material: Type 304 austenitic stainless steel



# LANL-B Packaging Description

- At each end, crushing tube energy absorbers (with ½-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



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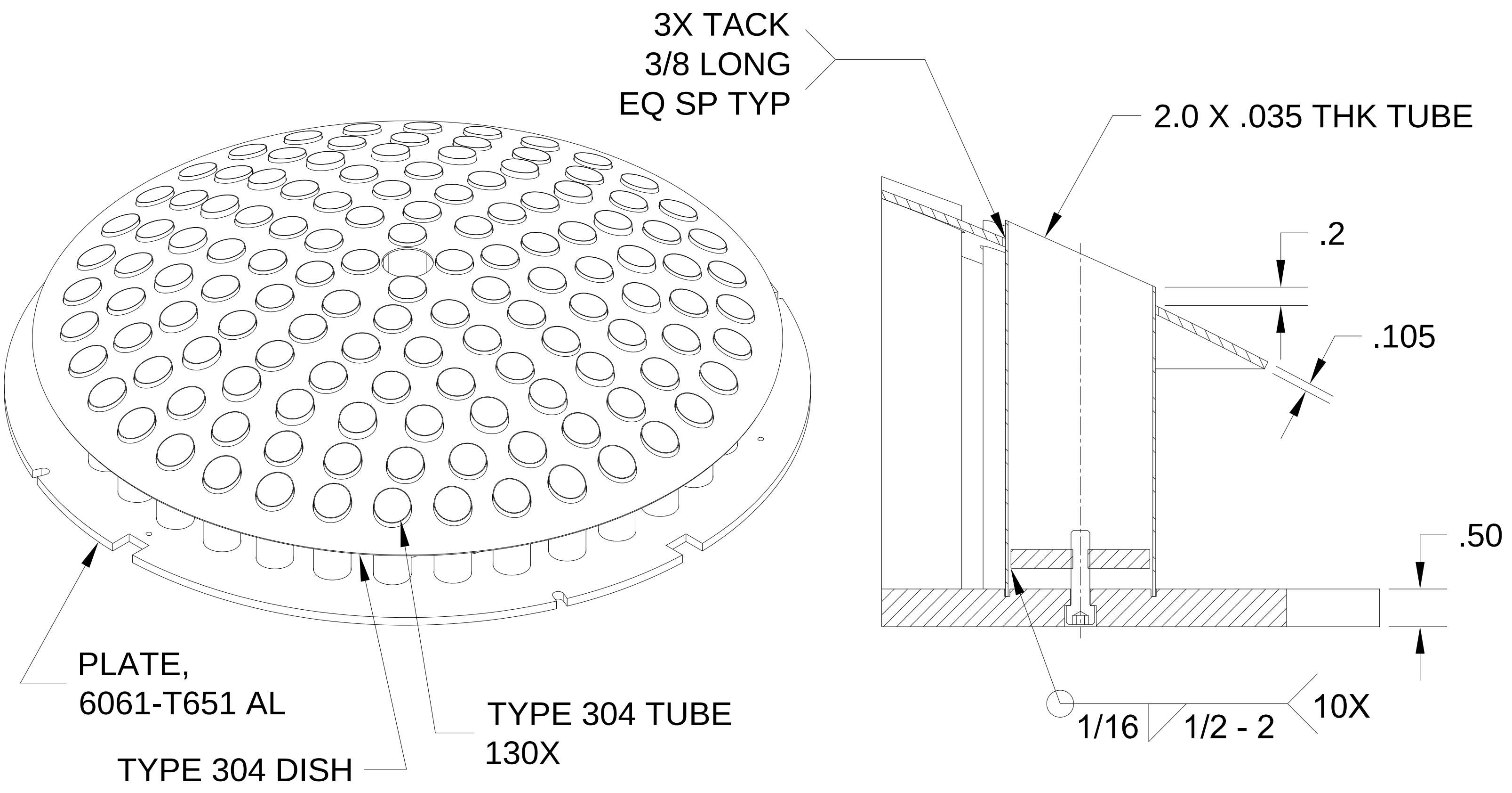
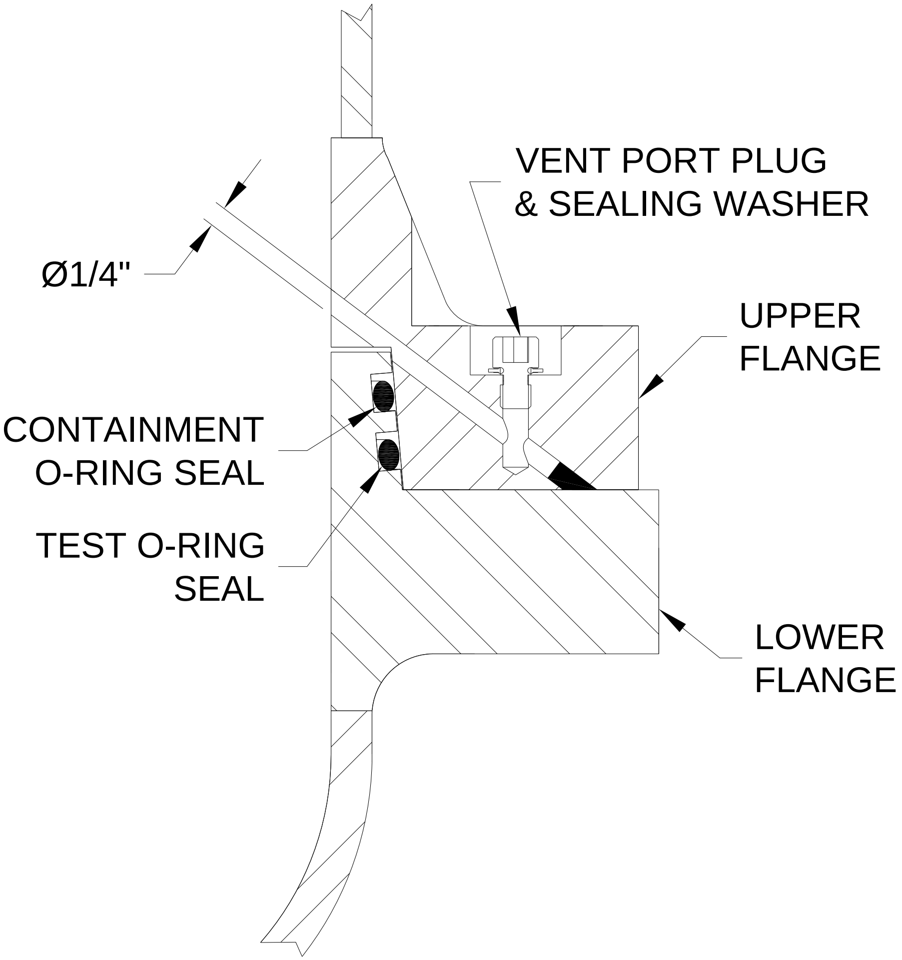
# LANL-B Packaging Description




