REPORT NUMBER: TWG-CAL06-03

NEW CAR ASSESSMENT PROGRAM (NCAP)
SIDE AIRBAG OUT-OF-POSITION INJURY TESTING

2006 HYUNDAI SONATA
FOUR DOOR SEDAN

NHTSA NUMBER: M60506TWG2

CALSPAN CORPORATION TEST NUMBER: 8642-TWG-20

CALSPAN CORPORATION
TRANSPORTATION SCIENCES CENTER
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June 8, 2006

FINAL REPORT

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Rulemaking
Office of Crashworthiness Standards
Mail Code: NVS-111
400 Seventh Street, SW, Room No. 5313
Washington, DC 20590

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Accepted By: _____

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16. Abstract

This side impact out-of-position test was performed in conjunction with a New Car Assessment Program (NCAP). This test was conducted at the Calspan Corporation Crash Test Facility in Buffalo, New York, on June 8, 2006.

Injury Summary

HIC15	HIC36	Clip (g's)	Chest Displacement (mm)	NIJ NTF	NIJ NTE	NIJ NCF	NIJ NCE
5.9	7.7	22.8	-1.5	0.09	0.22	0.20	0.24

17. Key Words New Car Assessment Program (NCAP) Side Airbag Out-of-Position	18. Distribution Statement Copies of this report are available from: National Highway Traffic Safety Administration Technical Reference Division Room 5111 (NAD-52) 400 Seventh St., S.W. Washington, D.C. 20590 Telephone No. (202) 366-4946 ATTN: Robert Hornicle

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SECTION 1

PURPOSE AND SUMMARY OF TEST M60506TWG2

1.1 PURPOSE

The purpose of this test was to obtain data in a static out-of-position side impact. These data constitute part of the general consumer information collected by the New Car Assessment Program (NCAP) sponsored by the National Highway Traffic Safety Administration (NHTSA) under contract No. DTNH22-03-D-22005.

1.2 SUMMARY

The effects of both a seat-mounted side airbag and a curtain airbag deployment in a 2006 Hyundai Sonata with an out-of-position six-year-old child were evaluated. The test was performed by Calspan Corporation on June 8, 2006. Pre-and post-test photographs of the vehicle and dummy can be found in Appendix A.

One high-speed digital camera was used to document the side airbag deployment event. The camera was placed in perpendicular the right-front seat centerline as to capture the deployment event. The recorded image rate is 1000 frames per second.

One part 572, Hybrid III six–year-old child anthropomorphic test device (ATD), was placed in the right front seat situated in the forward facing position according to dummy placement instructions specified in the Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags as prepared by the Side Airbag Out-of-Position Injury Technical Working Group (TWG).

The child dummy was instrumented with head, chest, upper and lower sternum and pelvic triaxial accelerometers. In addition upper and lower six axial neck force and moment load cell sensors and left and right femur load cell sensors were utilized.

Twenty-six channels of data were recorded using an on-board data acquisition system. Appendix A contains photographs. Appendix B contains dummy response data traces. Appendix C contains the Instrumentation Data Channel assignments.

The Hybrid IIII six-year-old child dummy's visible contact points were as follows: The seat airbag to the right scapula and right side of the posterior thorax and pelvis and the curtain airbag to the top and the back of the head.

The six-year old child dummy was placed on the outboard edge of foam block, aligning the upper spine with the deployment trajectory of the airbag. The dummy's head was placed in between the seat bolster and pillar trim to minimize the fore-aft clearance between the neck and the seatback. The head remained in its neutral orientation. The legs were aligned such that they crossed the heel placement points but the feet did overhang the seat cushion. The dummy was then positioned so the dummy's neck/torso junction was aligned vertically with the top edge of the airbag module. While maintaining the neck/torso top of the airbag module alignment, the vehicle door was closed and the pelvis was moved outboard until it made contact the door trim/armrest. The outboard forearm was placed on the armrest. The inboard arm was positioned such that the upper arm contacted the seat back and the fingertips contacted the booster seat. The dummy's arms were then bent at the elbow until the fingers contacted the booster seat. This orientation complies with section 3.3.3.5 of the TWG Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Airbags as defined by Lund, et al and the Technical Working Group First Revision dated July, 2003.

SECTION 2

DATA SHEET NO. 1

TEST SUMMARY

TEST CONFIGURATION INFORMATION:

	TEST DATA	DESCRIPTION
Seating Position:	P2	Right Front Seating Position
Test:	3.3.3.5*	Forward facing Hybrid-III six-year-old child dummy on booster block
Airbag:	Seat; Side Rail	Bolster mounted thorax side airbag and side curtain airbag.
Booster Block	300mm x 450 mm x 75 mm	Block consisted of HD36 foam with a density of 44.8 g/L
ATD Type/Serial No.:	P572N/186	Hybrid III six-year-old child dummy

*- Procedure as defined by Lund, et al and the Technical Working Group dated July, 2003

Number of Data Channels	26	
Number of Cameras:	0	Real Time
	1	High Speed Digital
	0	High Speed Film

VISIBLE DUMMY CONTACT POINTS

Head Contact:	The back (occipital) and the top (parietal) of the head by the side curtain.
Upper Torso Contact:	Side airbag to the right scapula and right side of the posterior thorax
Lower Torso Contact:	Side airbag to the right side of the pelvis (ilium)
Left Knee Contact:	None
Right Knee Contact:	None

DATA SHEET 2

VEHICLE PARAMETER DATA

TEST VEHICLE INFORMATION:

Year/Make/Model/Body Style: 2006 Hyundai Sonata Four-Door Sedan ‡

NHTSA No. : M60506 ; VIN: KMHET46CX6A078130 ; Color: Black

Engine Data: 4 cylinders; - CID; 2.4 Liters; - cc

Placement: - Longitudinal or In-Line; X Transverse or Lateral

Transmission Data: 5 speeds; - Manual; X Automatic; X Overdrive

Final Drive: - Rear Wheel Drive; X Front Wheel Drive; - Four Wheel Drive

AUTOMATIC DOOR LOCKS:

Is test vehicle equipped with Automatic Door Locks (ADLs)? X Yes; - No;

Does vehicle owner's manual describe how to deactivate ADLs? - Yes; X No; - N/A

DEALER AND DELIVERY INFORMATION:

Date Received: 7-26-2005 ; Odometer Reading 121 km

Selling Dealer: Northtown Hyundai

Dealer Address: 3675 Sheridan Drive Amherst, NY 14226

TEST VEHICLE OPTIONS:

X AC; X Power Steering; X Power Brakes; X Power Locks; - Power Seats

X ABS; X Tilt Wheel; X Stability Control X Traction Control X Anti-Theft

SAFETY BELT FEATURES:

Driver: X Pretensioner (Shoulder); X Load Limiter; X Adjustable Anchorage

Passenger: X Pretensioner (Shoulder); X Load Limiter; X Adjustable Anchorage

AIRBAG FEATURES:

Position	Frontal	Knee Bolster	Side Torso	Side Head/Torso Combination	Side Curtain
Driver:	Yes	No	Yes	No	Yes
Passenger:	Yes	No	Yes	No	Yes
Rear Passenger:	No	N/A	No	No	Yes

DATA FROM VEHICLE'S CERTIFICATION LABEL:

Vehicle Manufactured by: Hyundai Motor Company

Date of Manufacture APR/22/2005

GVWR: 1950 kg; GAWR: 1140 kg FRONT; 970 kg REAR

VEHICLE CAPACITY DATA:

Type of Front Seats: - Bench; X Bucket; - Split Bench

Number of Occupants: 2 Front; 3 Rear; 5 Total

Vehicle Capacity Weight (VCW) = 390 kg

No. of Occupants x 68.04 kg = 340.2 kg

Rated Cargo/Luggage Weight (RCLW) = 49.8 kg

‡ This vehicle had previously been tested in an NCAP frontal impact on August 25, 2005.

DATA SHEET NO. 3

CHILD DUMMY POSITIONING IN VEHICLE

NHTSA No. M60506TWG2

Measurement		Value
Total Fore/Aft Travel (mm)		240
Test Distance Rearward of Full-Forward (mm)		220
Total Fore/Aft Travel (Detents)		25
Placed in Position #		22
Seat Back Angle	SA (^{o})	13
Airbag Module Width	AMW (mm)	95
Airbag Width	ABW (mm)	330
Airbag Module Length	AML (mm)	300
Airbag Length	ABL (mm)	365
Top of Airbag Module to Head/Neck Junction	AN (mm)	93
Head CG to Door Panel/Window	HD (mm)	135
Head to Seat Back Centerline	HSC (mm)	233
Head to B-Pillar (cg)	HB (mm)	154
Head to Roof, Z (top of the head)	HZ (mm)	185
Head to Header	HHD (mm)	416
Chest to Dash	CD (mm)	591
Chest to Seatback	CS (mm)	-178
Right Arm to Seat Back Centerline	RACL (mm)	350
Right Arm to Seat Back Centerline	RACL (^{o})	35
Left Arm to Seat Back Centerline	LACL (mm)	62
Left Arm to Seat Back Centerline	LACL (^{o})	67
Right Arm to Door Panel	RA (mm)	0
Left Arm to Door Panel	LA (mm)	350
Knee to Knee	KK (mm)	106
Toe to Toe	TT (mm)	150
Right Knee to Seat Cushion Centerline	KSCR (mm)	106
Left Knee to Seat Cushion Centerline	KSCL (mm)	0
Right Toe to Seat Cushion Centerline	TSCR (mm)	150
Left Toe to Seat Cushion Centerline	TSCL (mm)	0
Nose to Dash	ND (mm)	620
Nose to Seatback	NS (mm)	213
Nose to Header	NR (mm)	431
Foam Block Depth	(mm)	300
Foam Block Width	(mm)	450
Foam Block Thickness	(mm)	75
HD36 foam density	(g/L)	44.8

