

Reduction of Head and Neck Loads in Side Impacts



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Side Facing Aircraft Seats



Agenda

- *Side Facing Seat Special Condition*
- *Test Set Up*
 - *Side Facing Rigid Seat – Middle Position*
 - *Test ATD – ES2*
 - *Test Pulse – 16g and 21g*
 - *Restraint – 3pt Inflatable vs 3pt Core*
- *Dynamic Impact Test Result*
 - *Head and Neck Response*
 - *Test Video*
 - *Conclusions*

Side Facing Seats Special Condition

- *Side Facing Seats Must Offer “Equivalent Protection” as Forward Facing*
- *FAA Issue Paper sets Requirements for Application*
 - *No Body to Body Contact*
 - *Web Loads*
 - *Injury Criteria - (HIC plus FMVSS 214)*
 - *Research into Injury Evaluation in Process by CAMI*
 - *New Regulations Pending*

Side Facing Seating Positions

ES-2 Instrumentation

Location	Description	Channels
Head	Triax accelerometer pack	Ax,Ay,Az
Neck	6-axis upper load cell 6- axis lower load cell	Fx,Fy,Fz,Mx,My Fx,Fy,Fz,Mx,My,
Shoulder	Three axis load cell Triax accelerometer pack	Fx,Fy,Fz Ax,Ay,Az
Thorax	3 Rib displacements 3 Rib accelerations 4-axis torso back plate load cell T1 Triax accelerometer pack	Dy Ay Fx,Fy,My,Mz Ax,Ay,Az
Abdomen	Four axis T12 load cell 3 Abdomen load cells	Fx,Fy,Mx,My Fy
Pelvis	3-axis lower lumbar spine load cell Pubic symphysis load cell T12 Triax accelerometer pack	Fy,Fz,Mx Fy Ax,Ay,Az
Legs	Triax accelerometer pack Six axis femur load cell	Ax,Ay,Az Fx,Fy,Fz,Mx,My,Mz



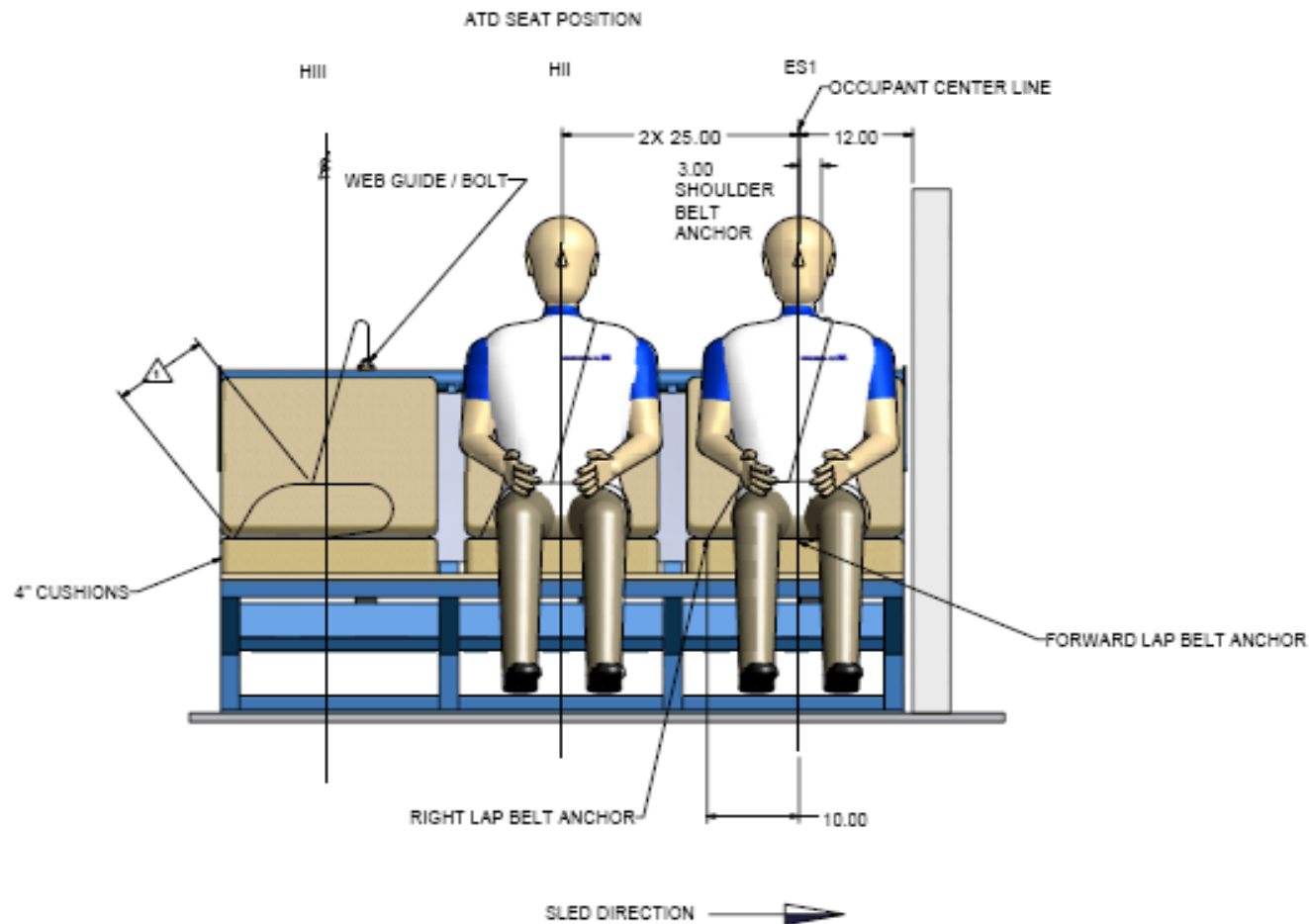
Current Side Facing Seats

Injury Criteria, FAA Special Conditions	
Criteria (50%M Hybrid III SID)	Limit
Head Injury Criteria (HIC)	HIC < 1000
Thoracic Trauma Index (TTI)	TTI < 85 g's
Pelvic lateral acceleration	peak < 130 g's
Webbing loads	Force peak < 1750 lbs
Body to body contact	No Injury (subjective)
Neck Injury	mentioned (not defined)

Anticipated Injury Criteria – SFS FAA

Criteria (50%M ES2)	Limits
HIC36	<1000
Rib Deflection, (mm)	35-44
Lower Spine Resultant (T12), (g)	82
Abdominal Force, Sum Fy (N)	2,400-2,800
Pubic Symphysis, (N)	6,000
Neck Injury, Nij Lateral	Coefficients TBD
Body-to-body contact (between the head, pelvis, or shoulder area of adjacent ATD)	Unacceptable
Shoulder Loads	< 7784 N
Occupant Retention (restrain ATD)	Within end of seat.

