Rear Seat Study

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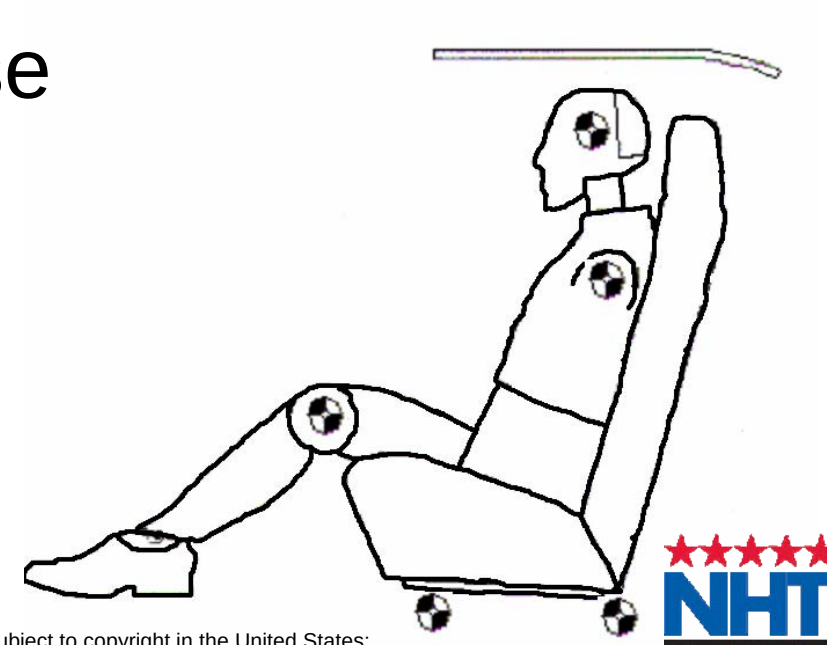
NHTSA

Rear Seat Study

- Seat Parameter Effects
  - Determine what seat properties affect the performance of restraints in the rear seats
- Crash Pulse Effects
  - Determine the effect of crash pulse on FF CRS
- Advanced Restraints
  - Improved protection for adults and the aged

Seat Parameter Effects

- Seat cushion stiffness
- Seat top surface angle
- Seat cushion height at front of the seat
- Seat support structure angle
- 2 Occupants / sled test: 5thF, FF CRS(3 YO)
- 35 mph Taurus pulse



