U.S. Department of Transportation

Federal Railroad Administration

Sled Tests Using the Hybrid III Rail Safety ATD and Workstation Tables for Passenger Trains

Office of Research,
Development
and Technology
Washington, DC 20590

DOT/FRA/ORD-17/10

Final Report
August 2017

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 2017	Technical Report

4. TITLE AND SUBTITLE
Sled Tests Using the Hybrid III Rail Safety ATD and Workstation Tables for Passenger Trains

5. FUNDING NUMBERS

6. AUTHOR(S)
David Hynd and Claire Willis

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Transport Research Laboratory (TRL)
Crowthorne House, Nine Mile Ride
Wokingham, Berkshire, UK, RG40 3GA

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Federal Railroad Administration
Office of Railroad Policy and Development
Office of Research, Development and Technology
Washington, DC 20590

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
DOT/FRA/ORD-17/10

11. SUPPLEMENTARY NOTES
COR: Jeffrey Gordon

12a. DISTRIBUTION/AVAILABILITY STATEMENT
This document is available to the public through the FRA Web site at http://www.fra.dot.gov.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The Hybrid III Rail Safety (H3-RS) anthropomorphic test device (ATD) is a crash test dummy developed in the United Kingdom to evaluate abdomen and lower thorax injuries that occur when passengers impact workstation tables during train accidents. The H3-RS is similar to the standard Hybrid III 50th Percentile Male ATD used in car crash test regulations worldwide, but with a more humanlike abdomen response under table edge loading conditions and with additional instrumentation to evaluate injury risk at multiple bilateral locations on the abdomen and thorax. Some of the objectives of this study are the following:

- Conduct six sled tests using the H3-RS ATD and a standard Hybrid III 50th percentile ATD;
- Evaluate the performance of commercial workstation tables designed for rail service in the United States and Europe; and
- Collect data to determine whether or not two options for demonstrating table crashworthiness result in equivalent safety.

14. SUBJECT TERMS
Hybrid III Rail Safety, H3-RS, anthropomorphic test device, ATD, workstation table, crashworthiness, occupant protection, collision protection, train accidents, crash test dummy

15. NUMBER OF PAGES
182

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by
ANSI Std. 239-18
298-102

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

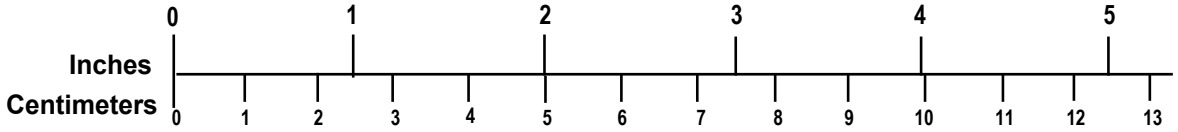
VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

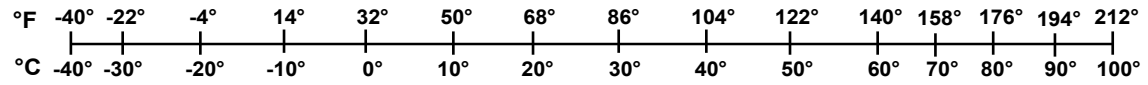
TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

Acknowledgements

The Transport Research Laboratory would like to thank the manufacturers who provided seats and tables for this test program.

Contents

1. Introduction 3
   1.1 Background 3
   1.2 Objectives 4
   1.3 Overall Approach 4
   1.4 Scope 4
   1.5 Organization of the Report 4
2. Test Preparation 5
   2.1 Sled Design and Build 5
   2.2 Measurements and Instrumentation 7
   2.3 Test Procedure 11
3. Results 12
   3.1 Test 1 12
   3.2 Test 2 18
   3.3 Test 3 25
   3.4 Test 4 33
   3.5 Test 5 40
   3.6 Test 6 48
   3.7 Summary 55
4. Discussion 60
5. Conclusions 64
6. References 65

Illustrations

Figure 1. Sled deceleration pulse from calibration run 6
Figure 2. Key table and seat geometry (values provided in Table 1) 7
Figure 3. Approximate positions of H3-RS thorax and abdomen body regions 9
Figure 4. Pre-test view of Test 1 – seat 1, table design 1 12
Figure 5. Post-test view of Test 1 – seat 1, table design 1 13
Figure 6. Test 1 deceleration pulse 13
Figure 7. Pre-test view of Test 2 – seat 1, table design 2 18
Figure 8. Post-test view of Test 2 – seat 1, table design 2 19
Figure 9. Test 2 deceleration pulse 19
Figure 10. Pre-test view of Test 3 – seat 1, table design 3 25
Figure 11. Post-test view of Test 3 – seat 1, table design 3 26
Figure 12. Test 3 deceleration pulse 26
Figure 13. Pre-test view of Test 4 – seat 1, table design 3 33
Figure 14. Post-test view of Test 4 – seat 1, table design 3 34
Figure 15. Test 4 deceleration pulse 34
Figure 16. Pre-test view of Test 5 – seat 1, table design 4 40
Figure 17. Post-test view of Test 5 – seat 1, table design 4 41
Figure 18. Test 5 deceleration pulse 41
Figure 19. Pre-test view of Test 6 – seat 1, table design 5 48
Figure 20. Post-test view of Test 6 – seat 1, table design 5 49
Figure 21. Test 6 deceleration pulse 50
Figure 22. Comparison between the kinematics of the H3-RS and Hybrid III in a typical workstation table test 63

Tables

Table 1. Test matrix with nominal table and seat geometry (dimensions A, B and C as depicted in Figure 2) 7
Table 2. Hybrid-III RS ATD sensor configuration 9
Table 3. Hybrid-III ATD sensor configuration 10
Table 4. APTA crashworthiness assessment 15
Table 5. Injury Criteria Results – Hybrid III RS, APTA requirements (APTA injury criteria definitions are provided in APTA-PR-CS-S-018-13) 16
Table 6. Injury Criteria Results – Hybrid III RS, GMRT-only requirements (GMRT injury criteria definitions are provided in GM/RT 2100) 17
Table 7. Injury Criteria Results – Hybrid III, APTA requirements 17
Table 8. APTA crashworthiness assessment 21
Table 9. Injury Criteria Results – Hybrid III RS, APTA requirements 22
Table 10. Injury Criteria Results – Hybrid III RS, GMRT-only requirements 23
Table 11. Injury Criteria Results – Hybrid III, APTA requirements 23
Table 12. APTA crashworthiness assessment 28
Table 13. Injury Criteria Results – Hybrid III RS, APTA requirements 29
Table 14. Injury Criteria Results – Hybrid III RS, GMRT-only requirements 31
Table 15. Injury Criteria Results – Hybrid III, APTA requirements 31
Table 16. APTA crashworthiness assessment 36
Table 17. Injury Criteria Results – Hybrid III RS, APTA requirements 36
Table 18. Injury Criteria Results – Hybrid III RS, GMRT-only requirements 38
Table 19. Injury Criteria Results – Hybrid III, APTA requirements 38
Table 20. APTA crashworthiness assessment 44
Table 21. Injury Criteria Results – Hybrid III RS, APTA requirements 45
Table 22. Injury Criteria Results – Hybrid III RS, GMRT-only requirements 46
Table 23. Injury Criteria Results – Hybrid III, APTA requirements 47
Table 24. APTA crashworthiness assessment 52
Table 25. Injury Criteria Results – Hybrid III RS, APTA requirements 53
Table 26. Injury Criteria Results – Hybrid III RS, GMRT-only requirements 54
Table 27. Injury Criteria Results – Hybrid III, APTA requirements 54
Table 28. Maximum thorax rib deflection (mm) (APTA limit = 63 mm) 57

Table 29. Maximum thorax rib VC (m/s) (APTA limit = 1 m/s) 57
Table 30. Maximum abdomen deflection (mm) (APTA limit = 67 mm) 57
Table 31. Maximum abdomen VC (m/s) (APTA limit = 1.98 m/s) 58
Table 32. Maximum Tibial Index (GM/RT2100 limit 1.3) and knee displacement (GM/RT2100 limit -16 mm) 58

Executive Summary

In 2015, the Transport Research Laboratory (TRL), which is located in the United Kingdom (UK), performed six workstation table sled tests with the Hybrid III Rail Safety (H3-RS) anthropomorphic test device (ATD) and a standard Hybrid III 50th Percentile ATD, with the goal of demonstrating the enhanced safety assessment made possible by the H3-RS.

The H3-RS is a crash test dummy that was developed in the UK to evaluate abdomen and lower thorax injuries that occur when passengers impact workstation tables during train accidents. The H3-RS is similar to the standard Hybrid III 50th Percentile Male ATD, which is used in car crash test regulations and consumer information programs worldwide, but the H3-RS has a more humanlike abdomen response under table edge loading conditions and includes additional instrumentation to measure compression and rate of compression at multiple bilateral locations in the chest and abdomen.

The objectives of this study were to perform the following:

- Conduct six sled tests using the H3-RS ATD and a standard Hybrid III 50th Percentile ATD;
- Collect head, chest, neck, and femur injury data from both ATDs, and injury data from the upper and lower abdominal transducers and four-point chest deflection transducers for the H3-RS ATD;
- Compare the injury measurements and kinematics of the two ATDs;
- Evaluate the performance of the H3-RS abdominal instrumentation under simulated collision conditions;
- Evaluate the performance of commercial workstation tables designed for rail service in the United States and Europe;
- Collect data to determine whether or not two options for demonstrating table crashworthiness result in equivalent safety.

The sled tests were conducted in accordance with sled test requirements defined in Section 5 of APTA PR-CS-S-018-13 (Fixed Workstation Tables in Passenger Rail Cars [1]). The crash pulse used in the testing was tuned to comply, as closely as possible, with the requirements of APTA PR-CS-S-018-13, and the speed was adjusted to make the pulse representative of those used in other test laboratories in the United States.

For each test, the seats and table were set up in a configuration which was as representative as possible of their positioning within an actual rail carriage. The ATDs were positioned according to the procedure within the standard, with the H3-RS ATD seated next to the wall and the standard Hybrid III ATD next to the aisle. Each test was filmed from three different angles, including an overhead and side distant view. The positions of key marker points on the table, seats and ATDs were recorded pre- and post-test, as well as the critical measurements specified in the Statement of Work for this study.

The ATD sensor data were recorded and analyzed according to the requirements of APTA PR-CS-S-018-13 and GM/RT2100 [2] to allow comparisons to be made between the two standards.

The test measurements demonstrated that none of the table designs complied with all the performance requirements of the APTA standard. All the table designs failed to comply with at least one of the injury criteria measurements taken at sensors located in the lower thorax and upper abdomen of the H3-RS (while no such sensors were available on the standard Hybrid III). In contrast, only one of table designs failed to comply with all the injury criteria measured with the standard Hybrid III.

The H3-RS instrumentation functioned as intended, effectively capturing the loading from the table edges. There were two instrumentation failures in the H3-RS when potentiometer wires broke, and one failure in the Hybrid III due to the potentiometer arm coming out of its guide rail.

The H3-RS demonstrated rather different kinematics to the Hybrid III, with a tendency to 'submarine' under the leading edge of the table; in contrast, the Hybrid III tended to remain very upright and demonstrated very little flexion or extension at the hip. This is most likely due to the more biofidelic design of the H3-RS, which has a much larger (and more humanlike) range of motion at the hip and a better-controlled abdomen stiffness.

Revision 1 of the APTA table standard (in draft form awaiting approval, as of this study) provides two options for demonstrating compliance with crashworthiness requirements. One option is to conduct dynamic sled tests with at least one ATD that is equipped to measure bilateral deflection and rates of deflection at locations in the upper and lower abdomen and upper and lower thorax. The tests described in this report demonstrate this option.

The alternative approach to demonstrating compliance with crashworthiness requirements includes two tests:

1) A similar dynamic sled test in which only standard Hybrid III ATDs are used in lieu of an ATD with bilateral deflection sensors in the abdomen and thorax.
2) A quasi-static, destructive loading test to demonstrate that a minimum amount of energy can be absorbed by the table.

Additional testing is planned to evaluate table performance during quasi-static testing and compare the two options for demonstrating table crashworthiness.

1. Introduction

The John A. Volpe National Transportation Center (Volpe) supported the Federal Railroad Administration's Office of Research, Development and Technology by developing a prototype crashworthy workstation table for passenger trains and created an industry safety standard with performance requirements for crashworthy tables (American Public Transportation Association (APTA) PR-CS-S-018-13).

The Hybrid III Rail Safety (H3-RS) anthropomorphic test device (ATD) is a crash test dummy developed in the UK to evaluate the safety of rail cars and cab interiors if a train accident occurs. The H3-RS ATD is used for the evaluating abdomen and thorax injury risk due to impacts with tables, and assessing the risk of head, neck and leg injuries. Seats and tables are typically evaluated in sled tests, but this dummy has also been used in full-scale rail carriage crash tests. This study investigates the performance of the H3-RS in evaluations of workstation table safety in accordance with the APTA-PR-CS-S-018-13 Rev.1 (Draft) standard.

1.1 Background

The H3-RS is similar to the standard Hybrid III 50th Percentile Male ATD, which is used in car crash test regulations and consumer information programs worldwide, but the H3-RS has a more humanlike abdomen response under table edge loading conditions and contains additional instrumentation for measuring compression and the rate of compression at multiple bilateral locations in the chest and abdomen.

The H3-RS has been designed to meet the biofidelity targets specified by the National Highway Traffic Safety Administration (NHTSA) for the next-generation frontal impact car crash test ATD (named "THOR"). The biofidelity targets define the response of a human to various loading conditions and ensure that the response of an ATD design is humanlike in crash tests. The H3-RS has also been designed to meet the certification requirements for the THOR ATD. These are tests, based on the biofidelity tests, to which every ATD is subjected on a regular basis that ensure that the ATD continues to perform as it should, and that every ATD of a given type performs in the same way – thereby ensuring reproducible results with different ATDs.

In December 2014, the Transportation Research Laboratory (TRL) received a contract from Volpe to perform a series of impact tests on the abdomen of the H3-RS ATD. These tests assessed the performance of the abdomen displacement transducers under a range of impact conditions, and evaluated the biofidelity and repeatability of the existing abdomen design and two new designs with modified abdomens. These tests were completed successfully and increased the confidence in the ability of the H3-RS ATD to accurately measure abdomen deflection under a variety of impact conditions.

The APTA table standard was recently revised to provide an alternative option for demonstrating compliance, which includes:

1. A simulated collision test with standard Hybrid III ATDs that are readily available.
2. A quasi-static loading test to ensure adequate energy absorption to mitigate severe abdomen and chest injuries. The performance requirements in the quasi-static loading test are intended to provide a level of safety equivalent to that provided by a table that meets

the performance requirements in the simulated collision test with advanced ATDs like the H3-RS.

Test data using commercial workstation tables were needed as one component in demonstrating that both options in the revised safety standard provide an equivalent level of safety. As part of this data set, this report documents six tests with five different workstation tables using the H3-RS dummy and their results.

1.2 Objectives

The test objectives were:

- Generate H3-RS injury data for a range of workstation table designs;
- Determine whether the tables comply with the APTA table standard's performance requirements;
- Determine whether the H3-RS instrumentation functioned as intended;
- Compare the kinematics of the H3-RS and standard Hybrid III ATDs;
- Evaluate the performance of tables designed to the UK table standard GM/RT2100, under test conditions specified in the US table standard.

1.3 Overall Approach

TRL provided the H3-RS ATD for the test program at the Impact Sled Facility, which is located at its head office in Crowthorne, UK. Four anonymous manufacturers provided workstation tables for the test program; two of the manufacturers provided two tables each, for a total of six tests. Interface plates for all seats and tables were designed and fabricated by TRL. Some of the tables were designed to meet the US APTA standard and some were designed to meet the UK GM/RT2100 standard.

The test program was conducted according to the Statement of Work in RFQ No. DTRT5715Q80061. Most of the tests were witnessed by a mechanical engineer with the Volpe National Transportation Center.

1.4 Scope

The six tests were conducted with five table designs. Some of the tables were designed to meet the latest APTA standard and some were not. Sourcing matching seats for every table type was not possible, so generic bay seats were used. For each test, the table and seats were mounted such as to match, as closely as possible, the ATD position relative to the table that was specified by the table manufacturer for its own seat design.

1.5 Organization of the Report

Section 2 details the test conditions simulated, the test procedures used and the measurements made. The results are presented in Section 3, with discussion and conclusion in Sections 4 and 5. Detailed test results are presented in Appendix A.

2. Test Preparation

2.1 Sled Design and Build

The tests were conducted using a standard TRL sled with a rail test base plate and side wall panel attached. The base plate and wall panel had a matrix of holes drilled in them to allow multiple seat and table designs to be accommodated. Interface plates were fabricated so the various tables and seats could be attached to the sled and their geometry could be adjusted to be as representative of the actual vehicle geometry as possible. However, the seats supplied for testing were from a single manufacturer and they did not exactly match the seats designed to be used with the other manufacturers' tables. The mounting of the seats and tables were adjusted slightly to best match the relative dimensions depicted in the installation drawings provided by each table manufacturer.

To ensure the seat and table configuration was correct, any table manufacturers viewing the testing were encouraged to inspect the set-up prior to testing.

In order to avoid spurious peaks in the deceleration pulse, which could be caused by the movement of ATDs and test pieces during the test, the sled was run with a large total mass of 2650 kg.

2.1.1 Deceleration Pulse

The calibration pulse obtained was the closest representative pulse that could be achieved within the timescale and is plotted in Figure 1. In this graph, and all subsequent graphs of deceleration pulse, the bilinear blue curve is the idealized pulse; the red curve is the measured pulse; the linear black line is used to determine if the pulse is acceptable according to specific requirements in SAE AS-8049 - Performance Standards for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft [3]. Note that the pulse met the prescriptions of the APTA standard, but was slightly below the target delta-v of 9.81 m/s that is indicated by the standard. For the purpose of comparison, the crash pulse requirement for the GM/RT2100 standard is also included in the plot. The GM/RT2100 standard specifies an upper and lower bound (green lines) that the measured pulse must not cross. Generally, the measured pulse is just slightly above the lower bound.

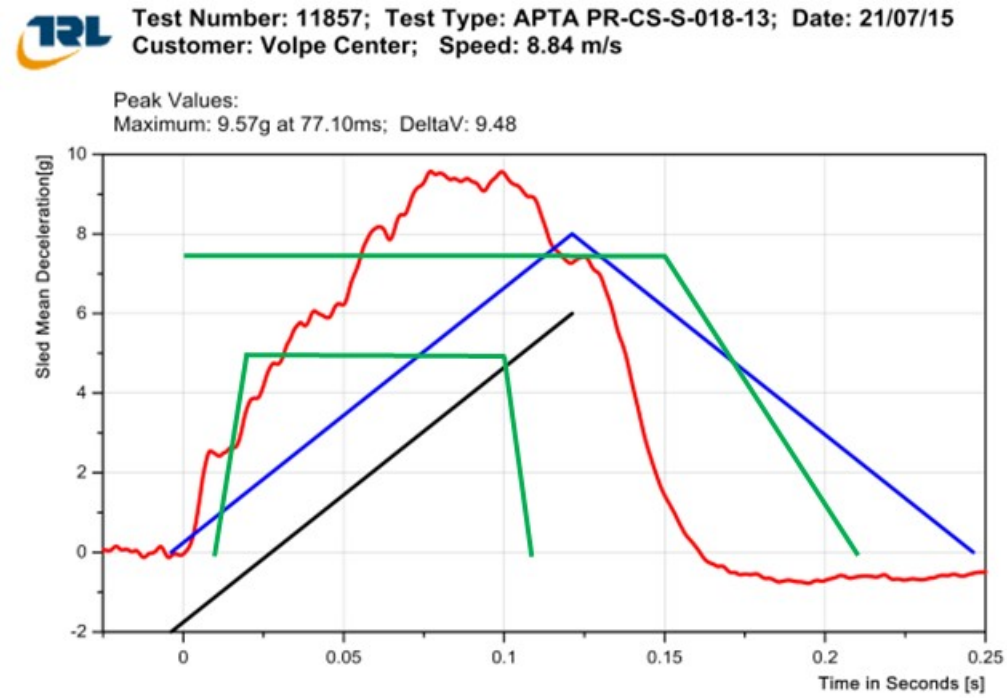


Figure 1. Sled deceleration pulse from calibration run

2.1.2 Seat and Table Configurations

Interface plates for all seats and tables were designed and fabricated by TRL. Since a single design of seat was used with all five table designs, the geometry of the seats and tables was adjusted to meet as closely as possible the table manufacturer's specifications for the seat that each table would be used with in service. The critical dimensions to be maintained were:

A. The relative horizontal distance between the edge of the table top and the seat back cushion on the side at which the ATD is seated.

B. The relative horizontal distance between the edge of the table top and the seat back cushion on the side opposite the ATD.

C. The relative vertical distance between the top of the table and the top of the forward-most point on the seat bottom cushion.

These dimensions are provided in Figure 2 and the values of these dimensions for each test are listed in Table 1.

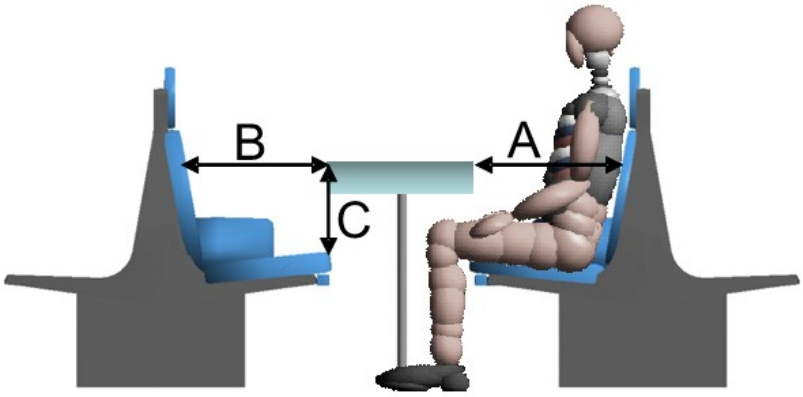


Figure 2. Key table and seat geometry (values provided in Table 1)

Table 1. Test matrix with nominal table and seat geometry (dimensions A, B and C as depicted in Figure 2)

Test Number	Table Design	A (mm)	B (mm)	C (mm)
1	1	428	444	313
2	2	432	440	340
3	3	410	502	302
4	3	425	515	304
5	4	500	498	278
6	5	505	536	294

2.2 Measurements and Instrumentation

2.2.1 ATDs

Each test was performed with a Hybrid III RS ATD in the wall seat and a standard Hybrid III ATD in the aisle seat. The ATDs and their instrumentation for these tests are described below.

The Hybrid III - Rail Safety

The H3-RS has features that are designed to improve the assessment of workstation table safety in rail testing, as compared with the standard Hybrid III ATD. These include:

- *Enhanced chest injury assessment capability compared with the Hybrid III*
    - H3-RS: four-point tri-axial chest deflection measurement, with two sensors at the left and right upper thorax and two at the left and right lower thorax, each measuring deflection in the X, Y and Z axes. The lower thorax instrumentation in particular is important for characterizing the injury risk from table loading.

    - Hybrid III: single-point uni-axial chest deflection measurement, with one sensor at the mid-line of the upper thorax.

- *Enhanced abdomen injury assessment capability compared with the Hybrid III*
    - H3-RS: four-point abdomen deflection measurement, with two tri-axial sensors at the left and right upper abdomen and two uni-axial sensors at the left and right lower abdomen.
    - Hybrid III: no abdomen instrumentation.
- *Biofidelic (more humanlike) abdomen*
    - H3-RS: The abdomen of the H3-RS meets the biofidelity requirements defined for the THOR ATD, and the performance of the abdomen is controlled by certification tests that ensure that the response of and measurements at the abdomen are repeatable and reproducible.
    - Hybrid III: No biofidelity requirements are defined for the Hybrid III abdomen and the performance of the abdomen is not controlled.
- *More biofidelic lumbar spine and pelvis 'bone' geometry*
    - H3-RS: The H3-RS uses a more humanlike lumbar spine and pelvis 'bone' geometry than the Hybrid III, which gives a more realistic interaction with tables and seats.
- *More biofidelic pelvis flesh*
    - H3-RS: The H3-RS uses a three-part upper thigh and pelvis flesh that allows the ATD to adopt a wider range of postures than the Hybrid III, which ensures humanlike kinematics of the ATD in tests without a seat-belt.
    - Hybrid III: The Hybrid III has a one-part pelvis flesh designed for testing with a seat-belt, where the dummy posture is constrained to that of the seat.

The H3-RS ATD was used in the window-side seat in each test. The locations of the H3-RS instrumentation are illustrated in Figure 3 and the sensor configuration for this test series is provided in Table 2.

Injury data were measured and recorded via the ATD instrumentation, and subsequently evaluated for injury severity. As part of the requirements in the APTA table standard, ATD compartmentalization was also evaluated. Compartmentalization is an occupant protection strategy that aims to contain occupants within defined spaces, e.g., between rows of seats or between a seat and a workstation table. Compartmentalization can limit the velocity with which an occupant impacts adjacent fixtures, and can prevent tertiary impacts with other objects or passengers.

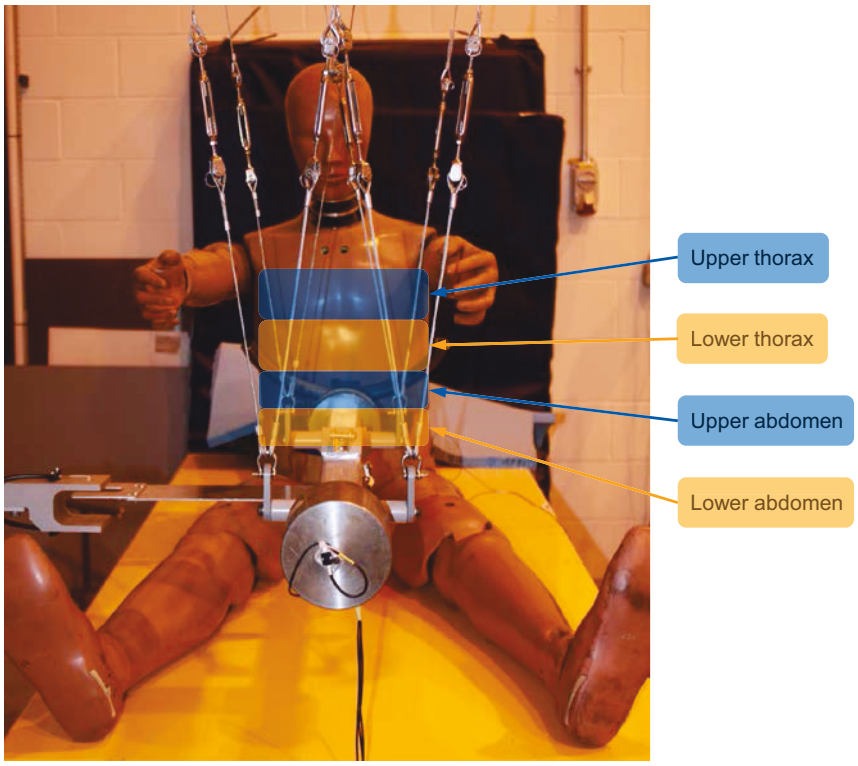


Figure 3. Approximate positions of H3-RS thorax and abdomen body regions

Table 2. Hybrid-III RS ATD sensor configuration

Body region	Sensors
Head	Tri-axial accelerometer
Neck	Upper neck 6-axis load cell
Thorax	Tri-axial accelerometer Upper and lower, left and right tri-axial displacement transducers (x, y and z axis chest compression at each point)
Abdomen	Upper abdomen left and right tri-axial displacement transducers (x, y and z axis compression at each point) Lower abdomen left and right Uni-axial displacement transducers (x axis compression at each point)
Lumbar Spine	6-axis load cell
Pelvis	Tri-axial accelerometer
Femurs	Tri-axial load cell (Fx, Fz and My)
Knees	Knee displacement left and right Knee shear force, left and right knees, lateral and medial

Body region	Sensors
Tibias	Upper and lower, left and right 4-axis load cells (Fx, Fz, My and Mx)

Hybrid III

A standard Hybrid III was used in the aisle-side seat in each test, with the instrumentation provided in Table 3.

Table 3. Hybrid-III ATD sensor configuration

Body region	Sensors
Head	Tri-axial accelerometer
Neck	Upper neck 6-axis load cell
Thorax	Tri-axial accelerometer
	Uni-axial mid-sternum compression transducer (rotary potentiometer attached to a sliding rod)
Femurs	Tri-axial load cell (Fx, Fz and My)

2.2.2 High-Speed Film Footage and Analysis

The tests were filmed using Olympus I-Speed 3 high-speed digital cameras running at 1000 frames per second. The views were a distant side shot, an overhead shot, and a close-up oblique angle shot to give detail of the ATD and table interaction.

Target markers were positioned on the sled to allow various views to be calibrated and track the points on the tables and ATDs.

2.2.3 Stills Photography

Each test followed a standard procedure to capture images of the test set-up from all angles and any specific details required for that particular test.

2.2.4 2D Point Measurements

A 2D laser pointer was used to take the vertical and horizontal positions of specific points on both dummies and on the table and seats in each test. The measurements specified in the APTA standard were recorded pre- and post-test for each test.

2.3 Test Procedure

The following test procedure was applied for each test:

- The sled and ATDs were prepared as above.
- Target markers were placed at suitable positions on the table and seats to allow the pre- and post-test positions to be compared and any permanent deformation to be quantified.
- The positions of the target markers were recorded using a 2D laser pointer.
- The ATDs were positioned according to the procedure in the standard.
- The positions of target markers on the ATDs were recorded using a 2D laser pointer.
- Pre-test ATD sensor checks were completed.
- Paint was applied to the ATDs to identify any contact points with the seats and tables during the impact.
- Pre- and post-test still photographs were taken.

3. Results

3.1 Test 1

3.1.1 Test 1: Background

This test was performed on a prototype (i.e., proof of concept) table that was designed to deform upon impact of the occupants and absorb their impact energy in a manner that reduces loads imparted to the occupants as they deform the table. The testing performed was experimental and was not intended to certify the design or invalidate the design concept.

3.1.2 Test 1: Test Configuration and Deceleration Pulse

The pre-test and post-test ATD and table positions are depicted in Figure 4 and Figure 5. The test pulse is plotted in Figure 6 and the calibration run pulse obtained prior to testing is plotted in Figure 1, which demonstrates that the test conforms as far as possible to the requirements of the standard.

