



**REPORT NUMBER: TWG-MGA-2011-011**

**SIDE AIRBAG OUT-OF-POSITION INJURY  
TECHNICAL WORKING GROUP**

**VOLVO CAR CORPORATION  
2011 VOLVO XC60  
NHTSA NUMBER: MB5902TWG2**

**TEST DATE: MAY 16, 2010**

**FINAL REPORT DATE: SEPTEMBER 16, 2011**

**FINAL REPORT**

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\_\_\_\_\_

Date: \_\_\_\_\_

The results presented in this report relate only to the specified test items.

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## **SECTION 1**

### **PURPOSE AND SUMMARY OF TEST**

#### **PURPOSE**

The purpose of this test was to obtain data in a static out-of-position side air bag deployment. These data constitute part of the general consumer information collected by Alpha Technology Associate, Inc.

#### **SUMMARY**

The effects of both a curtain and torso airbag deployment in a 2011 Volvo XC60 with an out-of-position Hybrid III 3-Year-Old child dummy were evaluated. The curtain and seat airbags were fired remotely. The test was performed by MGA Research Corporation on May 16, 2011. Pre and post test photographs of the vehicle and dummy can be found in Appendix A.

Three high-speed cameras (1000 fps) were used to document the side airbag deployment event. The following camera locations were used:

- Left Side Through Removed Driver Door
- Front Through Windshield
- Left Side  $\frac{3}{4}$  View Through Windshield

One Hybrid III 3-Year-Old child dummy (Serial Number 082) was placed in the right front passenger seat situated in the front-facing position along the outboard edge of the seat per Section 3.3.3.1 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 dummy was instrumented with the following instrumentation:

- Head Accelerations
- Upper Neck Load Cell
- Lower Neck Load Cell
- Upper Spine Acceleration
- Mid Spine Acceleration
- Lower Spine Acceleration
- Upper Sternum Acceleration
- Lower Sternum Acceleration
- Lower Rib @ Spine Acceleration

The 27 channels of data were recorded on an on-board data acquisition system. Appendix B contains the dummy data traces.

The Hybrid III 3-Year-Old child dummy's visible contact points were as follows:

- Curtain airbag to top of head, right side of head
- Torso/Pelvis bag to right shoulder and right torso

The Hybrid III 3-Year-Old child dummy was placed in the right front passenger seat along the outboard edge of the 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/side trim. The head remained in its neutral orientation. The legs were aligned so that the heels were placed on the placement points that were previously marked on the seat cushion. The feet were held in place and the pelvis slid forward and parallel to the centerline of the vehicle until the dummy's head/neck junction was aligned vertically with the top edge of the airbag module. The heels were then repositioned and placed at the heel placement points. With the vehicle door closed, the dummy's outboard arm was raised to clear the armrest and the pelvis and upper torso was slid outboard until the pelvis or torso contacted the door. The outboard arm was placed on the armrest. The inboard arm was flexed so that the upper arm contacted the seat back and the fingertips contacted the foam block.

The dummy's skullcap seam was taped with 4mm electrical tape to prevent the airbag from getting caught in the seam. The dummy's headskin was cleaned with alcohol and dusted with baby powder to achieve acceptable frictional characteristics.

This orientation complies with Section 3.3.3.1 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**  
**OCCUPANT AND VEHICLE INFORMATION / DATA SHEETS**

**DATA SHEET NO. 1**  
**TEST SUMMARY**

|                     | Test Data                   | Description                  |
|---------------------|-----------------------------|------------------------------|
| Seating Position    | P2                          | Right Front Seating Position |
| Test                | 3.3.3.1*                    | Forward-facing child dummy   |
| Curtain Airbag      | Roof-Rail Mounted           | Side Airbag                  |
| Torso Airbag        | Seat Mounted                | Side Airbag                  |
| ATD Type/Serial No. | Hybrid III 3 Year Old / 082 | Child Dummy                  |

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

|                            |    |
|----------------------------|----|
| Number of Data Channels    | 27 |
| Number of Airbag Channels  | 4  |
| Number of High-Speed Video | 3  |

| Visible Dummy Contact Points |                                              |
|------------------------------|----------------------------------------------|
| Head Contact                 | Curtain airbag to top and right side of head |
| Right Shoulder Contact       | Torso/Pelvis bag                             |
| Right Torso Contact          | Torso/Pelvis bag                             |
| Right Pelvis Contact         | None                                         |

**DATA SHEET NO. 2****TEST VEHICLE INFORMATION**

Please note that this vehicle had previously been tested in an  
NCAP Frontal Impact on December 10, 2010.

**TEST VEHICLE INFORMATION**

|                                                         |                      |
|---------------------------------------------------------|----------------------|
| Manufacturer                                            | Volvo                |
| Model                                                   | XC60                 |
| Body Style                                              | MPV                  |
| NHTSA No.                                               | MB5902TWG2           |
| VIN                                                     | YV4952DZ4B2148976    |
| Color                                                   | Savile Grey Metallic |
| Delivery Date                                           | 9/13/2010            |
| Odometer Reading (mile)                                 | 85                   |
| Dealer                                                  | Jenkins Import Inc.  |
| Transmission                                            | Automatic            |
| Final Drive                                             | AWD                  |
| Number of Cylinders                                     | 6                    |
| Engine Displacement (L)                                 | 3.2                  |
| Engine Placement                                        | Lateral              |
| Automatic Door Lock (ADL)                               | Yes                  |
| Owners Manual Details<br>Instructions on Disabling ADLs | Yes                  |
| Bucket Seats                                            | Yes                  |

**TEST VEHICLE OPTIONS**

|                                    |     |
|------------------------------------|-----|
| Driver Front Airbag                | Yes |
| Driver Side Curtain Airbag         | Yes |
| Driver Side Torso Airbag           | Yes |
| Rear Passenger Side Curtain Airbag | Yes |
| Rear Passenger Side Torso Airbag   | No  |
| Force Limiter                      | Yes |
| Pretensioner                       | Yes |
| Power Steering                     | Yes |
| Power Door Locks                   | Yes |
| Tilt Wheel                         | Yes |
| Air Conditioning                   | Yes |
| Anti-lock Brakes                   | Yes |
| Traction Control                   | Yes |
| All Wheel Drive                    | Yes |
| Power Seats                        | Yes |

**DATA FROM CERTIFICATION LABEL**

|                     |                       |
|---------------------|-----------------------|
| Manufactured By     | Volvo Car Corporation |
| Date of Manufacture | 07/10                 |

|                 |      |
|-----------------|------|
| GVWR (kg)       | 2429 |
| GAWR Front (kg) | 1270 |
| GAWR Rear (kg)  | 1198 |

| Measured Parameter      | Front  | Rear        | Third | Total |
|-------------------------|--------|-------------|-------|-------|
| Type of Seats           | Bucket | Split Bench |       |       |
| Number of Occupants     | 2      | 3           |       | 5     |
| Capacity Wt. (VCW) (kg) |        |             |       | 430   |
| Cargo Wt. (RCLW) (kg)   |        |             |       | 90    |

**DATA SHEET NO. 3**  
**DUMMY POSITIONING IN VEHICLE**

| Measurement                                        |           | Value    |
|----------------------------------------------------|-----------|----------|
| Seat Position                                      |           | Rearmost |
| Seat Height Position                               |           | Lowest   |
| Placed in Position No. 2                           |           | ---      |
| Seat Back Angle (at headrest post)                 | SA (°)    | 19       |
| Top of Curtain Airbag Module to Head/Neck Junction | AN (mm)   | 418      |
| Top of Seat Module to Head/Neck Junction           | AN (mm)   | 18       |
| Head CG to Door Panel/Window                       | HD (mm)   | 274      |
| Head to Seat Back Centerline                       | HSC (mm)  | 181      |
| Chest to Dash                                      | CD (mm)   | 722      |
| Chest to Seatback                                  | CS (mm)   | 186      |
| Right Arm to Seat Back Centerline                  | RACL (mm) | 300      |
| Left Arm to Seat Back Centerline                   | LACL (mm) | 105      |
| Right Arm to Door Panel                            | RA (mm)   | Contact  |
| Left Arm to B-Post                                 | LA (mm)   | 196      |
| Knee to Knee                                       | KK (mm)   | 122      |
| Toe to Toe                                         | TT (mm)   | 114      |
| Right Knee to Seat Cushion Centerline              | KSCR (mm) | 110      |
| Left Knee to Seat Cushion Centerline               | KSCL (mm) | 18       |
| Right Toe to Seat Cushion Centerline               | TSCR (mm) | 25       |
| Left Toe to Seat Cushion Centerline                | TSCL (mm) | 72       |
| Nose to Dash                                       | ND (mm)   | 731      |
| Nose to Seatback                                   | NS (mm)   | 260      |
| Top of Head to Headliner                           | HH (mm)   | 272      |

**DATA SHEET NO. 4**  
**DUMMY INJURY CRITERIA VALUES**

**NHTSA No. MB5902TWG2**

| DESCRIPTION            | UNIT | MAXIMUM VALUE  |           |         |           |
|------------------------|------|----------------|-----------|---------|-----------|
|                        |      | Position No. 2 |           |         |           |
|                        |      | MAXIMUM        | TIME (ms) | MINIMUM | TIME (ms) |
| Head X                 | g    | 38.4           | 13.2      | -5.8    | 25.9      |
| Head Y                 | g    | 2.6            | 58.9      | -33.4   | 12.4      |
| Head Z                 | g    | 22.3           | 17.5      | -15.4   | 11.7      |
| Head Resultant         | g    | 50.0           | 12.4      |         |           |
| Upper Neck Fx          | N    | 429.0          | 10.3      | -155.6  | 275.8     |
| Upper Neck Fy          | N    | 76.5           | 61.0      | -328.1  | 22.5      |
| Upper Neck Fz          | N    | 534.3          | 17.2      | -335.5  | 4.6       |
| Upper Neck F Resultant | N    | 657.6          | 17.2      |         |           |
| Upper Neck Mx          | Nm   | 10.1           | 10.1      | -26.0   | 17.8      |
| Upper Neck My          | Nm   | 25.5           | 12.5      | -9.3    | 46.7      |
| Upper Neck Mz          | Nm   | 10.4           | 287.5     | -19.8   | 29.9      |
| Upper Neck M Resultant | Nm   | 31.9           | 17.0      |         |           |
| Lower Neck Fx          | N    | 709.8          | 12.7      | -115.0  | 281.7     |
| Lower Neck Fy          | N    | 71.8           | 60.1      | -493.7  | 10.5      |
| Lower Neck Fz          | N    | 429.1          | 17.4      | -360.0  | 4.3       |
| Lower Neck F Resultant | N    | 810.7          | 10.7      |         |           |
| Lower Neck Mx          | Nm   | 12.8           | 60.5      | -47.7   | 22.5      |
| Lower Neck My          | Nm   | 12.9           | 300.0     | -32.6   | 12.8      |
| Lower Neck Mz          | Nm   | 11.2           | 287.4     | -8.2    | 50.9      |
| Lower Neck M Resultant | Nm   | 52.1           | 21.9      |         |           |
| Upper Spine X          | G    | 40.7           | 7.2       | -11.6   | 272.0     |
| Upper Spine Y          | G    | 15.9           | 22.5      | -37.9   | 7.5       |
| Upper Spine Z          | G    | 12.8           | 272.4     | -22.2   | 10.6      |
| Upper Spine Resultant  | G    | 55.9           | 7.4       |         |           |
| Mid Spine X            | G    | 45.6           | 6.1       | -7.1    | 272.6     |
| Mid Spine Y            | G    | 10.3           | 23.4      | -28.9   | 8.5       |
| Mid Spine Z            | G    | 11.6           | 6.5       | -4.3    | 12.0      |
| Mid Spine Resultant    | G    | 53.1           | 6.4       |         |           |
| Lower Spine X          | G    | 61.6           | 5.9       | -6.6    | 288.4     |
| Lower Spine Y          | G    | 7.2            | 24.7      | -38.4   | 6.5       |
| Lower Spine Z          | G    | 7.3            | 277.7     | -14.0   | 5.7       |
| Lower Spine Resultant  | G    | 73.2           | 6.0       |         |           |
| Upper Sternum X        | G    | 88.7           | 7.7       | -31.6   | 4.0       |
| Lower Sternum X        | G    | 123.3          | 7.7       | -24.8   | 25.8      |
| Lower Rib @ Spine X    | G    | 59.3           | 4.1       | -6.3    | 24.6      |