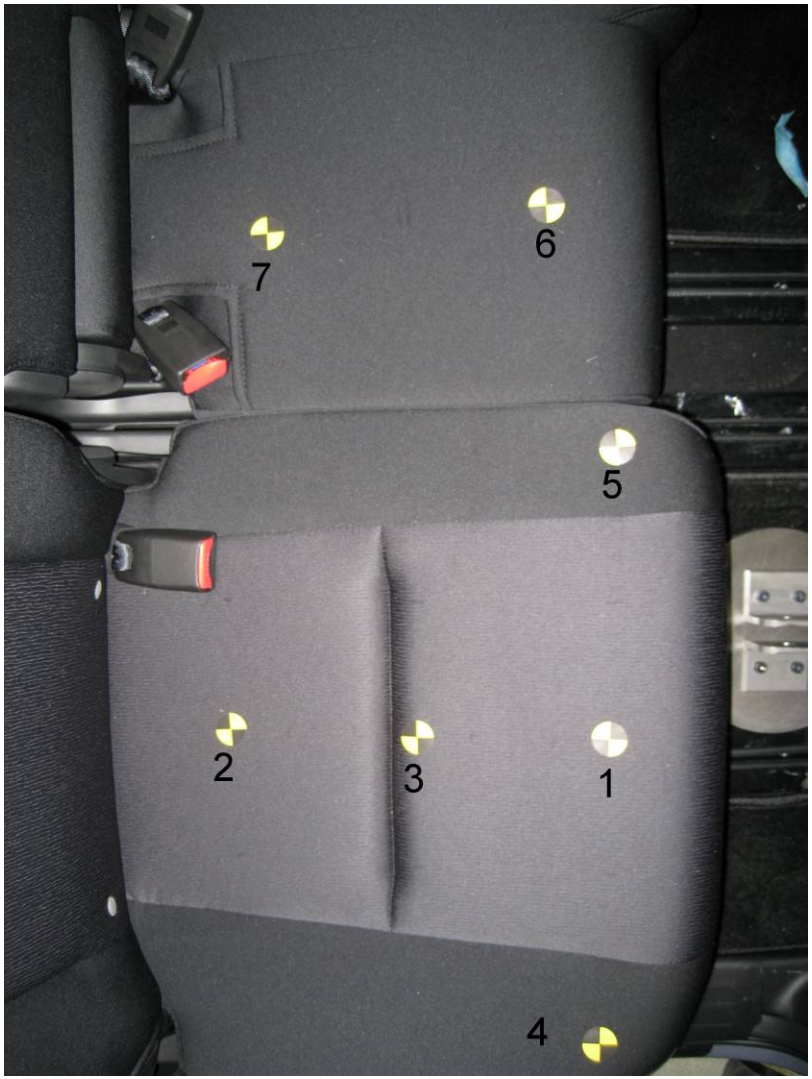
Seats Measured at VRTC - Setup

Test Setup:
Indentation plate = 8” dia

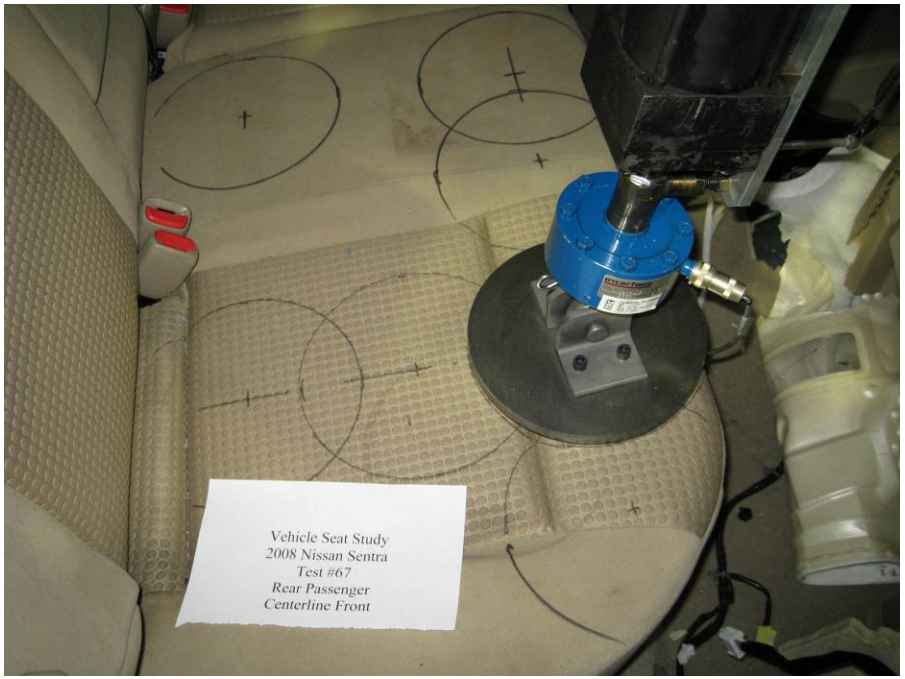
Seats Measured at VRTC - Locations

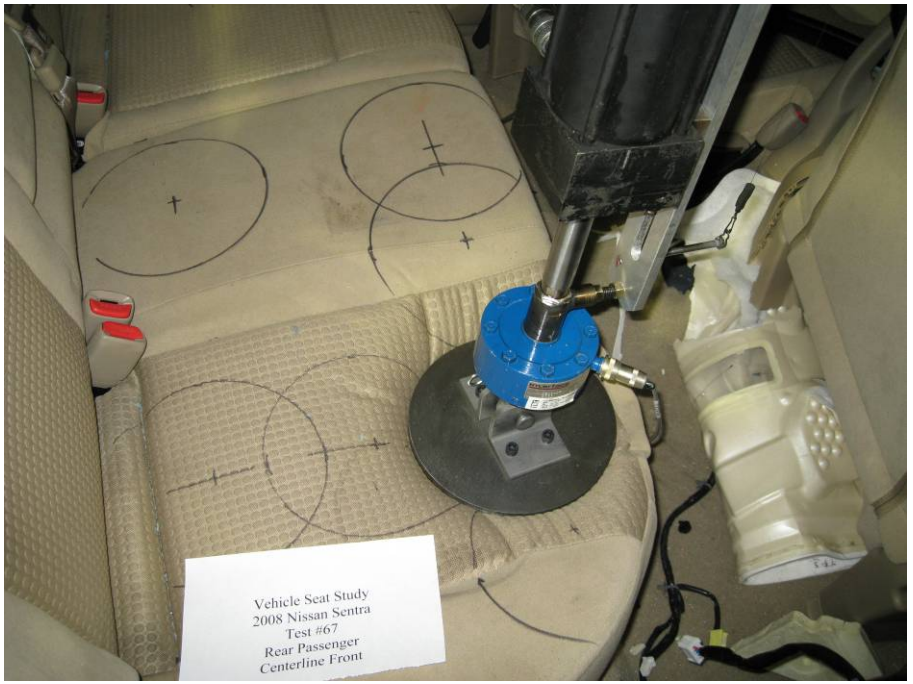
- Outboard seat measured at
  - 3 locations on longitudinal centerline
    - 4” from front edge (1)
    - 4” from seat bight (2)
    - Midway between the above points (3)
  - 2 additional locations on front of seat
    - 4” from outboard edge (4)
    - Highest point on the inboard side (at least 8” from location 1) (5)

- Middle seat measured at
  - 2 locations on the centerline
    - 4” from front edge (6)
    - 4” from seat bight (7)



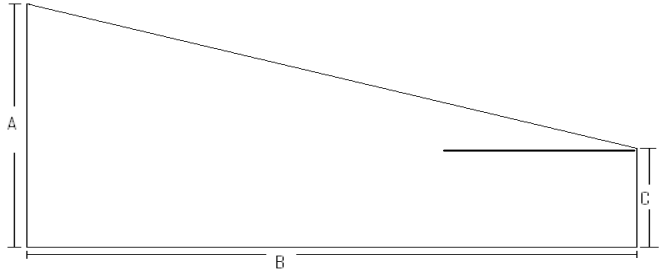
Seats Measured at VRTC - Setup





Indenter front aligned to cushion front edge

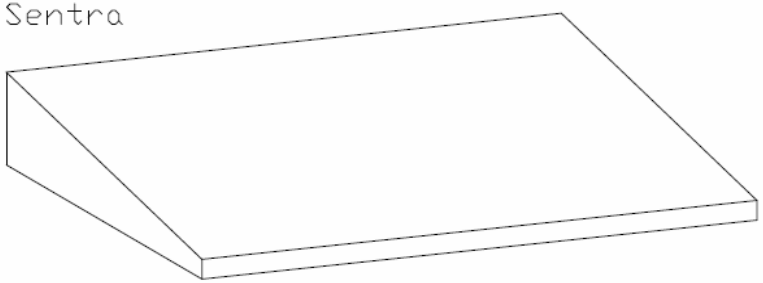
Vehicle Survey

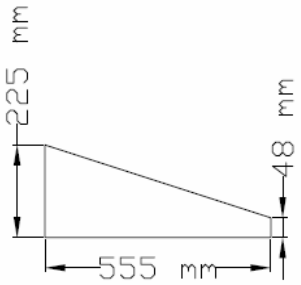


Vehicle Description	Front Seat Foam Thickness (A)	Seat Depth Front to Back (B)	Back Seat Foam Thickness (C)	Floor to Top of Seat	Seat Angle Degrees
2008 Ford Taruas X	100	510	90	380	6.7
1999 Volkswagon Beetle	100	450	95	340	8
1994 Honda Civic	105	500	70	275	12.9
2006 Volkswagon Passat	115	530	80	335	11
2002 Ford Focus	120	500	85	375	12.6
2007 Saturn Vue	130	520	80	302	8.6
2008 Subaru Tribeca	140	510	70	325	9
2002 Honda CRV	140	570	40	370	9.4
2007 Ford Expedition	140	520	65	340	10.2
2006 Dodge Durango	140	575	90	372	14.4
2007 Ford Edge	140	520	120	300	15.1
2008 Toyota Highlander	150	505	83	335	8.8
2005 Honda Odyssey	150	570	70	378	12.7
1996 Chevy Cavalier	160	490	60	320	8.2
2009 Chevy Equinox	160	690	60	365	10.8
2007 Jeep Commander	160	560	70	310	12.3
2006 Honda Ridgeline	165	500	50	375	11.4
2007 Mazda CX-9	170	515	50	295	11
2003 Honda Odyssey	170	520	90	373	13.4
1996 Chysler Concord	170	620	28	330	18
1990 Honda Civic	190	480	90	315	9.3
2007 Ford 500	210	540	70	360	15
1996 Ford Taurus	215	545	40	348	16.8
2008 Nissan Sentra	225	555	48	365	10.3

