TEST REPORT FOR:

# Seven Hills Engineering

## 2012 Hyundai Elantra into PJ Trailer

TESTED TO:

**47.2 mph Vehicle into Trailer Impact Test**

PREPARED FOR:

**Seven Hills Engineering**

**1114 Thomasville Road,**

**Tallahassee, FL 32303**

TEST REPORT NUMBER:

**TR-P37103-01-NC**

REPORT DATE:

**May 26, 2017**

TEST DATE:

**April 13, 2017**

**KARCO Engineering, LLC.**
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| | |
|---|---|
| Tested By: | Mr. Amjad A. Jadallah<br>Project Engineer |
| Report By: | Mr. Amjad A. Jadallah<br>Project Engineer |
| Reviewed By: | Mr. Andrew J. Espindola<br>Quality Assurance Manager |
| Approved By: | Mr. Michael L. Dunlap<br>Director of Operations |
| Approval Date: | May 26, 2017 |

**REVISION CONTROL LOG**

**TR-P37103-01**

| Revision | Date | Description |
|---|---|---|
| -NC | 05/26/17 | Original Test Report |
| | | |
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# TECHNICAL REPORT DOCUMENTATION PAGE

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| TR-P37103-01-NC | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| Final Report of 47.2 mph Vehicle into Trailer Impact Test<br>2012 Hyundai Elantra into PJ Trailer<br>Project No. P37103-01 | May 26, 2017 |
| | **6. Performing Organization Code**<br>KAR |
| **7. Authors**<br>Mr. Amjad A. Jadallah, Project Engineer, KARCO<br>Mr. Michael L. Dunlap, Director of Operations, KARCO | **8. Performing Organization Report No.**<br>TR-P37103-01-NC |
| **9. Performing Organization Name and Address**<br>KARCO Engineering, LLC.<br>9270 Holly Rd.<br>Adelanto, CA 92301 | **10. Work Unit No.** |
| | **11. Contract or Grant No.** |
| **12. Sponsoring Agency Name and Address** | **13. Type of Report and Period Covered**<br>Final Test Report, April 13 - May 26, 2017 |
| | **14. Sponsoring Agency Code** |

**15. Supplementary Notes**

**16. Abstract**


A 47.2 mph vehicle into trailer impact test was conducted on a 2012 Hyundai Elantra 4-door sedan in accordance with the instructions provided by Seven Hills Engineering. The test was conducted at the KARCO Engineering, LLC. facility in Adelanto, California on April 13, 2017.

The impact velocity of the vehicle was 47.88 mph (77.06 km/h) and the ambient temperature at the barrier face at the time of impact was 69.0° F. The test vehicle's performance is as follows:

| Measurement Description | Units | Driver ATD Result |
|---|---|---|
| Head Injury Criteria ($HIC_{15}$) | N/A | 154.1 |
| 3ms Chest Clip | g | 55.4 |
| Neck Tension | N | 1144.7 |
| Neck Compression | N | -197.0 |


| 17. Key Words | 18. Distribution Statement |
|---|---|
| 64° Oblique Frontal Impact<br>Frontal Impact | |

| 19. Security Classification of this report | 20. Security Classification of this page | 21. No. of Pages | 22. Price |
|---|---|---|---|
| | | 73 | |

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# SECTION 1
# INTRODUCTION

## PURPOSE

This 47.2 mph vehicle into trailer impact test was conducted for Seven Hills Engineering, LLC. The test was conducted in accordance with instructions provided by Seven Hills Engineering, LLC.

## SUMMARY

A 40 foot Flat-Deck Gooseneck Trailer manufactured by PJ Trailers connected to a 2004 Ford F-350 Super Duty Lariat was impacted by a 2012 Hyundai Elantra 4-door sedan at a velocity of 47.88 mph (77.06 km/h). The test was performed at KARCO Engineering, LLC. on April 13, 2017. Pre- and post-test photographs of the vehicles and dummies can be found in Appendix A of this report. Two (2) real-time cameras and five (5) high-speed cameras were used to document the oblique frontal impact event.

One Part 572O 5$^{th}$ percentile female anthropomorphic test device (ATD) was placed in the driver seating position and ballasted according to instructions given by Seven Hills Engineering, LLC. The driver 5$^{th}$ percentile female ATD was ballasted to 158.0 lbs.

The ATD was instrumented with head and chest tri-axial accelerometers, a chest deflection potentiometer and an upper neck force load cell. A tri-axial accelerometer was placed at the approximate center of gravity to record the deceleration of the vehicle. The maximum deceleration, in the x-axis, recorded was 48.8 g's and the change in velocity, recorded was 47.9 mph. Appendix B contains the dummy and vehicle data traces.

The driver ATD was calibrated prior to this test. Dummy calibration data can be found in Appendix C of this report.

As a result of the impact, the PJ trailer connected to the 2004 Ford F-350 Super Duty Lariat shifted downstream as it caused the front of the 2012 Hyundai Elantra 4-door sedan to pitch downward into the ground.

## SECTION 2

## DATA SHEETS

Test Vehicle: 2012 Hyundai Elantra 4-Door Sedan  Project No.: P37103-01

Test Program: 47.2 mph Vehicle into Trailer Impact Test  Test Date: 04/13/17

### CONVERSION FACTORS

| Quantity | Typical Application | Std Units | Metric Unit | Multiply By |
|---|---|---|---|---|
| Mass | Vehicle Weight | lb | kg | 0.4536 |
| Linear Velocity | Impact Velocity | miles/hr | km/hr | 1.609344 |
| Length or Distance | Measurements | in | mm | 25.4 |
| Volume | Fuel Systems | gal | liter | 3.785 |
| Volume | Small Fluids | oz | mL | 29.574 |
| Pressure | Tire Pressures | $lbf/in^2$ | kPa | 6.895 |
| Temperature | General Use | $^oF$ | $^oC$ | =(Tf -32)/1.8 |
| Force | Dynamic Forces | lbf | N | 4.448 |
| Moment | Torque | lbf-ft | N•m | 1.355 |

## DATA SHEET NO. 1

## GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2012 Hyundai Elantra 4-Door Sedan  Project No.: P37103-01

Test Program: 47.2 mph Vehicle into Trailer Impact Test  Test Date: 04/13/17

### TEST VEHICLE INFORMATION AND OPTIONS

| | |
|---|---|
| Project Number | P37103-01 |
| Model Year | 2012 |
| Make | Hyundai |
| Model | Elantra |
| Body Style | 4-Door Sedan |
| VIN | 5NPDH4AE2CH083966 |
| Body Color | Black Noir Pearl |
| Odometer Reading (km / mi) | 182,990 / 113,705 |
| Engine Displacement (L) | 1.8 |
| Type / No. of Cylinders | Inline 4 |
| Engine Placement | Longitudinal |
| Transmission Type | Automatic |
| Transmission Speeds | 6 |
| Overdrive | Yes |
| Final Drive | FWD |
| Roof Rack | No |
| Sunroof / T-Top | Yes |
| Running Boards | No |
| Tilt Steering Wheel | Yes |
| Power Seats | No |
| Anti-Lock Brakes (ABS) | Yes |

| | |
|---|---|
| Traction Control System (TCS) | Yes |
| Auto-Leveling System | No |
| Automatic Door Locks | Yes |
| Power Window Auto-Reverse | Yes |
| Other Optional Feature | No |
| Driver Front Airbag | Yes |
| Driver Curtain Airbag | Yes |
| Driver Torso Airbag | No |
| Driver Torso/Pelvis Airbag | Yes |
| Driver Pelvis Airbag | No |
| Driver Knee Airbag | No |
| Pass. Front Airbag | Yes |
| Pass. Curtain Airbag | Yes |
| Pass. Torso Airbag | No |
| Pass. Torso/Pelvis Airbag | Yes |
| Pass. Pelvis Airbag | No |
| Pass. Knee Airbag | No |
| Driver Seat Belt Pretensioner | Yes |
| Pass. Seat Belt Pretensioner | Yes |
| Driver Load Limiter | Yes |
| Pass. Load Limiter | Yes |
| Other Safety Restraint | No |

### DATA FROM CERTIFICATION LABEL

| | |
|---|---|
| Manufactured By | Hyundai Motor Manufacturing Alabama, LLC. |
| Date of Manufacture | Jun-11 |
| Vehicle Type | Passenger Car |

| | |
|---|---|
| GVWR (lbs) | 3792 |
| GAWR Front (lbs) | 2072 |
| GAWR Rear (lbs) | 1762 |

## DATA SHEET NO. 1 … (CONTINUED)

## GENERAL TEST AND VEHICLE PARAMETER DATA

Test Vehicle: 2012 Hyundai Elantra 4-Door Sedan  Project No.: P37103-01

Test Program: 47.2 mph Vehicle into Trailer Impact Test  Test Date: 04/13/17

### 2012 HYUNDAI ELANTRA VEHICLE WEIGHTS

| | Units | As Delivered Weights (UVW) | | | As Tested Weights (ATW) | | |
|---|---|---|---|---|---|---|---|
| | | Front Axle | Rear Axle | Total | Front Axle | Rear Axle | Total |
| Left | lbs | 884.0 | 530.0 | | 896.0 | 572.0 | |
| Right | lbs | 833.0 | 514.0 | | 887.0 | 473.0 | |
| Ratio | % | 62.2% | 37.8% | 100.0% | 63.0% | 37.0% | 100.0% |
| Total | lbs | 1717.0 | 1044.0 | 2761.0 | 1783.0 | 1045.0 | 2828.0 |

### PJ TRAILER WEIGHTS

| | Units | As Delivered Weights (UVW) | | | |
|---|---|---|---|---|---|
| | | Landing Gear | Front Axle | Rear Axle | Total |
| Left | lbs | 992.0 | 2024.0 | 2261.0 | |
| Right | lbs | 1880.0 | 1948.0 | 1979.0 | |
| Ratio | % | 25.9% | 35.8% | 38.3% | |
| Total | lbs | 2872.0 | 3972.0 | 4240.0 | 11084.0 [1] |

### 2004 FORD F-350 SUPER DUTY LARIAT

| | Units | As Delivered Weights (UVW) | | | As Tested Weights (ATW) | | |
|---|---|---|---|---|---|---|---|
| | | Front Axle | Rear Axle | Total | Front Axle | Rear Axle | Total |
| Left | lbs | 2080.0 | 1550.0 | | 2080.0 | 1550.0 | |
| Right | lbs | 2005.0 | 1546.0 | | 2005.0 | 1546.0 | |
| Ratio | % | 56.9% | 43.1% | 100.0% | 56.9% | 43.1% | 100.0% |
| Total | lbs | 4085.0 | 3096.0 | 7181.0 | 4085.0 | 3096.0 | 7181.0 |

### 2012 HYUNDAI ELANTRA VEHICLE ATTITUDES

| Condition | Units | LF | RF | LR | RR |
|---|---|---|---|---|---|
| As-Tested | Inches | 26.5 | 26.7 | 26.6 | 27.0 |

### PJ TRAILER DECK HEIGHTS

| Condition | Units | LF | RF |
|---|---|---|---|
| As Tested | Inches | 39.5 | 40.0 |

*All vehicle weights and ballasts were provided by Seven Hills Engineering, LLC.

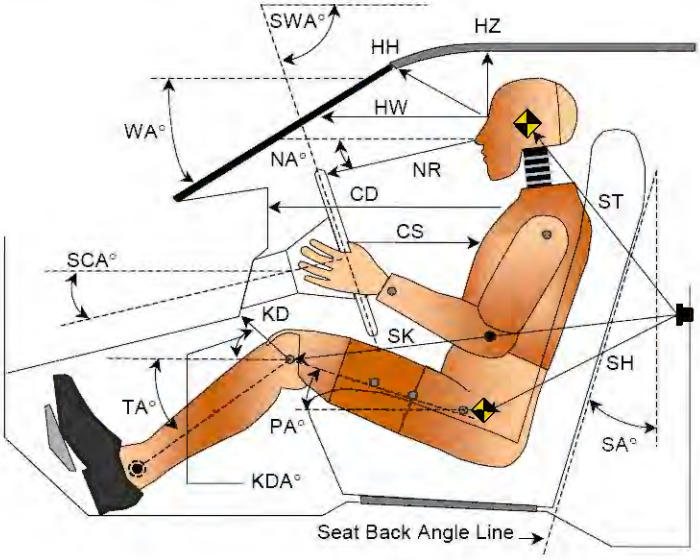
[1]Prior to testing, the trailer ramps were removed at the request of Seven Hills Engineering, LLC. The total weight of the ramps was 408 lbs.

## DATA SHEET NO. 2

## DUMMY LONGITUDINAL CLEARANCE DIMENSIONS

Test Vehicle: 2012 Hyundai Elantra 4-Door Sedan  Project No.: P37103-01

Test Program: 47.2 mph Vehicle into Trailer Impact Test  Test Date: 04/13/17




**LEFT SIDE VIEW**

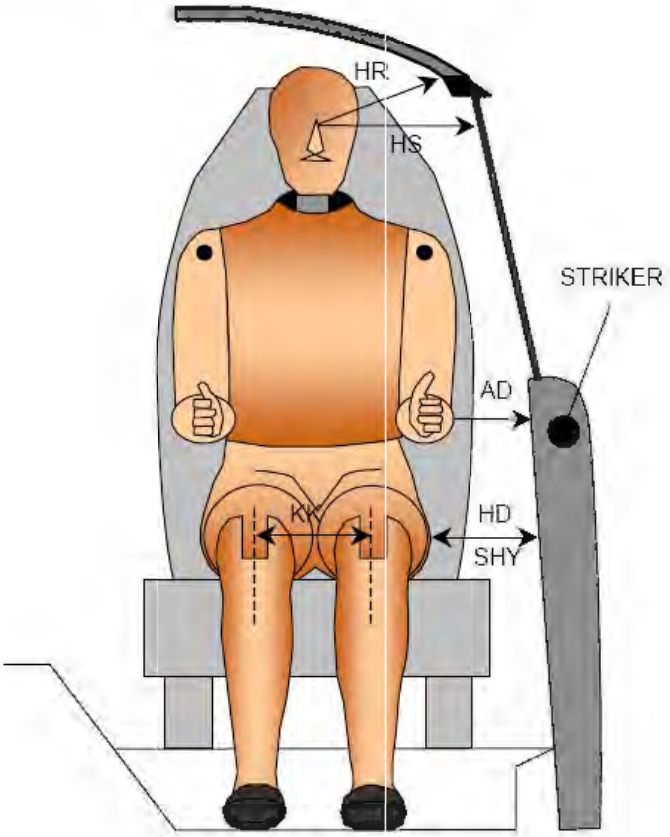
| Code | Measurement Description | Driver | |
|---|---|---|---|
| | | Length (mm) | Angle (°) |
| WA° | Windshield Angle | | 23.8 |
| SWA° | Steering Wheel Angle | | 66.4 |
| SCA° | Steering Column Angle | | 21.8 |
| SA° | Seat Back Angle (On Seat Back) | | 11.4 |
| HZ | Head to Roof | 266 | 90.0 |
| HH | Head to Header | 370 | |
| HW | Head to Windshield | 772 | 0.0 |
| NR | Nose to Rim | 394 | |
| CD | Chest to Dash | 520 | 0.0 |
| CS | Chest to Steering Hub | 363 | 0.0 |
| RA | Rim to Abdomen | 220 | 0.0 |
| KDL | Left Knee to Dash | 149 | |
| KDR | Right Knee to Dash | 151 | |
| SK | Striker to Knee | 655 | |
| ST | Striker to Head | 585 | |
| SH | Striker to H-Point | 360 | |

**DATA SHEET NO. 3**

**DUMMY LATERAL CLEARANCE DIMENSIONS**

Test Vehicle: 2012 Hyundai Elantra 4-Door Sedan Project No.: P37103-01

Test Program: 47.2 mph Vehicle into Trailer Impact Test Test Date: 04/13/17




| Code | Description | Driver (mm) |
|---|---|---|
| AD | Arm to Door | 149 |
| HD | H-Point to Door | 175 |
| HS | Head to Side Window | 294 |

## DATA SHEET NO. 4

## TEST VEHICLE INSTRUMENTATION AND CAMERA SUMMARY

Test Vehicle: 2012 Hyundai Elantra 4-Door Sedan  Project No.: P37103-01

Test Program: 47.2 mph Vehicle into Trailer Impact Test  Test Date: 04/13/17

### INSTRUMENTATION

| | |
|---|---|
| Driver Dummy Accelerometers | 19 |
| Vehicle Structure Accelerometers | 3 |
| Total | 22 |

### CAMERA COVERAGE

| | |
|---|---|
| High-Speed Off Board | 3 |
| High-Speed On-Board | 2 |
| Real Time | 2 |
| Total | 7 |

## DATA SHEET NO. 5

## POST-TEST OBSERVATIONS

Test Vehicle: 2012 Hyundai Elantra 4-Door Sedan  Project No.: P37103-01

Test Program: 47.2 mph Vehicle into Trailer Impact Test  Test Date: 04/13/17

### TEST DUMMY INFORMATION AND CONTACT

| Description | Driver |
|---|---|
| Dummy Type | Ballasted P572O 5th Percentile Female ATD |
| Head Contact | Front Airbag, Side Curtain, Seat Back |
| Upper Torso Contact | Front Airbag |
| Lower Torso Contact | None |
| Left Knee Contact | None |
| Right Knee Contact | Knee Bolster |

### SUPPLEMENTAL RESTRAINT SYSTEM INFORMATION

| Restraint Type | Driver | |
|---|---|---|
| | Installed | Operated |
| Front Airbag | Yes | Yes |
| Side Airbag 1 (Curtain) | Yes | Yes |
| Side Airbag 2 (Torso/Pelvis) | Yes | Yes |
| Seat Belt Retractor | Yes | Yes |
| Seat Belt Load Limiter | Yes | Yes |

### TEST VEHICLE SPEED DATA

| Measured Parameter | Units | Value |
|---|---|---|
| Trap No. 1 Velocity (Primary) | km/h | 77.06 |
| Trap No. 2 Velocity (Redundant) | km/h | 76.98 |

# APPENDIX A
# PHOTOGRAPHS

## TABLE OF PHOTOGRAPHS

## TABLE OF PHOTOGRAPHS … (CONTINUED)

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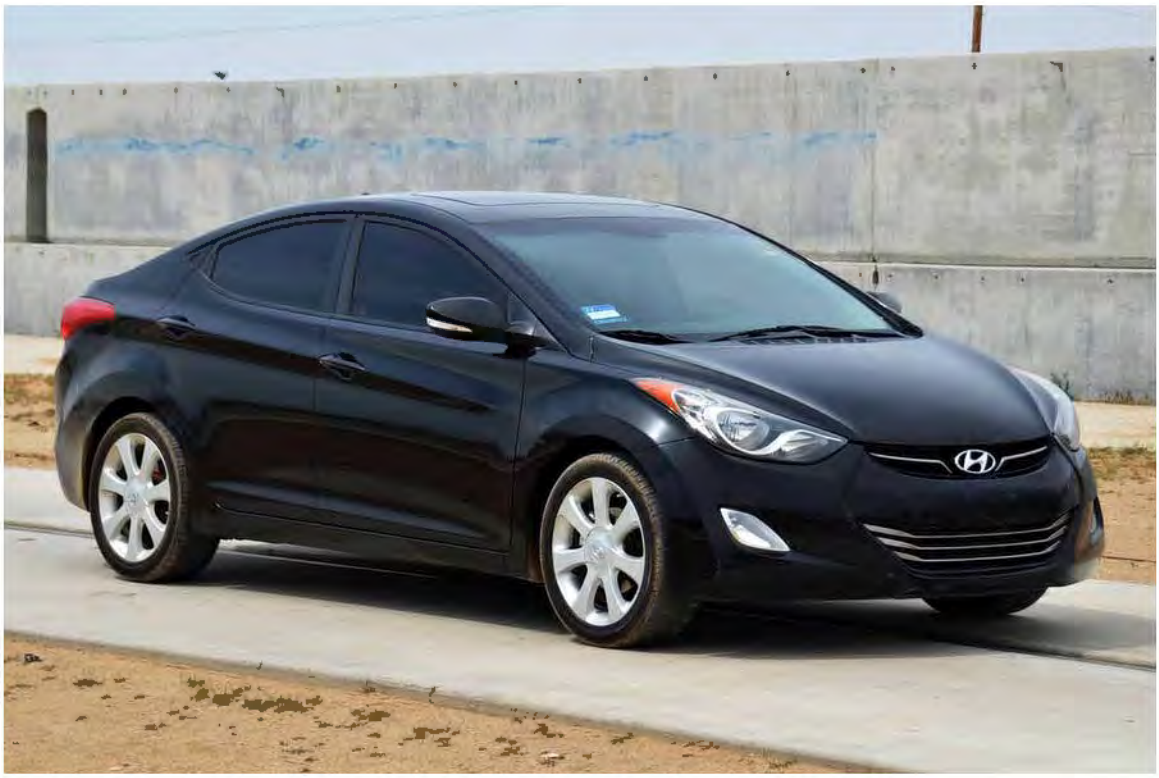