**DATA SHEET NO. 4 (continued)**  
**DUMMY INJURY CRITERIA VALUES**

**NHTSA No. MB5902TWG2**

| ATD position         | HEAD INJURY CRITERIA (HIC) |                          |                          |       |                          |                          |
|----------------------|----------------------------|--------------------------|--------------------------|-------|--------------------------|--------------------------|
|                      | HIC15                      |                          |                          | HIC36 |                          |                          |
|                      | HIC                        | T <sup>1</sup><br>(msec) | T <sup>2</sup><br>(msec) | HIC   | T <sup>1</sup><br>(msec) | T <sup>2</sup><br>(msec) |
| No. 2<br>Right Front | 65.2                       | 9.7                      | 19.4                     | 65.2  | 9.7                      | 19.4                     |

**Position 2 Neck Injury Summary (3-Year-Old – Out-Of-Position)**

|                                   | Nij            | Time (msec) | Z Force (N)<br>(CFC 600)               | X Force (N)<br>(CFC 600) | Y Moment (N-m)<br>(CFC 600) |
|-----------------------------------|----------------|-------------|----------------------------------------|--------------------------|-----------------------------|
| Ntf                               | 0.50           | 17.0        | 513.01                                 | 373.29                   | 17.84                       |
| Nte                               | 0.49           | 275.7       | 330.48                                 | -155.27                  | -9.08                       |
| Ncf                               | 0.38           | 14.1        | -159.48                                | 333.29                   | 20.89                       |
| Nce                               | 0.28           | 37.7        | -54.01                                 | 23.31                    | -6.86                       |
| <b>Peak Tension<br/>(CFC1000)</b> | <b>534.3 N</b> |             | <b>Peak Compression<br/>(CFC 1000)</b> |                          | <b>-335.5 N</b>             |

**Critical Values**

| Nij Intercepts    |        |                  |        | Peak Limits |        |
|-------------------|--------|------------------|--------|-------------|--------|
| Tension (CVt)     | 2120 N | Extension (mCVe) | 27 N-m | Tension     | 1130 N |
| Compression (CVc) | 2120 N | Flexion (mCVf)   | 68 N-m | Compression | 1380 N |

**APPENDIX A**  
**PHOTOGRAPHS**

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Right ¾ Front View of Vehicle, As Received



Vehicle Certification Placard



Pre-Test Vehicle Left Side View



Post-Test Vehicle Left Side View



Pre-Test 6-Year-Old Child Dummy Left Side View



Post-Test 6-Year-Old Child Dummy Left Side View



Pre-Test 6-Year-Old Child Dummy Left Side Closeup View



Post-Test 6-Year-Old Child Dummy Left Side Closeup View



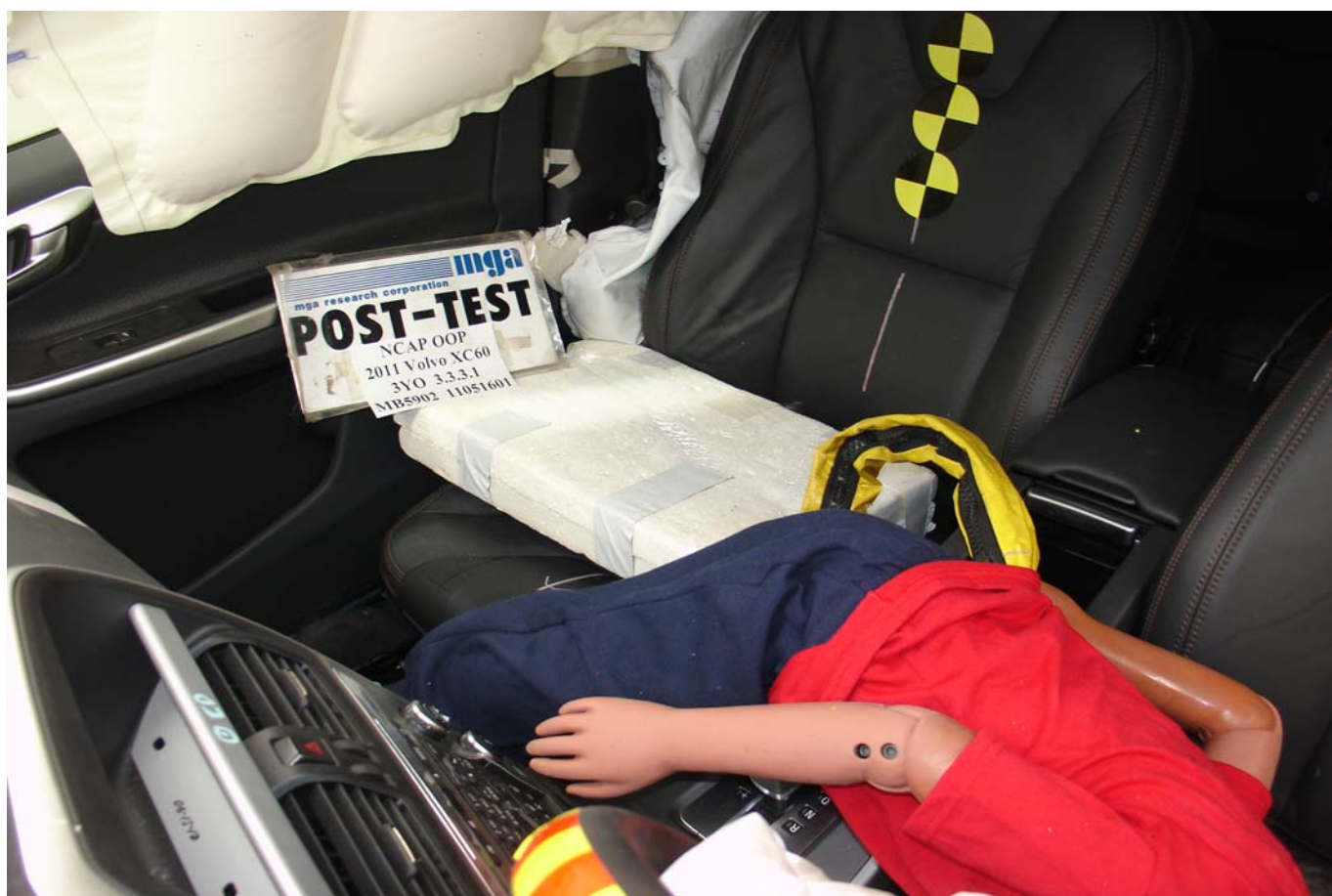
Pre-Test 6-Year-Old Child Dummy Left  $\frac{3}{4}$  Front View



Post-Test 6-Year-Old Child Dummy Left  $\frac{3}{4}$  Front View



Pre-Test 6-Year-Old Child Dummy Left  $\frac{3}{4}$  Front Closeup View



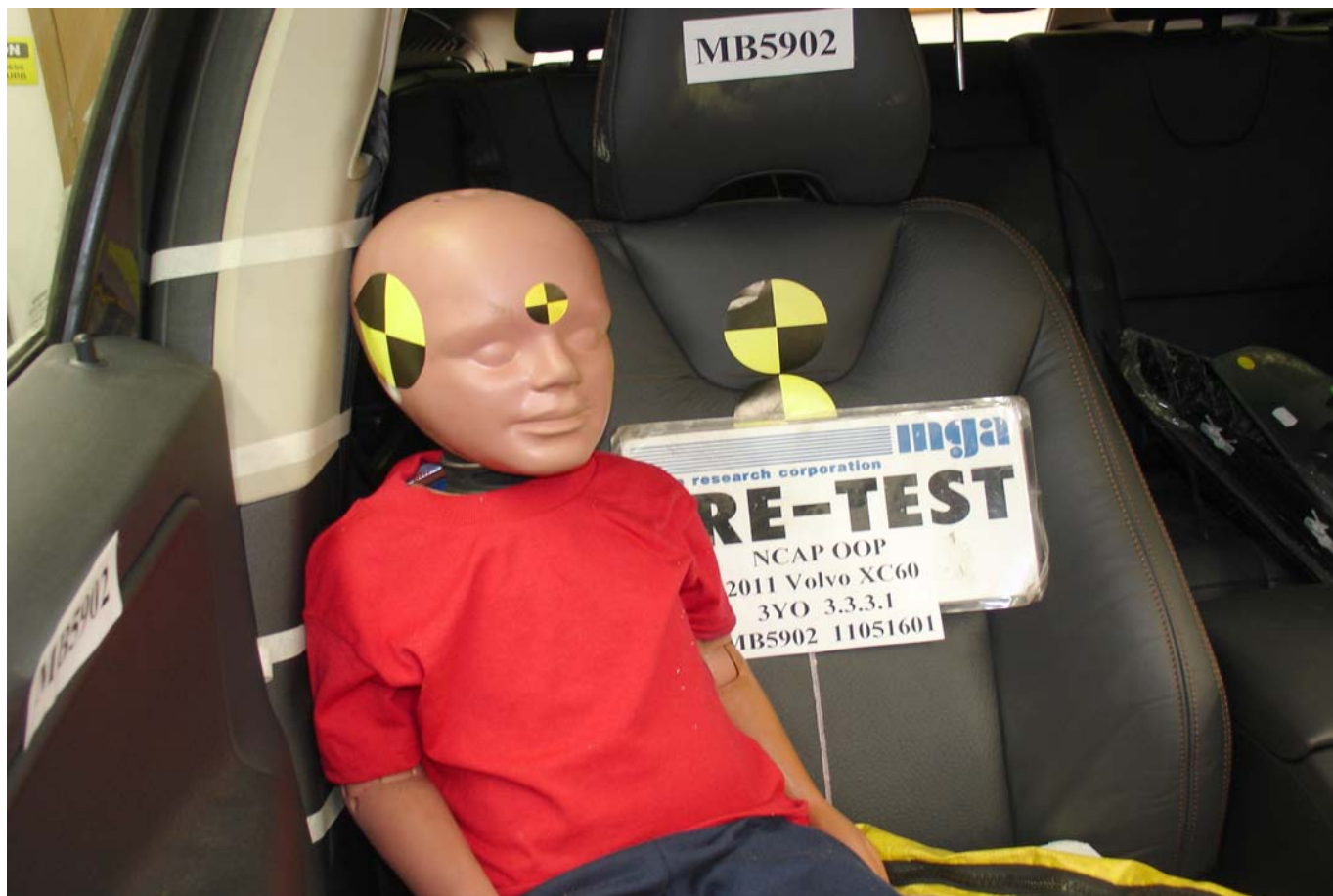
Post-Test 6-Year-Old Child Dummy Left  $\frac{3}{4}$  Front Closeup View



