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HI-STAR ATB 1T BENCHMARK TEST PROGRAM

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Chuck Bullard
Manager, Applied Mechanics

Holtec International
Holtec Center
One Holtec Drive
Marlton, New Jersey, USA

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Meeting Objectives

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- To present further details of Holtec's proposed test program for the HI-STAR ATB 1T to support 10CFR71 license application
- To receive and discuss feedback from the NRC regarding the general acceptability of the proposed test program, including the test model, test sequence, and test measurements

Presentation Overview

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- Background
- Overview of Test Plan
- Details of ¼ Scale Test Model
- Test Sequence
- Test Facility
- Instrumentation of ¼ Scale Test Model
- Additional Topics
- Schedule

Background

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- Holtec submitted HI-STAR ATB 1T license application on September 23, 2015
- Received Request for Supplemental Information (RSI) on November 10, 2015
- Public meeting on November 24, 2015 to discuss RSIs
  - NRC Staff expressed concern regarding lack of benchmarking of LS-DYNA model
- Public meeting on January 19, 2016
  - Holtec outlines plan for benchmark test program
  - NRC raised concern regarding puncture drop on trunnion

Overview of Test Plan

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- Benchmark Test Program
  - Perform limited number of physical drop tests of scale model as a means to benchmark analytical model
  - Final compliance demonstration with 10CFR71 safety regulations will be based on numerical analysis
- Use ¼ Scale Test Model (Type A-4 per UCRL-ID-121673)
  - Use identical fabrication materials and welding processes as full-scale cask
  - Secondary packaging (BFA Tank) is free to move inside cask, but the contents of BFA Tank are fixed
- Perform (3) Sequential Drop Tests Using Single Test Model
  - Top-Down Drop/Slapdown
  - Bottom CGOC Drop
  - Puncture Drop onto Trunnion

Details of ¼ Scale Test Model

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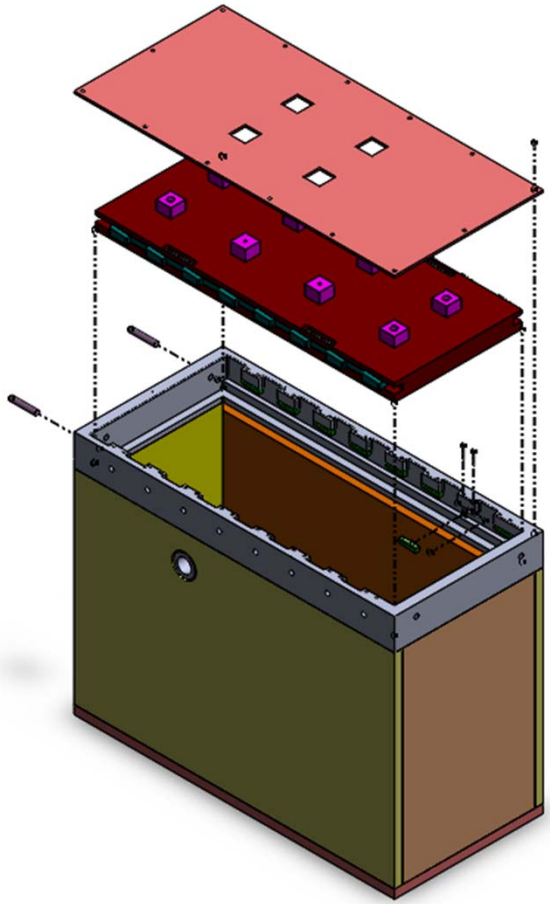

Overall Dimensions (inches)	
Length	36.75
Width	17.0625
Height	28.375
Weights (pounds)	
HI-STAR ATB 1T Cask (Empty)	2,100
BFA Tank (Loaded)	1,800
Total	3,900

Details of ¼ Scale Test Model (cont.)