DATA SHEET 4

CHILD DUMMY INJURY CRITERIA VALUES

NHTSA No. M60506TWG2

		MAXIMUM VALUE			
		Position #2			
DESCRIPTION	**Unit**	**Maximum**	**Time (ms)**	**Minimum**	**Time (ms)**
Head X	**g**	7.7	14.2	-10.6	26.5
Head Y	**g**	3.6	23.3	-8.5	14.7
Head Z	**g**	13.4	22.2	-6.9	8.7
Head Resultant	**g**	15.2	24.1	0.0	-10.7
Upper Neck Fx	**N**	213.5	37.4	-13.6	5.4
Upper Neck Fy	**N**	13.0	4.7	-268.3	37.4
Upper Neck Fz	**N**	178.4	21.2	-490.2	37.4
Upper Neck F Resultant	**N**	598.2	37.4	0.1	-18.7
Upper Neck Mx	**N-m**	§	§	§	§
Upper Neck My	**N-m**	17.5	13.7	-6.0	57.1
Upper Neck Mz	**N-m**	0.1	4.7	-6.1	85.1
Upper Neck M Resultant	**N-m**	§	§	§	§
Lower Neck Fx	**N**	369.9	11.9	-48.8	46.4
Lower Neck Fy	**N**	25.9	5.6	-413.2	13.2
Lower Neck Fz	**N**	152.7	22.2	-253.1	9.1
Lower Neck F Resultant	**N**	579.4	12.7	0.1	1.2
Lower Neck Mx	**N-m**	1.8	4.9	-31.4	32.3
Lower Neck My	**N-m**	0.4	4.2	-22.1	21.6
Lower Neck Mz	**N-m**	8.8	47.3	-16.4	12.9
Lower Neck M Resultant	**N-m**	37.5	15.1	0.0	-5.3
Upper Sternum Ax	**g**	58.6	8.2	-13.4	15.3
Lower Sternum Ax	**g**	80.4	7.4	-27.8	12.2
Chest X	**g**	35.6	5.1	-1.1	31.9
Chest Y	**g**	4.0	33.7	-25.5	8.7
Chest Z	**g**	3.7	6.6	-3.9	14.3
Chest Resultant	**g**	36.7	5.1	0.0	-19.6
Chest Displacement	**mm**	1.9	27.6	-1.5	7.7
Pelvic X	**g**	4.0	15.5	-5.5	11.8
Pelvic Y	**g**	3.1 1	19.6	-10.7	15.4
Pelvic Z	**g**	2.4	39.0	-7.5	11.2
Pelvic Resultant	**g**	11.5	15.1	0.0	-18.6
Left Femur	**N**	23.2	42.4	-121.7	12.0
Right Femur	**N**	27.0	74.7	-48.4	9.9

§-Upper Neck Mx connector failed

DATA SHEET 4

CHILD DUMMY INJURY CRITERIA VALUES (CONTINUED)

NHTSA No. M60506TWG2

	HEAD INJURY CRITERIA (HIC)							
	HIC15				HIC36			
	HIC	t_1 (msec)	t_2 (msec)	Average Acceleration t_1 to t_2	HIC	t_1 (msec)	t_2 (msec)	Average Acceleration t_1 to t_2
Position #2 – Right Front	5.9	12.5	27.5	10.9	7.7	7.0	30.8	10.1

	CLIP SUMMARY*			
	CLIP (g's)	t_1 (msec)	t_2 (msec)	CSI
Position #2 – Right Front	22.8	7.9	10.9	36.9

* The maximum chest resultant acceleration is defined as the maximum acceleration which exceeds 0.003 seconds in duration.

Position 2 Neck Injury Summary (HIII 6 year old – Out of Position)

Nij V10	Nij	Time (ms)	Z Force (N)	X Force (N)	Y Moment (N-m)
Ntf	0.09	19.8	164.6	115.2	3.3
Nte	0.22	68.4	10.3	135.7	-8.0
Ncf	0.20	12.9	-139.5	171.4	13.9
Nce	0.24	57.7	-25.3	141.1	-8.5

Peak Tension (CFC1000) 178.4 N **Peak Compression (CFC1000) 490.2 N**

Critical Values

Nij Intercepts				Peak Limits	
Tension (CVt)	2880 N	Extension (mCVe)	37 N-m	Tension	1890 N
Compression (CVc)	2880 N	Flexion (mCVf)	93 N-m	Compression	-1820 N

Condyle Offset -0.01778

APPENDIX A

PHOTOGRAPHS

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Figure A-2: Post-Test Vehicle Left Side View

Figure A-3: Vehicle Certification Placard

Figure A-4: Vehicle Tire Placard

Figure A-5: Pre-Test Dummy Frontal View

Figure A-6: Post-Test Dummy Frontal View

Figure A-7: Pre-Test Left Side of Dummy View

Figure A-8: Post-Test Left Side of Dummy View

Figure A-9: Pre-Test Right Side of Dummy View

Figure A-10: Post-Test Right Side of Dummy View

APPENDIX B

CHILD DUMMY RESPONSE DATA TRACES

TABLE OF DATA PLOTS

PLOT	PLOT NAME[UNITS, CHANNEL FILTER CLASS]	PAGE
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2	P2 Head y [g, CFC_1000]	B-3
3	P2 Head z [g, CFC_1000]	B-3
4	P2 Head Resultant [g, CFC_1000]	B-3
5	P2 Upper Neck Fx [N, CFC_1000]	B-4
6	P2 Upper Neck Fy [N, CFC_1000]	B-4
7	P2 Upper Neck Fz [N, CFC_1000]	B-4
8	P2 Upper Neck F Resultant [N, CFC_1000]	B-4
9	P2 Upper Neck Mx [N-m, CFC_600]	B-5
10	P2 Upper Neck My [N-m, CFC_600]	B-5
11	P2 Upper Neck Mz [N-m, CFC_600]	B-5
12	P2 Upper Neck M Resultant [N-m, CFC_600]	B-5
13	P2 Lower Neck Fx [N, CFC_1000]	B-6
14	P2 Lower Neck Fy [N, CFC_1000]	B-6
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18	P2 Lower Neck My [N-m, CFC_600]	B-7
19	P2 Lower Neck Mz [N-m, CFC_600]	B-7
20	P2 Lower Neck M Resultant [N-m, CFC_600]	B-7
21	P2 Upper Sternum Ax [g, CFC_180]	B-8
22	P2 Lower Sternum Ax [g, CFC_180]	B-8
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24	P2 Chest y [g, CFC_180]	B-9
25	P2 Chest z [g, CFC_180]	B-9
26	P2 Chest Resultant [g, CFC_180]	B-9
27	P2 Chest Compression [mm, CFC_600]	B-10
28	P2 Pelvic x [g, CFC_1000]	B-11
29	P2 Pelvic y [g, CFC_1000]	B-11
30	P2 Pelvic z [g, CFC_1000]	B-11
31	P2 Pelvic Resultant [g, CFC_1000]	B-11
32	P2 Left Femur Fz [N, CFC_600]	B-12
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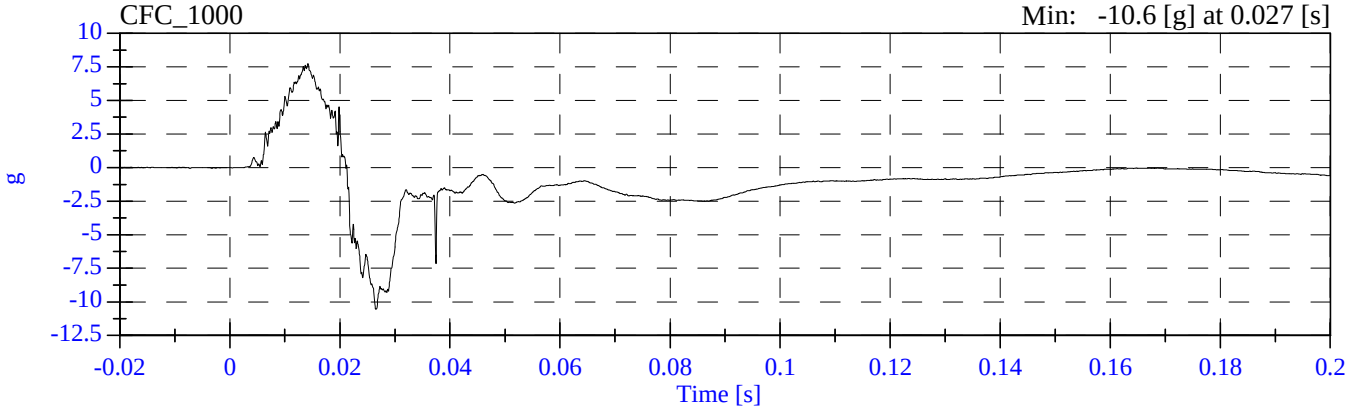
2006 TWG Test 3 2006 Hyundai Sonata
M60506TWG2 - June 08, 2006

P2 Head x
CFC_1000
Max: 7.7 [g] at 0.014 [s]
Min: -10.6 [g] at 0.027 [s]