FIGURE 1. As Received Right Front ¾ View of Bullet Vehicle


FIGURE 2. As Received Left Rear ¾ View of Bullet Vehicle


FIGURE 3. Manufacturer's Label

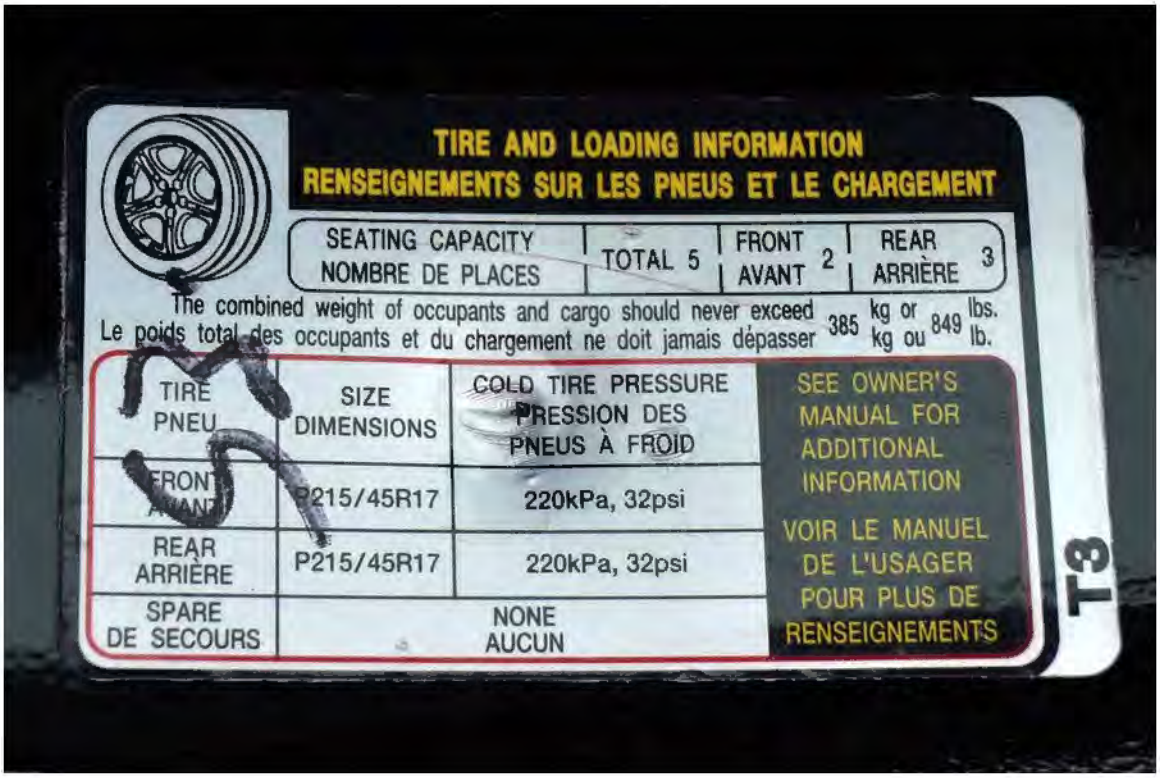



FIGURE 4. Tire Information Label


FIGURE 5. As Received Right Front ¾ View of Test Article

FIGURE 6. As Received Left Rear ¾ View of Test Article

FIGURE 7. As Received Right Front ¾ View of Support Vehicle


FIGURE 8. As Received Left Rear ¾ View of Support Vehicle


FIGURE 9. Test Setup


FIGURE 10. Test Setup

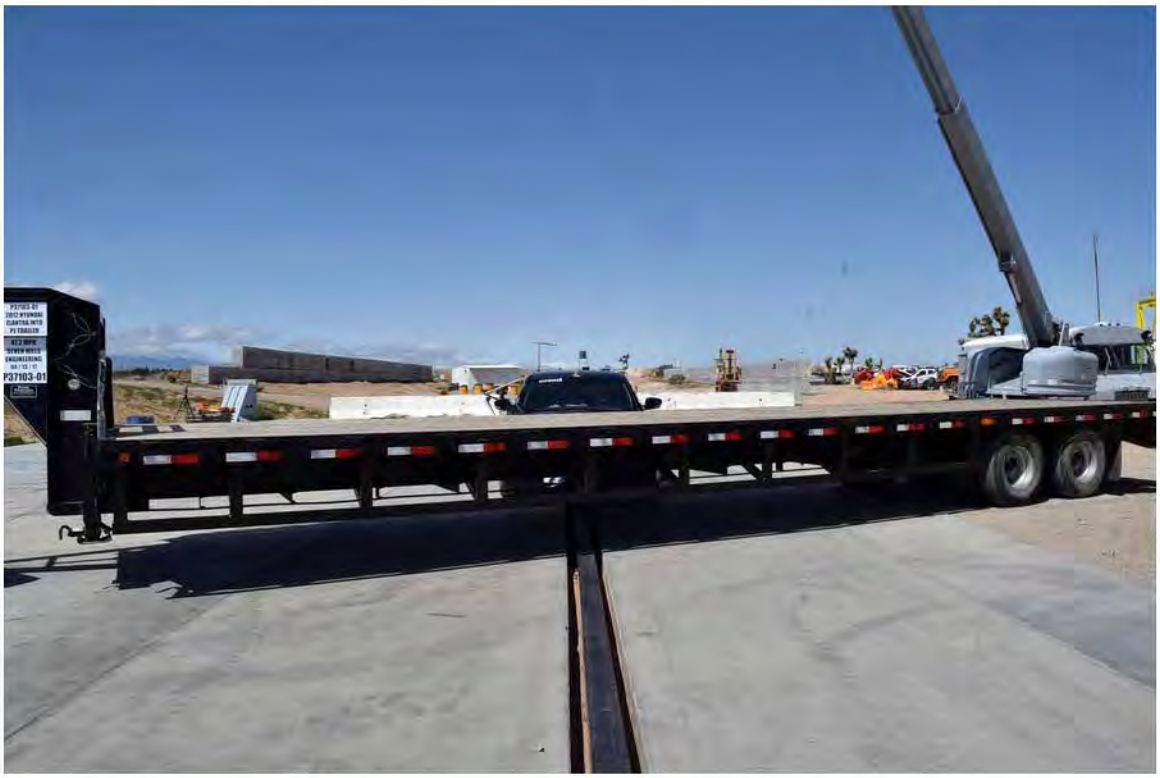



FIGURE 11. Test Setup

FIGURE 12. Test Setup


FIGURE 13. Test Setup


FIGURE 14. Test Setup


FIGURE 15. Test Setup


FIGURE 16. Test Setup


FIGURE 17. Pre-Test Left View of Bullet Vehicle


FIGURE 18. Post-Test Left View of Bullet Vehicle


FIGURE 19. Pre-Test Left Front ¾ View of Bullet Vehicle


FIGURE 20. Post-Test Left Front ¾ View of Bullet Vehicle


FIGURE 21. Pre-Test Front View of Bullet Vehicle


FIGURE 22. Post-Test Front View of Bullet Vehicle

FIGURE 23. Pre-Test Right Front ¾ View of Bullet Vehicle

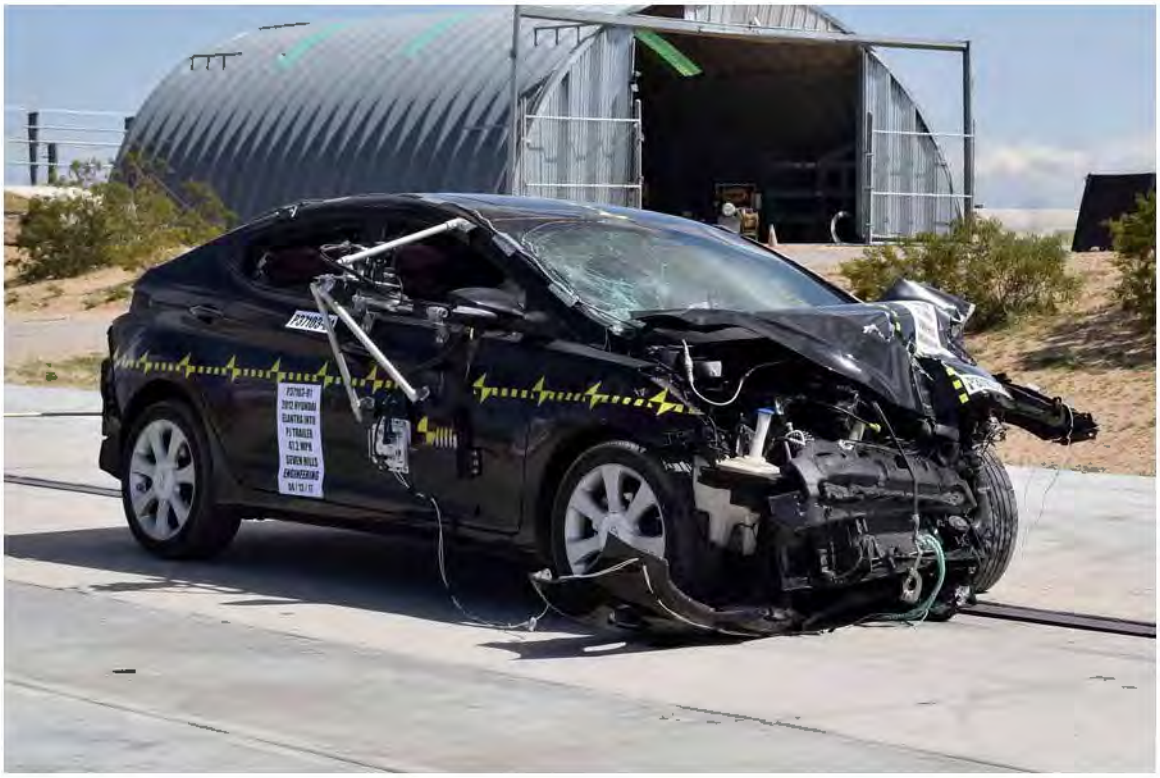


FIGURE 24. Post-Test Right Front ¾ View of Bullet Vehicle


FIGURE 25. Pre-Test Right View of Bullet Vehicle


FIGURE 26. Post-Test Right View of Bullet Vehicle


FIGURE 27. Pre-Test Right Rear ¾ View of Bullet Vehicle


FIGURE 28. Post-Test Right Rear ¾ View of Bullet Vehicle


FIGURE 29. Pre-Test Rear View of Bullet Vehicle


FIGURE 30. Post-Test Rear View of Bullet Vehicle


FIGURE 31. Pre-Test Left Rear ¾ View of Bullet Vehicle


FIGURE 32. Post-Test Left Rear ¾ View of Bullet Vehicle


FIGURE 33. Pre-Test Front Compartment


FIGURE 34. Post-Test Front Compartment


FIGURE 35. Pre-Test View of Test Article

FIGURE 36. Post-Test View of Test Article


FIGURE 37. Pre-Test View of Test Article

FIGURE 38. Post-Test View of Test Article

FIGURE 39. Pre-Test View of Test Article

FIGURE 40. Post-Test View of Test Article

FIGURE 41. Pre-Test View of Test Article

FIGURE 42. Post-Test View of Test Article


FIGURE 43. Pre-Test Windshield


FIGURE 44. Post-Test Windshield

FIGURE 45. Pre-Test Front View of Dummy

FIGURE 46. Post-Test Front View of Dummy


FIGURE 47. Pre-Test Side View of Dummy


FIGURE 48. Post-Test Side View of Dummy

FIGURE 49. Pre-Test Dummy and Vehicle Interior

FIGURE 50. Post-Test Dummy and Vehicle Interior

FIGURE 51. Pre-Test Dummy Feet

FIGURE 52. Post-Test Dummy Feet

FIGURE 53. Pre-Test Right Side View of Dummy
and Front Seat Occupant Compartment

FIGURE 54. Post-Test Right Side View of Dummy
and Front Seat Occupant Compartment

FIGURE 55. Post-Test Dummy Face

FIGURE 56. Post-Test Dummy Contact with Front Airbag

FIGURE 57. Post-Test Driver Inner Door Panel View

Showing Dummy Contact Locations

FIGURE 58. Post-Test Dummy Contact with Seatback

FIGURE 59. Post-Test Dummy Contact with Side Airbag

FIGURE 60. Test Vehicle Damage


FIGURE 61. Test Vehicle Damage

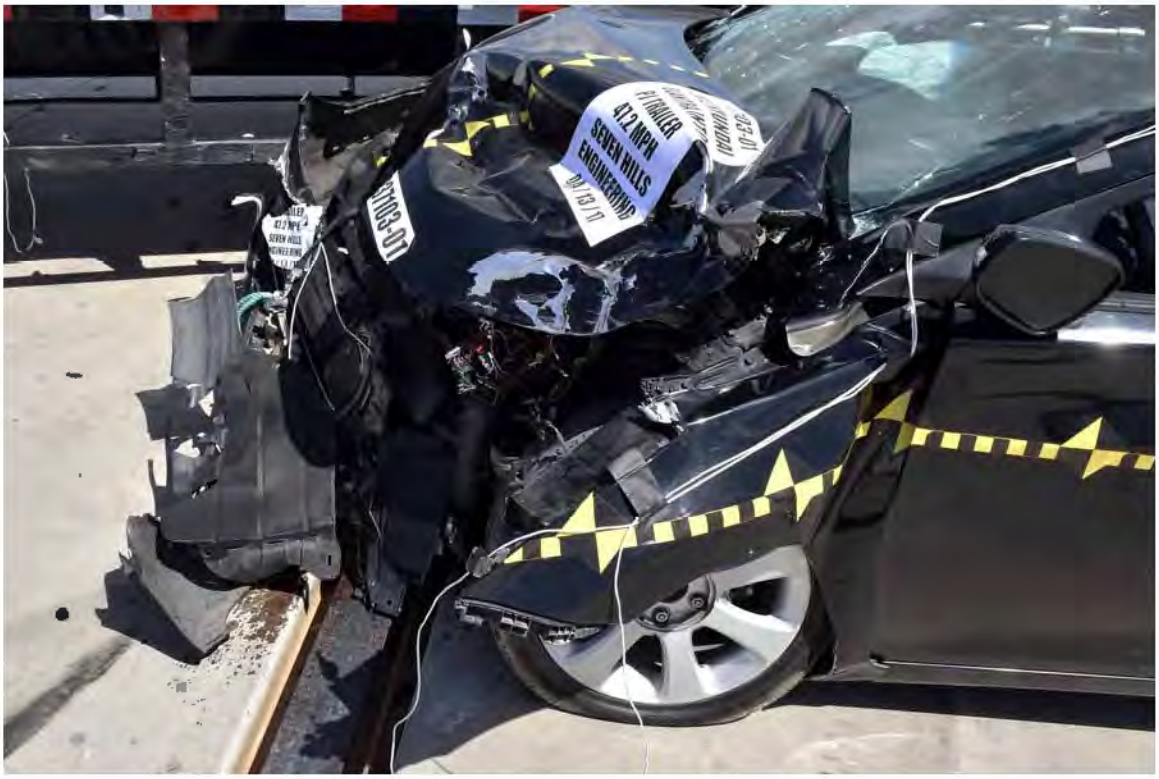



FIGURE 62. Test Vehicle Damage

FIGURE 63. Test Vehicle Damage

FIGURE 64. Test Article Damage

FIGURE 65. Test Article Damage


FIGURE 66. Test Article Damage

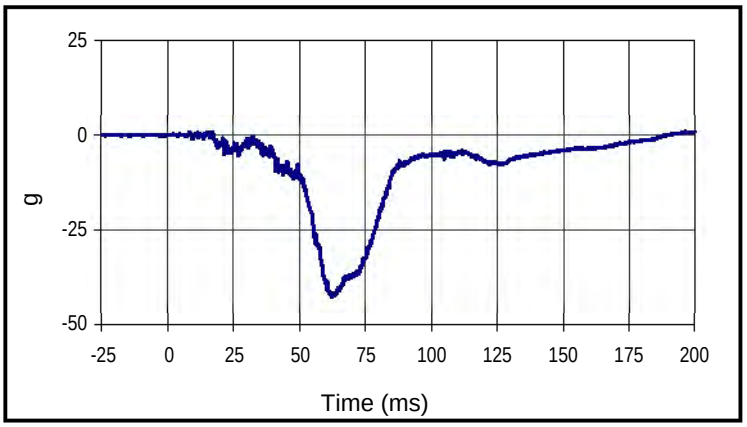

FIGURE 67. Test Article Damage

FIGURE 68. Test Article Damage

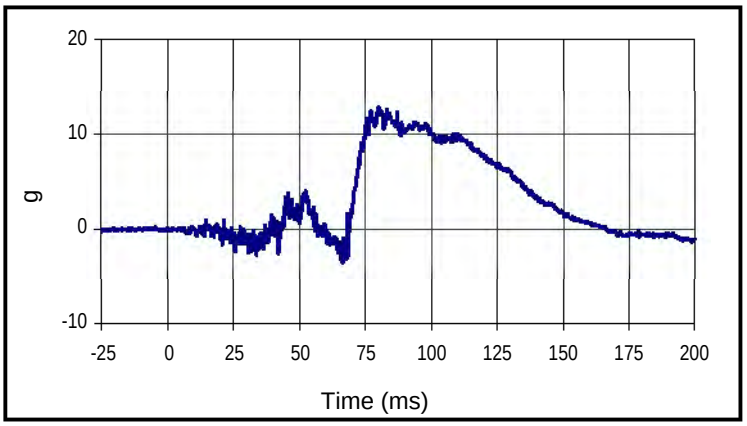

FIGURE 69. Impact Event

## TABLE OF DATA PLOTS

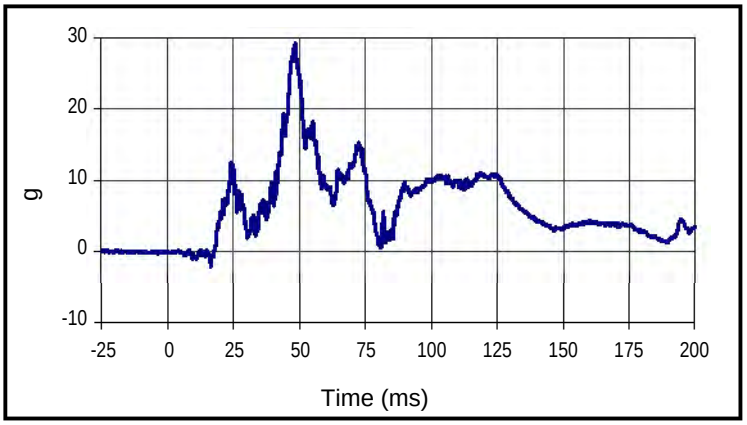
| | | | |
|---|---|---|---|
| Test Vehicle: | 2012 Hyundai Elantra 4-Door Sedan | Project No.: | P37103-01 |
| Test Program: | 47.2 mph Vehicle into Trailer Impact Test | Test Date: | 4/13/17 |