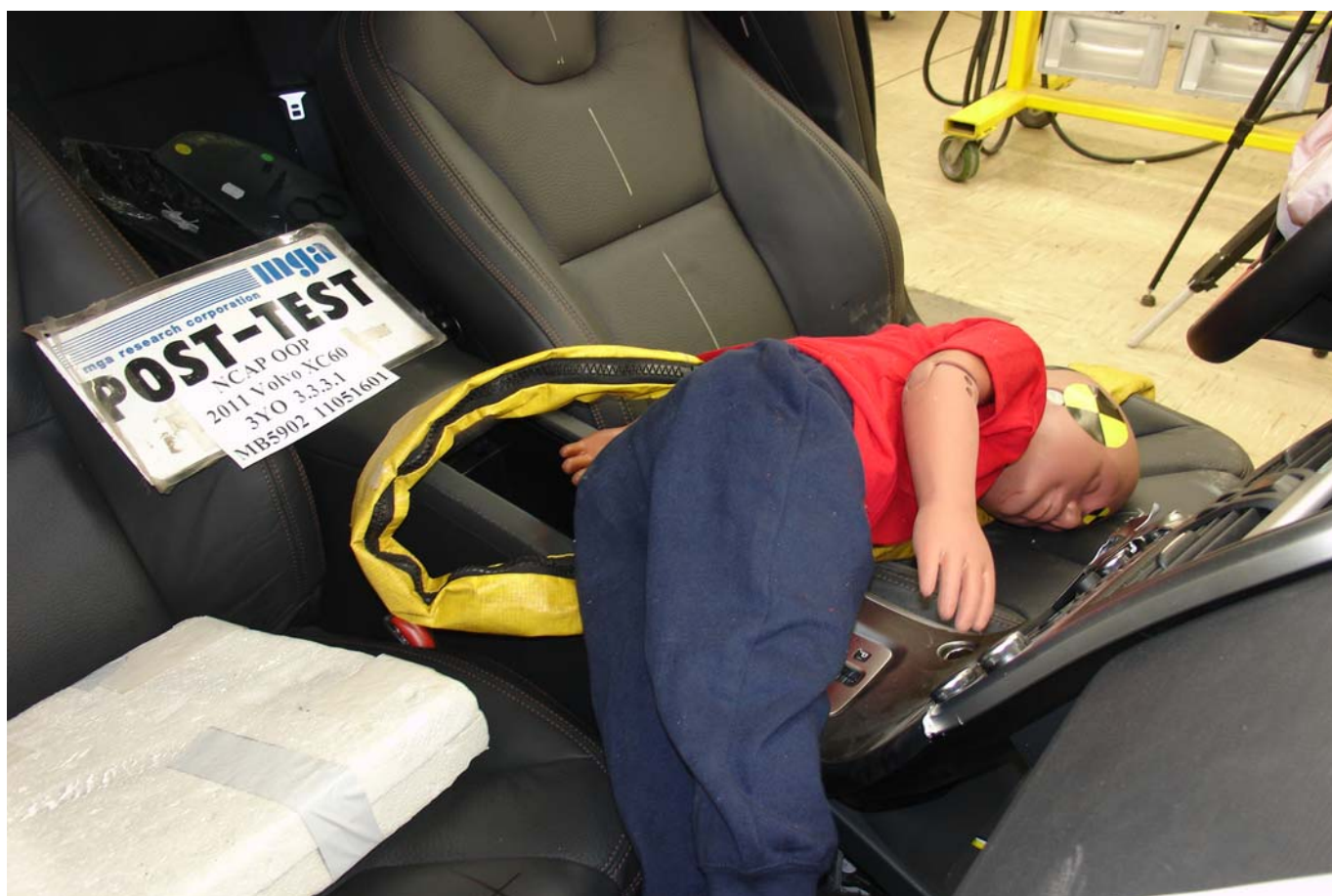
Pre-Test 6-Year-Old Child Dummy Front View



Post-Test 6-Year-Old Child Dummy Front View



Pre-Test 6-Year-Old Child Dummy Front Closeup View



Post-Test 6-Year-Old Child Dummy Front Closeup View



Pre-Test 6-Year-Old Child Dummy Right  $\frac{3}{4}$  Front View



Post-Test 6-Year-Old Child Dummy Right  $\frac{3}{4}$  Front View



Pre-Test 6-Year-Old Child Dummy Right Side View



Post-Test 6-Year-Old Child Dummy Right Side View



Post-Test Curtain Airbag Left View



Post-Test Curtain Airbag Left ¾ Front View



Post-Test Curtain Airbag Front View

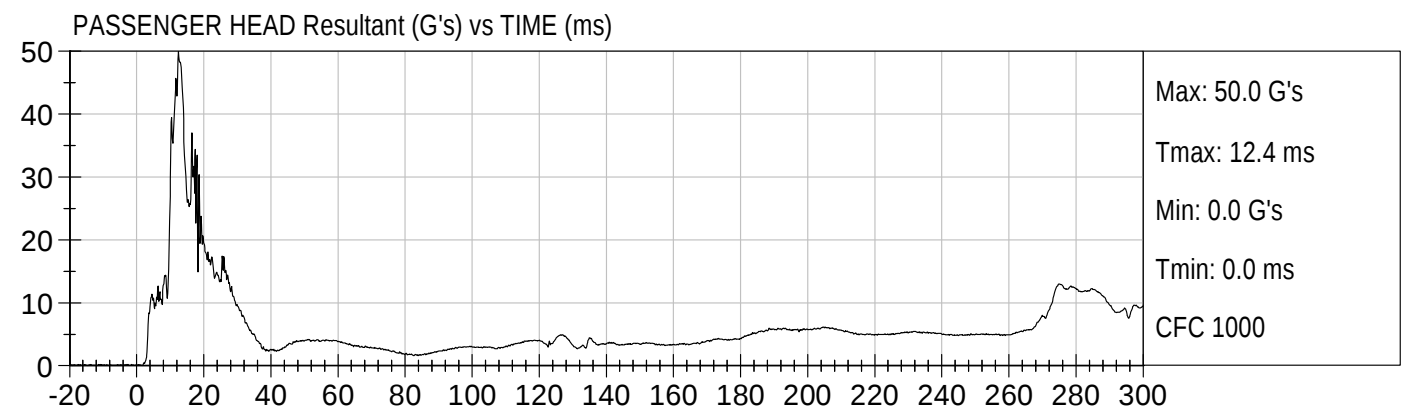
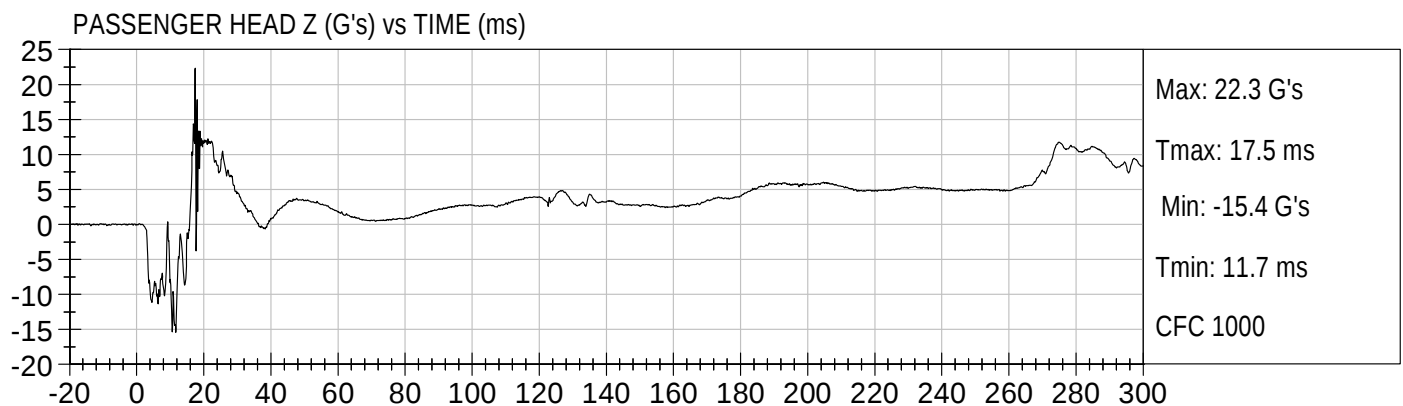
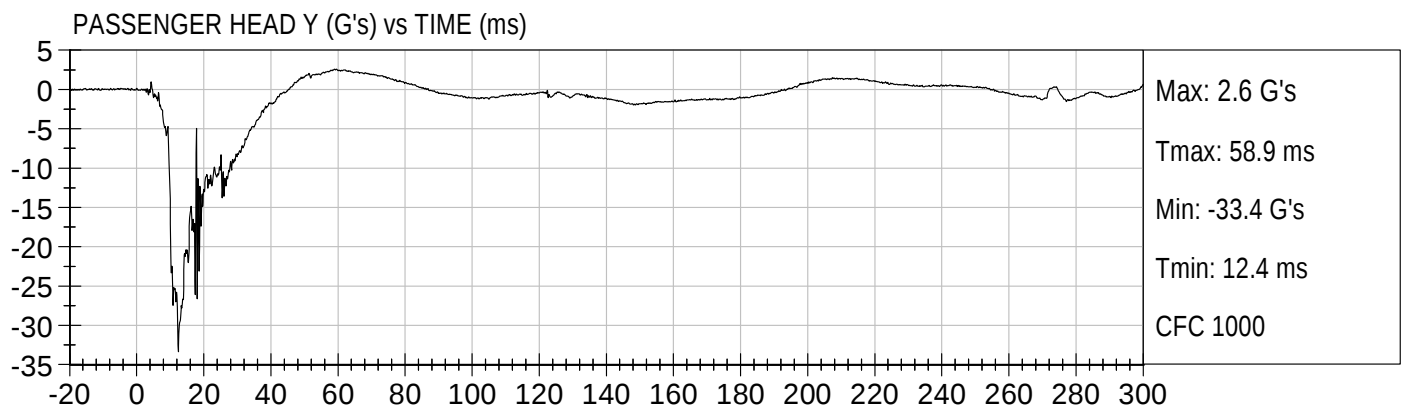
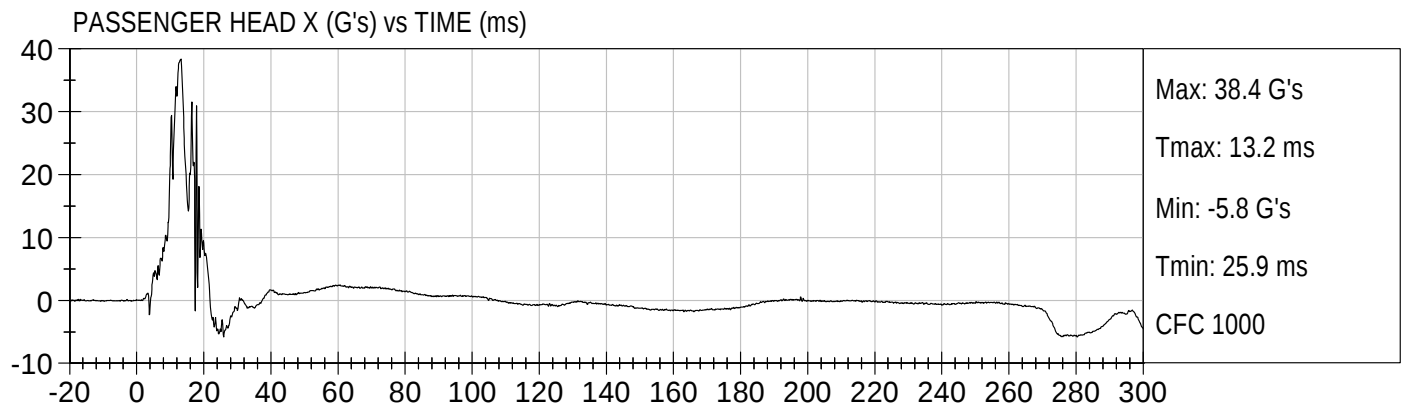
**APPENDIX B**