**Internal absorber – top and bottom**

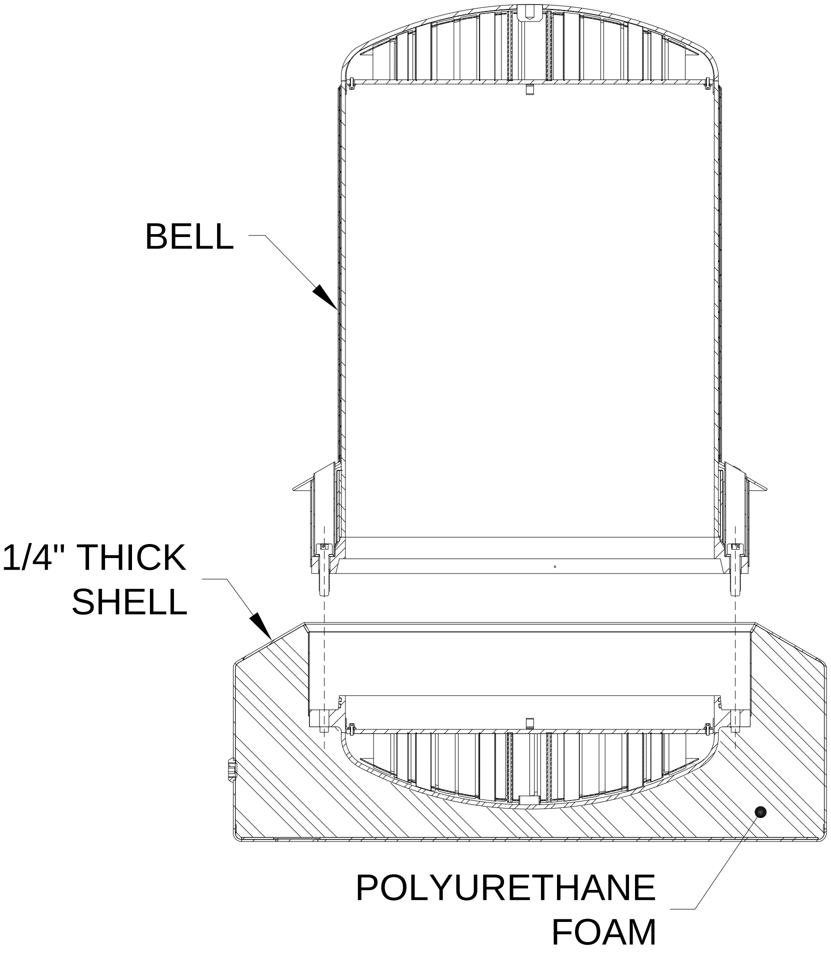
# LANL-B Packaging Description

- **Containment seal and test seal ⅜-inch diameter butyl rubber on 5º 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**



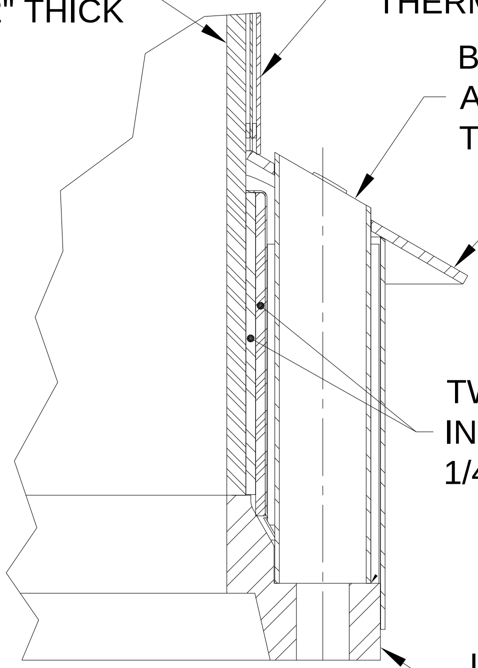
# LANL-B Packaging Description

- 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/ft$^3$
- IL shell is ¼ inch thick, maximum use of rolled corners and full-thickness welds



# LANL-B Packaging Description

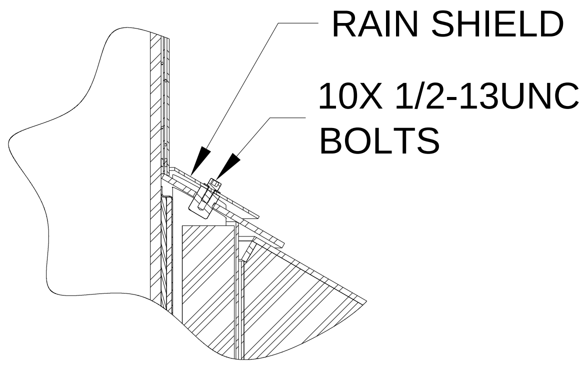
- Upper component ("bell") has 2-1/4" I.D. tubes for access to closure bolts and ports
- Two layers of ¼-inch insulation reduce heat input to lower bell
- Tube sheet (¼-inch thick) holds tubes securely and improves puncture protection
- Dual thermal shield covers cylindrical outer surface



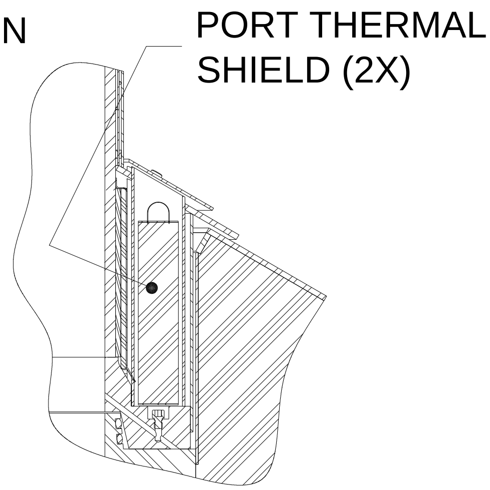
BELL DETAIL

# LANL-B Packaging Description

- Rain shield keeps bolt and port tubes dry and also serves as fire shield
- Rain shield attached using 10, ½-13 UNC bolts
- Port thermal shields used in vent and test port tubes
- Port thermal shields retained by rain shield