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- Differences between ¼ Scale Test Model & Full Scale Model
  - No hydraulic system for remote lid operation
  - No closure lid seals or leak test ports
  - No collapsible trunnions or trunnion sleeves (except at one location)
  - Strongback lifting attachments on closure lid are simplified
  - Locking wedge locking pin is simplified
- Same welding processes (TIG, MIG, SAW) used consistently for both ¼ Scale Test Model & Full Scale Model
  - No post-weld heat treatment (not required for stainless steel per ASME Section III, Subsection NB)
  - Same NDE inspections as Full Scale Model

Details of ¼ Scale Test Model (cont.)

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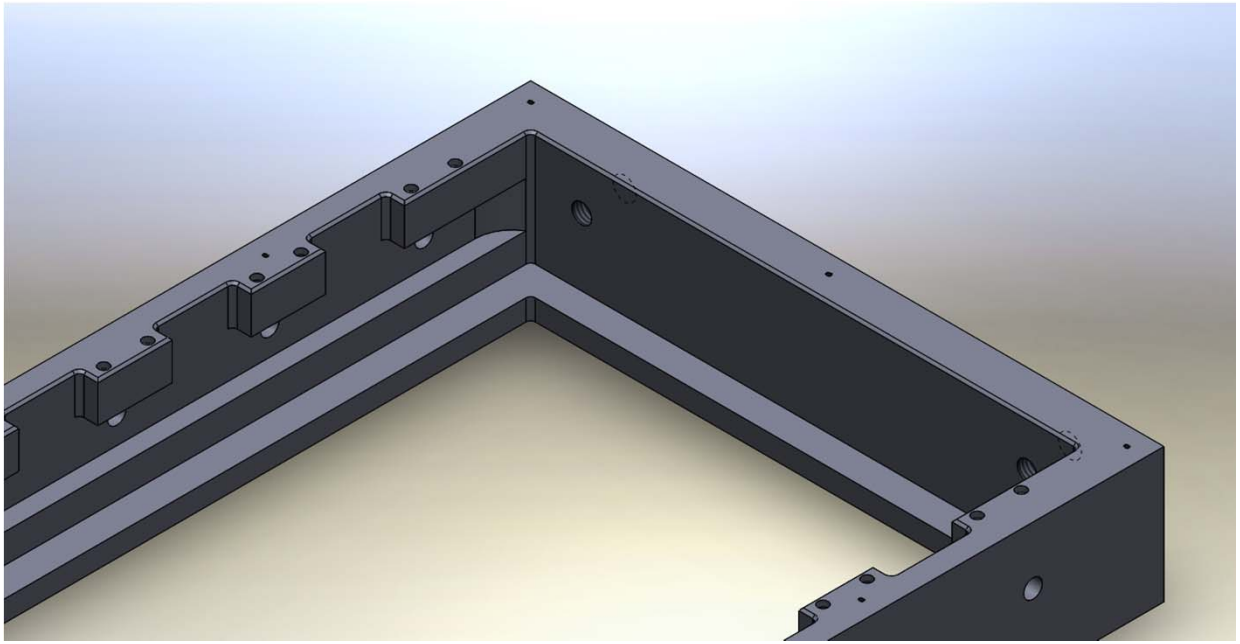
- Top Flange will be machined as a single piece part
  - Wedge block locations have been shifted slightly to facilitate machining (change will be carried over to Full Scale Model)
  - Tool radii have also been added at several vertical corners consistent with machining operations



Test Sequence

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- A total of three drop tests will be performed using the same ¼ Scale Test Model, which are (in sequential order):
  - 9-Meter Top-Down Drop/Slapdown onto Closure Lid
  - 9-Meter Center-of-Gravity-Over-Corner (CGOC) Drop on Bottom Corner
  - 1-Meter Puncture Drop onto Trunnion
- After each drop event, the ¼ Scale Test Model will be carefully opened to remove BFA Tank, and subjected to the following evaluations:
  - Dimensional inspection (including designated measurement locations)
  - Visual inspection of all welds and liquid penetrant (PT) examination of select welds (based on accessibility and load consideration)
- Damage from one drop orientation will be carried into next drop orientation

Test Sequence (cont.)