Figure 4. Pre-test view of Test 1 – seat 1, table design 1

Figure 5. Post-test view of Test 1 – seat 1, table design 1

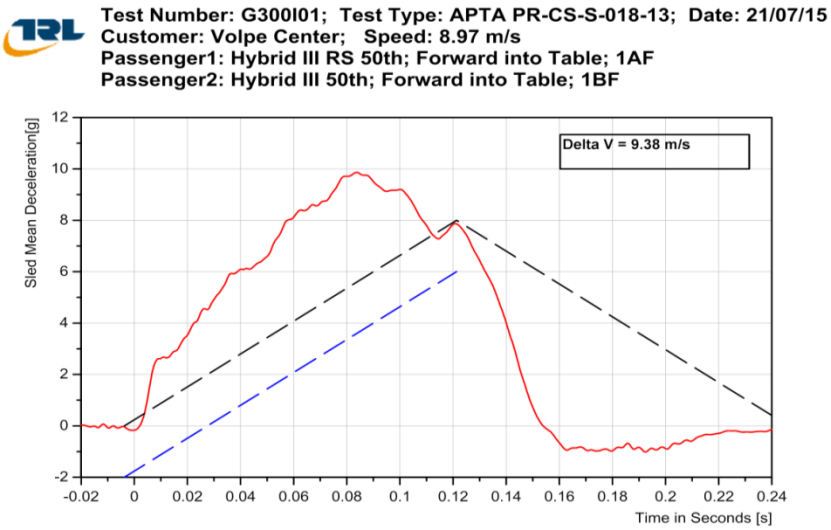


Figure 6. Test 1 deceleration pulse

3.1.3 Test 1: Observations

The table folded as it was designed to do, leaving clear survival space

The table deformation allowed the occupants to slide forward, resulting in leg contact with the opposing seats. This result is primarily a function of the initial seat pitch. Leg contact with opposing seats can help to limit the load on the thorax and abdomen.

The table and seats all remained securely attached to the sled and no parts (e.g. parts of the table/arm rests) became detached during the impact

3.1.4 Test 1: Crashworthiness Assessment

Table 4. APTA crashworthiness assessment

Requirement	Details
The table effectively absorbs kinetic energy whilst limiting contact force between occupants and the table.	The table folding mechanism appeared to function as intended, but the lower left and right chest deflections of the wall side occupant exceeded the criterion.
The table remains attached to the test sled or fixture.	No part of the table detached during the test.
The table effectively compartmentalizes the occupants.	The height of the table top and the energy absorbing deformation allowed the occupants to slide forward, resulting in leg contact with the opposing seats. As a result of the occupants' forward motion, their posteriors were no longer supported by the launch seat, but compartmentalization was achieved.
Table deformation does not expose occupants to sharp edges or spaces capable of entrapping an occupant during a rail accident. The longitudinal survival space opposite the table (dimension 'C' in Figure 2) shall not be less than 381 mm (15 inches).	Despite the table folding, there were no sharp edges exposed at points where the occupant could contact them during the impact. The post-test longitudinal survival space measured 450 mm or more, which satisfies the minimum requirement of 381 mm. The vertical distance between the seat and the underside of the table edge was reduced by the folding mechanism, but the remaining clearance of 190 mm is greater than the required clearance for a 95th percentile male (168 mm).
The table effectively limits human injury of the head, chest, neck, abdomen and femurs.	See Table 5 – lower left and lower right chest deflections exceeded the APTA limit.

3.1.5 Test 1: Injury Criteria Summary

Table 5. Injury Criteria Results – Hybrid III RS, APTA requirements (APTA injury criteria definitions are provided in APTA-PR-CS-S-018-13)

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	23.63	700	Pass	500	Pass
Neck peak axial tension (kN)	0.81	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-0.91kN	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.18	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.20	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.42	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.10	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	17.63	60	Pass	60	Pass
Upper left chest deflection (mm)	-53.69	-63	Pass	-63	Pass
Upper right chest deflection (mm)	-45.39	-63	Pass	-63	Pass
Lower left chest deflection (mm)	**-80.23**	-63	**Fail**	-63	**Fail**
Lower right chest deflection (mm)	**-68.58**	-63	**Fail**	-63	**Fail**
Upper left chest viscous criterion (m/s)	0.44	1.0	Pass	1.0	Pass
Upper right chest viscous criterion (m/s)	0.33	1.0	Pass	1.0	Pass
Lower left chest viscous criterion (m/s)	0.89	1.0	Pass	1.0	Pass
Lower right chest viscous criterion (m/s)	0.76	1.0	Pass	1.0	Pass
Upper left abdomen deflection (mm)	-38.67	-67	Pass	N/A	N/A
Upper right abdomen deflection (mm)	-44.43	-67	Pass	N/A	N/A
Lower left abdomen deflection (mm)	-13.12	-67	Pass	N/A	N/A
Lower right abdomen deflection (mm)	-11.38	-67	Pass	N/A	N/A
Upper left abdomen viscous criterion (m/s)	0.28	1.98	Pass	1.98	Pass
Upper right abdomen viscous criterion (m/s)	0.34	1.98	Pass	1.98	Pass
Lower left abdomen viscous criterion (m/s)	0.05	1.98	Pass	1.98	Pass
Lower right abdomen viscous criterion (m/s)	0.03	1.98	Pass	1.98	Pass
Left femur compression (kN)	-2.39	-10.0	Pass	-4.3/-5.7	Pass
Right femur compression (kN)	-2.8	-10.0	Pass	-4.3/-5.7	Pass

Table 6. Injury Criteria Results – Hybrid III RS, GMRT-only requirements (GMRT injury criteria definitions are provided in GM/RT 2100)

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head acceleration 3ms exceedence (*g*)	20.45	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	51.82	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-41.19	N/A	N/A	-135	Pass
Upper chest combined thoracic index (CTI)	0.21	N/A	N/A	1.0	Pass
Left knee displacement (mm)	-13.8	N/A	N/A	-16	Pass
Right Knee Displacement (mm)	-0.18	N/A	N/A	-16	Pass
Upper left tibia compression (kN)	-1.1	N/A	N/A	-8.0	Pass
Lower left tibia compression (kN)	-0.71	N/A	N/A	-8.0	Pass
Upper left tibial index	0.87	N/A	N/A	1.3	Pass
Lower left tibial index	0.63	N/A	N/A	1.3	Pass
Upper right tibia compression (kN)	-0.59	N/A	N/A	-8.0	Pass
Lower right tibia compression (kN)	-0.64	N/A	N/A	-8.0	Pass
Upper right tibial index	1.12	N/A	N/A	1.3	Pass
Lower right tibial index	0.63	N/A	N/A	1.3	Pass

Note: The deceleration pulse to which the table was tested was more severe than that of GM/RT 2100. It is not readily possible to determine how these results would vary if the table were tested to the deceleration pulse prescribed by GM/RT 2100.

Table 7. Injury Criteria Results – Hybrid III, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	103.78	700	Pass	500	Pass
Head acceleration 3ms exceedence (*g*)	37.16	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	30.33	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-32.84	N/A	N/A	-135	Pass
Neck peak axial tension (kN)	1.10	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-0.15	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.35	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.16	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.01	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.03	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	24.47	60	Pass	60	Pass

Chest deflection (mm)	-50.49	-63	Pass	-63	Pass
Chest viscous criterion (m/s)	0.47	1.0	Pass	1.0	Pass
Left femur compression (kN)	4.00	-10.0	Pass	-4.3/-5.7	Pass
Right femur compression (kN)	2.67	-10.0	Pass	-4.3/-5.7	Pass

3.2 Test 2

3.2.1 Test 2: Background

This test was performed on a prototype table that is structurally identical to the table in the previous test except that the height of the table top is 28mm higher above the floor than in the previous test. The purpose was to see the influence of table height on injury values. The testing performed was experimental and not intended to neither certify the design nor invalidate the design concept.

3.2.2 Test 2: Test Configuration and Deceleration Pulse

The pre- and post-test ATD and table positions are depicted in Figure 7 and Figure 8. The test pulse is plotted in Figure 9 and the calibration run pulse obtained prior to testing is plotted in Figure 1, which demonstrated that the test conforms as far as possible to the requirements of the standard.

Figure 7. Pre-test view of Test 2 – seat 1, table design 2

Figure 8. Post-test view of Test 2 – seat 1, table design 2

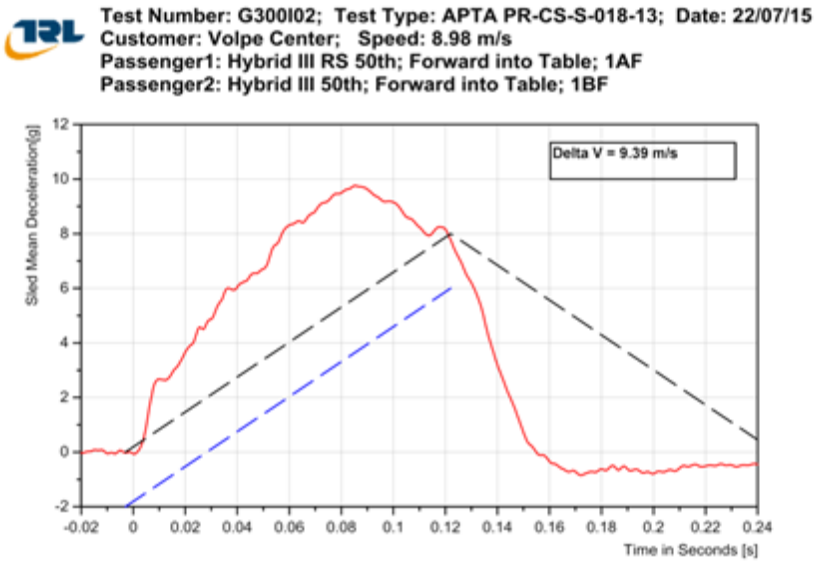
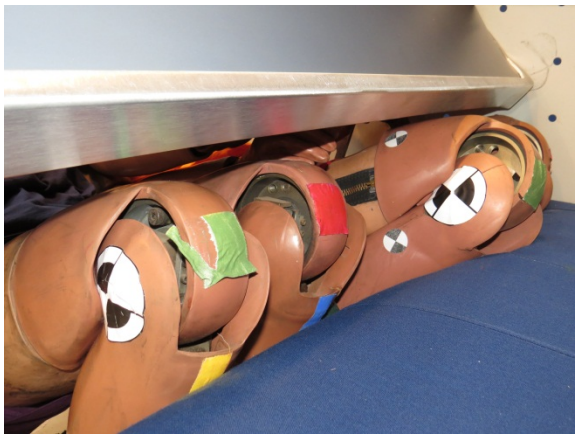


Figure 9. Test 2 deceleration pulse

3.2.3 Test 2: Observations

The table side deformed less at the corners and least at the wall.



There was more significant impact of the occupant legs with the facing seat compared to the previous test. Had this test been assessed for GM/RT2100 lower leg injury criteria such as Tibial Index and knee deflection it would have failed. It should be noted that this crash pulse had a higher velocity than the minimum prescribed by GM/RT 2100.

The energy associated with the mass of the moving occupants deformed the table as intended, causing the occupants to move forward to the point where their posterior was no longer supported by the launch seat.

3.2.4 Test 2: Crashworthiness Assessment

Table 8. APTA crashworthiness assessment

Requirement	Details
The table effectively absorbs kinetic energy whilst limiting contact force between occupants and the table	The table folding mechanism appeared to function as intended, but the upper and lower wall side chest deflection of the wall-side occupant exceeded the criteria
The table remains attached to the test sled or fixture	No part of the table detached during the test
The table effectively compartmentalizes the occupants	The table height, position, and energy absorbing deformation allowed the occupants to slide forward, resulting in leg contact with the opposing seats. The energy associated with the mass of the moving occupants deformed the table, which allowed the occupants to slide forward to the point where their posterior was no longer supported by the launch, but compartmentalization was achieved. The increase in table height allowed more forward movement of the lower part of the occupants' bodies.
Table deformation does not expose occupants to sharp edges or spaces capable of entrapping an occupant during a rail accident. The longitudinal survival space opposite the table (dimension 'C' in Figure 2) shall not be less than 381 mm (15 inches).	Despite the table folding, there were no sharp edges exposed at points where the occupant could contact them during the impact The post-test longitudinal survival space measured 417 mm or more, which satisfies the minimum requirement of 381 mm The Hybrid III-RS ATD had a final resting position with its knees between the table and the seat opposite. Given that the data collected indicate that lower leg injuries were more likely in this case than the previous test, egress may have been difficult for this passenger
The table effectively limits human injury of the head, chest, neck, abdomen and femurs	See Table 9 – the upper left and lower left chest deflection exceeded the APTA limits

3.2.5 Test 2: Injury Criteria Summary

Table 9. Injury Criteria Results – Hybrid III RS, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	83.67	700	Pass	500	Pass
Neck peak axial tension (kN)	1.26	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-1.63	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.23	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.31	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.29	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.32	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	21.73	60	Pass	60	Pass
Upper left chest deflection (mm)	**-66.48**	-63	**Fail**	-63	**Fail**
Upper right chest deflection (mm)	-54.28	-63	Pass	-63	Pass
Lower left chest deflection (mm)	**-80.73**	-63	**Fail**	-63	**Fail**
Lower right chest deflection (mm)	*	-63	N/A	-63	N/A
Upper left chest viscous criterion (m/s)	0.58	1.0	Pass	1.0	Pass
Upper right chest viscous criterion (m/s)	0.46	1.0	Pass	1.0	Pass
Lower left chest viscous criterion (m/s)	0.79	1.0	Pass	1.0	Pass
Lower right chest viscous criterion (m/s)	*	1.0	Pass	1.0	Pass
Upper left abdomen deflection (mm)	-28.73	-67	Pass	N/A	N/A
Upper right abdomen deflection (mm)	-31.51	-67	Pass	N/A	N/A
Lower left abdomen deflection (mm)	-3.70	-67	Pass	N/A	N/A
Lower right abdomen deflection (mm)	-1.63	-67	Pass	N/A	N/A
Upper left abdomen viscous criterion (m/s)	0.17	1.98	Pass	1.98	Pass
Upper right abdomen viscous criterion (m/s)	0.16	1.98	Pass	1.98	Pass
Lower left abdomen viscous criterion (m/s)	0.00	1.98	Pass	1.98	Pass
Lower right abdomen viscous criterion (m/s)	0.02	1.98	Pass	1.98	Pass
Left femur compression (kN)	-4.24	-10.0	Pass	-4.3/-5.7	Pass
Right femur compression (kN)	-4.51	-10.0	Pass	-4.3/-5.7	N/A‡

* A chest deflection potentiometer broke during this test

‡ Tibial index was not measured, so the full GM/RT2100 criterion cannot be assessed

Table 10. Injury Criteria Results – Hybrid III RS, GMRT-only requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head acceleration 3ms exceedence (*g*)	36.04	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	57.92	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-28.60	N/A	N/A	-135	Pass
Upper chest combined thoracic index	0.25	N/A	N/A	1.0	Pass
Left knee displacement (mm)	**-24.46**	N/A	N/A	-16	**Fail**
Right Knee Displacement (mm)	-0.26	N/A	N/A	-16	Pass
Upper left tibia compression (kN)	-0.44	N/A	N/A	-8.0	Pass
Lower left tibia compression (kN)	-0.68	N/A	N/A	-8.0	Pass
Upper left tibial index	**1.85**	N/A	N/A	1.3	**Fail**
Lower left tibial index	1.29	N/A	N/A	1.3	Pass
Upper right tibia compression (kN)	-0.70	N/A	N/A	-8.0	Pass
Lower right tibia compression (kN)	-0.73	N/A	N/A	-8.0	Pass
Upper right tibial index	**1.84**	N/A	N/A	1.3	**Fail**
Lower right tibial index	**1.63**	N/A	N/A	1.3	**Fail**

Note: The deceleration pulse to which the table was tested was more severe than that of GM/RT 2100. It is not readily possible to determine how these results would vary if the table were tested to the deceleration pulse prescribed by GM/RT 2100.

Table 11. Injury Criteria Results – Hybrid III, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	17.47	700	Pass	500	Pass
Head acceleration 3ms exceedence (*g*)	18.25	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	44.27	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-42.42	N/A	N/A	-135	Pass
Neck peak axial tension (kN)	0.63	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-0.18	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.37	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.20	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.01	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.07	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	14.16	60	Pass	60	Pass
Chest deflection (mm)	-54.33	-63	Pass	63	Pass
Chest viscous criterion (m/s)	0.50	1.0	Pass	1.0	Pass
Left femur compression (kN)	5.07	-10.0	Pass	-4.3/-5.7	N/A‡

Right femur compression (kN)	2.66	-10.0	Pass	-4.3/-5.7	Pass

‡ Tibial index was not measured, so the full GM/RT2100 criterion cannot be assessed

3.3 Test 3

3.3.1 Test 3: Background

This test was performed on a prototype table that was designed to absorb energy when impacted by occupants during an accident. The testing was experimental and was not intended to certify the design or invalidate the design concept.

3.3.2 Test 3: Test Configuration and Deceleration Pulse

The pre- and post-test ATD and table positions are depicted in Figure 10 and Figure 11. The test pulse is plotted in Figure 12, and the calibration run pulse obtained prior to testing is plotted in Figure 1, which demonstrated that the test conforms as far as possible to the requirements of the standard.

Figure 10. Pre-test view of Test 3 – seat 1, table design 3

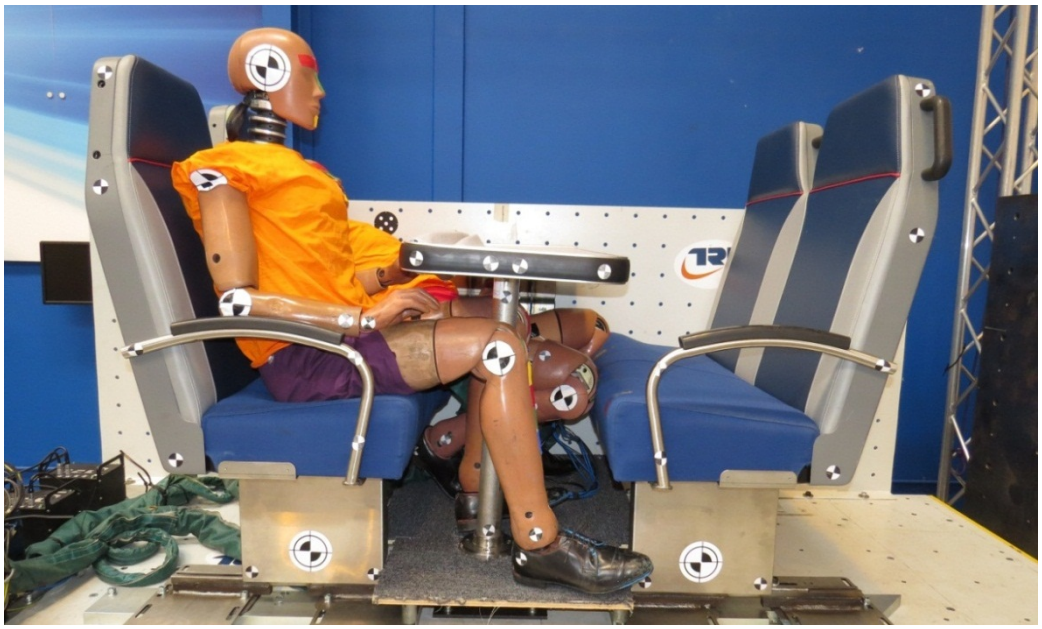


Figure 11. Post-test view of Test 3 – seat 1, table design 3

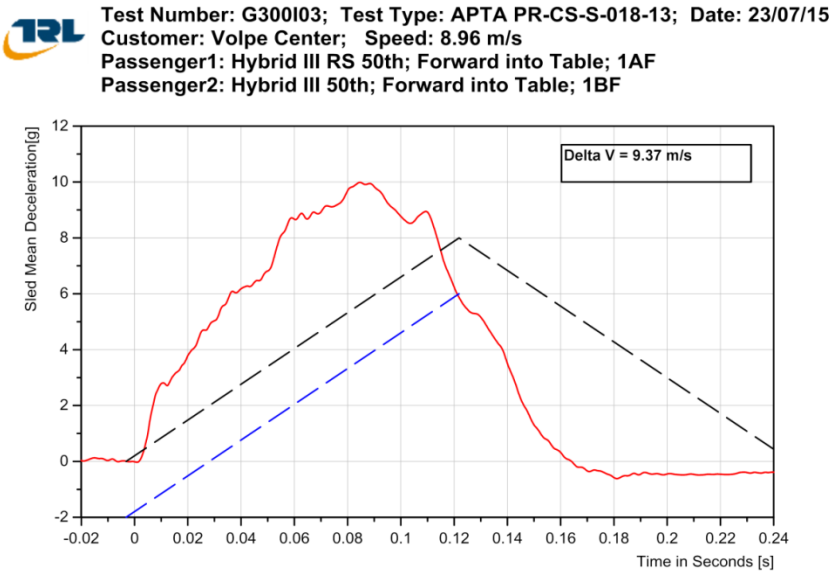


Figure 12. Test 3 deceleration pulse

Test 3: Observations

The Hybrid III-RS slid under the table such that its knees contacted the seat opposite.

The Hybrid III-RS was able to slide under the table so its resting position was with its knees against the opposing seat and its buttocks off the edge of its seat.

The Hybrid III did not have any leg contact against the table leg.

The table and seats all remained securely attached to the sled and no parts (e.g. parts of the table/ arm rests) became detached during the impact.

3.3.3 Test 3: Crashworthiness Assessment

Table 12. APTA crashworthiness assessment

Requirement	Details
The table effectively absorbs kinetic energy whilst limiting contact force between occupants and the table.	The table deformation mechanism appeared to function as intended, but the lower left chest deflection and viscous criterion on the wall-side occupant were both exceeded.
The table remains attached to the test sled or fixture.	No part of the table detached during the test.
The table effectively compartmentalizes the occupants.	As a result of the forward motion of the H3-RS ATD, its posterior was no longer supported by the launch seat, but compartmentalization was achieved.

Table deformation does not expose occupants to sharp edges or spaces capable of entrapping an occupant during a rail accident. The longitudinal survival space opposite the table (dimension 'C' in Figure 2) shall not be less than 381 mm (15 inches).	There were no sharp edges exposed at pointns where the occupant could contact them during the impact. The post-test longitudinal survival space measured 470 mm or more, which satisfies the minimum requirement of 381 mm.
The table effectively limits human injury of the head, chest, neck, abdomen and femurs.	See Table 13 – the lower left chest deflection and VC exceeded the APTA limits.

3.3.4 Test 3: Injury Criteria Summary

Table 13. Injury Criteria Results – Hybrid III RS, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	124.6	700	Pass	500	Pass
Neck peak axial tension (kN)	0.96	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-1.33	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.25	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.24	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.67	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.10	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	21.73	60	Pass	60	Pass
Upper left chest deflection (mm)	-45.76	-63	Pass	-63	Pass
Upper right chest deflection (mm)	-47.33	-63	Pass	-63	Pass
Lower left chest deflection (mm)	**-68.89**	-63	**Fail**	-63	**Fail**
Lower right chest deflection (mm)	*	-63	N/A	-63	N/A
Upper left chest viscous criterion (m/s)	0.44	1.0	Pass	1.0	Pass
Upper right chest viscous criterion (m/s)	0.33	1.0	Pass	1.0	Pass
Lower left chest viscous criterion (m/s)	**1.07**	1.0	**Fail**	1.0	**Fail**
Lower right chest viscous criterion (m/s)	*	1.0	Pass	1.0	Pass
Upper left abdomen deflection (mm)	-55.06	-67	Pass	N/A	N/A
Upper right abdomen deflection (mm)	-65.67	-67	Pass	N/A	N/A
Lower left abdomen deflection (mm)	-25.91	-67	Pass	N/A	N/A

Lower right abdomen deflection (mm)	-24.28	-67	Pass	N/A	N/A
Upper left abdomen viscous criterion (m/s)	0.45	1.98	Pass	1.98	Pass
Upper right abdomen viscous criterion (m/s)	0.78	1.98	Pass	1.98	Pass
Lower left abdomen viscous criterion (m/s)	0.24	1.98	Pass	1.98	Pass
Lower right abdomen viscous criterion (m/s)	0.17	1.98	Pass	1.98	Pass
Left femur compression (kN)	-3.4	-10.0	Pass	-4.3/-5.7	Pass
Right femur compression (kN)	-4.08	-10.0	Pass	-4.3/-5.7	Pass

* A chest deflection potentiometer broke during this test

Table 14. Injury Criteria Results – Hybrid III RS, GMRT-only requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head acceleration 3ms exceedence (*g*)	51.75	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	40.60	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-63.42	N/A	N/A	-135	Pass
Upper chest combined thoracic index	0.3	N/A	N/A	1.0	Pass
Left knee displacement (mm)	**-22.07**	N/A	N/A	-16	**Fail**
Right knee displacement (mm)	-4.89	N/A	N/A	-16	Pass
Upper left tibia compression (kN)	-0.89	N/A	N/A	-8.0	Pass
Lower left tibia compression (kN)	-0.72	N/A	N/A	-8.0	Pass
Upper left tibial index	**1.59**	N/A	N/A	1.3	**Fail**
Lower left tibial index	**1.45**	N/A	N/A	1.3	**Fail**
Upper right tibia compression (kN)	-1.28	N/A	N/A	-8.0	Pass
Lower right tibia compression (kN)	-0.94	N/A	N/A	-8.0	Pass
Upper right tibial index	**1.70**	N/A	N/A	1.3	**Fail**
Lower right tibial index	**1.42**	N/A	N/A	1.3	**Fail**

Note: The deceleration pulse to which the table was tested was more severe than that of GM/RT 2100. It is not readily possible to determine how these results would vary if the table were tested to the deceleration pulse prescribed by GM/RT 2100.

Table 15. Injury Criteria Results – Hybrid III, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	27.43	700	Pass	500	Pass
Head acceleration 3ms exceedence (*g*)	20.96	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	32.75	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-15.24	N/A	N/A	-135	Pass
Neck peak axial tension (kN)	0.70	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-0.05	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.17	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.15	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.01	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.01	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	17.97	60	Pass	60	Pass
Chest deflection (mm)	-52.28	-63	Pass	-63	Pass
Chest viscous criterion (m/s)	0.88	1.0	Pass	1.0	Pass
Left femur compression (kN)	0.17	-10.0	Pass	-4.3/-5.7	Pass

Right femur compression (kN)	5.31	-10.0	Pass	-4.3/-5.7	N/A‡

‡ Tibial index was not measured, so the full GM/RT2100 criterion cannot be assessed

3.4 Test 4

3.4.1 Test 4: Background

This test was performed on a prototype table that was designed to absorb energy when impacted by occupants during an accident. The testing was experimental and was not intended to certify the design or invalidate the design concept.

3.4.2 Test 4: Test Configuration and Deceleration Pulse

The pre- and post-test ATD and table positions are depicted in Figure 13 and Figure 14. The test pulse is plotted in Figure 15, and the calibration run pulse obtained prior to testing is plotted in Figure 1, which demonstrated that the test conforms as far as possible to the requirements of the standard.

Figure 13. Pre-test view of Test 4 – seat 1, table design 3

Figure 14. Post-test view of Test 4 – seat 1, table design 3

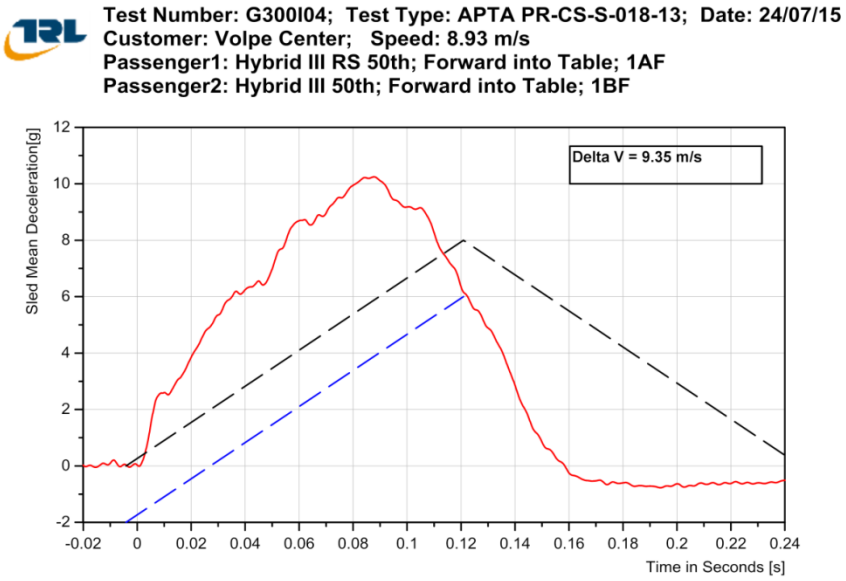


Figure 15. Test 4 deceleration pulse

3.4.3 Test 4: Observations

The table deformation allowed the ATDs to slide forward, resulting in leg contact with the opposing seats. This result is primarily a function of the initial seat pitch.

The final position of the standard Hybrid III was near its original position on the launch seat.

Both ATDs experienced contact with the opposing seat. This contact can serve to limit to load on the abdomen, although this may be dependent on the seat pitch.

The table and seats all remained securely attached to the sled and no parts (e.g. parts of the table/ arm rests) became detached during the impact.

3.4.4 Test 4: Crashworthiness Assessment

Table 16. APTA crashworthiness assessment

Requirement	Details
The table effectively absorbs kinetic energy whilst limiting contact force between occupants and the table.	The table deformation appeared to function as intended; however, the upper right abdomen deflection for the wall-side occupant exceeded the criterion.
The table remains attached to the test sled or fixture.	No part of the table detached during the test.
The table effectively compartmentalizes the occupants.	The Hybrid III-RS was able to slide under the table during the impact, coming to rest with its knees against the opposing seat. This motion caused the Hybrid III-RS head to contact the seat back during rebound, resulting in high neck compressive loading at approximately 300 ms after impact. Nevertheless, compartmentalization was achieved.
Table deformation does not expose occupants to sharp edges or spaces capable of entrapping an occupant during a rail accident. The longitudinal survival space opposite the table (dimension 'C' in Figure 2) shall not be less than 381 mm (15 inches).	No sharp edges were exposed. The post-test longitudinal survival space measured 455 mm or more, which satisfies the minimum requirement of 381 mm.
The table effectively limits human injury of the head, chest, neck, abdomen and femurs.	See Table 17 – the upper right abdomen deflection exceeded the APTA requirements.