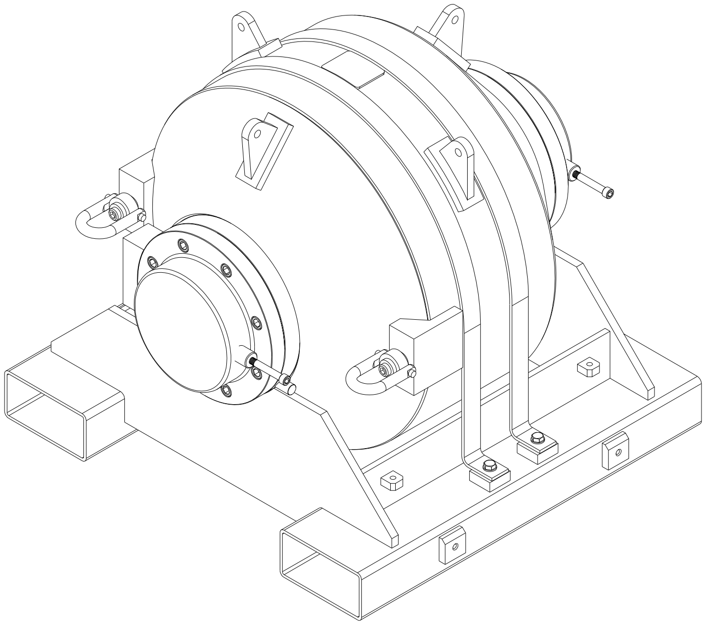

SECTION BETWEEN BOLT TUBES



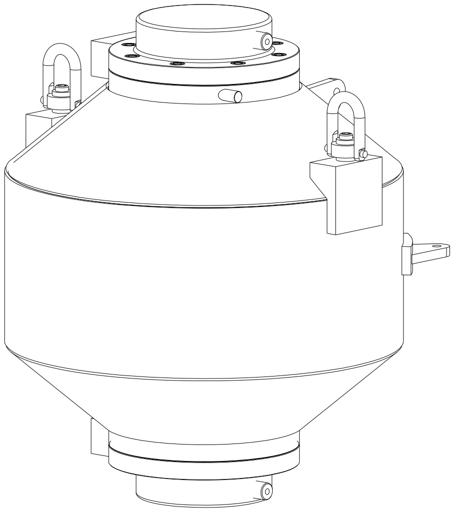

SECTION AT VENT PORT

# Payloads

- **LTSS**



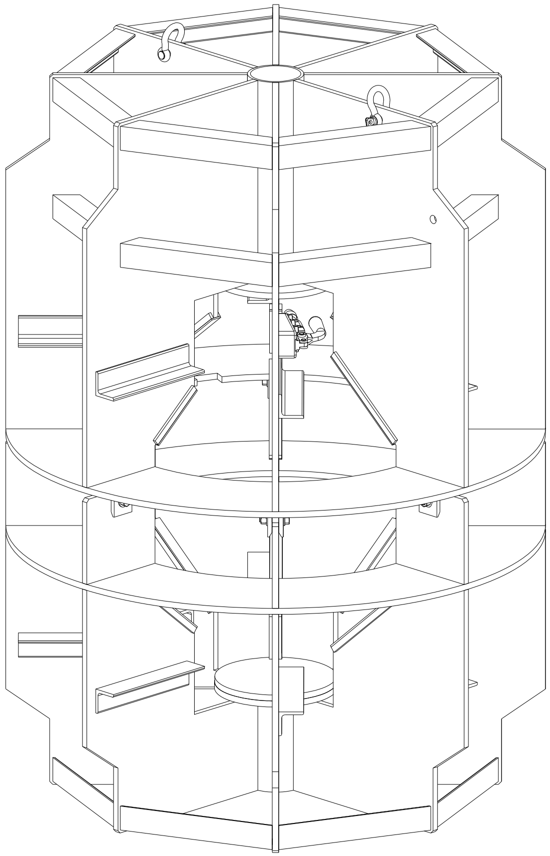
AS STORED



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





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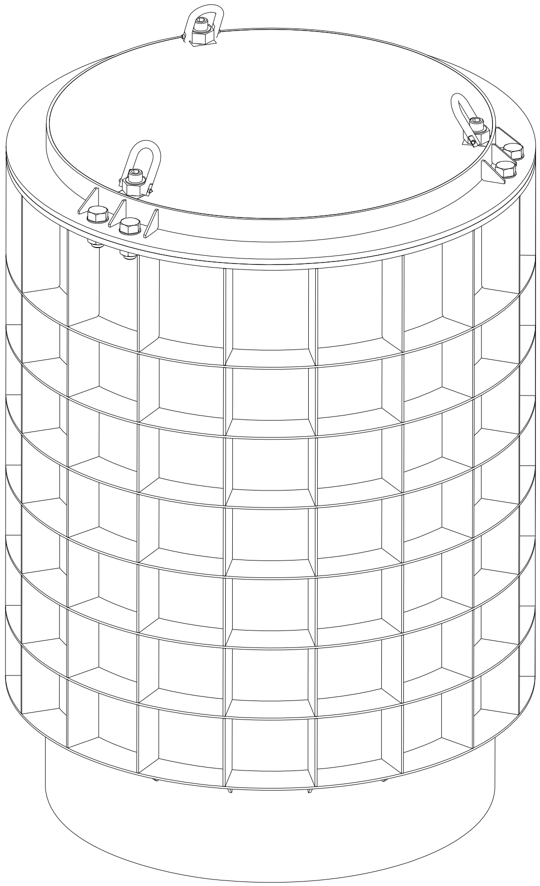
# Payloads

- **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**





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# 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**



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# 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



