Reduction of Head and Neck Loads in Side Impacts

FifthTriennial Fire and Cabin Safety Conference

October 30, 2007

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Side Facing Aircraft Seats

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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*

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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*

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Side Facing Seating Positions

ES-2 Instrumentation

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

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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)

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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 Symphisis, (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.

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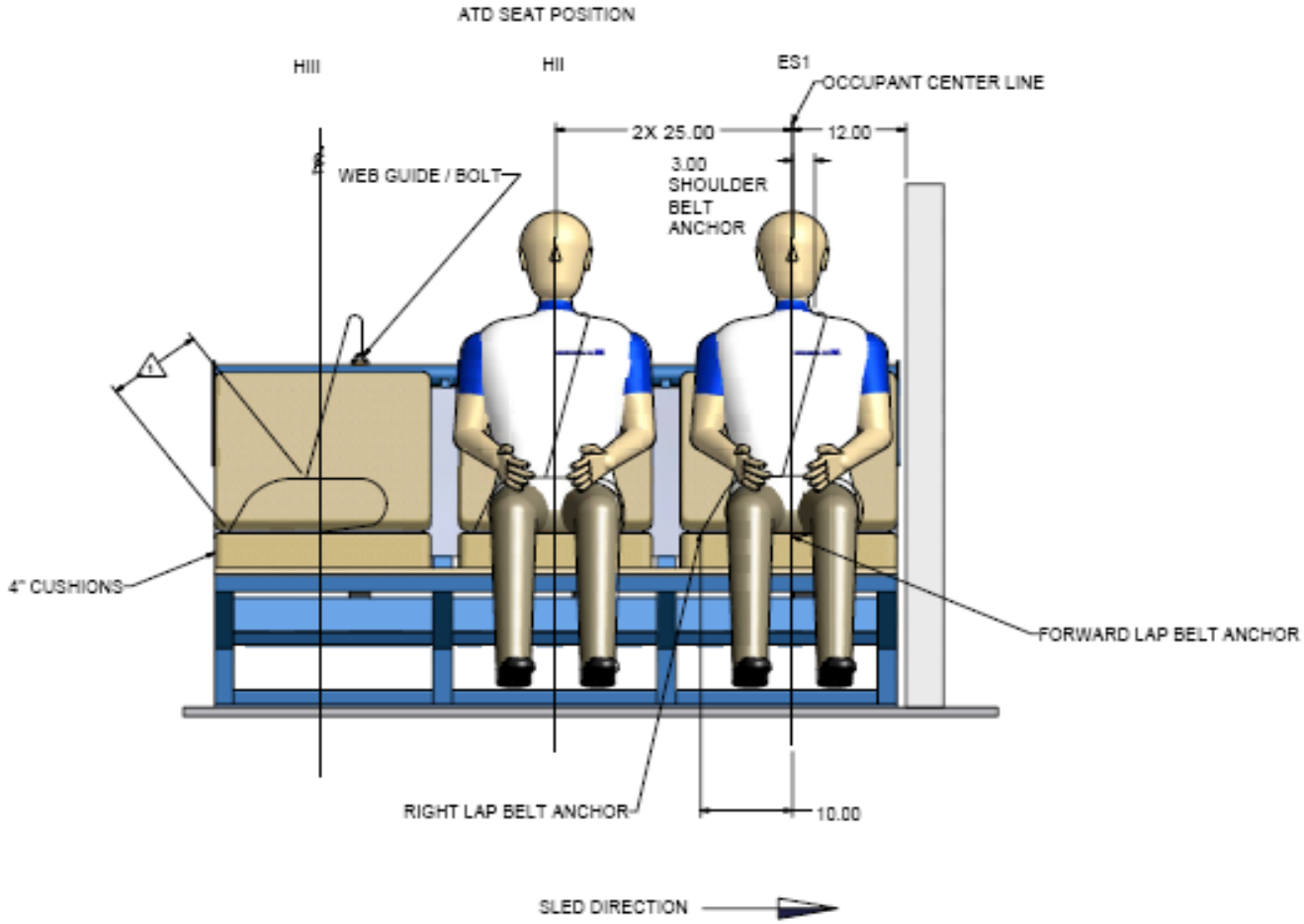
Test Setup



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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