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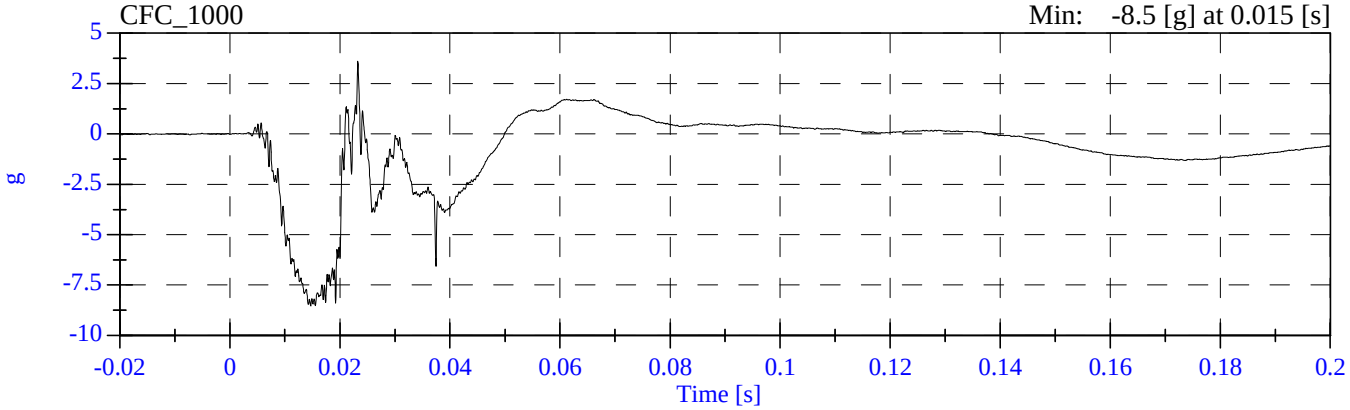
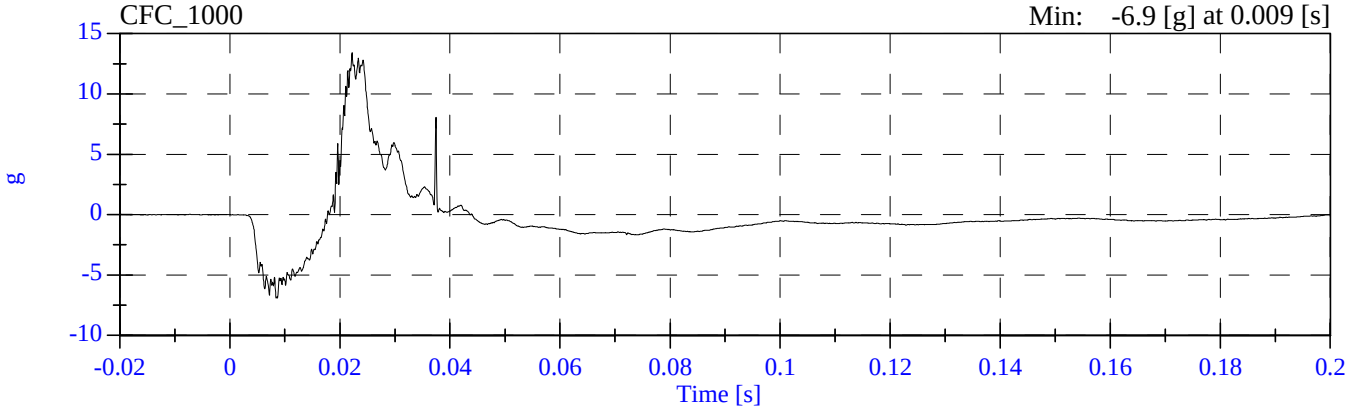
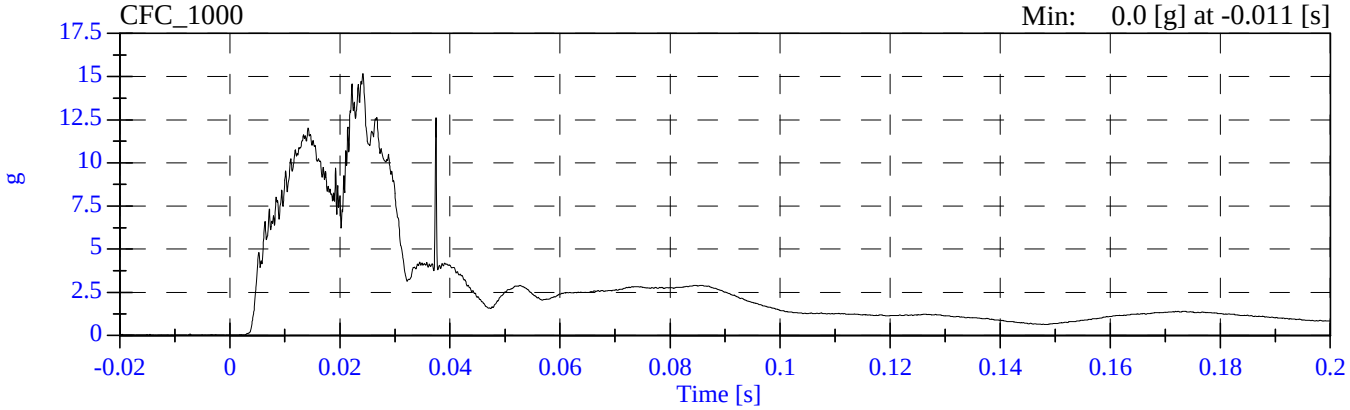


P2 Head z
CFC_1000
Max: 13.4 [g] at 0.022 [s]
Min: -6.9 [g] at 0.009 [s]



P2 Head Resultant
CFC_1000
Max: 15.2 [g] at 0.024 [s]
Min: 0.0 [g] at -0.011 [s]



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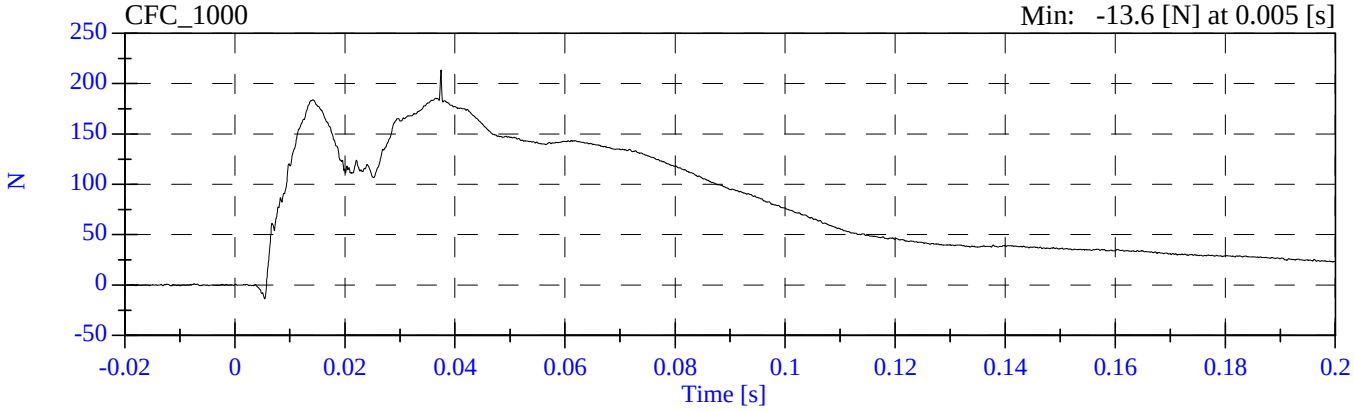
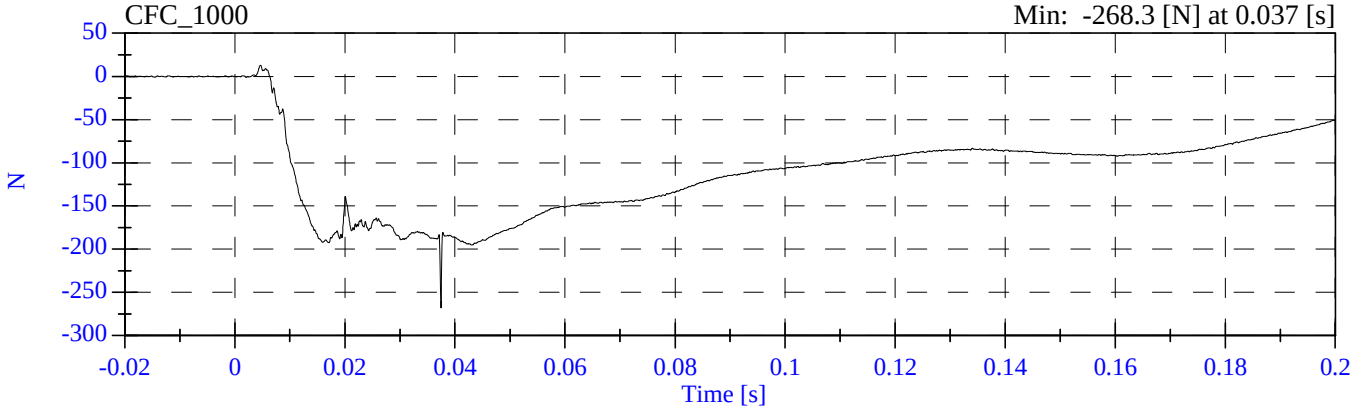
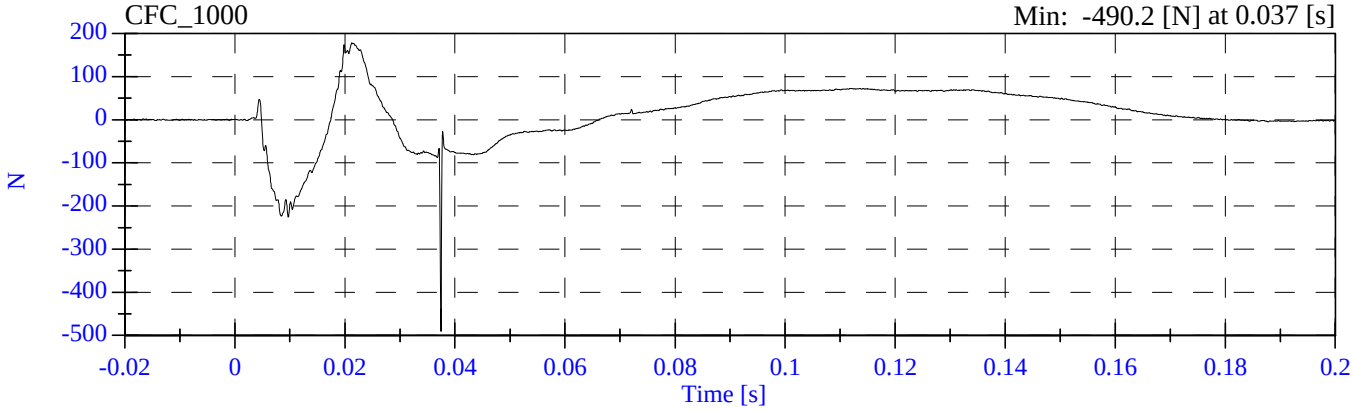
P2 Upper Neck Fx
CFC_1000
Max: 213.5 [N] at 0.037 [s]
Min: -13.6 [N] at 0.005 [s]



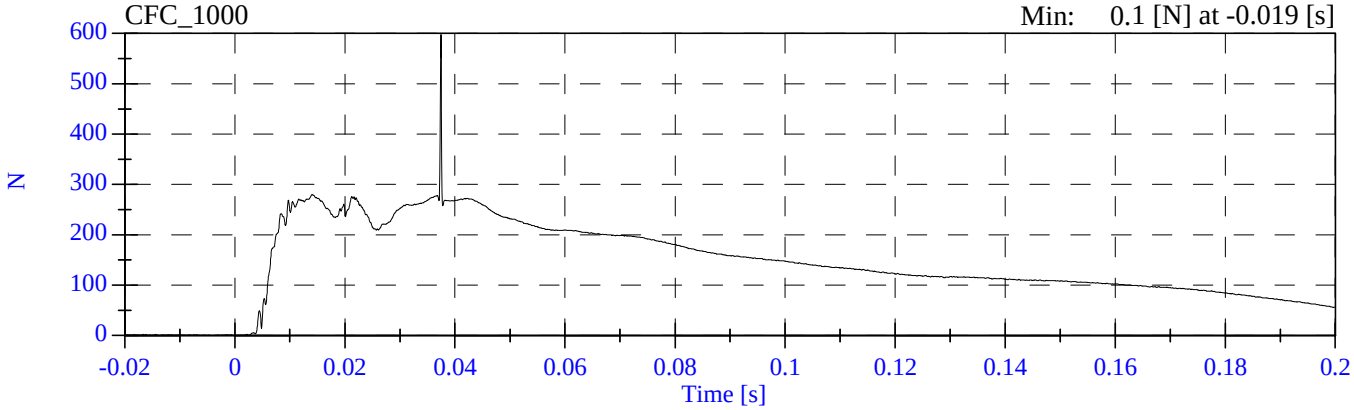
P2 Upper Neck Fy
CFC_1000
Max: 13.0 [N] at 0.005 [s]
Min: -268.3 [N] at 0.037 [s]