3.4.5 Test 4: Injury Criteria Summary

Table 17. Injury Criteria Results – Hybrid III RS, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	103.82	700	Pass	500	Pass
Neck peak axial tension (kN)	0.91	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-1.62	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.21	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.21	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.90	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.19	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	25.05	60	Pass	60	Pass

Upper left chest deflection (mm)	-40.06	-63	Pass	-63	Pass
Upper right chest deflection (mm)	-42.43	-63	Pass	-63	Pass
Lower left chest deflection (mm)	-58.38	-63	Pass	-63	Pass
Lower right chest deflection (mm)	-58.24	-63	Pass	-63	Pass
Upper left chest viscous criterion (m/s)	0.30	1.0	Pass	1.0	Pass
Upper right chest viscous criterion (m/s)	0.30	1.0	Pass	1.0	Pass
Lower left chest viscous criterion (m/s)	0.62	1.0	Pass	1.0	Pass
Lower right chest viscous criterion (m/s)	0.67	1.0	Pass	1.0	Pass
Upper left abdomen deflection (mm)	-53.54	-67	Pass	N/A	N/A
Upper right abdomen deflection (mm)	**-67.91**	-67	**Fail**	N/A	N/A
Lower left abdomen deflection (mm)	-22.71	-67	Pass	N/A	N/A
Lower right abdomen deflection (mm)	-21.41	-67	Pass	N/A	N/A
Upper left abdomen viscous criterion (m/s)	0.52	1.98	Pass	1.98	Pass
Upper right abdomen viscous criterion (m/s)	0.69	1.98	Pass	1.98	Pass
Lower left abdomen viscous criterion (m/s)	0.12	1.98	Pass	1.98	Pass
Lower right abdomen viscous criterion (m/s)	0.14	1.98	Pass	1.98	Pass
Left femur compression (kN)	-3.81	-10.0	Pass	-4.3/-5.7	Pass
Right femur compression (kN)	-4.29	-10.0	Pass	-4.3/-5.7	Pass

Table 18. Injury Criteria Results – Hybrid III RS, GMRT-only requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head acceleration 3ms exceedence (*g*)	46.7	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	30.85	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-85.93	N/A	N/A	-135	Pass
Upper chest combined thoracic index	0.3	N/A	N/A	1.0	Pass
Left knee displacement (mm)	**-24.41**	N/A	N/A	-16	**Fail**
Right Knee Displacement (mm)	-0.35	N/A	N/A	-16	Pass
Upper left tibia compression (kN)	-0.87	N/A	N/A	-8.0	Pass
Lower left tibia compression (kN)	-0.76	N/A	N/A	-8.0	Pass
Upper left tibial index	**1.60**	N/A	N/A	1.3	**Fail**
Lower left tibial index	**1.63**	N/A	N/A	1.3	**Fail**
Upper right tibia compression (kN)	-1.17	N/A	N/A	-8.0	Pass
Lower right tibia compression (kN)	-0.92	N/A	N/A	-8.0	Pass
Upper right tibial index	**1.80**	N/A	N/A	1.3	**Fail**
Lower right tibial index	**1.40**	N/A	N/A	1.3	**Fail**

Note: The deceleration pulse to which the table was tested was more severe than that of GM/RT 2100. It is not readily possible to determine how these results would vary if the table were tested to the deceleration pulse prescribed by GM/RT 2100.

Table 19. Injury Criteria Results – Hybrid III, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	26.44	700	Pass	500	Pass
Head acceleration 3ms exceedence (*g*)	20.47	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	28.46	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-13.69	N/A	N/A	-135	Pass
Neck peak axial tension (kN)	0.72	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-0.04	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.14	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.12	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.02	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.05	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	22.62	60	Pass	60	Pass
Chest deflection (mm)	-50.35	-63	Pass	-63	Pass
Chest viscous criterion (m/s)	0.35	1.0	Pass	1.0	Pass

Left femur compression (kN)	0.35	-10.0	Pass	-4.3/-5.7	Pass
Right femur compression (kN)	5.51	-10.0	Pass	-4.3/-5.7	N/A‡

‡ Tibial index was not measured, so the full GM/RT2100 criterion cannot be assessed

3.5 Test 5

3.5.1 Test 5: Background

This test was performed on a table that was designed to comply with European safety standards, rather than the APTA table standard. The testing was experimental and was not intended to certify the design or invalidate the design concept.

3.5.2 Test 5: Test Configuration and Deceleration Pulse

The pre- and post-test ATD and table positions are depicted in Figure 16 and Figure 17. The test pulse is plotted in Figure 18, and the calibration run pulse obtained prior to testing is plotted in Figure 1, which demonstrates that the test conforms as far as possible to the requirements of the standard.

Figure 16. Pre-test view of Test 5 – seat 1, table design 4

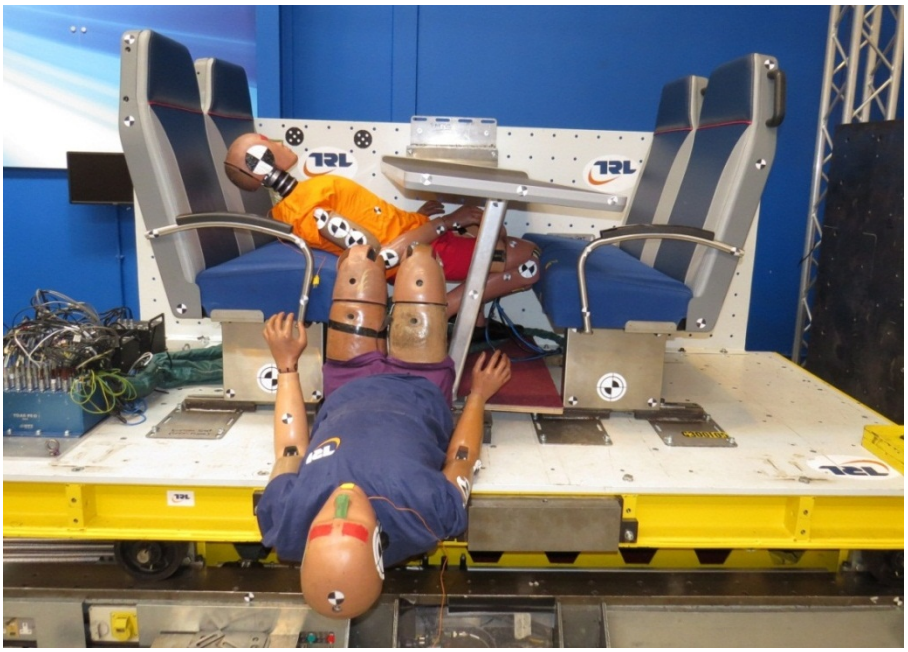


Figure 17. Post-test view of Test 5 – seat 1, table design 4

Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

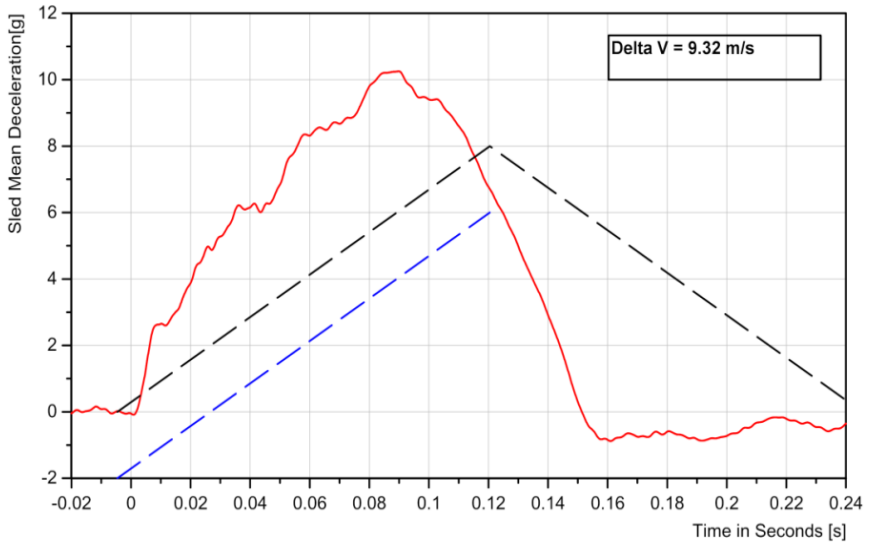
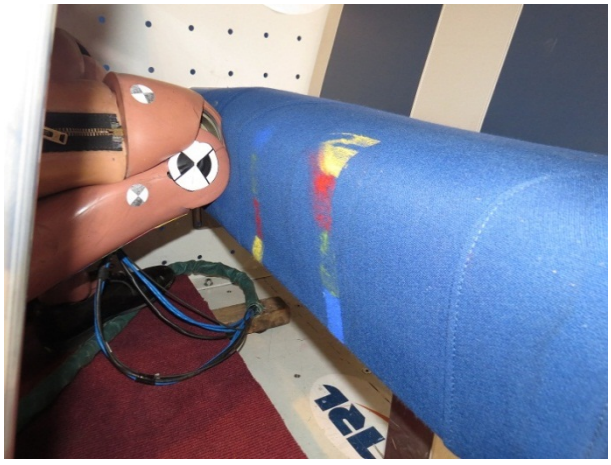


Figure 18. Test 5 deceleration pulse

3.5.3 Test 5: Observations

The deformation of the table caused the ATD in the aisle seat to fall into the aisle after impact with the table, but compartmentalization was achieved as defined by the APTA standard.



Leg contact with the opposing seats occurred during the impact and the Hybrid III-RS came to rest with its legs still in contact with the opposing seat.

3.5.4 Test 5: Crashworthiness Assessment

Table 20. APTA crashworthiness assessment

Requirement	Details
The table effectively absorbs kinetic energy whilst limiting contact force between occupants and the table.	The table rotated about the wall bracket, but the lower right and left chest deflection and viscous criterion on the wall-side occupant exceeded the limits, as well as the upper right abdomen deflection.
The table remains attached to the test sled or fixture.	No part of the table detached during the test.
The table effectively compartmentalizes the occupants.	The table rotation caused the wall-side occupant to slide under it and become wedged against the opposite seat and the aisle-side occupant to be fell from his seat, but compartmentalization was achieved according to the definition in the APTA standard.
Table deformation does not expose occupants to sharp edges or spaces capable of entrapping an occupant during a rail accident. The longitudinal survival space opposite the table (dimension 'C' in Figure 2) shall not be less than 381 mm (15 inches).	No sharp edges were exposed. The rotation of the table meant that occupants in the opposing seats would have been trapped post-impact. The post-test longitudinal survival space measured 360 mm or more, which **failed** to satisfy the minimum requirement of 381 mm.
The table effectively limits human injury of the head, chest, neck, abdomen and femurs.	See Table 21 – the lower left and lower right chest deflections and VC exceeded the APTA limits, as did the upper right abdomen deflection.

3.5.5 Test 5: Injury Criteria Summary

Table 21. Injury Criteria Results – Hybrid III RS, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	252.43	700	Pass	500	Pass
Neck peak axial tension (kN)	2.32	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-2.3	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.69	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.67	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.73	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.45	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	47.5	60	Pass	60	Pass
Upper left chest deflection (mm)	-51.01	-63	Pass	-63	Pass
Upper right chest deflection (mm)	-45.19	-63	Pass	-63	Pass
Lower left chest deflection (mm)	**-90.43**	-63	**Fail**	-63	**Fail**
Lower right chest deflection (mm)	**-80.45**	-63	**Fail**	-63	**Fail**
Upper left chest viscous criterion (m/s)	0.55	1.0	Pass	1.0	Pass
Upper right chest viscous criterion (m/s)	0.32	1.0	Pass	1.0	Pass
Lower left chest viscous criterion (m/s)	**1.41**	1.0	**Fail**	1.0	**Fail**
Lower right chest viscous criterion (m/s)	**1.19**	1.0	**Fail**	1.0	**Fail**
Upper chest combined thoracic index	0.56	N/A	N/A	1.0	Pass
Upper left abdomen deflection (mm)	-61.4	-67	Pass	N/A	N/A
Upper right abdomen deflection (mm)	**-75.95**	-67	**Fail**	N/A	N/A
Lower left abdomen deflection (mm)	-17.41	-67	Pass	N/A	N/A
Lower right abdomen deflection (mm)	-31.67	-67	Pass	N/A	N/A
Upper left abdomen viscous criterion (m/s)	0.94	1.98	Pass	1.98	Pass
Upper right abdomen viscous criterion (m/s)	1.14	1.98	Pass	1.98	Pass
Lower left abdomen viscous criterion (m/s)	0.05	1.98	Pass	1.98	Pass
Lower right abdomen viscous criterion (m/s)	0.27	1.98	Pass	1.98	Pass
Left femur compression (kN)	-1.58	-10.0	Pass	-4.3/-5.7	Pass
Right femur compression (kN)	-3.72	-10.0	Pass	-4.3/-5.7	Pass

Table 22. Injury Criteria Results – Hybrid III RS, GMRT-only requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head acceleration 3ms exceedence (*g*)	54.95	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	141.26	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-61.68	N/A	N/A	-135	Pass
Left knee displacement (mm)	**-17.51**	N/A	N/A	-16	**Fail**
Right Knee Displacement (mm)	-1.52	N/A	N/A	-16	Pass
Upper left tibia compression (kN)	-0.27	N/A	N/A	-8.0	Pass
Lower left tibia compression (kN)	-0.39	N/A	N/A	-8.0	Pass
Upper left tibial index	1.19	N/A	N/A	1.3	Pass
Lower left tibial index	0.91	N/A	N/A	1.3	Pass
Upper right tibia compression (kN)	-0.92	N/A	N/A	-8.0	Pass
Lower right tibia compression (kN)	-0.73	N/A	N/A	-8.0	Pass
Upper right tibial index	**1.77**	N/A	N/A	1.3	**Fail**
Lower right tibial index	1.24	N/A	N/A	1.3	Pass

Table 23. Injury Criteria Results – Hybrid III, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	48.72	700	Pass	500	Pass
Head acceleration 3ms exceedence (*g*)	27.07	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	38.51	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-16.94	N/A	N/A	-135	Pass
Neck peak axial tension (kN)	1.13	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-0.06	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.16	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.24	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.01	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.02	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	29.34	60	Pass	60	Pass
Chest deflection (mm)	*	-63	N/A	-63	N/A
Chest viscous criterion (m/s)	*	1.0	N/A	1.0	N/A
Left femur compression (kN)	5.20	-10.0	Pass	-4.3/-5.7	N/A‡
Right femur compression (kN)	5.01	-10.0	Pass	-4.3/-5.7	N/A‡

* The potentiometer arm came out of the guide track due to the high loading, so the measurement was not reliable

‡ Tibial index was not measured, so the full GM/RT2100 criterion cannot be assessed

3.6 Test 6

3.6.1 Test 6: Background

This test was performed on a table that was designed to comply with European safety standards, rather than the APTA table standard. The testing was experimental and was not intended to certify the design or invalidate the design concept.

3.6.2 Test 6: Test Configuration and Deceleration Pulse

The pre- and post-test ATD and table positions are depicted in Figure 19 and Figure 20. The test pulse is plotted in Figure 21; the calibration run pulse obtained prior to testing is plotted in Figure 1, demonstrating that the test conforms as far as possible to the requirements of the standard.

Figure 19. Pre-test view of Test 6 – seat 1, table design 5

Figure 20. Post-test view of Test 6 – seat 1, table design 5

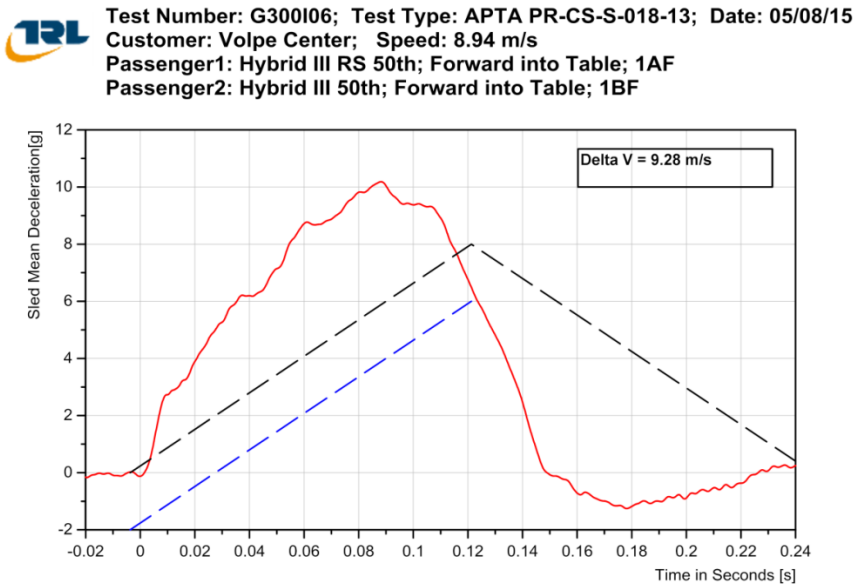


Figure 21. Test 6 deceleration pulse

3.6.3 Test 6: Observations

The wall-side occupant slid under the table and was contained by contact with the opposing seat.

The aisle-side occupant fell into the aisle during the rebound phase.

View of opposing (rear facing) seat pan cushion and witness marks from knee contacts.

Post-test position of wall-side ATD depicting angle of occupant.

3.6.4 Test 6: Crashworthiness Assessment

Table 24. APTA crashworthiness assessment

Requirement	Details
The table effectively absorbs kinetic energy whilst limiting contact force between occupants and the table.	The chest deflections seen by the occupants in this test were extremely high and hence it can be assumed that the table has not absorbed the kinetic energy of the occupants effectively. The lower left and right chest deflection on the wall-side occupant and the chest viscous criterion on the aisle-side occupant exceeded the allowable limits.
The table remains attached to the test sled or fixture.	No part of the table detached during the test.
The table effectively compartmentalizes the occupants.	The aisle-side occupant fell into the aisle on rebound and the wall-side occupant ended up with its shoulders on the aisle-side occupant's seat and its knees on the seat opposite; however, compartmentalization was achieved as defined by the APTA standard.
Table deformation does not expose occupants to sharp edges or spaces capable of entrapping an occupant during a rail accident. The longitudinal survival space opposite the table (dimension 'C' in Figure 2) shall not be less than 381 mm (15 inches).	No sharp edges were exposed. The post-test longitudinal survival space measurements were not collected, but comparison of the photos from the other tests indicates that the requirement was likely met.
The table effectively limits human injury of the head, chest, neck, abdomen and femurs.	See Table 25 – the lower left and lower right chest deflection exceeded the APTA limits.

3.6.5 Test 6: Injury Criteria Summary

Table 25. Injury Criteria Results – Hybrid III RS, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion (HIC 15)	40.48	700	Pass	500	Pass
Neck peak axial tension (kN)	0.99	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-0.06	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.24	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.17	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.01	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.15	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	20.74	60	Pass	60	Pass
Upper left chest deflection (mm)	-51.84	-63	Pass	-63	Pass
Upper right chest deflection (mm)	-44.43	-63	Pass	-63	Pass
Lower left chest deflection (mm)	**-72.14**	-63	**Fail**	-63	**Fail**
Lower right chest deflection (mm)	**-69.03**	-63	**Fail**	-63	**Fail**
Upper left chest viscous criterion (m/s)	0.28	1.0	Pass	1.0	Pass
Upper right chest viscous criterion (m/s)	0.29	1.0	Pass	1.0	Pass
Lower left chest viscous criterion (m/s)	0.69	1.0	Pass	1.0	Pass
Lower right chest viscous criterion (m/s)	0.73	1.0	Pass	1.0	Pass
Upper left abdomen deflection (mm)	-58.66	-67	Pass	N/A	N/A
Upper right abdomen deflection (mm)	*	-67	Pass	N/A	N/A
Lower left abdomen deflection (mm)	-17.57	-67	Pass	N/A	N/A
Lower right abdomen deflection (mm)	-23.36	-67	Pass	N/A	N/A
Upper left abdomen viscous criterion (m/s)	0.77	1.98	Pass	1.98	Pass
Upper right abdomen viscous criterion (m/s)	*	1.98	Pass	1.98	Pass
Lower left abdomen viscous criterion (m/s)	0.08	1.98	Pass	1.98	Pass
Lower right abdomen viscous criterion (m/s)	0.13	1.98	Pass	1.98	Pass
Left femur compression (kN)	-3.93	-10.0	Pass	-4.3/-5.7	Pass
Right femur compression (kN)	-4.12	-10.0	Pass	-4.3/-5.7	Pass

* An abdomen deflection potentiometer broke during this test

Table 26. Injury Criteria Results – Hybrid III RS, GMRT-only requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head acceleration 3ms exceedence (*g*)	54.95	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	141.26	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-61.68	N/A	N/A	-135	Pass
Upper chest combined thoracic index	0.28	N/A	N/A	1.0	Pass
Left knee displacement (mm)	**-17.51**	N/A	N/A	-16	**Fail**
Right Knee Displacement (mm)	-1.52	N/A	N/A	-16	Pass
Upper left tibia compression (kN)	-0.27	N/A	N/A	-8.0	Pass
Lower left tibia compression (kN)	-0.39	N/A	N/A	-8.0	Pass
Upper left tibial index	1.19	N/A	N/A	1.3	Pass
Lower left tibial index	0.91	N/A	N/A	1.3	Pass
Upper right tibia compression (kN)	-0.92	N/A	N/A	-8.0	Pass
Lower right tibia compression (kN)	-0.73	N/A	N/A	-8.0	Pass
Upper right tibial index	**1.77**	N/A	N/A	1.3	**Fail**
Lower right tibial index	1.24	N/A	N/A	1.3	Pass

Table 27. Injury Criteria Results – Hybrid III, APTA requirements

Injury Criterion	Value	APTA Limit	Pass/ Fail	GMRT Limit	Pass/ Fail
Head injury criterion HIC 15	17.78	700	Pass	500	Pass
Head 3ms exceedence (*g*)	21.6	N/A	N/A	80	Pass
Neck peak flexion bending moment (Nm)	35.09	N/A	N/A	310	Pass
Neck peak extension bending moment (Nm)	-43.33	N/A	N/A	-135	Pass
Neck peak axial tension (kN)	1.06	4.17	Pass	4.17	Pass
Neck peak axial compression (kN)	-0.20	-4.0	Pass	-4.0	Pass
Neck injury Nij NTE (tension-extension)	0.39	1.0	Pass	1.0	Pass
Neck injury Nij NTF (tension-flexion)	0.22	1.0	Pass	1.0	Pass
Neck injury Nij NCE (compression-extension)	0.04	1.0	Pass	1.0	Pass
Neck injury Nij NCF (compression-flexion)	0.14	1.0	Pass	1.0	Pass
Chest acceleration 3ms exceedence (*g*)	26.84	60	Pass	60	Pass
Chest deflection (mm)	-59.19	-63	Pass	-63	Pass
Chest viscous criterion (m/s)	**1.49**	1.0	**Fail**	1.0	**Fail**
Left femur compression (kN)	0.51	-10.0	Pass	-4.3/-5.7	Pass
Right femur compression (kN)	**5.94**	-10.0	Pass	-4.3/-5.7	**Fail**

3.7 Summary

Table 28 through Table 31 contain the key thorax and abdomen injury assessment results are provided below, with those measurements that exceed the APTA limits emphasized in bold. The additional leg injury metrics required in the UK GM/RT2100 standard but not in the APTA standard, are identified in Table 32, and those measurements that exceed the GM/RT2100 limits are emphasized.

In each test, the H3-RS ATD slid forward and its buttocks slid off the front edge of the seat. The same thing also happened with the Hybrid III ATD in the first two tests, and in the last two tests the Hybrid III (which was originally in the aisle seat) fell out of the seat/table area and on to the aisle floor on rebound. Nevertheless, in all tests the ATDs were compartmentalized according to the definition in the APTA standard.

In all cases, the energy absorbing table edges bent more at the middle of the table than at the edges. No detachments and no sharp edges were exposed in any of the tests.

In many cases, the ATD measurements indicated that lower leg injuries were likely. These measurements are not assessed in the APTA standard, but they may impact significantly on the ability of the occupant to egress the carriage after a collision. However, had the legs not impacted the opposite seat, the full impact would have been sustained by the chest and abdomen, resulting in more severe injuries to these body parts.

The individual tests are summarized below:

Test 1

This table design absorbed energy through the folding of the table top. The table folding mechanism appeared to function as intended, and sufficient clearance was left for a 95th percentile occupant on the facing seat. Though not a violation of a specific requirement, the gap between the table edge and the arm rest was small and may have made emergency egress difficult. Normally, seats at workstation tables would have fold-up arm rests. The seats used in these tests had fixed arm rests, because seats with fold-up armrests were not available for the test. Lower left and right chest deflections exceeded the APTA limits; all other measurements would have passed APTA and GM/RT2100 limits.

The measurements from the standard Hybrid III ATD all met the APTA requirements.

Test 2

This table design absorbed energy through folding of the table top. Again, the table folding mechanism appeared to function as intended, and sufficient clearance was left for a 95th percentile occupant on the facing seat. Though not a violation of a specific requirement, the gap between the table edge and the arm rest was small and may have made emergency egress difficult. Normally, seats at workstation tables would have fold-up arm rests. The seats used in these tests had fixed arm rests, because seats with fold-up armrests were not available or the test Upper and lower left chest deflections exceeded the APTA limits; the ATD would also have failed four of the GM/RT2100 knee and tibia injury metrics (which are not assessed in the APTA standard).

The measurements from the standard Hybrid III ATD all met the APTA requirements.

Test 3

This table design absorbed energy by compression of the table edge. Nevertheless, the lower left chest deflection and VC exceeded the APTA limits; the ATD would also have failed five of the GM/RT2100 knee and tibia injury metrics (which are not assessed in the APTA standard).

The measurements from the standard Hybrid III ATD all met the APTA requirements.

Test 4

This table design absorbed energy through the compression of the table edge. Nevertheless, the upper right abdomen deflection exceeded the APTA limit; the ATD would also have failed five of the GM/RT2100 knee and tibia injury metrics (which are not assessed in the APTA standard).

The measurements from the standard Hybrid III ATD all met the APTA requirements.

Test 5

This design did not have an energy absorbing table top and the table rotated significantly during the impact, causing the aisle-side occupant to fall to the floor after rebounding from the table impact. Lower left and right chest deflections and VC exceeded the APTA limits, as did upper right abdomen deflection; the ATD would also have failed two of the GM/RT2100 knee and tibia injury metrics (which are not assessed in the APTA standard).

The measurements from the standard Hybrid III ATD all met the APTA requirements.

Test 6

This table design absorbed energy by sliding of the table top along its mounting bracket. It was designed for the lower energy absorption requirement associated with the crash pulse in the GM/RT2100 standard, but it could be modified to absorb the increased energy associated with the crash pulse in the APTA table standard. It is apparent from the plot of CRUX deflections on page 164 that each of the chest deflection measurements plateaus, or begins to decrease, while the table top slides and absorbs energy. Once the stroke is exhausted, the chest deflections begin to rise again, with the lower left and right deflection exceeding the injury criteria. There is potential to modify the table design to increase the stroke and/or the average crush force to absorb more energy and limit the peak chest deflection.

After rebounding from the table impact, the aisle-side occupant fell off the test sled. The lower left and lower right thorax deflection exceeded the APTA limits; the ATD would also have failed two of the GM/RT2100 knee and tibia injury metrics (which are not assessed in the APTA standard).

In this test, the standard Hybrid III also failed the chest VC and right femur compression APTA limits.

Table 28. Maximum thorax rib deflection (mm) (APTA limit = 63 mm)

	Hybrid III RS				Hybrid III
Test No.	Upper left rib deflection	Upper right rib deflection	Lower left rib deflection	Lower right rib deflection	Sternum deflection
1	53.7	45.4	**80.2**	**68.6**	50.5
2	**66.5**	54.3	**80.7**	*	54.3
3	45.8	47.3	**68.9**	*	52.3
4	40.1	42.4	58.4	58.2	50.4
5	51.0	45.2	**90.4**	**80.5**	‡
6	51.8	44.4	**72.1**	**69.0**	59.2

*The mid Potentiometer failed during this test and hence these results are not reliable. An examination of the raw data implies that the values should have been similar to those for Test No. 4.

‡ The potentiometer arm came out of the guide track due to the high loading, so the measurement was not reliable

Table 29. Maximum thorax rib VC (m/s) (APTA limit = 1 m/s)

	Hybrid III RS				Hybrid III
Test No.	Upper left rib VC	Upper right rib VC	Lower left rib VC	Lower right rib VC	Sternum VC
1	0.44	0.33	0.89	0.76	0.47
2	0.58	0.46	0.79	*	0.50
3	0.44	0.33	**1.07**	*	0.88
4	0.30	0.30	0.62	0.67	0.35
5	0.55	0.32	**1.41**	**1.19**	‡
6	0.28	0.29	0.69	0.73	**1.49**

Table 30. Maximum abdomen deflection (mm) (APTA limit = 67 mm)

	Hybrid III RS				Hybrid III
Test No.	Upper left abdomen deflection	Upper right abdomen deflection	Lower left abdomen deflection	Lower left abdomen deflection	Abdomen deflection
1	36.8	44.4	13.1	11.4	-
2	24.1	31.5	3.7	1.63	-
3	59.8	65.7	26	24	-
4	60.2	**67.9**	22.71	21.41	-
5	53.0	**76.0**	17.41	31.67	-
6	60.2	†	17.57	23.36	-

† Double-gimballed string potentiometer (DGSP) failed

Table 31. Maximum abdomen VC (m/s) (APTA limit = 1.98 m/s)

	Hybrid III RS				Hybrid III
Test No.	Upper left abdomen VC	Upper right abdomen VC	Lower left abdomen VC	Lower right abdomen VC	Abdomen VC
1	0.24	0.34	0.05	0.03	-
2	0.17	0.16	0.00	0.02	-
3	0.45	0.78	0.24	0.17	-
4	0.52	0.69	0.12	0.14	-
5	0.94	1.14	0.05	0.27	-
6	0.77	†	0.08	0.13	-

† Double-gimballed string potentiometer (DGSP) failed

Table 32. Maximum Tibial Index (GM/RT2100 limit 1.3) and knee displacement (GM/RT2100 limit -16 mm)

	Hybrid III RS					
Test No.	**Upper left TI**	**Upper right TI**	**Lower left TI**	**Lower right TI**	**Left knee displacement**	**Right knee displacement**
1	0.87	1.12	0.63	0.63	-13.80	‡
2	**1.85**	**1.84**	1.29	**1.63**	**-24.46**	‡
3	**1.59**	**1.70**	**1.45**	**1.42**	**-22.07**	‡
4	**1.60**	**1.80**	**1.63**	**1.40**	**-24.47**	‡
5	1.19	**1.77**	0.91	1.24	**-17.51**	**-21.35**
6	**1.76**	**1.85**	1.17	1.25	**-23.10**	**-24.37**

‡ No data recorded due to sensor failure

4. Discussion

In this test series, high vertical (Z-axis) chest deflections were measured by the H3-RS because the ATD 'submarined' underneath the table and the resultant deflections would be markedly higher than the X-axis deflections used in the APTA (and other) standard. No injury metrics using the Z-axis deflections have been developed, so it is not possible to quantify the injury risk, but it is likely that a given X-axis chest compression would be more injurious if combined with a significant Z-axis deflection than with no Z-axis deflection. This parameter is not measured in the Hybrid III ATD, so it is not possible to determine whether it sustained the same loads.

