Test Procedures for Evaluating Ejection Mitigation Systems

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Vehicle Research and Test Center

Ejection Fatalities

10,302 Ejected Fatalities in 1999 (32%)

- 70% completely ejected
- 30% partially ejected
- 74% through glazing
- 57% through side windows
  - 60% of these occur in rollovers

Total Ejections

51,078 Ejected Occupants in 1999 (1%)

- 64% completely ejected
- 36% partially ejected
- 69% through glazing
- 50% through side windows

Ejection Problem Summary

- 1/3 of Fatalities are Ejected
  - Over represented based on ejection occurrence
- 2/3 of Ejections are Complete
  - Almost all were unbelted
  - Partial ejection not insignificant
- 3/4 of Ejections are Through Glazing
- 1/2 of Ejections are Through Side Windows
  - 3/5 of these are in rollovers

Previous Test Procedure Development

- Full-Scale Rollover Tests
  - Evaluated full-dummy ejection
  - Not repeatable
- Full-Dummy Inverted Drop Tests
  - Evaluated full-dummy ejections
  - Not rollover simulation
  - Demonstrated ejection mitigation capability of advanced glazing systems

Previous Test Procedure Development

- Potential Compliance Tests for Advanced Glazing Systems
  - Retention test
    - 18 kg guided impactor
  - Head injury assessment test
    - FMVSS 201 free-motion headform
  - Could include pre-impact roof crush
- Sled Tests
  - Measure Neck Loading

Ejection Mitigation
Potential Countermeasures
(passive systems)

- Advanced Glazing Systems
  - Only possibility, until recently
- Inflatable Systems
- Combination of Above

Ejection Mitigation
Evaluating Potential Countermeasures
(passive systems)

- Advanced Glazing Systems
  - Demonstrated capability to mitigate ejections
  - Component tests developed
- Inflatable and/or Combination Systems
  - Are they effective in mitigating ejections?
  - Is retention test developed for glazings suitable?

Ejection Mitigation
Current Research Program

- Are Inflatable and/or Combined Systems Effective in Mitigating Ejections?
  - Developed Dynamic Rollover Fixture (DRF)
    - Produces repeatable, full-dummy ejections
    - Allows measurement of dummy responses
    - Research tool only
- Is Retention Test Developed for Glazings Suitable for Inflatable/Combined Systems?
  - 18 kg guided impactor

Dynamic Rollover Fixture

- Acceleration controlled by adjustable weight stack
- Currently using a C/K1500 test buck.
- Testing using 50th, 5th, and 6YO dummies