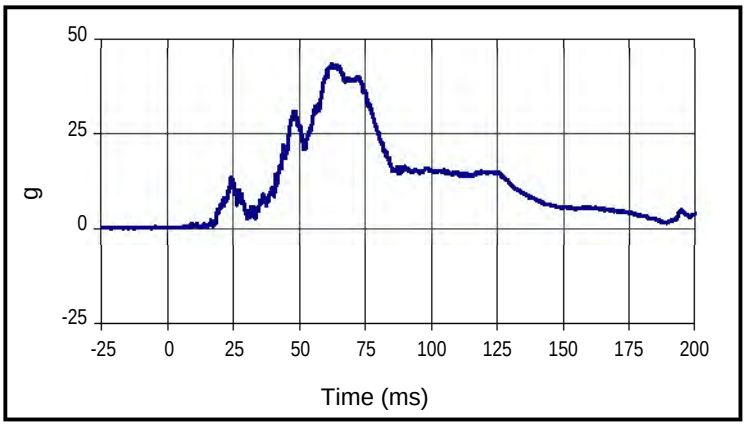

| Curve Description | | | |
|---|---|---|---|
| Driver Head Acceleration X Primary | | | |
| Plot No. | | SAE Class | Units |
| 001 | | 1000 | g |
| Max | Time | Min | Time |
| 0.9 | 200.0 | -42.4 | 62.2 |




| Curve Description | | | |
|---|---|---|---|
| Driver Head Acceleration Y Primary | | | |
| Plot No. | | SAE Class | Units |
| 002 | | 1000 | g |
| Max | Time | Min | Time |
| 12.8 | 80.1 | -3.5 | 66.5 |



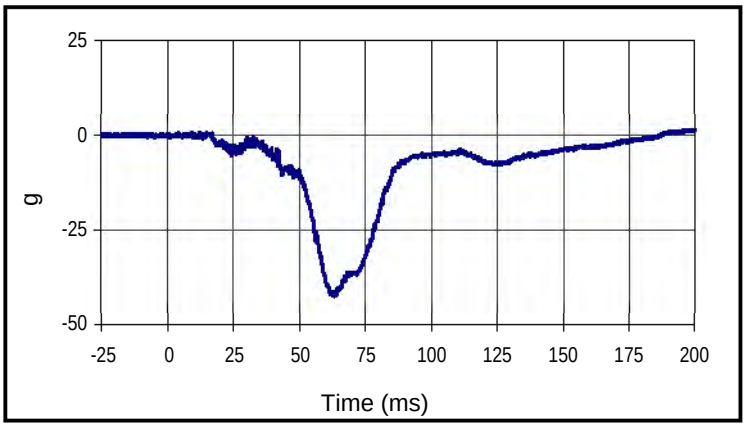

| Curve Description | | | |
|---|---|---|---|
| Driver Head Acceleration Z Primary | | | |
| Plot No. | | SAE Class | Units |
| 003 | | 1000 | g |
| Max | Time | Min | Time |
| 29.2 | 48.6 | -2.1 | 16.7 |



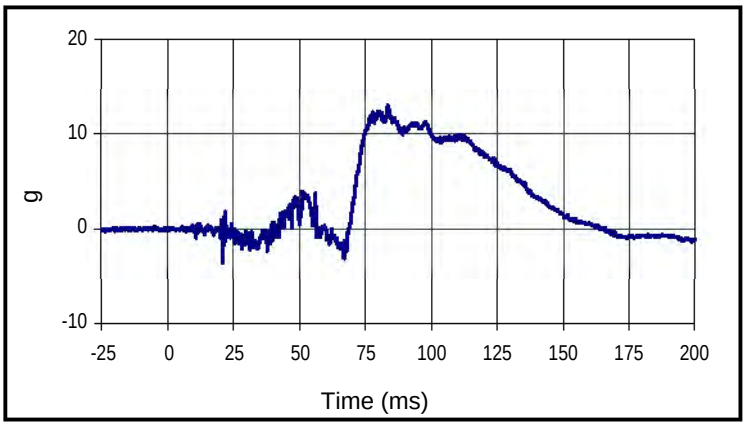

| Curve Description | | | |
|---|---|---|---|
| Driver Head Resultant Acceleration Primary | | | |
| Plot No. | | SAE Class | Units |
| 004 | | 1000 | g |
| Max | Time | Min | Time |
| 43.1 | 62.2 | 0.0 | 1.6 |

| | Value | T1 | T2 |
|---|---|---|---|
| HIC15 | 154.1 | 59.0 | 74.0 |
| HIC36 | 230.1 | 45.7 | 81.3 |

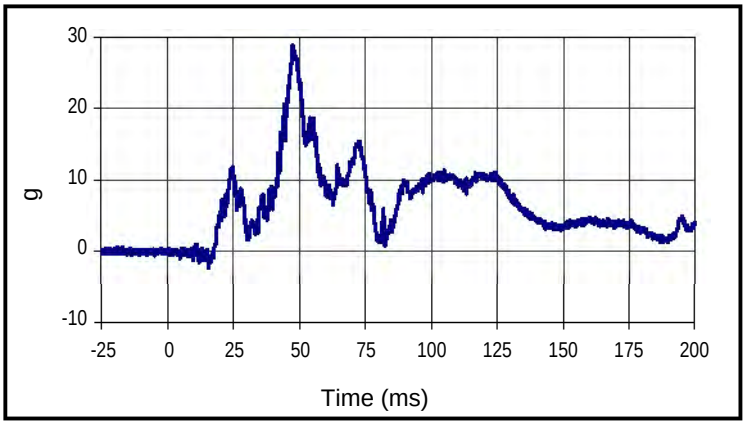
| | | | |
|---|---|---|---|
| Test Vehicle: | 2012 Hyundai Elantra 4-Door Sedan | Project No.: | P37103-01 |
| Test Program: | 47.2 mph Vehicle into Trailer Impact Test | Test Date: | 4/13/17 |



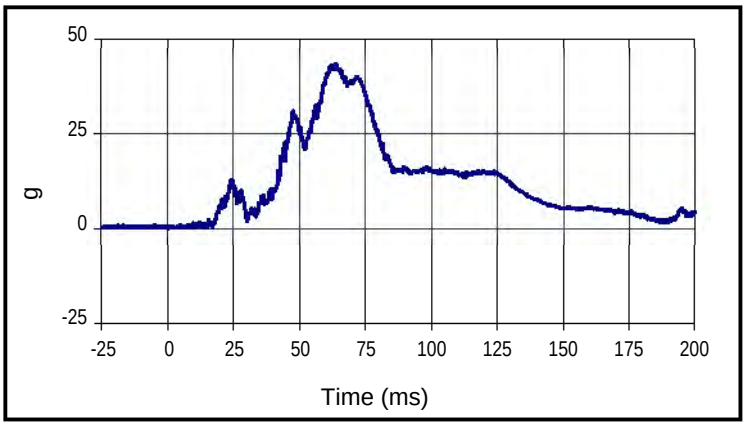

| Curve Description | | | |
|---|---|---|---|
| Driver Head Acceleration X Redundant | | | |
| Plot No. | | SAE Class | Units |
| 005 | | 1000 | g |
| Max | Time | Min | Time |
| 1.6 | 197.9 | -42.3 | 63.1 |




| Curve Description | | | |
|---|---|---|---|
| Driver Head Acceleration Y Redundant | | | |
| Plot No. | | SAE Class | Units |
| 006 | | 1000 | g |
| Max | Time | Min | Time |
| 13.0 | 83.5 | -3.5 | 21.1 |



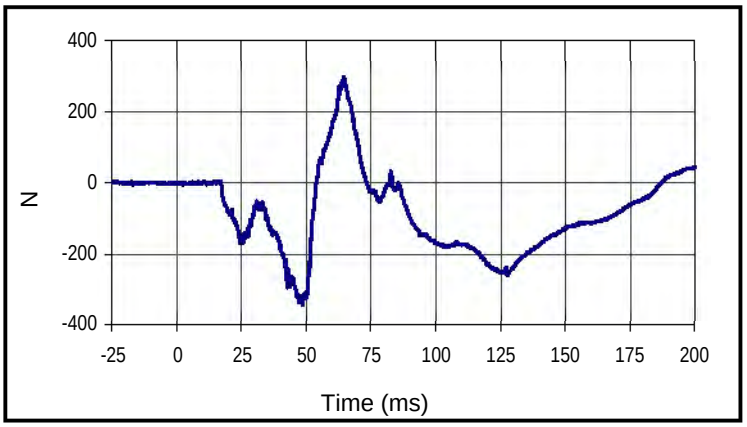

| Curve Description | | | |
|---|---|---|---|
| Driver Head Acceleration Z Redundant | | | |
| Plot No. | | SAE Class | Units |
| 007 | | 1000 | g |
| Max | Time | Min | Time |
| 28.8 | 47.6 | -2.4 | 15.7 |



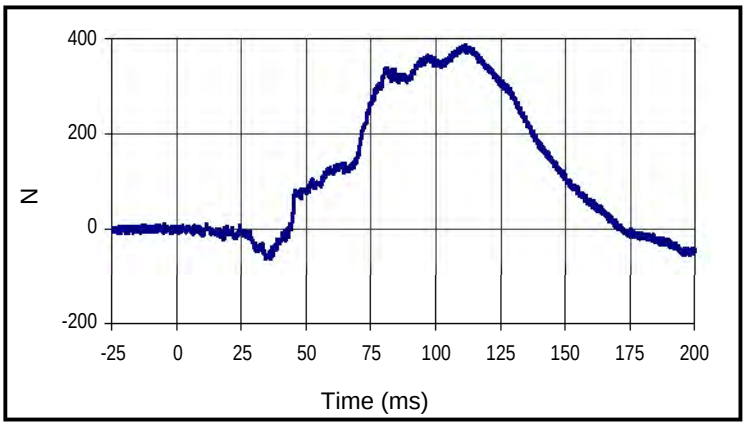

| Curve Description | | | |
|---|---|---|---|
| Driver Head Resultant Acceleration Redundant | | | |
| Plot No. | | SAE Class | Units |
| 008 | | 1000 | g |
| Max | Time | Min | Time |
| 43.1 | 64.0 | 0.0 | 0.4 |

| | Value | T1 | T2 |
|---|---|---|---|
| HIC15 | 151.5 | 59.0 | 74.0 |
| HIC36 | 226.1 | 45.3 | 81.3 |

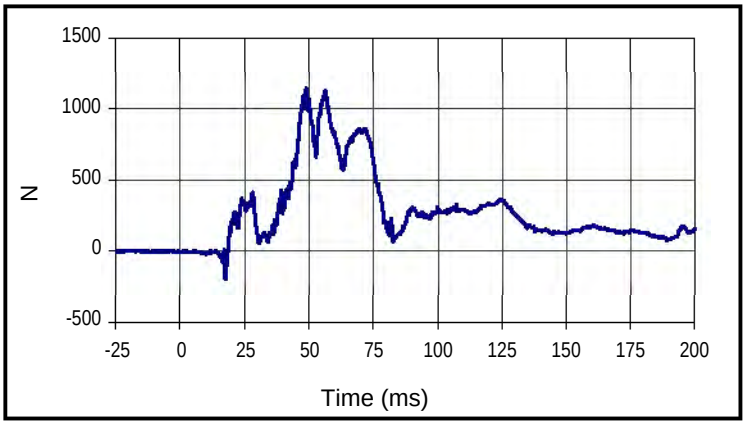
| | | | |
|---|---|---|---|
| Test Vehicle: | 2012 Hyundai Elantra 4-Door Sedan | Project No.: | P37103-01 |
| Test Program: | 47.2 mph Vehicle into Trailer Impact Test | Test Date: | 4/13/17 |



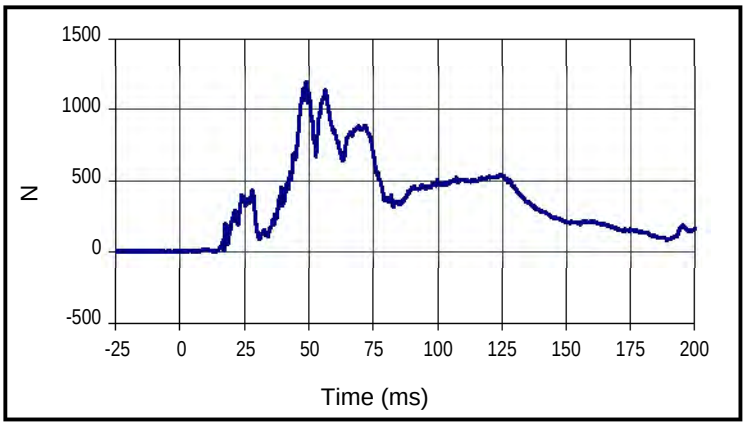

| Curve Description | | | |
|---|---|---|---|
| Driver Upper Neck Force X | | | |
| Plot No. | | SAE Class | Units |
| 009 | | 1000 | N |
| Max | Time | Min | Time |
| 296.8 | 64.6 | -341.1 | 48.6 |




| Curve Description | | | |
|---|---|---|---|
| Driver Upper Neck Force Y | | | |
| Plot No. | | SAE Class | Units |
| 010 | | 1000 | N |
| Max | Time | Min | Time |
| 386.7 | 111.3 | -63.0 | 34.5 |

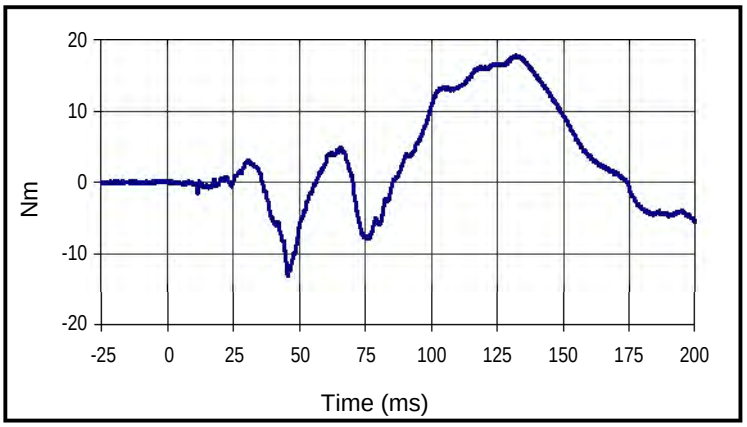



| Curve Description | | | |
|---|---|---|---|
| Driver Upper Neck Force Z | | | |
| Plot No. | | SAE Class | Units |
| 011 | | 1000 | N |
| Max | Time | Min | Time |
| 1144.7 | 49.0 | -197.0 | 17.4 |

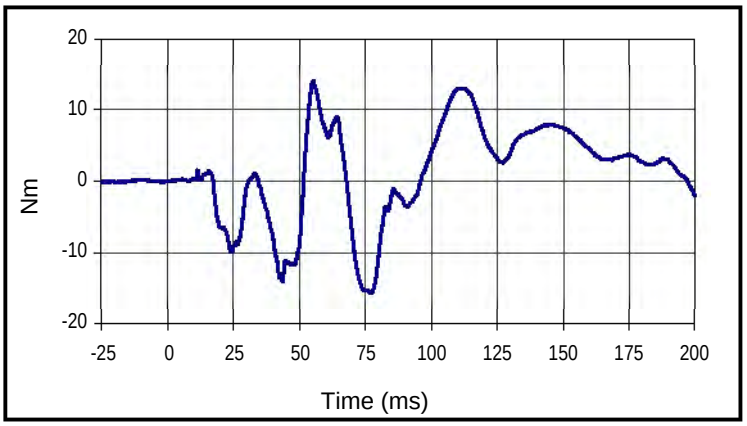



| Curve Description | | | |
|---|---|---|---|
| Driver Upper Neck Force Res. | | | |
| Plot No. | | SAE Class | Units |
| 012 | | 1000 | N |
| Max | Time | Min | Time |
| 1190.0 | 49.0 | 1.1 | 5.9 |

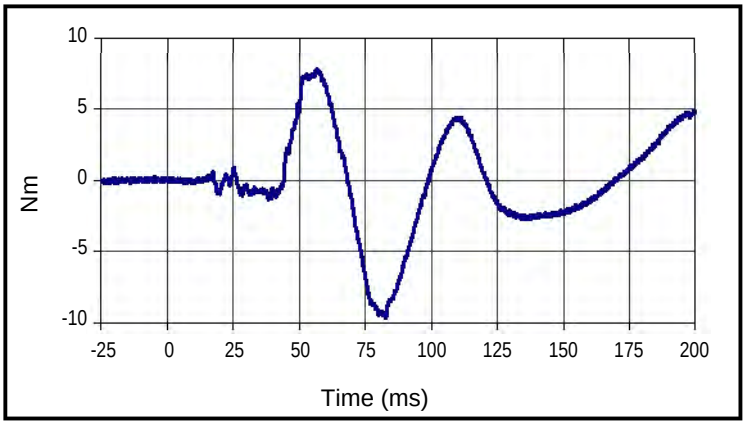
| | | | |
|---|---|---|---|
| Test Vehicle: | 2012 Hyundai Elantra 4-Door Sedan | Project No.: | P37103-01 |
| Test Program: | 47.2 mph Vehicle into Trailer Impact Test | Test Date: | 4/13/17 |



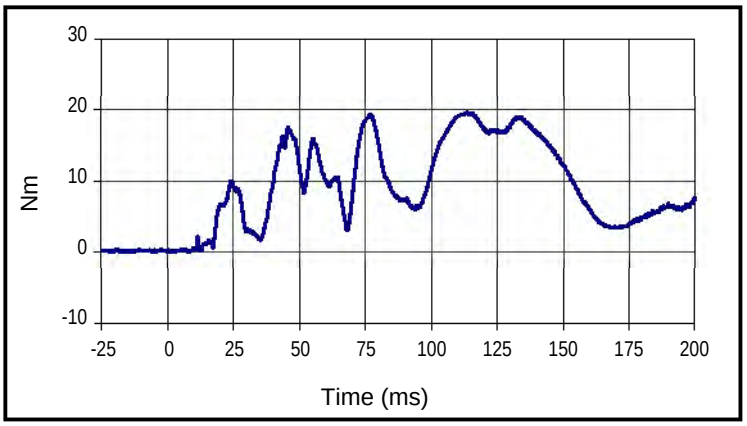

| Curve Description | | | |
|---|---|---|---|
| Driver Upper Neck Moment X | | | |
| Plot No. | | SAE Class | Units |
| 013 | | 600 | Nm |
| Max | Time | Min | Time |
| 17.8 | 132.1 | -13.2 | 45.7 |




| Curve Description | | | |
|---|---|---|---|
| Driver Upper Neck Moment Y | | | |
| Plot No. | | SAE Class | Units |
| 014 | | 600 | Nm |
| Max | Time | Min | Time |
| 14.1 | 55.3 | -15.7 | 77.1 |

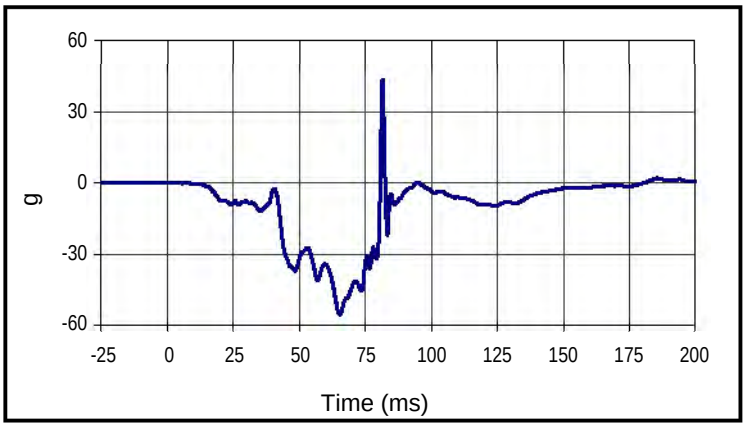



| Curve Description | | | |
|---|---|---|---|
| Driver Upper Neck Moment Z | | | |
| Plot No. | | SAE Class | Units |
| 015 | | 600 | Nm |
| Max | Time | Min | Time |
| 7.8 | 57.0 | -9.6 | 82.8 |