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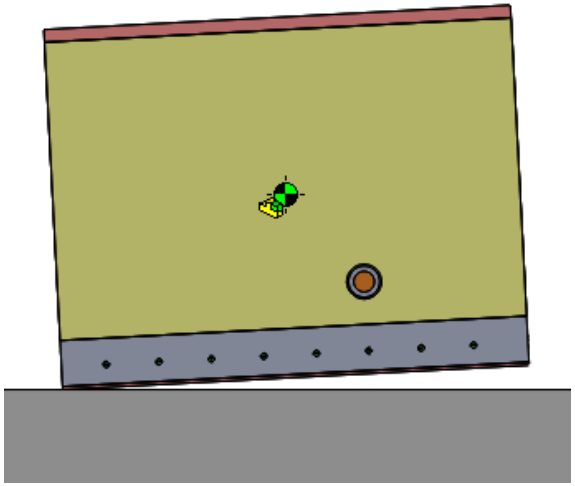

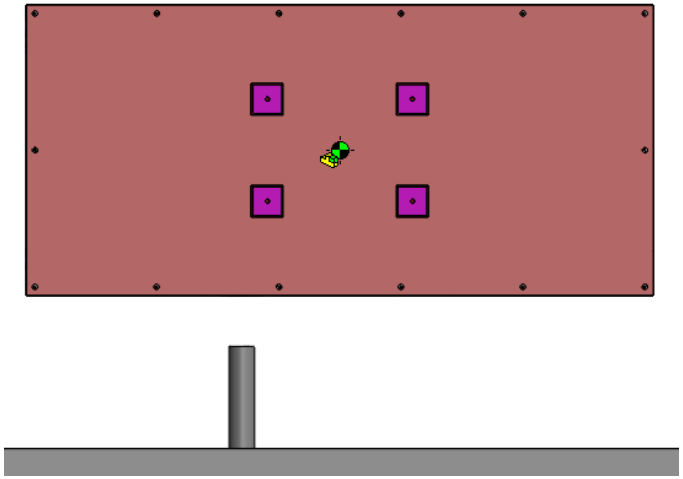

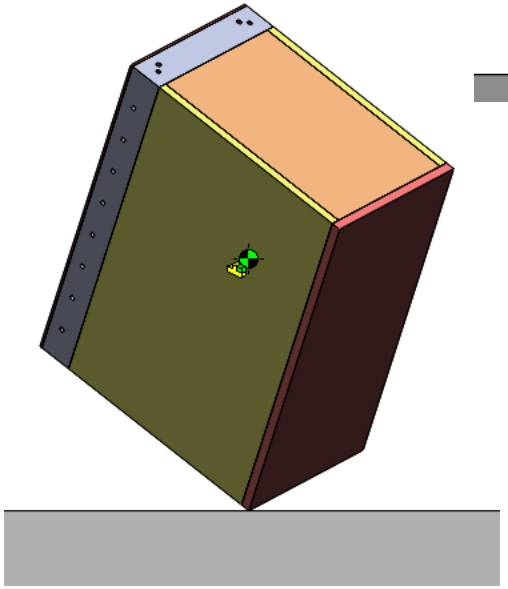

Test Facility

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- Holtec has requested proposals from Sandia and Oakridge National Laboratories to conduct HI-STAR ATB 1T Benchmark Test Program
- Preliminary discussions have taken place with both test facilities regarding instrumentation, rigging, weld inspections, etc.
- Holtec expects to select a test facility by the end of March 2016