Also, in one test vertical motion sufficient to reach the physical limit of z-axis motion of the upper abdomen instrumentation was clearly visible in the raw data. No damage to the instrumentation was caused by this.

The femurs of the H3-RS are much more biofidelic than those of the Hybrid III, with a compliant element to reduce the stiffness of the 'femur' bone. This means that the ATD loads its environment (e.g. the seat in front) in a more realistic manner, and also that the loads in the femur are more realistic. The H3-RS femur response is more biofidelic than the standard HIII ATD, thus the current femur criteria is more applicable to the H3-RS ATD. Additionally, there is growing evidence that the rate of loading and impulse are also important factors in determining risk of femur injury. Consideration could be given to altering the femur injury criterion in the standard to account for the peak force together with impulse.

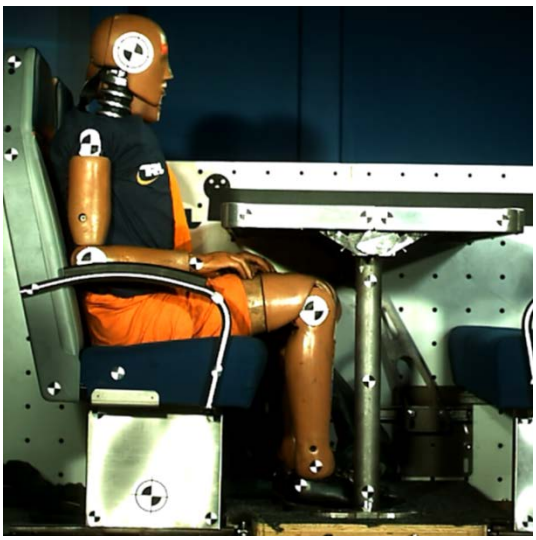
In most tests, there was a significant difference between the kinematics of the H3-RS and the standard Hybrid III ATD: the Hybrid III tended to remain upright during the table contact phase in most tests, whereas the H3-RS tended to 'submarine' under the table. This may be due to a number of differences in the design of the two dummies:

- The H3-RS has a split pelvis and upper thigh flesh, which allows a greater, more biofidelic range of motion at the hip joint. The Hybrid III has a one-piece upper thigh and pelvis flesh that is molded into the shape of a standard automotive seating posture; this means that the Hybrid III is less able to straighten-out at the hip than a human would be.
- The abdomen stiffness is uncontrolled in the standard Hybrid III (i.e. there are no performance requirements or certification tests for this body region) and there is nothing to prevent table penetration between the ribs and abdomen. In the H3-RS, the abdomen properties and response are well controlled and significant table penetration between the ribs and the abdomen instrumentation is not possible.
- The abdomen flesh protrudes slightly further forward in the H3-RS compared with the Hybrid III (as depicted in Figure 21); this means that the abdomen contacts the table edge slightly earlier, which may influence the kinematics. NB: the abdomen depth of the H3-RS is greater than the chest depth, which better reflects the University of Michigan Transportation Research Institute (UMTRI) anthropometry [4] where the abdomen has a 30 mm greater depth than the lower thorax; in contrast, the Hybrid III abdomen has a slightly smaller depth than the lower thorax.
- The lumbar spine design of the two dummies is fundamentally different. The Hybrid III lumbar spine is longer than that of the H3-RS, is curved and of approximately circular

cross-section. The H3-RS lumbar spine is shorter, straight and of rectangular cross section.

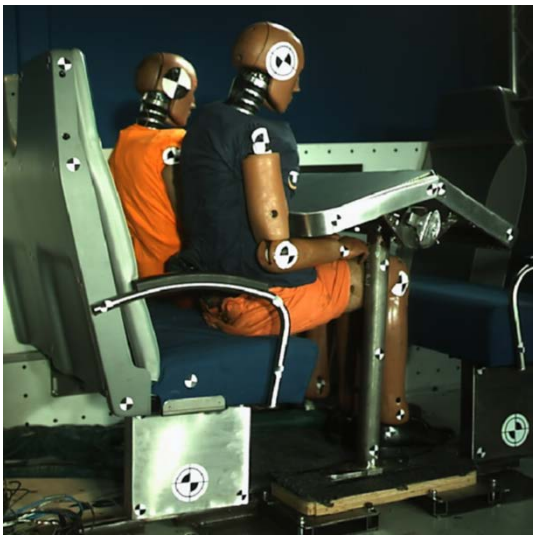
The difference in kinematics may also be due to the fact that there is less flexion in the table at the wall end (where the H3-RS is positioned) and more at the aisle end (where the Hybrid III is positioned).

The figures below demonstrate the posture of both ATDs during an example impact sequence, with the Hybrid III nearest the camera and the H3-RS behind that.



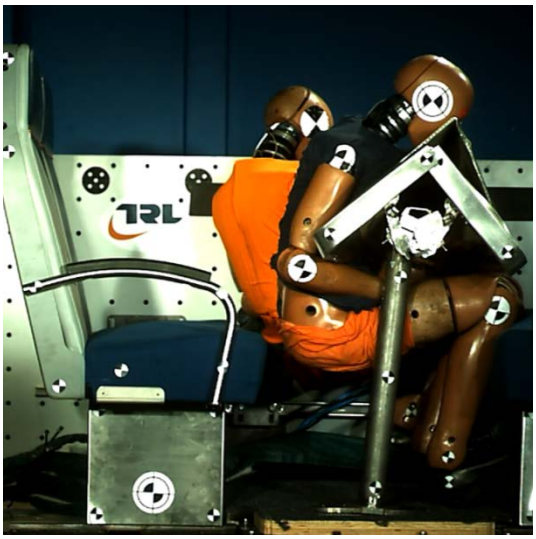
Just after T_0, depicting slightly different shape of abdomen in the H3-RS (furthest from camera, in the orange T-shirt).

At time of initial contact of the Hybrid III with the table edge (91 ms); both dummies still have a very similar, upright posture.



33 ms after initial contact with the table edge (124 ms); both dummies still have a very similar, upright posture.

56 ms after initial contact with the table edge (147 ms); the H3-RS has started to submarine under the table, but the Hybrid III remains very upright.



At time of maximum table penetration into the Hybrid III abdomen (187 ms); the H3-RS is considerably reclined due to the submarining action, but the Hybrid III hip angle has remained fixed in the molded position and the upper body has wrapped around the table.

Figure 22. Comparison between the kinematics of the H3-RS and Hybrid III in a typical workstation table test

In five out of six tests, the lower thorax deflection measurements on the H3-RS exceeded the APTA limit; in the remaining test, the upper abdomen deflection exceeded the APTA limit and the single-point upper chest deflection measurement of the Hybrid III ATD did not exceed the limit in any test. However, the loading was severe in one test, causing the potentiometer arm to come out of the guide track; it is possible that this test may have exceeded the limit if the instrumentation had not failed. Therefore, the H3-RS exposed deficiencies in all five table designs that were not apparent with the Hybrid III ATD.

The VC limit was also exceeded in two tests with the H3-RS and in one (different) test with the Hybrid III.

In five out of six tests, the lower leg (tibia and knee) injury metrics exceeded the limits in the UK GM/RT2100 rail standard, with between two and five of the requirements exceeded per test. These lower leg injury metrics are not used in the APTA standard.

In this test series the limits were assessed up to 300 ms after T_0, which was long enough to get peak head accelerations due to own-seat impacts, but may not have been quite long enough for peak compressive neck forces due to rebound in some tests. Any peaks due to the dummy falling from the sled would not be included in this timescale.

Both ATDs demonstrated good robustness, considering the severity of the loading. The Hybrid III had the chest deflection measurement failure mentioned above in one test, the H3-RS had a damaged wire in the chest deflection instrumentation in one test and the abdomen instrumentation in another test.

5. Conclusions

The performance of the H3-RS ATD was evaluated in workstation table tests in order to:

- Generate H3-RS injury data for a range of workstation table designs;
- Determine whether the tables comply with the performance requirements in the APTA table standard;
- Determine whether the H3-RS instrumentation functioned as intended;
- Compare the kinematics of the H3-RS and standard Hybrid III ATDs;
- Evaluate the performance of tables designed to the UK table standard GM/RT2100 under test conditions specified in the US table standard.

The injury data were generated to demonstrate that none of the table designs met all the performance requirements of the APTA standard when tested with the H3-RS. In contrast, the standard Hybrid III complied with all the injury measurements, in all but one of the six table tests. The difference may have been partly because the standard Hybrid III ATD was positioned in the aisle seat, where the table tends to deflect more, and the H3-RS was seated in the wall seat, where the table tends to be stiffer. However, all the table designs failed at the lower thorax and upper abdomen H3-RS measurement locations, none of which are available on the standard Hybrid III.

The H3-RS instrumentation functioned as intended, effectively capturing the loading from the table edges. There were two instrumentation failures in the H3-RS due to potentiometer wires breaking, and one in the Hybrid III due to the potentiometer arm coming out of its guide rail. The loss of one potentiometer in a test with the H3-RS is important, because the whole deflection measurement at that location is lost. However, an advantage of the ATD is that the bilateral measurement at each level (upper thorax, lower thorax, upper abdomen and lower abdomen) means that some assessment of safety is still possible even if one channel fails. When the chest deflection instrumentation failed in the Hybrid III, no assessment of the chest and abdomen injury risk was possible. This is the key assessment in workstation table testing because head and neck loading is typically low.

The H3-RS demonstrated different kinematics to the Hybrid III, with a tendency to ‘submarine’ under the leading edge of the table; in contrast, the Hybrid III tended to remain very upright and exhibited very little flexion or extension at the hip. This is most likely due to the more biofidelic design of the H3-RS, which has a much larger (and more humanlike) range of motion at the hip and a better-controlled abdomen stiffness.

6. References

1. APTA (2013). Fixed Workstation Tables in Passenger Rail Cars. APTA Standard PR-CS-S-018-13 Rev.1 (Draft 29 April 2015). http://www.apta.com/resources/standards/press/Pages/default.aspx
2. GM/RT 2100 (2010). Requirements for Rail Vehicle Structures. Railway Group Standard GM/RT 2100, Issue 4, December 2010. https://www.rssb.co.uk/rgs/standards/GMRT2100%20Iss%204.pdf
3. SAE (1997). Performance Standards for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft. SAE Aerospace Standard AS8049 Rev. A, 1997-09. http://standards.sae.org/as8049/1a/
4. Schneider LW, Robbins DH, Pflüg MA and Snyder RG (1983). Development of anthropometrically based design specifications for an advanced adult anthropomorphic dummy family, volume 1. University of Michigan Transport Research Institute, Ann Arbor, MI. Report number UMTRI-83-53-1.

Appendix A. Detailed Test Results

A.1 Test 1

Test Number	G300I01
Configuration	Forward Facing
Test Type	APTA-PR-CS-S-018-13 Prototype Table Test
Dummies	Hybrid III RS and Hybrid III both 50th Percentile
Result	Failure of lower left and right chest deflection criteria, H3-RS (wall-side ATD)

A.1.1 Test 1: Summary

Figure A.1.1: Pre-Test

This injury test was for the seat configuration depicted above. The seat design was ‘Seat 1’ and the table design was ‘Table 1.’ The installation of seats and table was carried out by TRL test staff; all mountings and interface plates were designed and fabricated by TRL.

The test pulse is plotted in Figure A.1.3, and the calibration run pulse obtained prior to testing is plotted in Figure A.1.4, which demonstrates that the test conforms as far as possible to the requirements of the standard.

Figure A.1.2: Post-Test

The test was filmed from several viewpoints using high-speed digital cameras running at 1000 fps. Still photographs were used to document the set-up and record any seat deformation and contact points post-test. 2D point measurements have been used to compare seat and dummy positions before and after the test; this allows survival space and deformation to be quantified. A checklist was completed during testing to ensure compliance with the requirements of APTA-PR-CS-S-018-13.

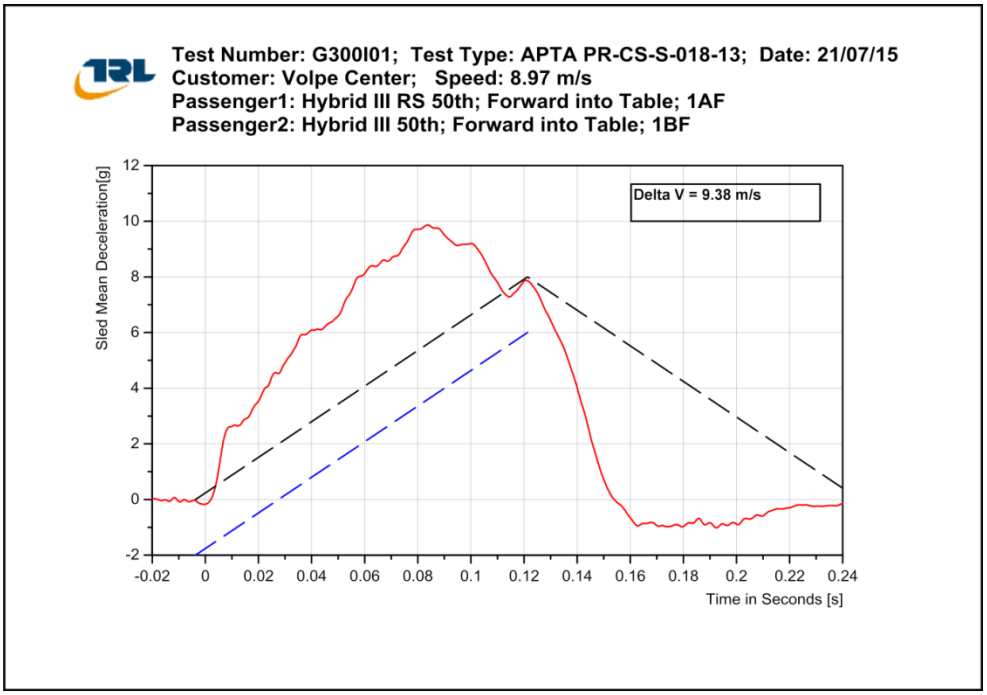


Figure A.1.3: Test 1 Deceleration Pulse

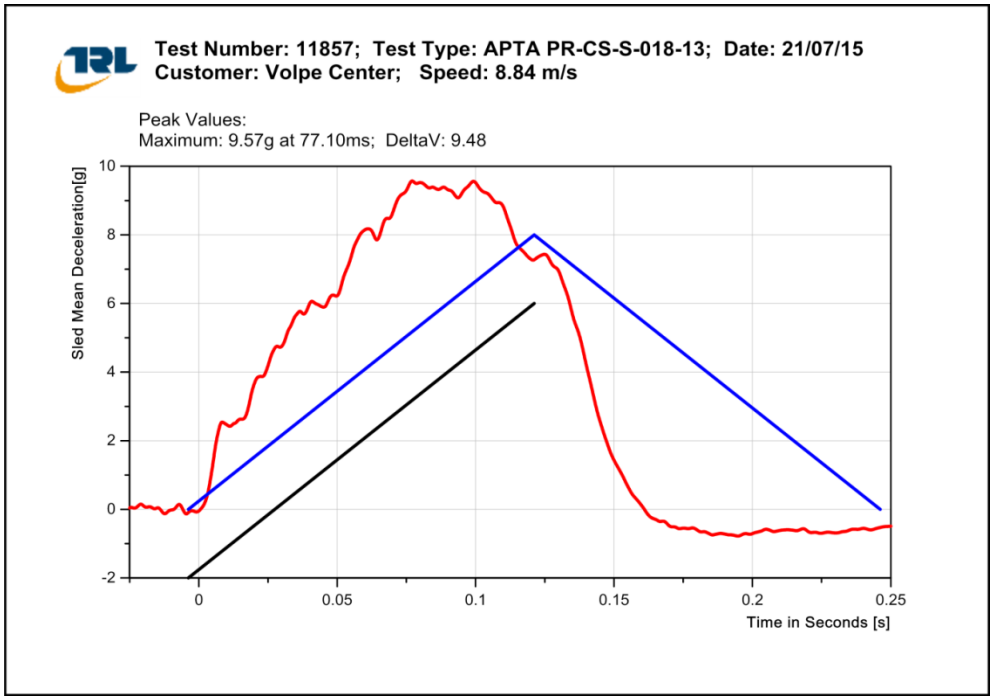
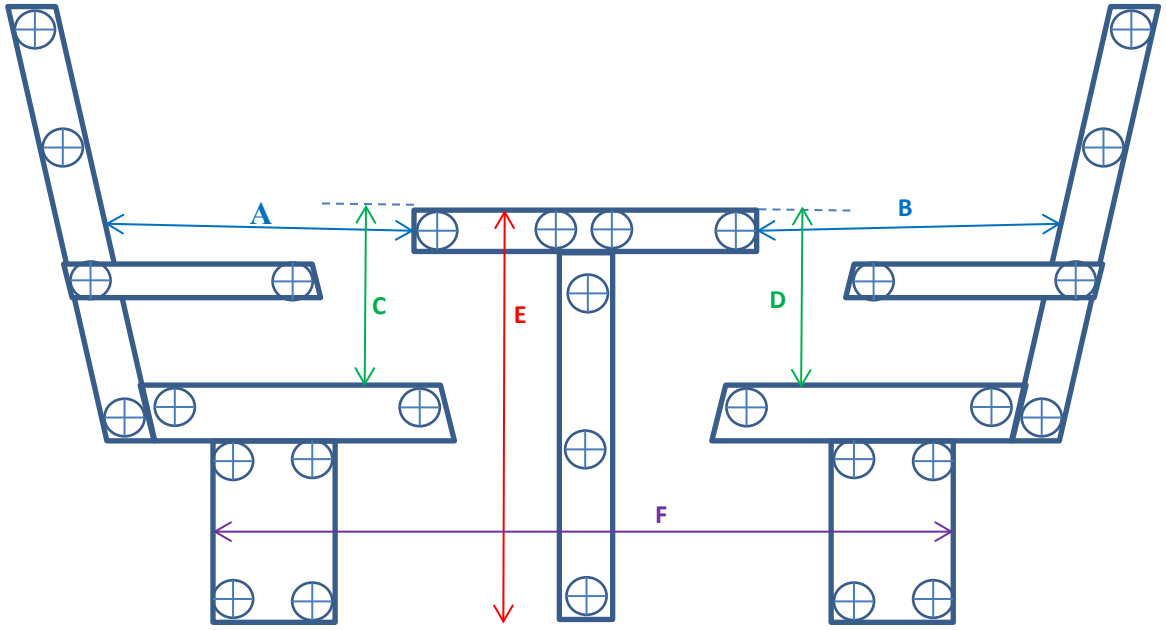
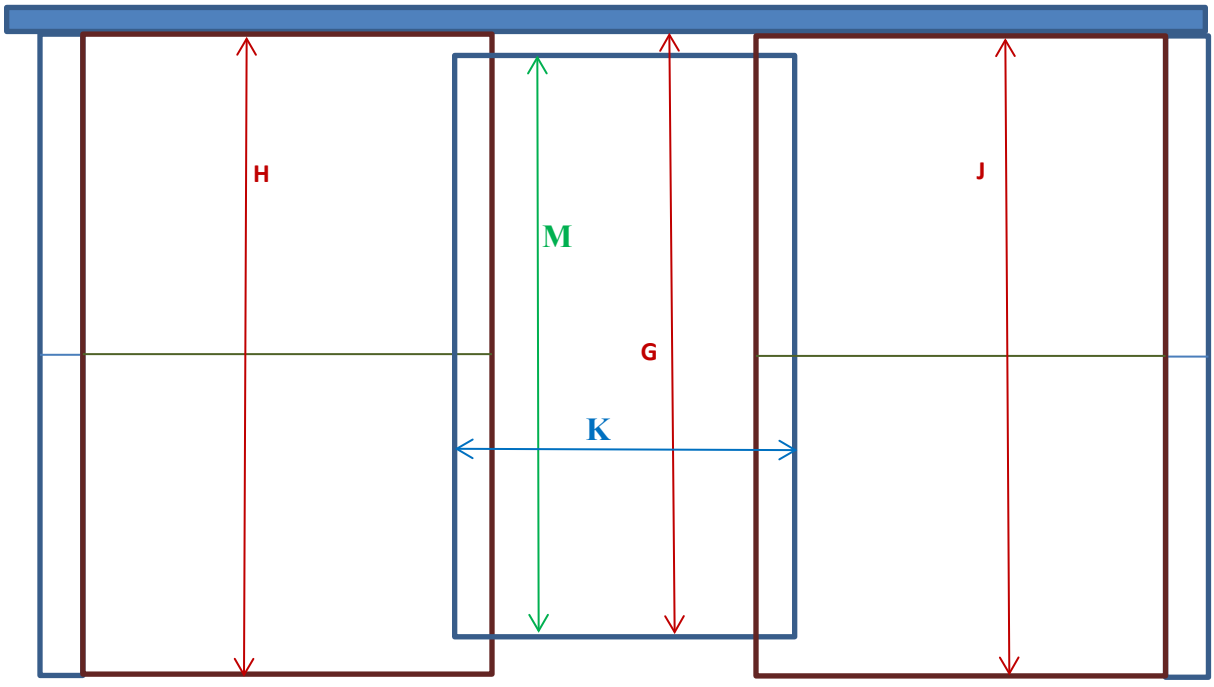


Figure A.1.4: Calibration Run Deceleration Pulse

A.1.3 Test 1: Pre and Post Test Measurements



Overhead View



Measurement	Pre-Test Value (mm)	Post-Test Value (mm)
Longitudinal Distance between the front edge of the table top and the seat back (ATD 1) A	428	610
Longitudinal Distance between the front edge of the table top and the seat back (ATD 2) A	424	640
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 1) B	444	480
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 2) B	445	450
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 1) C	313	250
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 2) C	303	255
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 1) D	305	195
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 2) D	310	190
Vertical Distance from Table Top to Floor E	742	980 middle / 935 peak
Longitudinal Distance from outside Rear Pedestal Base to outside of Front Pedestal Base F	1375	1370
Lateral Distance from Wall to Edge of Table G	1135	0
Lateral Distance from Wall to Edge of Forward Facing Seats H	1073 (inside armrest)	1073 (inside armrest)
Lateral Distance from Wall to Edge of Rear Facing Seats J	1080 (inside armrest)	1080 (inside armrest)
Table Top Thickness	55	57
Table Top Lateral (width) K	713	530
Table Top Longitudinal (depth) M	1122	1180

A.1.4 Test 1: Injury Criteria Summary

Test Number: G300l01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 1

Body Region	APTA Limit	HII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Head - HIC 15	700	23.63	Pass	103.78	Pass
Neck Peak Axial Tension	4.17kN	0.81kN	Pass	1.10kN	Pass
Neck Peak Axial Compression	-4kN	-0.91kN	Pass	-0.15kN	Pass
Neck - Nij NTE	1.0	0.18	Pass	0.35	Pass
Neck- Nij NTF	1.0	0.20	Pass	0.16	Pass
Neck - Nij NCE	1.0	0.42	Pass	0.01	Pass
Neck - Nij NCF	1.0	0.10	Pass	0.03	Pass
Chest - 3ms Exceedence	60g	17.63g	Pass	24.47g	Pass
Upper Left Chest Max Deflection	-63mm	-53.69mm	Pass	N/A	N/A
Upper Right Chest Max Deflection	-63mm	-45.39mm	Pass	N/A	N/A
Lower Left Chest Max Deflection	-63mm	-80.23mm	Fail	N/A	N/A
Lower Right Chest Max Deflection	-63mm	-68.58mm	Fail	N/A	N/A
Chest Max Deflection (HIII)	-63mm	N/A	N/A	-50.49	Pass
Upper Left Chest Viscous Criterion	1.0m/s	0.44m/s	Pass	N/A	N/A
Upper Right Chest Viscous Criterion	1.0m/s	0.33m/s	Pass	N/A	N/A
Lower Left Chest Viscous Criterion	1.0m/s	0.89m/s	Pass	N/A	N/A
Lower Right Chest Viscous Criterion	1.0m/s	0.76m/s	Pass	N/A	N/A
Chest Viscous Criterion (HIII)	1.0m/s	N/A	N/A	0.47	Pass
Upper Left Abdomen Deflection	-67mm	-38.67mm	Pass	N/A	N/A
Upper Right Abdomen Deflection	-67mm	-44.43mm	Pass	N/A	N/A
Lower Left Abdomen Deflection	-67mm	-13.12mm	Pass	N/A	N/A
Lower Right Abdomen Deflection	-67mm	-11.38mm	Pass	N/A	N/A

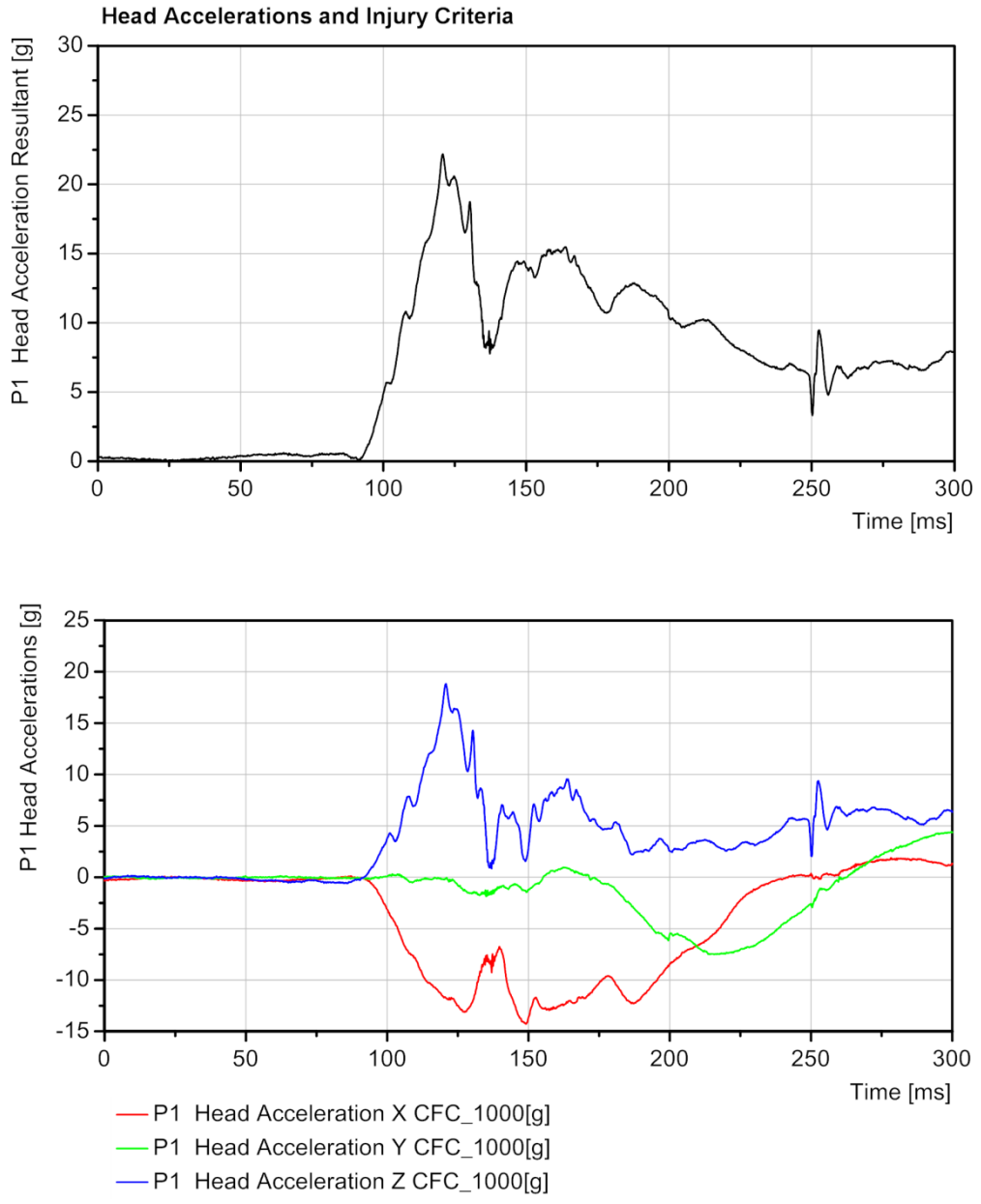
Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 2

Body Region	APTA Limit	HIII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Upper Abdomen Left VC	1.98m/s	0.28m/s	Pass	N/A	N/A
Upper Abdomen Right VC	1.98m/s	0.34m/s	Pass	N/A	N/A
Lower Abdomen Left VC	1.98m/s	0.05m/s	Pass	N/A	N/A
Lower Abdomen Right VC	1.98m/s	0.03m/s	Pass	N/A	N/A
Left Femur Peak Compression	-7kN	-2.39kN	Pass	-4kN	Pass
Right Femur Peak Compression	-7kN	-2.8kN	Pass	-2.67kN	Pass

