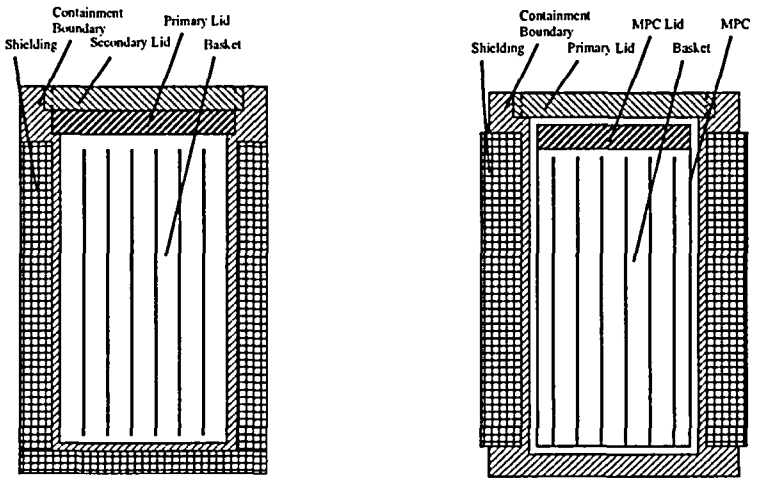
HI-STAR 180
Structural Considerations

Presentation to NRC
August 4, 2006
by
Holtec International

Introduction

- In a meeting on May 25, Holtec presented to the NRC the design of a new transportation cask, designated HI-STAR 180.
- As a follow-up, today's presentation focuses on
  - Benchmarking of codes for impact limiter qualification
  - Analytical modeling of the containment sealing
  - Structural acceptance criteria

Comparison of HI-STAR 180 and HI-STAR 100



HI-STAR 180 Design Details

- For future qualification as storage cask, the double lid system will enable monitoring of the leak tightness of the cask
- The secondary lid provides a redundant closure to prevent water intrusion during accident condition (moderator exclusion)

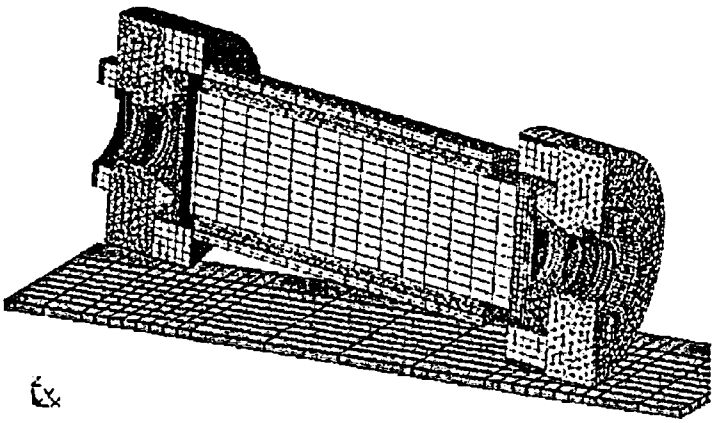
Advantages of an Analysis Based Performance Evaluation

- Analysis permits determination of remaining margins; a single test provides only a pass/fail outcome.
- Test scaling anomalies, instrumentation problems, and measurement errors are eliminated.
- Results are obtained for the entire structure, not just at selected locations.
- Effects of configuration modifications/sensitivity are obtainable.

Impact Limiter Qualification

- **HI-STAR 100**
  - Holtec performed demonstration of impact limiter performance (¼ scale drop testing -4 configurations) and simplified confirmatory analyses in 1997 for initial transport license.
- **HI-STAR HB** (A shorter and lighter version of HI-STAR 100)
  - *Impact limiter qualification by dynamic finite element analysis* (LS-DYNA)
  - The finite element model includes all relevant details of the impact limiter, including internal steel backbone structure
- Benchmarking of LS-DYNA is performed using test data from HI-STAR 100 drop tests in 1997.
  - Four configurations: end drop, side drop, cg-over corner, slapdown
  - Comparison of maximum deceleration, deformation, and deceleration over time

LS-DYNA Model for HI-STAR 100 Benchmark Simulations

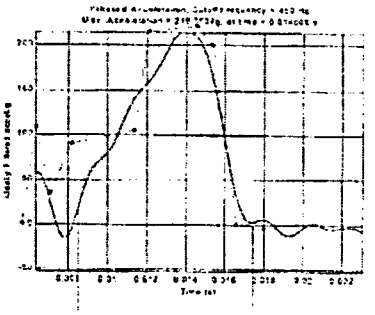


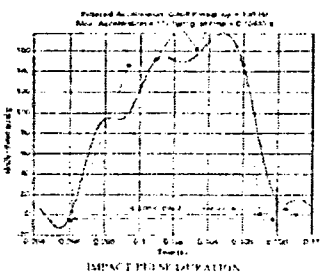
Comparison of Test Results and LS-DYNA Simulation Results

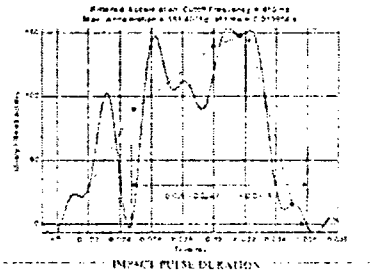
	Deceleration (g's)		Total Crush Depth (inch)		Impact Duration (milli-seconds)	
Case I.D.	Measured	Predicted	Measured	Predicted	Measured	Predicted
a. End Drop	53.9	55.35	10.6	10.34	37.2/40.7	44
B. C.G.-Over-Corner	38.8	37.13	9.82/15.25	18.91	61	62.5
C. Side Drop	45.7	49.18	12.5	12.65	53.1	47.5
D. Slap-Down						
Primary	49.0	48.04	10.7	9.77	44.4	45
Secondary	59.0	62.74	13.5	14.63	41.2	42