Instrumentation of ¼ Scale Test Model

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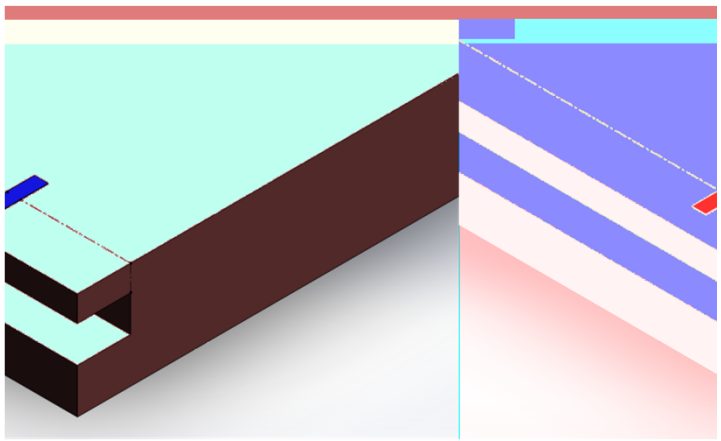
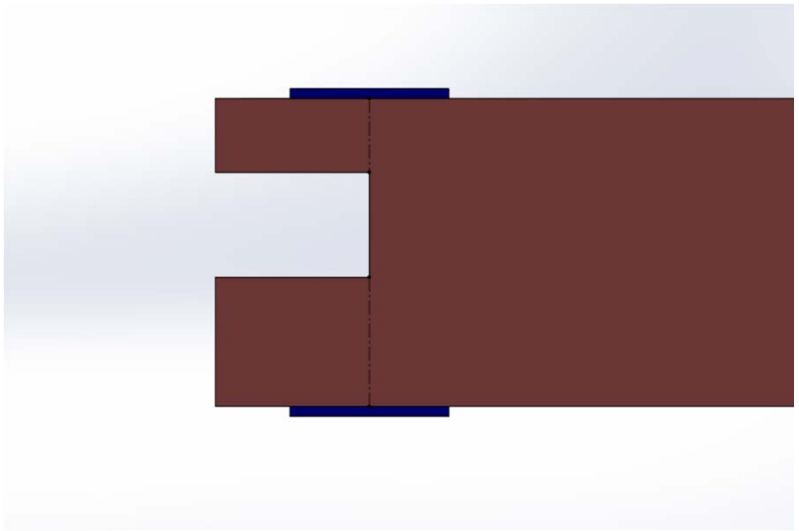
- Accelerometers
  - Installed on Cask Body, Closure Lid, & BFA Tank
- Strain Gages
  - Installed on Top Flange & Closure Lid (for Top-Down Drop), on the interior and exterior surfaces of the Cask Body (for Bottom CGOC Drop), and on the side wall opposite to the trunnion (for the Puncture Drop)





Instrumentation of ¼ Scale Test Model (cont.)

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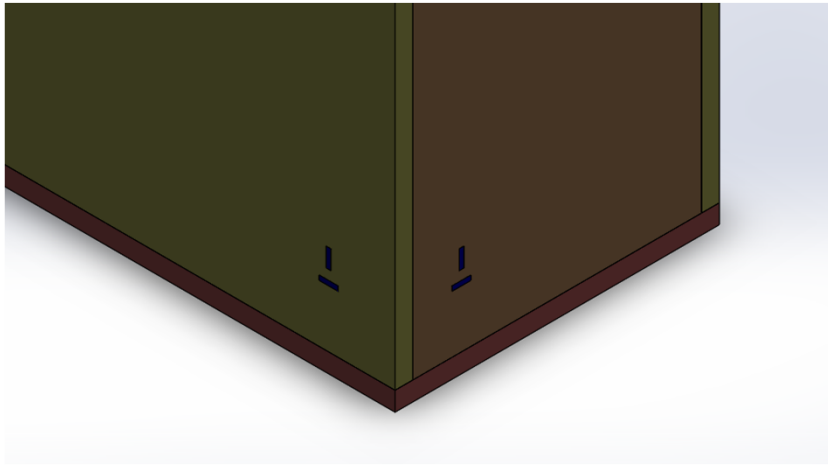