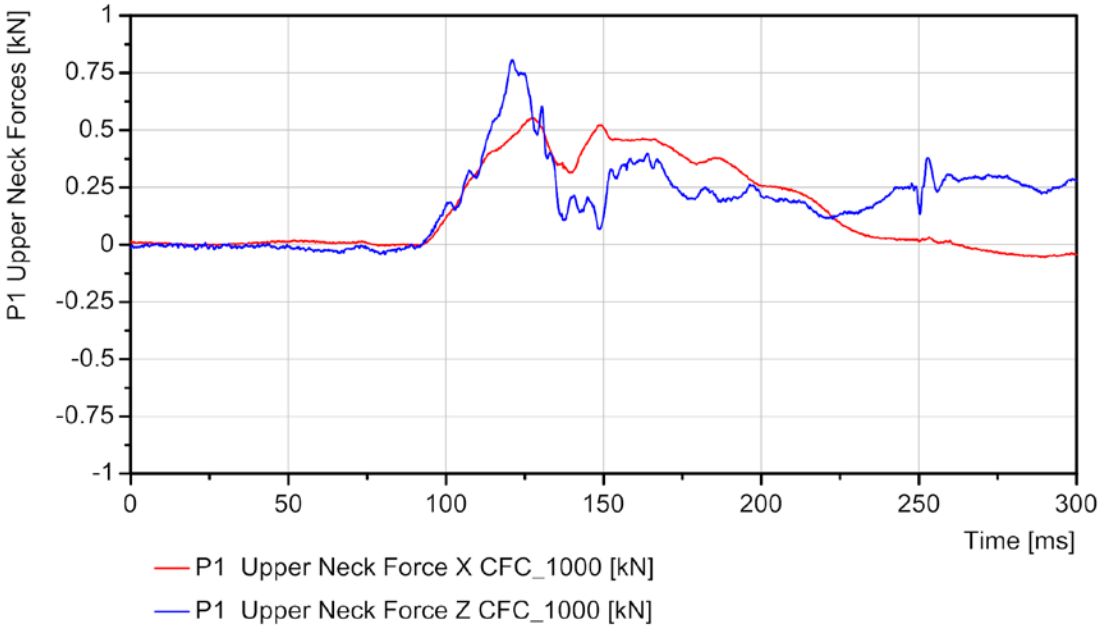
A.1.5 Test 1: ATD Sensor Data

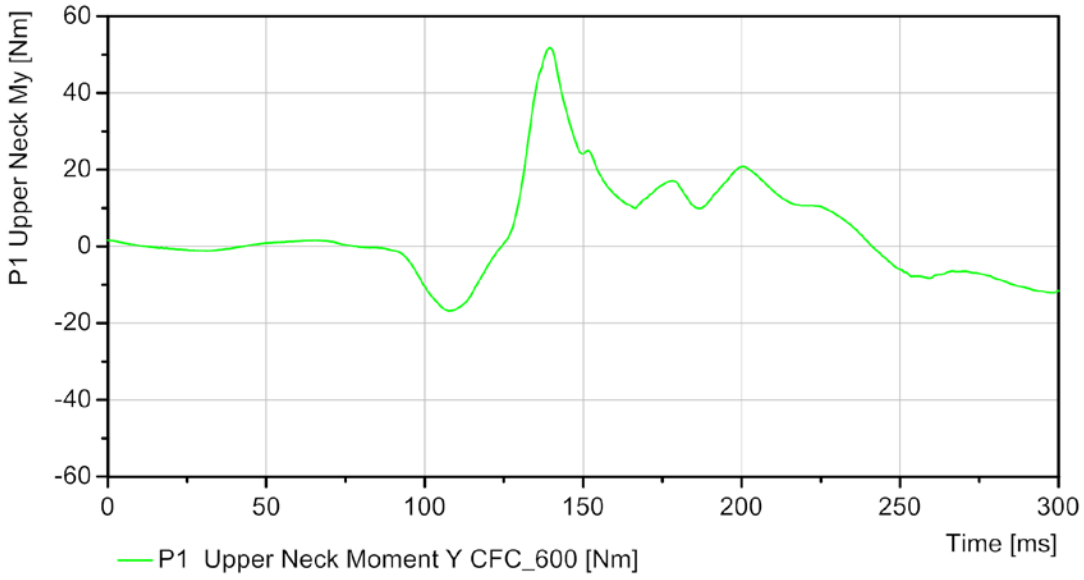
Test Number: G300l01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF



Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

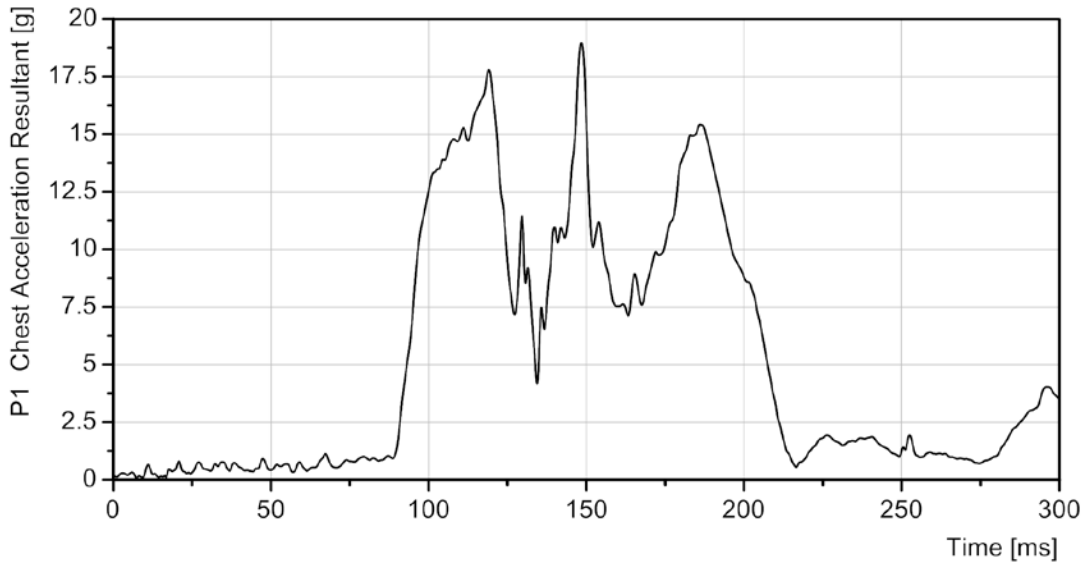
Upper Neck Forces

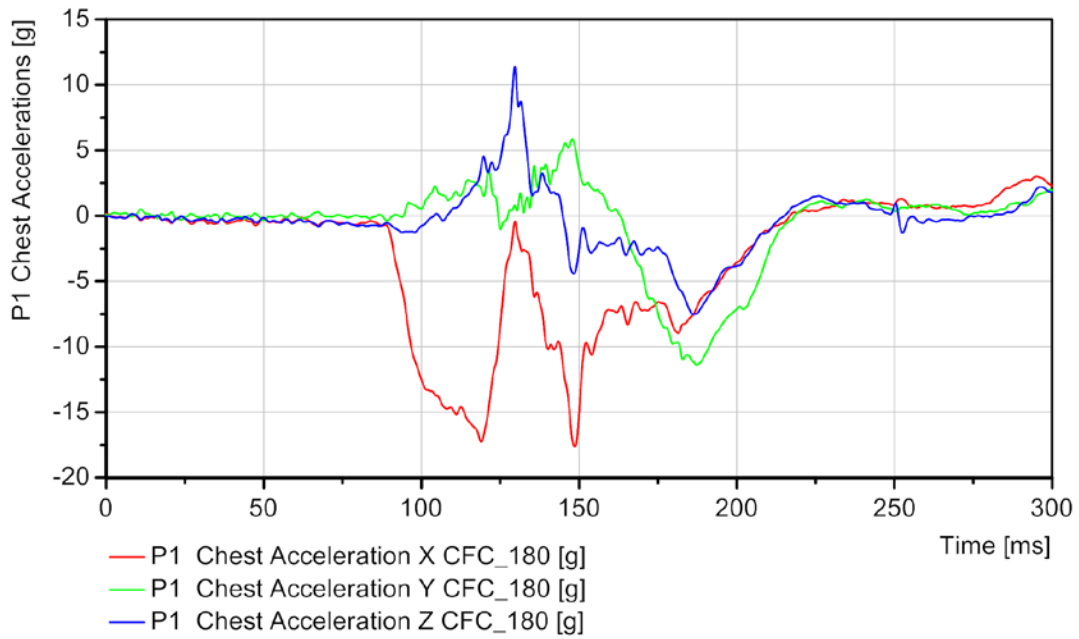




Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

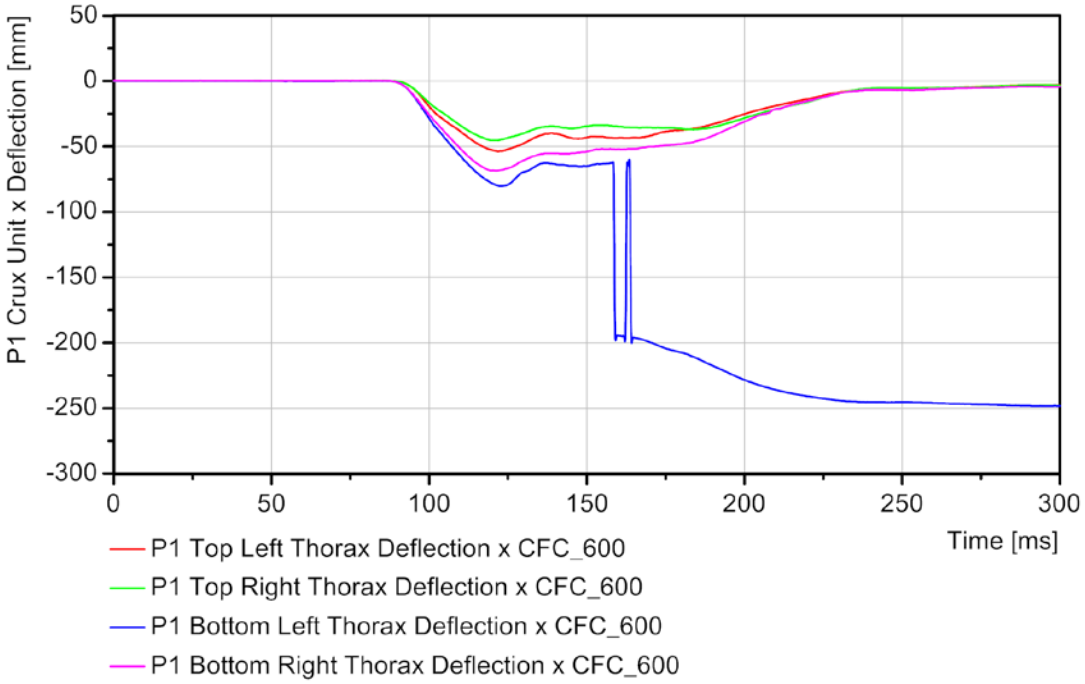
Chest Accelerations and Injury Criteria





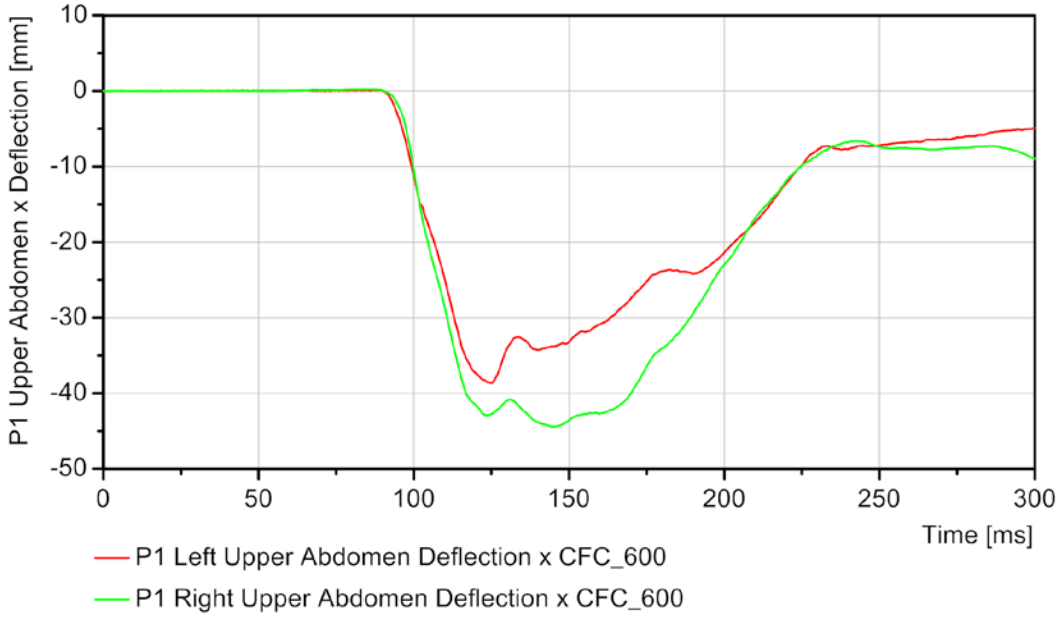
Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

Crux Unit Outputs

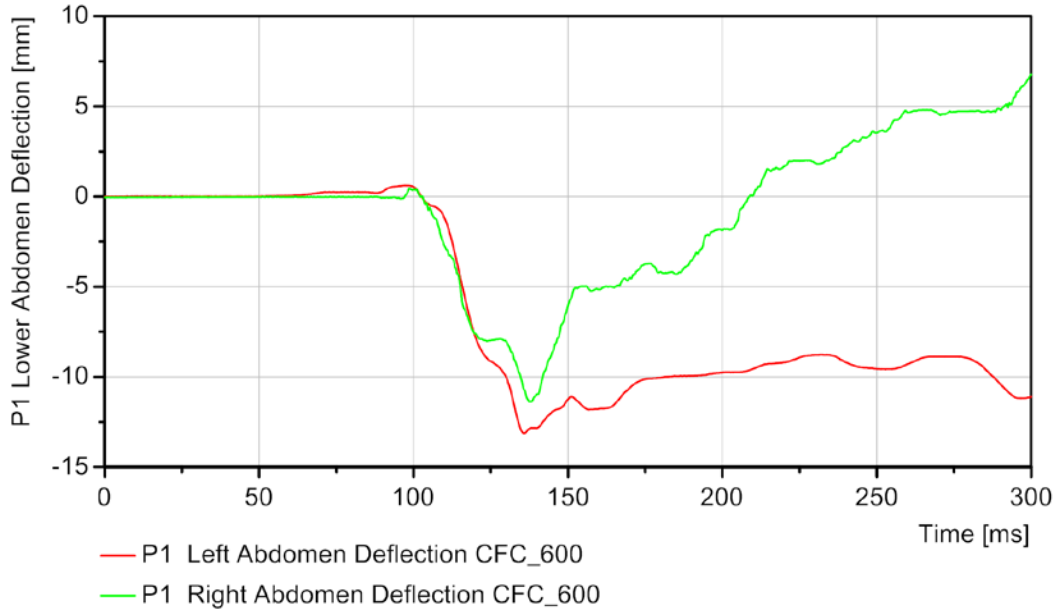


Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

DGSP Unit Outputs

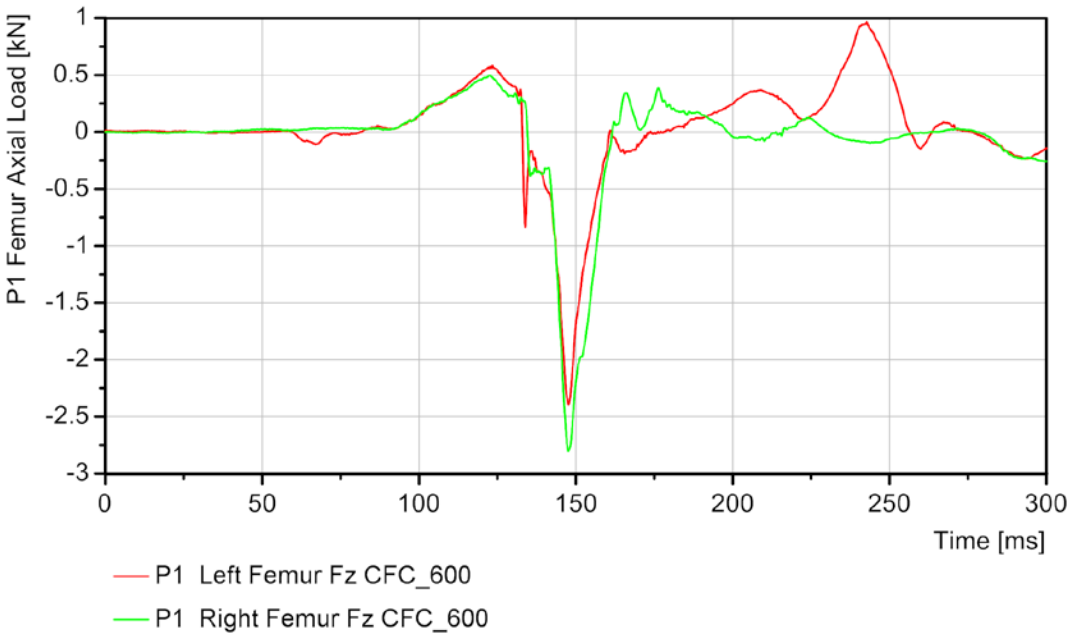


Lower Abdomen Deflections



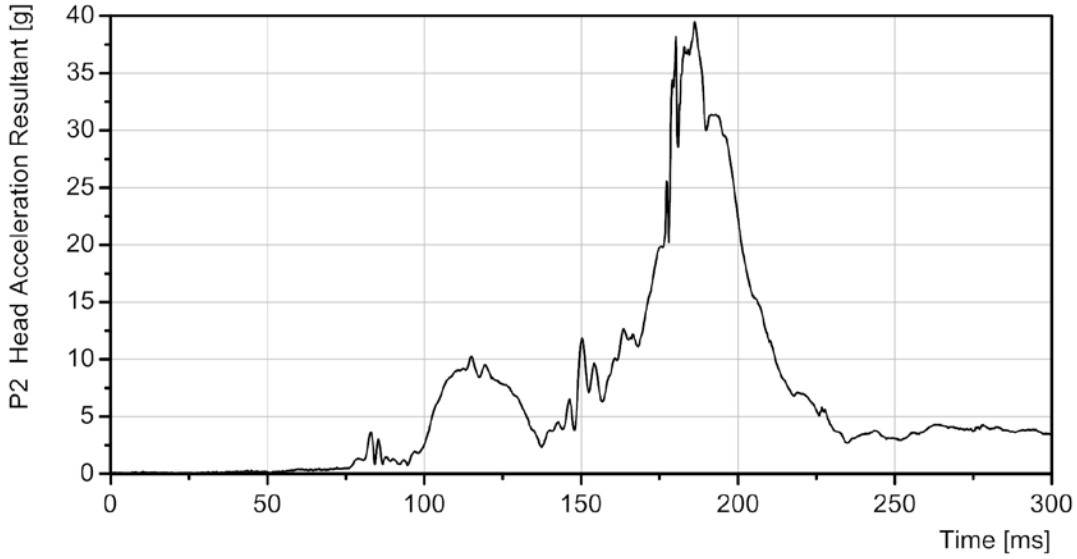
Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

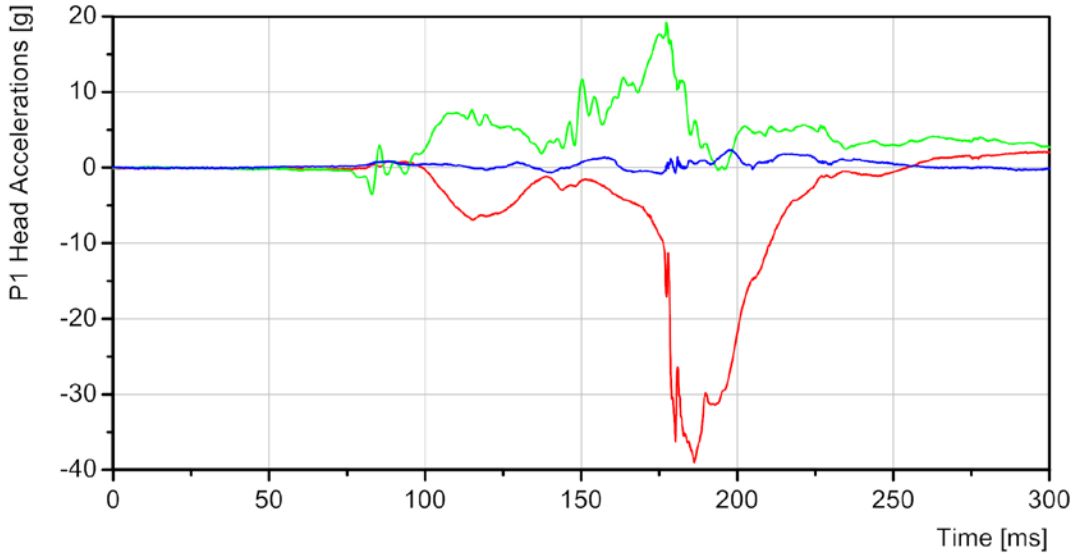
Femur Axial Loads



Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Head Accelerations and Injury Criteria

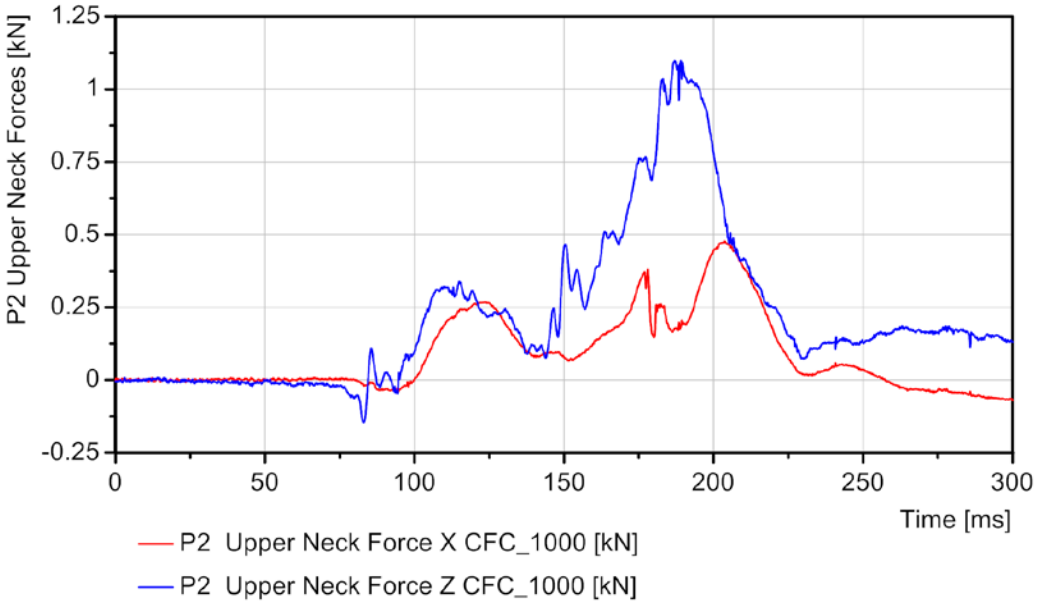




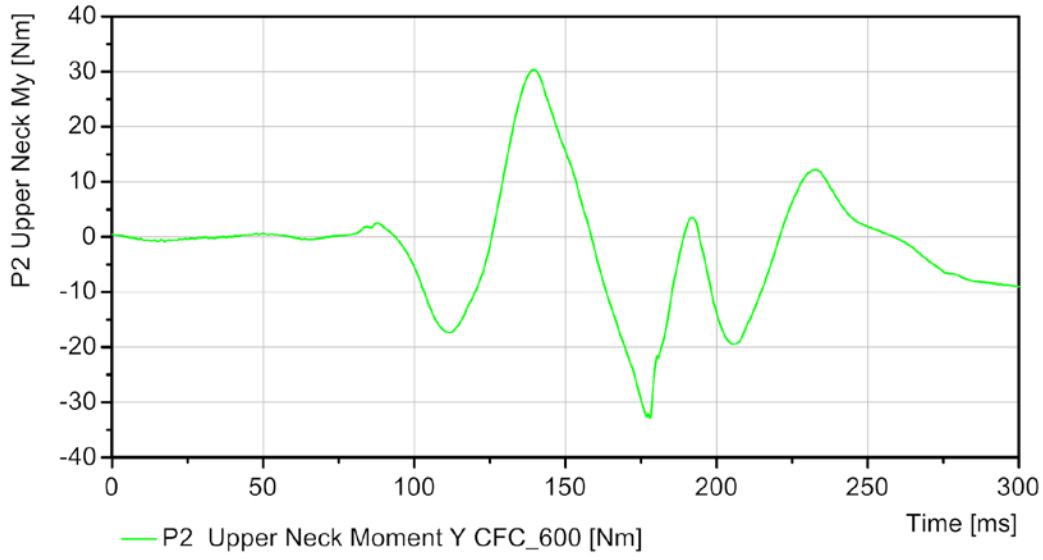
P2 Head Acceleration X CFC_1000[g]
P2 Head Acceleration Y CFC_1000[g]
P2 Head Acceleration Z CFC_1000[g]

Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Upper Neck Forces

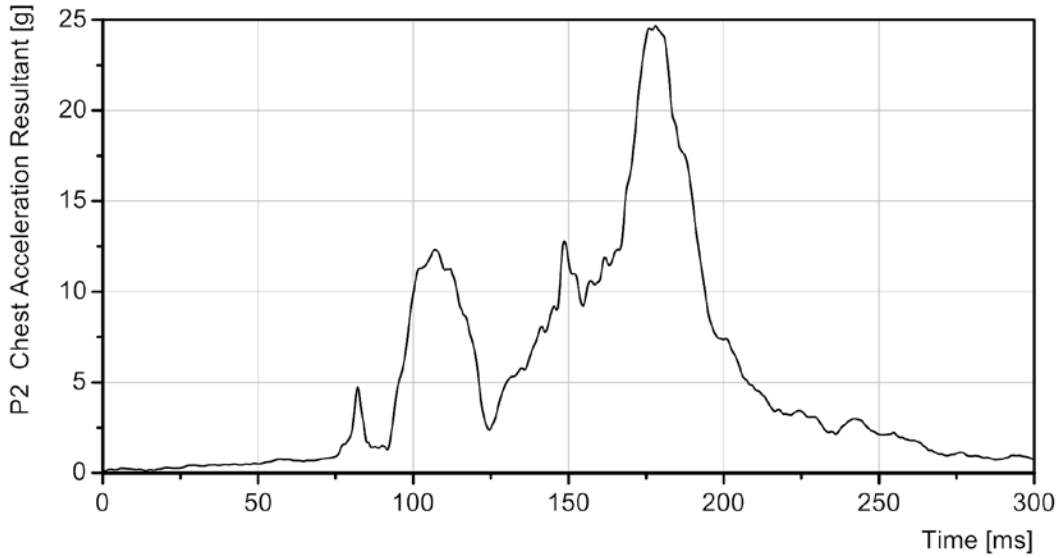


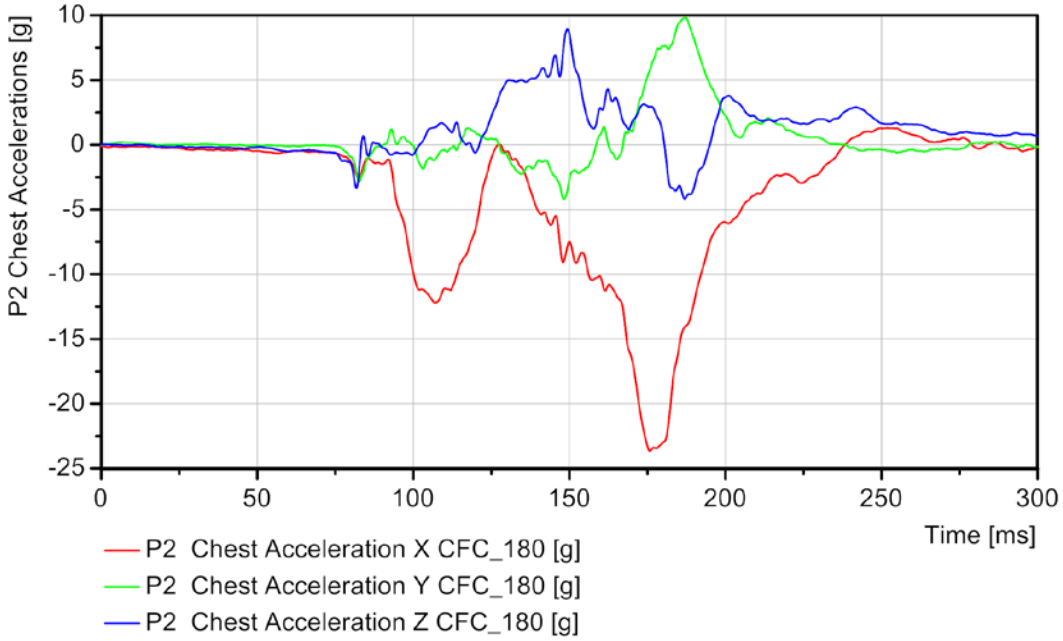
Upper Neck Moments



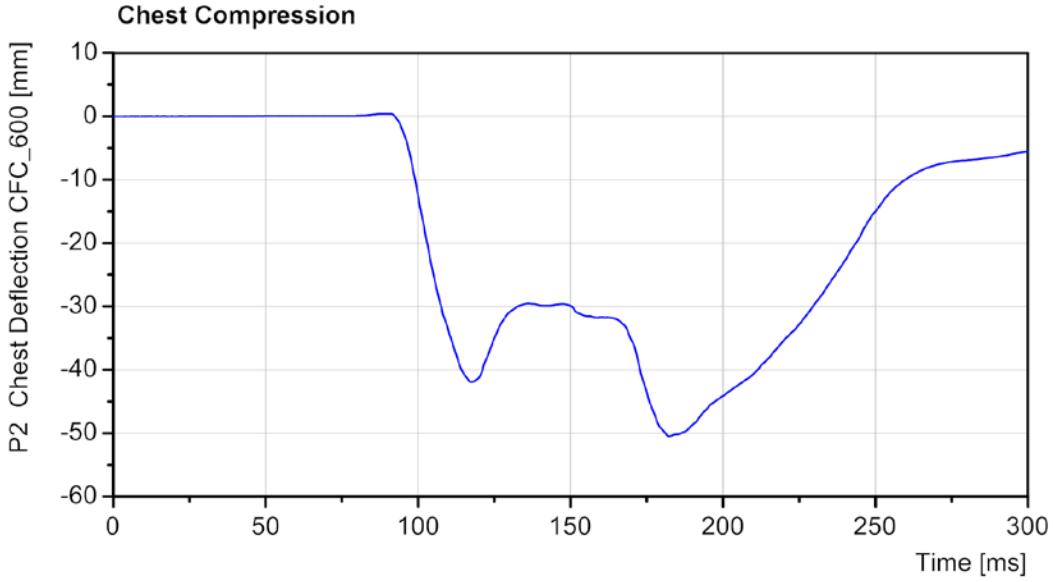
Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Chest Accelerations and Injury Criteria