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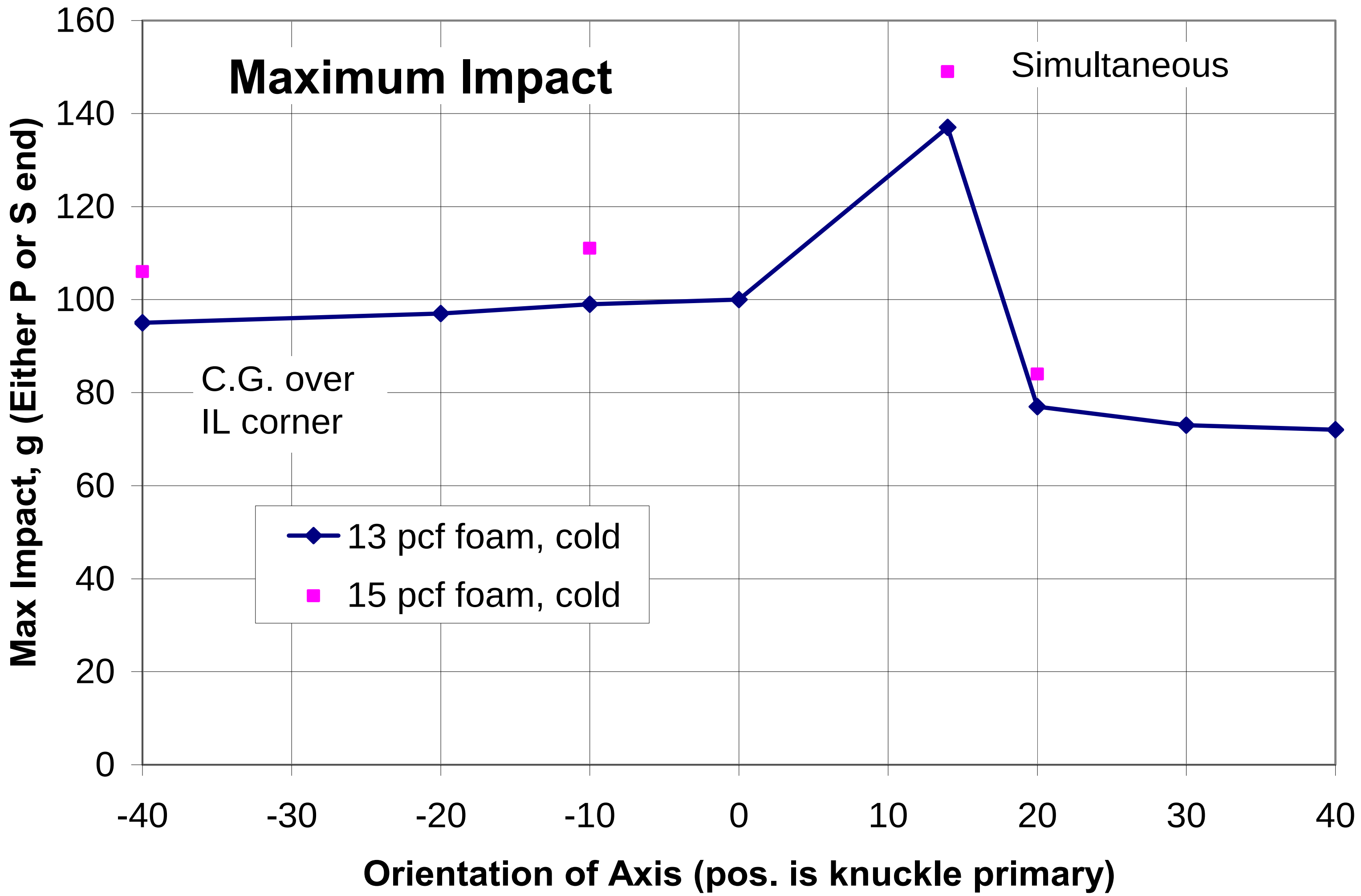
# Significant Damage Scenarios