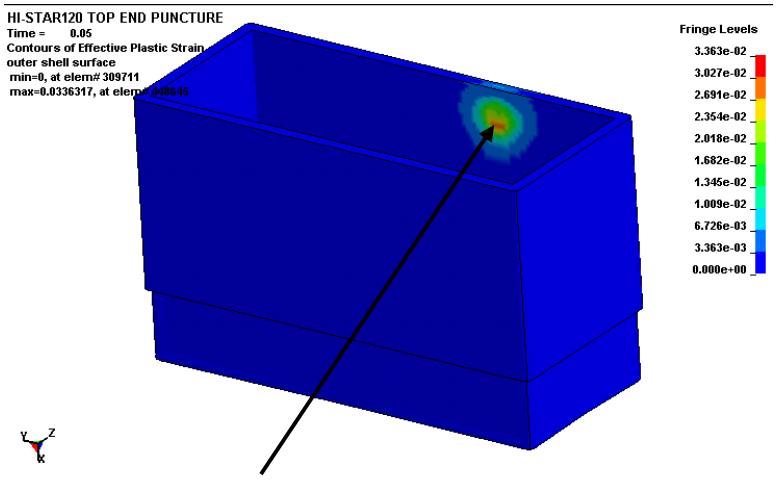

Strain Gage Location

- High Speed Videography
  - Use digital imaging software to obtain strain field on exterior surfaces of Cask Body
- Small access holes will be drilled in cask side wall to accommodate internal wiring
- Small reliefs will be machined into scale model BFA Tank (as needed) to protect accelerometers/strain gages during drop tests

Additional Topics

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The following "additional topics" were identified in the NRC's Summary of January 19, 2016 meeting (ML16040A185):

- "…component with the lowest safety factor is the lid when the package is dropped in a horizontal configuration with the lid top side up."
  - Table 2.6.2 of HI-STAR ATB 1T SAR (Proposed Rev. 0) reports minimum safety factors of 1.1 and 1.07, respectively, for the closure lid and the base plate. However, these safety factors are attributed to the 0.3 meter top end drop, which is a Normal Condition of Transport and, therefore, is subject to NB stress intensity limits (not strain limits).
  - Benchmark test program includes 9-meter top end drop, which is most challenging to the Closure Lid Locking System
- (1) No leak testing will be performed on ¼ Scale Test Model. However, leak testing will be performed on the seal region plus the entire containment boundary for the Full Scale Model.

Additional Topics (cont.)

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- (2) Use of ASME minimum strength properties for compliance demonstration of full scale package by analysis
  - All drop 9-meter drop simulations will be performed initially using true stress-strain curves derived from ASME minimum strength properties
  - Limiting drop orientation(s) will be re-performed using typical true stress-strain curve for Type 304 stainless steel obtained from Atlas of Stress-Strain Curves (which is referenced in NUREG-1864)
- (3) Use of CMTR data to develop stress-strain curves for benchmark analysis
  - CMTR data must be used for benchmark analysis to match response of as-fabricated ¼ Scale Test Model
  - True stress-strain curves will be developed from CMTR data using the methodology described in Holtec Position Paper DS-307, which has been used previously by Holtec to qualify the HI-STAR 180 & HI-STAR 180D transport casks
  - Development of stress-strain curves will be fully documented in Benchmark Analysis Report

Additional Topics (cont.)

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- (5) Weld performance based on the welding process (e.g., gas-tungsten arc welding vs. submerged metal arc welding)
  - Multiple weld processes (GTAW, GMAW, SAW) will be used to fabricate ¼ Scale Test Model
  - Larger welds on the outside surfaces will be made using submerged metal arc welding (SAW), which is an automated process that provides greater control over welding parameters (i.e., travel speed, heat input, etc.)
  - Welds on the inside of the package will be made using gas-tungsten arc welding (GTAW) due to restricted access
  - All welding processes used by HMD have been qualified via Procedure Qualification Records (PQR) in accordance ASME Section IX
  - All containment boundary welds will be subject to RT/UT examination during fabrication

Additional Topics (cont.)

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- (6) Evaluation of package vibratory response by way of modal survey
  - Holtec will explore this possibility with Sandia and Oakridge
  - Predominant frequency modes can also be obtained by performing FFT of time history measurement data from drop tests

Schedule

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- May 2016: Complete Fabrication of ¼ Scale Test Model
- July 2016: Perform Drop Tests at Test Facility
- September 2016: Complete Benchmarking of LS-DYNA Model
- November 2016: Resubmit HI-STAR ATB 1T SAR

Open Discussion

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End of Presentation