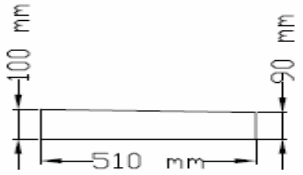
Extreme Cushion Depths

2008 Nissan Sentra



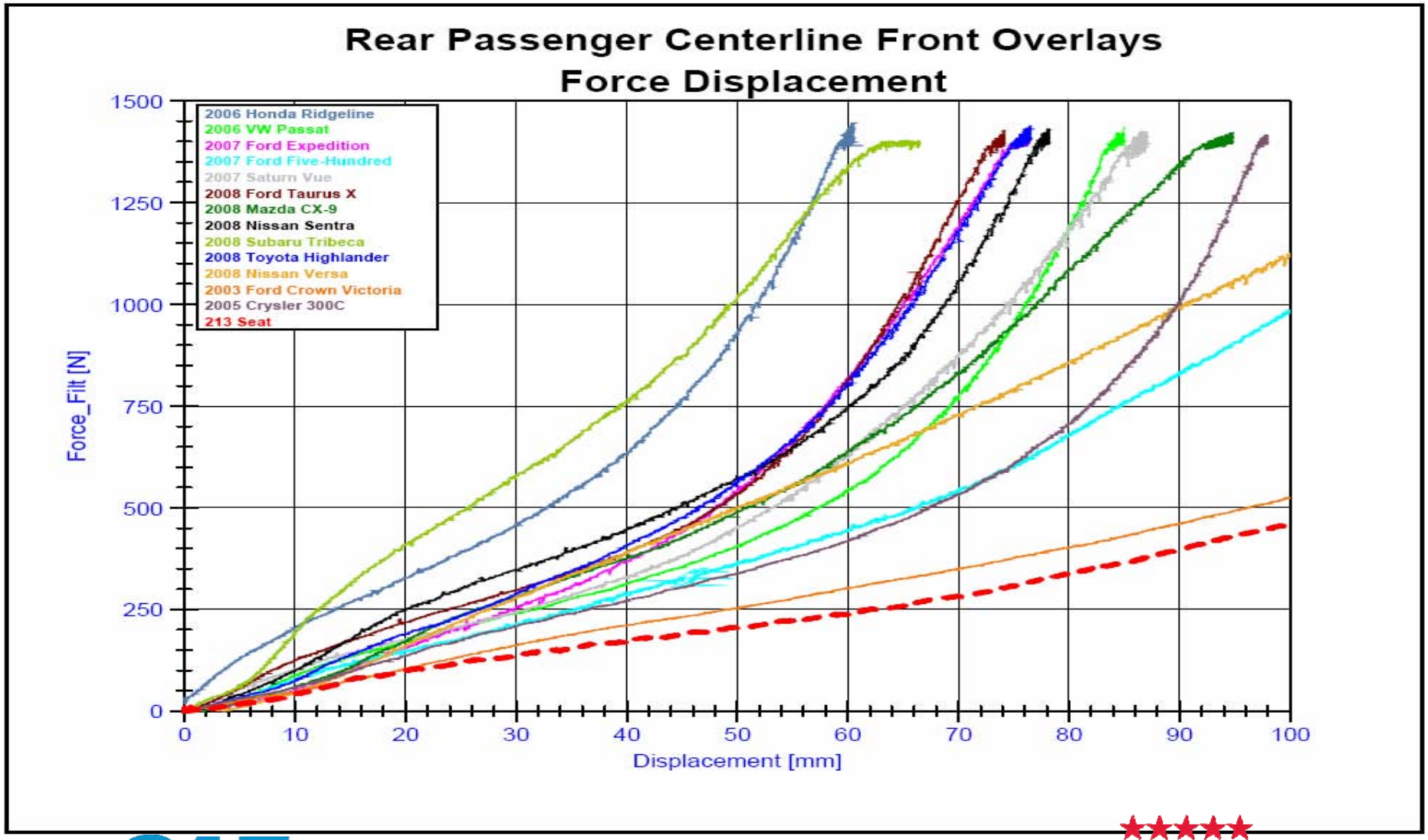


Taurus X



Vehicle Cushion Stiffness

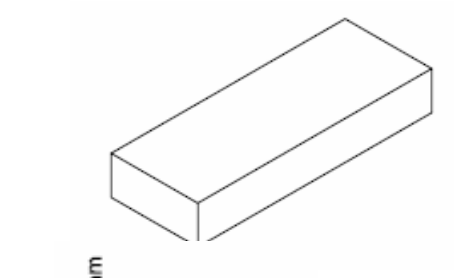
- Will use stiffness at front of the seat (possibly more relevant for CRS bottoming out)

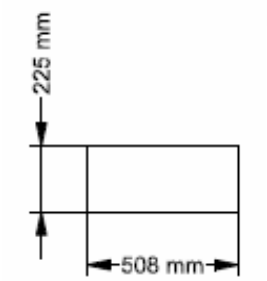


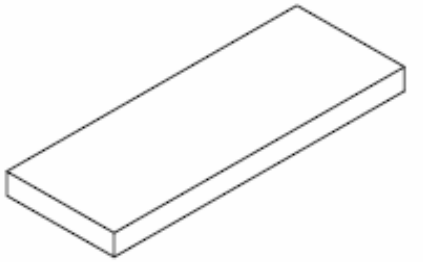
Independent Variables

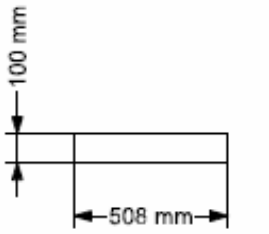
- Cushion stiffness = soft, hard
- Cushion top surface angle = 7º, 16º
- Cushion height at front = 225 mm, 100 mm
- Seat frame support angles = 7º, 16º
  - Current FMVSS-213 is at 15º
  - Anti-submarining ramp in Ford 500 is at 12º
- Seat pan width (1372 mm), depth (508 mm) same as FMVSS-213
- Seat back angle, shape, foam same as FMVSS-213
- 2 Occupants in each sled test: 5th F, FF CRS (3 YO)