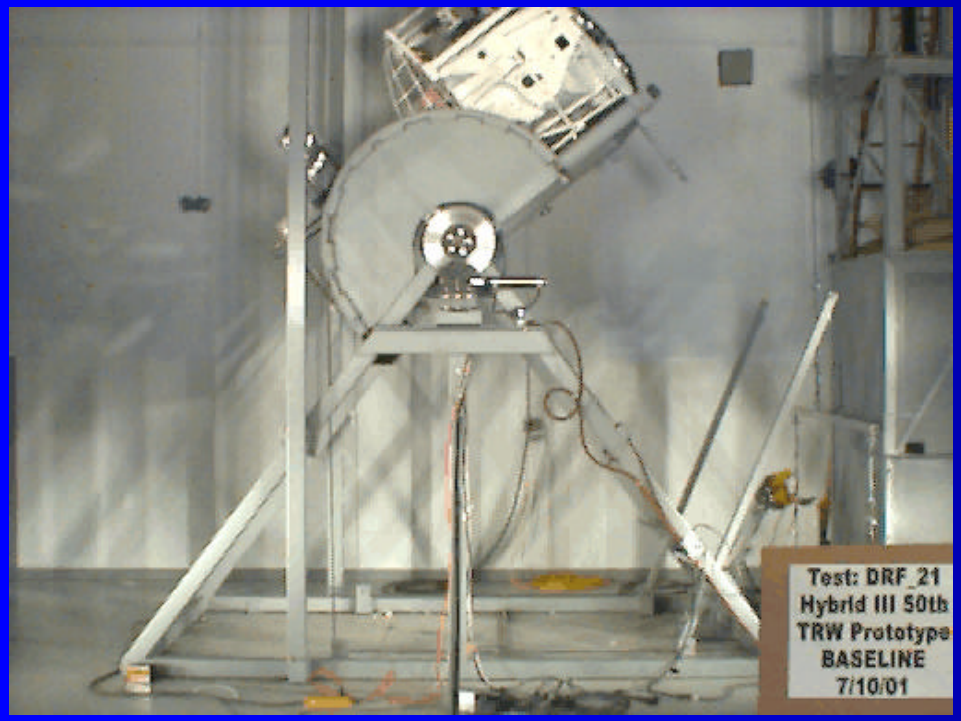
DRF Operational Features

- Achieve Angular Roll Rates up to 360 deg/sec
- Lateral Position from Roll Center is Adjustable
  - Vary occupant trajectory
- Test Buck Yaw Angle Adjustable
  - Vary occupant-to-window impact location
- Drop Height and Mass Adjustable (not explored yet)
- Inflatable Devices Can be Actively Deployed

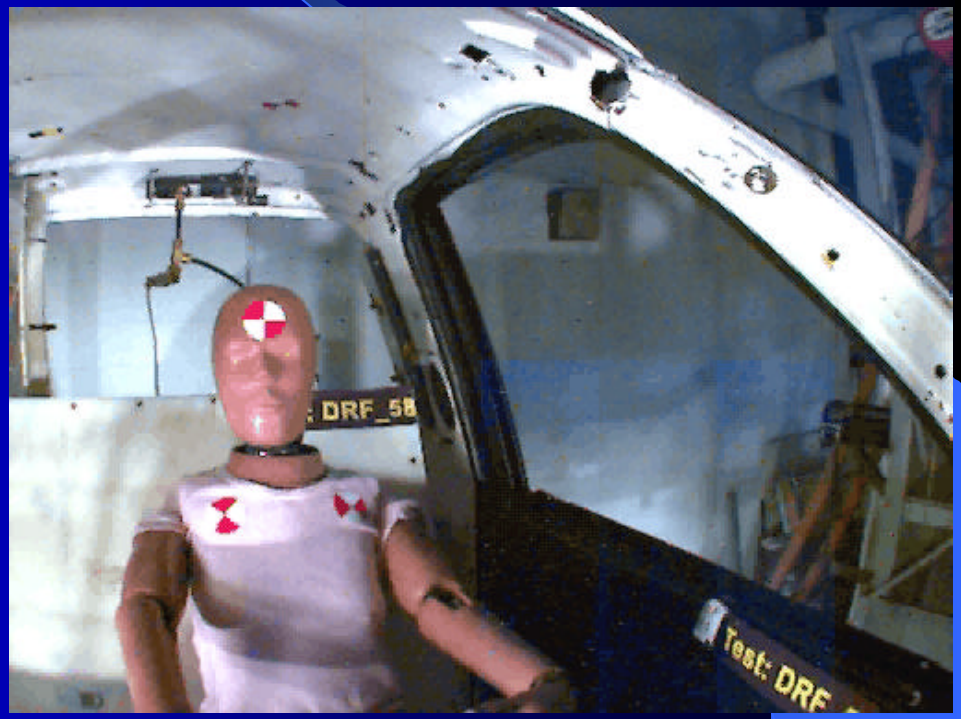
DRF Restrictions

- Not a Potential Compliance Test
- Does Not Simulate Linear Vehicle Accelerations
  - Rollover sensor performance evaluation may be limited
- Does Not Evaluate Effects of Vehicle Damage
  - Roof crush
  - Distortion of anchorage locations