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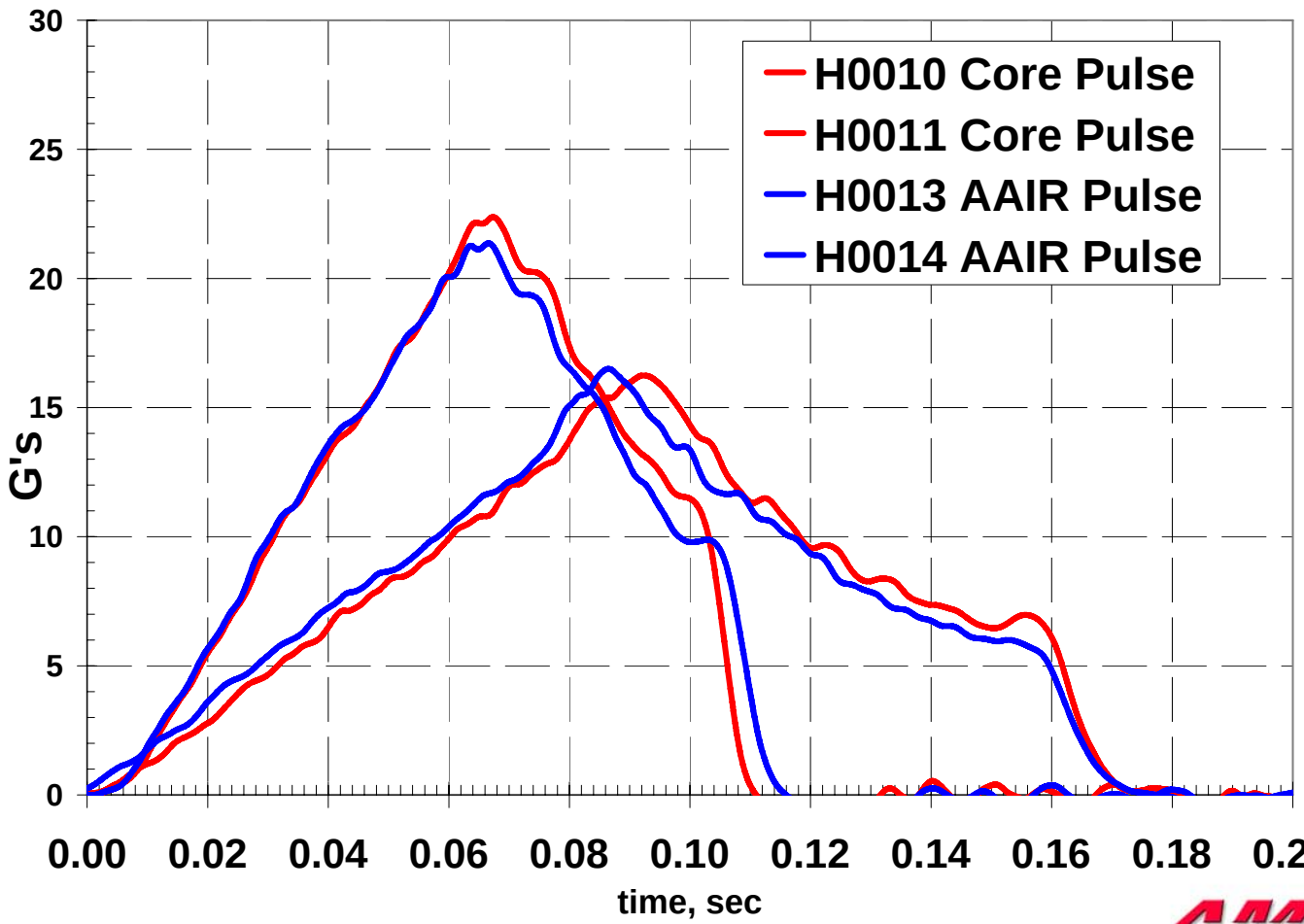
Images of 16 g Impact Test

Impact Conditions



Min Delta Velocity:

42 ft/sec

(12.8 m/sec)

44 ft/sec

(13.4 m/sec)

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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

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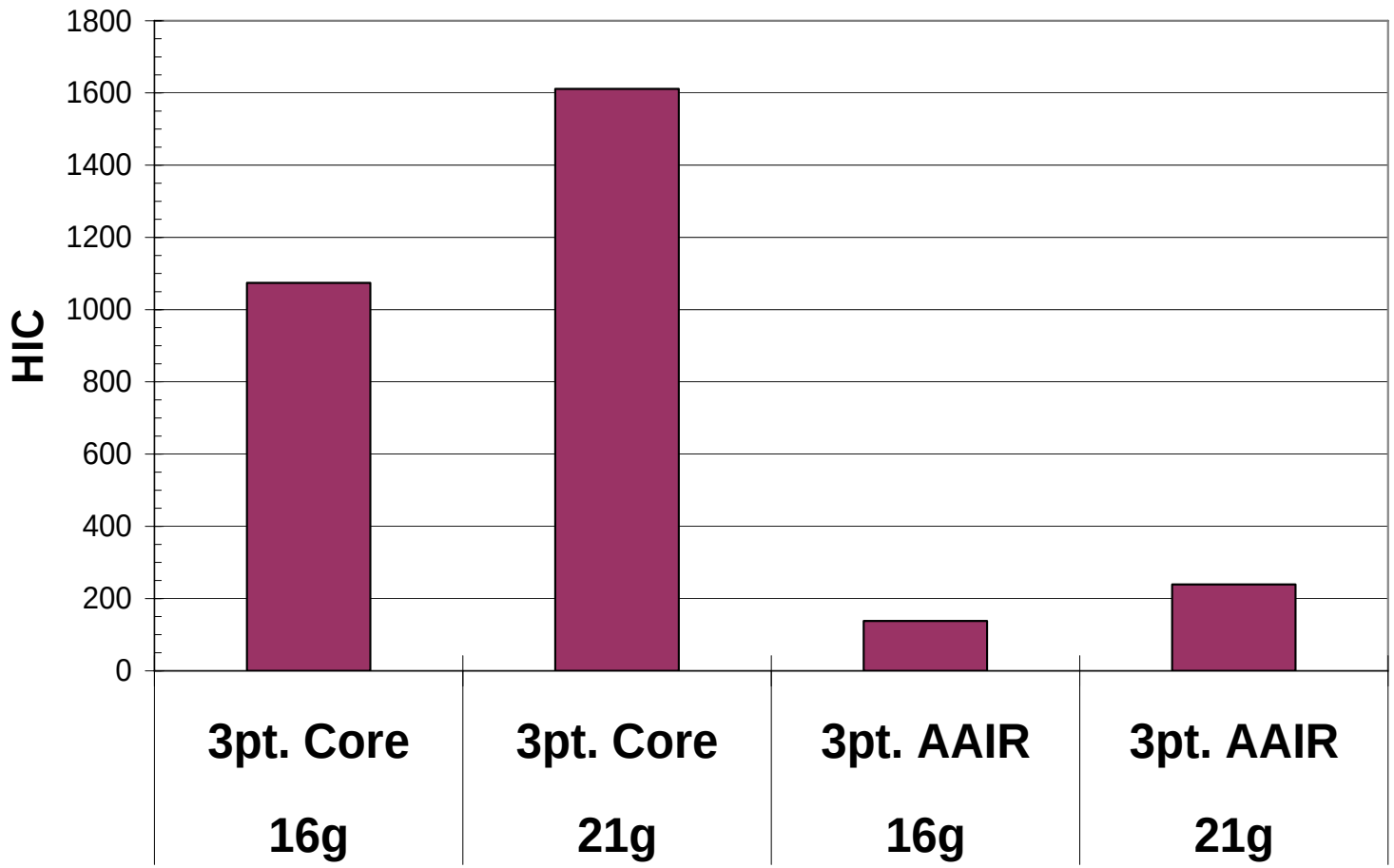
Head ES2 Response