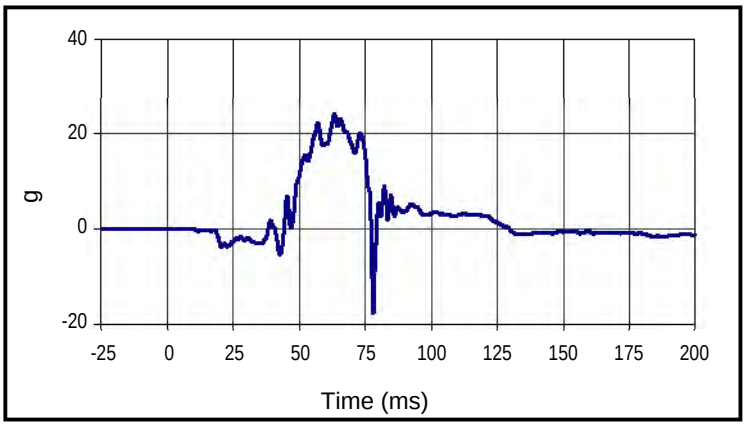



| Curve Description | | | |
|---|---|---|---|
| Driver Upper Neck Moment Res. | | | |
| Plot No. | | SAE Class | Units |
| 016 | | 600 | Nm |
| Max | Time | Min | Time |
| 19.6 | 113.7 | 0.0 | 2.9 |

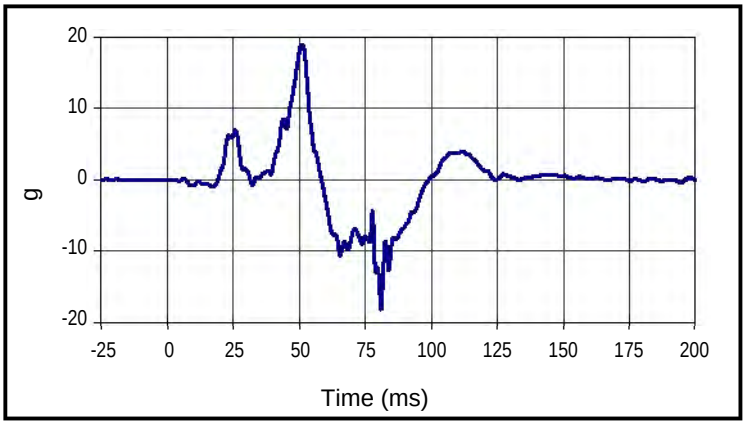
| | | | |
|---|---|---|---|
| Test Vehicle: | 2012 Hyundai Elantra 4-Door Sedan | Project No.: | P37103-01 |
| Test Program: | 47.2 mph Vehicle into Trailer Impact Test | Test Date: | 4/13/17 |



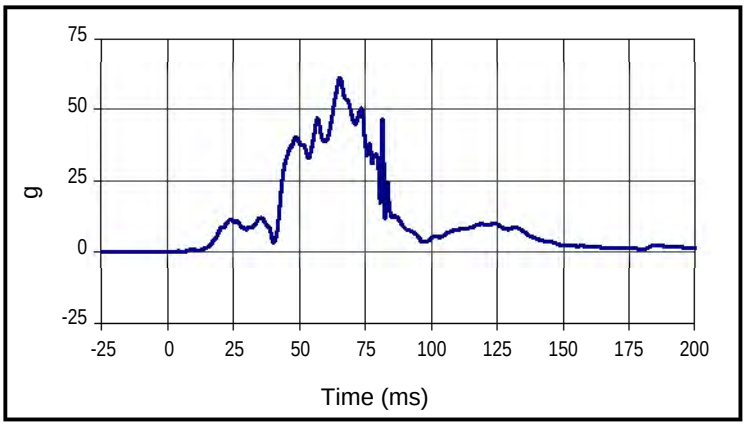

| Curve Description | | | |
|---|---|---|---|
| Driver Chest Acceleration X Primary | | | |
| Plot No. | | SAE Class | Units |
| 017 | | 180 | g |
| Max | Time | Min | Time |
| 43.6 | 81.6 | -55.4 | 65.4 |




| Curve Description | | | |
|---|---|---|---|
| Driver Chest Acceleration Y Primary | | | |
| Plot No. | | SAE Class | Units |
| 018 | | 180 | g |
| Max | Time | Min | Time |
| 24.0 | 63.3 | -17.6 | 78.1 |



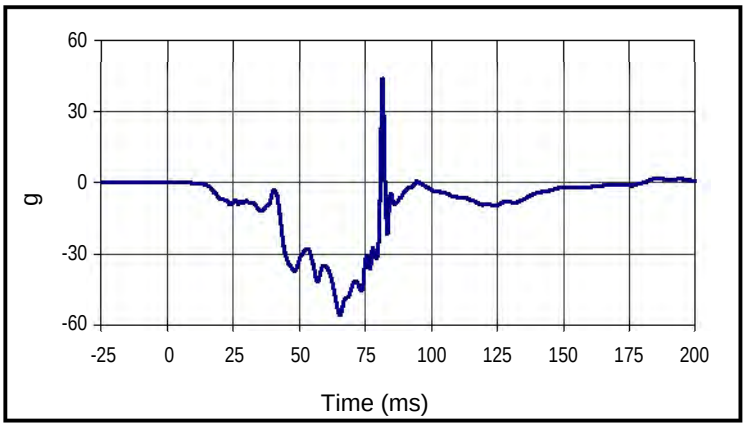

| Curve Description | | | |
|---|---|---|---|
| Driver Chest Acceleration Z Primary | | | |
| Plot No. | | SAE Class | Units |
| 019 | | 180 | g |
| Max | Time | Min | Time |
| 18.9 | 51.0 | -18.1 | 81.0 |



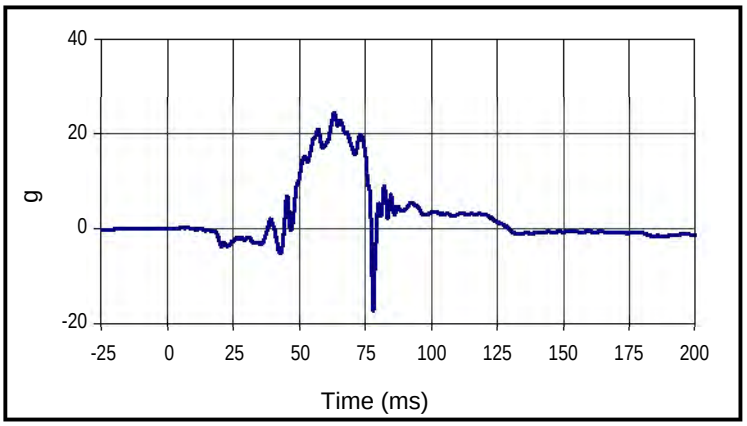

| Curve Description | | | |
|---|---|---|---|
| Driver Chest Resultant Acceleration Primary | | | |
| Plot No. | | SAE Class | Units |
| 020 | | 180 | g |
| Max | Time | Min | Time |
| 60.9 | 65.4 | 0.1 | 0.9 |

| | Value | T1 | T2 |
|---|---|---|---|
| 3 ms. Clip | 55.4 | 63.9 | 66.9 |

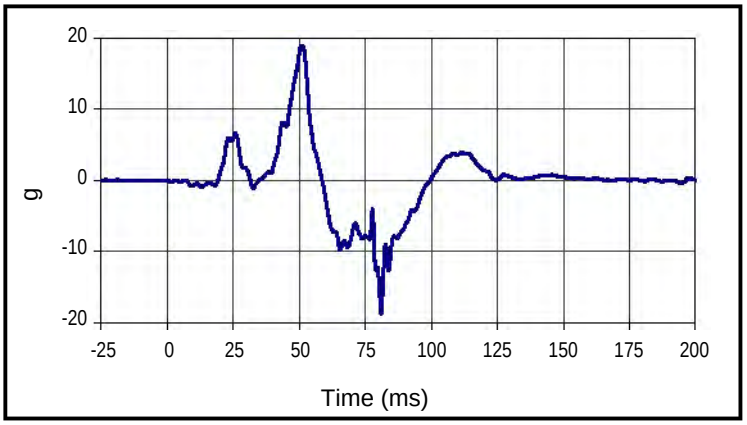
| | | | |
|---|---|---|---|
| Test Vehicle: | 2012 Hyundai Elantra 4-Door Sedan | Project No.: | P37103-01 |
| Test Program: | 47.2 mph Vehicle into Trailer Impact Test | Test Date: | 4/13/17 |



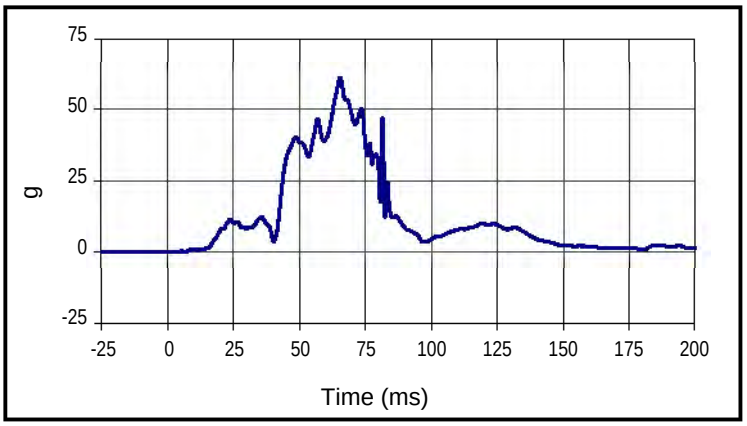

| Curve Description | | | |
|---|---|---|---|
| Driver Chest Acceleration X Redundant | | | |
| Plot No. | | SAE Class | Units |
| 021 | | 180 | g |
| Max | Time | Min | Time |
| 43.8 | 81.6 | -55.7 | 65.4 |




| Curve Description | | | |
|---|---|---|---|
| Driver Chest Acceleration Y Redundant | | | |
| Plot No. | | SAE Class | Units |
| 022 | | 180 | g |
| Max | Time | Min | Time |
| 24.4 | 63.3 | -17.2 | 78.1 |




| Curve Description | | | |
|---|---|---|---|
| Driver Chest Acceleration Z Redundant | | | |
| Plot No. | | SAE Class | Units |
| 023 | | 180 | g |
| Max | Time | Min | Time |
| 18.9 | 51.0 | -18.7 | 81.1 |

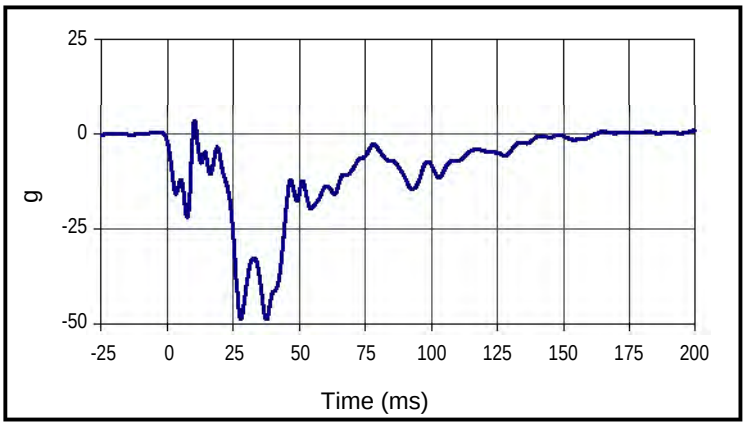



| Curve Description | | | |
|---|---|---|---|
| Driver Chest Resultant Acceleration Redundant | | | |
| Plot No. | | SAE Class | Units |
| 024 | | 180 | g |
| Max | Time | Min | Time |
| 61.0 | 65.4 | 0.1 | 3.6 |

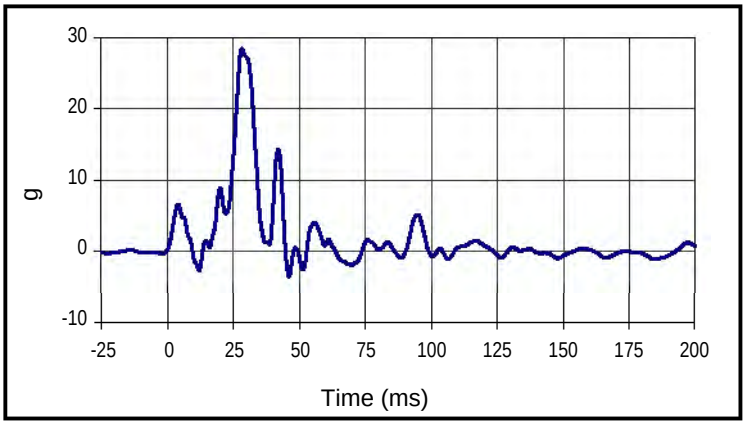
| | Value | T1 | T2 |
|---|---|---|---|
| 3 ms. Clip | 55.1 | 63.9 | 66.9 |

| | | | |
|---|---|---|---|
| Test Vehicle: | 2012 Hyundai Elantra 4-Door Sedan | Project No.: | P37103-01 |
| Test Program: | 47.2 mph Vehicle into Trailer Impact Test | Test Date: | 4/13/17 |

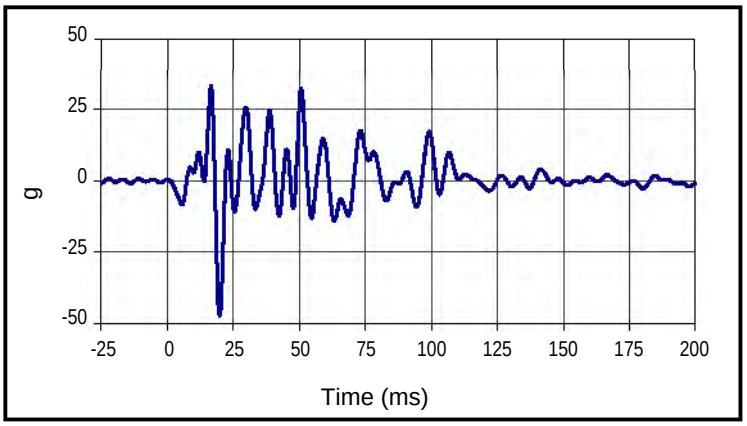

| Curve Description | | | |
|---|---|---|---|
| Driver Chest Deflection | | | |
| Plot No. | | SAE Class | Units |
| 025 | | 600 | mm |
| Max | Time | Min | Time |
| 0.1 | 15.6 | -15.4 | 52.6 |




| Curve Description | | | |
|---|---|---|---|
| Vehicle CG Acceleration X | | | |
| Plot No. | | SAE Class | Units |
| 026 | | 60 | g |
| Max | Time | Min | Time |
| 3.4 | 10.4 | -48.8 | 37.5 |

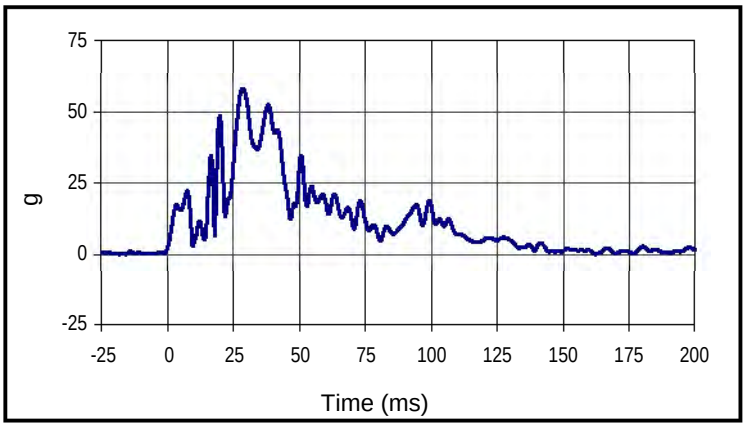



| Curve Description | | | |
|---|---|---|---|
| Vehicle CG Acceleration Y | | | |
| Plot No. | | SAE Class | Units |
| 027 | | 60 | g |
| Max | Time | Min | Time |
| 28.5 | 28.3 | -3.5 | 46.1 |




| Curve Description | | | |
|---|---|---|---|
| Vehicle CG Acceleration Z | | | |
| Plot No. | | SAE Class | Units |
| 028 | | 60 | g |
| Max | Time | Min | Time |
| 33.1 | 16.7 | -47.5 | 19.9 |

| | | | |
|---|---|---|---|
| Test Vehicle: | 2012 Hyundai Elantra 4-Door Sedan | Project No.: | P37103-01 |
| Test Program: | 47.2 mph Vehicle into Trailer Impact Test | Test Date: | 4/13/17 |




| Curve Description | | | |
|---|---|---|---|
| Vehicle CG Resultant Acceleration | | | |
| Plot No. | | SAE Class | Units |
| 029 | | 60 | g |
| Max | Time | Min | Time |
| 58.0 | 28.5 | 0.1 | 162.0 |


| Curve Description | | | |
|---|---|---|---|
| Vehicle CG X Velocity | | | |
| Plot No. | | SAE Class | Units |
| 030 | | 180 | MPH |
| Max | Time | Min | Time |
| 47.9 | 1.7 | 6.8 | 163.4 |

Test Program: Damage Checklist Test Date: 4/3/17

ATD.: Hybrid III 5th Percentile Female Test I.D.: N/A

| Dummy Item | Inspect for | Comments | Damaged | OK |
|---|---|---|---|---|
| Entire Dummy | Perform general cleaning | | | X |
| Outer Skin | Gashes, rips, cracks | | | X |
| Head | Ballast secure | | | X |
| | General appearance | | | X |
| Neck | Broken or cracked rubber | | | X |
| | Upper neck bracket firmly attached to the lower neck bracket | | | X |
| | Looseness at the condyle joint | | | X |
| | Nodding blocks cracked or out of position | | | X |
| Spine | Broken or cracks in rubber | | | X |
| Ribs | Broken or bent ribs | | | X |
| | Broken or bent rib supports | | | X |
| | Damping material separated or cracked | | | X |
| | Rubber bumpers in place | | | X |
| Chest Displacement Assembly | Bent shaft | | | X |
| | Slider arm riding in track | | | X |
| Transducer Leads | Torn cables | | | X |
| Accelerometer Mountings | Head mounting secure | | | X |
| | Chest mounting secure | | | X |
| Knees | Skin condition | | | X |
| | Insert (do not remove) | | | X |
| | Casting | | | X |
| Limbs | Normal movement and adjustment | | | X |
| Knee Sliders | Wires intact | | | X |
| | Rubber returned to "at rest" position | | | X |
| Pelvis | Broken | | | X |
| Other | | | | X |

Describe the repair on or replacement of parts:

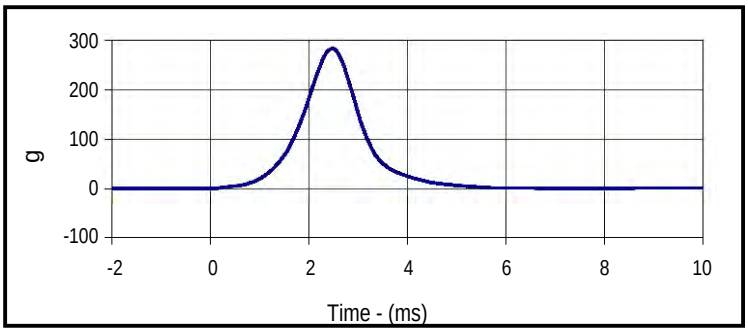
Test Program: External Measurements Test Date: 4/3/17