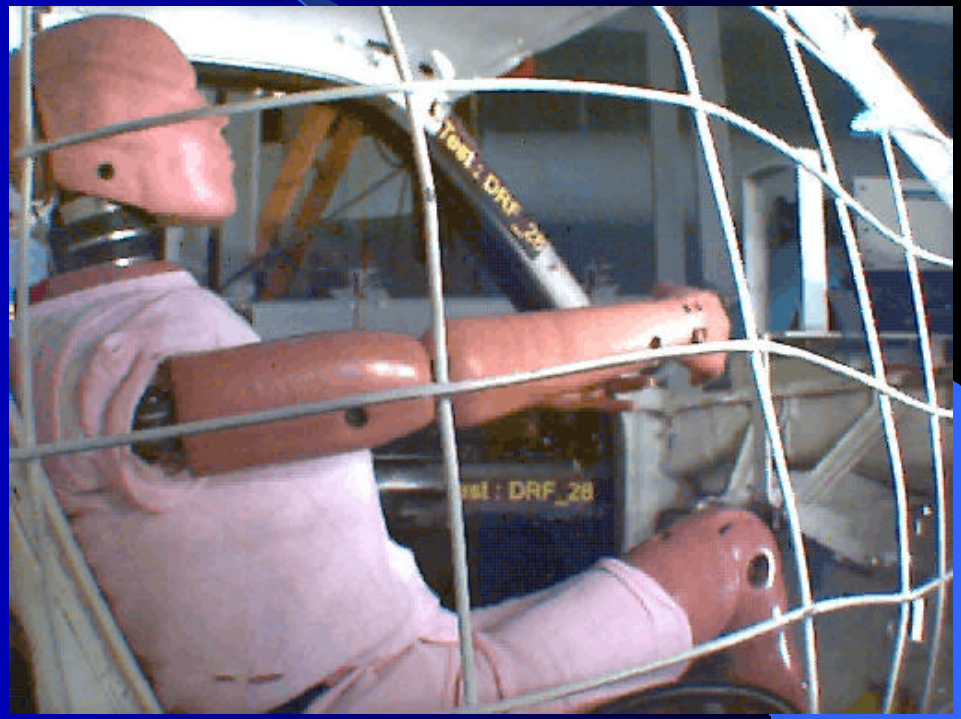
Dynamic Rollover Fixture



Roll Radius Effect

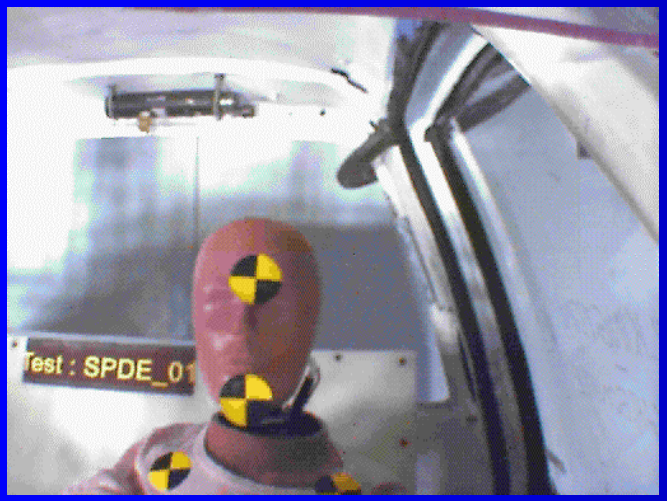


Yaw Angle Effect

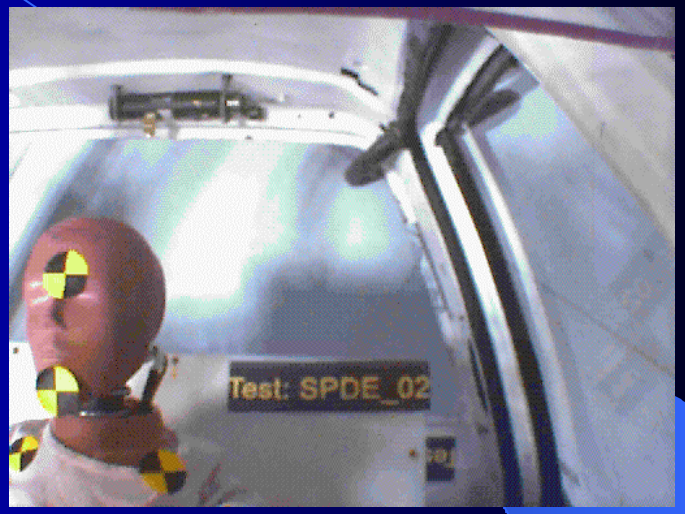


Head Impact Speed

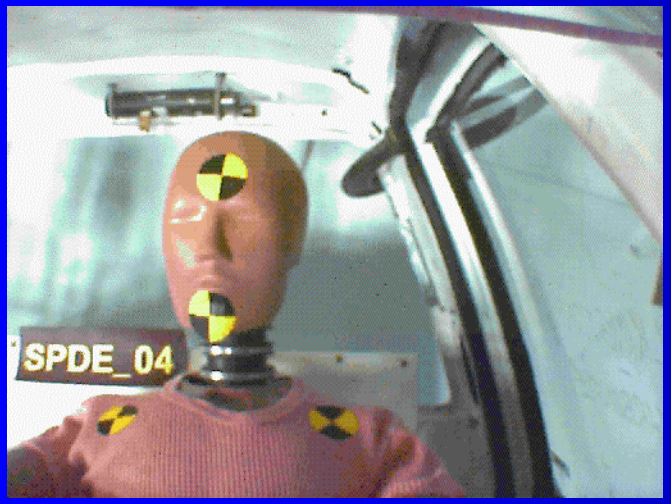
Impact Speed: 14 kmph (9 mph)



Impact Speed: 30.5 kmph (19 mph)



Impact Speed: 18 kmph (11 mph)



Impact Speed: 29 kmph (18 mph)

DRF Testing – 50th Male

Prototype Inflatable System #1 - Pre-Deployed

DRF Testing – 5th Female

Prototype Inflatable System #2 – Actively Deployed

Inflatable Systems
Findings From DRF Tests – to date

- Occupant Retention
  - Adult dummies – mitigates full ejection
    - Upper body loads air bag
    - Lower body loads door
    - Allows arms to ‘escape’ beneath air bag
    - Are dummies as flexible as humans?
  - Child dummy - TBD

Inflatable Systems

Findings From DRF Tests – to date (cont.)

- Injury Causing Potential
  - HIC responses very low (3 to 156)
- Neck Loading Low
  - Compression from 181 N to 2520 N
  - Tension from 240 N to 1120 N
  - Lateral shear loads from 315 N to 950 N
  - Lateral bending moment from 14 N-m to 61 N-m