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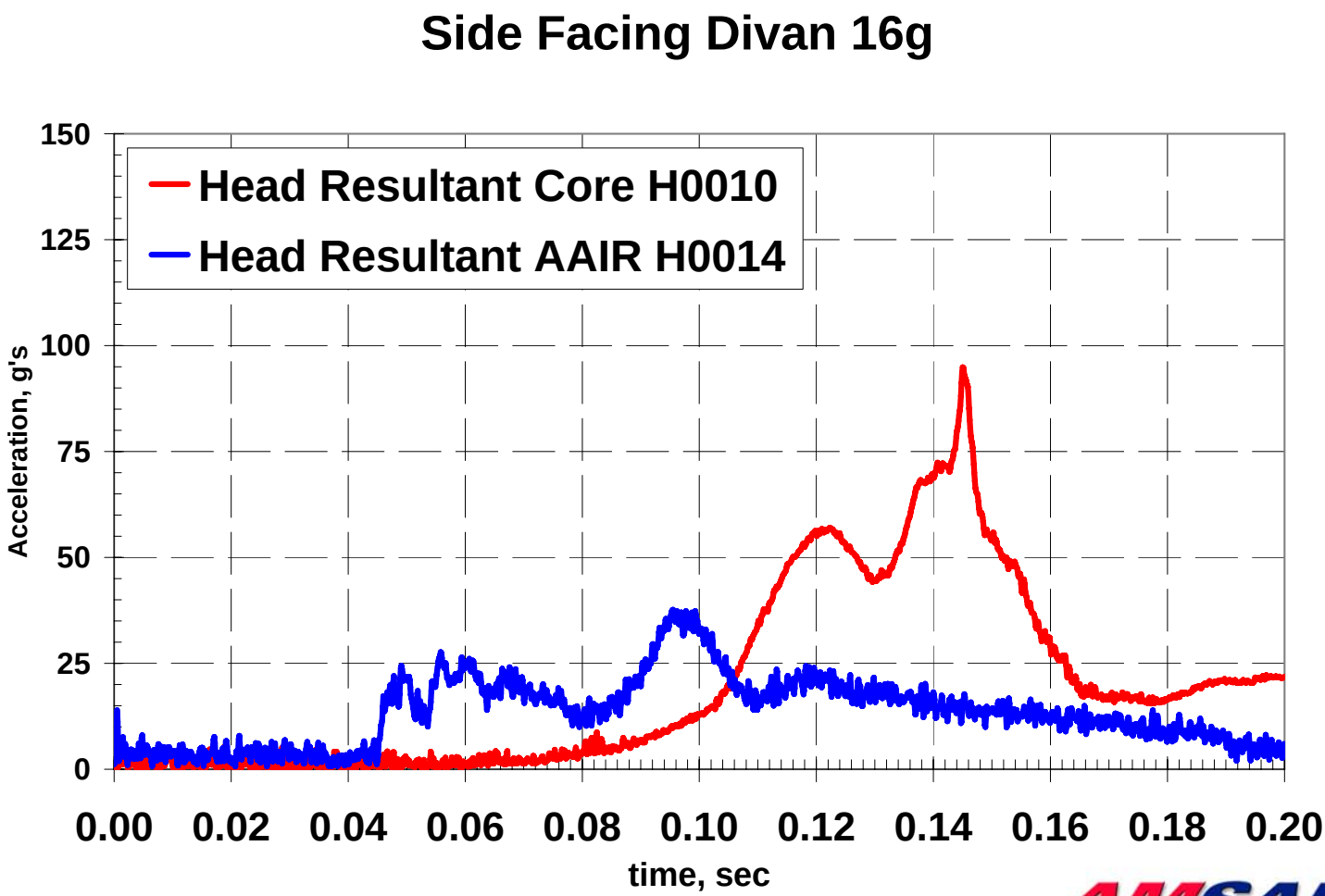
Head ES2 Response