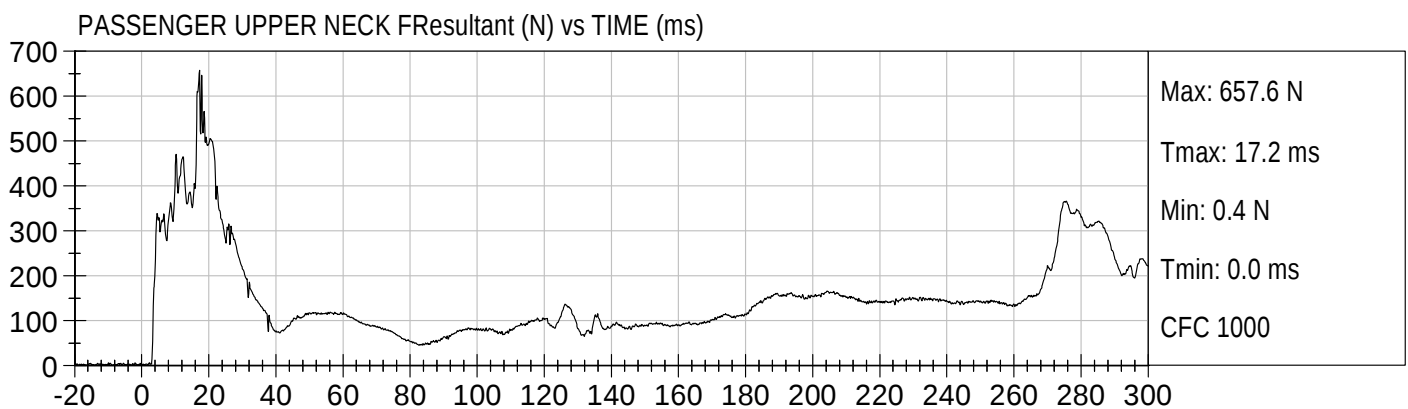
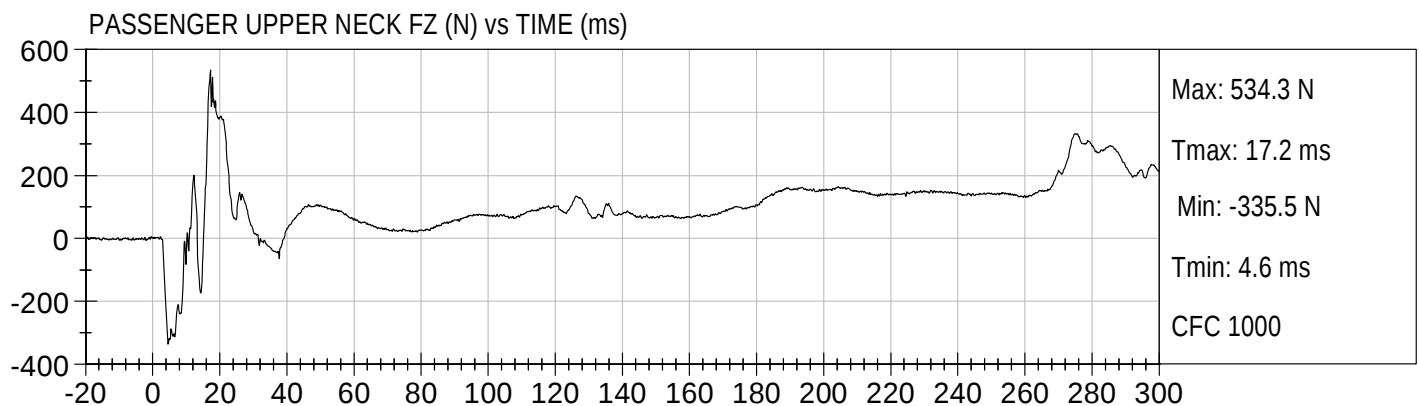
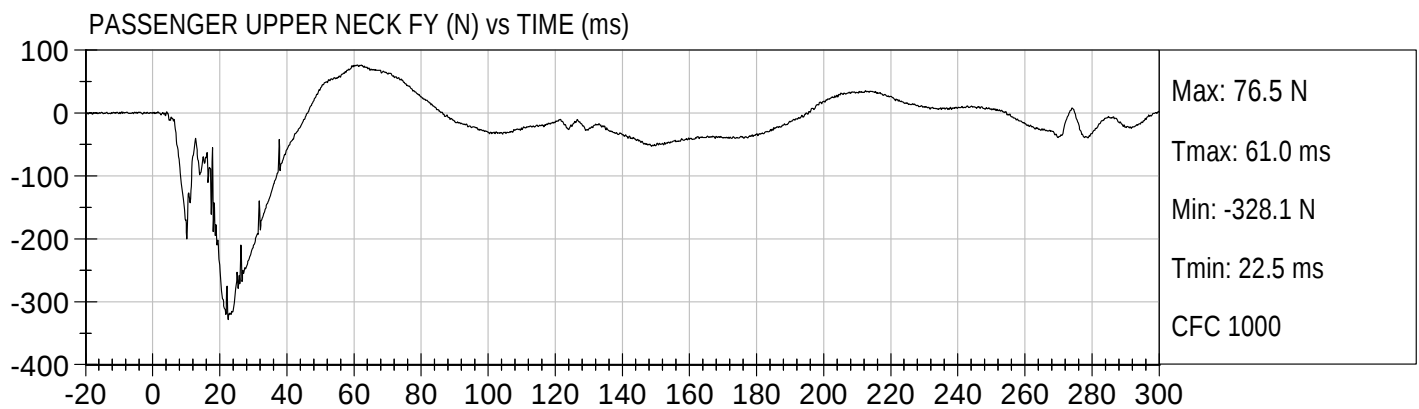
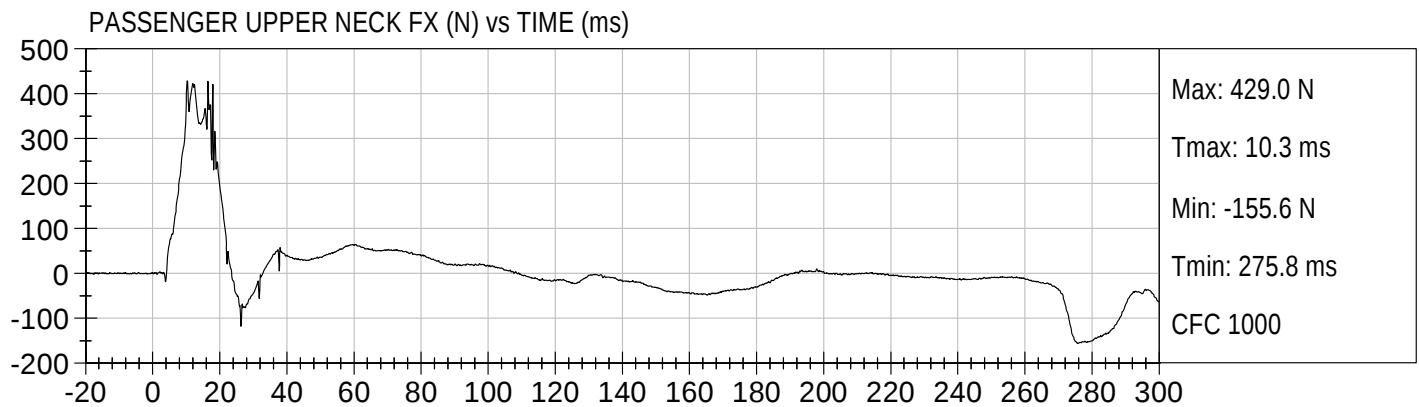
**DUMMY RESPONSE DATA TRACES**

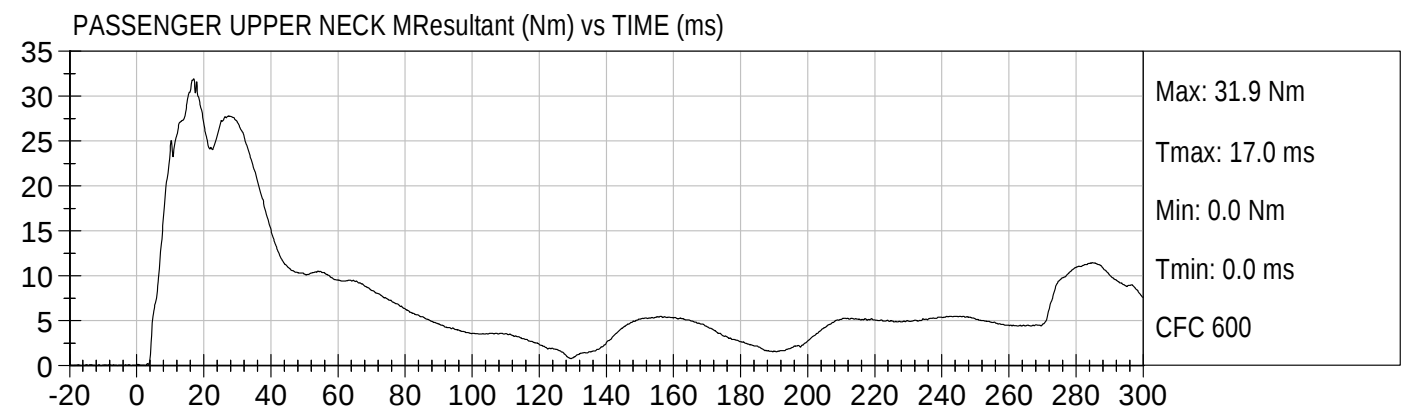
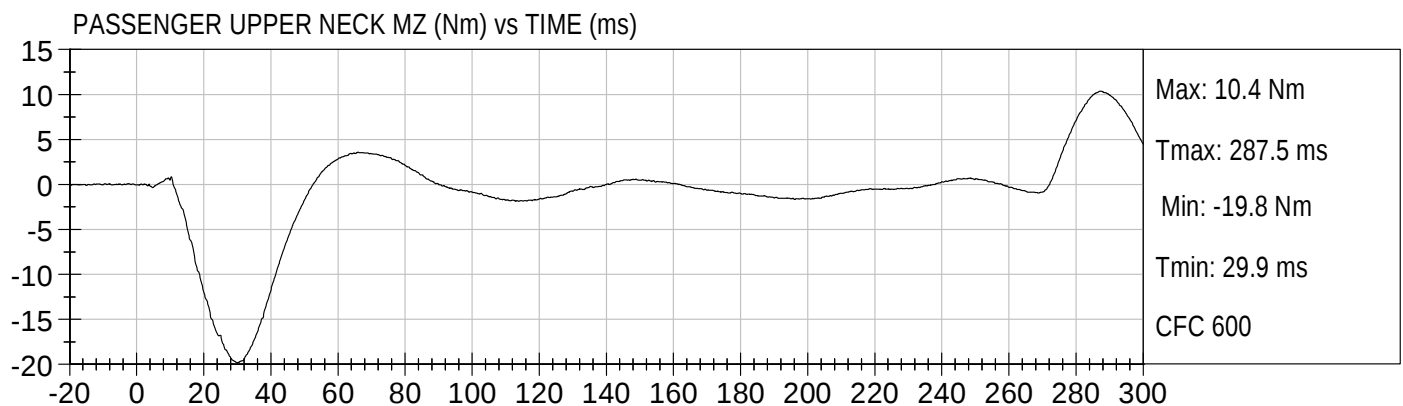
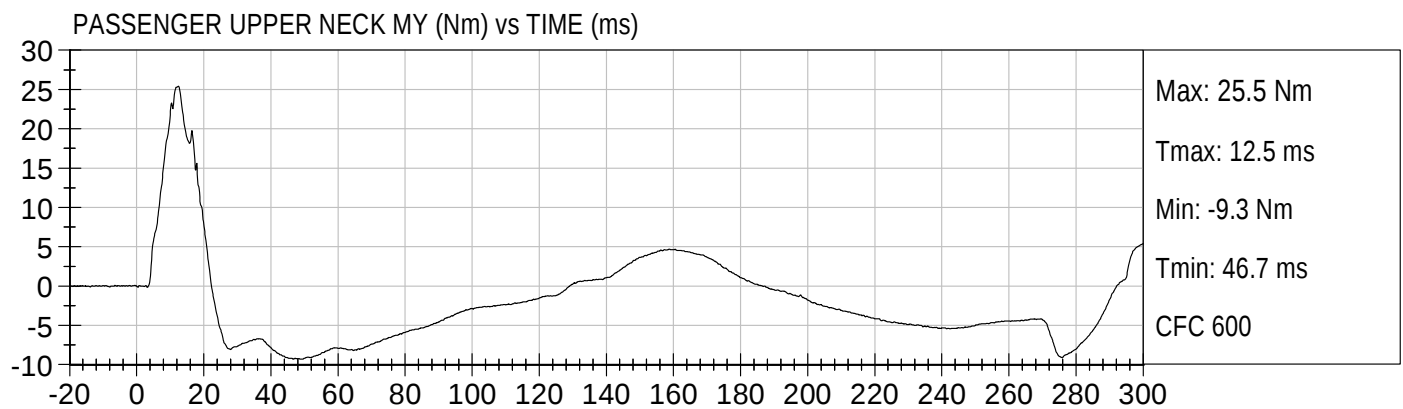
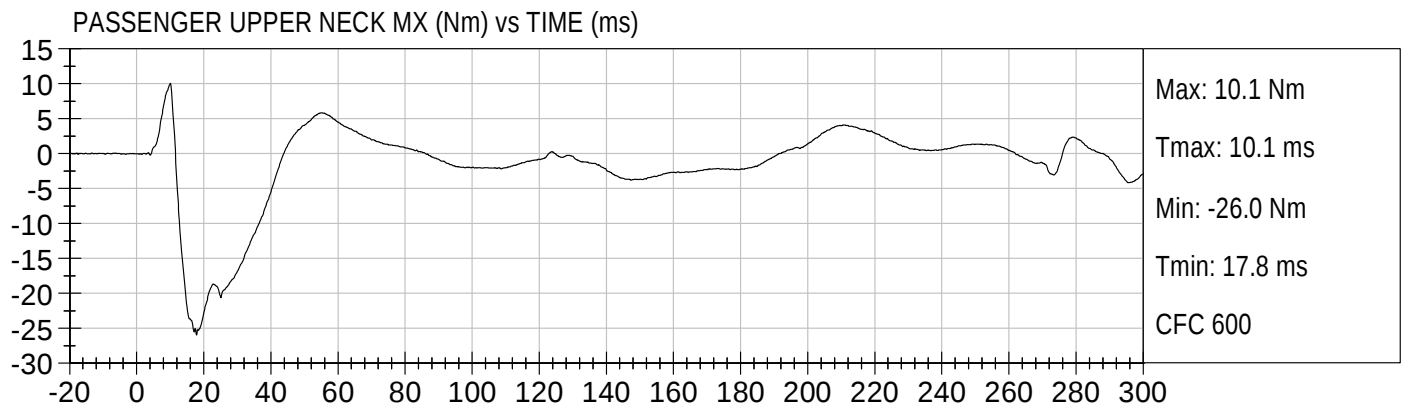
**TABLE OF DATA PLOTS**