Test Setup



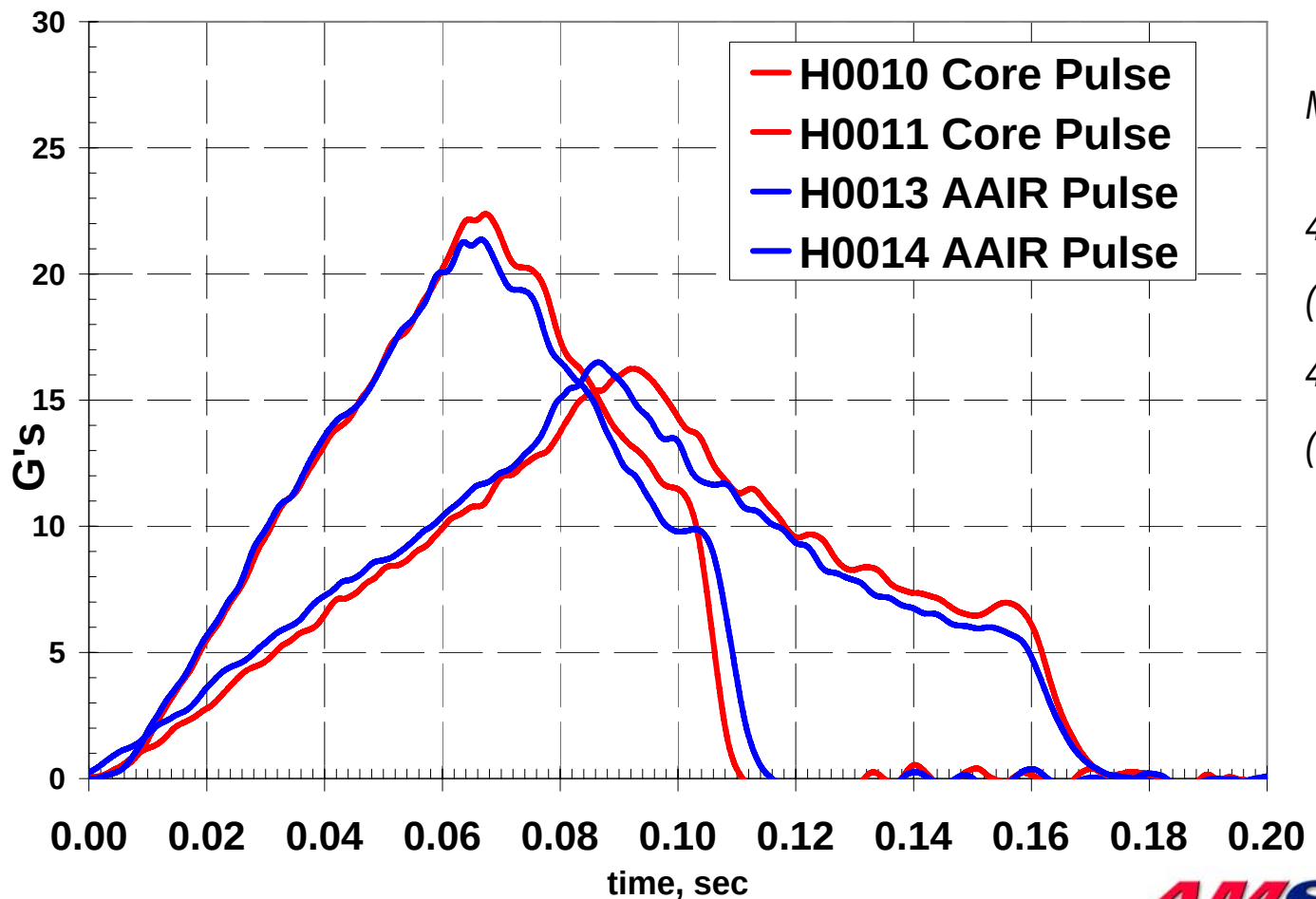
Test Matrix

Test Pulse	Restraint Type	ATD	Seat Position	Test No.
16g	3pt. Core	ES2	Middle	H0010
21g	3pt. Core	ES2	Middle	H0011
16g	3pt. AAIR	ES2	Middle	H0014
21g	3pt. AAIR	ES2	Middle	H0013

Images of 16 g Impact Test



Impact Conditions



Min Delta
Velocity:

42 ft/sec

(12.8 m/sec)

44 ft/sec

(13.4 m/sec)