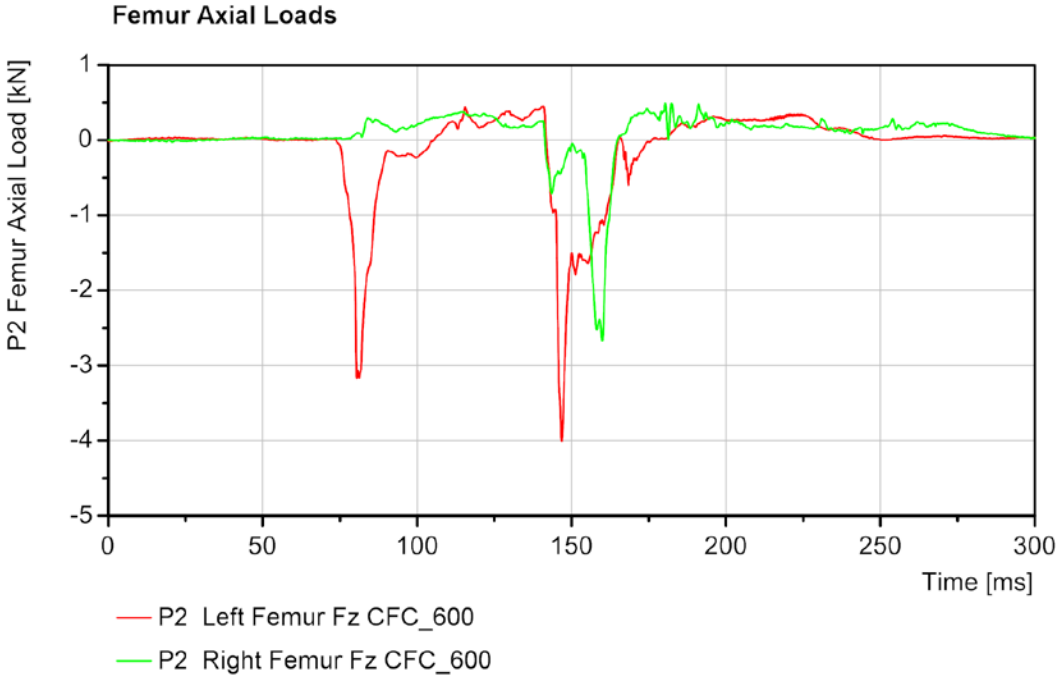




Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



Test Number: G300I01; Test Type: APTA PR-CS-S-018-13; Date: 21/07/15
Customer: Volpe Center; Speed: 8.97 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



A.2 Test 2

Test Number	G300I02
Configuration	Forward Facing
Test Type	APTA-PR-CS-S-018-13 Prototype Table Test (28 mm taller than in Test 1)
Dummies	Hybrid III RS and Hybrid III both 50th Percentile
Result	Failure of upper and lower left chest deflection criteria, H3-RS (wall-side ATD)

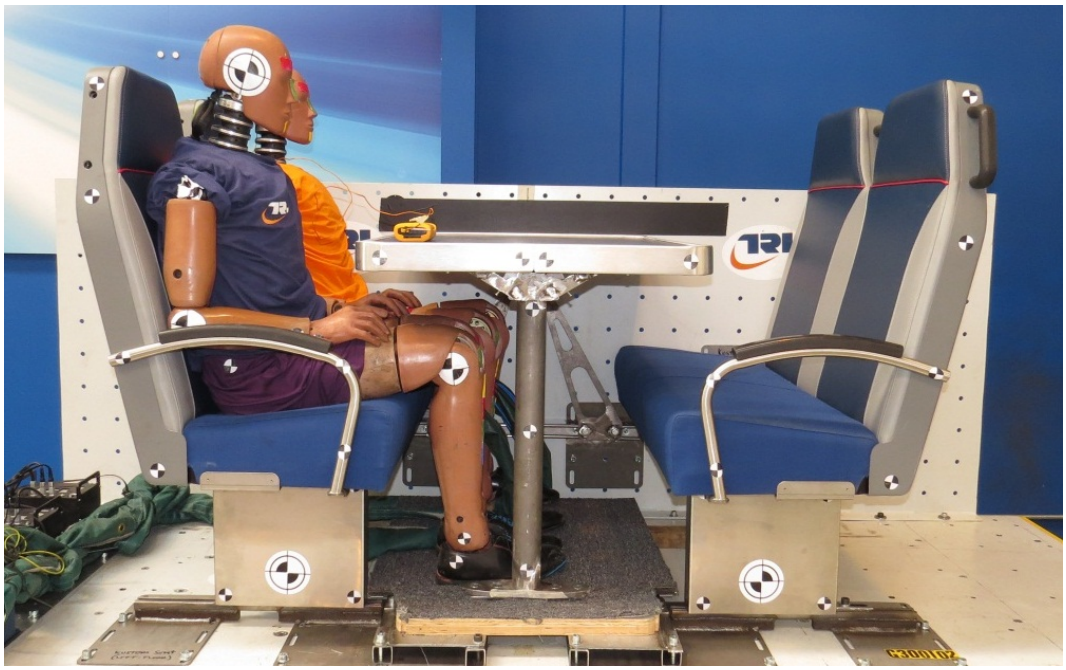


Figure A.2.1: Pre-Test

A.2.1 Test 2: Summary

This injury test was for the seat configuration depicted above. The seat design was 'Seat 1' and the table design was 'Table 2'. The installation of seats and table was carried out by TRL test staff; all mountings and interface plates were designed and fabricated by TRL.

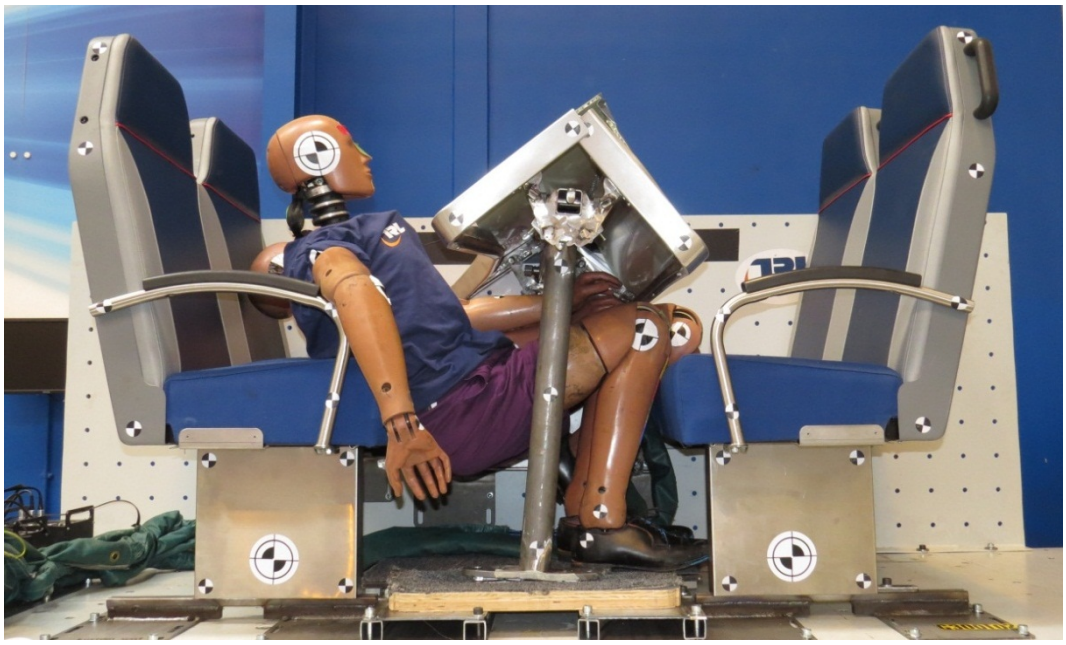


Figure A.2.2: Post-Test

The test pulse is depicted in Figure A.2.3; the calibration run pulse obtained prior to testing is plotted in Figure A.2.4, demonstrating that the test conforms as far as possible to the requirements of the standard.

The test was filmed from several viewpoints using high-speed digital cameras running at 1000 fps. Still photographs were used to document the set-up and record any seat deformation and contact points post-test. 2D point measurements have been used to compare seat and dummy positions before and after the test; this allows survival space and deformation to be quantified.

A checklist was completed during testing to ensure compliance with the requirements of APTA-PR-CS-S-018-13.

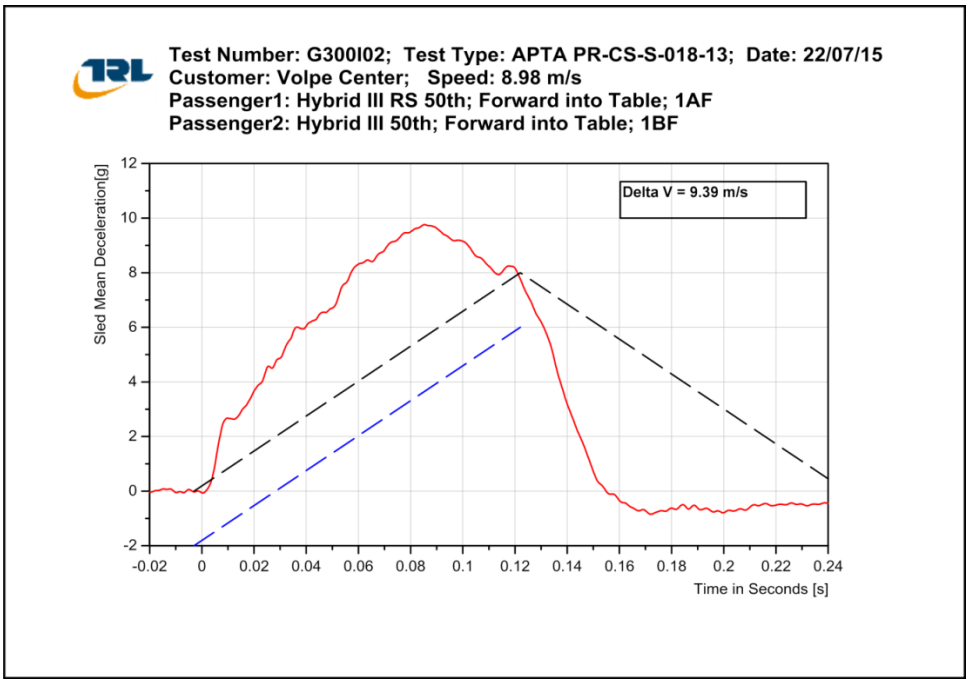


Figure A.2.3: Test 2 Deceleration Pulse

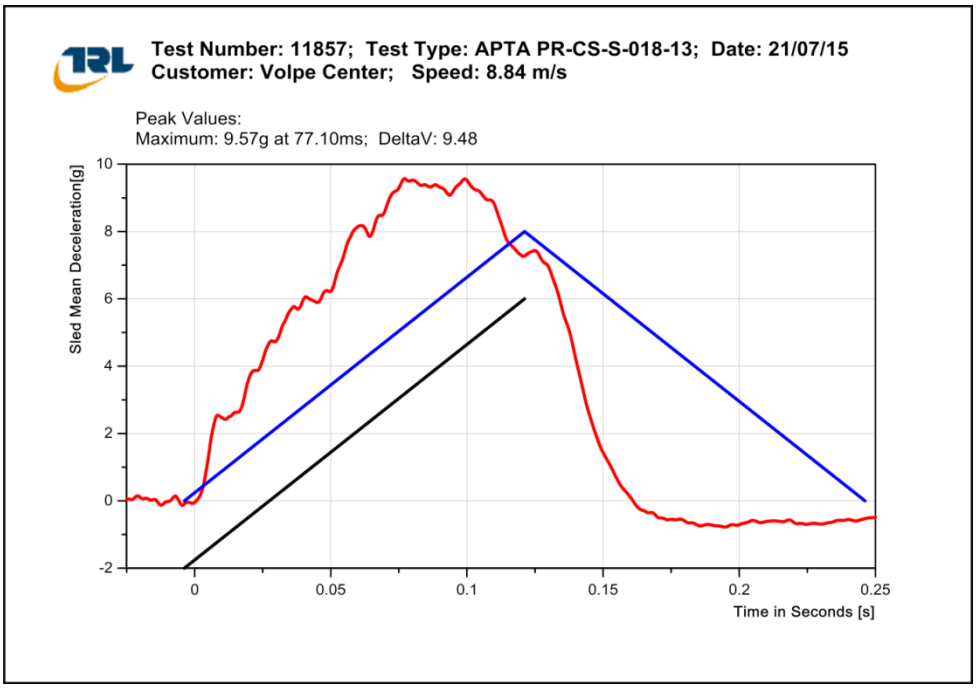
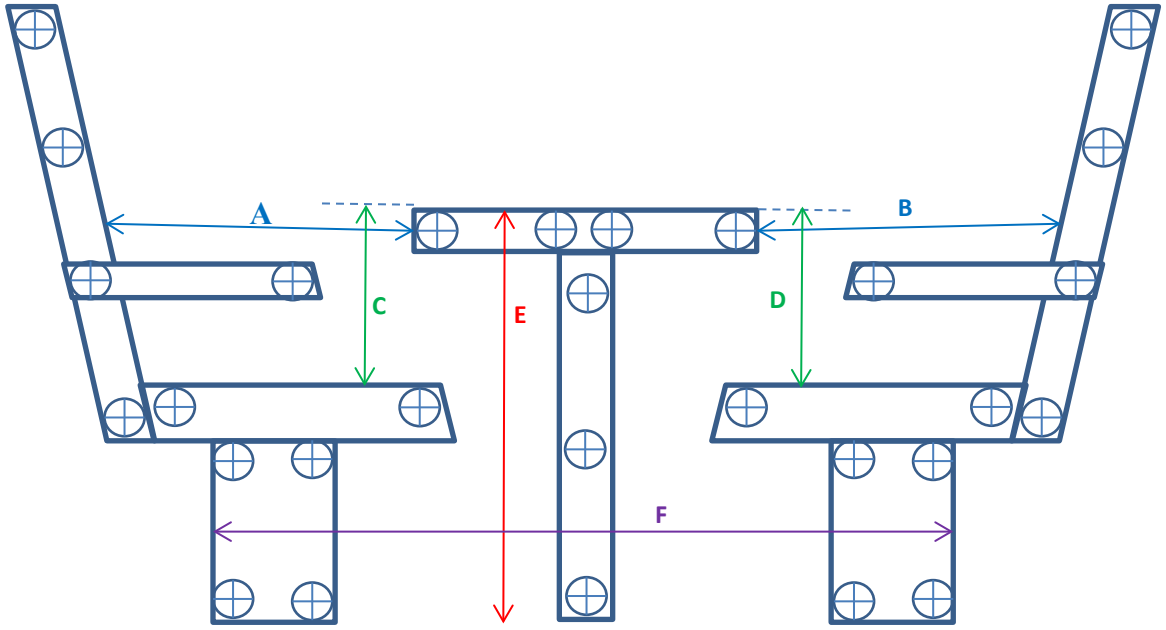
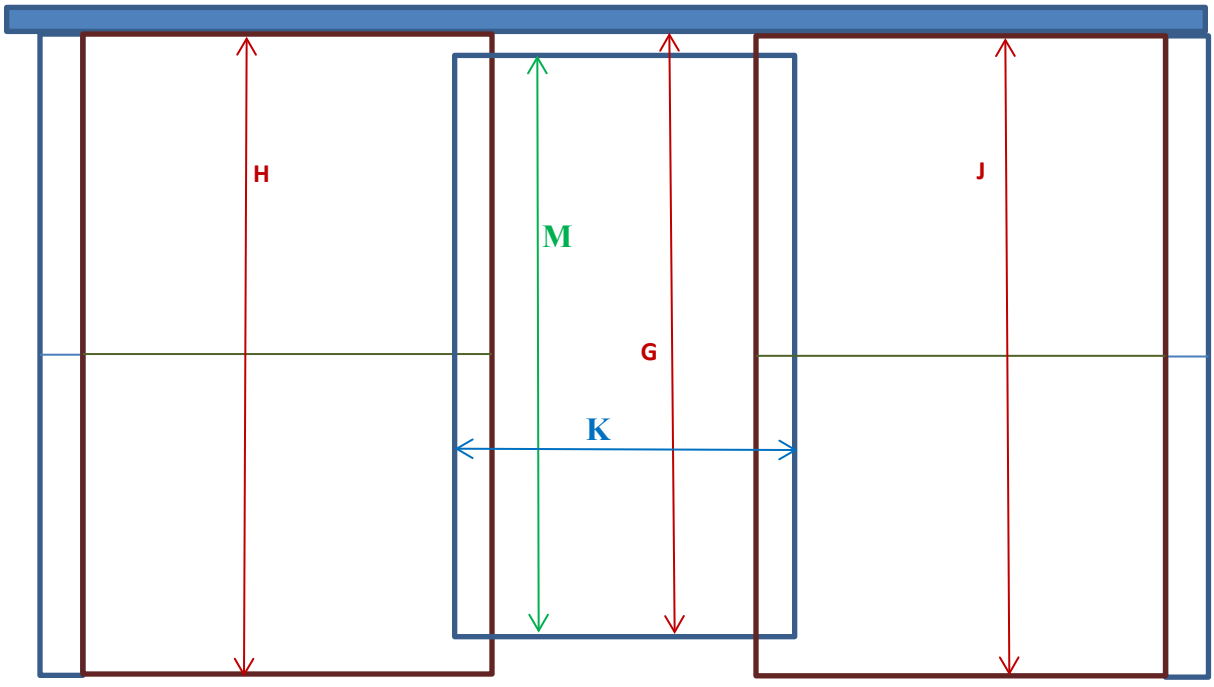


Figure A.2.4: Calibration Run Deceleration Pulse

A.2.2 Test 2: Pre and Post Test Measurements



Overhead View



Measurement	Pre-Test Value (mm)	Post-Test Value (mm)
Longitudinal Distance between the front edge of the table top and the seat back (ATD 1) A	432	595
Longitudinal Distance between the front edge of the table top and the seat back (ATD 2) A	435	605
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 1) B	440	420
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 2) B	440	417
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 1) C	340	260 (Video)
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 2) C	350	260 (Video)
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 1) D	330	210
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 2) D	330	205
Vertical Distance from Table Top to Floor E	770	
Longitudinal Distance from outside Rear Pedestal Base to outside of Front Pedestal Base F	1370	1370
Lateral Distance from Wall to Edge of Table G	1120	
Lateral Distance from Wall to Edge of Forward Facing Seats H	1109	
Lateral Distance from Wall to Edge of Rear Facing Seats J	1115	
Table Top Thickness	55	
Table Top Lateral (width) K	710	
Table Top Longitudinal (depth) M	1115	

A.2.3 Test 2: Injury Criteria Summary

Test Number: G300l02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 1

Body Region	APTA Limit	HII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Head - HIC 15	700	83.67	Pass	17.47	Pass
Neck Peak Axial Tension	4.17kN	1.26kN	Pass	0.63kN	Pass
Neck Peak Axial Compression	-4kN	-1.63kN	Pass	-0.18kN	Pass
Neck - Nij NTE	1.0	0.23	Pass	0.37	Pass
Neck- Nij NTF	1.0	0.31	Pass	0.20	Pass
Neck - Nij NCE	1.0	0.29	Pass	0.01	Pass
Neck - Nij NCF	1.0	0.32	Pass	0.07	Pass
Chest - 3ms Exceedence	60g	21.73g	Pass	14.16g	Pass
Upper Left Chest Max Deflection	-63mm	-66.48mm	Fail	N/A	N/A
Upper Right Chest Max Deflection	-63mm	-54.28mm	Pass	N/A	N/A
Lower Left Chest Max Deflection	-63mm	-80.73mm	Fail	N/A	N/A
Lower Right Chest Max Deflection	-63mm	*	*	N/A	N/A
Chest Max Deflection (HIII)	-63mm	N/A	N/A	-54.33	Pass
Upper Left Chest Viscous Criterion	1.0m/s	0.58m/s	Pass	N/A	N/A
Upper Right Chest Viscous Criterion	1.0m/s	0.46m/s	Pass	N/A	N/A
Lower Left Chest Viscous Criterion	1.0m/s	0.79m/s	Pass	N/A	N/A
Lower Right Chest Viscous Criterion	1.0m/s	*	*	N/A	N/A
Chest Viscous Criterion (HIII)	1.0m/s	N/A	N/A	0.50	Pass
Upper Left Abdomen Deflection	-67mm	-28.73mm	Pass	N/A	N/A
Upper Right Abdomen Deflection	-67mm	-31.51mm	Pass	N/A	N/A
Lower Left Abdomen Deflection	-67mm	-3.7mm	Pass	N/A	N/A
Lower Right Abdomen Deflection	-67mm	-1.63mm	Pass	N/A	N/A

*The Lower Right Crux Unit had an instrumentation failure and will be excluded

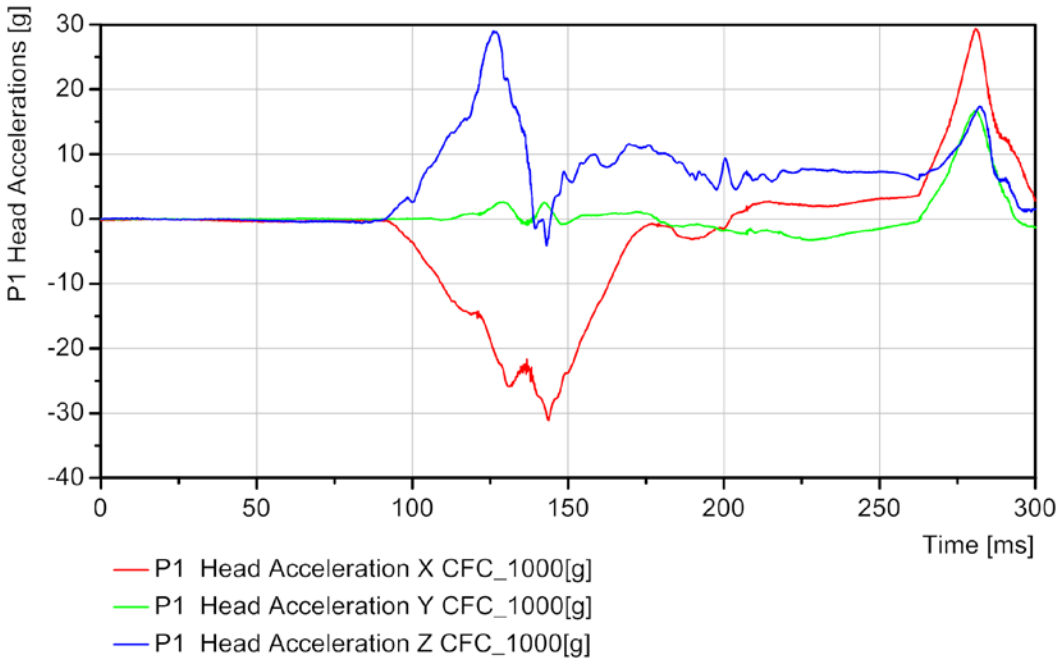
Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 2

Body Region	APTA Limit	HIII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Upper Abdomen Left VC	1.98m/s	0.17m/s	Pass	N/A	N/A
Upper Abdomen Right VC	1.98m/s	0.16m/s	Pass	N/A	N/A
Lower Abdomen Left VC	1.98m/s	0.00m/s	Pass	N/A	N/A
Lower Abdomen Right VC	1.98m/s	0.02m/s	Pass	N/A	N/A
Left Femur Peak Compression	-7kN	-4.24kN	Pass	-5.07kN	Pass
Right Femur Peak Compression	-7kN	-4.51kN	Pass	-2.66kN	Pass

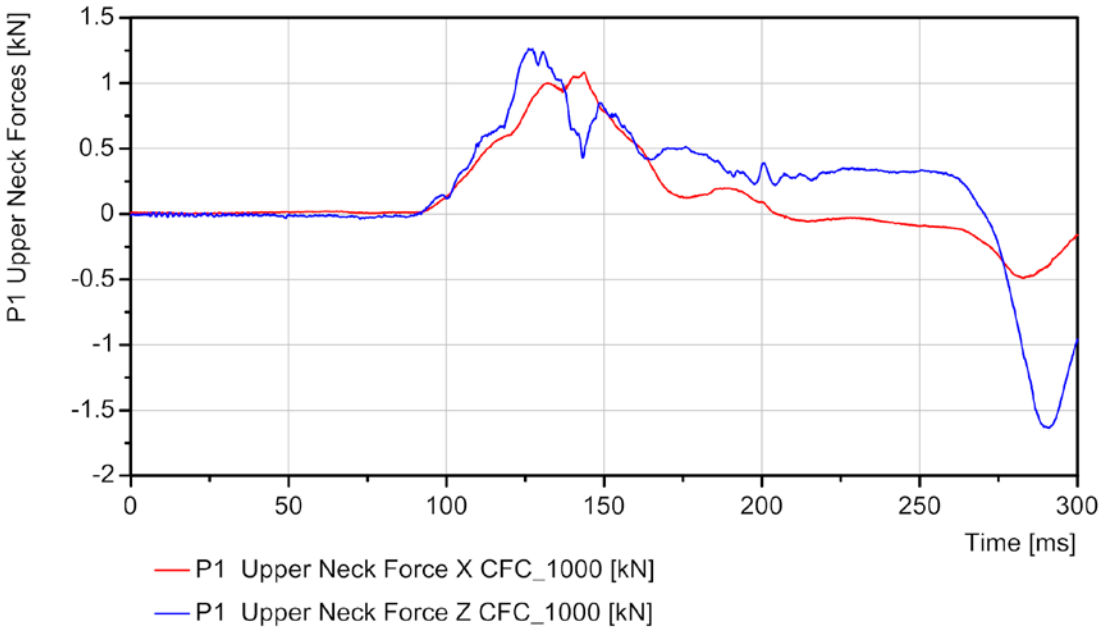
Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