P2 Upper Neck Fz
CFC_1000
Max: 178.4 [N] at 0.021 [s]
Min: -490.2 [N] at 0.037 [s]



P2 Upper Neck F Resultant
CFC_1000
Max: 598.2 [N] at 0.037 [s]
Min: 0.1 [N] at -0.019 [s]



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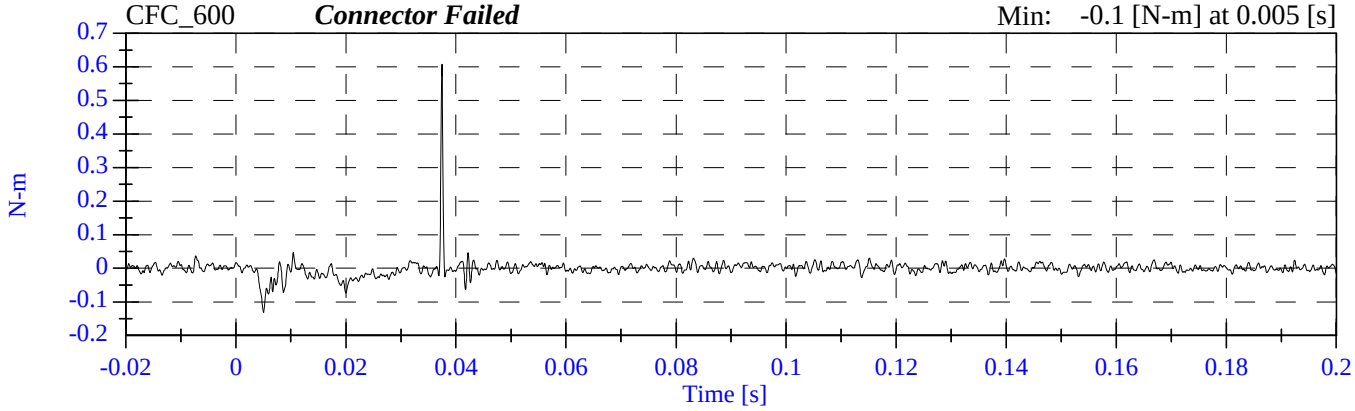
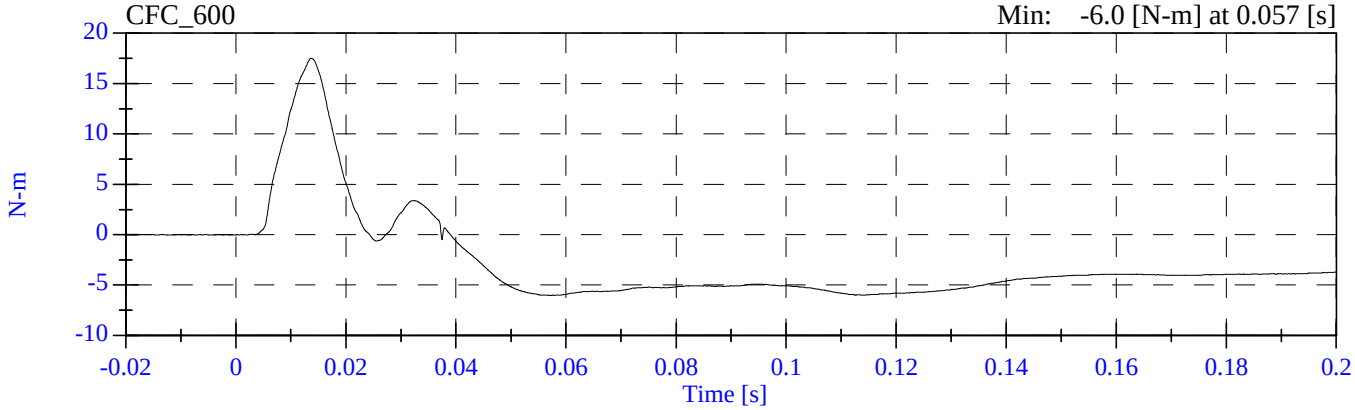
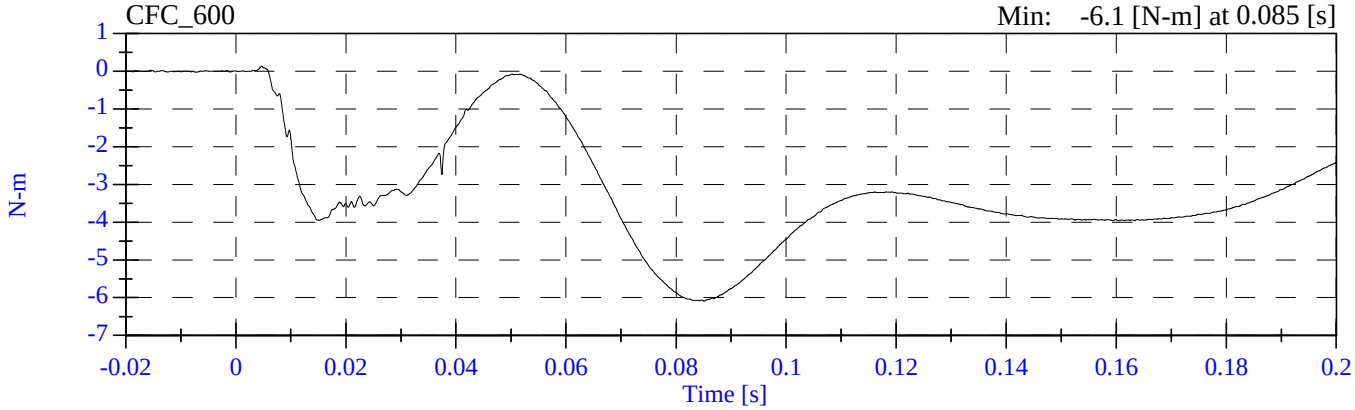
P2 Upper Neck Mx
CFC_600 ***Connector Failed***
Max: 0.6 [N-m] at 0.037 [s]
Min: -0.1 [N-m] at 0.005 [s]



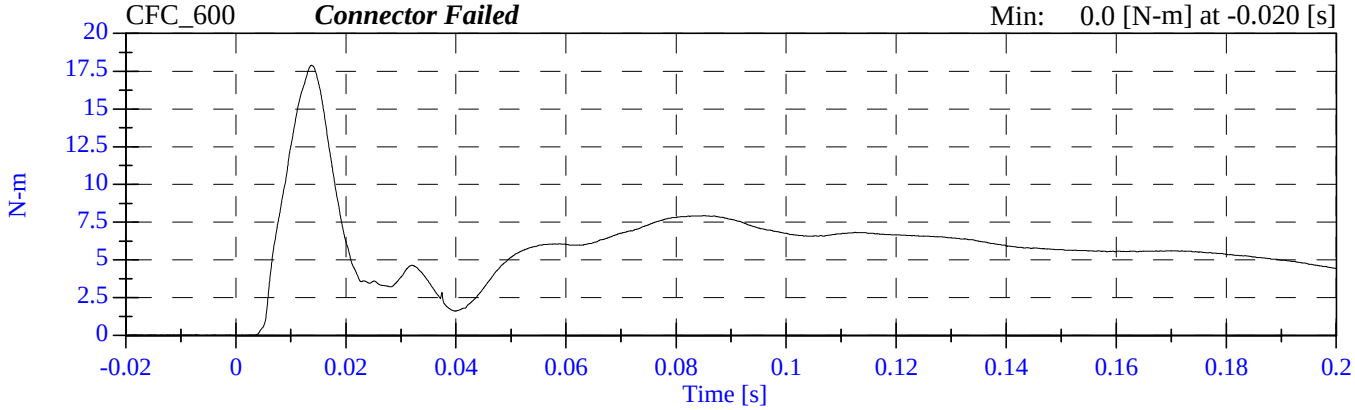
P2 Upper Neck My
CFC_600
Max: 17.5 [N-m] at 0.014 [s]
Min: -6.0 [N-m] at 0.057 [s]



P2 Upper Neck Mz
CFC_600
Max: 0.1 [N-m] at 0.005 [s]
Min: -6.1 [N-m] at 0.085 [s]



P2 Upper Neck M Resultant
CFC_600 ***Connector Failed***
Max: 17.9 [N-m] at 0.014 [s]
Min: 0.0 [N-m] at -0.020 [s]