Head and Neck Response

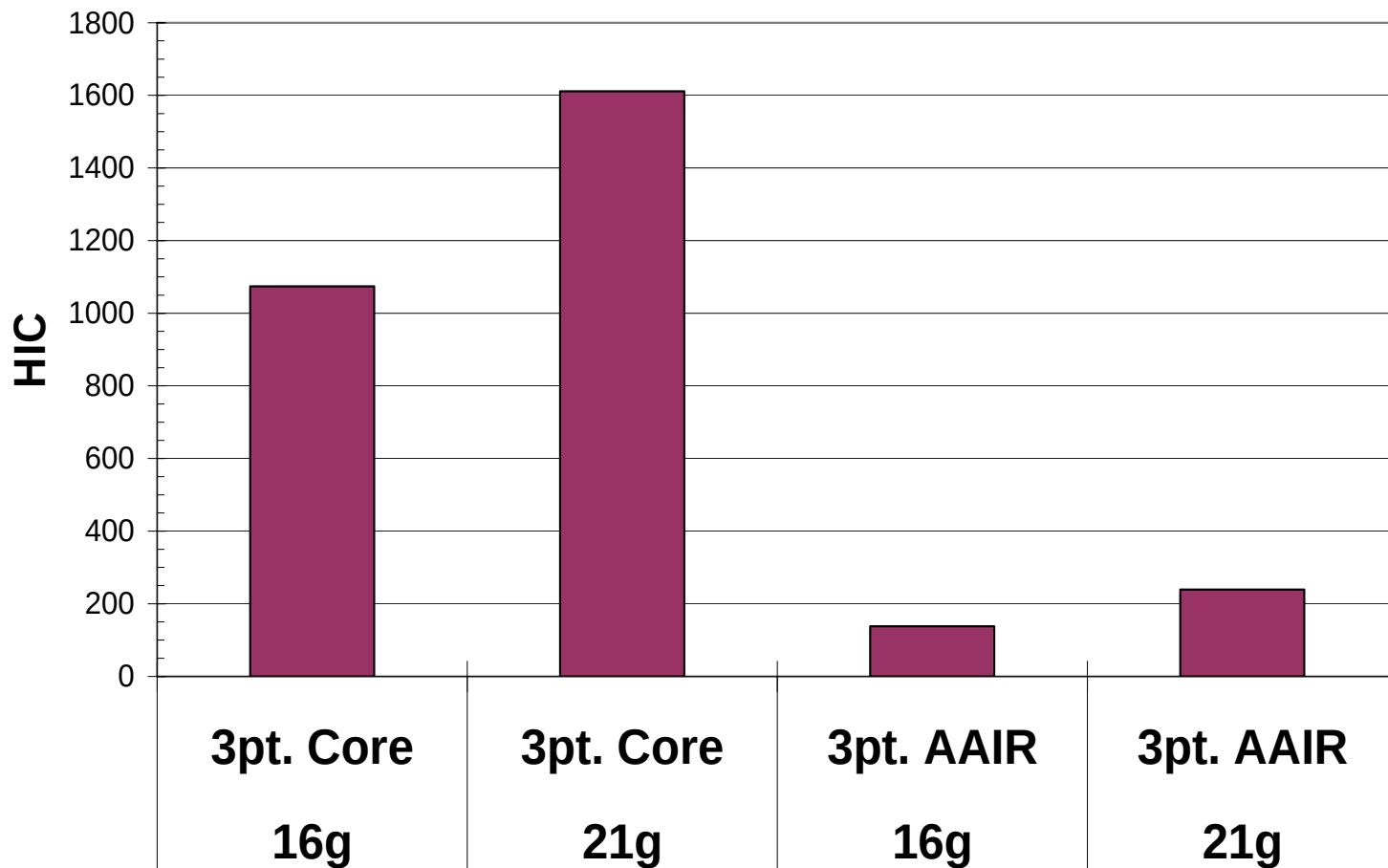
Side Facing Seat Test Environment

Test Pulse (g)	16.2	22.4	16.5	21.4
delta V (ft/sec)	45.0	42.5	44.8	42.3
Restraint Type	3pt. Core	3pt. Core	3pt. AAIR	3pt. AAIR

ES2 ATD Response

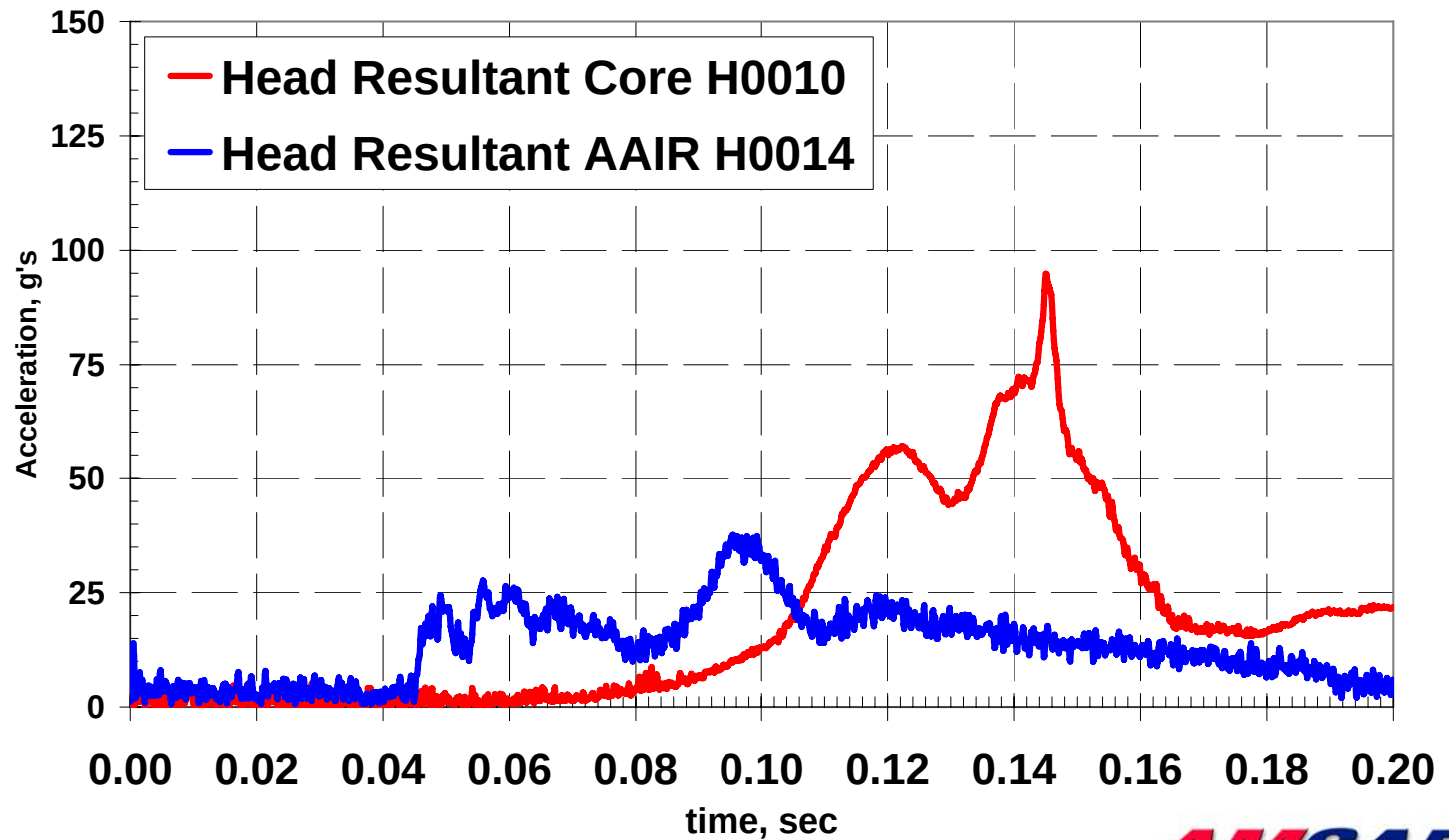
HIC	1074	1611	138	239
Nij lateral	1.23	1.19	0.58	0.7
Nij fore/aft	0.47	0.56	0.55	0.56