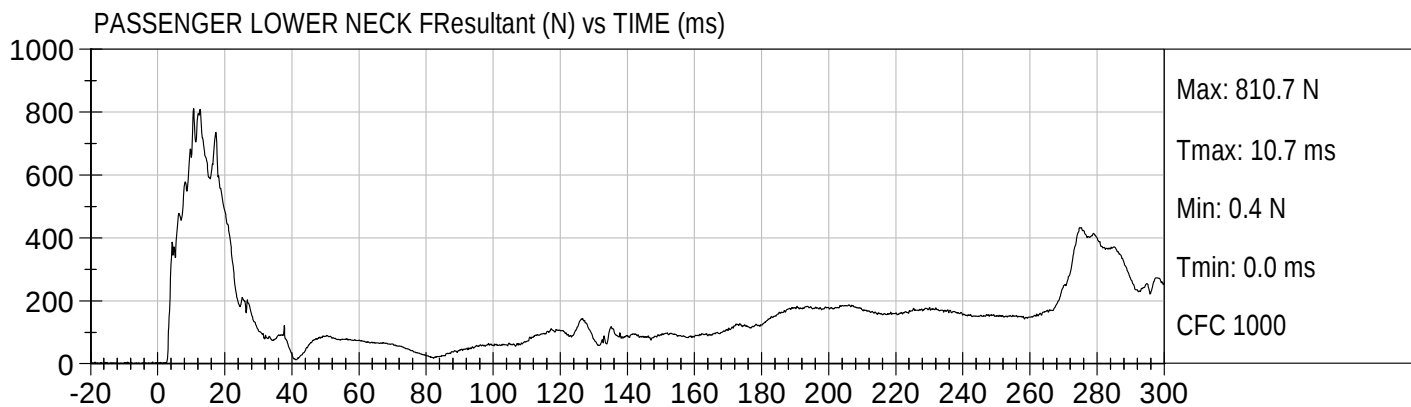
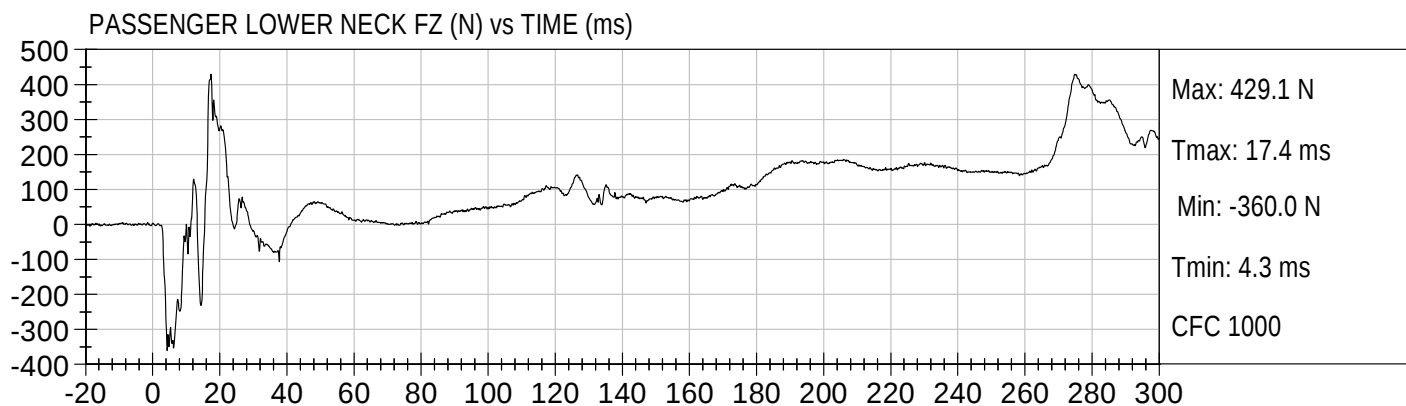
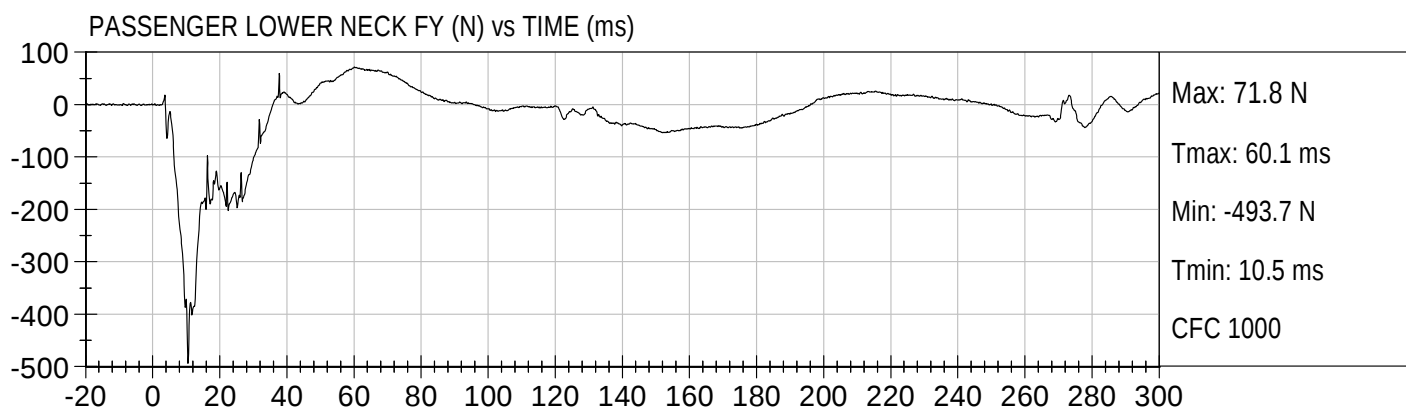
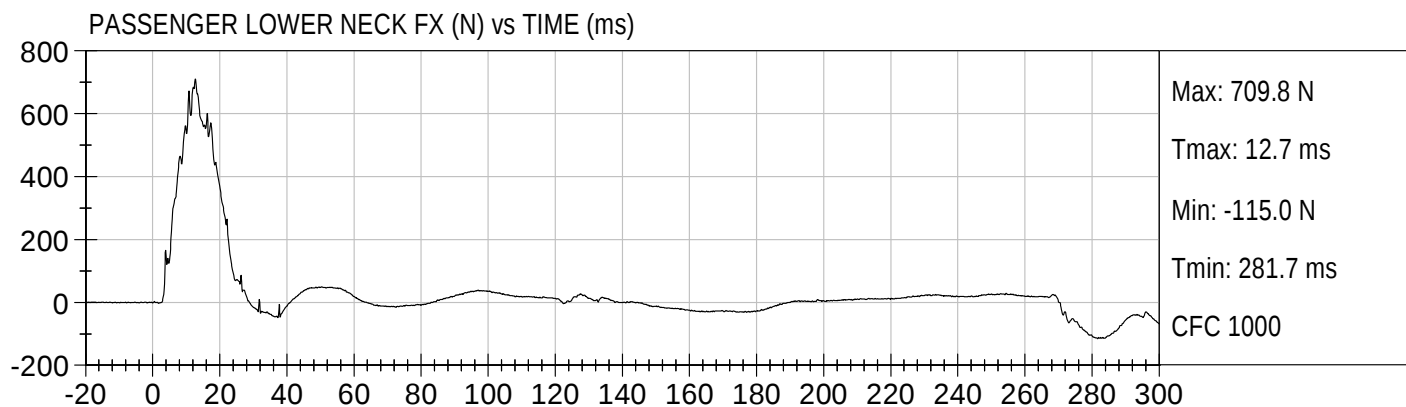
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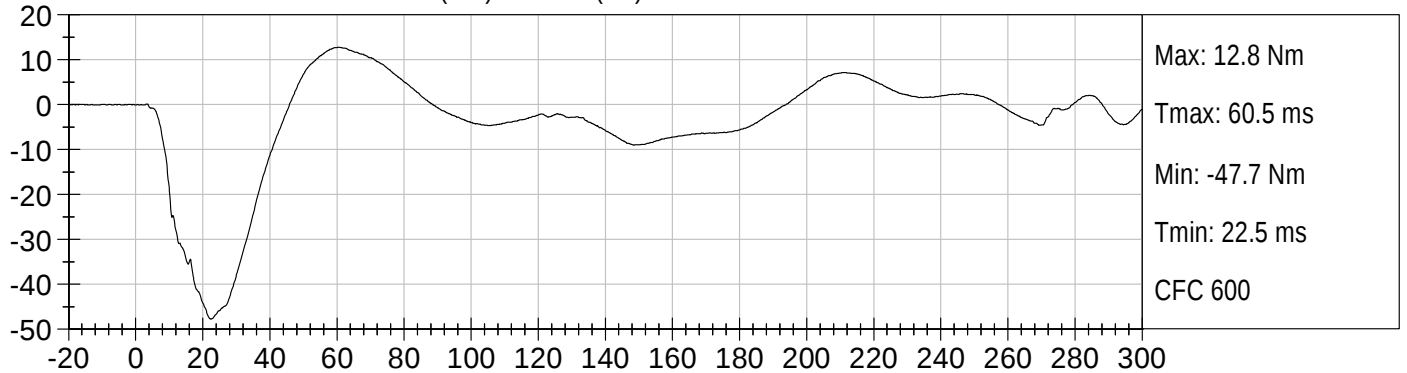




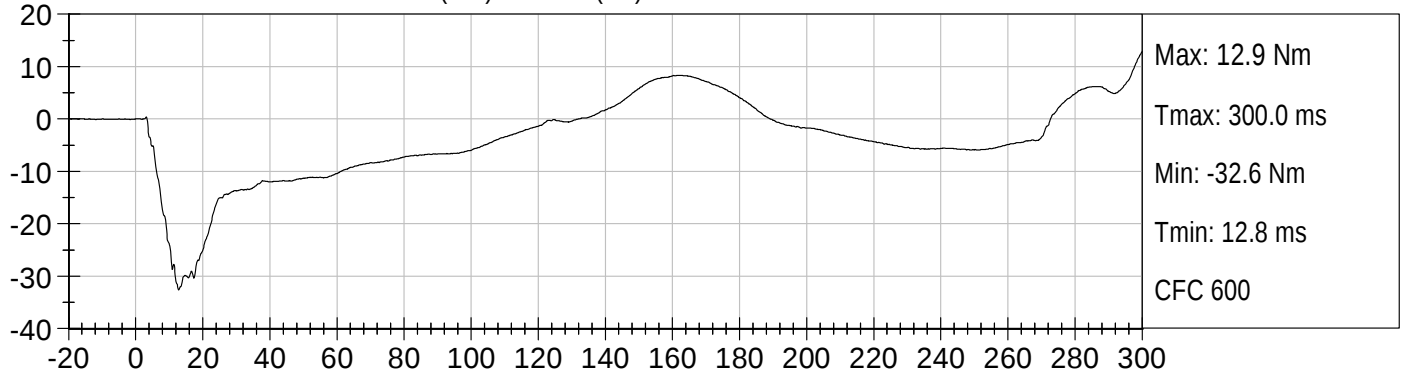




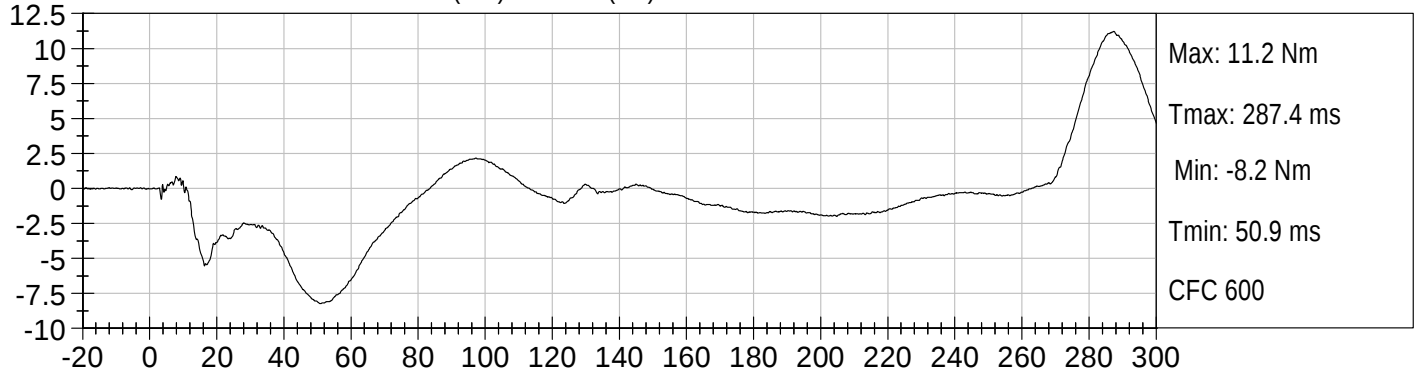
PASSENGER LOWER NECK MX (Nm) vs TIME (ms)