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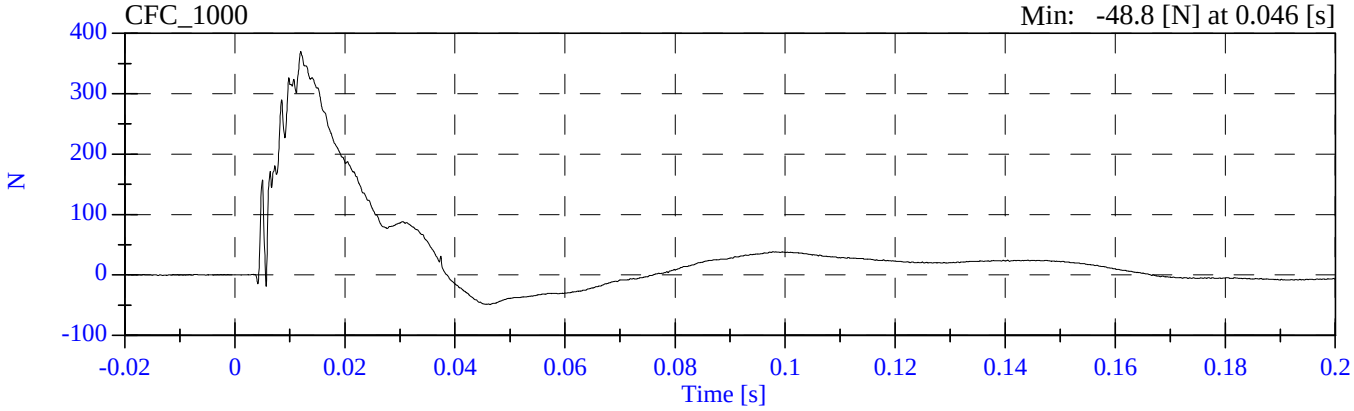
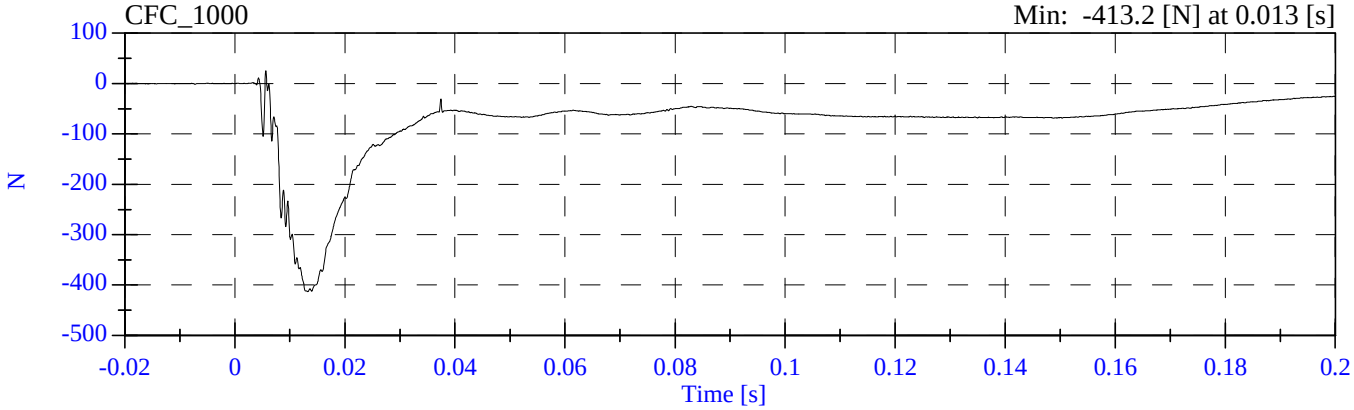
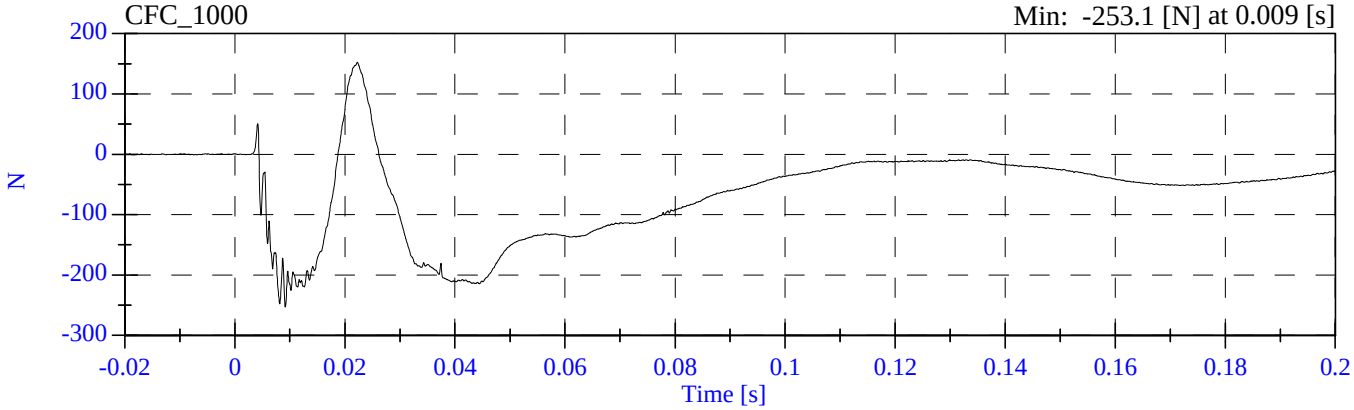
P2 Lower Neck Fx
CFC_1000
Max: 369.9 [N] at 0.012 [s]
Min: -48.8 [N] at 0.046 [s]



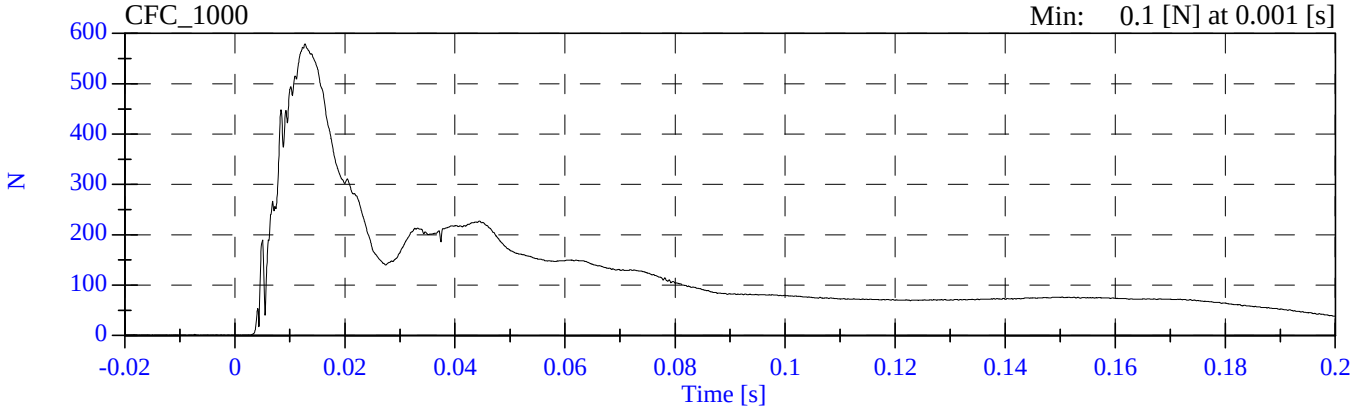
P2 Lower Neck Fy
CFC_1000
Max: 25.9 [N] at 0.006 [s]
Min: -413.2 [N] at 0.013 [s]



P2 Lower Neck Fz
CFC_1000
Max: 152.7 [N] at 0.022 [s]
Min: -253.1 [N] at 0.009 [s]



P2 Lower Neck F Resultant
CFC_1000
Max: 579.4 [N] at 0.013 [s]
Min: 0.1 [N] at 0.001 [s]



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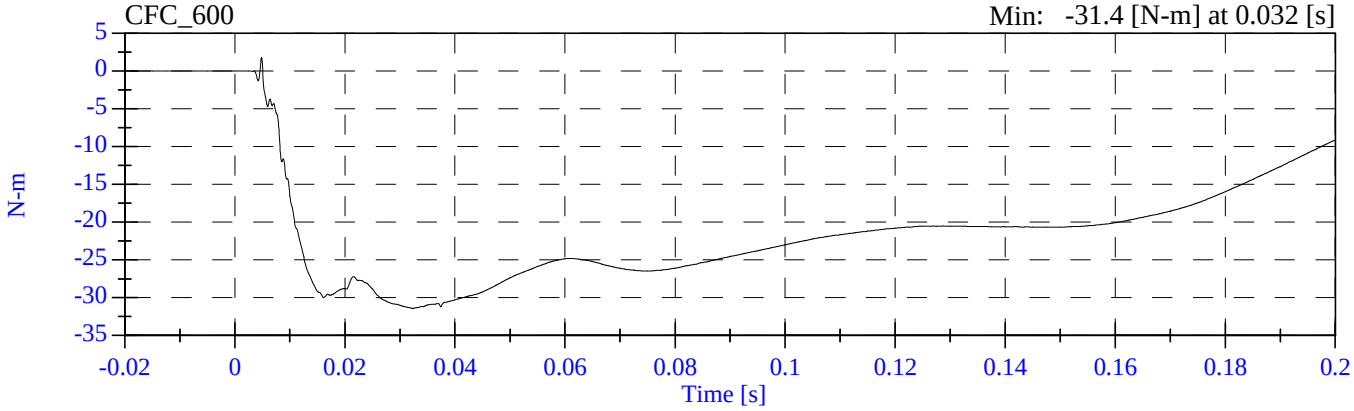
P2 Lower Neck Mx

Max: 1.8 [N-m] at 0.005 [s]

CFC_600

Min: -31.4 [N-m] at 0.032 [s]

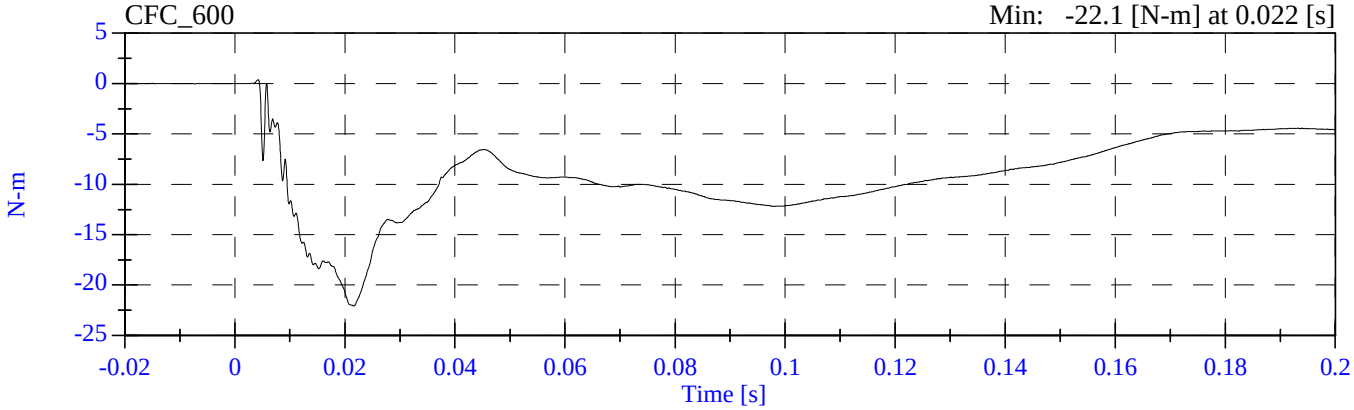


P2 Lower Neck My

Max: 0.4 [N-m] at 0.004 [s]

CFC_600

Min: -22.1 [N-m] at 0.022 [s]