ATD.: Hybrid III 5th Percentile Female Test I.D.: N/A

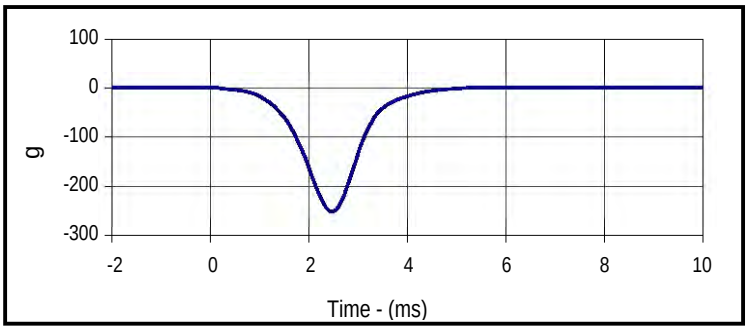
| Tested Parameter | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|
| Laboratory Temperature | °C | 20.6 to 22.2 | 21.22 | Pass |
| Laboratory Relative Humidity | % | 10 to 70 | 30.3 | Pass |
| A - Total sitting height | mm | 774.7 to 800.1 | 786 | Pass |
| B - Shoulder pivot height | mm | 431.8 to 457.2 | 450 | Pass |
| C - H point height | mm | 81.3 to 86.3 | 85 | Pass |
| D - H point location from backline | mm | 144.8 to 149.8 | 146 | Pass |
| E - Shoulder pivot from backline | mm | 68.6 to 83.8 | 77 | Pass |
| F - Thigh clearance | mm | 119.4 to 134.6 | 126 | Pass |
| G - Back of elbow to wrist pivot | mm | 243.9 to 259.1 | 250 | Pass |
| H - Head back to backline | mm | 40.7 to 45.7 | 44 | Pass |
| I - Shoulder to elbow length | mm | 276.8 to 297.2 | 285 | Pass |
| J - Elbow rest height | mm | 182.8 to 203.2 | 198 | Pass |
| K - Buttock to knee length | mm | 520.7 to 546.1 | 531 | Pass |
| L - Popliteal length | mm | 355.6 to 376.0 | 371 | Pass |
| M - Knee pivot height | mm | 393.7 to 419.1 | 402 | Pass |
| N - Buttock popliteal length | mm | 414.0 to 439.4 | 420 | Pass |
| O - Chest depth without jacket | mm | 175.3 to 190.5 | 186 | Pass |
| P - Foot length | mm | 218.5 to 233.7 | 221 | Pass |
| R - Buttock to Knee Pivot Length | mm | 457.2 to 482.6 | 473 | Pass |
| S - Head Breadth | mm | 137.1 to 147.3 | 144 | Pass |
| T - Head Depth | mm | 177.8 to 188.0 | 180 | Pass |
| U - Hip Breadth | mm | 299.7 to 314.9 | 302 | Pass |
| V - Shoulder breadth | mm | 350.5 to 365.7 | 359 | Pass |
| W - Foot breadth | mm | 78.8 to 94.0 | 90 | Pass |
| X - Head circumference | mm | 528.3 to 548.7 | 541 | Pass |
| Y - Chest circumference (with chest jacket) | mm | 850.8 to 881.3 | 864 | Pass |
| Z - Waist circumference | mm | 759.5 to 789.9 | 766 | Pass |
| AA - Location for chest circumference | mm | 299.7 to 309.9 | 300 | Pass |
| BB - Location for waist circumference | mm | 160.1 to 170.2 | 164 | Pass |
| | | Overall Test Results | | Pass |

| | | | |
|---|---|---|---|
| Test Program: | Head Drop Test | Test Date: | 4/3/17 |
| ATD.: | Hybrid III 5th Percentile Female | Test I.D.: | FHDP37103-01 |

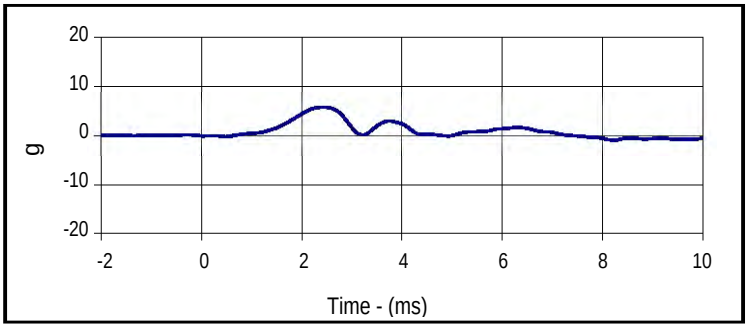
| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Head Assembly Soak Time | | Minutes | ≥240 | 302 | Pass |
| Temperature During Soak | Max | °C | 18.9 to 25.6 | 22.2 | Pass |
| | Min | °C | | 21.2 | Pass |
| Humidity During Soak | Max | % | 10.0 to 70.0 | 30.4 | Pass |
| | Min | % | | 30.3 | Pass |
| Laboratory Temperature During Test | | °C | 18.9 to 25.6 | 21.2 | Pass |
| Laboratory Humidity During Test | | % | 10.0 to 70.0 | 30.3 | Pass |
| Peak Resultant Acceleration | | g | 250.0 to 300.0 | 283.0 | Pass |
| Peak Lateral Acceleration | | g | ≤15.0 | 5.6 | Pass |
| Oscillations After Main Pulse | | % | <10% of peak Res. Acceleration | 5.0 | Pass |
| Is Acceleration Unimodal? | | Yes/No | Yes | Yes | Pass |
| | | | Overall Test Results | | Pass |



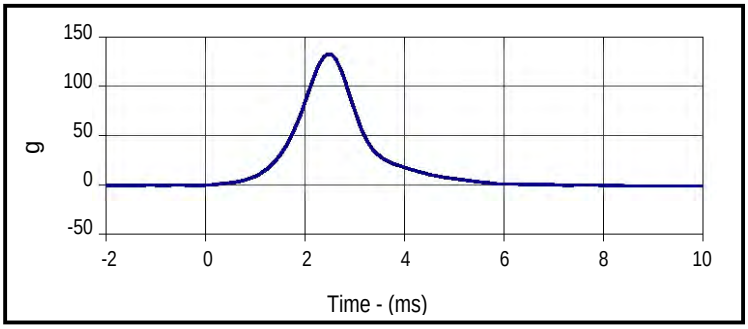

| Curve Description | | | |
|---|---|---|---|
| Head Resultant | | | |
| Plot No. | Type | SAE Class | Units |
| 001 | RES | 1000 | g |
| Max | Time | Min | Time |
| 283.0 | 2.5 | 0.2 | 55.8 |




| Curve Description | | | |
|---|---|---|---|
| Head X | | | |
| Plot No. | Type | SAE Class | Units |
| 002 | FIL | 1000 | g |
| Max | Time | Min | Time |
| 0.4 | 5.8 | -250.0 | 2.5 |




| Curve Description | | | |
|---|---|---|---|
| Head Y | | | |
| Plot No. | Type | SAE Class | Units |
| 003 | FIL | 1000 | g |
| Max | Time | Min | Time |
| 5.6 | 2.4 | -1.0 | 8.2 |

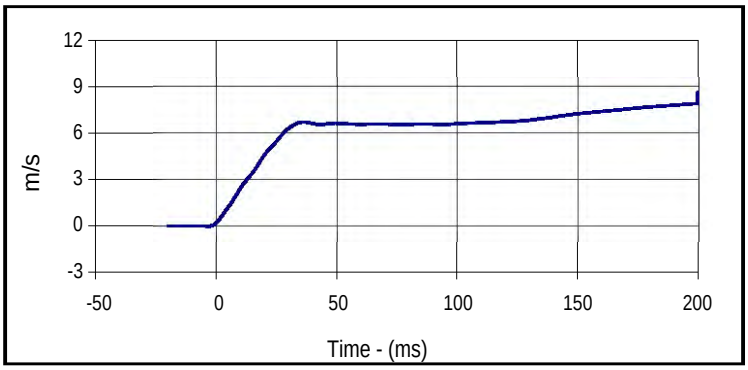



| Curve Description | | | |
|---|---|---|---|
| Head Z | | | |
| Plot No. | Type | SAE Class | Units |
| 004 | FIL | 1000 | g |
| Max | Time | Min | Time |
| 132.4 | 2.5 | -1.2 | 8.7 |

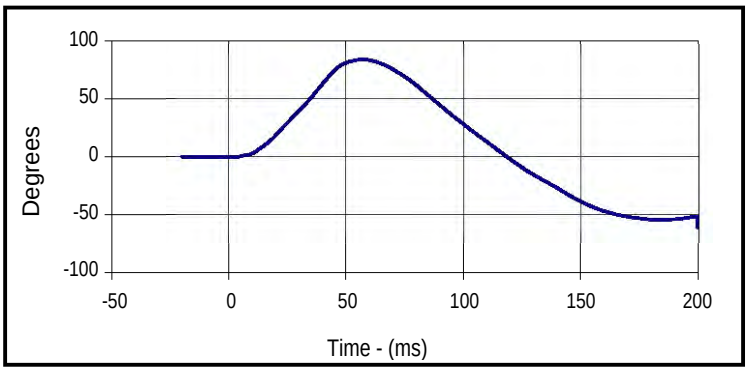
Test Program: Hybrid III 5th Percentile Female Neck Flexion Test  Test Date: 4/3/17

ATD.: Hybrid III 5th Percentile Female  Test I.D.: FNFP37103-01

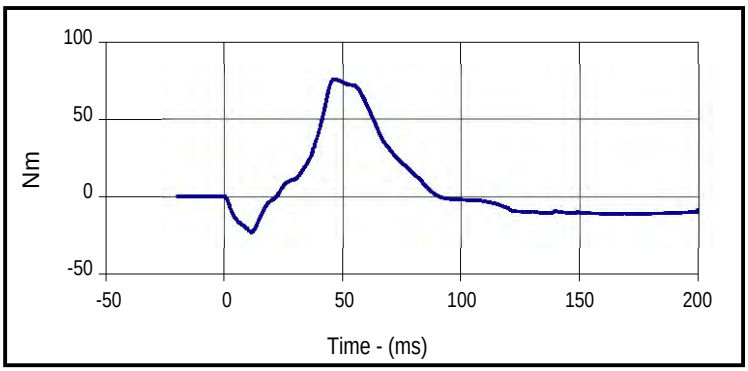
| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Neck Assembly Soak Time | | Minutes | ≥240 | 367 | Pass |
| Temperature During Soak | Max | °C | 20.6 to 22.2 | 22.2 | Pass |
| | Min | °C | | 21.2 | Pass |
| Humidity During Soak | Max | % | 10.0 to 70.0 | 30.4 | Pass |
| | Min | % | | 30.3 | Pass |
| Laboratory Temperature During Test | | °C | 20.6 to 22.2 | 21.2 | Pass |
| Laboratory Humidity During Test | | % | 10.0 to 70.0 | 30.4 | Pass |
| Pendulum Velocity | | m/s | 6.89 to 7.13 | 6.90 | Pass |
| Pendulum Deceleration | 10 Msec. | m/s | 2.1 to 2.5 | 2.4 | Pass |
| | 20 Msec. | m/s | 4.0 to 5.0 | 4.6 | Pass |
| | 30 Msec. | m/s | 5.8 to 7.0 | 6.3 | Pass |
| "D" Plane Rotation | Max | Degrees | 77.0 to 91.0 | 84.0 | Pass |
| Peak Moment in Rotation | Max | Nm | 69.0 to 83.0 | 75.2 | Pass |
| Positive Moment Decay, Time To 10 Nm | | Msec. | 80.0 to 100.0 | 81.6 | Pass |
| | | | Overall Test Results | | Pass |




| Curve Description | | | |
|---|---|---|---|
| Pendulum Velocity | | | |
| Plot No. | Type | SAE Class | Units |
| 001 | FIL | 180 | m/s |
| Max | Time | Min | Time |
| 8.6 | 199.5 | 0.0 | -3.4 |

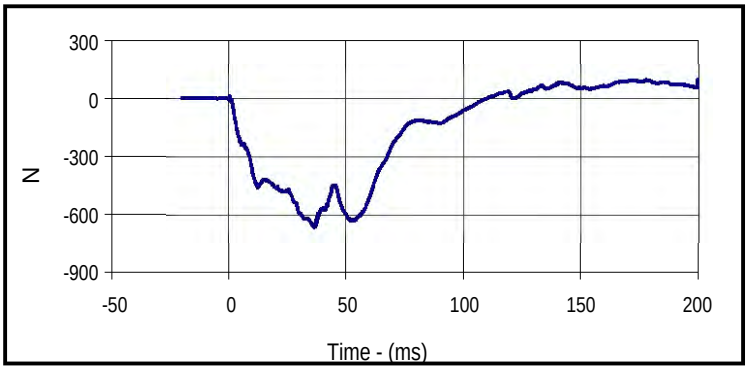



| Curve Description | | | |
|---|---|---|---|
| "D" Plane Rotation | | | |
| Plot No. | Type | SAE Class | Units |
| 002 | FIL | 60 | Degrees |
| Max | Time | Min | Time |
| 84.0 | 57.2 | -61.3 | 199.5 |

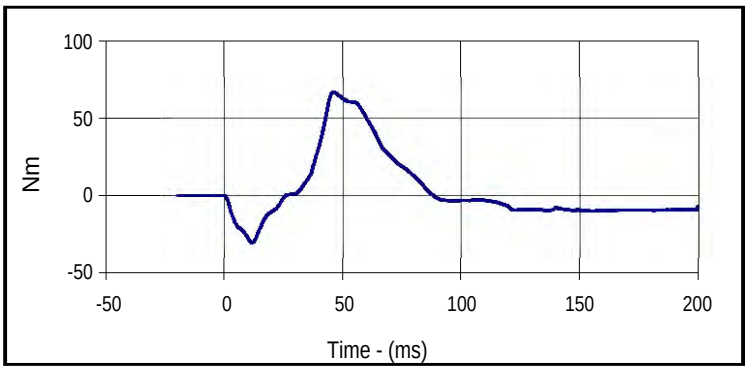



| Curve Description | | | |
|---|---|---|---|
| Moment About Occipital Condyle | | | |
| Plot No. | Type | SAE Class | Units |
| 003 | FIL | 600 | Nm |
| Max | Time | Min | Time |
| 75.2 | 46.6 | -22.9 | 11.3 |

| | | | |
|---|---|---|---|
| Test Program: | Hybrid III 5th Percentile Female Neck Flexion Test | Test Date: | 4/3/17 |
| ATD.: | Hybrid III 5th Percentile Female | Test I.D.: | FNFP37103-01 |



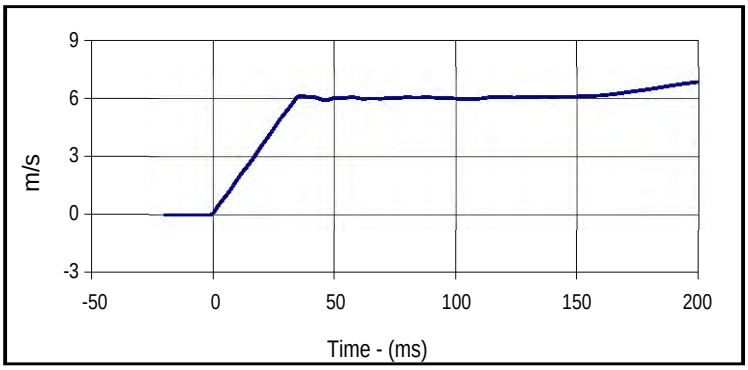

| Curve Description | | | |
|---|---|---|---|
| Neck Force X | | | |
| Plot No. | Type | SAE Class | Units |
| 004 | FIL | 1000 | N |
| Max | Time | Min | Time |
| 94.5 | 199.5 | -663.8 | 36.2 |



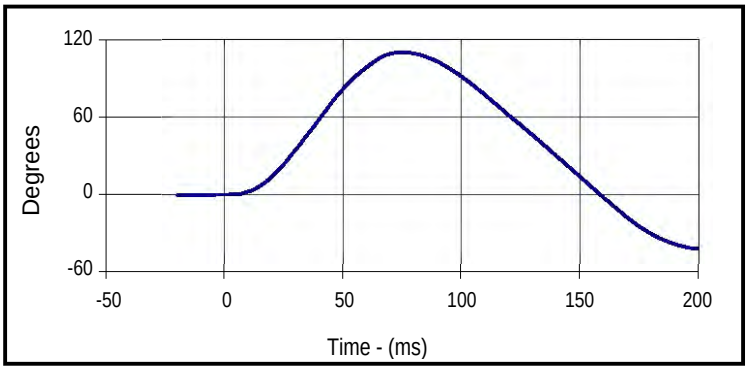

| Curve Description | | | |
|---|---|---|---|
| Neck Moment Y | | | |
| Plot No. | Type | SAE Class | Units |
| 005 | FIL | 600 | Nm |
| Max | Time | Min | Time |
| 67.0 | 45.8 | -30.6 | 11.4 |

| | | | |
|---|---|---|---|
| Test Program: | Neck Extension Test | Test Date: | 4/3/17 |
| ATD.: | Hybrid III 5th Percentile Female | Test I.D.: | FNEP37103-01 |

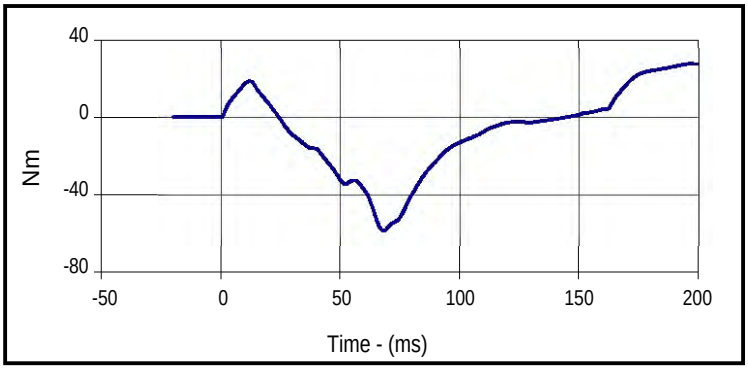
| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Neck Assembly Soak Time | | Minutes | ≥240 | 432 | Pass |
| Temperature During Soak | Max | °C | 20.6 to 22.2 | 22.2 | Pass |
| | Min | °C | | 21.2 | Pass |
| Humidity During Soak | Max | % | 10.0 to 70.0 | 30.4 | Pass |
| | Min | % | | 30.3 | Pass |
| Laboratory Temperature During Test | | °C | 20.6 to 22.2 | 22.2 | Pass |
| Laboratory Humidity During Test | | % | 10.0 to 70.0 | 30.3 | Pass |
| Pendulum Velocity | | m/s | 5.95 to 6.19 | 6.06 | Pass |
| Pendulum Deceleration | 10 Msec. | m/s | 1.5 to 1.9 | 1.8 | Pass |
| | 20 Msec. | m/s | 3.1 to 3.9 | 3.6 | Pass |
| | 30 Msec. | m/s | 4.6 to 5.6 | 5.3 | Pass |
| "D" Plane Rotation | Max | Degrees | 99.0 to 114.0 | 110.3 | Pass |
| Peak Moment in Rotation | Max | Nm | -53.0 to -65.0 | -58.6 | Pass |
| Positive Moment Decay, Time To -10 Nm | | Msec. | 94.0 to 114.0 | 106.3 | Pass |
| | | | Overall Test Results | | Pass |




| Curve Description | | | |
|---|---|---|---|
| Pendulum Velocity | | | |
| Plot No. | Type | SAE Class | Units |
| 001 | FIL | 180 | m/s |
| Max | Time | Min | Time |
| 6.8 | 199.4 | 0.0 | -1.4 |

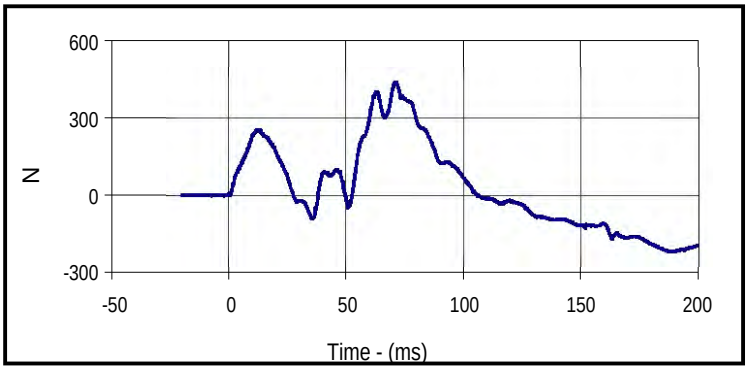



| Curve Description | | | |
|---|---|---|---|
| "D" Plane Rotation | | | |
| Plot No. | Type | SAE Class | Units |
| 002 | FIL | 60 | Degrees |
| Max | Time | Min | Time |
| 110.3 | 74.9 | -41.6 | 199.4 |