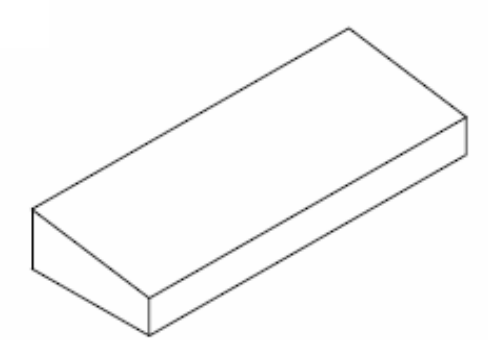
Test Matrix – 4 Cushion Shapes

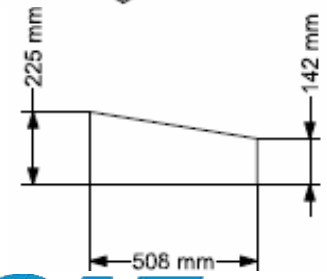


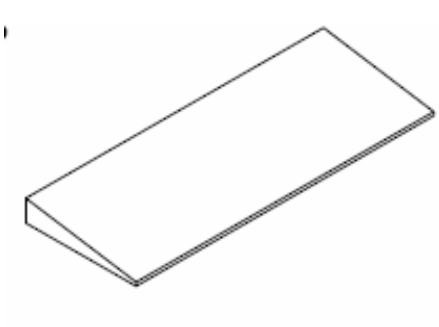


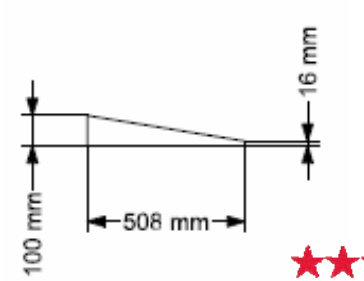




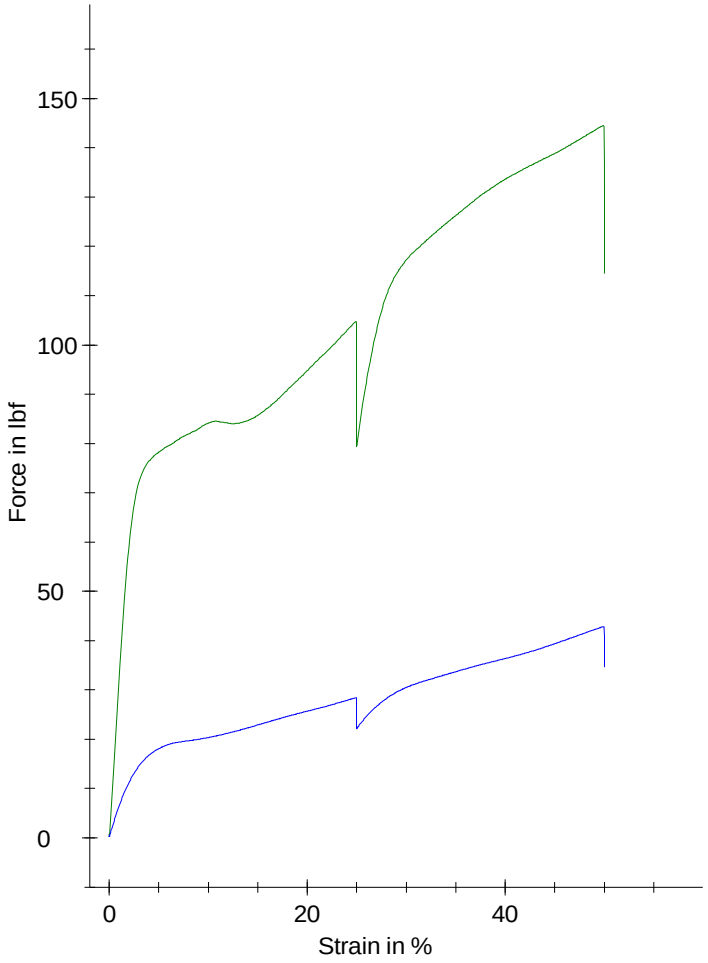








Test Matrix – 2 Stiffness

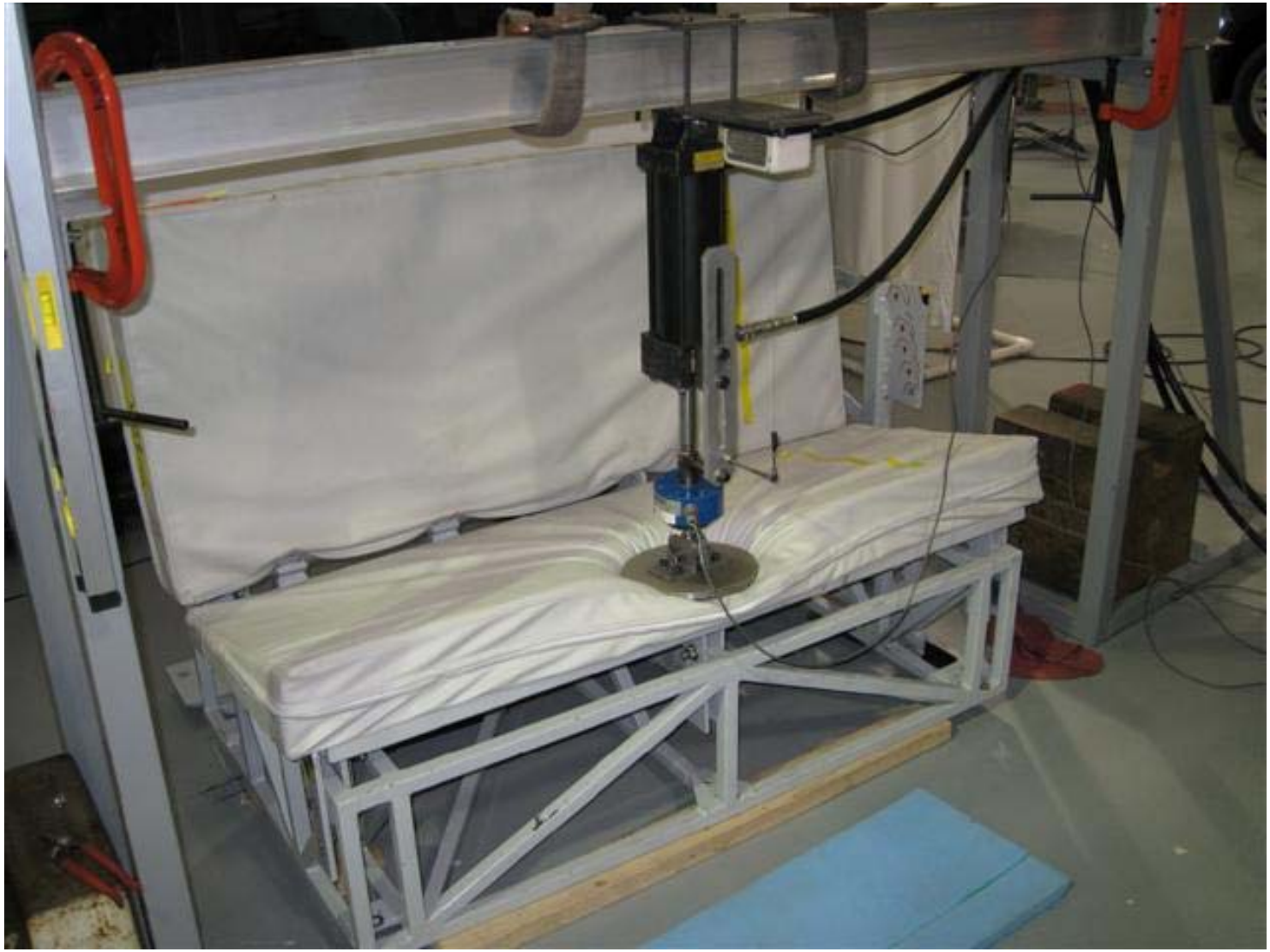


Polyurethane foam
based on toluene diisocyanate (TDI)
Used in North American market