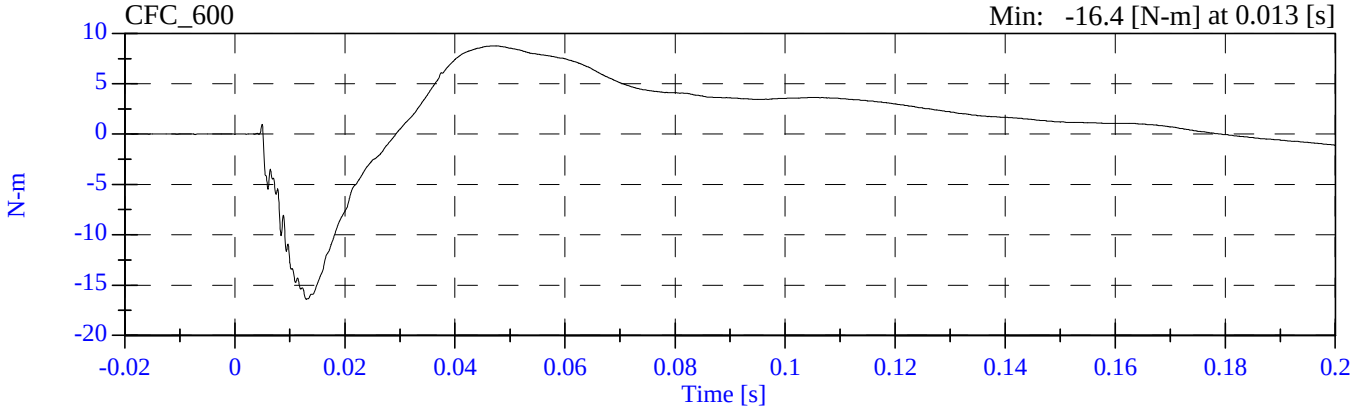


P2 Lower Neck Mz

Max: 8.8 [N-m] at 0.047 [s]

CFC_600

Min: -16.4 [N-m] at 0.013 [s]

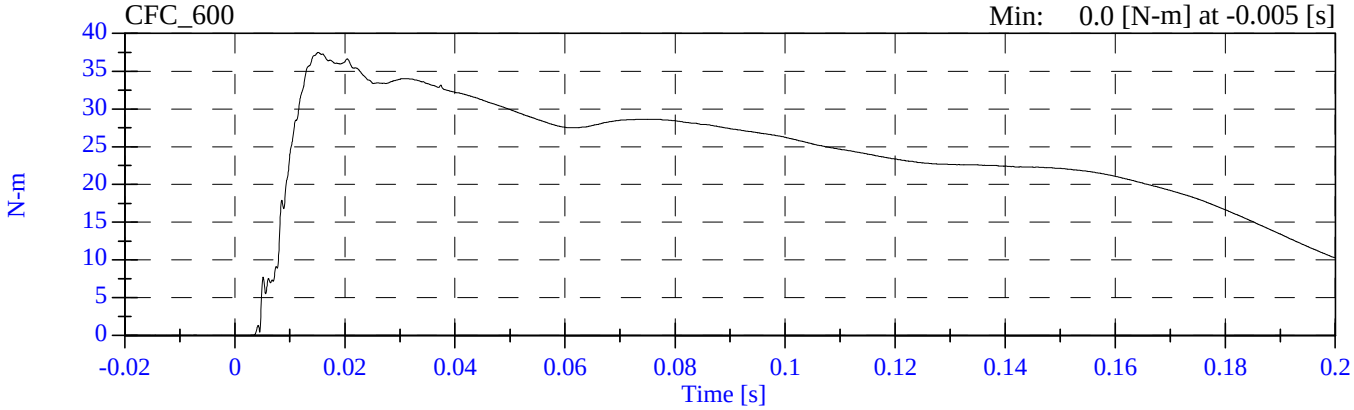


P2 Lower Neck M Resultant

Max: 37.5 [N-m] at 0.015 [s]

CFC_600

Min: 0.0 [N-m] at -0.005 [s]



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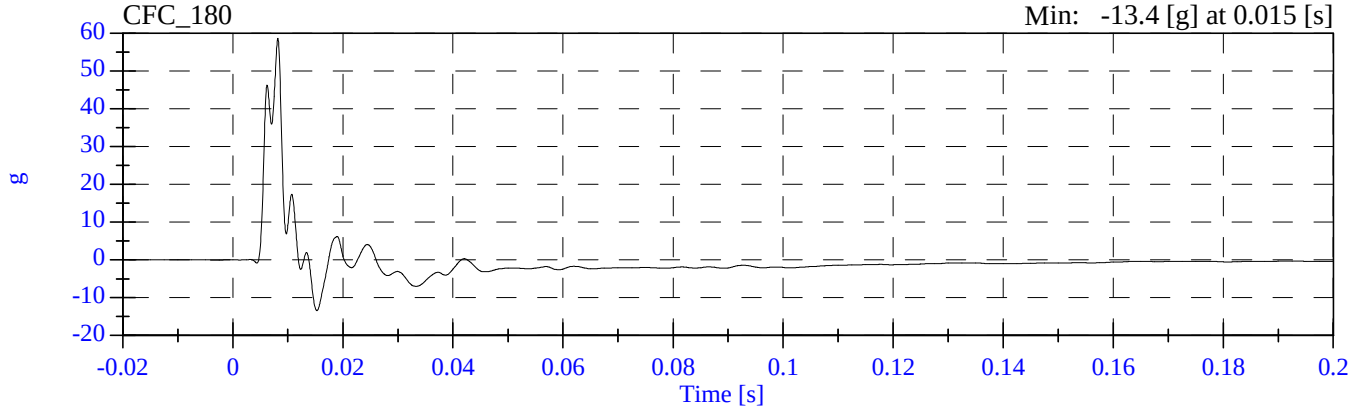
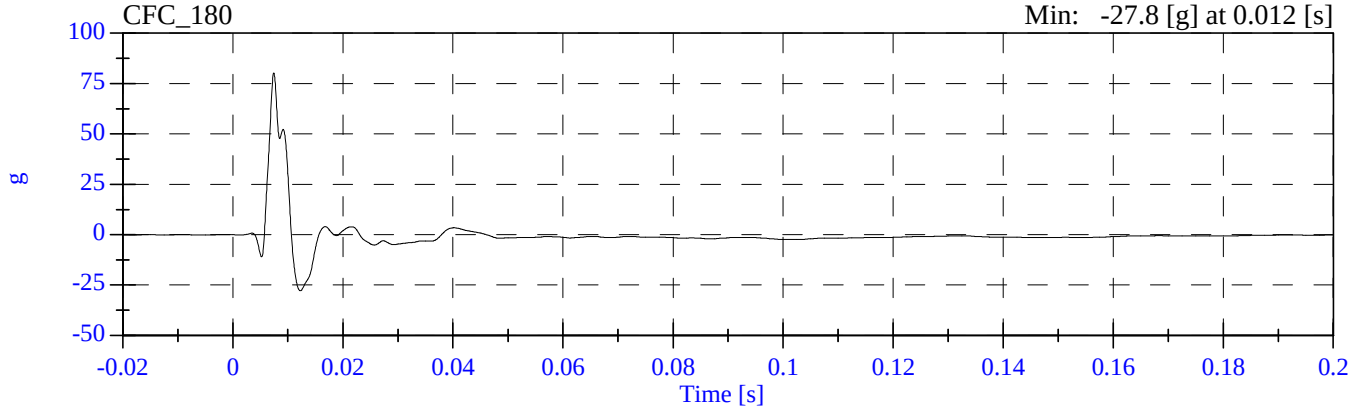
P2 Upper Sternum Ax
CFC_180
Max: 58.6 [g] at 0.008 [s]
Min: -13.4 [g] at 0.015 [s]



P2 Lower Sternum Ax
CFC_180
Max: 80.4 [g] at 0.007 [s]
Min: -27.8 [g] at 0.012 [s]



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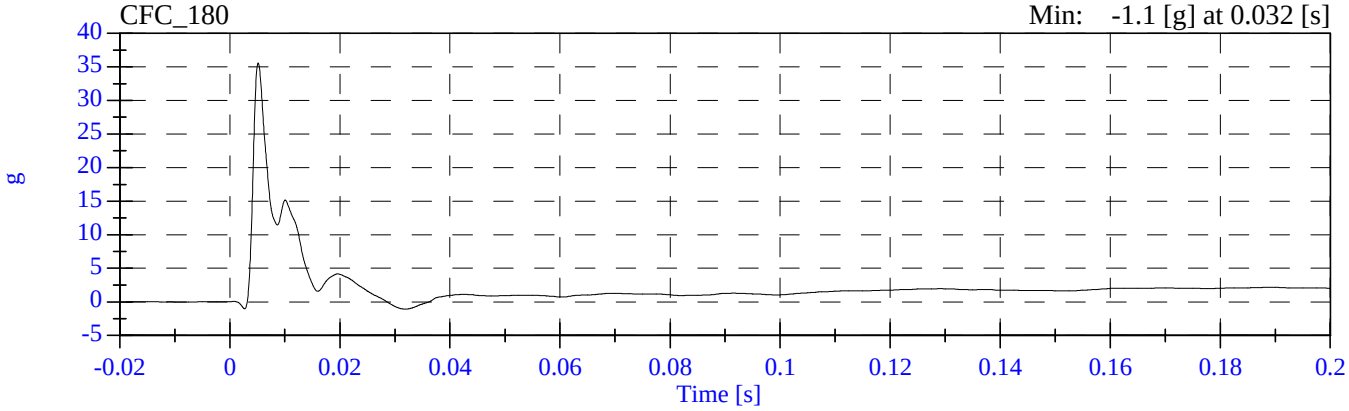
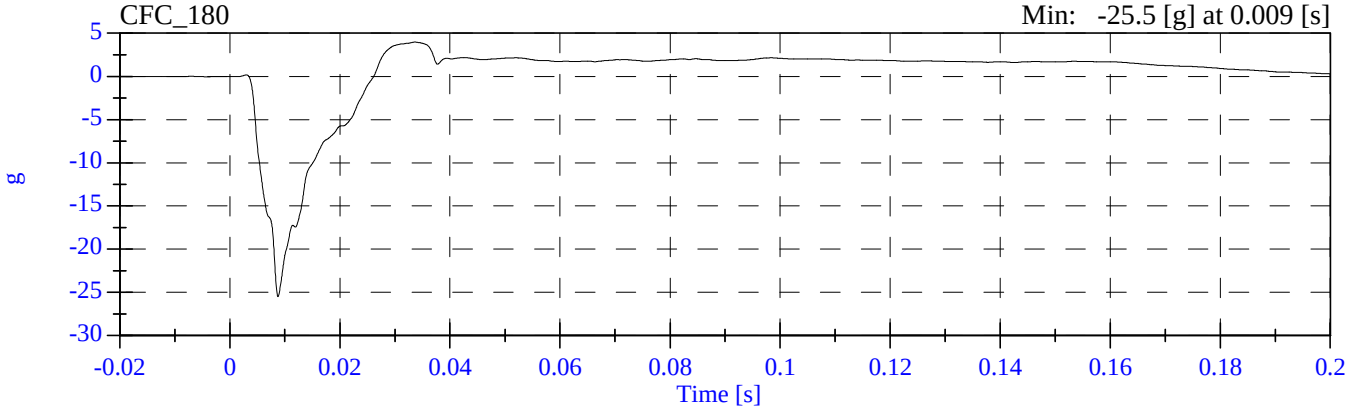
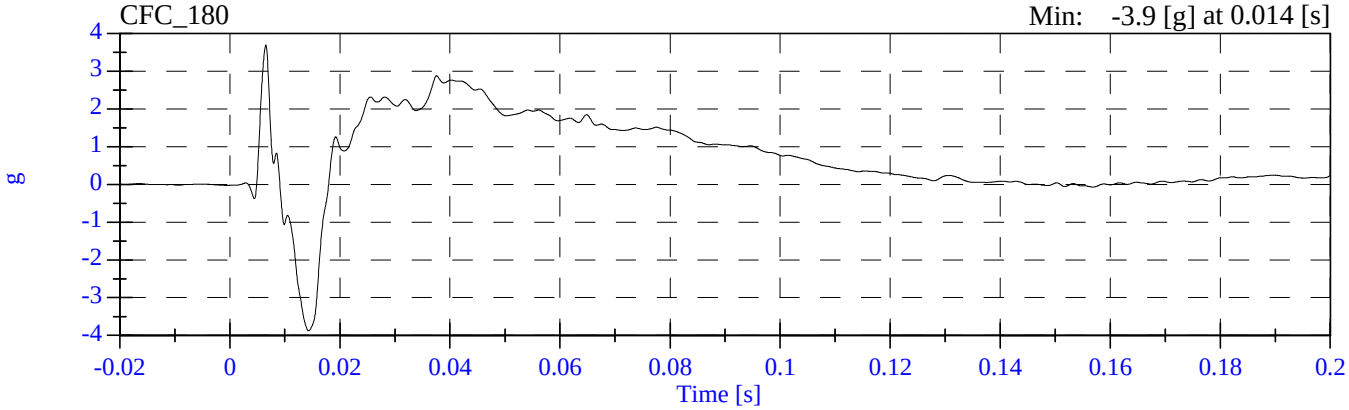
P2 Chest x
CFC_180
Max: 35.6 [g] at 0.005 [s]
Min: -1.1 [g] at 0.032 [s]