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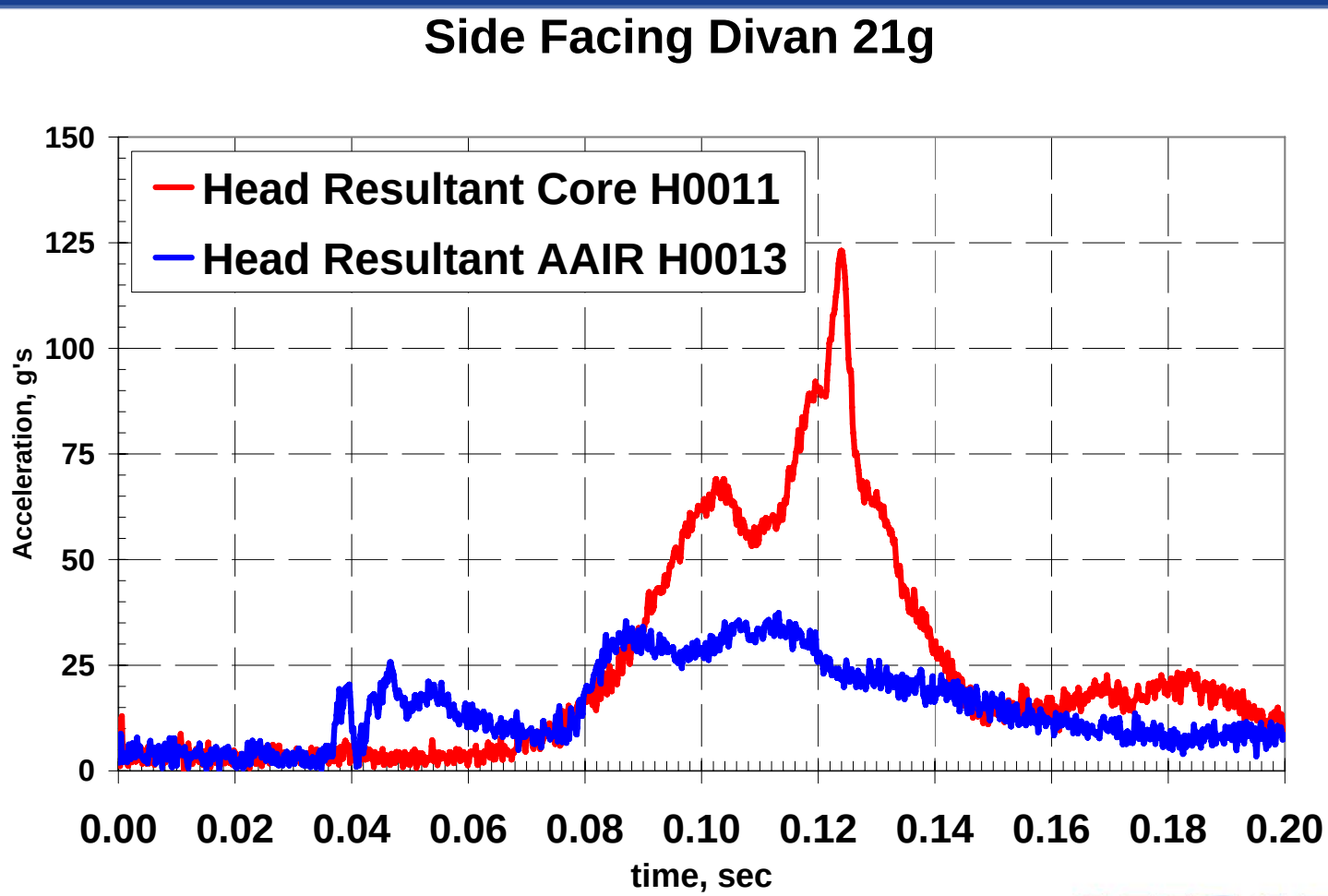
Head ES2 Response



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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}

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

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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.

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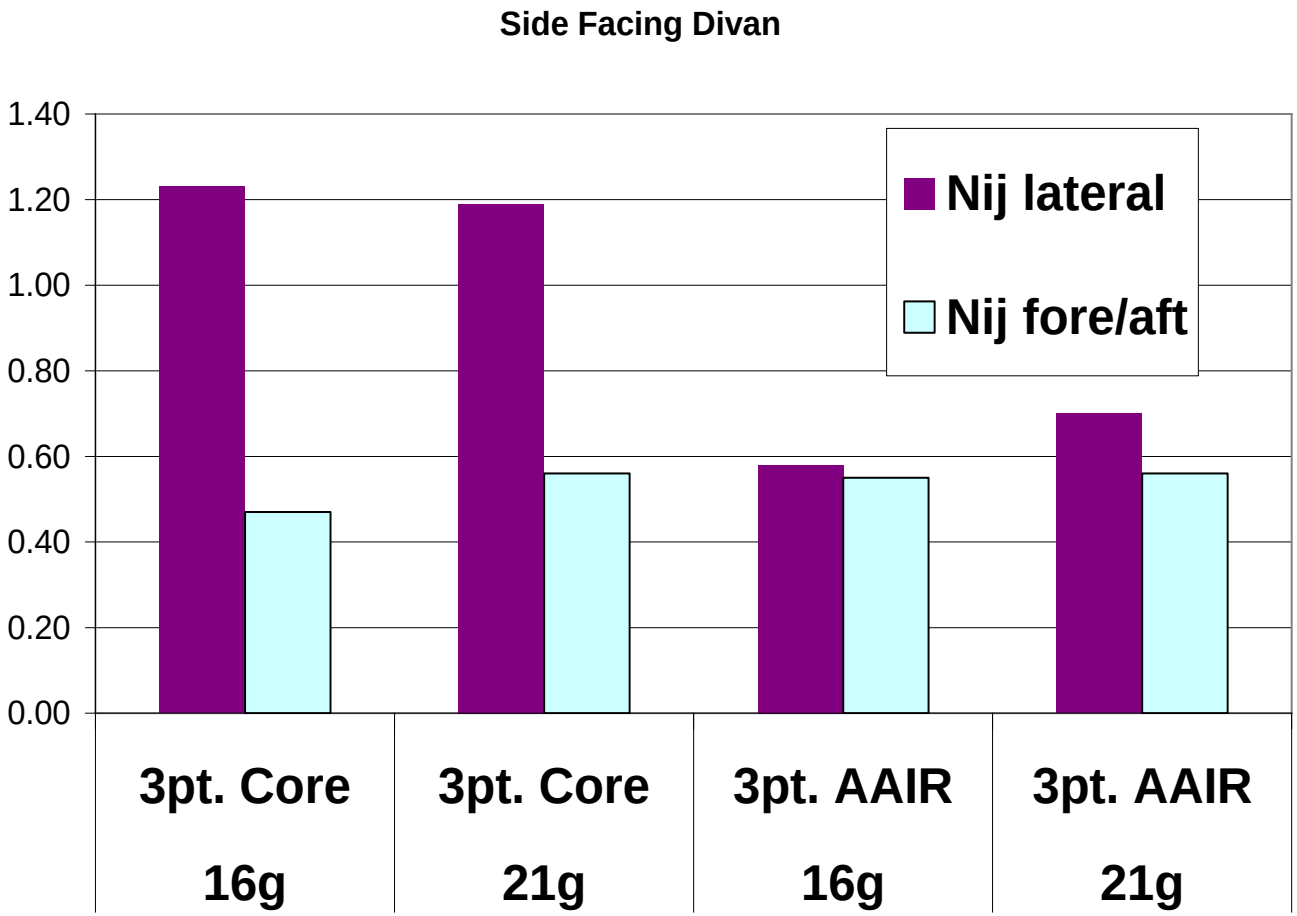
Upper Neck ES2 Response