- **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**

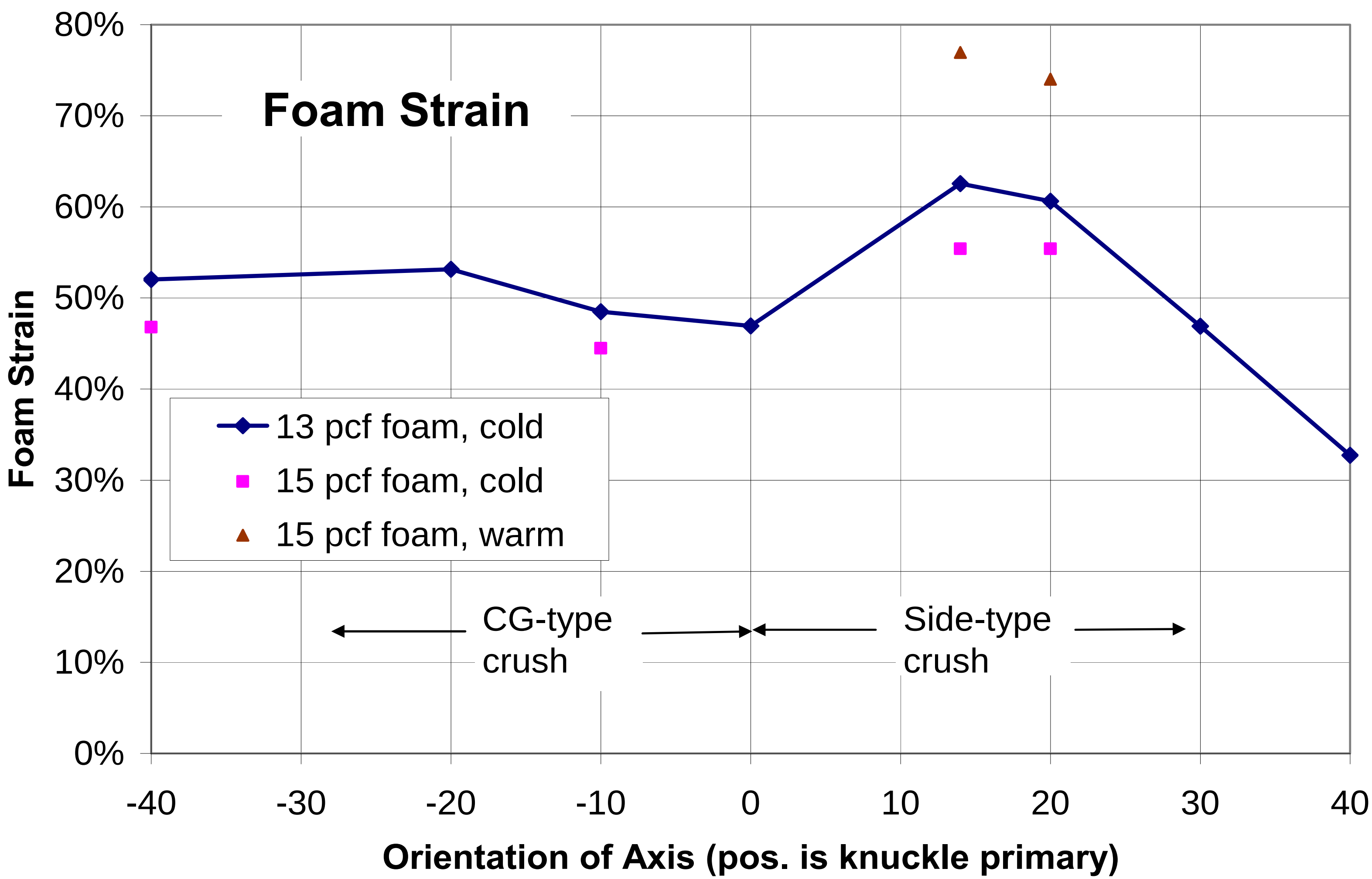
# Analysis Results Guidance

- 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 $lb/ft^3$ foam density; prototype is 15 $lb/ft^3$
  - All runs use early version of lodgment
- These differences do not have a significant effect on comparative results (and will be corrected in application)

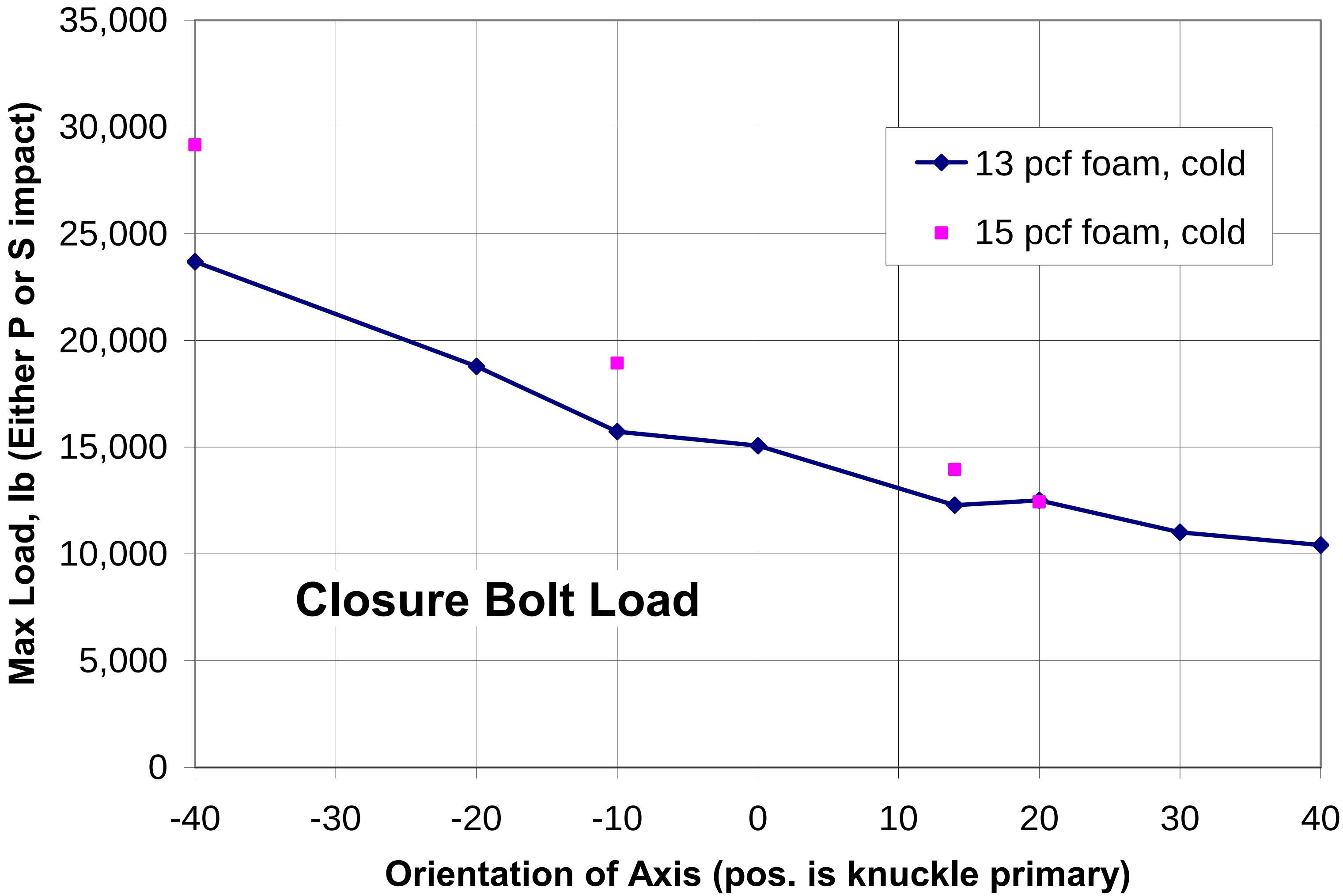
# Analysis Results Guidance



# Analysis Results Guidance

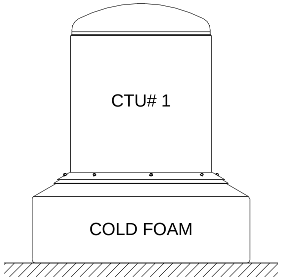


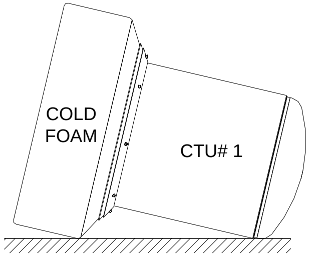
# Analysis Results Guidance



# Discussion of Free Drops

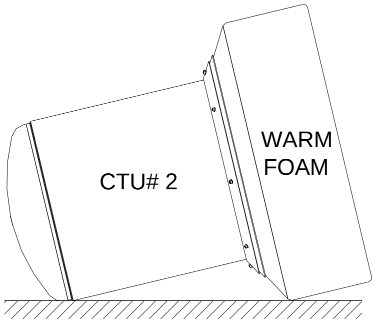
- The largest impact is vertical, bottom-down (cold)
  - Greatest challenge to impact limiter attachment to lower flange
  - Greatest challenge to energy absorbing tubes
  - Greatest challenge to lodgment or IC along vertical axis
- Second largest impact is the simultaneous side drop (cold)
  - Knuckle 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