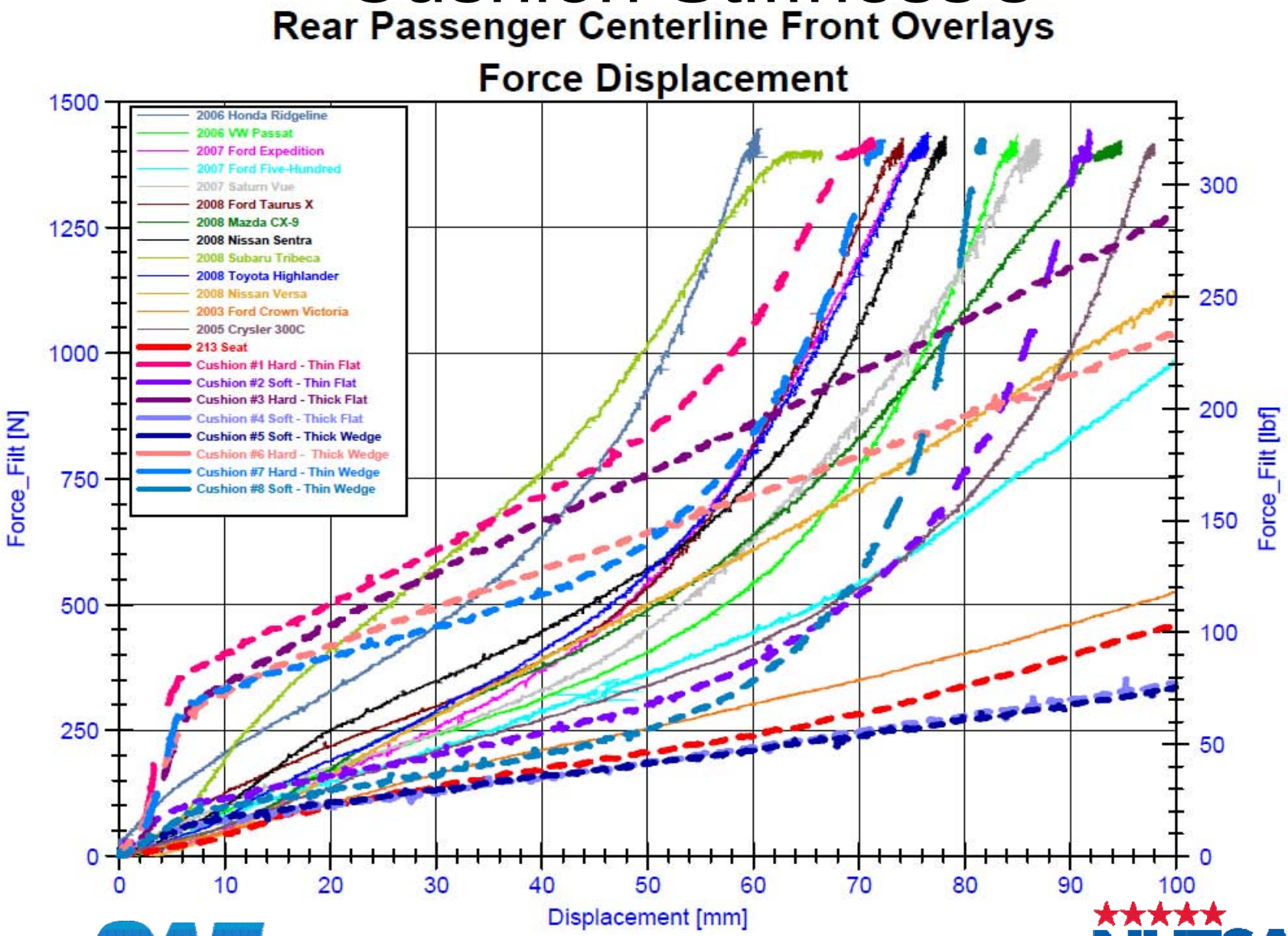
Comment	Height mm	Force at 25 % Fapply lbf	Force at 50 % Fapply lbf
26 Block - Material A	101.25	22.14	34.59
80 Block - Material B	103.96	79.32	114.59