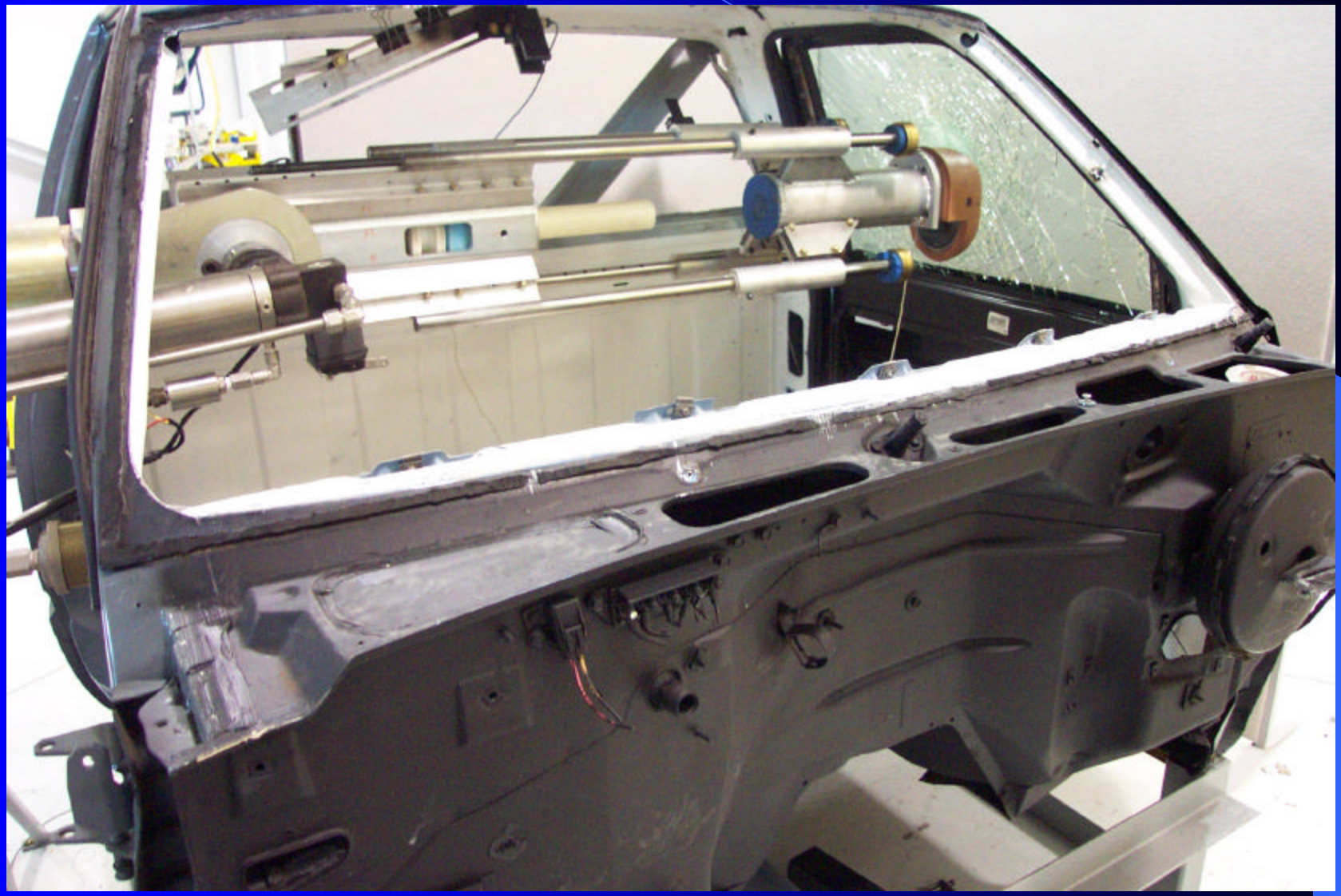
18 kg Guided Impactor

- Developed as Retention Test for Advanced Glazing Systems
- Details in First NHTSA Status Report for Advanced Glazing Research, November 1995