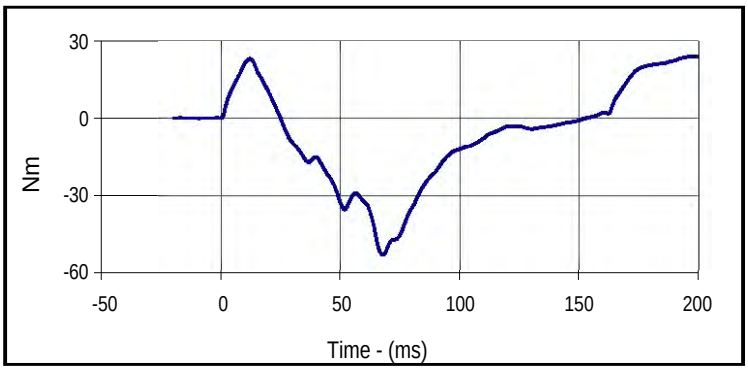



| Curve Description | | | |
|---|---|---|---|
| Moment About Occipital Condyle | | | |
| Plot No. | Type | SAE Class | Units |
| 003 | FIL | 600 | Nm |
| Max | Time | Min | Time |
| 27.5 | 197.0 | -58.6 | 68.0 |

| | | | |
|---|---|---|---|
| Test Program: | Neck Extension Test | Test Date: | 4/3/17 |
| ATD.: | Hybrid III 5th Percentile Female | Test I.D.: | FNEP37103-01 |



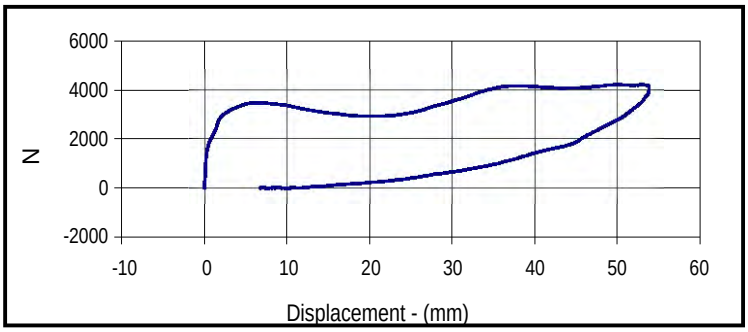

| Curve Description | | | |
|---|---|---|---|
| Neck Force X | | | |
| Plot No. | Type | SAE Class | Units |
| 004 | FIL | 1000 | N |
| Max | Time | Min | Time |
| 436.9 | 71.1 | -219.3 | 188.9 |



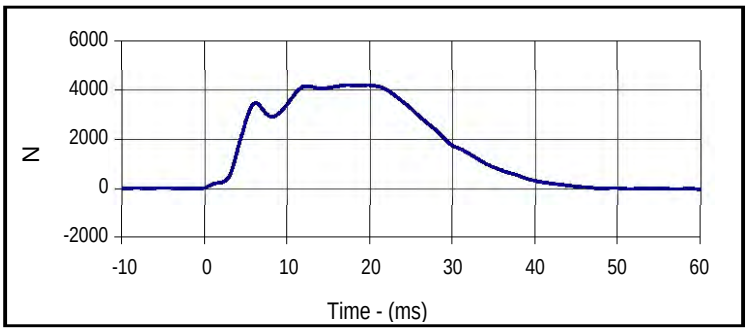

| Curve Description | | | |
|---|---|---|---|
| Neck Moment Y | | | |
| Plot No. | Type | SAE Class | Units |
| 005 | FIL | 600 | Nm |
| Max | Time | Min | Time |
| 23.9 | 197.0 | -52.9 | 67.6 |

| | | | |
|---|---|---|---|
| Test Program: | Thorax Impact Test | Test Date: | 4/3/17 |
| ATD.: | Hybrid III 5th Percentile Female | Test I.D.: | FCHP37103-01 |

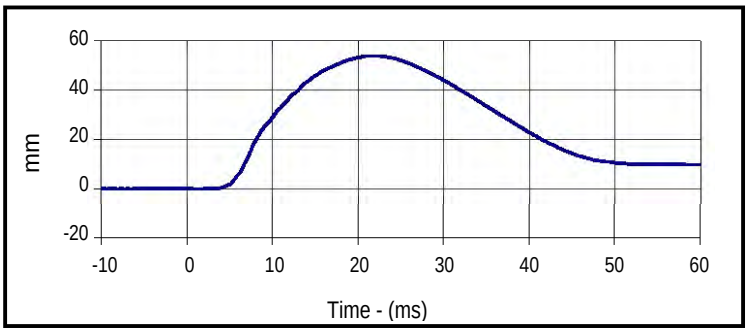
| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Dummy Soak Time | | Minutes | ≥240 | 477 | Pass |
| Temperature During Soak | Max | °C | 20.6 to 22.2 | 22.2 | Pass |
| | Min | °C | | 21.2 | Pass |
| Humidity During Soak | Max | % | 10.0 to 70.0 | 30.4 | Pass |
| | Min | % | | 30.3 | Pass |
| Laboratory Temperature During Test | | °C | 20.6 to 22.2 | 21.2 | Pass |
| Laboratory Humidity During Test | | % | 10.0 to 70.0 | 30.4 | Pass |
| Probe Velocity | | m/s | 6.59 to 6.83 | 6.73 | Pass |
| Peak Chest Deflection | | mm | 50.0 to 58.0 | 53.9 | Pass |
| Peak Force Between 50 and 58 MM | | N | 3900 to 4400 | 4190 | Pass |
| Peak Force Between 18 and 50 MM | | N | ≤4600 | 4190 | Pass |
| Internal Hysterysis | | % | 69 to 85 | 75.0 | Pass |
| | | | Overall Test Results | | Pass |



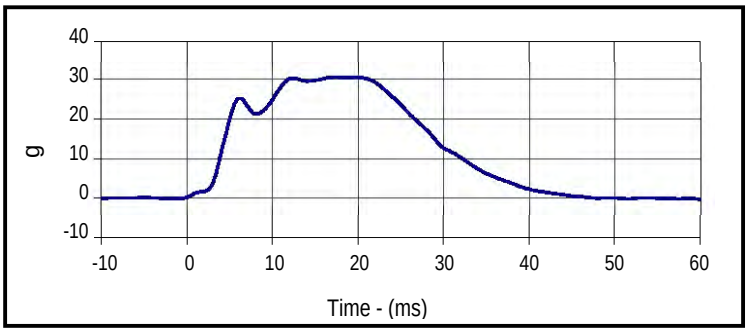

| Curve Description | | | |
|---|---|---|---|
| Probe Force vs. Chest Deflection | | | |
| Plot No. | Type | SAE Class | Hysterysis |
| 001 | FIL | 180 | 75.0 |
| Peak Probe Force | | Peak Chest Deflection | |
| 4190.2 | | 53.9 | |




| Curve Description | | | |
|---|---|---|---|
| Probe Force | | | |
| Plot No. | Type | SAE Class | Units |
| 002 | FIL | 180 | N |
| Max | Time | Min | Time |
| 4190.2 | 17.3 | -29.4 | 59.8 |




| Curve Description | | | |
|---|---|---|---|
| Chest Deflection | | | |
| Plot No. | Type | SAE Class | Units |
| 003 | FIL | 600 | mm |
| Max | Time | Min | Time |
| 53.9 | 21.4 | 0.0 | 1.0 |




| Curve Description | | | |
|---|---|---|---|
| Impactor Acceleration | | | |
| Plot No. | Type | SAE Class | Units |
| 004 | FIL | 180 | g |
| Max | Time | Min | Time |
| 30.6 | 17.3 | -0.2 | 59.8 |

| | | | |
|---|---|---|---|
| Test Program: | Knee Impact Test | Test Date: | 4/3/17 |
| ATD.: | Hybrid III 5th Percentile Female | Test I.D.: | FLKP37103-01 , FRKP37103-01 |

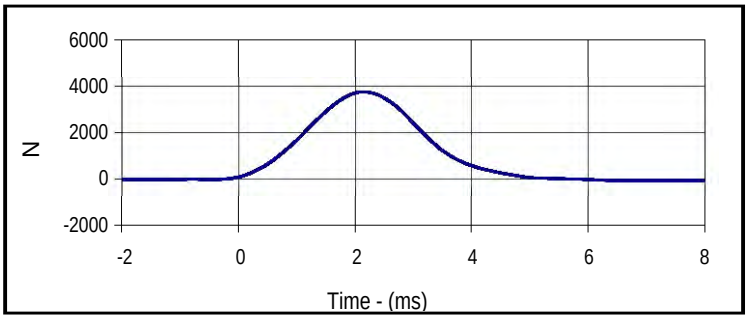
KARCO Engineering

**Left Knee**

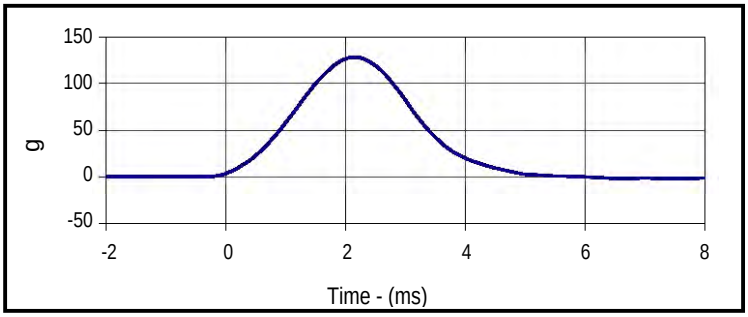
| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Knee Assembly Soak Time | | Minutes | ≥240 | 532 | Pass |
| Temperature During Soak | Max | °C | 18.9 to 25.6 | 22.2 | Pass |
| | Min | °C | | 21.2 | Pass |
| Humidity During Soak | Max | % | 10.0 to 70.0 | 30.4 | Pass |
| | Min | % | | 30.3 | Pass |
| Laboratory Temperature During Test | | °C | 18.9 to 25.6 | 21.2 | Pass |
| Laboratory Humidity During Test | | % | 10.0 to 70.0 | 30.4 | Pass |
| Pendulum Velocity at T=0 | | m/sec | 2.07 to 2.13 | 2.09 | Pass |
| Peak Probe Force | | N | 3450 to 4060 | 3749 | Pass |
| | | | Overall Test Results | | Pass |

**Right Knee**

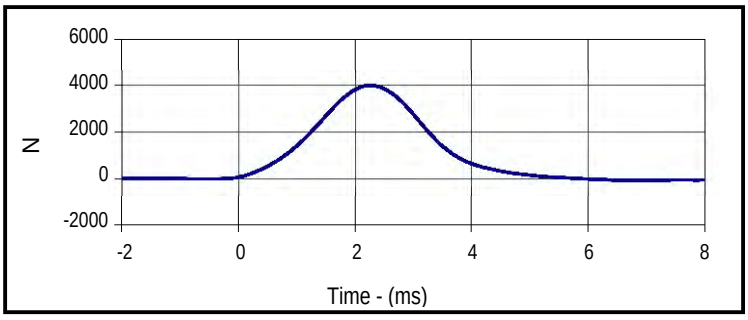
| | | | | |
|---|---|---|---|---|
| Pendulum Velocity at T=0 | m/sec | 2.07 to 2.13 | 2.10 | Pass |
| Peak Probe Force | N | 3450 to 4060 | 3964 | Pass |
| | | Overall Test Results | | Pass |



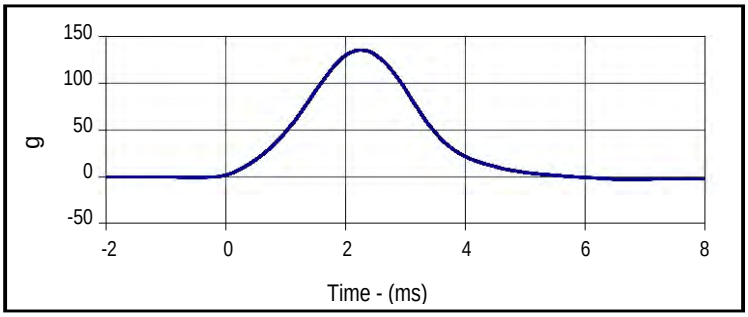

| Curve Description | | | |
|---|---|---|---|
| Left Knee Probe Force | | | |
| Plot No. | Type | SAE Class | Units |
| 001 | FIL | 600 | N |
| Max | Time | Min | Time |
| 3749.3 | 2.1 | -4802.9 | 39.6 |




| Curve Description | | | |
|---|---|---|---|
| Left Knee Acceleration | | | |
| Plot No. | Type | SAE Class | Units |
| 002 | FIL | 600 | g |
| Max | Time | Min | Time |
| 127.9 | 2.1 | -163.9 | 39.6 |



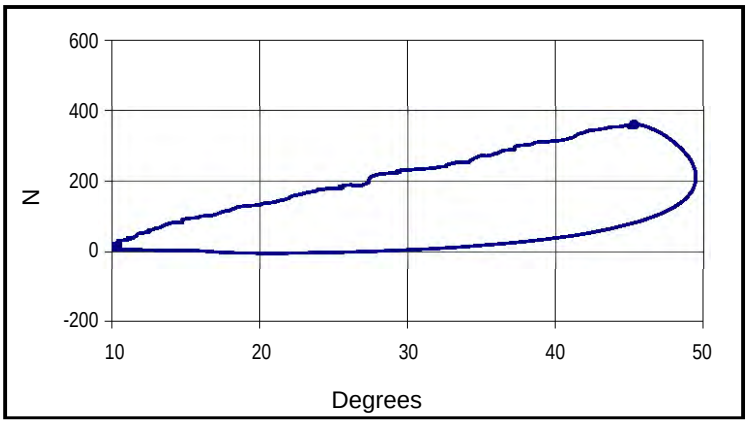

| Curve Description | | | |
|---|---|---|---|
| Right Knee Probe Force | | | |
| Plot No. | Type | SAE Class | Units |
| 003 | FIL | 600 | N |
| Max | Time | Min | Time |
| 3963.8 | 2.3 | -66.1 | 6.7 |



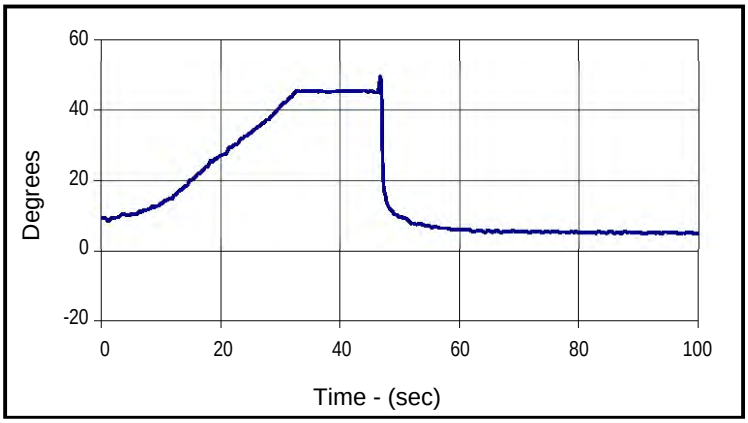

| Curve Description | | | |
|---|---|---|---|
| Right Knee Acceleration | | | |
| Plot No. | Type | SAE Class | Units |
| 004 | FIL | 600 | g |
| Max | Time | Min | Time |
| 135.2 | 2.3 | -2.3 | 6.7 |

| | | | |
|---|---|---|---|
| Test Program: | Torso Flexion Test | Test Date: | 4/3/17 |
| ATD.: | Hybrid III 5th Percentile Female | Test I.D.: | TFP37103-01 |

| Tested Parameter | | Units | Specification | Result | Pass/Fail |
|---|---|---|---|---|---|
| Dummy Soak Time | | Minutes | ≥240 | 597 | Pass |
| Temperature During Soak | Max | °C | 18.9 to 25.6 | 22.2 | Pass |
| | Min | °C | | 21.2 | Pass |
| Humidity During Soak | Max | % | 10.0 to 70.0 | 30.4 | Pass |
| | Min | % | | 30.3 | Pass |
| Laboratory Temperature During Test | | °C | 18.9 to 25.6 | 21.2 | Pass |
| Laboratory Humidity During Test | | % | 10.0 to 70.0 | 30.4 | Pass |
| Initial Reference Plane Angle | | Degrees | ≤ 20 | 9.4 | Pass |
| Peak Force at 45° +/-0.5° | | N | 320.0 to 390.0 | 369.9 | Pass |
| Torso Rotation Rate | | deg/sec | 0.5 to 1.5 | 1.1 | Pass |
| Final Reference Plane Angle | | Degrees | +/-8 | 5.1 | Pass |
| | | | Overall Test Results | | Pass |




| Curve Description | | |
|---|---|---|
| Force vs Torso Rotation | | |
| Plot No. | Type | Filter Freq |
| 001 | FIL | 1 Hz |
| Peak Force | | Peak Rotation |
| 369.9 | | 49.5 |




| Curve Description | | | |
|---|---|---|---|
| Torso Rotation | | | |
| Plot No. | Type | Filter Freq | Units |
| 002 | FIL | 1 Hz | Degrees |
| Max | Time | Min | Time |
| 49.5 | 46.7 | 4.8 | 99.2 |

EDR

## Vehicle Information

| HYUNDAI I ELANTRA COUPE(JK) I 2013 I AIRBAG SYSTEM | |
|---|---|
| VIN as Programmed into EMS | |

## Additional Information

| | |
|---|---|
| User-entered VIN | KMHDH4AE1DU014163 |
| User Name | |
| Case Number | |
| Crash Date | |
| Saved-on Date | 2017-04-13 19:19 |
| EDR Tool Version | E-N-H-01-00-0019 |
| EDR Report Version | EDR001-R01 |
| Tire Size(s) | |
| Memo | |

## Data Limitation

### General Information:

Tools for downloading and interpreting the EDRs in Hyundai vehicles have been developed for vehicles produced after September 1, 2012. Currently, there is no tool for downloading and accurate interpreting data from the EDRs in Hyundai vehicles produced prior to this date.

The EDR Report requires Adobe Reader Version 9.00 or higher to open.

### EDR(Event Data Recorder):

- The EDR function is part of the Airbag Control Unit(ACU).

- ACU can store up to two events.

- Event means a crash or other physical occurrence that causes the trigger threshold to be met or exceeded, or any non-reversible deployable restraint to be deployed, whichever occurs first:

  1. Deployment Event:
     1) the event which is recorded if an airbag is commanded to deploy.
     2) the event is locked and cannot be overwritten.

  2. Non-deployment Event:
     1) the event which is recorded, but in which an airbag is not commanded to deploy
     2) the event is not locked and can be overwritten by a subsequent event (Deployment or Non-deployment event), for example, Pretensioner(s) only deployment
     3) An example of a non-deployment event is a pretensioner-only deployment with no airbag deployments

- Ignition cycle count will increment by 1 in the following cases

  1. the power mode change from OFF/Accessary to IGN ON/RUN

  2. EDR data download by tools

- The ACU can record data for all or some of the following events. But, depending on the vehicle's configurations, data for side crash and/or rollover crash(event) may not be recorded.

- If power supply to the ACU is lost during an event, all or part of the data may not be recorded.

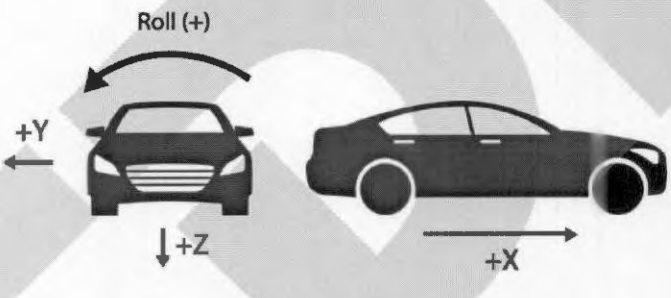
# Data Limitation

## Data Element Sign Convention:

The following table provides an explanation of the sign notation for data elements that may be included in the EDR report. Directional references to sign convention are from the point of view of the driver.

| Data element name | Positive sign | Note |
|---|---|---|
| Longitudinal acceleration | Forward direction | +X at the figure 1 |
| Delta V, longitudinal | Forward direction | +X at the figure 1 |
| Lateral acceleration | Left to Right direction | +Y at the figure 1 |
| Delta V, lateral | Left to Right direction | +Y at the figure 1 |
| Normal(vertical) acceleration | Downward direction | +Z at the figure 1 |
| Vehicle roll angle | Clockwise about the longitudinal axis | Roll(+) at the figure 1 |
| Steering input | Counterclockwise rotation | - |

Figure 1. Sign Conventions




## Data Sources:

Many EDR data elements are sourced from other control modules in the vehicle.