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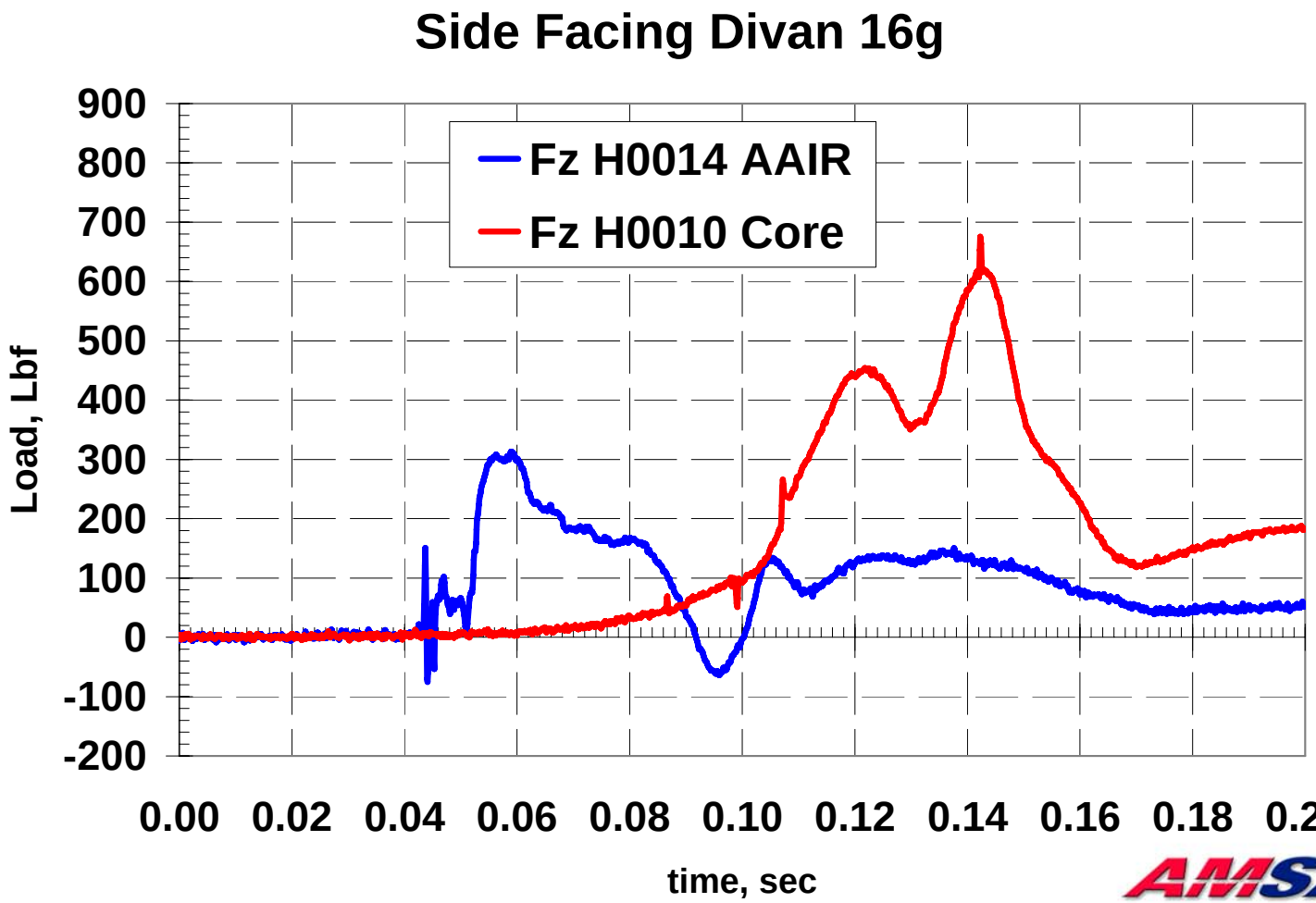
Neck Response – ES2 ATD