Head ES2 Response



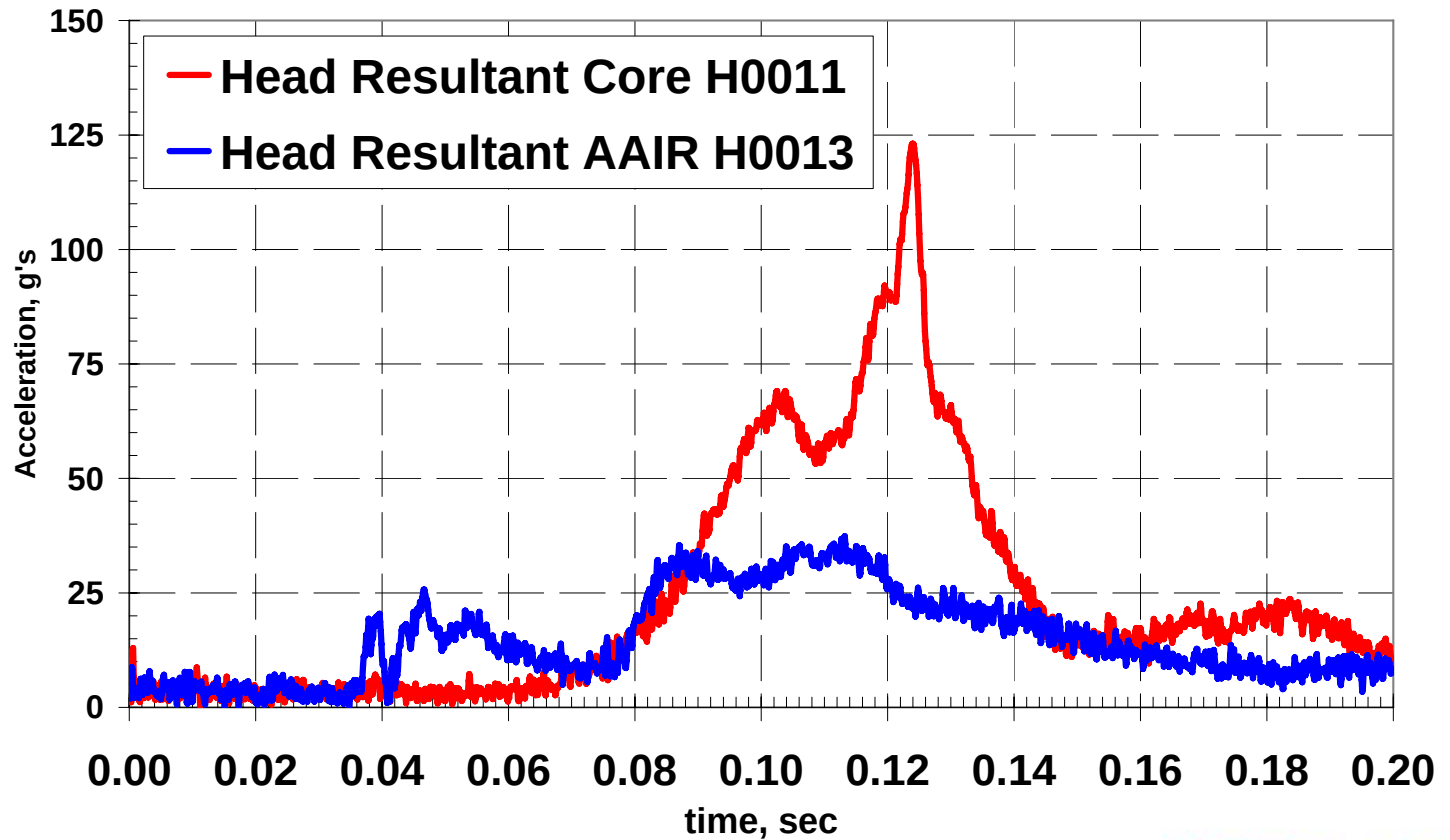
Head ES2 Response

Side Facing Divan 16g



Head ES2 Response

Side Facing Divan 21g



Neck Injury Criteria

Fore/aft N_{ij}

$$N_{ij} = \frac{\text{tension (Fz)}}{\text{critical tension (Fzc)}} + \frac{\text{flexion moment (My)}}{\text{critical flexion moment (Myc)}}$$

Lateral N_{ij}

$$N_{ij} = \frac{\text{tension (Fz)}}{\text{critical tension (Fzc)}} + \frac{\text{lateral moment (Mx)}}{\text{critical flexion moment (Mxc)}}$$

Neck Injury Criteria

Nij Coefficients

Forward (FMVS 208)