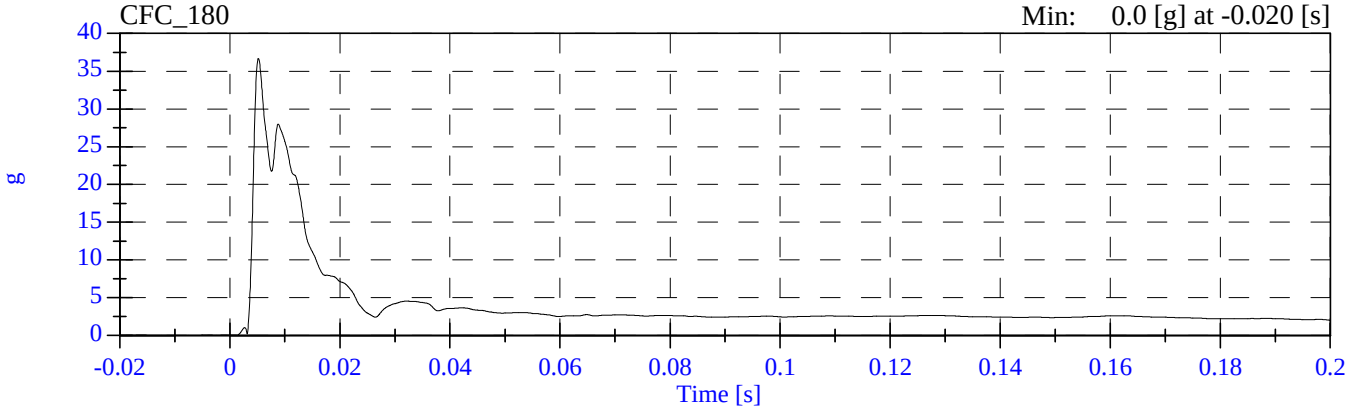
P2 Chest y
CFC_180
Max: 4.0 [g] at 0.034 [s]
Min: -25.5 [g] at 0.009 [s]



P2 Chest z
CFC_180
Max: 3.7 [g] at 0.007 [s]
Min: -3.9 [g] at 0.014 [s]



P2 Chest Resultant
CFC_180
Max: 36.7 [g] at 0.005 [s]
Min: 0.0 [g] at -0.020 [s]



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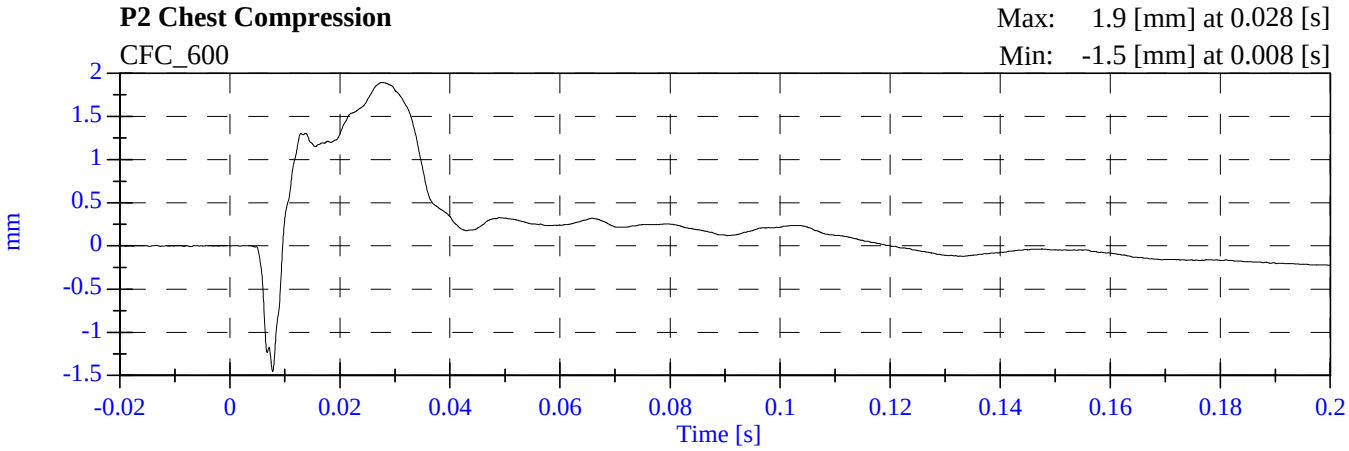

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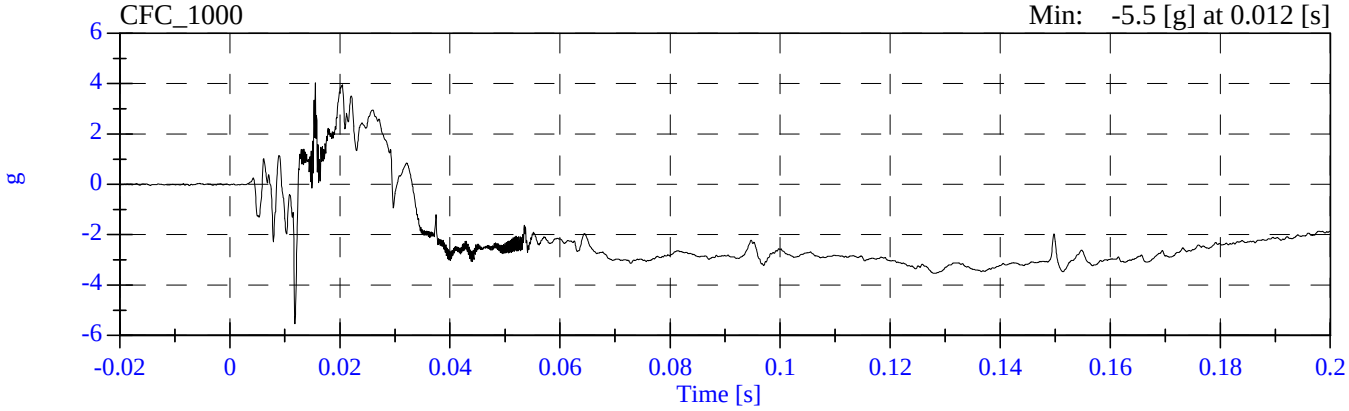
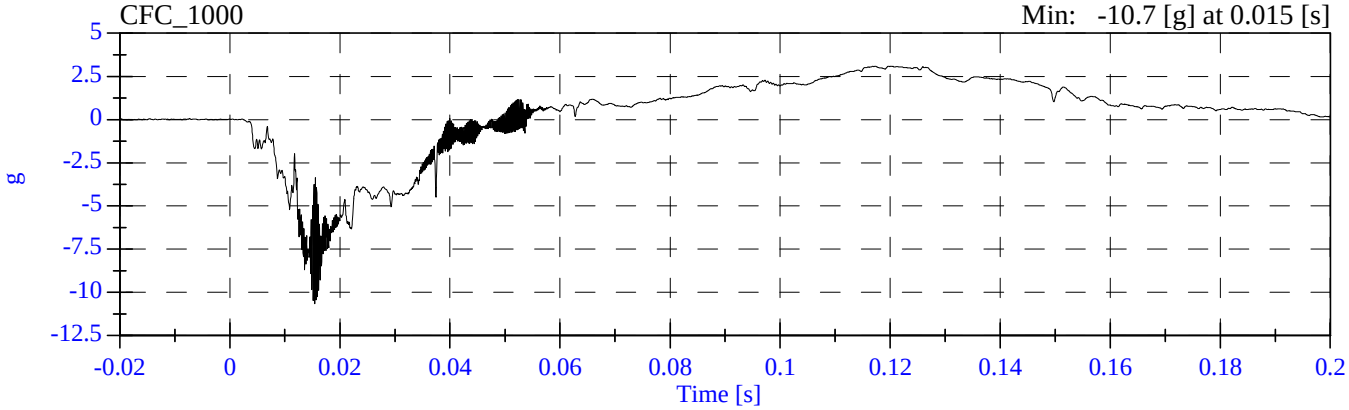
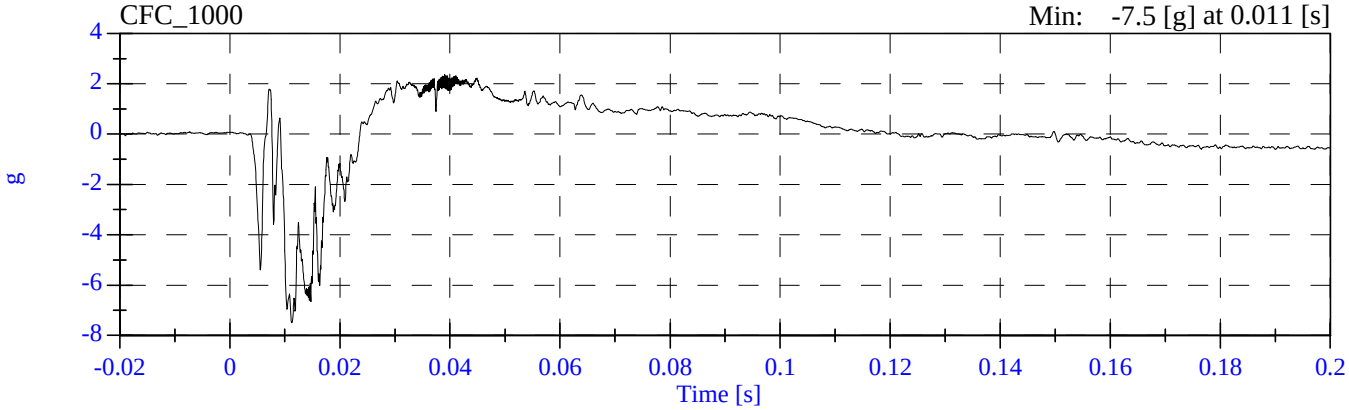
P2 Pelvic x
CFC_1000
Max: 4.0 [g] at 0.015 [s]
Min: -5.5 [g] at 0.012 [s]