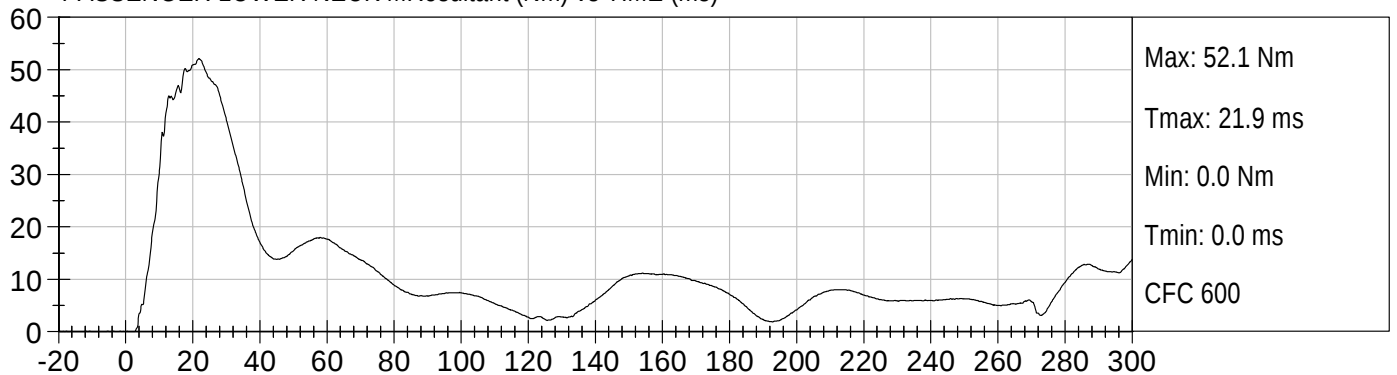
PASSENGER LOWER NECK MY (Nm) vs TIME (ms)

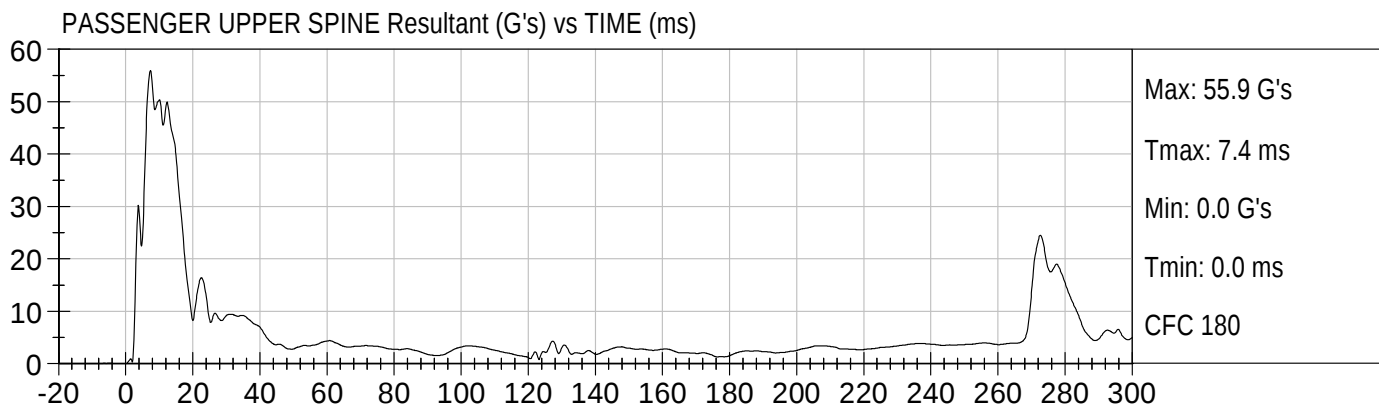
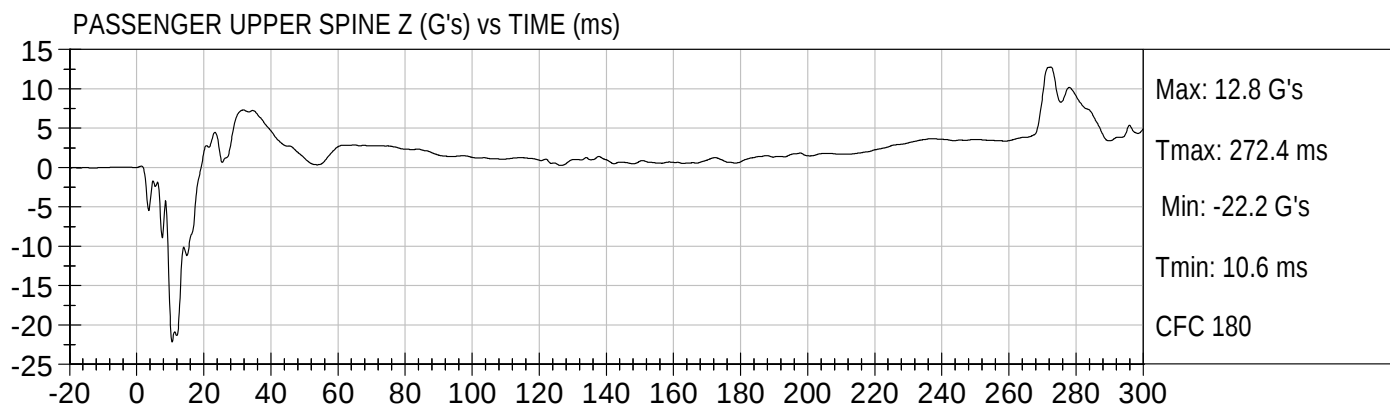
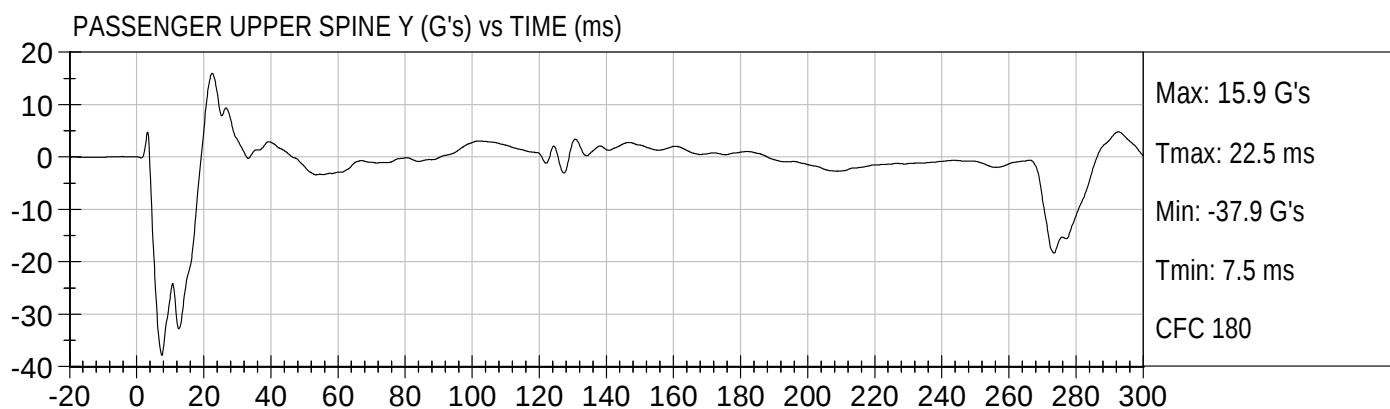
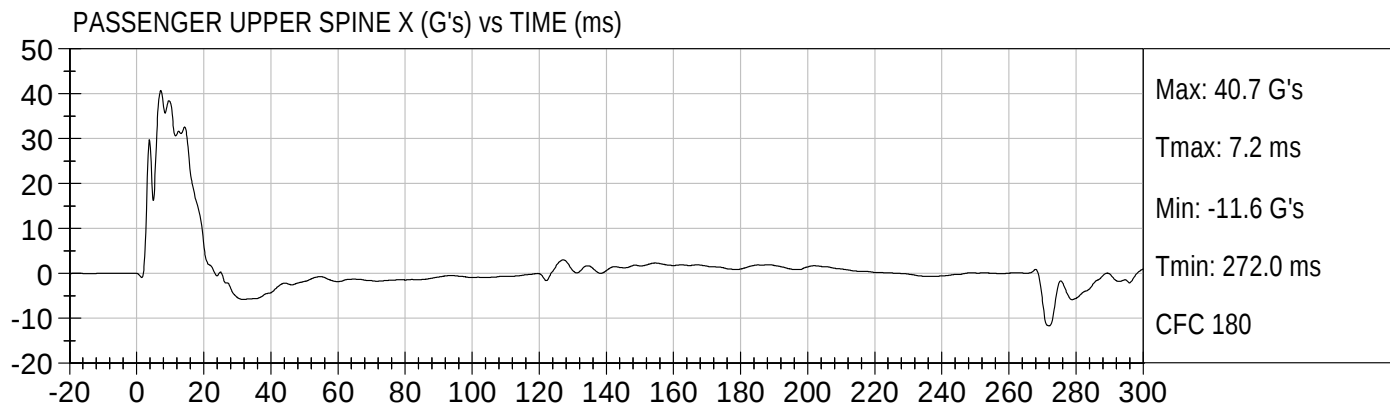