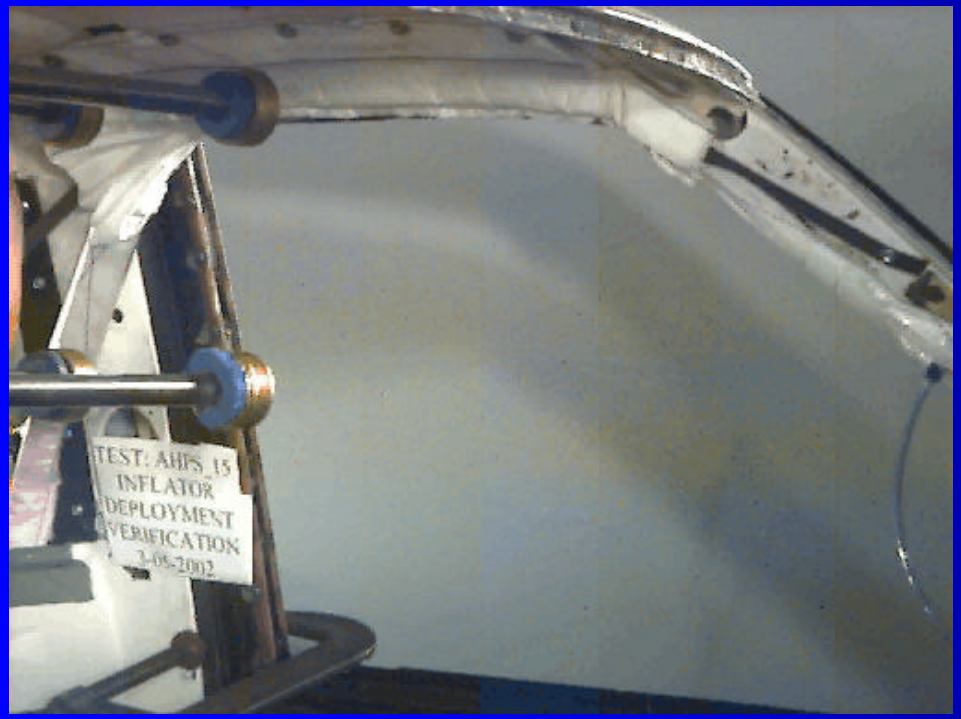
18 kg Guided Impactor

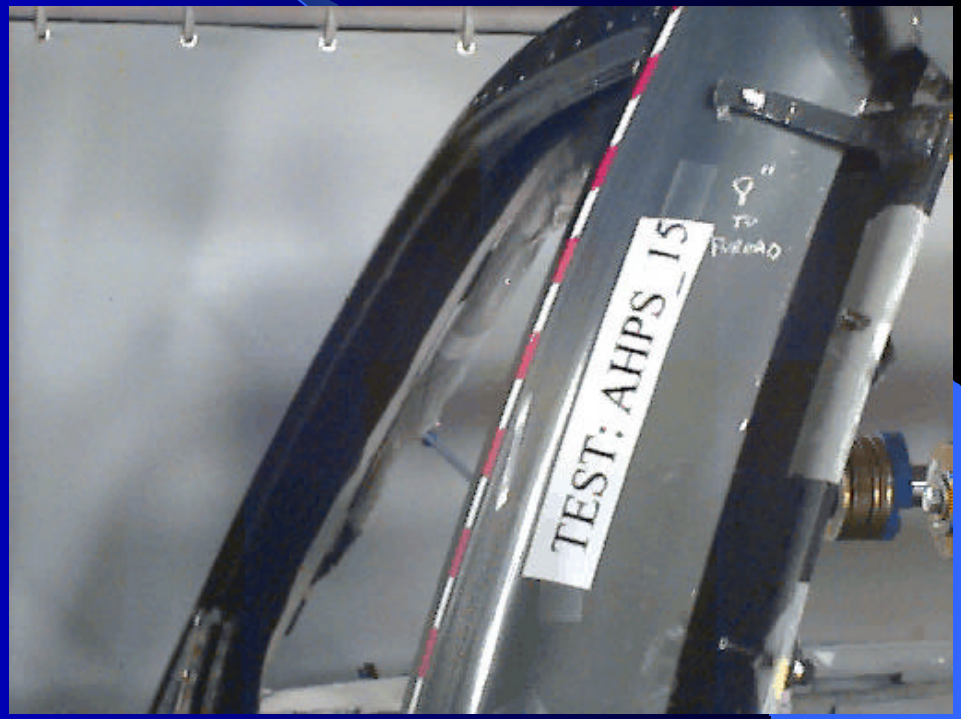
- Impactor Weight from Effective Mass Study Using Full Dummy
  - Sled & linear pendulum testing
- Impactor Face Represents Aggregate Front and Side of Head
- Impact Speed Range 10 to 15 mph
  - Based on crash test film analysis