1. Most of them can be measured and calculated by the ACU. For example, Delta-V and Rollover angle can be calculated from internal sensors in the ACU (if applicable).

2. The following pre-crash data can be transmitted to the ACU via the vehicle's communication network.
   - Vehicle Speed
   - Engine RPM
   - Engine Throttle
   - Acceleration Pedal
   - Service Brake
   - ABS Activity
   - Stability Control
   - Steering Input Angle

   *Note) Depending on the vehicle's configuration and the conditions described above, some items may not be recorded.

3. Pre-crash data is recorded in discrete intervals. Due to different refresh rates within the vehicle's electronics, the data recorded may be asynchronous to each other.

# Data Limitation

## Data Definitions:

- Data recorded by the ACU and imaged by the EDR tool is displayed relative to Time zero(T0). Time zero(T0) is not typically the time at which the vehicle made contact with another vehicle or object.

- Time zero (T0) means whichever of the following occurs first

  1. For systems with "wake-up" air bag control systems, the time at which the occupant restraint control algorithm is activated; or

  2. For continuously running algorithms,

  1) The first point in the interval where a longitudinal cumulative delta-V of over 0.8 km/h (0.5 mph) is reached within a 20msec time period; or

  2) For vehicles that record "delta-V, lateral," the first point in the interval where a lateral cumulative delta-V of over 0.8 km/h (0.5 mph) is reached within a 5msec time period; or

  3. Deployment of a non-reversible deployable restraint.

- Multi-event crash means the occurrence of 2 events, the first and last of which begin not more than 5 seconds apart. If an event is not part of a multi-event crash, the value of this data element will be "1".

- Service brake, on or off means the status of the device that is installed in or connected to the brake pedal system to detect whether the pedal was pressed. The device can include the brake pedal switch or other driver-operated service brake control,

- Engine RPM means

  1. For vehicles powered by internal combustion engines, the number of revolutions per minute of the main crankshaft of the vehicle's engine, and

  2. For vehicles not entirely powered by internal combustion engines, the number of revolutions per minute of the motor shaft at the point at which it enters the vehicle transmission gearbox.

- Engine Throttle is a measure of the throttle position.

- Accelerator Pedal is a measure of the accelerator pedal value.

- Seat belt status is determined by whether the buckle switch is open or closed.

- Delta-V means the cumulative change in velocity, and is calculated from internal sensors in the ACU

## EDR Information

| | |
|---|---|
| Part No. (EOL Code) as programmed into ACU | 95910-3Y000(TC04) |
| ECU SW Version as programmed into ACU | 030902 |
| EDR Version as programmed into ACU | |

## < Event 1 >

## Event Status at Event

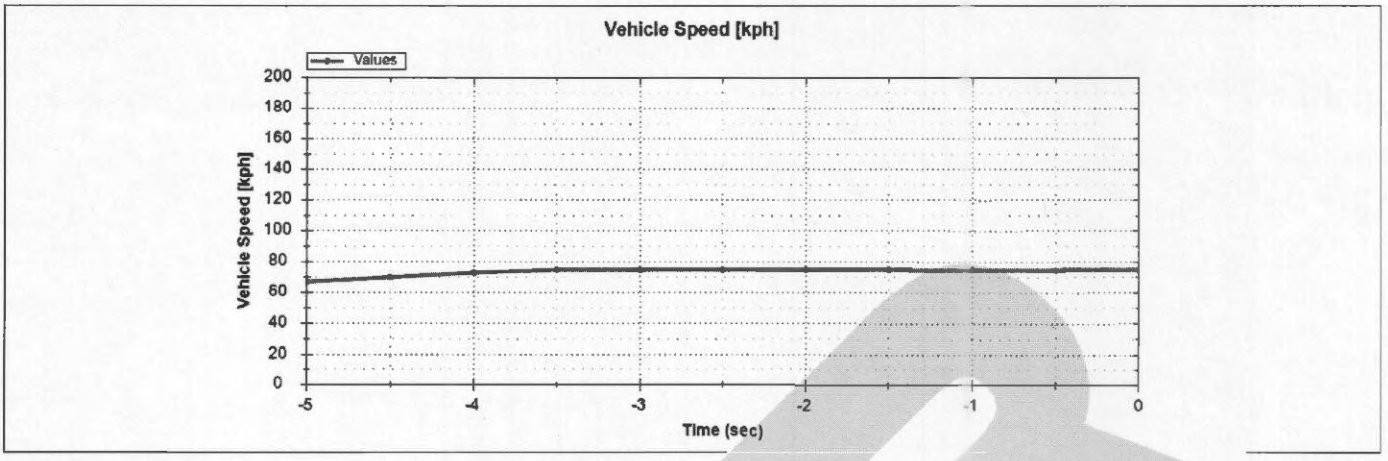
| | |
|---|---|
| Multi-event, Number of Event (1 or 2) | 1 event |
| Time from Event 1 to 2 [msec] | 0 |
| Completed File Recorded (Yes or No) | YES |
| Ignition cycle, crash [cycle] | 14322 |
| Ignition cycle, download [cycle] | 14323 |

## Pre-Crash Information (-5 ~ 0 sec)

| Time (sec) | Vehicle Speed [kph] | Engine RPM [rpm] | Engine Throttle [%] | Service Brake [on/off] | ABS Activity [on/off] | Stability Control [on/off/engaged] | Steering Input [degree] |
|---|---|---|---|---|---|---|---|
| -5.0 | 67 | 0 | 5 | OFF | OFF | on | 0 |
| -4.5 | 70 | 0 | 5 | OFF | OFF | on | 0 |
| -4.0 | 73 | 0 | 5 | OFF | OFF | on | 0 |
| -3.5 | 75 | 0 | 5 | OFF | OFF | on | 0 |
| -3.0 | 75 | 0 | 5 | OFF | OFF | on | 0 |
| -2.5 | 75 | 0 | 5 | OFF | OFF | on | 0 |
| -2.0 | 75 | 0 | 5 | OFF | OFF | on | 0 |
| -1.5 | 75 | 0 | 5 | OFF | OFF | on | 0 |
| -1.0 | 75 | 0 | 5 | OFF | OFF | on | 0 |
| -0.5 | 75 | 0 | 5 | OFF | OFF | on | 0 |
| 0.0 | 75 | 0 | 5 | OFF | OFF | on | 0 |

# < Event 1 >

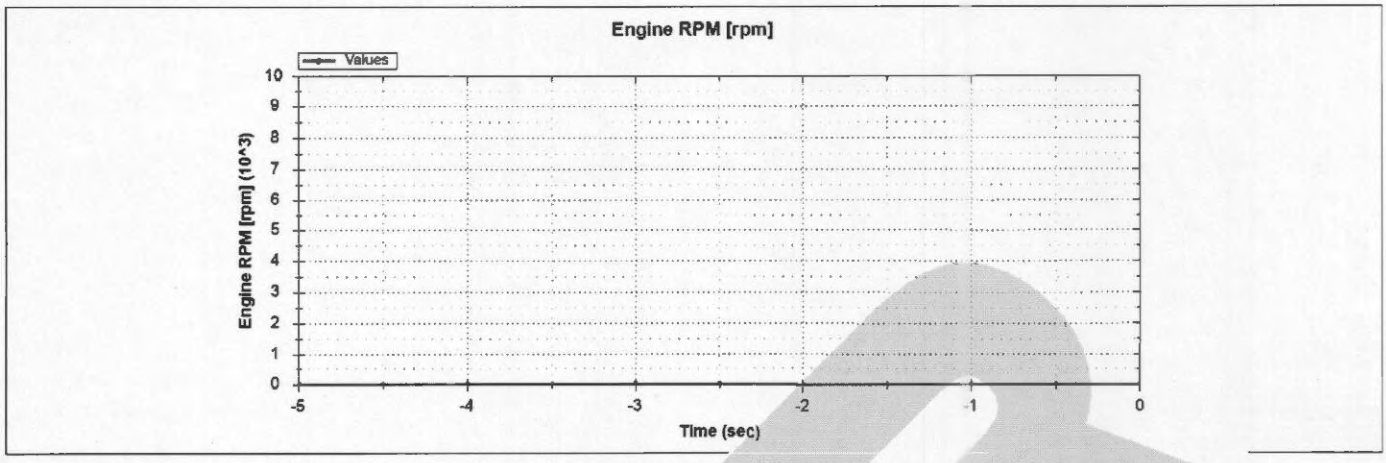
## Vehicle Speed




| Num | Time (sec) | Vehicle Speed [kph] |
|---|---|---|
| 1 | -5.0 | 67 |
| 2 | -4.5 | 70 |
| 3 | -4.0 | 73 |
| 4 | -3.5 | 75 |
| 5 | -3.0 | 75 |
| 6 | -2.5 | 75 |
| 7 | -2.0 | 75 |
| 8 | -1.5 | 75 |
| 9 | -1.0 | 75 |
| 10 | -0.5 | 75 |
| 11 | 0.0 | 75 |

# < Event 1 >

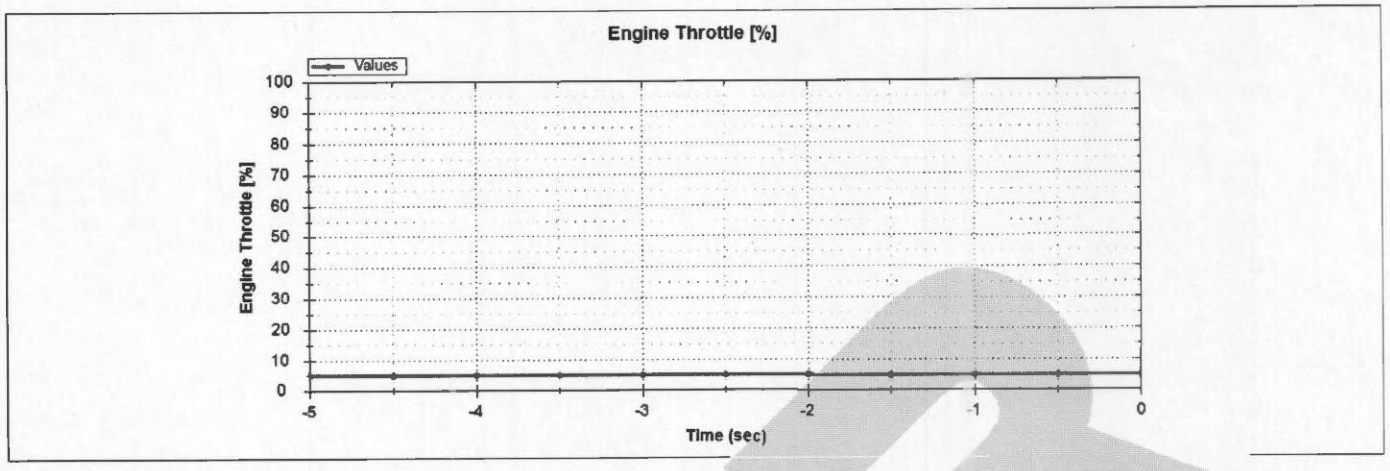
## Engine RPM




| Num | Time (sec) | Engine RPM [rpm] |
|---|---|---|
| 1 | -5.0 | 0 |
| 2 | -4.5 | 0 |
| 3 | -4.0 | 0 |
| 4 | -3.5 | 0 |
| 5 | -3.0 | 0 |
| 6 | -2.5 | 0 |
| 7 | -2.0 | 0 |
| 8 | -1.5 | 0 |
| 9 | -1.0 | 0 |
| 10 | -0.5 | 0 |
| 11 | 0.0 | 0 |

# < Event 1 >

## Engine Throttle




| Num | Time (sec) | Engine Throttle [%] |
|---|---|---|
| 1 | -5.0 | 5 |
| 2 | -4.5 | 5 |
| 3 | -4.0 | 5 |
| 4 | -3.5 | 5 |
| 5 | -3.0 | 5 |
| 6 | -2.5 | 5 |
| 7 | -2.0 | 5 |
| 8 | -1.5 | 5 |
| 9 | -1.0 | 5 |
| 10 | -0.5 | 5 |
| 11 | 0.0 | 5 |

## < Event 1 >

## Service Brake

| Num | Time (sec) | Service Brake [on/off] |
|---|---|---|
| 1 | -5.0 | OFF |
| 2 | -4.5 | OFF |
| 3 | -4.0 | OFF |
| 4 | -3.5 | OFF |
| 5 | -3.0 | OFF |
| 6 | -2.5 | OFF |
| 7 | -2.0 | OFF |
| 8 | -1.5 | OFF |
| 9 | -1.0 | OFF |
| 10 | -0.5 | OFF |
| 11 | 0.0 | OFF |

## ABS Activity

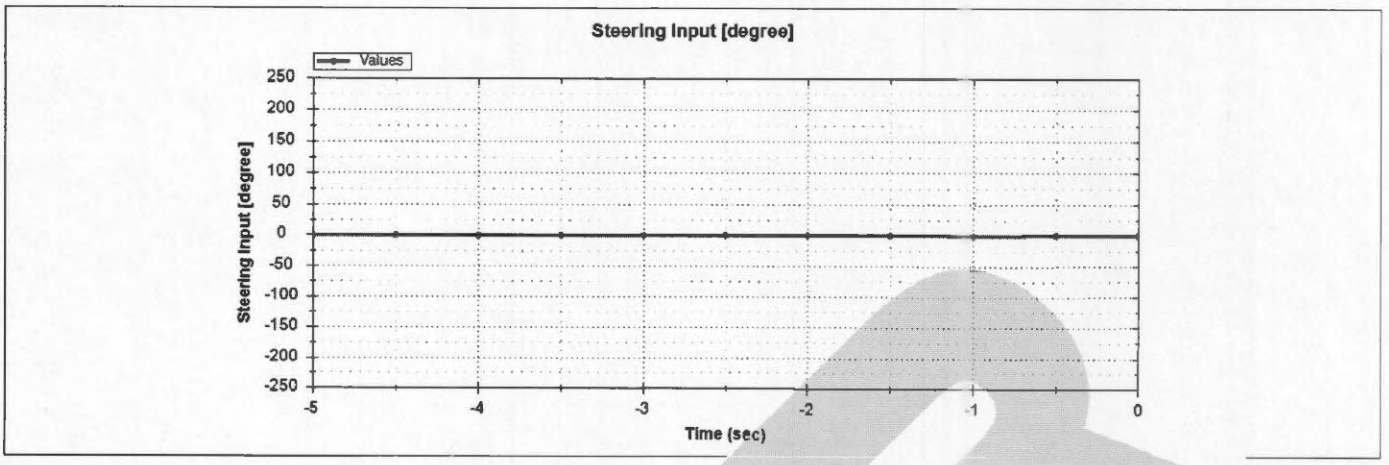
| Num | Time (sec) | ABS Activity [on/off] |
|---|---|---|
| 1 | -5.0 | OFF |
| 2 | -4.5 | OFF |
| 3 | -4.0 | OFF |
| 4 | -3.5 | OFF |
| 5 | -3.0 | OFF |
| 6 | -2.5 | OFF |
| 7 | -2.0 | OFF |
| 8 | -1.5 | OFF |
| 9 | -1.0 | OFF |
| 10 | -0.5 | OFF |
| 11 | 0.0 | OFF |

## Stability Control

| Num | Time (sec) | Stability Control [on/off/engaged] |
|---|---|---|
| 1 | -5.0 | on |
| 2 | -4.5 | on |
| 3 | -4.0 | on |
| 4 | -3.5 | on |
| 5 | -3.0 | on |
| 6 | -2.5 | on |
| 7 | -2.0 | on |
| 8 | -1.5 | on |
| 9 | -1.0 | on |
| 10 | -0.5 | on |
| 11 | 0.0 | on |

# < Event 1 >

## Steering Input




| Num | Time (sec) | Steering Input [degree] |
|---|---|---|
| 1 | -5.0 | 0 |
| 2 | -4.5 | 0 |
| 3 | -4.0 | 0 |
| 4 | -3.5 | 0 |
| 5 | -3.0 | 0 |
| 6 | -2.5 | 0 |
| 7 | -2.0 | 0 |
| 8 | -1.5 | 0 |
| 9 | -1.0 | 0 |
| 10 | -0.5 | 0 |
| 11 | 0.0 | 0 |

Note) Positive value(CCW), Negative value(CW)

# < Event 1 >

## System Status at Event

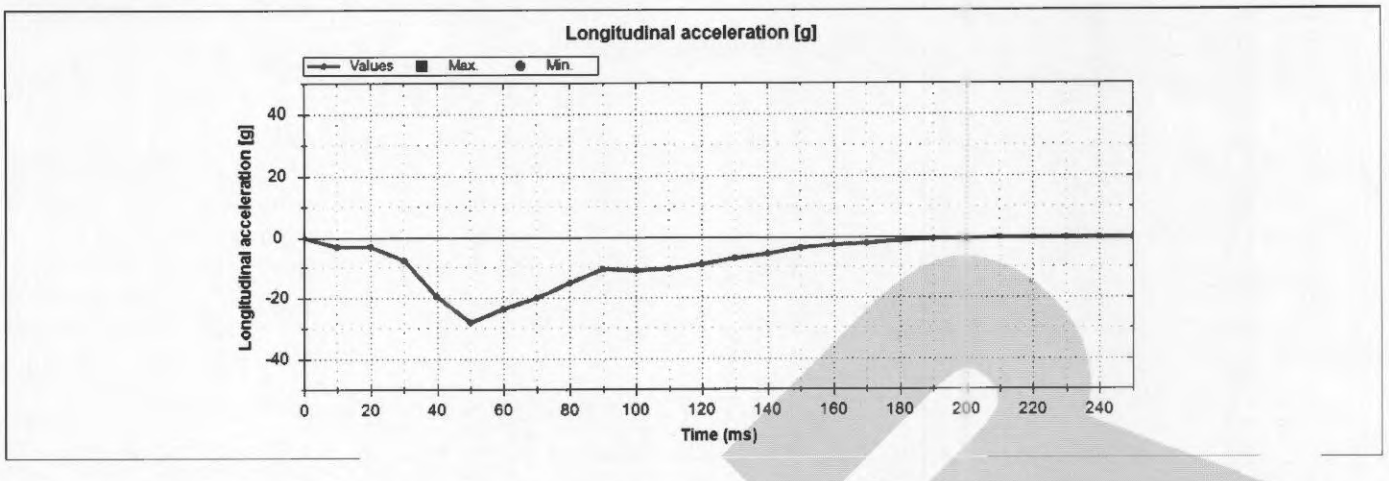
| | |
|---|---|
| Airbag warning lamp on/off | On |
| Safety belt status, driver | On |
| Safety seat belt, passenger | Fault |
| Seat track position switch foremost status, driver | Not Supported |
| Seat track position switch foremost status, passenger | Not Supported |
| Occupant size classification, driver (5% female or larger) | Not Supported |
| Occupant size classification, passenger (child) | No |

## Deployment Command Data at Event

| | |
|---|---|
| Front airbag deployment time, driver (first stage) [msec] | 6 |
| Front airbag deployment time, passenger (first stage) [msec] | 6 |
| Front airbag deployment time, driver (second stage) [msec] | 16 |
| Front airbag deployment time, passenger (second stage) [msec] | 16 |
| Front airbag deployment time, driver (third stage) [msec] | Not Supported |
| Front airbag deployment time, passenger (third stage) [msec] | Not Supported |
| Front airbag disposal deployment, driver (second stage) (Yes or No) | No |
| Front airbag disposal deployment, passenger (second stage) (Yes or No) | No |
| Front side airbag deployment time, driver [msec] | 27 |
| Front side airbag deployment time, passenger [msec] | No deployment |
| Curtain airbag deployment time, driver [msec] | 27 |
| Curtain airbag deployment time, passenger [msec] | No deployment |
| Seat belt pretensioner deployment time, driver [msec] | 6 |
| Seat belt pretensioner deployment time, passengerr [msec] | 6 |