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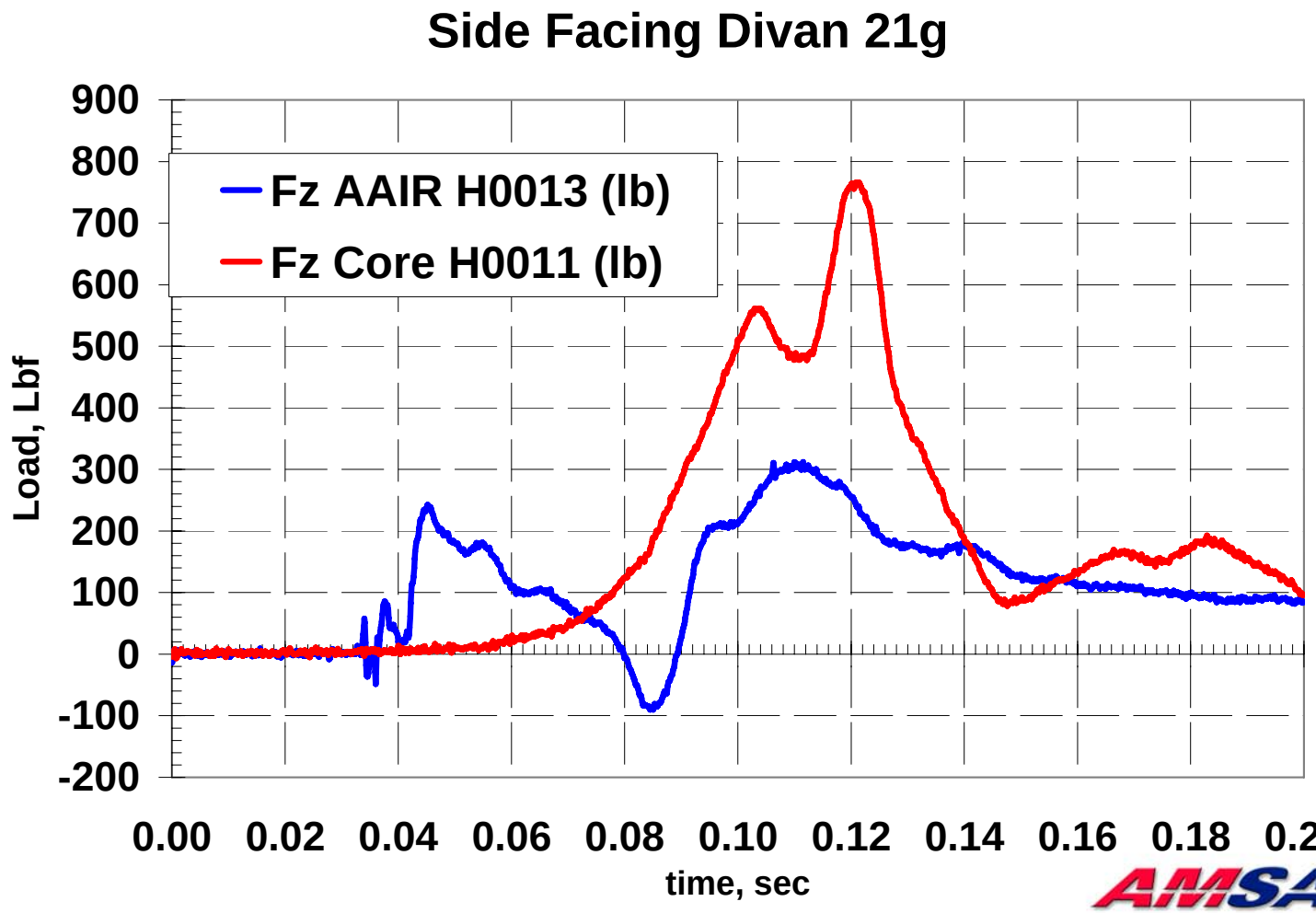
Neck Response – ES2 ATD



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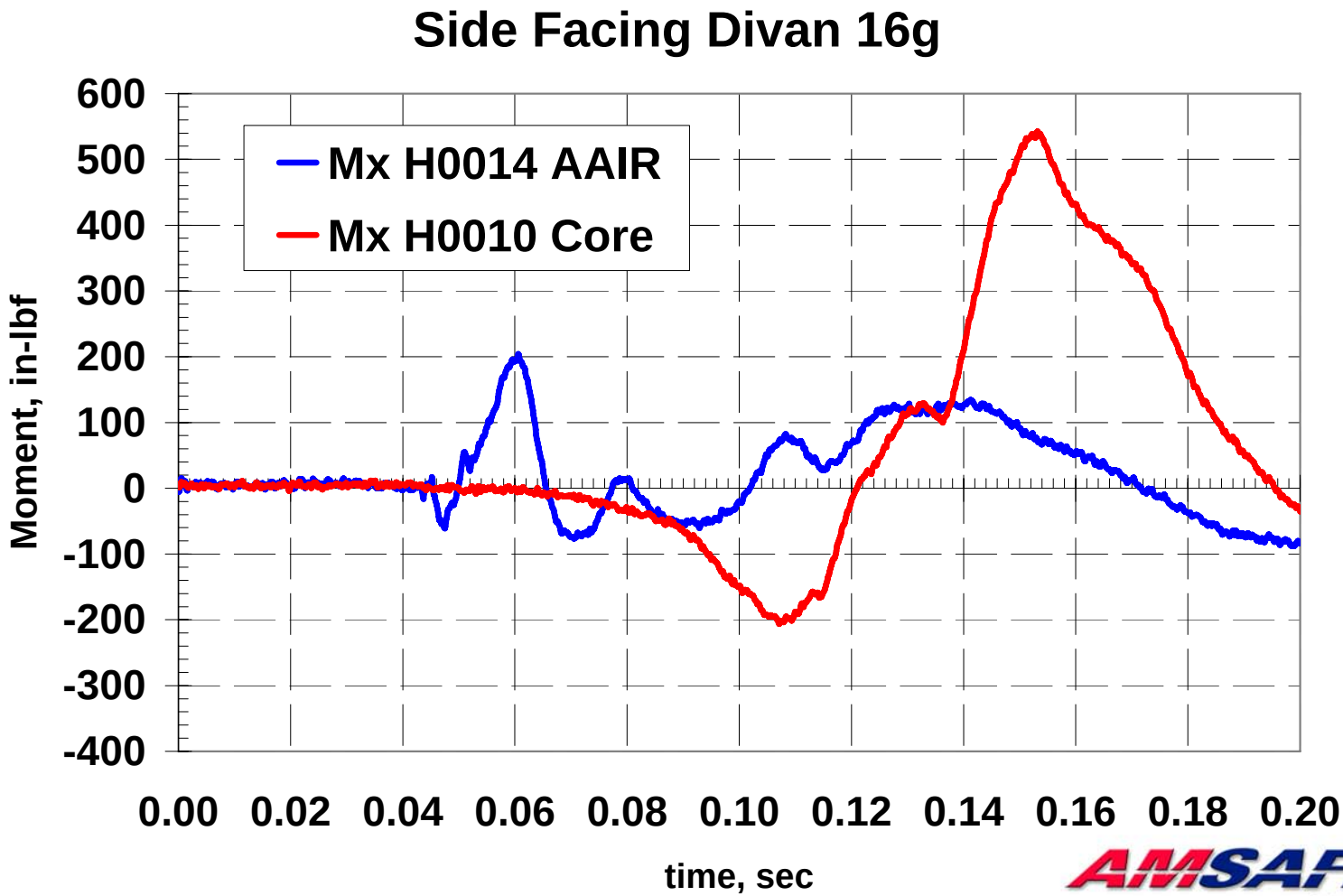
Neck Response – ES2 ATD