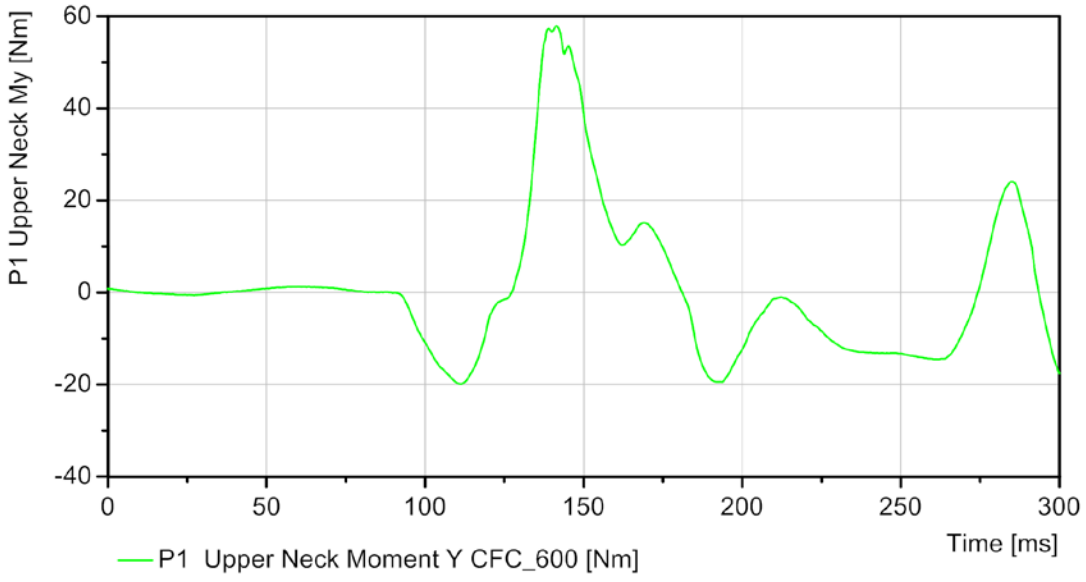
Head Accelerations and Injury Criteria



Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

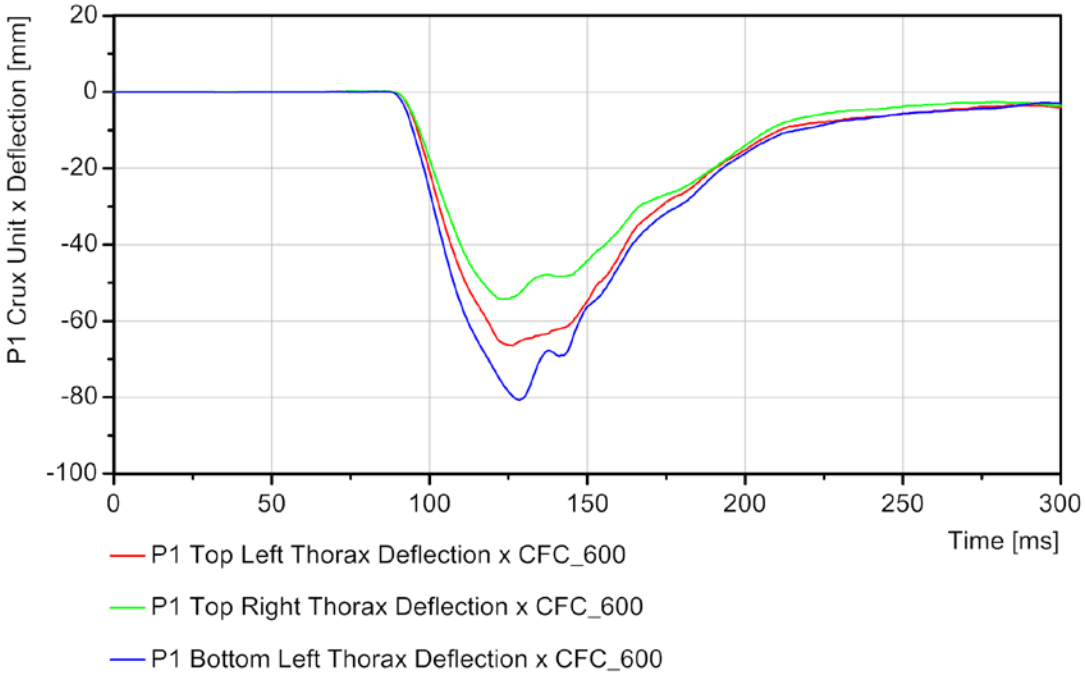
Upper Neck Forces





Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

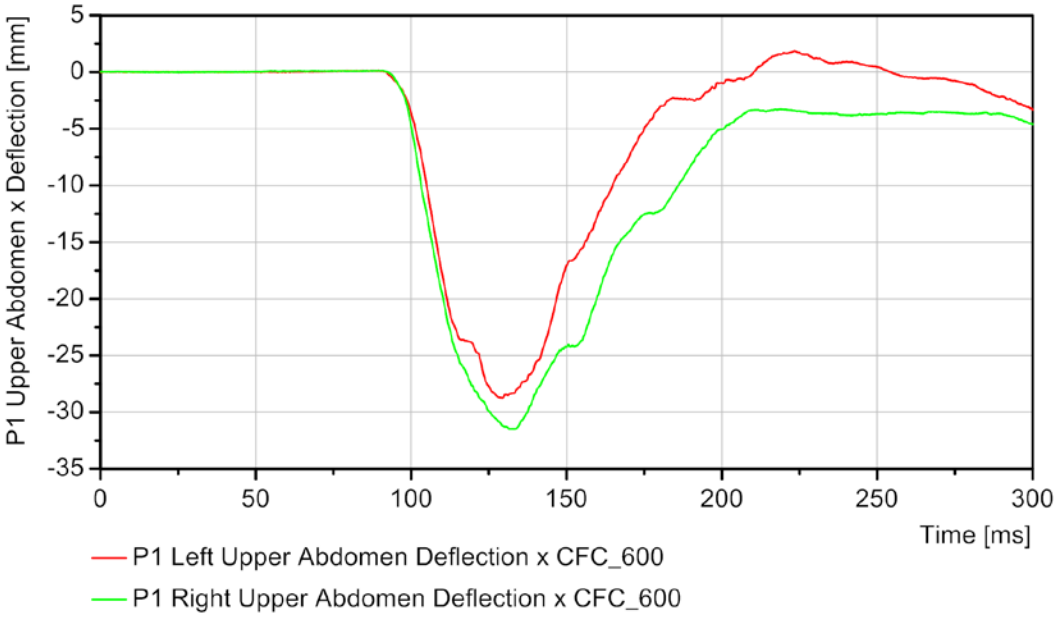
Crux Unit Outputs



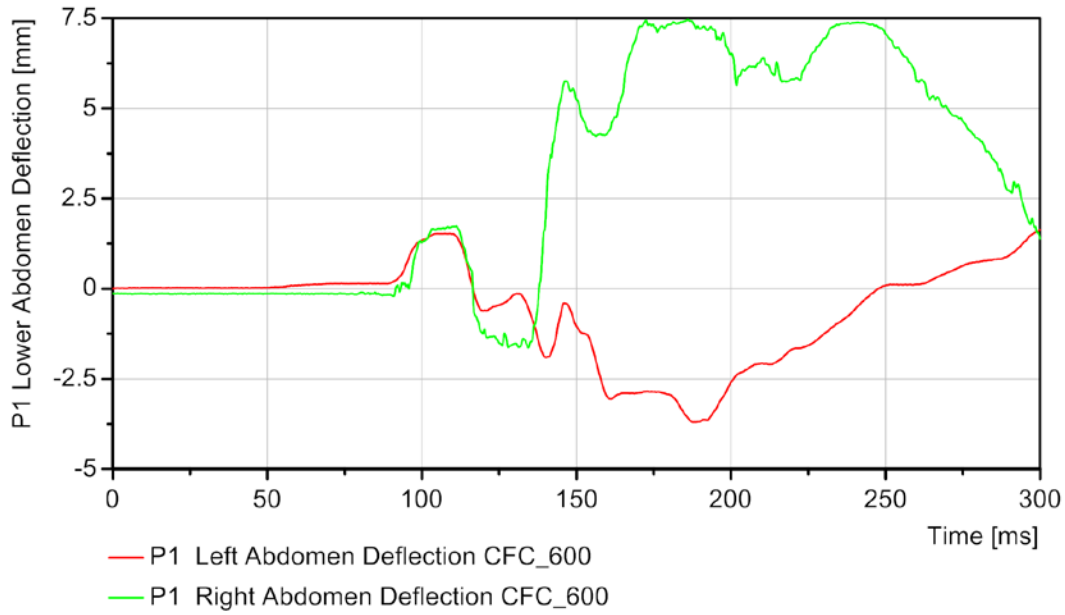
The Lower Right Crux Unit had an instrumentation failure and will be excluded

Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

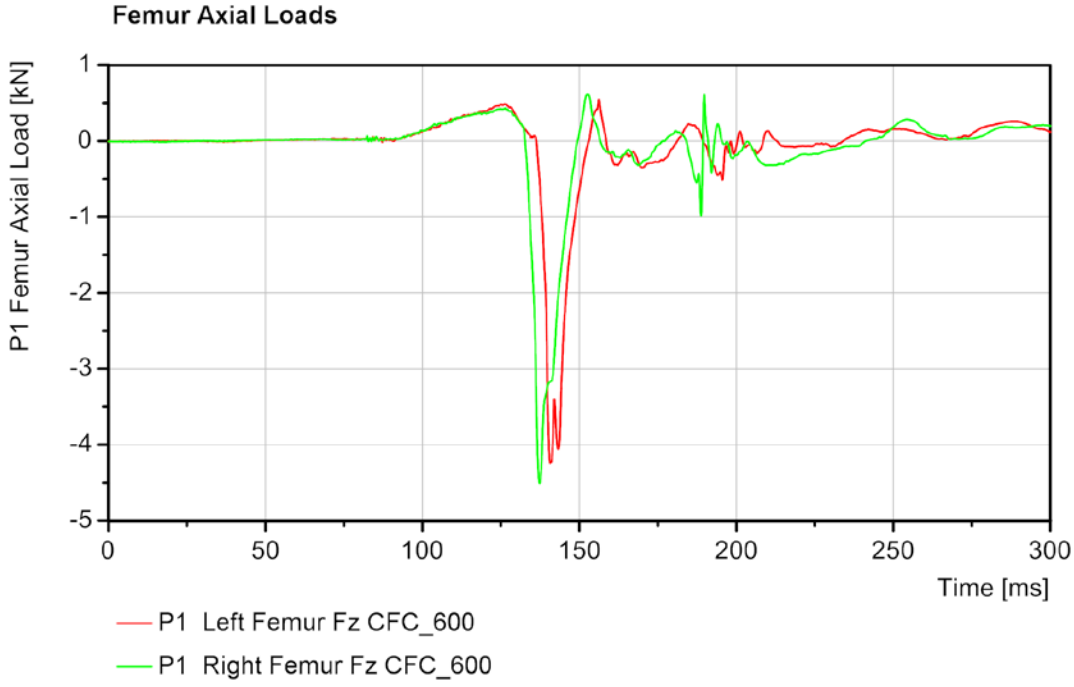
DGSP Unit Outputs



Lower Abdomen Deflections

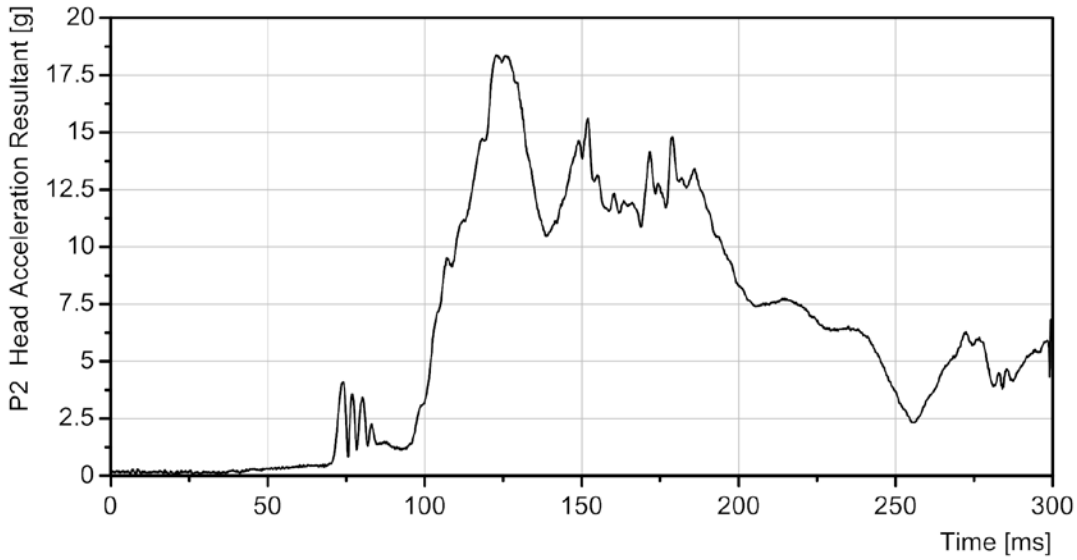


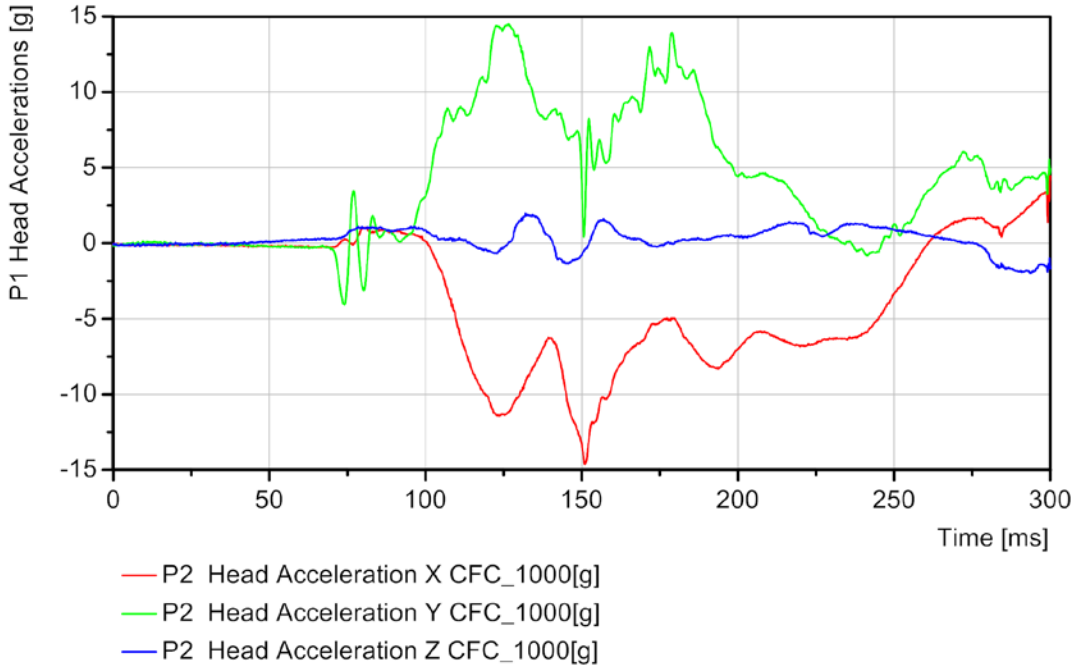
Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF



Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

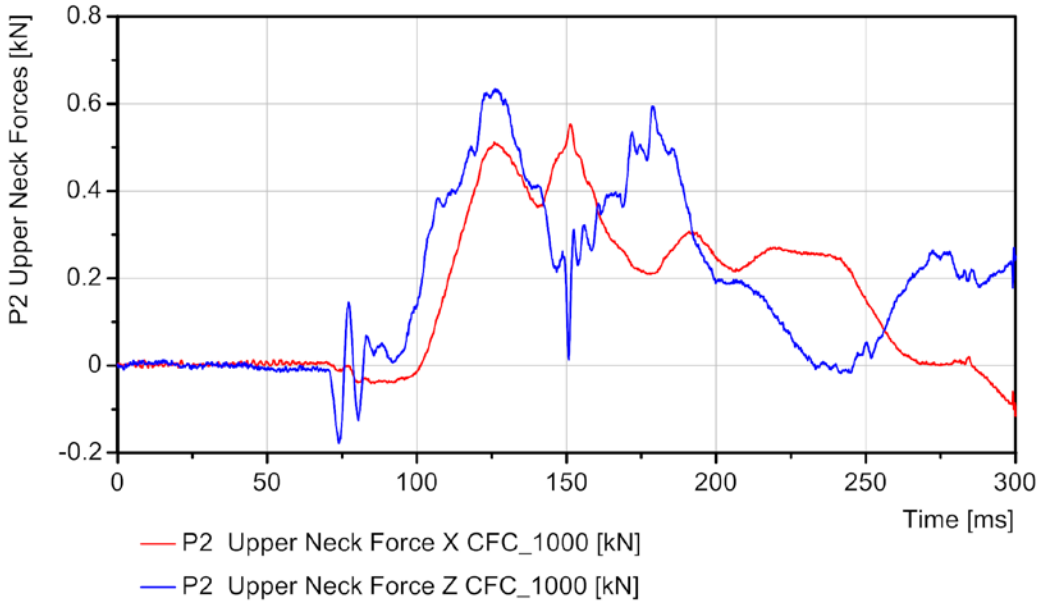
Head Accelerations and Injury Criteria



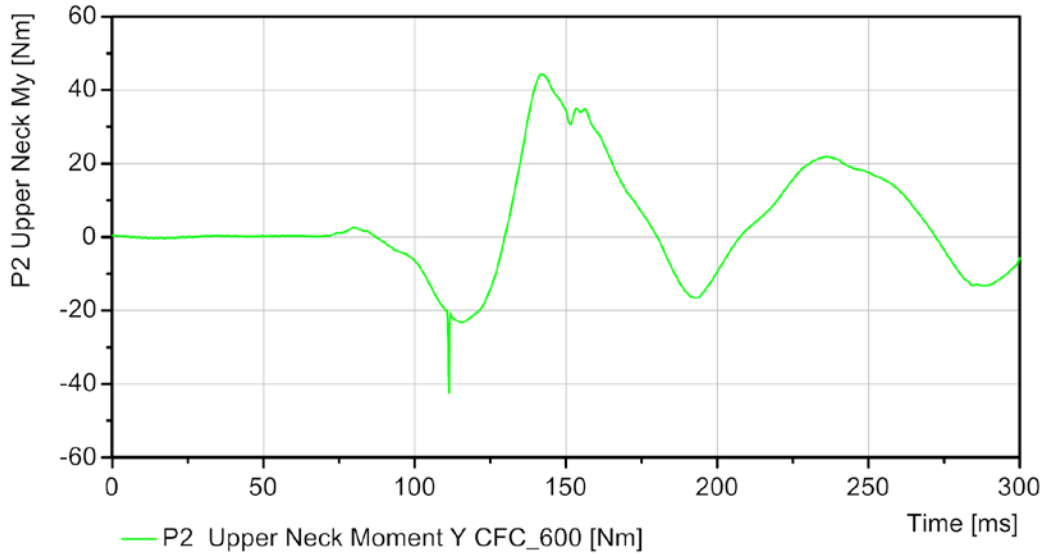


Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Upper Neck Forces

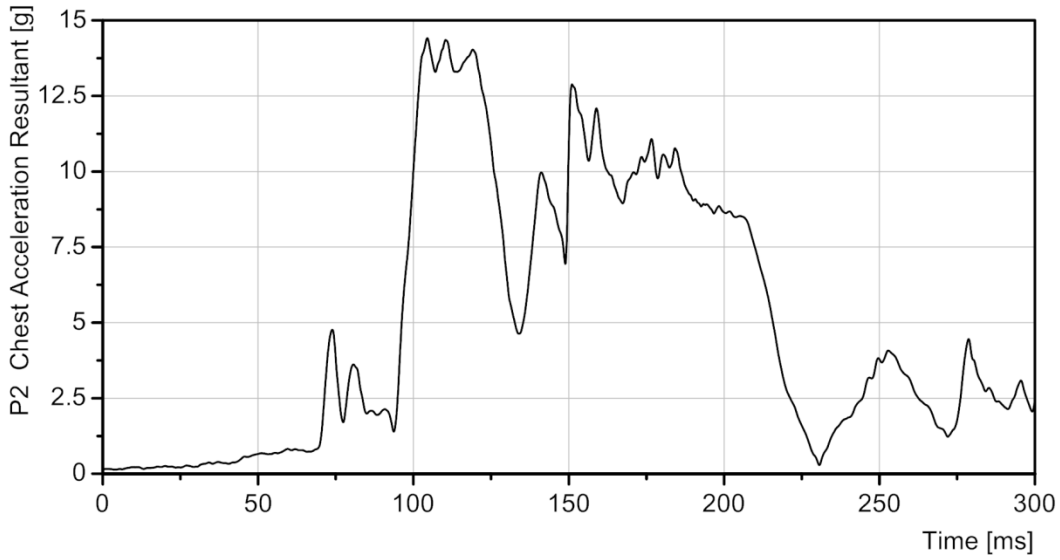


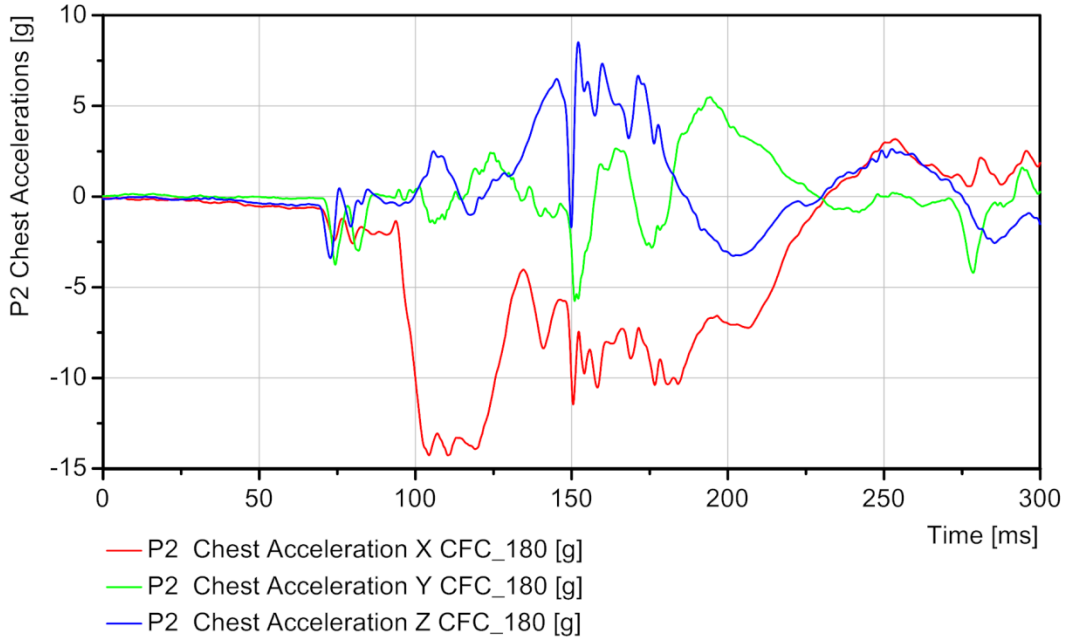
Upper Neck Moments



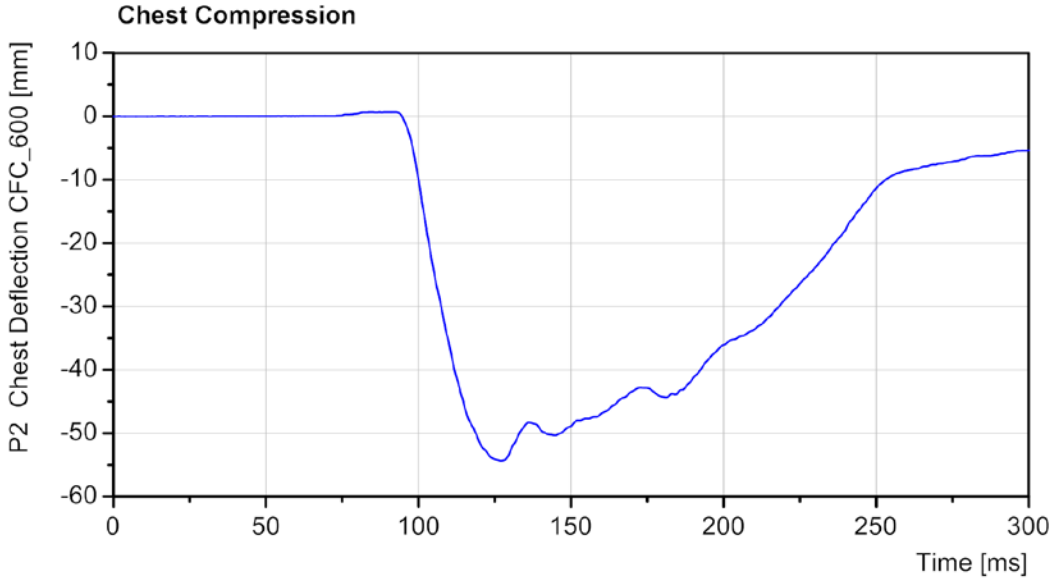
Test Number: G300l02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Chest Accelerations and Injury Criteria

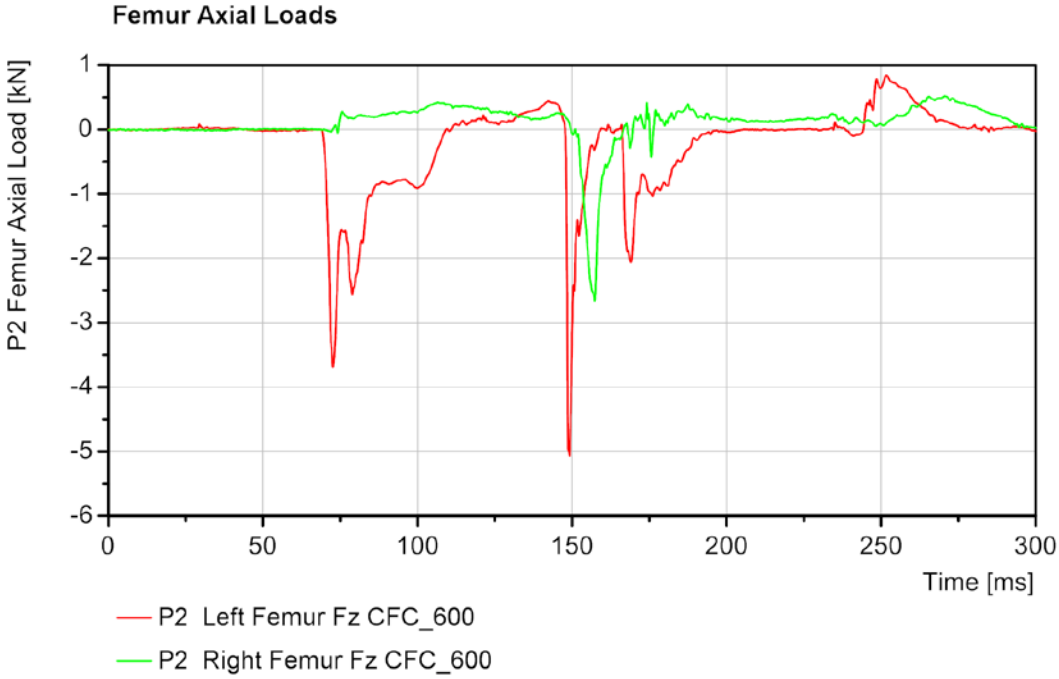




Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



Test Number: G300I02; Test Type: APTA PR-CS-S-018-13; Date: 22/07/15
Customer: Volpe Center; Speed: 8.98 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



A.3 Test 3

Test Number	G300I03
Configuration	Forward Facing
Test Type	APTA-PR-CS-S-018-13 Table Test
Dummies	Hybrid III RS and Hybrid III both 50th Percentile
Result	Failure of lower left chest deflection and VC, H3-RS (wall-side ATD)

A.3.1 Test 3: Summary

Figure A.3.1: Pre-Test

This injury test was for the seat configuration depicted above. The seat design was 'Seat 1' and the table design was 'Table 3.' Since the table was not designed to be used with these seats, it was placed asymmetrically (per the installation drawing) to give a representative distance from the ATD chest to the table edge and from the ATD knees to the opposing seats. The installation of seats and table was carried out by TRL test staff, and all mountings and interface plates were designed and fabricated by TRL.

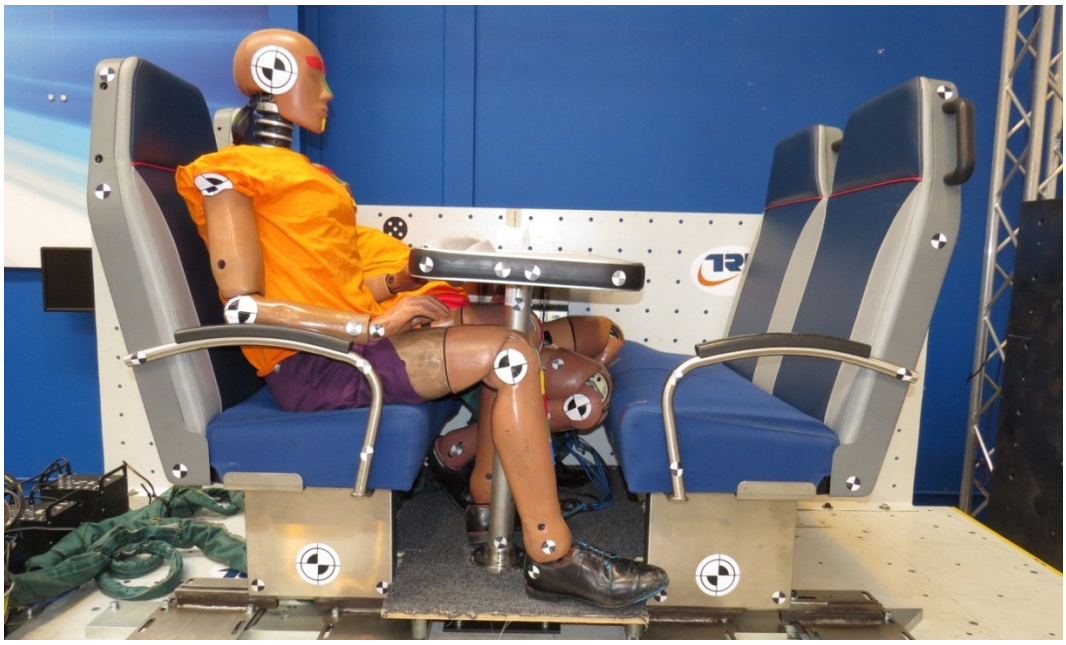


Figure A.3.2: Post-Test

The test pulse is plotted in Figure A.3.3; the calibration run pulse obtained prior to testing is plotted in Figure A.3.4, demonstrating that the test conforms as far as possible to the requirements of the standard.

The test was filmed from several viewpoints using high-speed digital cameras running at 1000 fps. Still photographs were used to document the set-up and record any seat deformation and contact points post-test. 2D point measurements have been used to compare seat and dummy positions before and after the test; this allows survival space and deformation to be quantified. A checklist was completed during testing to ensure compliance with the requirements of APTA-PR-CS-S-018-13.