18 kg Guided Impactor



18 kg Guided Impactor
Inflatable Systems

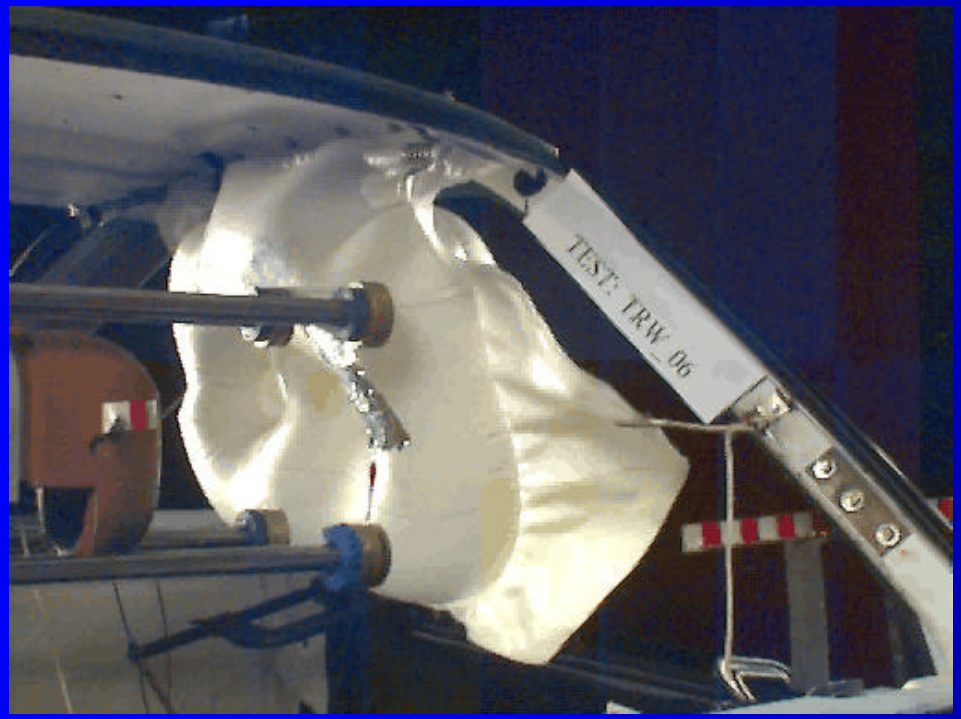


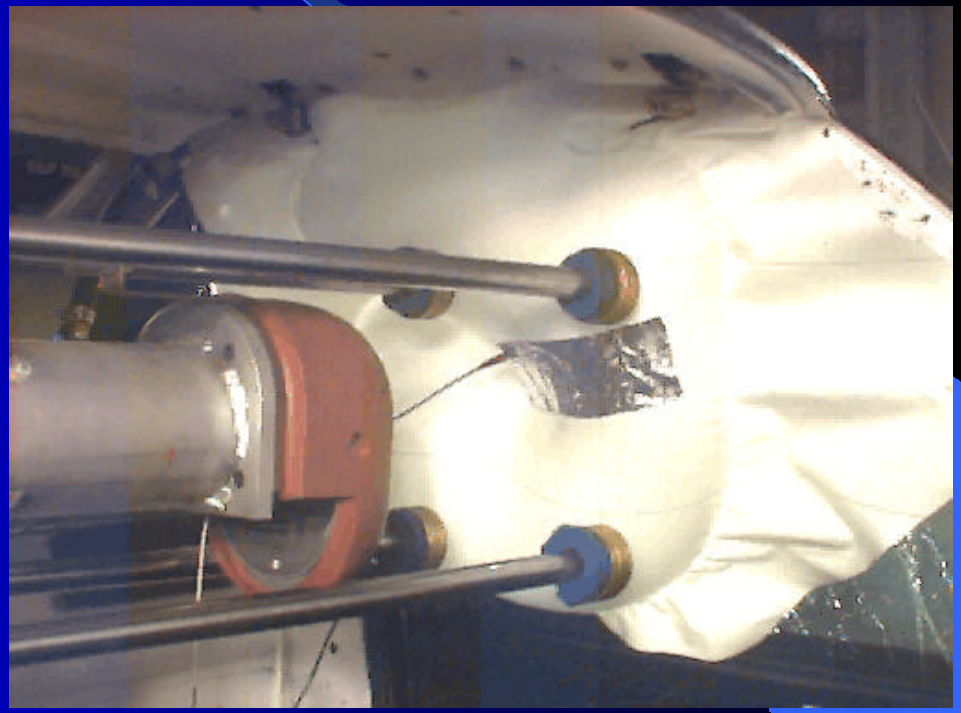


Prototype Inflatable System #2 – Actively Deployed

10 mph Impact

18 kg Guided Impactor
Inflatable Systems





Left - Prototype Inflatable System #1 Only – 10 mph

Right – Prototype Inflatable System #1 with Advanced Glazing – 15 mph

Summary

- Ejection Through Side Windows is a Significant Safety Issue
  - Over 25,000 ejections per year
  - Over 5000 fatal ejections per year
- Substantial Research Completed for Advanced Glazing Systems
  - Demonstrated ejection mitigation capability
  - Component tests developed to evaluate them

Summary

- DRF Developed to Evaluate Occupant Retention Capability for Ejection Mitigation Systems
  - Produces repeatable, realistic roll rates
  - Produces full-dummy ejection through open windows
  - Allows measurement of dummy responses
  - Occupant trajectories and impact areas are variable
    - Dummy size
    - Initial dummy position
    - Buck configuration

Summary

- DRF Testing to Evaluate Inflatable Systems is Ongoing. Limited evaluation indicates:
  - Good potential to mitigate full-body ejections
  - May be susceptible to ejection of arms below air bag
  - Low potential to produce head or neck injuries
  - Limited potential to evaluate rollover sensor performance
    - Linear vehicle accelerations not simulated
- 18 kg Guided Impactor Testing is Ongoing. Limited evaluation indicates:
  - More concentrated loading area than full-dummy in DRF tests
  - Evaluation with roof deformation not straight-forward
  - No potential to evaluate rollover sensor performance