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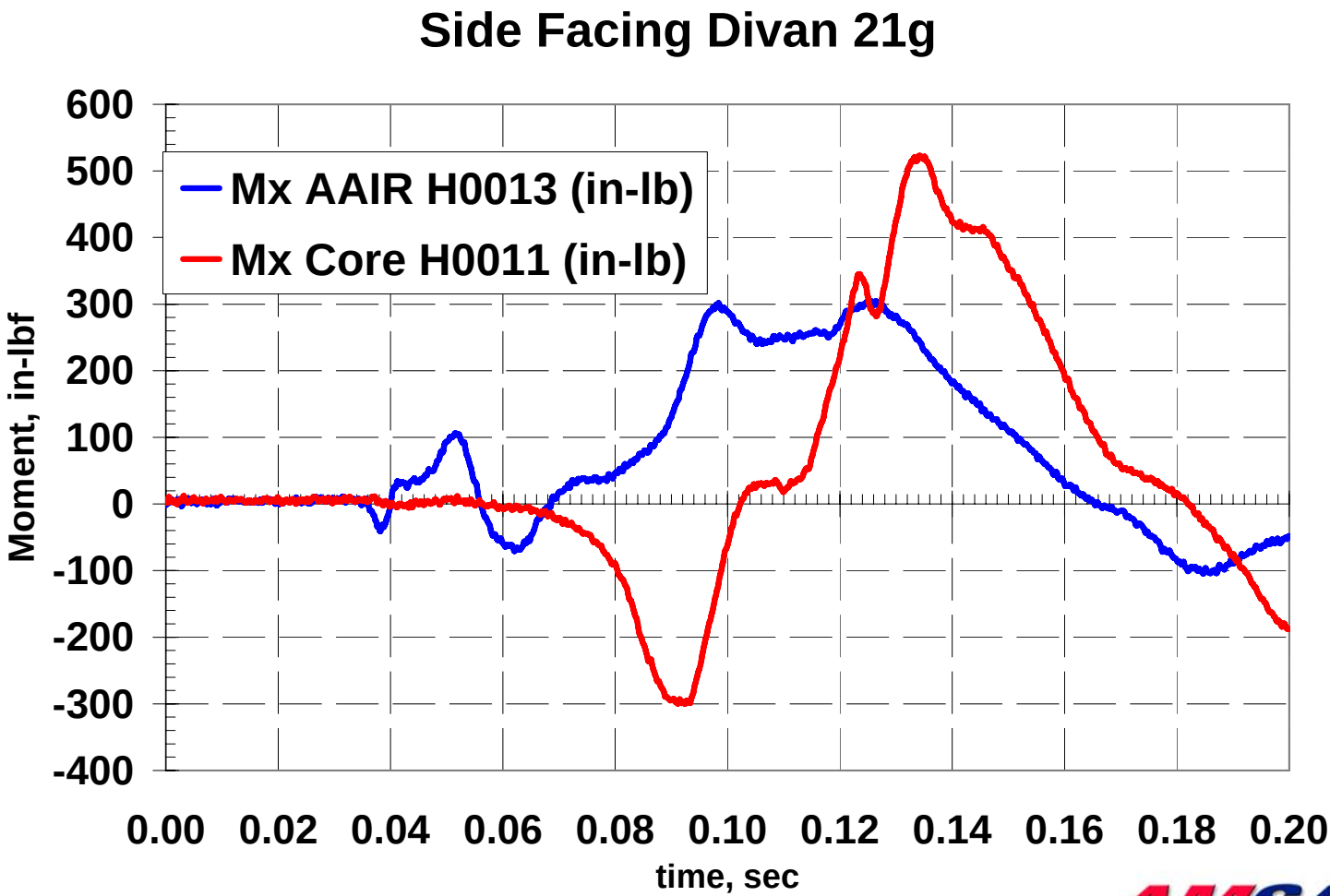
Neck Response – ES2 ATD



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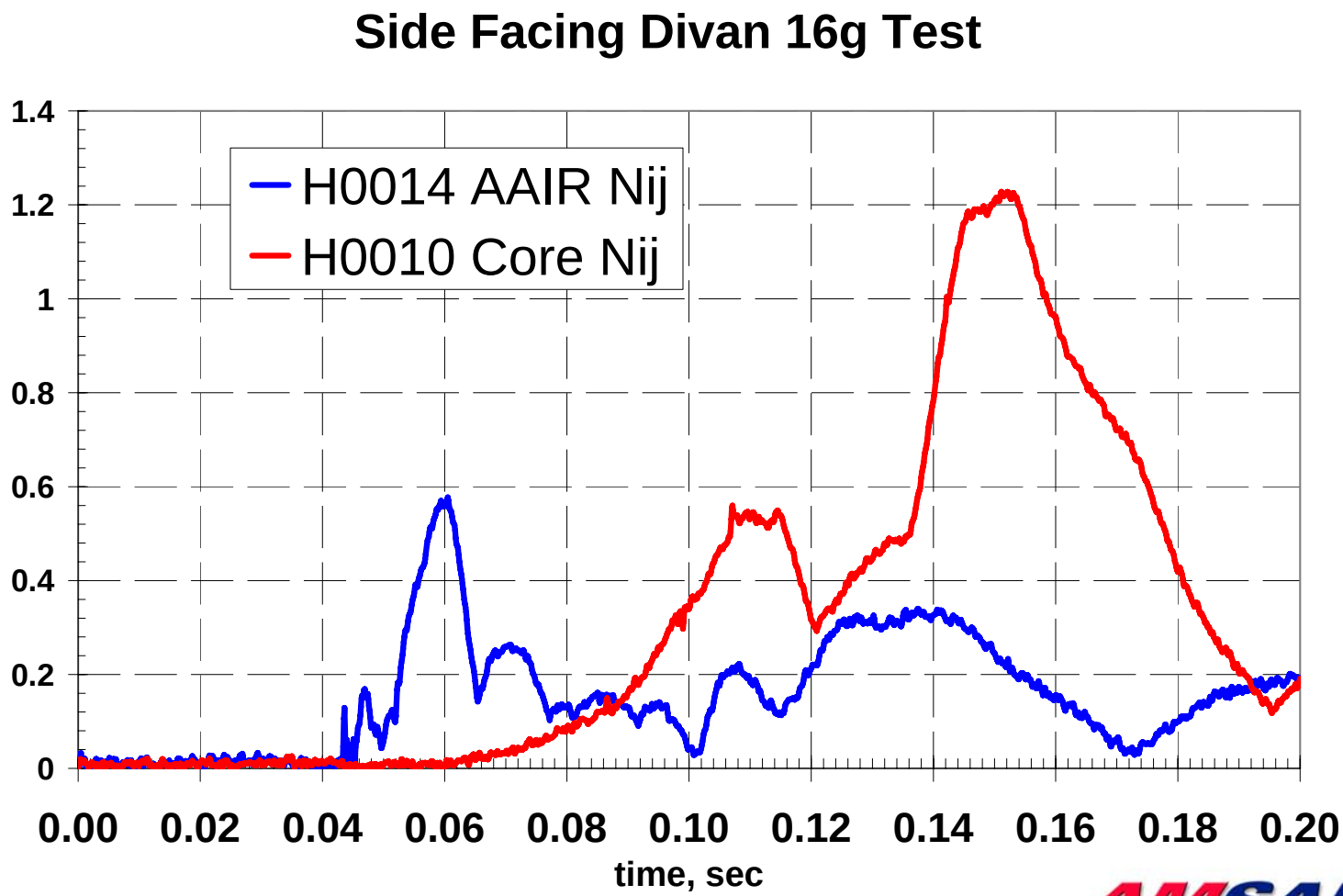
Neck Injury Potential