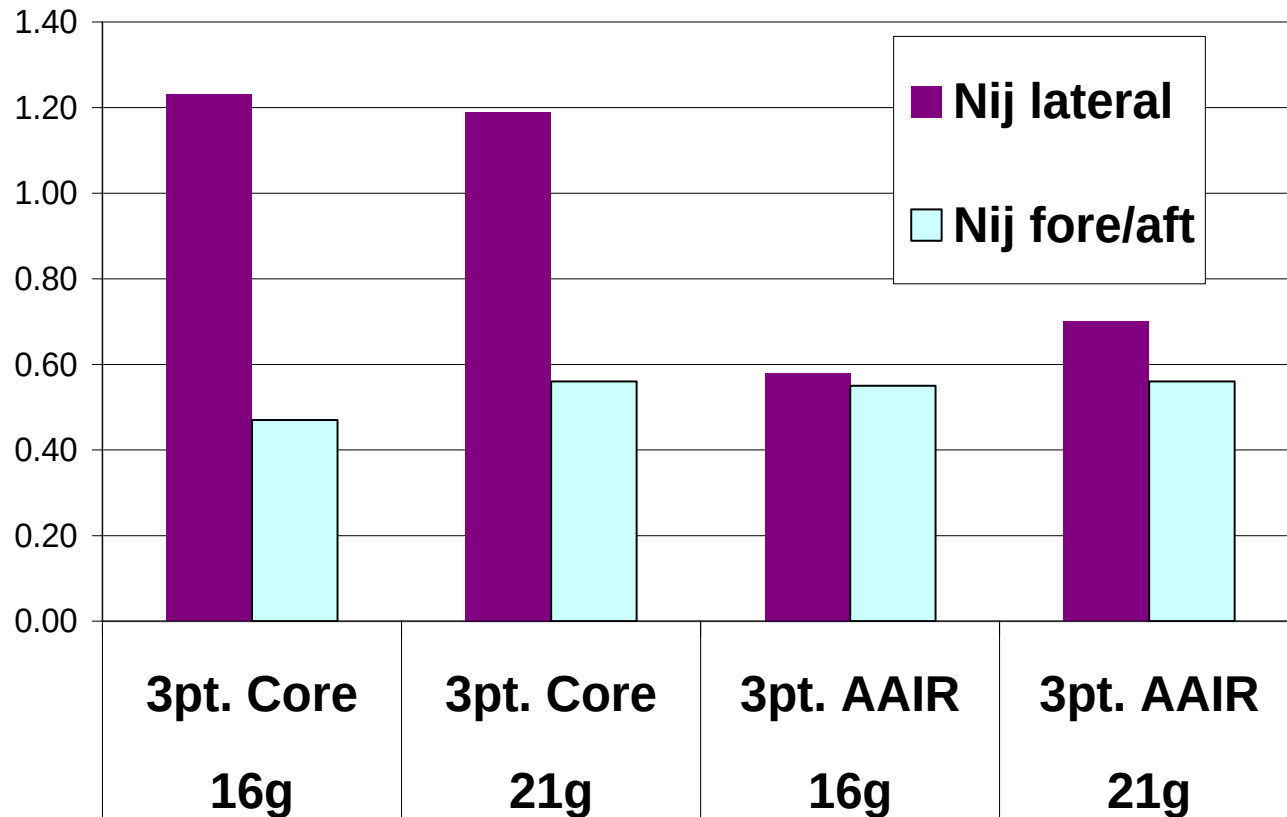
Myc (flexion)	2748	in-lb.
Myc (extension)	1200	in-lb.
Fzc (tension)	1530	lb.
Fzc (compression)	1385	lb.

Lateral (FAA Proposed)

Mxc (left)	530	in-lb.
Mxc (right)	530	in-lb.
Fzc (tension)	1530	lb.
Fzc (compression)	1385	lb.