Tested per ASTM D 3574 – 08
15” x 15” x 4” block using 8” dia loading plate

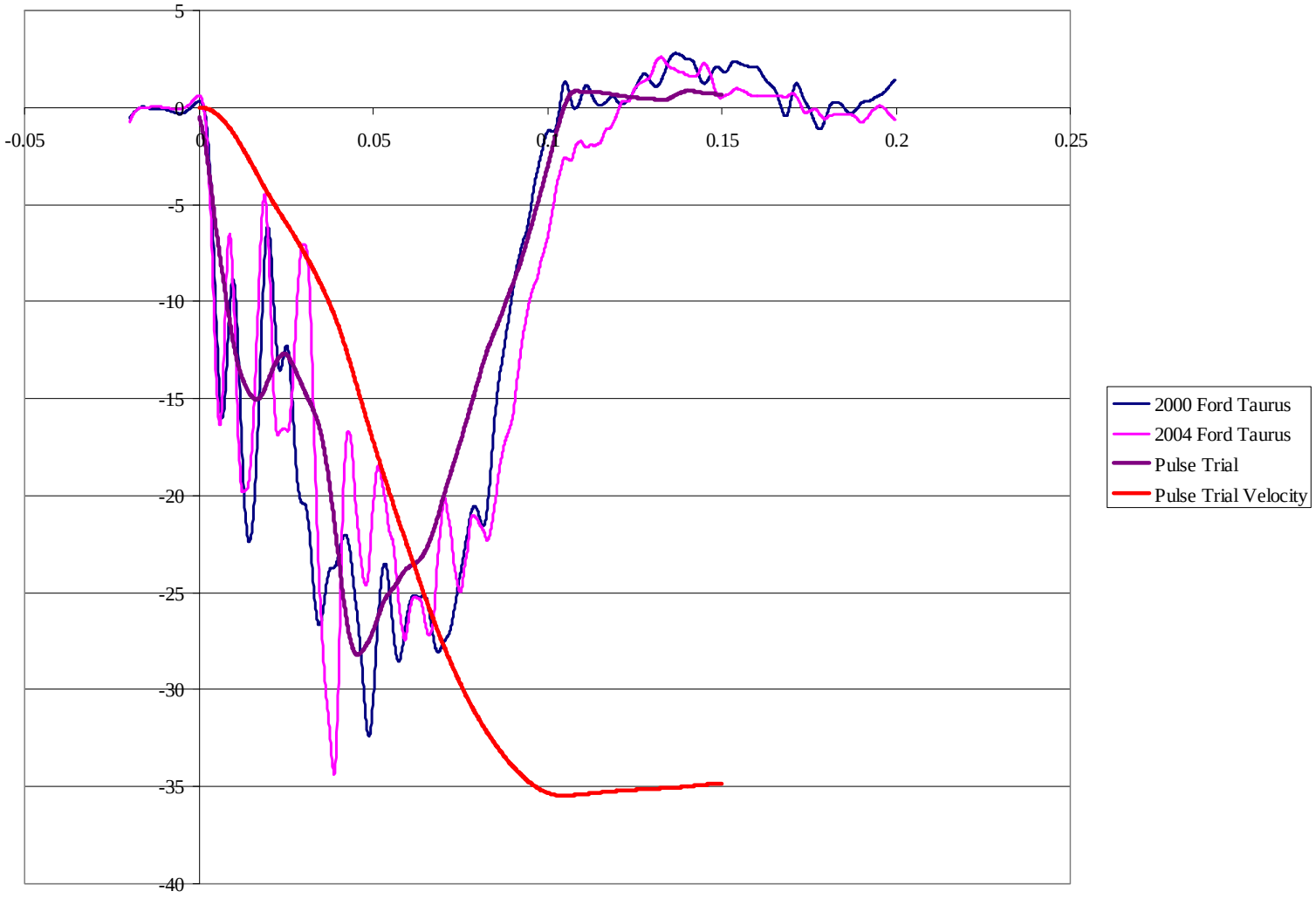
Test of Sled Test Cushions



Cushion Stiffness's



Crash Pulse



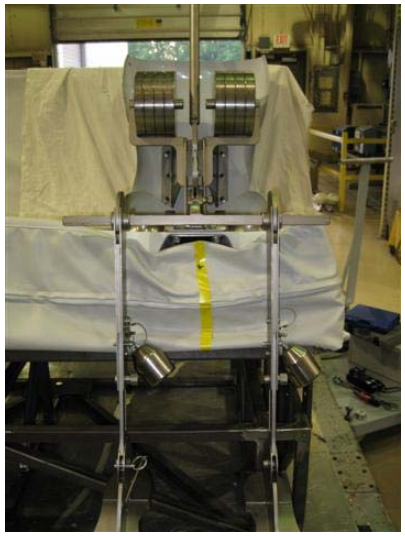
Peak G = -28.390 g at 46.160 ms ΔV = -35.973 Mph at 106.480 ms

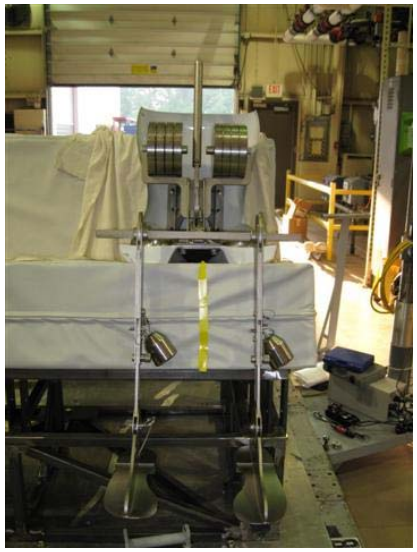
Test Matrix Summary

- Foam shapes: 4 (thick, thin; flat, wedge)
- Foam Stiffness: 2 (soft; hard)
- Base-Plate Angle: 2 (7º; 16º)
- Total # of tests = 16
- Crash Pulse: 2004 Taurus 35 mph NCAP
- Occupants: Belted 5th F, 3 YO in CRS
- CRS Used: Evenflo Titan Elite DLX Convertible Car Seat (Forward Facing)
  - Mounted by lower anchor and top tether (LATCH)

Locating LATCH and Belt Anchors

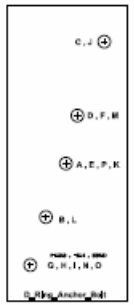
Dummies sit at different positions for different cushion thickness, stiffness, shapes





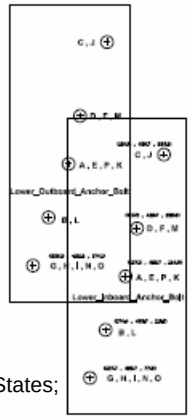
Seat Belt Anchor Locations

- Belted 5th F
  - Record anchor locations in Taurus relative to OSCAR H-Point
  - OSCAR the sled with the different cushions, base-plate angles (16 possibilities)
  - Determine belt anchor locations (at the same positions relative to the OSCAR H-point in Taurus) for all 16 configurations
  - Belts and retractors changed after each test
- Similar locations of LATCH anchors



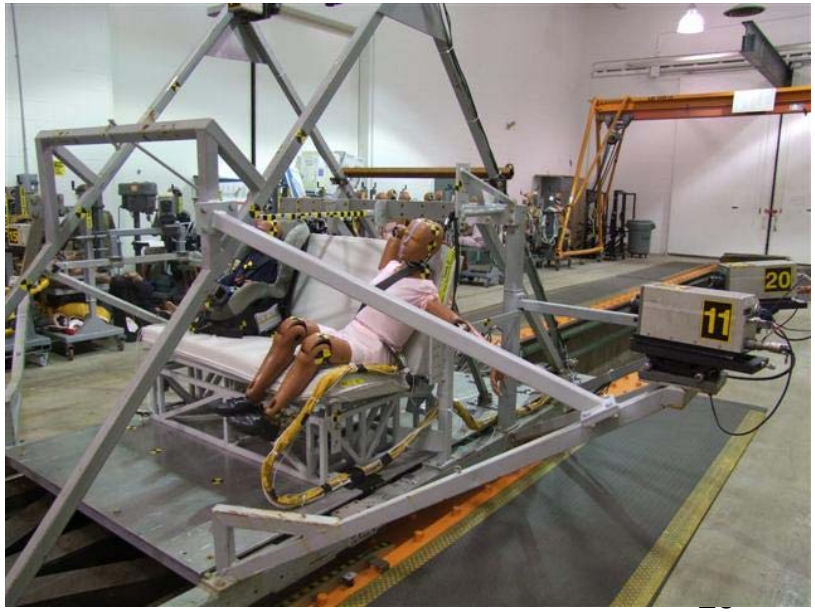
D - Ring

Outboard Lap Belt



Inboard Lap Belt

Typical Test Setup



Dummy Instrumentation

- HIC15
- Nij
- Neck Tension
- Chest G
- Chest Deflection
- Head excursion (3D Photogrammetry)

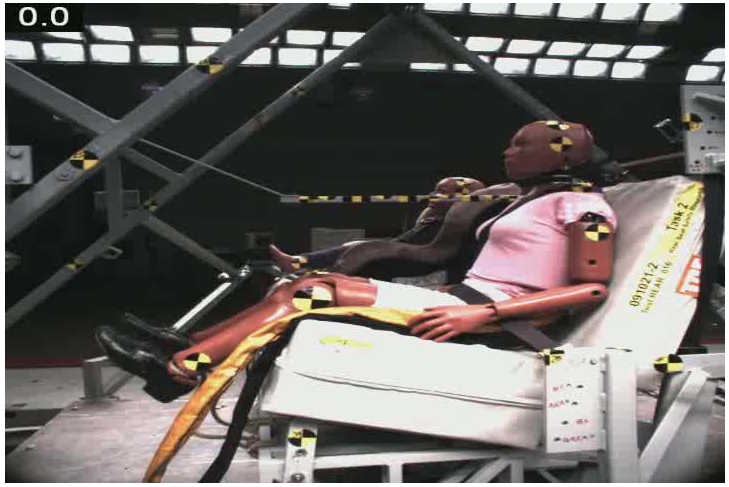
Dummy IAV's (Scaled)