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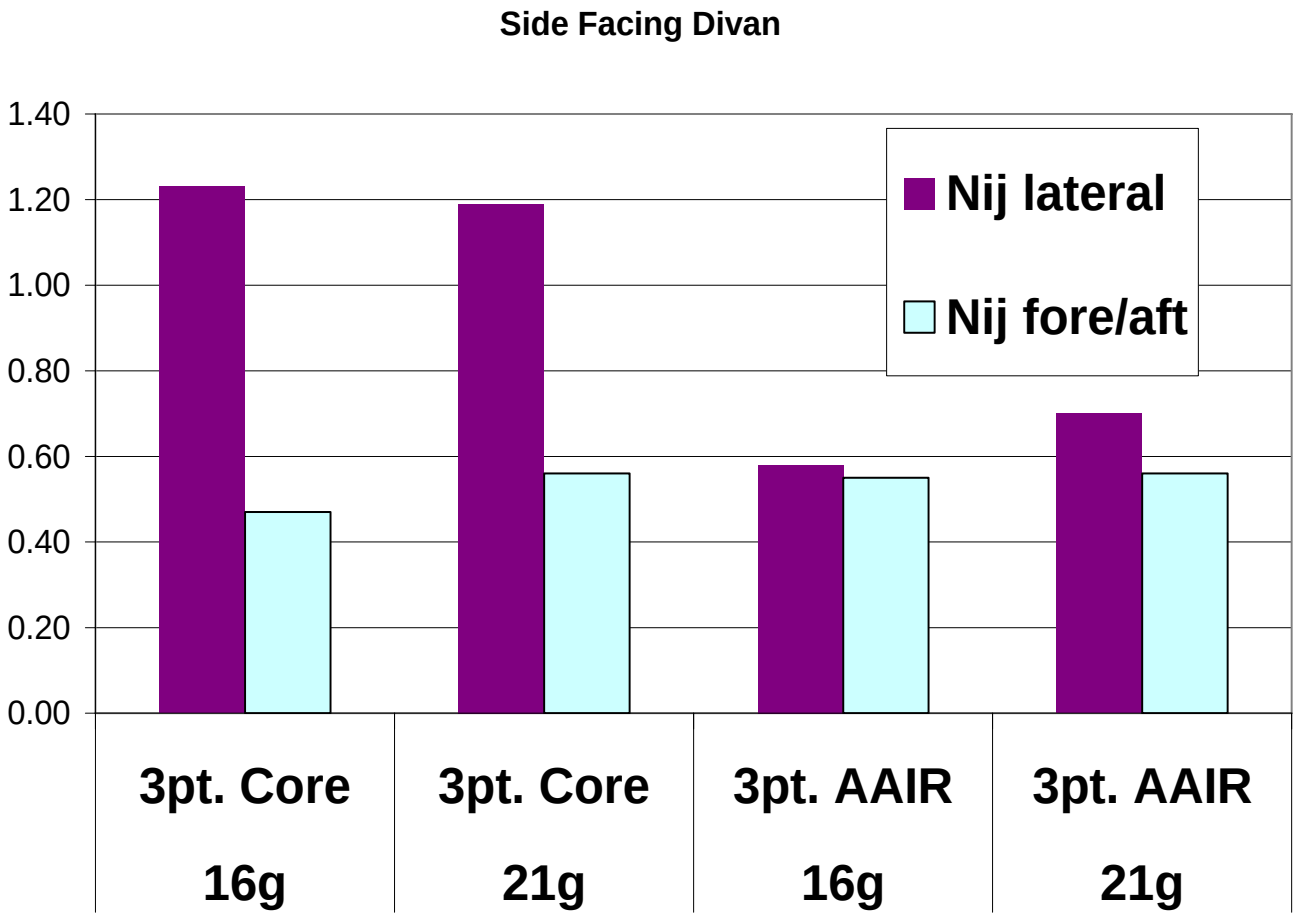
Upper Neck ES2 Response



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16 g Impact Test

Videos Deleted

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21 g Impact Test

Videos Deleted

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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*

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