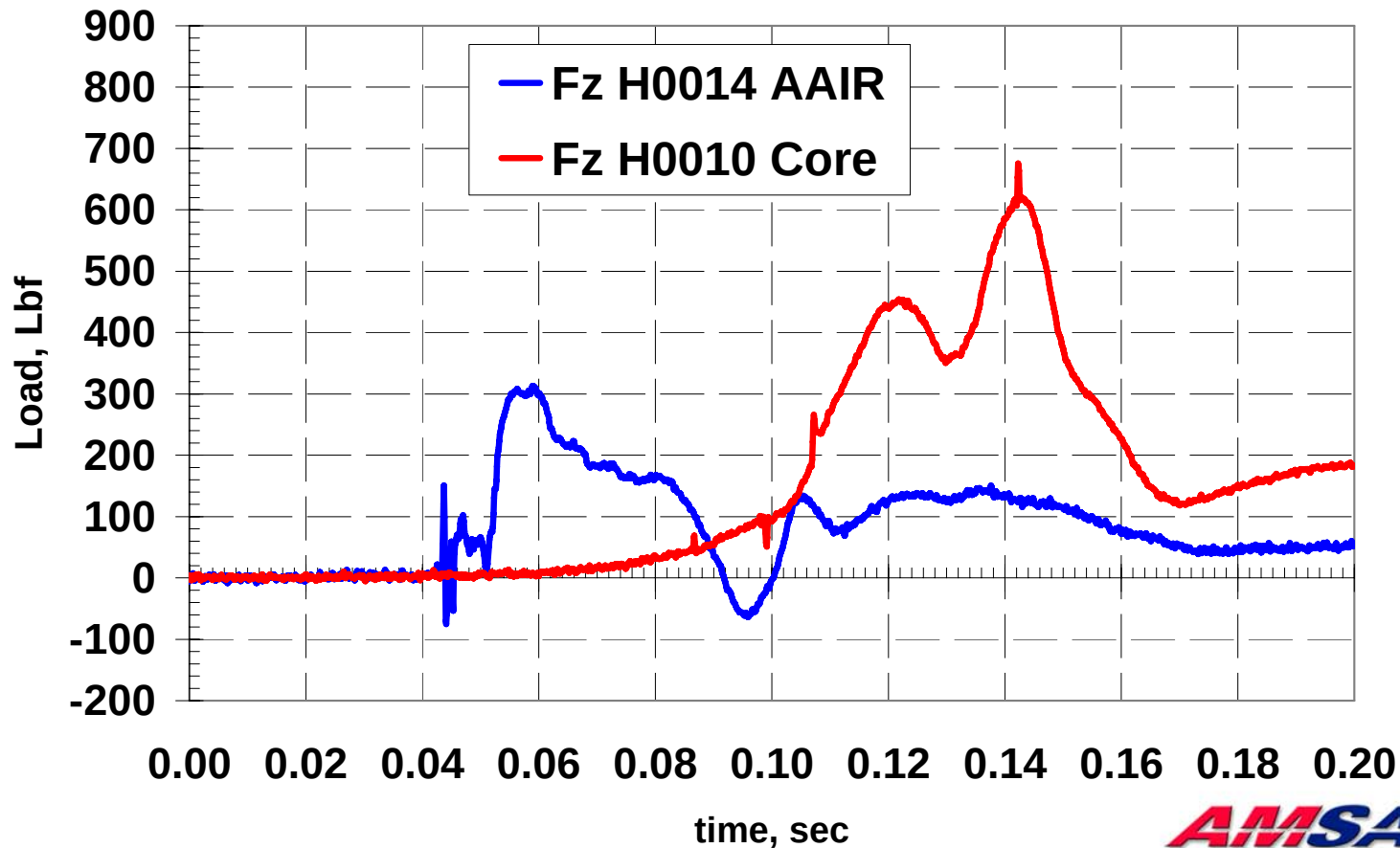
Upper Neck ES2 Response

Side Facing Divan



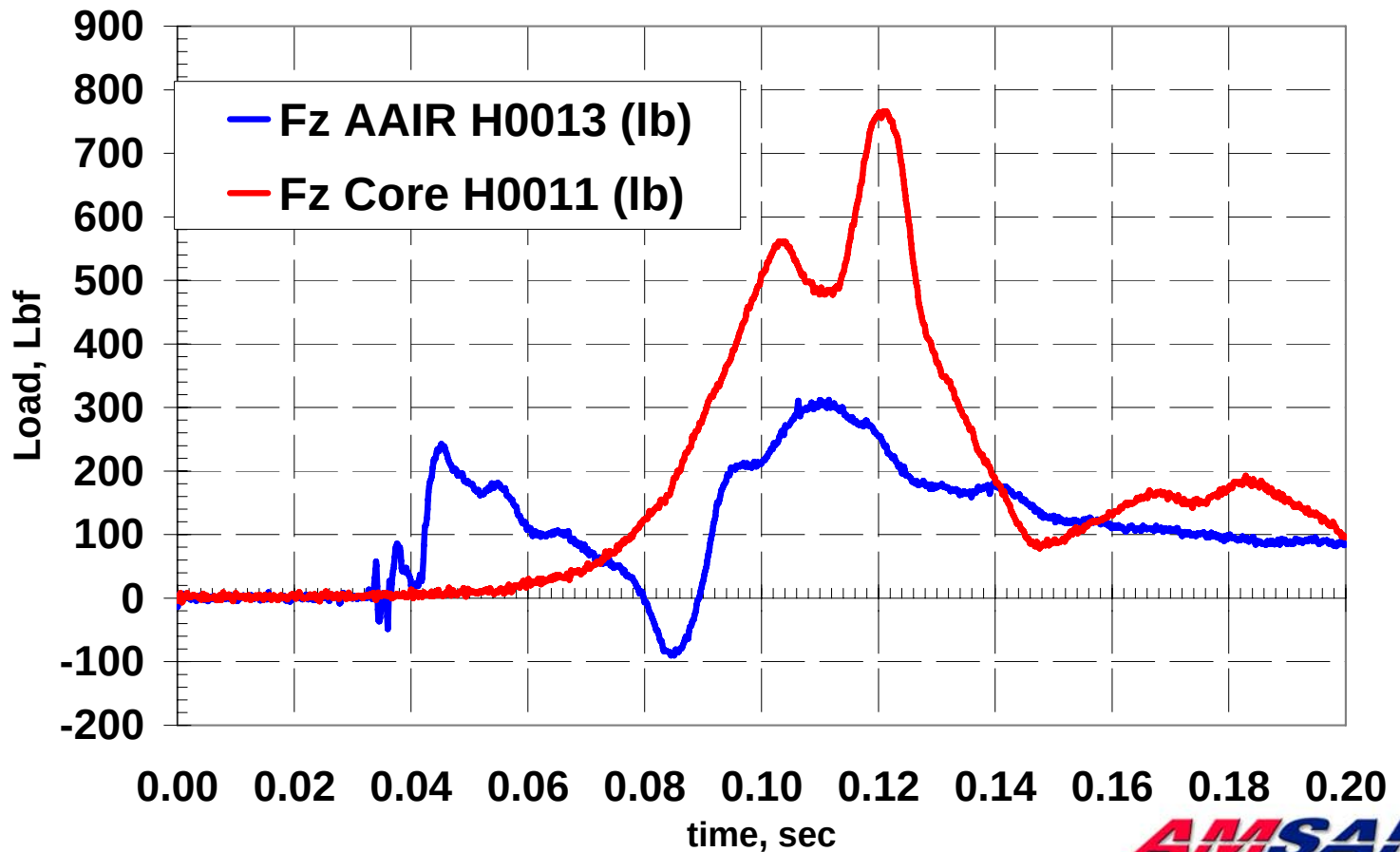
Neck Response – ES2 ATD

Side Facing Divan 16g



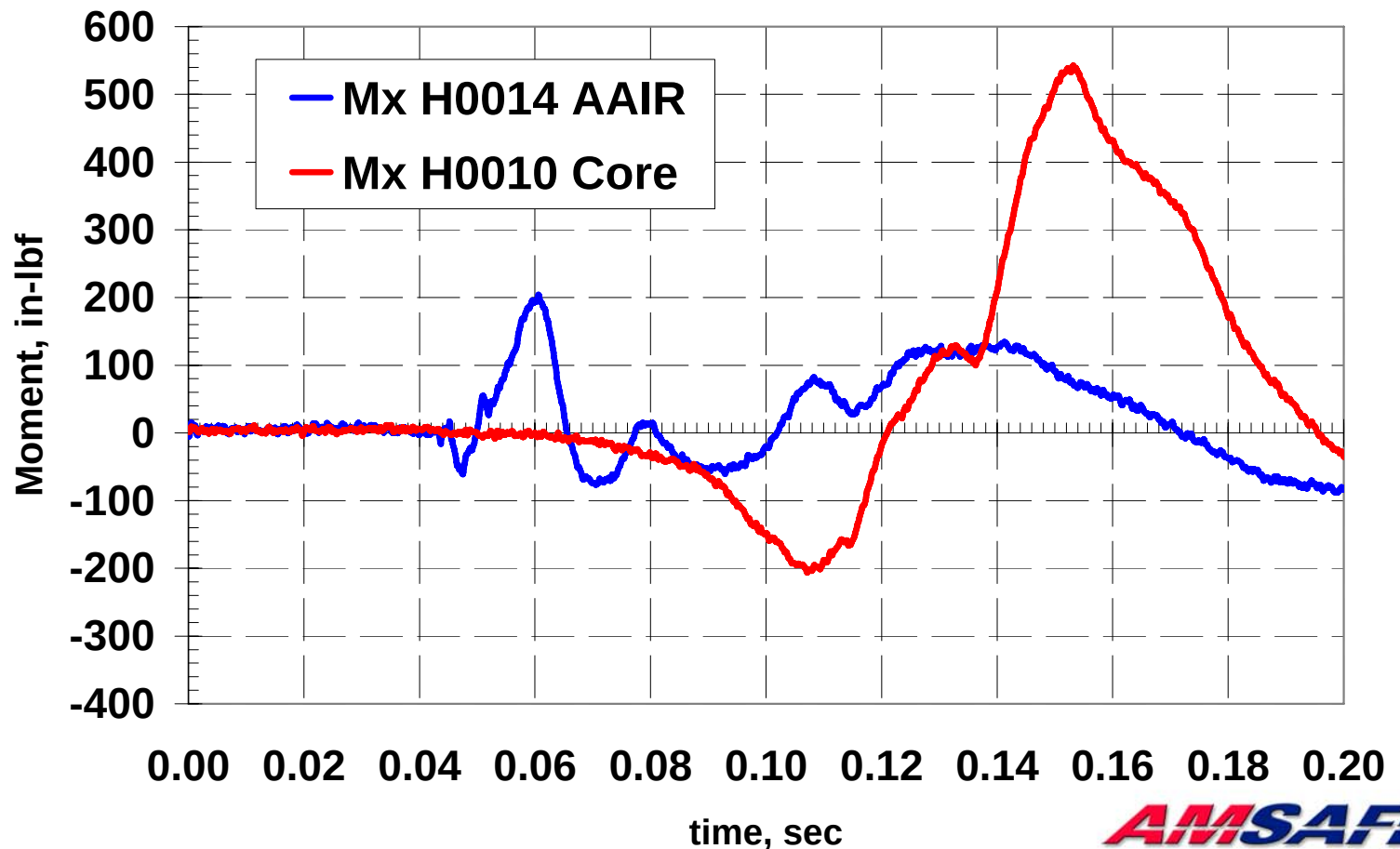
Neck Response – ES2 ATD

Side Facing Divan 21g



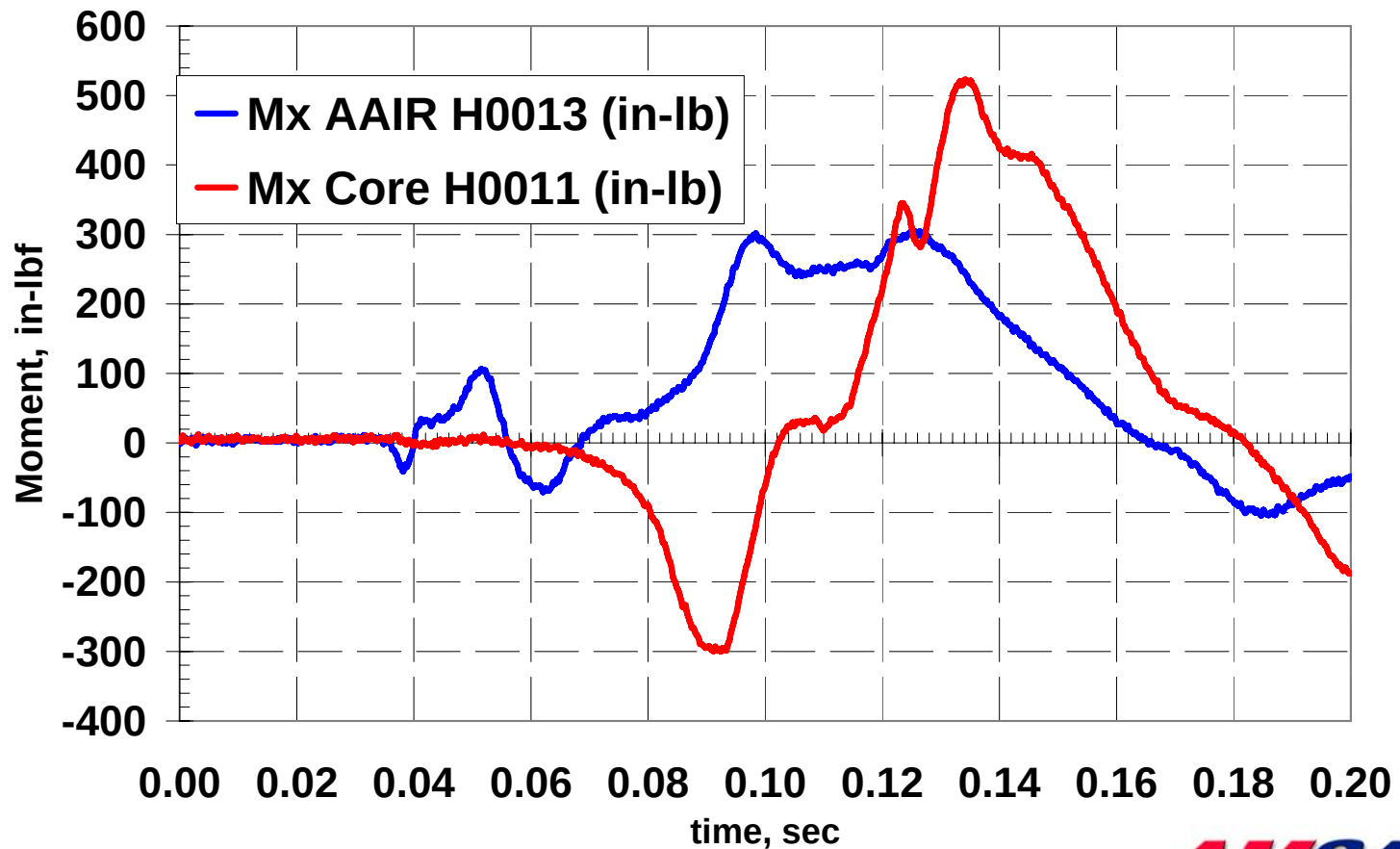
Neck Response – ES2 ATD