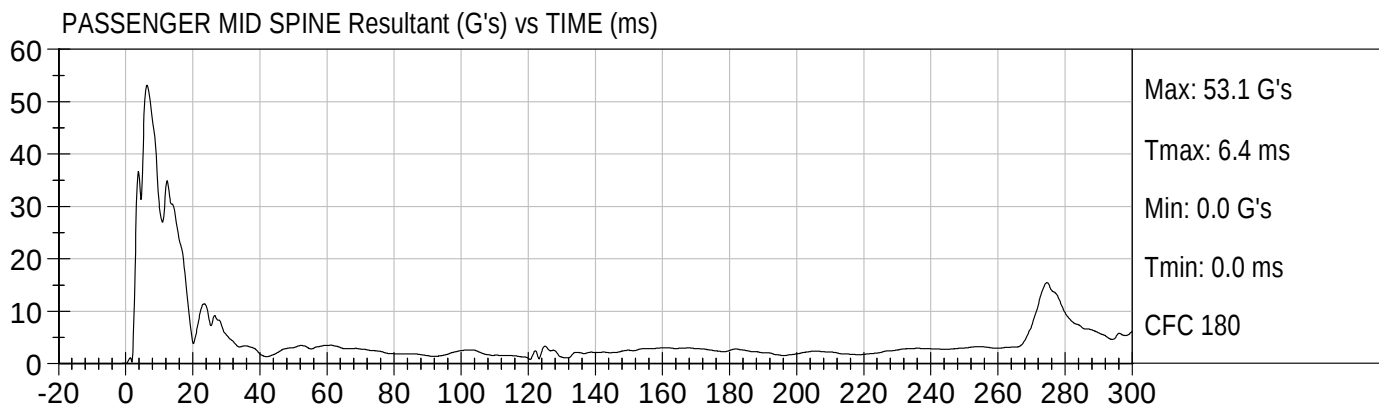
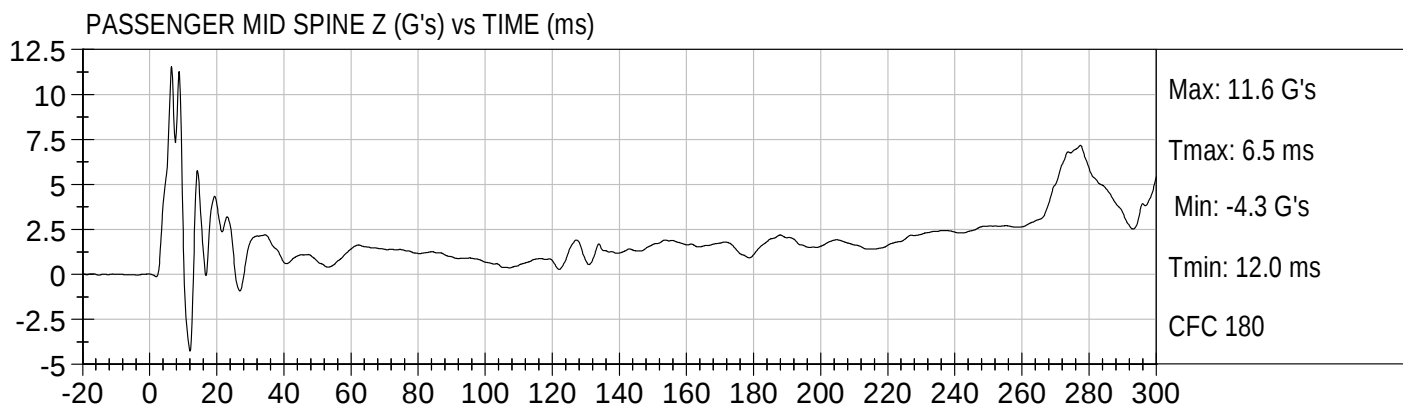
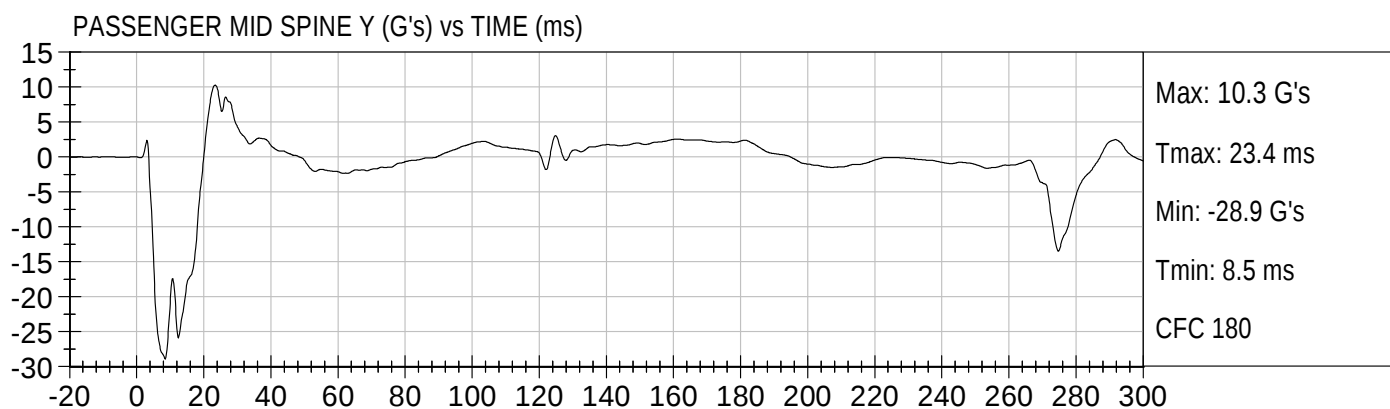
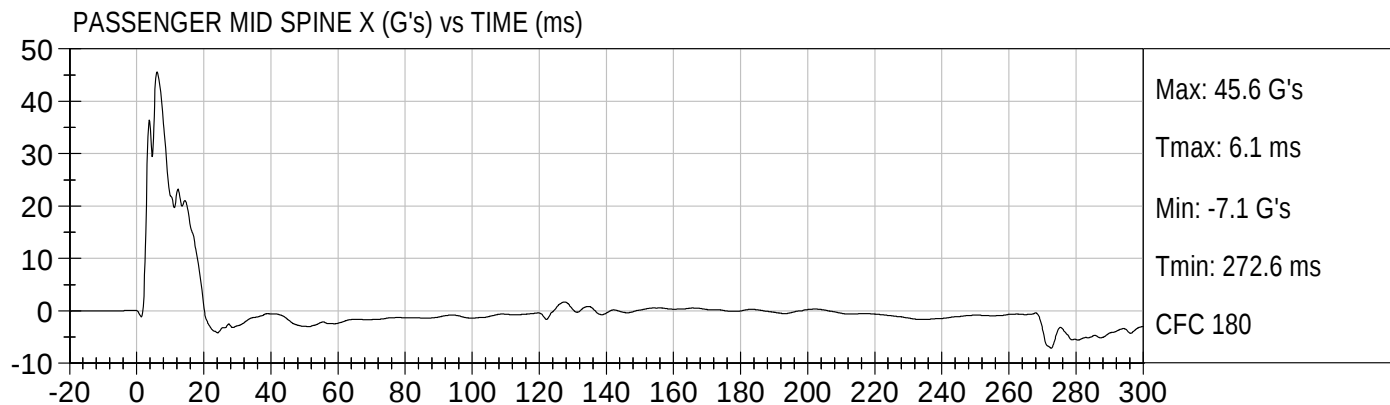
PASSENGER LOWER NECK MZ (Nm) vs TIME (ms)

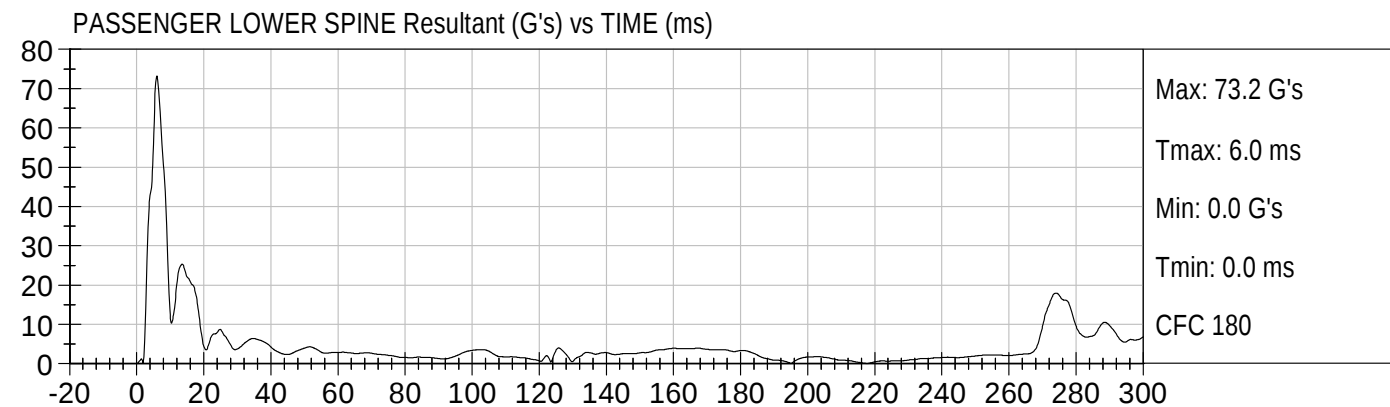
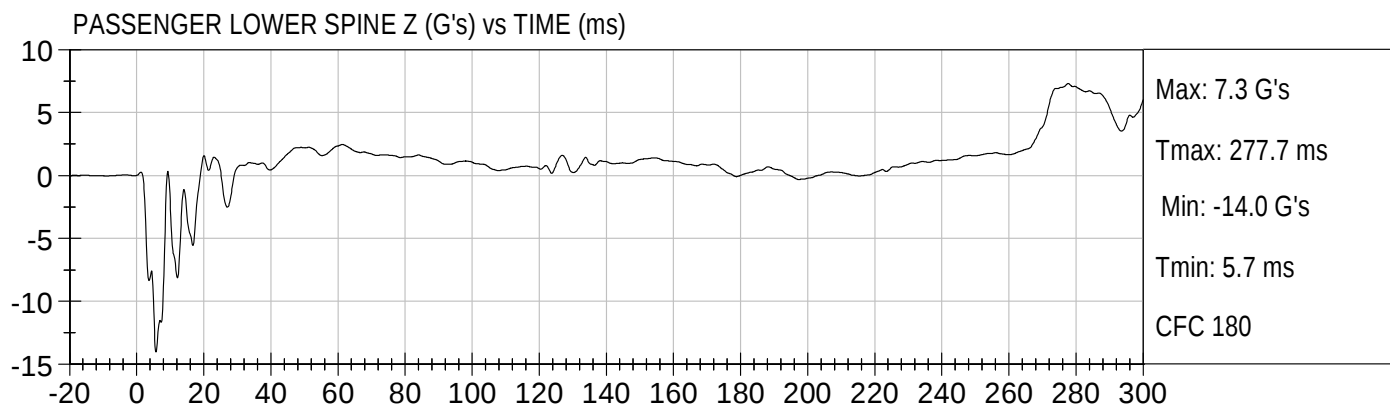
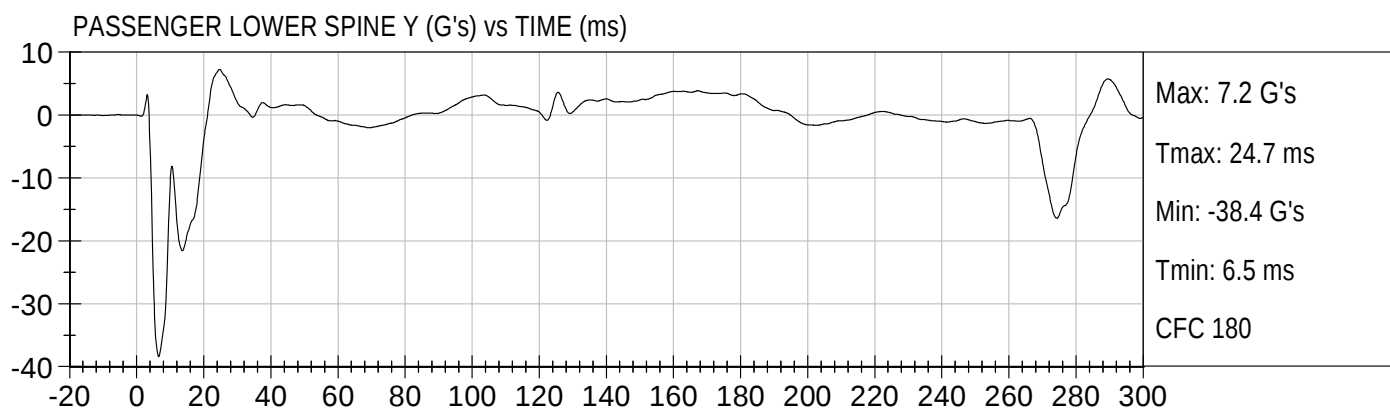
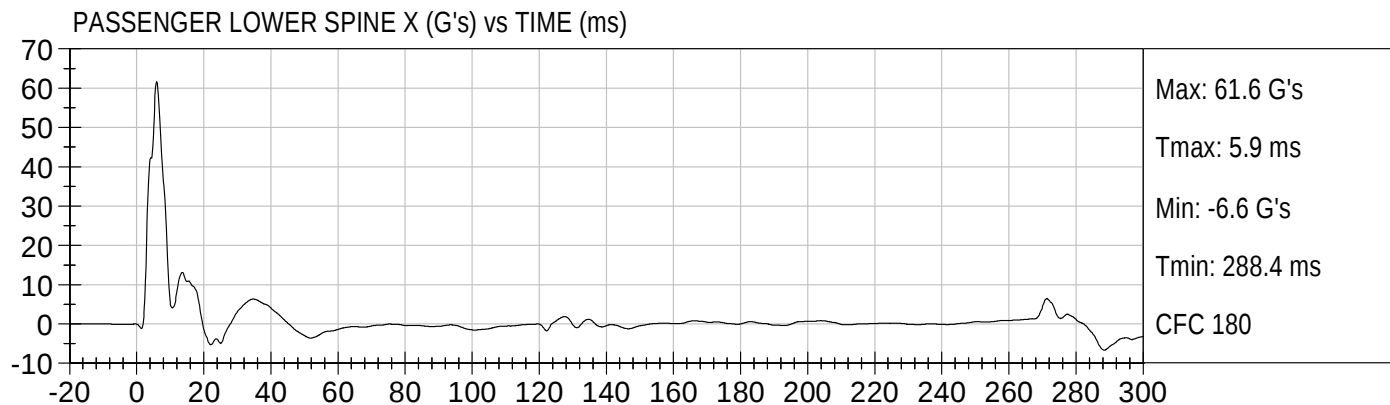