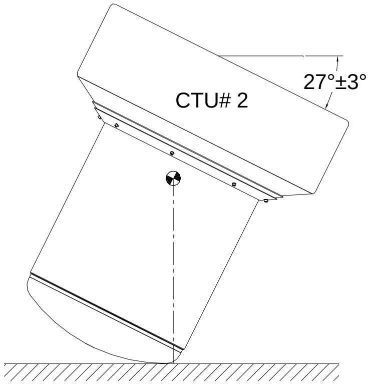
# Discussion of Free Drops

- 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



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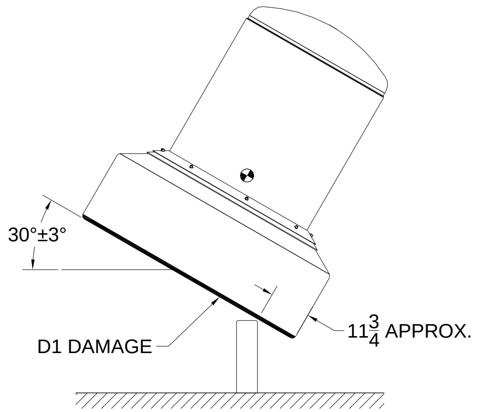
# Discussion of Punctures

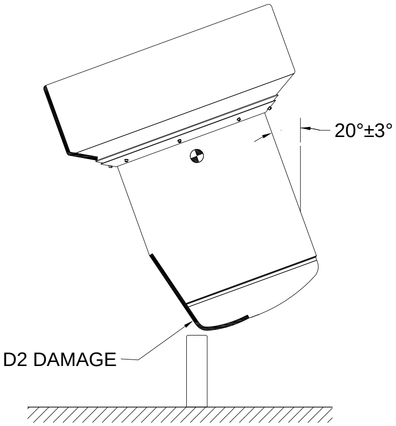
- Puncture drops will occur on prior free drop damage
- Predicted free drop damage has been evaluated to determine the worst-case puncture drop that could be applied

- On bottom-down free drop damage
  - Risk of perforation of impact limiter shell and loss of foam
  - Could expose lower head to fire

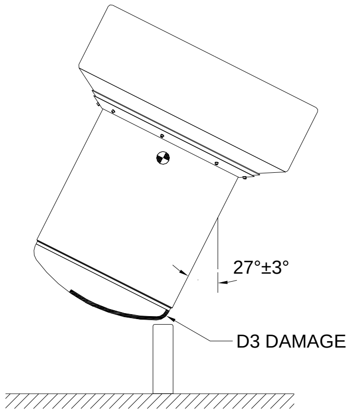


# Discussion of Punctures

- On side free drop damage to knuckle
  - Could damage containment boundary
  - Most damage occurs if puncture is through CG

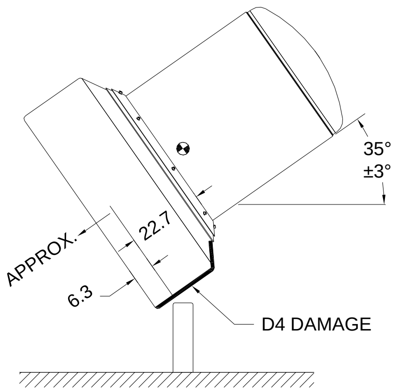



- On CG-over-knuckle free drop damage
  - Could damage containment boundary
  - Puncture through CG in same orientation as free drop

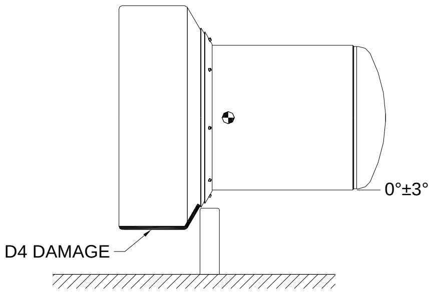


# Discussion of Punctures

- 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**



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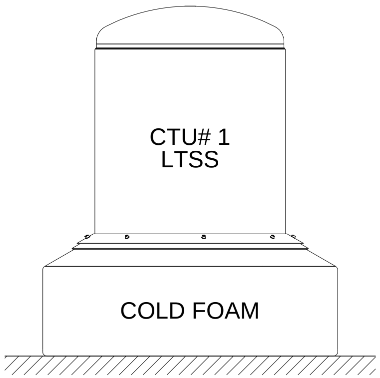
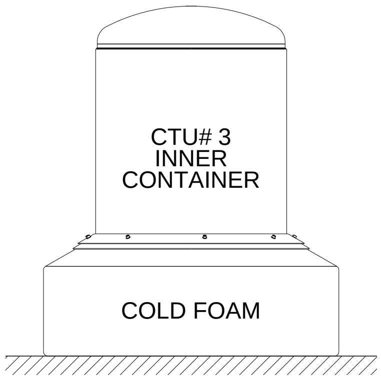
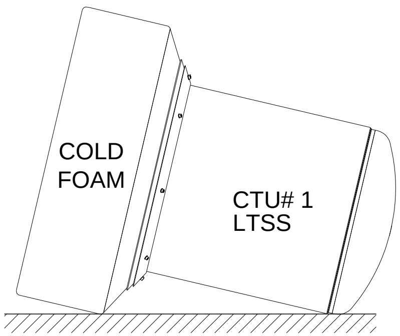
# Free Drop Test Summary