LS-DYNA Simulation vs. Test

- End Drop
- CG-over-Corner
- Side Drop

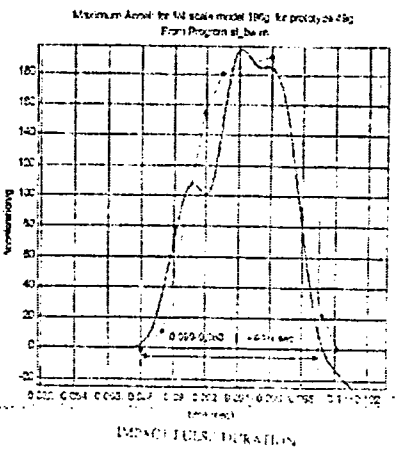


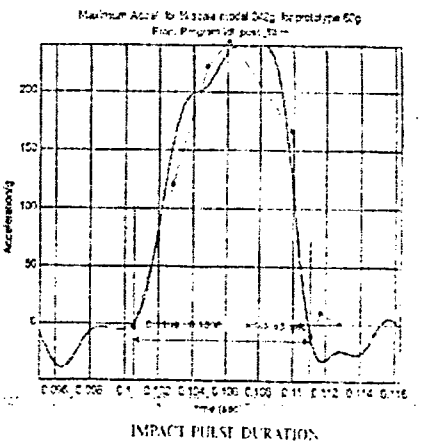




LS-DYNA Simulation vs. Test

Slapdown – Primary and Secondary Impact





LS-DYNA Simulation vs. TEST – Conclusions

- LS-DYNA calculated maximum deceleration, crush depth, impact duration, and deceleration over time are in excellent agreement with tests
- LS-DYNA models capture the underlying physical processes with great accuracy

LS-DYNA Simulation for HI-STAR 180

- Initial design concept for HI-STAR 180 anticipated foam-based crush material
- Final design uses aluminum honeycomb, the same material as used in the HI-STAR 100 impact limiters
- Overall, impact limiter features for HI-STAR 180 are the same as for HI-STAR 100
  - Cylindrical impact limiter
  - Steel backbone structure to "extend" target surface for side and slapdown
  - Aluminum honeycomb crush material
  - Long ductile axially directed studs attach impact limiter to cask
  - Buttress plate to resist shear and protect top end lid studs
- Benchmarking of LS-DYNA is directly applicable to HI-STAR 180

Containment Seals

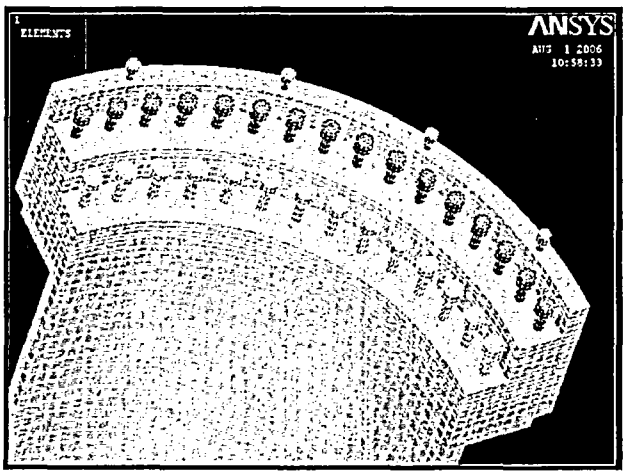
- Seal characteristics chosen to ensure acceptable leak rate is not exceeded. This translates to specifying a minimum compression during and after the event
- Ideal joint design – after initial preload, any new applied joint load is balanced by change in interface load; bolt load and seal compression do not change
- Studs remain in elastic range so seal compression is maintained

Containment Seals - Modeling

- Detailed finite element model of studs, lids, and seal region
- Studs modeled as 3-d solids, not as beams, to assure proper representation of local behavior.
- Establish desired pre-load by implicit solution
- Perform explicit dynamic analyses, starting from implicit solution. Track interface compressive loading adjacent to each stud. Sealing maintained if compression at local interface is maintained during and after simulation.

Containment sealing model

(primary and secondary lids and stud extension into the top flange not shown)



Acceptance Criteria For Containment

- Containment material is ASME code material
- Stress and stress intensity limits per ASME NB applicable for normal conditions of transport (primary and secondary stress) and for hypothetical accidents (primary stress intensity)
- Performance – primary lid sealing against release maintained under all conditions

Acceptance Criteria For Secondary Lid

- Normal conditions of transport – same as containment for structure and performance. (Secondary lid can be used as containment seal if leakage performance of primary lid is in question)
- Hypothetical accidents – secondary lid prevents water intrusion (demand on the seal is reduced).

Acceptance Criteria For Shielding Surrounding Containment

- Shielding must ensure applicable dose rate limits are met subsequent to any hypothetical accident.

Structural Acceptance Criteria for Fuel Basket

- Normal conditions of transport
  - Primary stresses remain in elastic range
- Hypothetical accidents
  - Limited permanent deformation

Summary

- New HI-STAR 180 Cask system without MPC
- Double bolted lid to permit water exclusion under transport accident conditions
- Accident conditions evaluated by state-of-the-art transient FE analysis, benchmarked using HI-STAR 100 drop test results