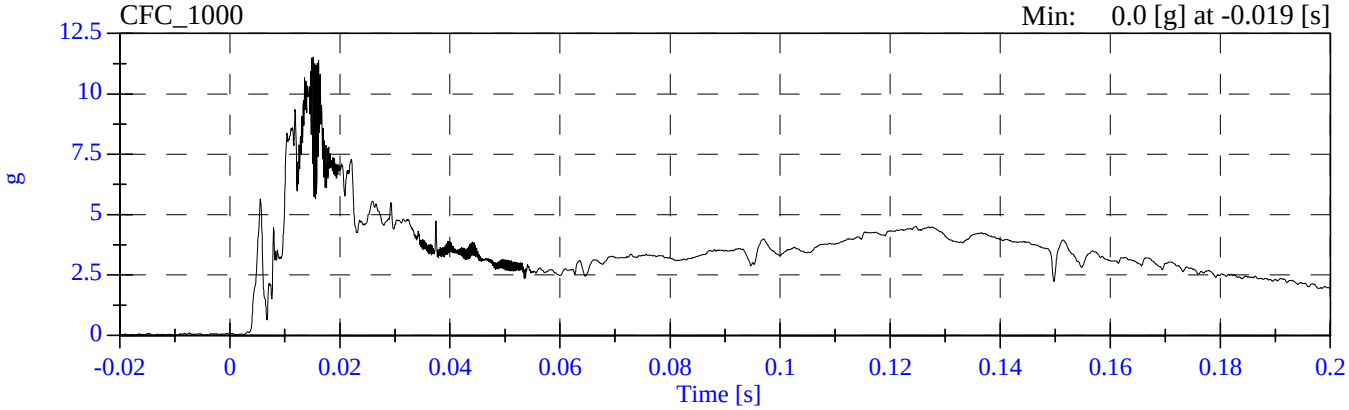
P2 Pelvic y
CFC_1000
Max: 3.1 [g] at 0.120 [s]
Min: -10.7 [g] at 0.015 [s]



P2 Pelvic z
CFC_1000
Max: 2.4 [g] at 0.039 [s]
Min: -7.5 [g] at 0.011 [s]



P2 Pelvic Resultant
CFC_1000
Max: 11.5 [g] at 0.015 [s]
Min: 0.0 [g] at -0.019 [s]



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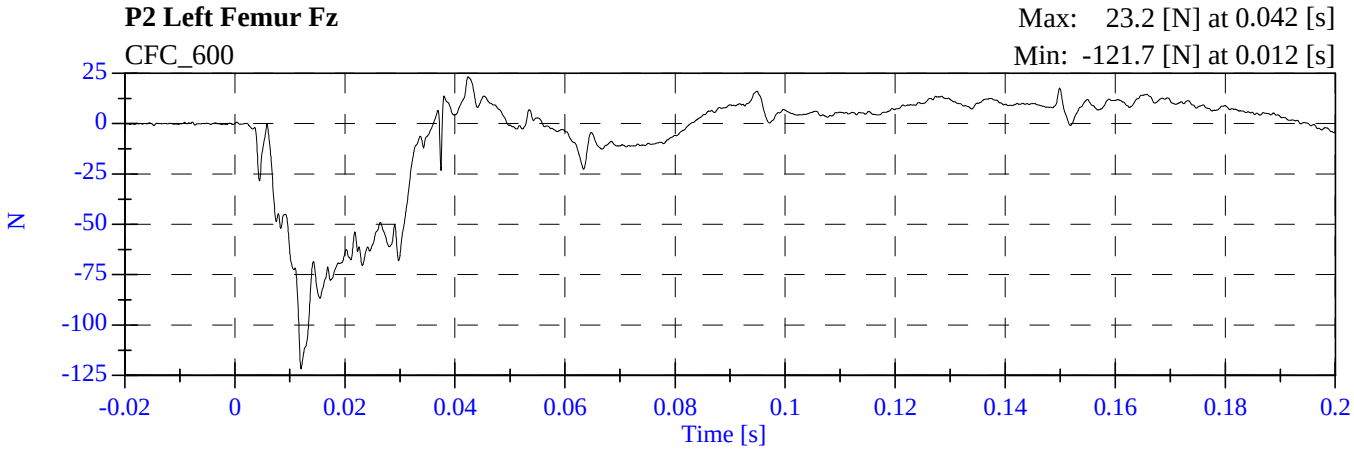

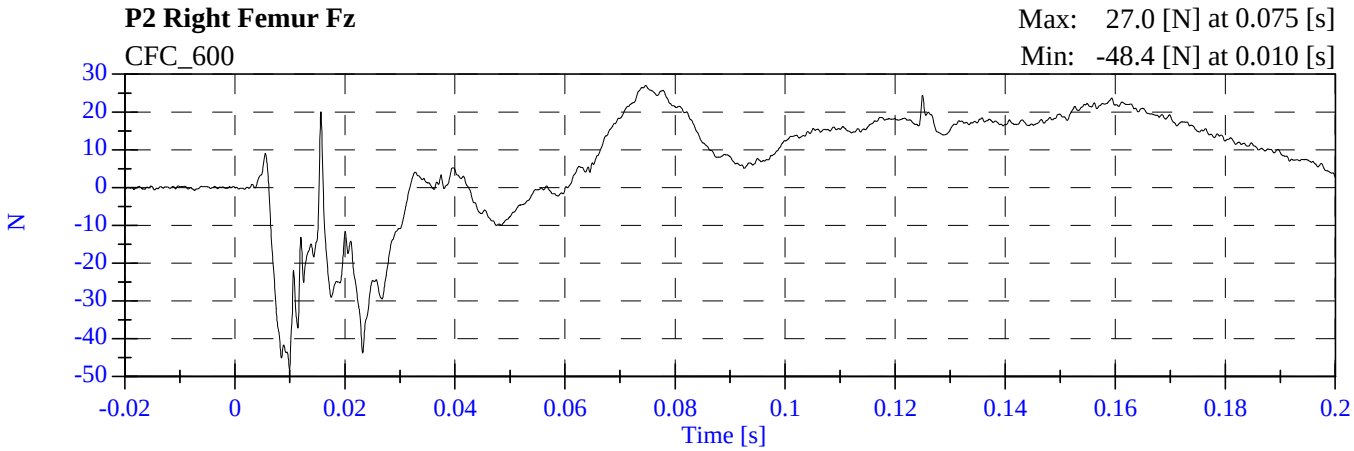

APPENDIX C

TEST EQUIPMENT LIST AND CALIBRATION INFORMATION

TEST EQUIPMENT LIST AND CALIBRATION INFORMATION

P572N INSTRUMENTATION

	POSITION #2 (RIGHT FRONT) SERIAL NO.: 186		
	SERIAL NUMBER	MANUFACTURER	CALIBRATION DATE
HEAD AX	AC-04J04I20-Z23	ENTRAN	11-Apr-06
HEAD AY	AC-04J04I01-R12	ENTRAN	14-Apr-06
HEAD AZ	AC-02I02I16-A08	ENTRAN	14-Apr-06
UPPER NECK FX	LC-175Fx	DENTON	03-May-06
UPPER NECK FY	LC-175Fy	DENTON	03-May-06
UPPER NECK FZ	LC-175Fz	DENTON	03-May-06
UPPER NECK MX	LC-175Mx	DENTON	03-May-06
UPPER NECK MY	LC-175My	DENTON	03-May-06
UPPER NECK MZ	LC-175Mz	DENTON	03-May-06
LOWER NECK FX	LC-138Fx	DENTON	18-May-06
LOWER NECK FY	LC-138Fy	DENTON	18-May-06
LOWER NECK FZ	LC-138Fz	DENTON	18-May-06
LOWER NECK MX	LC-138Mx	DENTON	18-May-06
LOWER NECK MY	LC-138My	DENTON	18-May-06
LOWER NECK MZ	LC-138Mz	DENTON	18-May-06
UPPER STERNUM AX	AC-02A16-A26	ENTRAN	14-Apr-06
LOWER STERNUM AX	AC-99H12-F24	ENTRAN	11-Apr-06
CHEST AX	AC-04J04I08-F25	ENTRAN	11-Apr-06
CHEST AY	AC-03E03E20-N05	ENTRAN	11-Apr-06
CHEST AZ	AC-03E03D30-N08	ENTRAN	10-Apr-06
CHEST DISPLACEMENT X	DS-186	SERVO	10-May-06
PELVIS AX	AC-04J04I01-R06	ENTRAN	22-May-06
PELVIS AY	AC-03E03D30-N03	ENTRAN	14-Apr-06
PELVIS AZ	AC-03D03D16-F04	ENTRAN	10-Apr-06
LEFT FEMUR FZ	LC-247	DENTON	18-May-06
RIGHT FEMUR FZ	LC-248	DENTON	16-May-06