## < Event 1 >

# Longitudinal crash pulse_acceleration (g, 0 ~ 250msec)

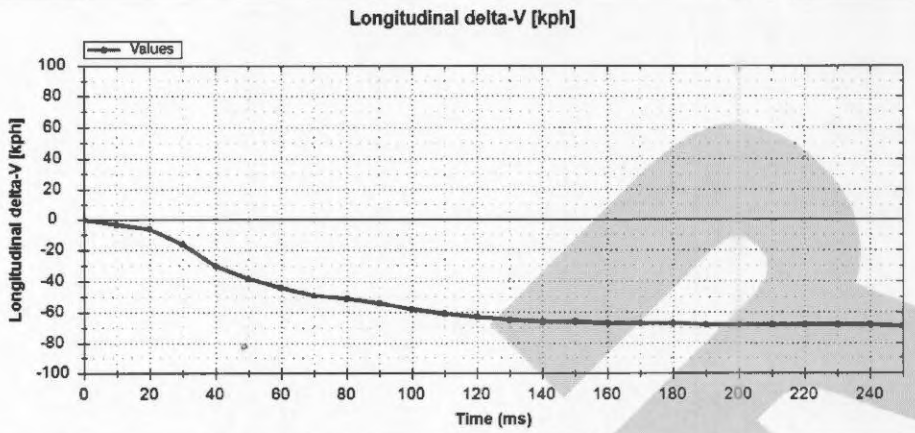



| Num | Time (ms) | Longitudinal acceleration [g] |
|---|---|---|
| 1 | 0.0 | 0.0 |
| 2 | 10.0 | -3.0 |
| 3 | 20.0 | -3.0 |
| 4 | 30.0 | -7.5 |
| 5 | 40.0 | -19.5 |
| 6 | 50.0 | -28.0 |
| 7 | 60.0 | -23.5 |
| 8 | 70.0 | -20.0 |
| 9 | 80.0 | -15.0 |
| 10 | 90.0 | -10.5 |
| 11 | 100.0 | -11.0 |
| 12 | 110.0 | -10.5 |
| 13 | 120.0 | -9.0 |
| 14 | 130.0 | -7.0 |
| 15 | 140.0 | -5.5 |
| 16 | 150.0 | -3.5 |
| 17 | 160.0 | -2.5 |
| 18 | 170.0 | -2.0 |
| 19 | 180.0 | -1.0 |
| 20 | 190.0 | -0.5 |
| 21 | 200.0 | -0.5 |
| 22 | 210.0 | 0.0 |
| 23 | 220.0 | 0.0 |
| 24 | 230.0 | 0.0 |
| 25 | 240.0 | 0.0 |
| 26 | 250.0 | 0.0 |

## < Event 1 >

# Longitudinal crash pulse_delta-v (kph, 0 ~ 250msec)

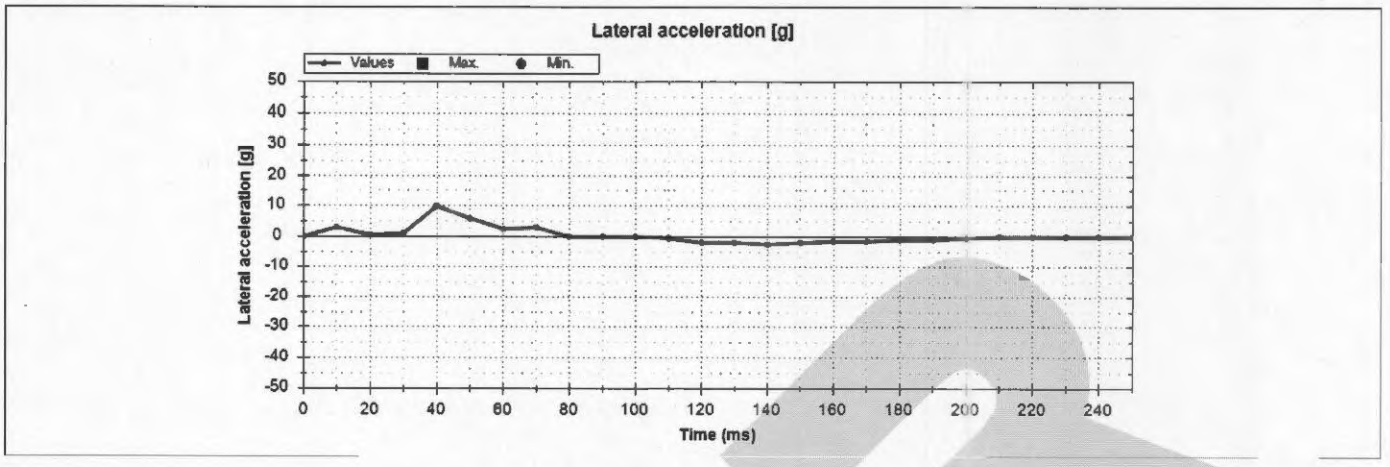
| | |
|---|---|
| Max. delta-V [kph] | -69 |
| Time, Max. delta-V [msec] | 250.0 |




| Num | Time (ms) | Longitudinal delta-V [kph] |
|---|---|---|
| 1 | 0.0 | 0 |
| 2 | 10.0 | -3 |
| 3 | 20.0 | -6 |
| 4 | 30.0 | -16 |
| 5 | 40.0 | -30 |
| 6 | 50.0 | -38 |
| 7 | 60.0 | -44 |
| 8 | 70.0 | -49 |
| 9 | 80.0 | -51 |
| 10 | 90.0 | -54 |
| 11 | 100.0 | -58 |
| 12 | 110.0 | -61 |
| 13 | 120.0 | -63 |
| 14 | 130.0 | -65 |
| 15 | 140.0 | -66 |
| 16 | 150.0 | -66 |
| 17 | 160.0 | -67 |
| 18 | 170.0 | -67 |
| 19 | 180.0 | -67 |
| 20 | 190.0 | -68 |
| 21 | 200.0 | -68 |
| 22 | 210.0 | -68 |
| 23 | 220.0 | -68 |
| 24 | 230.0 | -68 |
| 25 | 240.0 | -68 |
| 26 | 250.0 | -69 |

## < Event 1 >

# Lateral crash pulse_acceleration (g, 0 ~ 250msec)

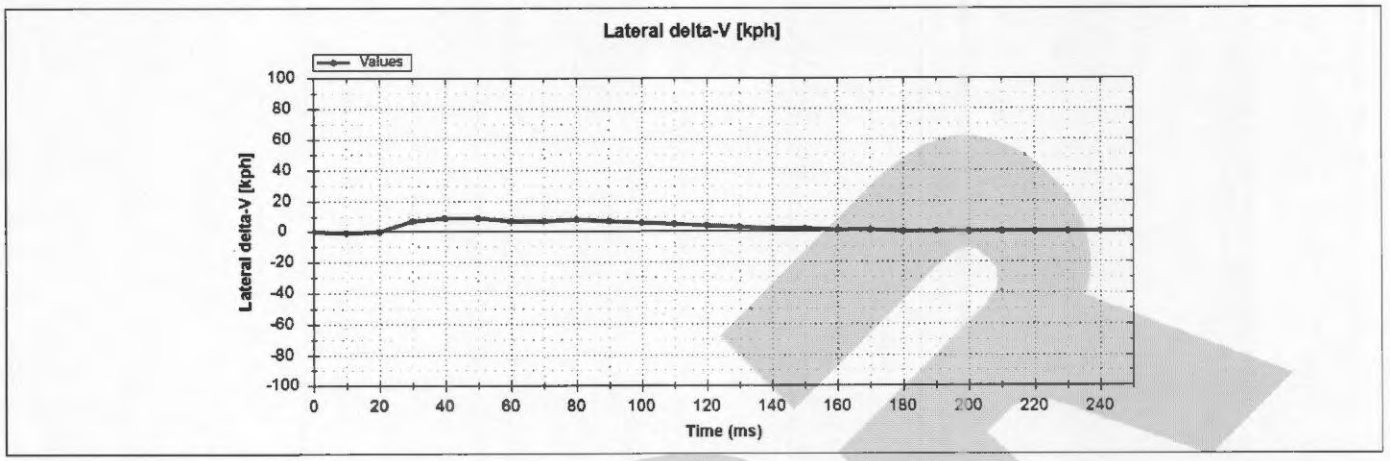



| Num | Time (ms) | Lateral acceleration [g] |
|---|---|---|
| 1 | 0.0 | 0.0 |
| 2 | 10.0 | 3.0 |
| 3 | 20.0 | 0.5 |
| 4 | 30.0 | 1.0 |
| 5 | 40.0 | 10.0 |
| 6 | 50.0 | 6.0 |
| 7 | 60.0 | 2.5 |
| 8 | 70.0 | 3.0 |
| 9 | 80.0 | 0.0 |
| 10 | 90.0 | 0.0 |
| 11 | 100.0 | 0.0 |
| 12 | 110.0 | -0.5 |
| 13 | 120.0 | -2.0 |
| 14 | 130.0 | -2.0 |
| 15 | 140.0 | -2.5 |
| 16 | 150.0 | -2.0 |
| 17 | 160.0 | -1.5 |
| 18 | 170.0 | -1.5 |
| 19 | 180.0 | -1.0 |
| 20 | 190.0 | -1.0 |
| 21 | 200.0 | -0.5 |
| 22 | 210.0 | 0.0 |
| 23 | 220.0 | 0.0 |
| 24 | 230.0 | 0.0 |
| 25 | 240.0 | 0.0 |
| 26 | 250.0 | 0.0 |

## < Event 1 >

# Lateral crash pulse_delta-v (kph, 0 ~ 250msec)

| | |
|---|---|
| Max. delta-V [kph] | 10 |
| Time, Max. delta-V [msec] | 45.0 |



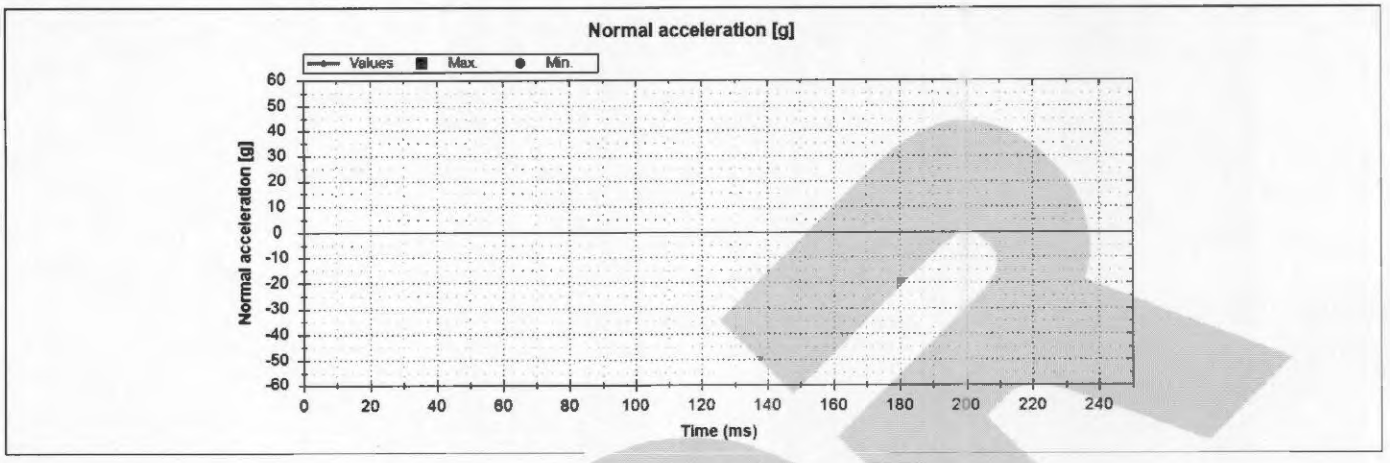

| Num | Time (ms) | Lateral delta-V [kph] |
|---|---|---|
| 1 | 0.0 | 0 |
| 2 | 10.0 | -1 |
| 3 | 20.0 | 0 |
| 4 | 30.0 | 7 |
| 5 | 40.0 | 9 |
| 6 | 50.0 | 9 |
| 7 | 60.0 | 7 |
| 8 | 70.0 | 7 |
| 9 | 80.0 | 8 |
| 10 | 90.0 | 7 |
| 11 | 100.0 | 6 |
| 12 | 110.0 | 5 |
| 13 | 120.0 | 4 |
| 14 | 130.0 | 3 |
| 15 | 140.0 | 2 |
| 16 | 150.0 | 2 |
| 17 | 160.0 | 1 |
| 18 | 170.0 | 1 |
| 19 | 180.0 | 0 |
| 20 | 190.0 | 0 |
| 21 | 200.0 | 0 |
| 22 | 210.0 | 0 |
| 23 | 220.0 | 0 |
| 24 | 230.0 | 0 |
| 25 | 240.0 | 0 |
| 26 | 250.0 | 0 |

## < Event 1 >

## Crash pulse Resultant, Time_Max. delta-V resultant (0 ~ 300 msec)

| | |
|---|---|
| Time, Max. delta-V, resultant [msec] | 250.0 |

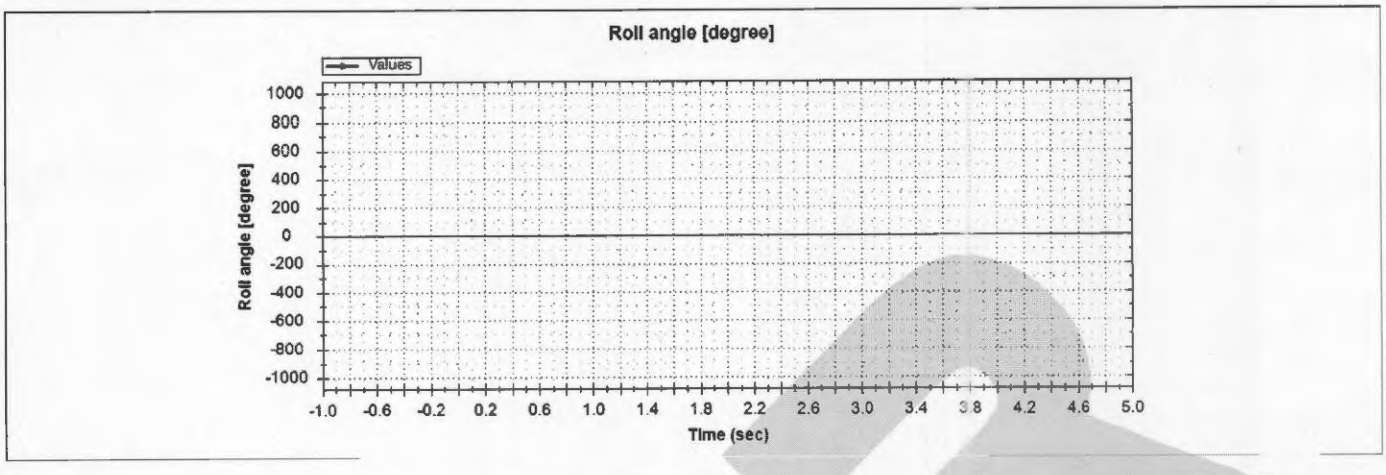
## Normal acceleration (g, 0 ~ 250msec)




| Num | Time (ms) | Normal acceleration [g] |
|---|---|---|
| 1 | 0.0 | Not supported |
| 2 | 10.0 | Not supported |
| 3 | 20.0 | Not supported |
| 4 | 30.0 | Not supported |
| 5 | 40.0 | Not supported |
| 6 | 50.0 | Not supported |
| 7 | 60.0 | Not supported |
| 8 | 70.0 | Not supported |
| 9 | 80.0 | Not supported |
| 10 | 90.0 | Not supported |
| 11 | 100.0 | Not supported |
| 12 | 110.0 | Not supported |
| 13 | 120.0 | Not supported |
| 14 | 130.0 | Not supported |
| 15 | 140.0 | Not supported |
| 16 | 150.0 | Not supported |
| 17 | 160.0 | Not supported |
| 18 | 170.0 | Not supported |
| 19 | 180.0 | Not supported |
| 20 | 190.0 | Not supported |
| 21 | 200.0 | Not supported |
| 22 | 210.0 | Not supported |
| 23 | 220.0 | Not supported |
| 24 | 230.0 | Not supported |
| 25 | 240.0 | Not supported |
| 26 | 250.0 | Not supported |

## < Event 1 >

# Roll angle (degree, -1 ~ 5sec)




| Num | Time (sec) | Roll angle [degree] |
|---|---|---|
| 1 | -1.0 | Not supported |
| 2 | -0.9 | Not supported |
| 3 | -0.8 | Not supported |
| 4 | -0.7 | Not supported |
| 5 | -0.6 | Not supported |
| 6 | -0.5 | Not supported |
| 7 | -0.4 | Not supported |
| 8 | -0.3 | Not supported |
| 9 | -0.2 | Not supported |
| 10 | -0.1 | Not supported |
| 11 | 0.0 | Not supported |
| 12 | 0.1 | Not supported |
| 13 | 0.2 | Not supported |
| 14 | 0.3 | Not supported |
| 15 | 0.4 | Not supported |
| 16 | 0.5 | Not supported |
| 17 | 0.6 | Not supported |
| 18 | 0.7 | Not supported |
| 19 | 0.8 | Not supported |
| 20 | 0.9 | Not supported |
| 21 | 1.0 | Not supported |
| 22 | 1.1 | Not supported |
| 23 | 1.2 | Not supported |
| 24 | 1.3 | Not supported |
| 25 | 1.4 | Not supported |
| 26 | 1.5 | Not supported |
| 27 | 1.6 | Not supported |
| 28 | 1.7 | Not supported |
| 29 | 1.8 | Not supported |
| 30 | 1.9 | Not supported |
| 31 | 2.0 | Not supported |

| | | |
|---|---|---|
| 32 | 2.1 | Not supported |
| 33 | 2.2 | Not supported |
| 34 | 2.3 | Not supported |
| 35 | 2.4 | Not supported |
| 36 | 2.5 | Not supported |
| 37 | 2.6 | Not supported |
| 38 | 2.7 | Not supported |
| 39 | 2.8 | Not supported |
| 40 | 2.9 | Not supported |
| 41 | 3.0 | Not supported |
| 42 | 3.1 | Not supported |
| 43 | 3.2 | Not supported |
| 44 | 3.3 | Not supported |
| 45 | 3.4 | Not supported |
| 46 | 3.5 | Not supported |
| 47 | 3.6 | Not supported |
| 48 | 3.7 | Not supported |
| 49 | 3.8 | Not supported |
| 50 | 3.9 | Not supported |
| 51 | 4.0 | Not supported |
| 52 | 4.1 | Not supported |
| 53 | 4.2 | Not supported |
| 54 | 4.3 | Not supported |
| 55 | 4.4 | Not supported |
| 56 | 4.5 | Not supported |
| 57 | 4.6 | Not supported |
| 58 | 4.7 | Not supported |
| 59 | 4.8 | Not supported |
| 60 | 4.9 | Not supported |
| 61 | 5.0 | Not supported |

## < Event 1 >

## Raw Data

FF 80 00 00 7F 7C 79 6F 61 59 53 4E 4C 49 45 42 40 3E 3D 3D 3C 3C 3C 3B 3B 3B 3B 3B 3B 3A
3A 64 7F 7E 7F 86 88 88 86 86 87 86 85 84 83 82 81 81 80 80 7F 7F 7F 7F 7F 7F 7F 7F 89 12
64 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00

FF FF FF FC 43 46 49 4B 4B 4B 4B 4B 4B 4B 05 05 05 05 05 05 05 05 05 05 55 55 15 37
F2 01 01 06 06 00 00 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 55 55 15 7F 7F 7F 7F 7F
7F 7F 7F 7F 7F 7F 02 03 03 07 05 10 10 1B 00 1B 00 06 06 00 00

E0 00 00 00 7F 79 79 70 58 47 50 57 61 6A 69 6A 6D 71 74 78 7A 7B 7D 7E 7E 7F 7F 7F 7F 7F
7F 85 80 81 93 8B 84 85 7F 7F 7F 7E 7B 7B 7A 7B 7C 7C 7D 7D 7E 7F 7F 7F 7F 7F 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

FF FF F0 00 89 C0 FA FF FF FF FF FF FF FF FF 00 00 FF FF FF FF 00 00 37 F3