Side Facing Divan 16g



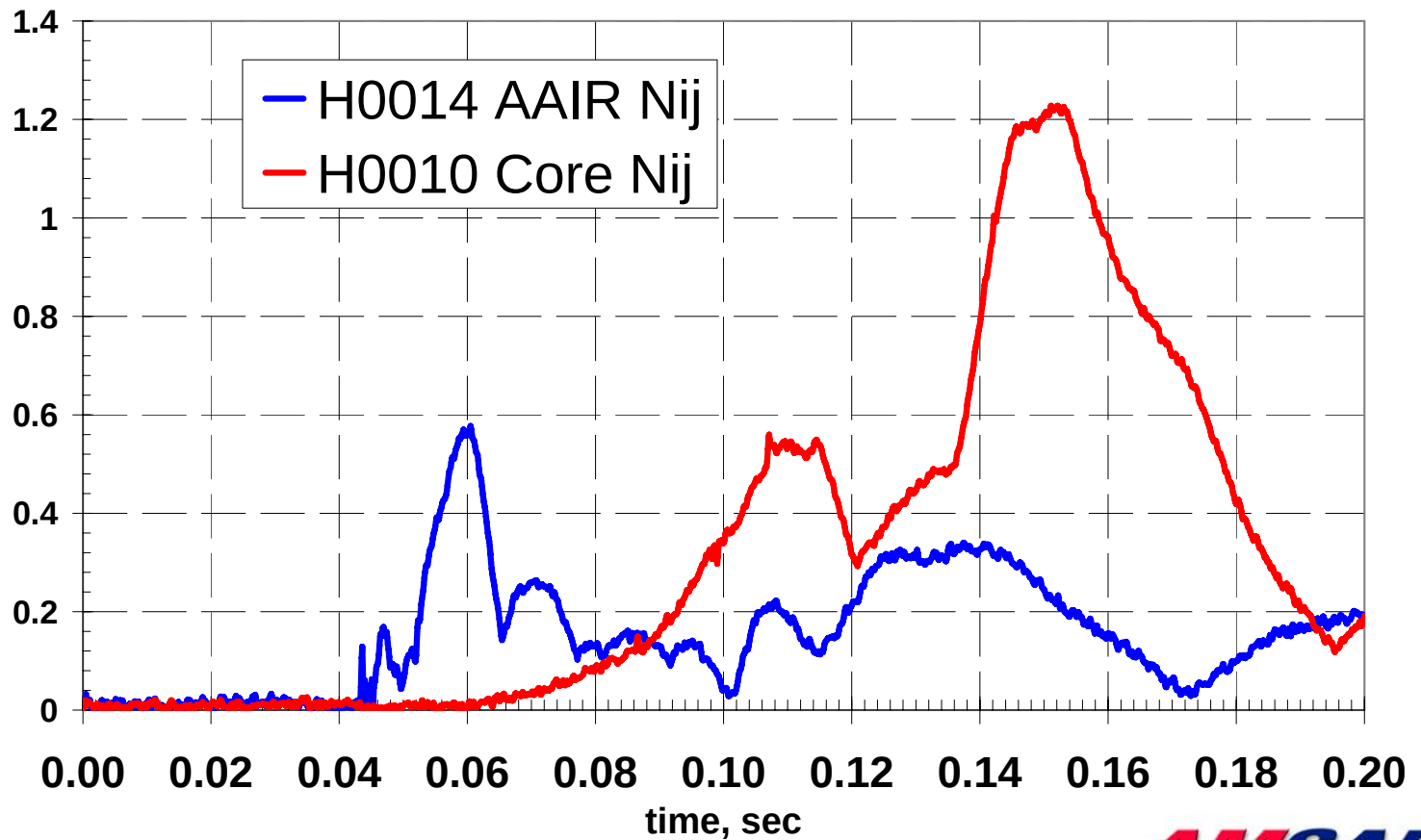
Neck Response – ES2 ATD

Side Facing Divan 21g



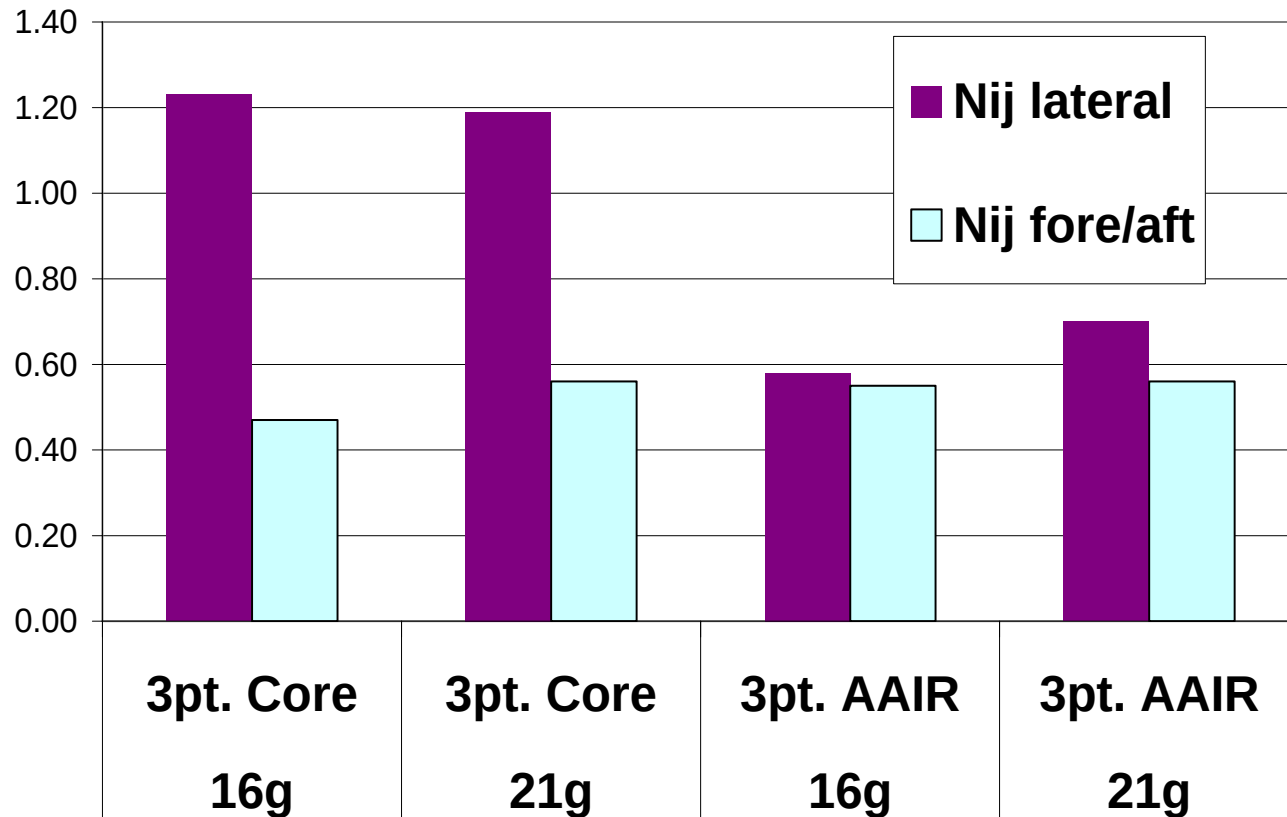
Neck Injury Potential

Side Facing Divan 16g Test



Upper Neck ES2 Response

Side Facing Divan



16 g Impact Test



21 g Impact Test



Conclusions

- *Standard 3pnt Restraint Demonstrated a high risk potential for head and neck injury*
- *Airbag 3pnt Restraint Demonstrated ability to mitigate both head and neck injury*
- *Side Facing configurations can pass the current and proposed regulatory injury criteria using AAIR*
- *AAIR demonstrated a step change in reducing head and neck loading*