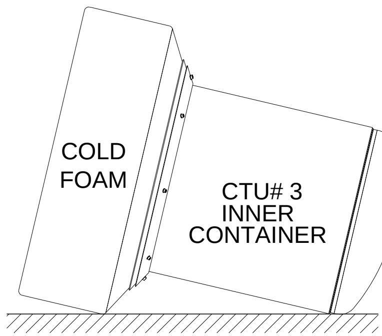

D1N & D1H



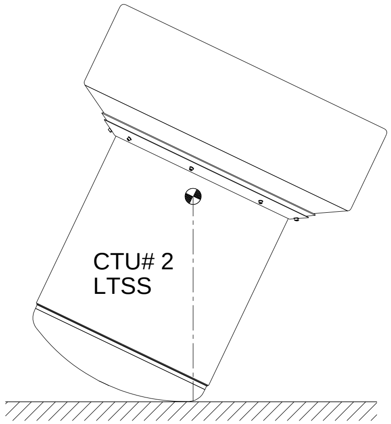

D5N & D5H



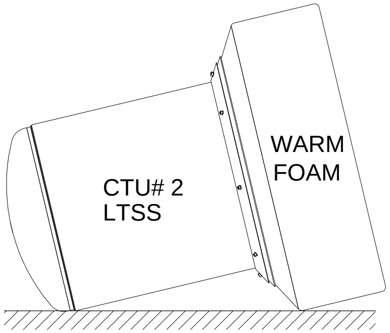

D2N & D2H




D6N & D6H




D3N & D3H




D4N & D4H



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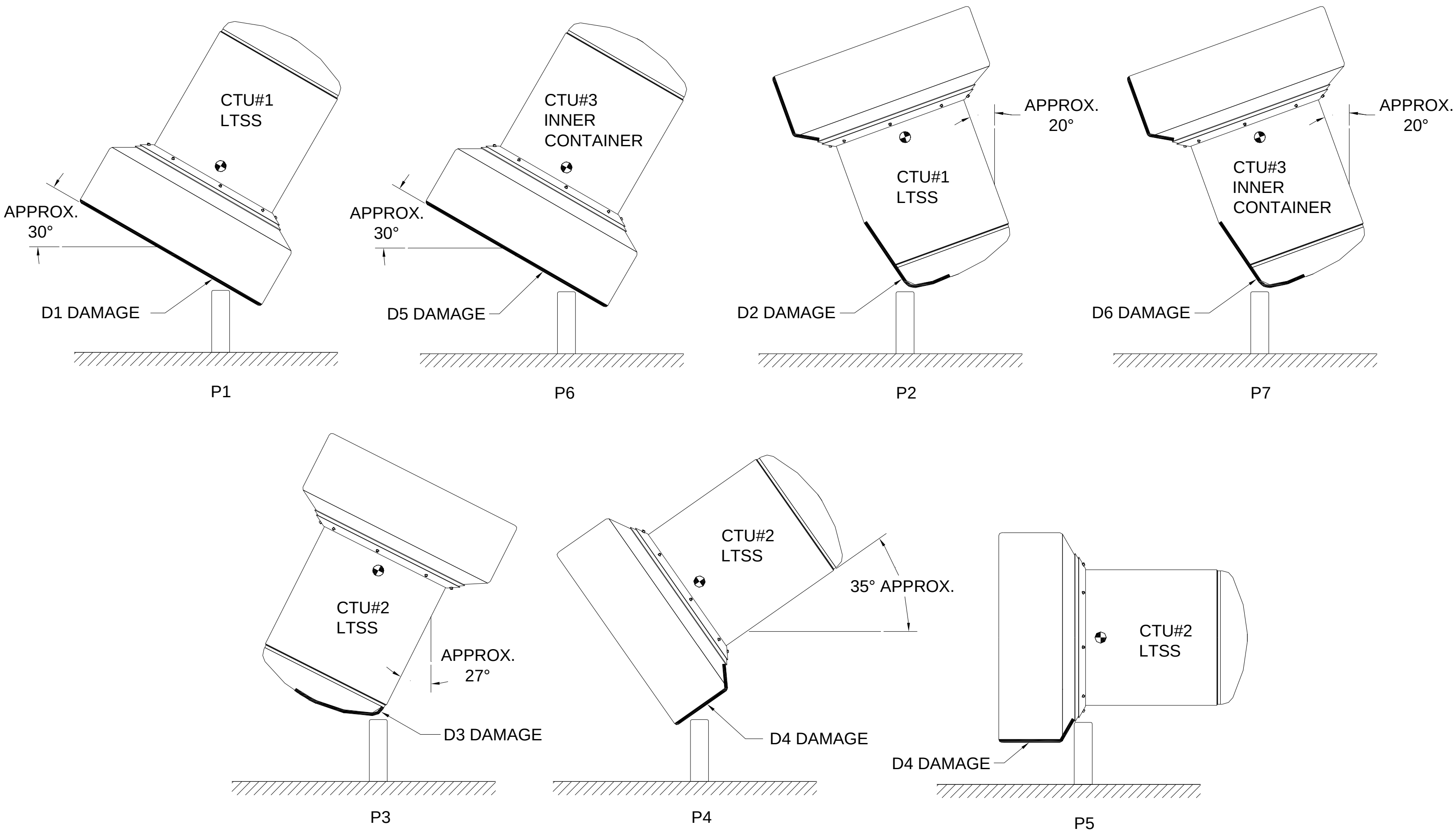
# Puncture Drop Test Summary



# 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



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# 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 $lb/ft^3$ and cooled to 0 °F
- Behavior of 16 $lb/ft^3$ foam at 0 °F is essentially identical to behavior of 15 $lb/ft^3$ foam at -40 °F – see plot