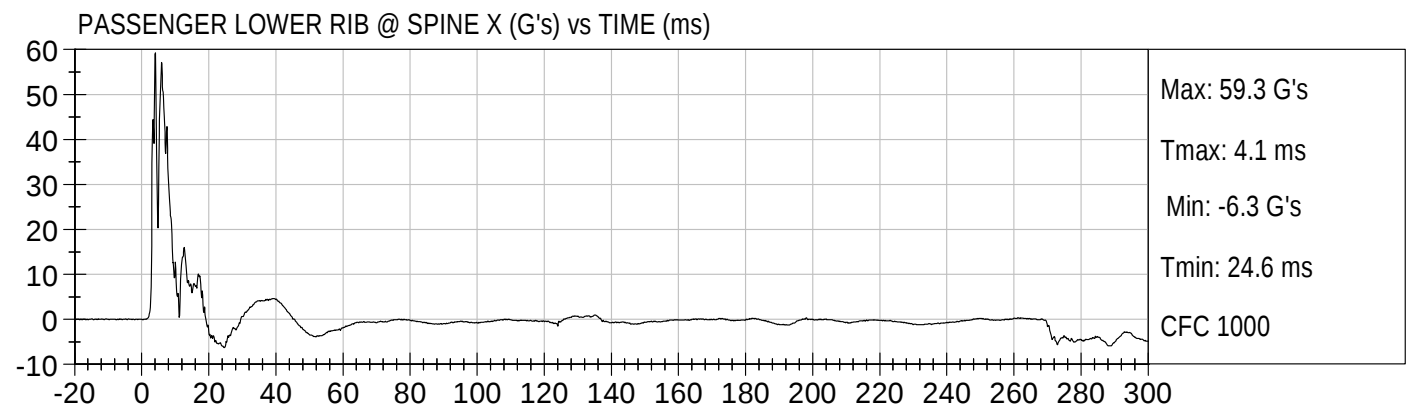
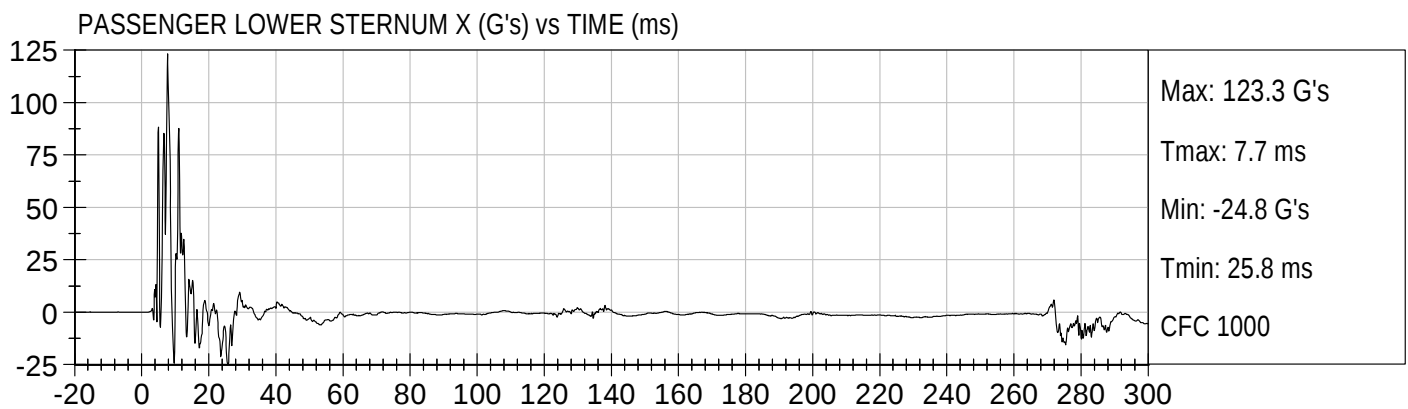
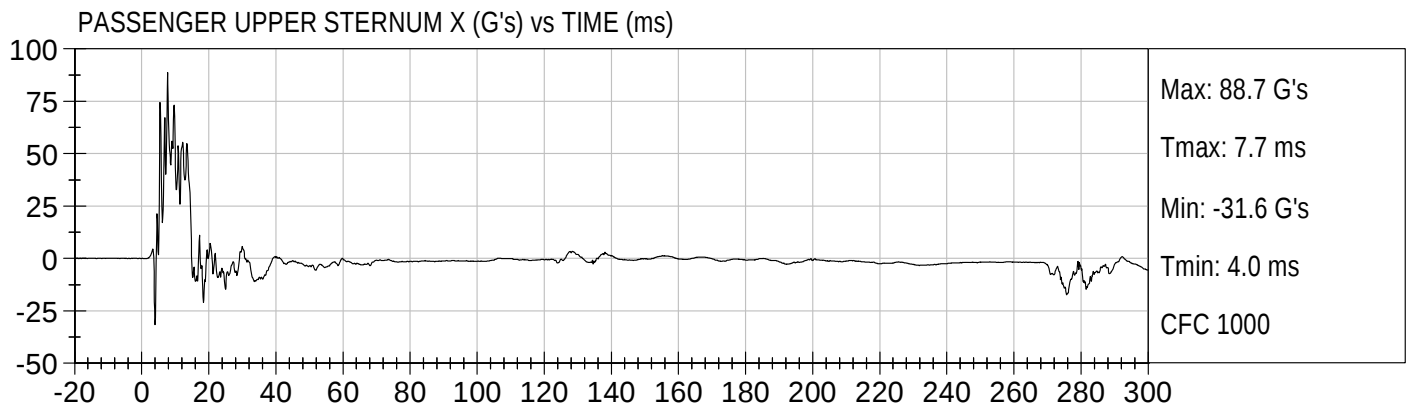
PASSENGER LOWER NECK MResultant (Nm) vs TIME (ms)





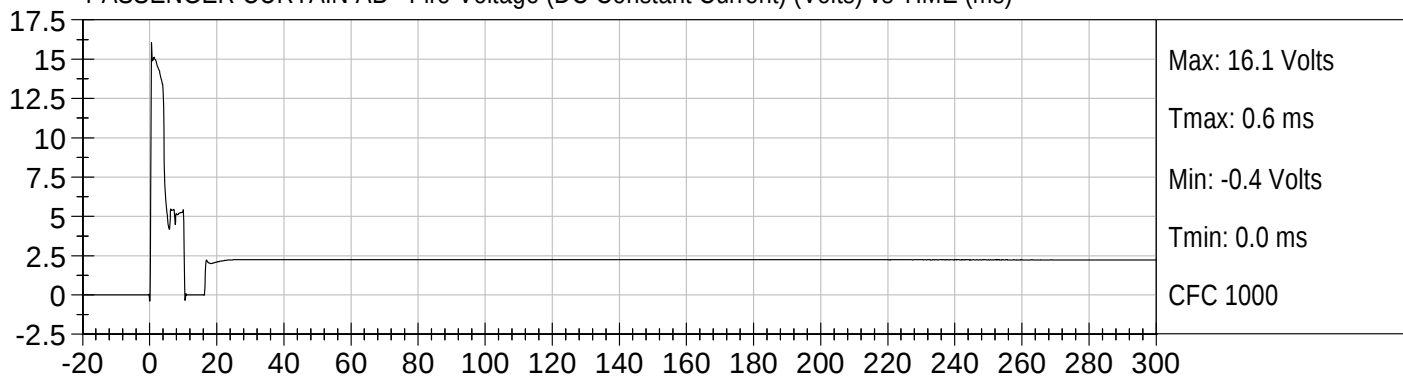




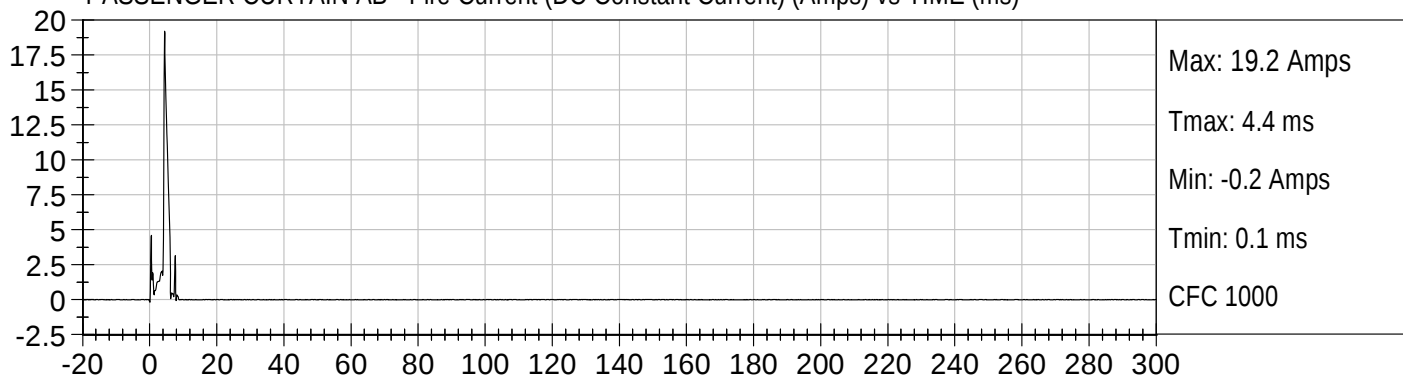




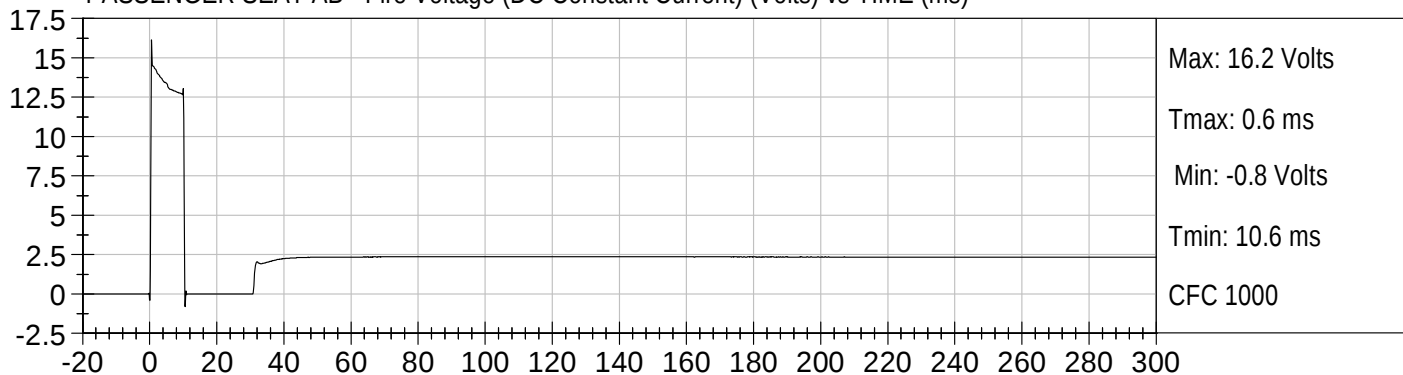
PASSENGER CURTAIN AB - Fire Voltage (DC Constant Current) (Volts) vs TIME (ms)



PASSENGER CURTAIN AB - Fire Current (DC Constant Current) (Amps) vs TIME (ms)



PASSENGER SEAT AB - Fire Voltage (DC Constant Current) (Volts) vs TIME (ms)



PASSENGER SEAT AB - Fire Current (DC Constant Current) (Amps) vs TIME (ms)