- 5th Female
  - HIC 15: 0.66 – 1.33
  - Nij: 0.82 – 1.26
  - Neck T: 0.82 – 1.48
  - Chest G: 0.73 – 0.96
  - Chest D: 0.59 – 0.80
  - Head X: 0.88 – 1.00*
- Lowest max-IAV (Head X = 0.93) in Test 6: Thin, Flat, Soft, 16º
- Highest max-IAV (Neck T = 1.53) in Test 13: Thick, Flat, Soft, 16º

- 3 YO
  - HIC 15: 0.40 – 0.65
  - Nij: 1.03 – 1.26
  - Neck T: 1.62 – 1.88
  - Chest G: 0.84 – 0.98
  - Chest D: 0.50 – 0.69
  - Head X: 0.78 – 1.00 *
- Lowest max-IAV (Neck T = 1.62) in Test 14: Thick, Flat, Soft, 7º
- Highest max-IAV (Neck T = 1.88) in Test 16: Thick, Flat, Hard, 16º

* Head excursion scaled to the maximum observed in all 16 tests

5th F – Head Excursions

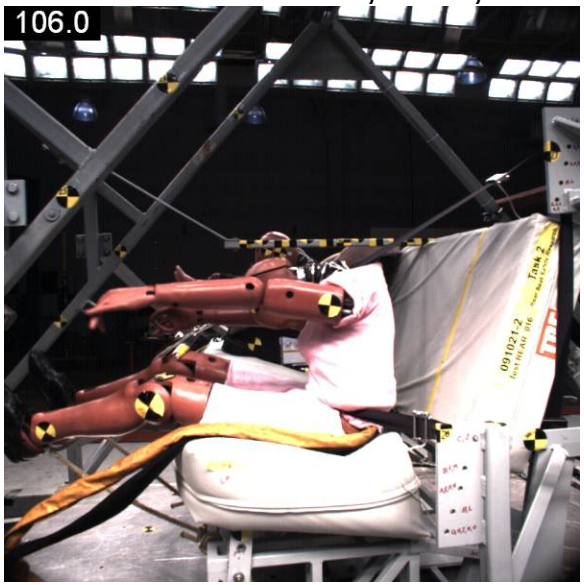


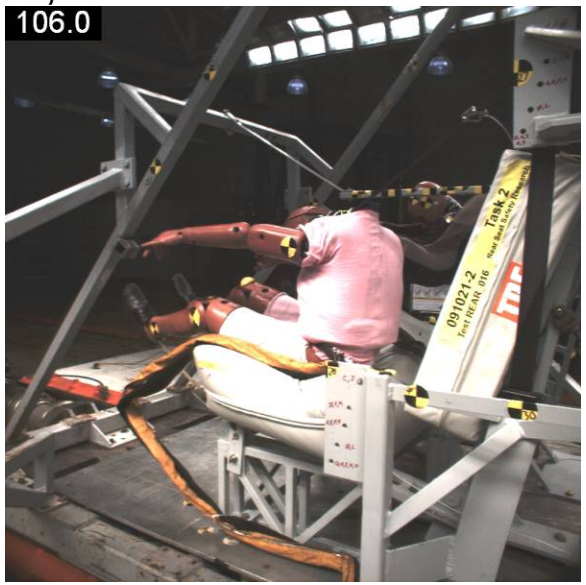
Test # 16: Thick, Flat, Hard, 16º; Head X = 472 mm from normally seated

Test # 2: Thin, Wedge, Hard, 16º; Head X = 414 mm from normally seated

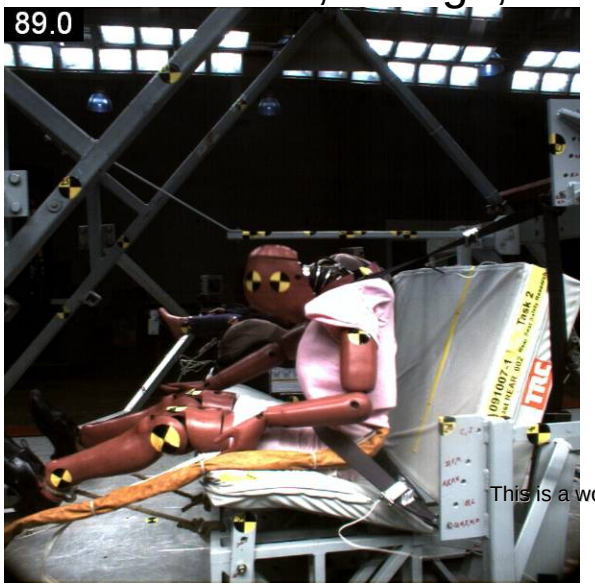
5th F - Head Excursions

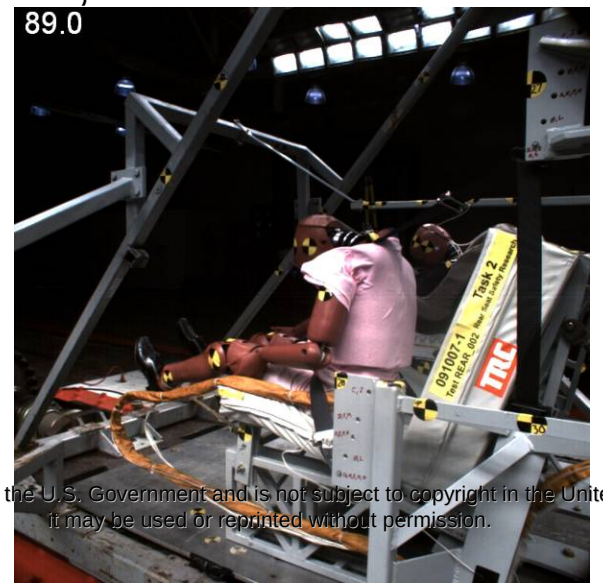
Test # 16: Thick, Flat, Hard, 16º; Head X = 472 mm from normally seated (2.3” more)