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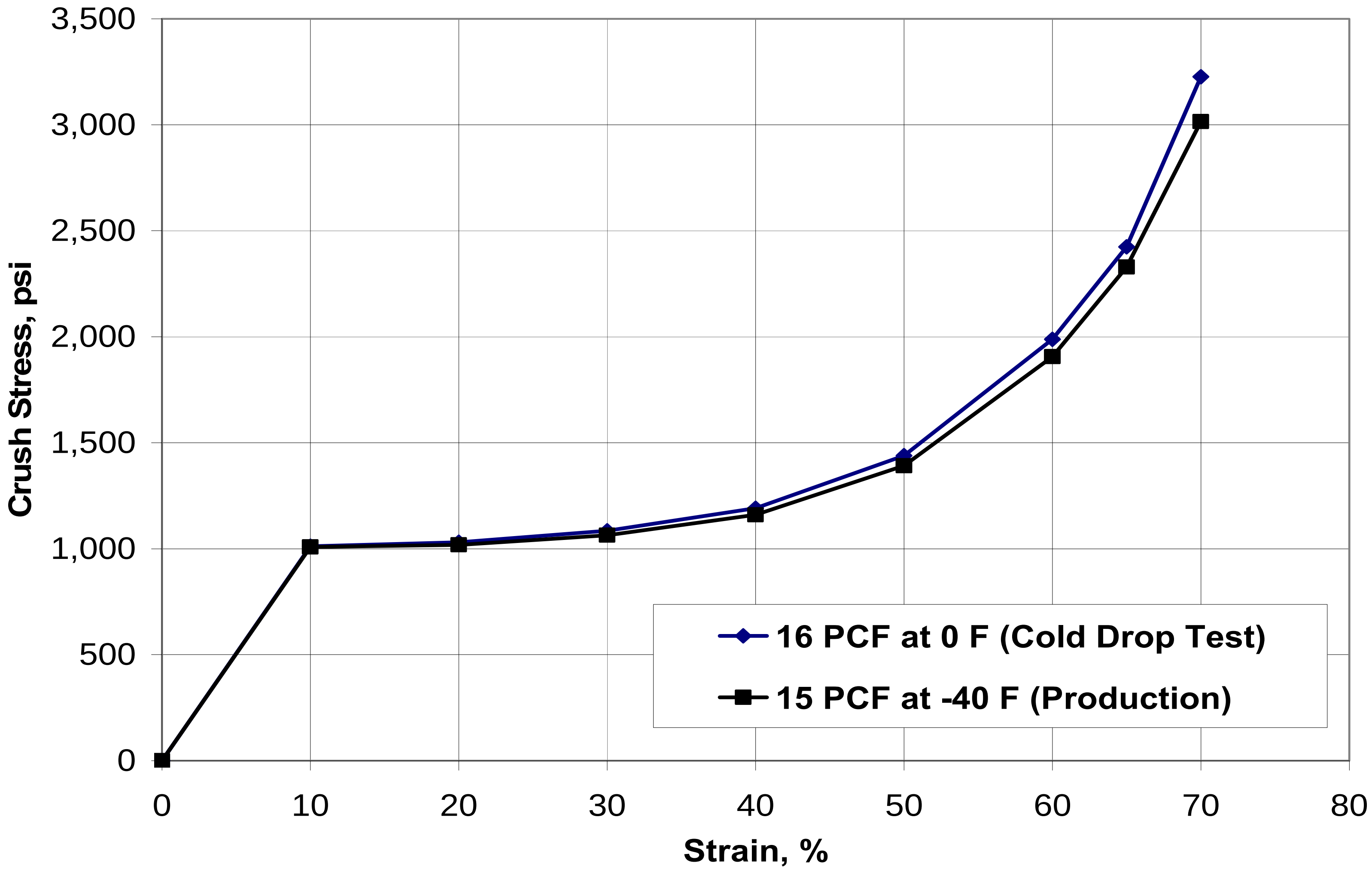
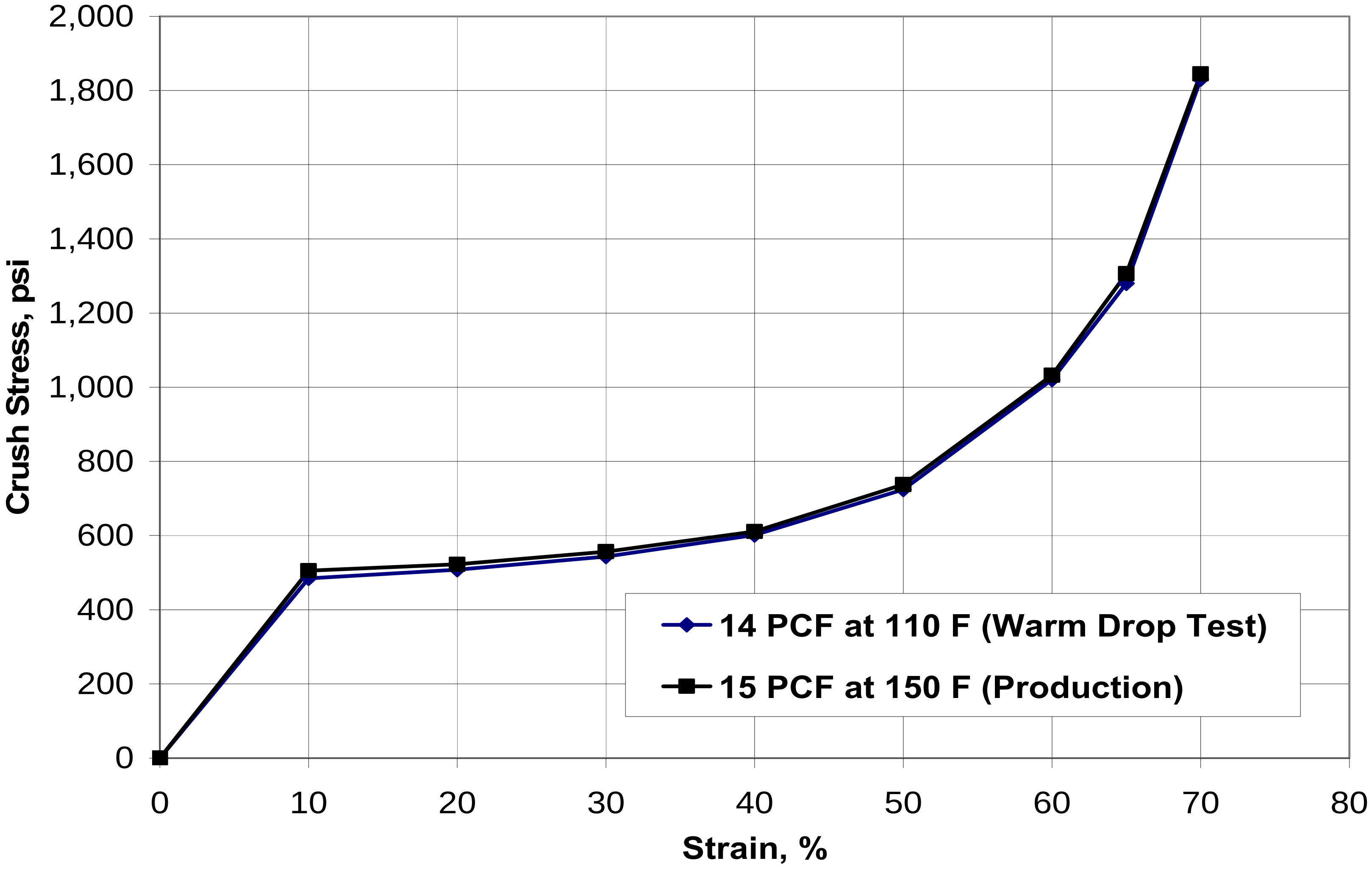
# CTU Configuration



# 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/ft$^3$ and warmed to 110 °F
- Behavior of 14 lb/ft$^3$ foam at 110 °F is essentially identical to behavior of 15 lb/ft$^3$ 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



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# NRC Staff Comments & Suggestions