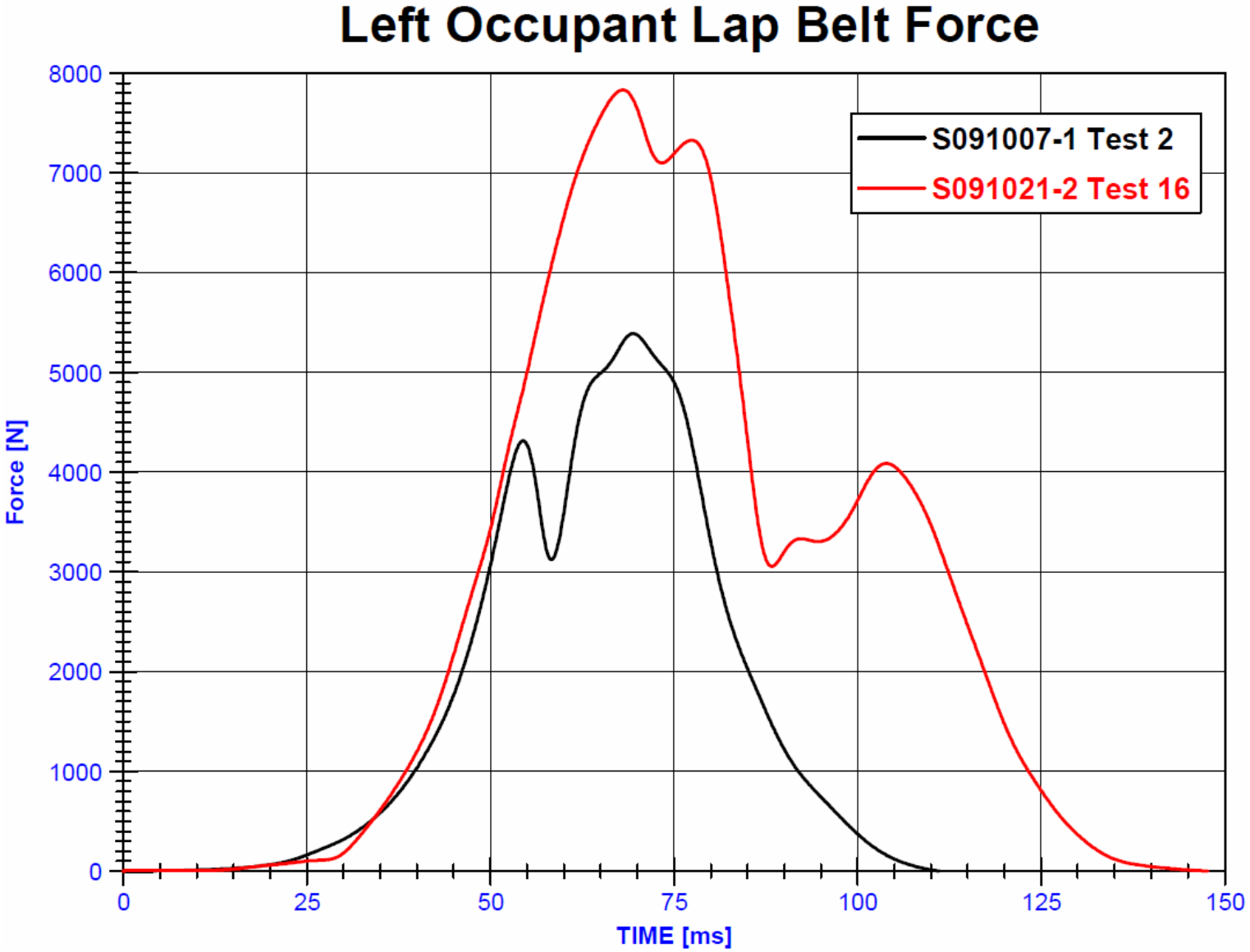


Test # 2: Thin, Wedge, Hard, 16º; Head X = 414 mm from normally seated





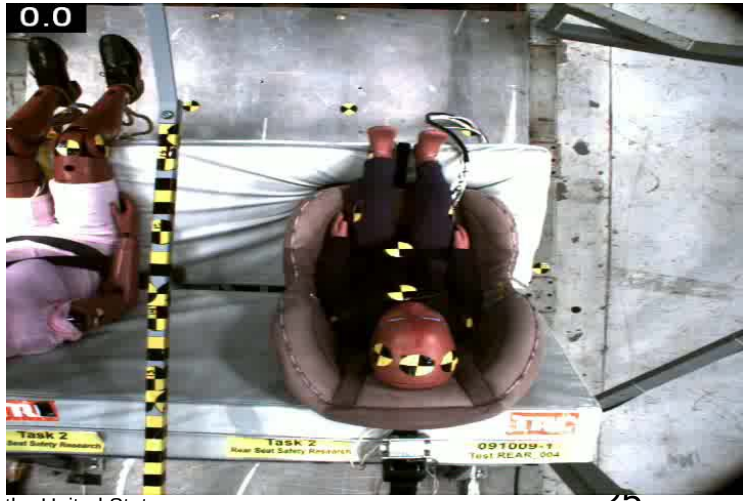
Submarining (5th F)



3 YO – Head Excursions

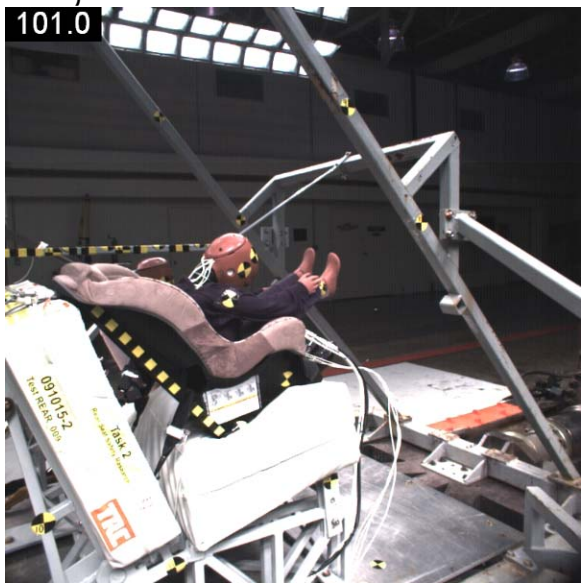
Test # 9: Thick, Wedge, Soft, 16º; Head X = 433 mm from normally seated

Test # 4: Thin, Wedge, Soft, 16º; Head X = 352 mm from normally seated



3 YO – Head Excursions

Test # 9: Thick, Wedge, Soft, 16º; Head X = 433 mm from normally seated (3.2” more)



Test # 4: Thin, Wedge, Soft, 16º; Head X = 352 mm from normally seated

ANOVA Analysis

- One-way ANOVA analysis for effect on injury data of: thickness, stiffness, shape and angle
  - Variables that were at least 80% likely to be significant were analyzed using linear regression:
    - For each dummy individually
    - Scaled data analyzed jointly
- Thickness is the dominant variable

Combined Data for Both Dummies

Effect of Thickness, *(95% Probability)*			
Injury Criteria	Effect	Values	Statistically Different, $\alpha = 0.20$
Hic15_scaled	Thick > Thin	0.716 | 0.689	No
NIJ_scaled	Thick > Thin	1.126 | 1.085	No
Fz_scaled	Thick > Thin	1.520 | 1.412	No
Chdef_scaled	Thick > Thin	0.655 | 0.630	No
Ch3_scaled	Thick > Thin	0.852 | 0.843	No
Hdx_scaled	Thick > Thin	0.942 | 0.878	**Yes**

Observations

- Cushion Thickness has the most effect on IAV
- Max difference in Head Excursion is 2.3” (5th F), and 3.2” (3 YO)
- Thin cushion provides a more stable surface
- Thick cushion may cause submarining (5th F) or slack in CRS attachment
- A different CRS may produce different results

The End