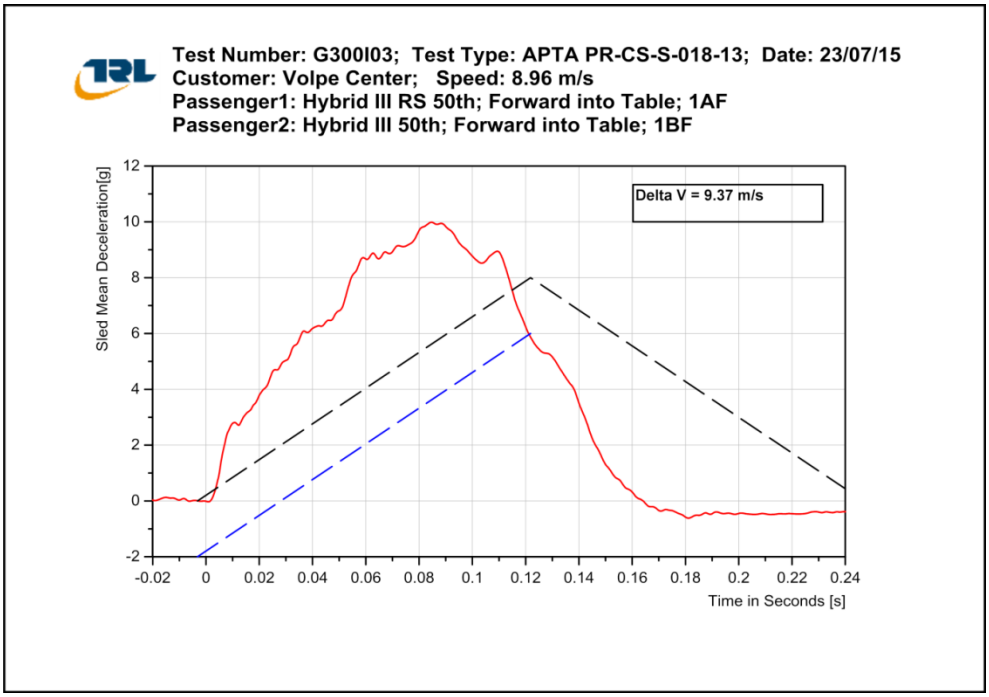


Figure A.3.3: Test G300I03 Deceleration Pulse

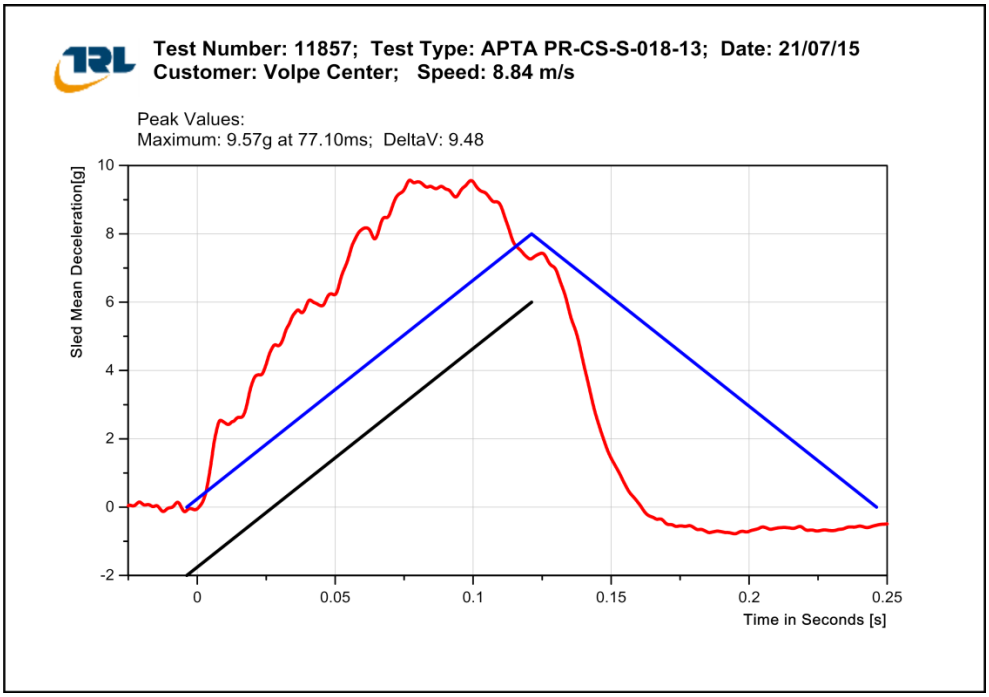
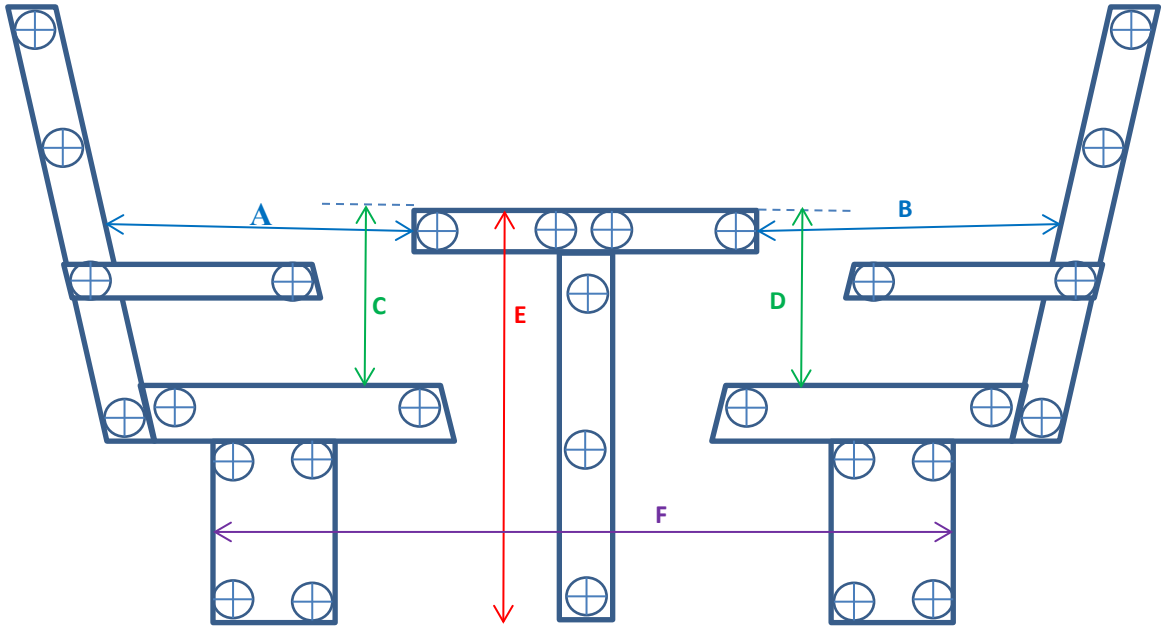
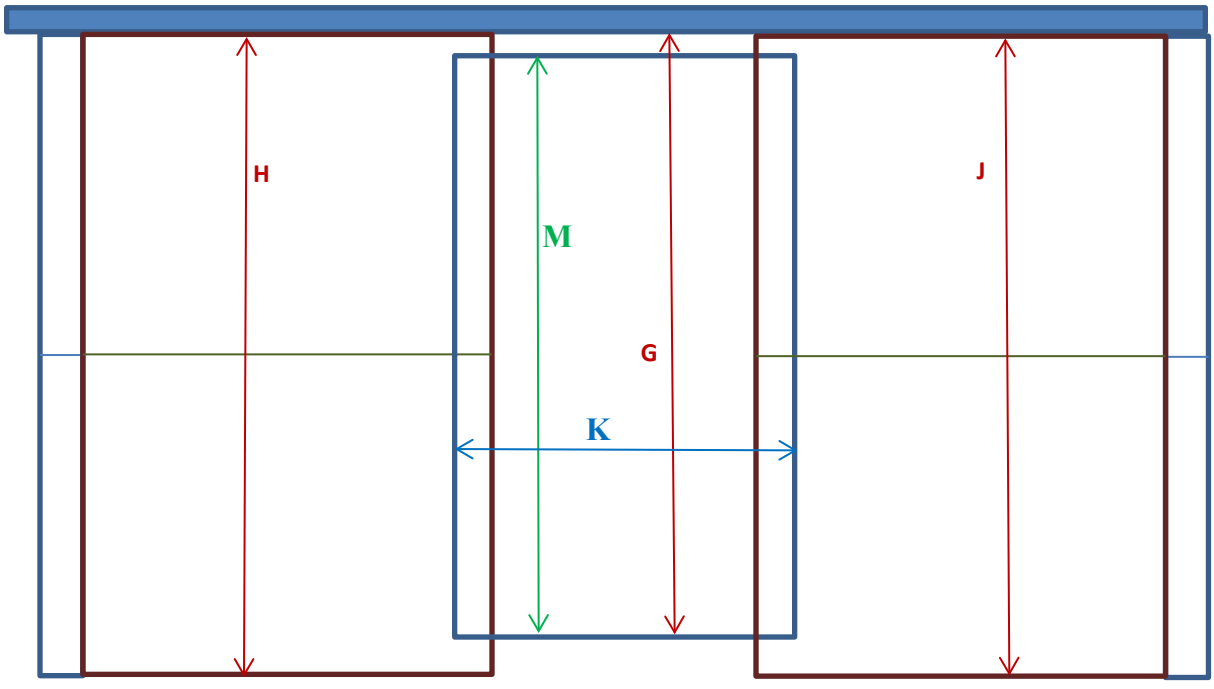


Figure A.3.4: Calibration Run Deceleration Pulse

A.3.2 Test 3: Pre and Post Test Measurements



Overhead View



Measurement	Pre-Test Value (mm)	Post-Test Value (mm)
Longitudinal Distance between the front edge of the table top and the seat back (ATD 1) A	410	540
Longitudinal Distance between the front edge of the table top and the seat back (ATD 2) A	409	520
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 1) B	502	495
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 2) B	515	470
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 1) C	302	301
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 2) C	303	300
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 1) D	300	305
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 2) D	301	290
Vertical Distance from Table Top to Floor E	739	745
Longitudinal Distance from outside Rear Pedestal Base to outside of Front Pedestal Base F	1228	1228
Lateral Distance from Wall to Edge of Table G	1078	1080
Lateral Distance from Wall to Edge of Forward Facing Seats H	1115	1120
Lateral Distance from Wall to Edge of Rear Facing Seats J	1114	1116
Table Top Thickness	60	60
Table Top Lateral (width) K	515	480 (edge)/ 400 (middle)
Table Top Longitudinal (depth) M	1023	1020

A.3.3 Test 3: Injury Criteria Summary

Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 1

Body Region	APTA Limit	HII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Head - HIC 15	700	124.6	Pass	27.43	Pass
Neck Peak Axial Tension	4.17kN	0.96kN	Pass	0.70kN	Pass
Neck Peak Axial Compression	-4kN	-1.33kN	Pass	-0.05kN	Pass
Neck - Nij NTE	1.0	0.25	Pass	0.17	Pass
Neck- Nij NTF	1.0	0.24	Pass	0.15	Pass
Neck - Nij NCE	1.0	0.67	Pass	0.01	Pass
Neck - Nij NCF	1.0	0.10	Pass	0.01	Pass
Chest - 3ms Exceedence	60g	21.73g	Pass	17.97g	Pass
Upper Left Chest Max Deflection	-63mm	-45.76mm	Pass	N/A	N/A
Upper Right Chest Max Deflection	-63mm	-47.33mm	Pass	N/A	N/A
Lower Left Chest Max Deflection	-63mm	-68.89mm	Fail	N/A	N/A
Lower Right Chest Max Deflection	-63mm	*	*	N/A	N/A
Chest Max Deflection (HIII)	-63mm	N/A	N/A	-52.28	Pass
Upper Left Chest Viscous Criterion	1.0m/s	0.44m/s	Pass	N/A	N/A
Upper Right Chest Viscous Criterion	1.0m/s	0.33m/s	Pass	N/A	N/A
Lower Left Chest Viscous Criterion	1.0m/s	1.07m/s	Fail	N/A	N/A
Lower Right Chest Viscous Criterion	1.0m/s	*	*	N/A	N/A
Chest Viscous Criterion (HIII)	1.0m/s	N/A	N/A	0.88	Pass
Upper Left Abdomen Deflection	-67mm	-55.06mm	Pass	N/A	N/A
Upper Right Abdomen Deflection	-67mm	-65.67mm	Pass	N/A	N/A
Lower Left Abdomen Deflection	-67mm	-25.91mm	Pass	N/A	N/A
Lower Right Abdomen Deflection	-67mm	-24.28mm	Pass	N/A	N/A

*The Lower Right Crux Unit had an instrumentation failure and will be excluded

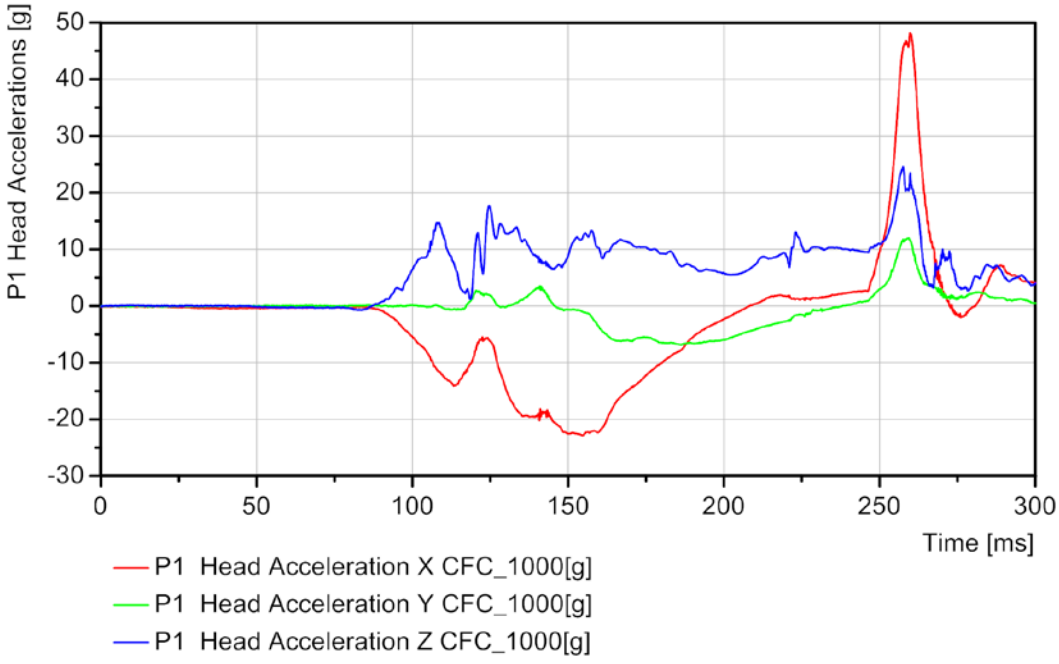
Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 2

Body Region	APTA Limit	HIII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Upper Abdomen Left VC	1.98m/s	0.45m/s	Pass	N/A	N/A
Upper Abdomen Right VC	1.98m/s	0.78m/s	Pass	N/A	N/A
Lower Abdomen Left VC	1.98m/s	0.24m/s	Pass	N/A	N/A
Lower Abdomen Right VC	1.98m/s	0.17m/s	Pass	N/A	N/A
Left Femur Peak Compression	-7kN	-3.4kN	Pass	-0.17kN	Pass
Right Femur Peak Compression	-7kN	-4.08kN	Pass	-5.31kN	Pass

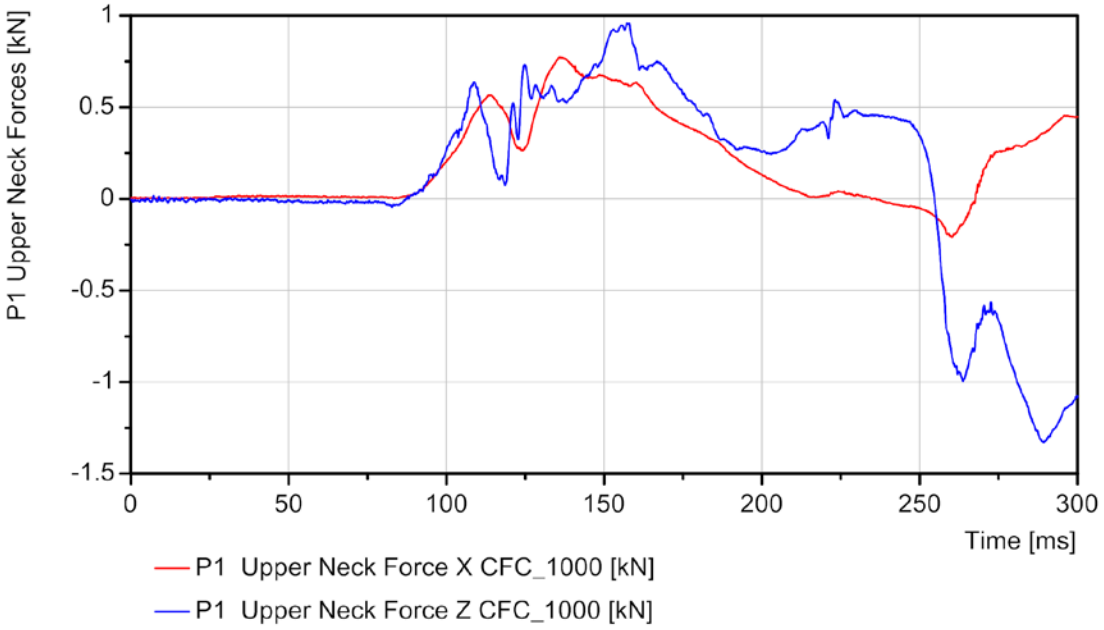
Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

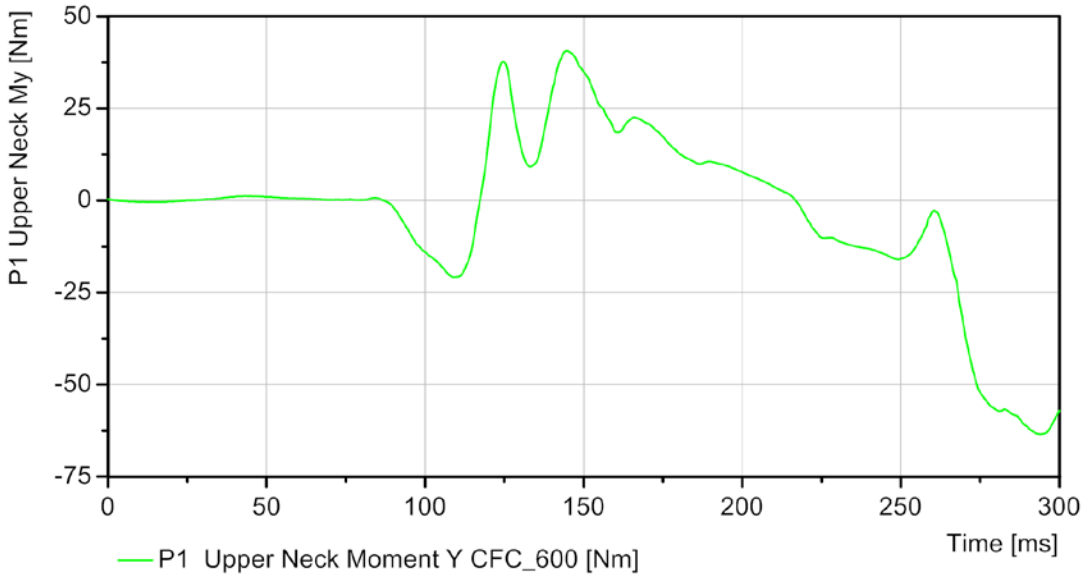
Head Accelerations and Injury Criteria



Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

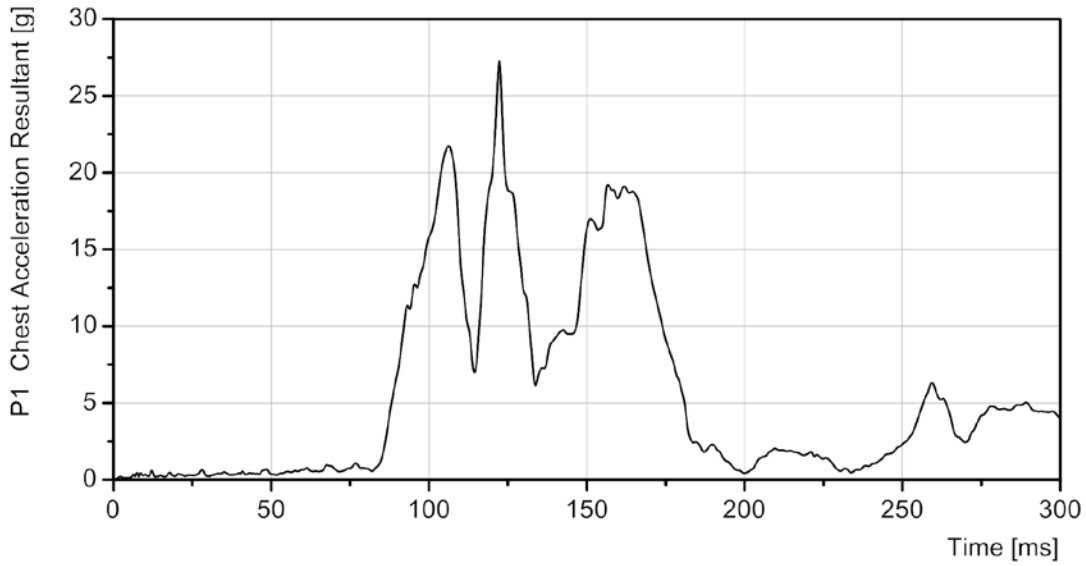
Upper Neck Forces

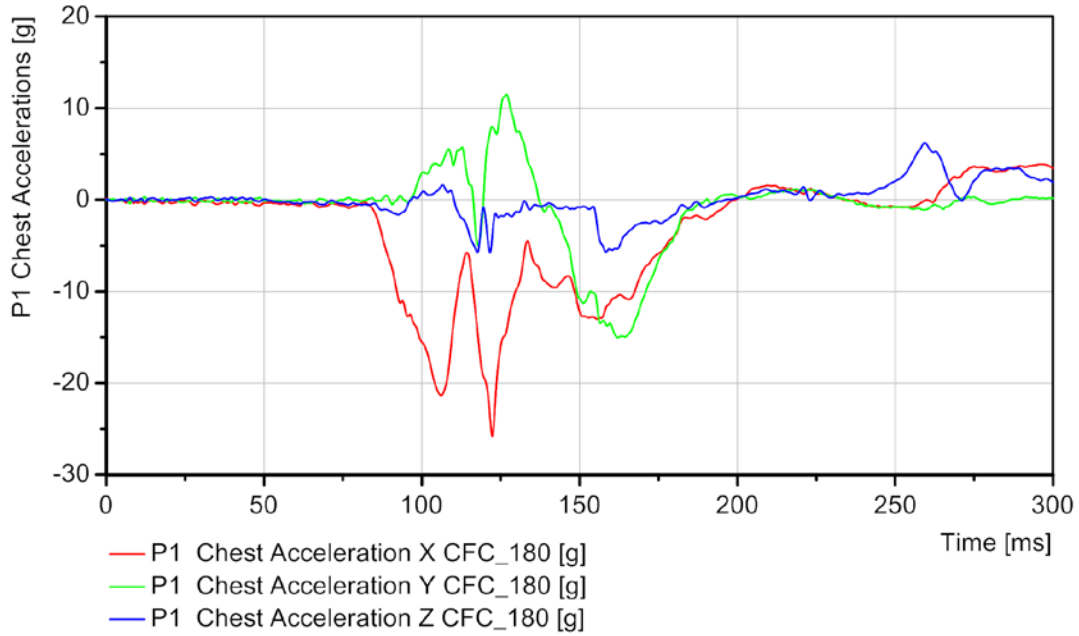




Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

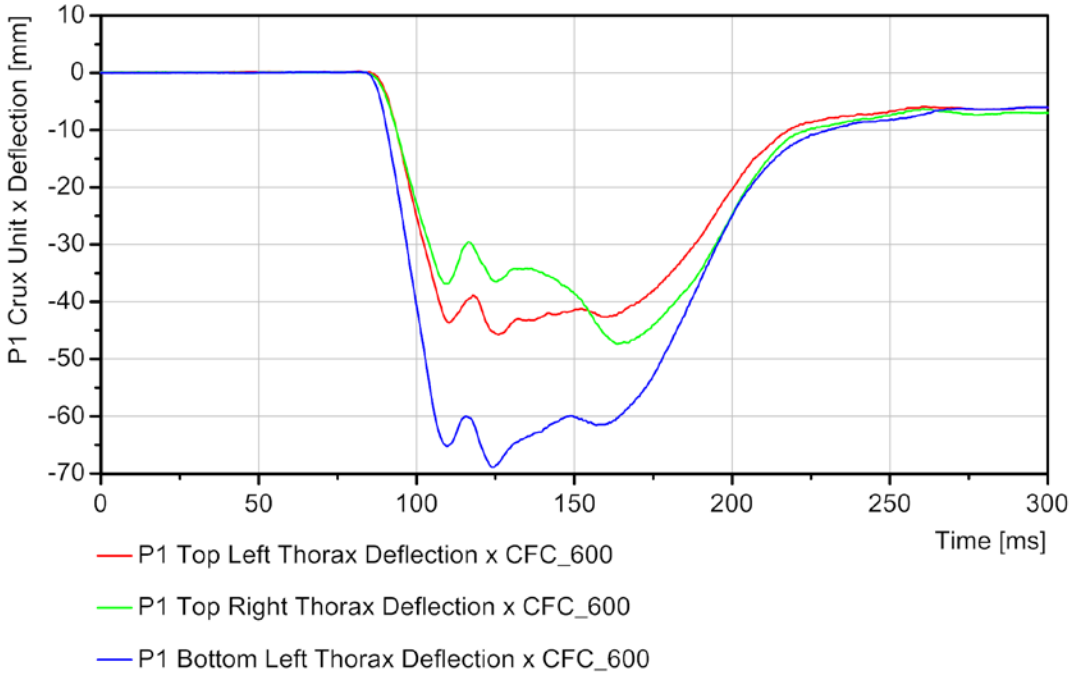
Chest Accelerations and Injury Criteria





Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

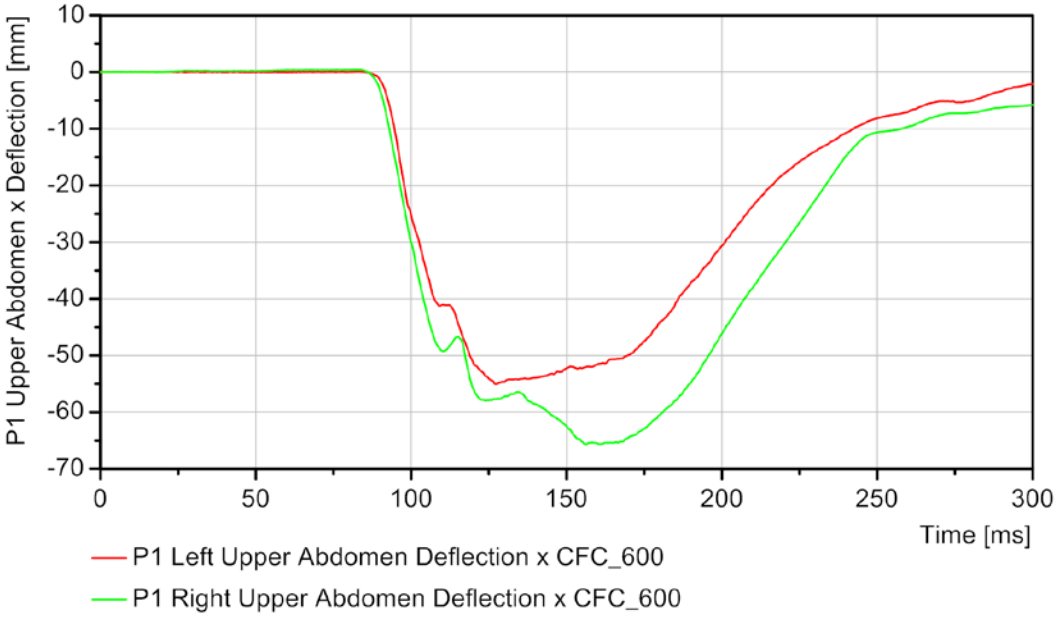
Crux Unit Outputs



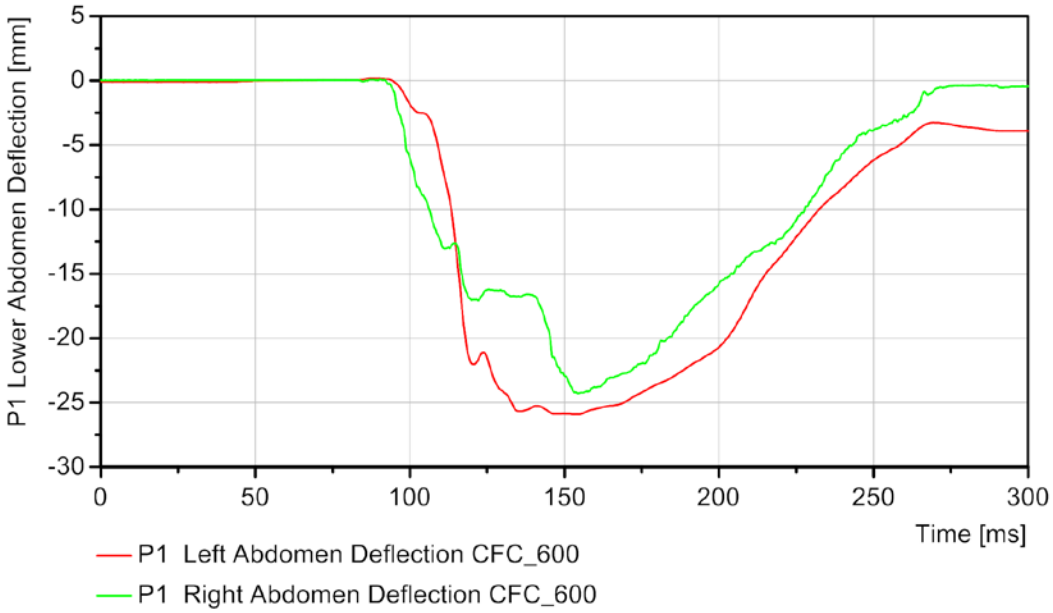
The Lower Right Crux Unit had an instrumentation failure and will be excluded

Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

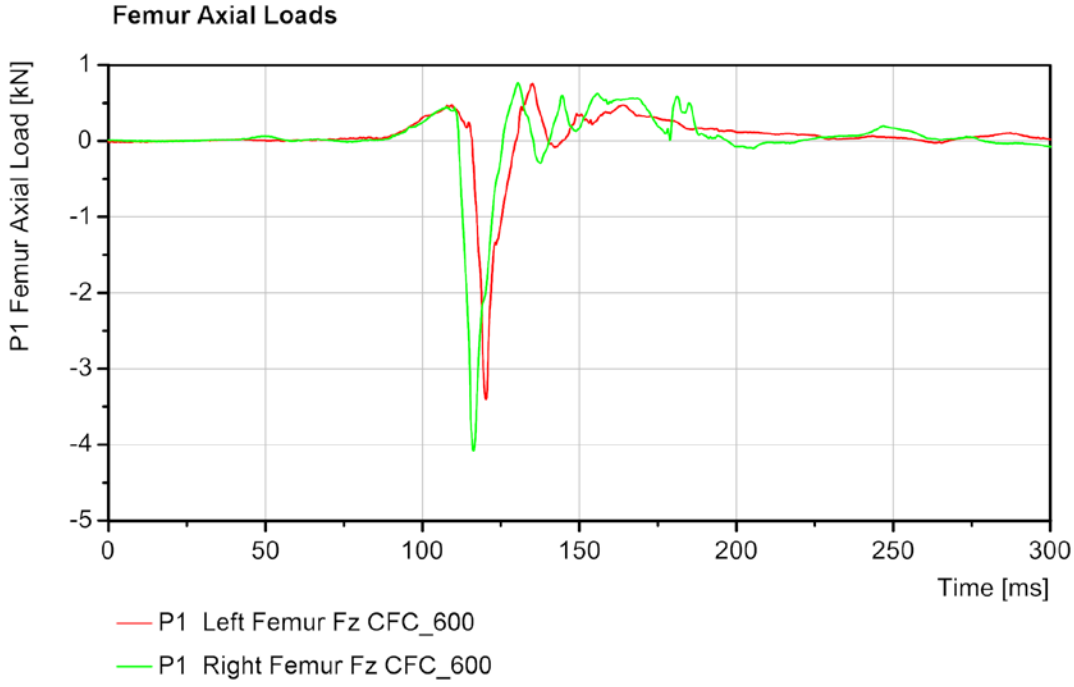
DGSP Unit Outputs



Lower Abdomen Deflections

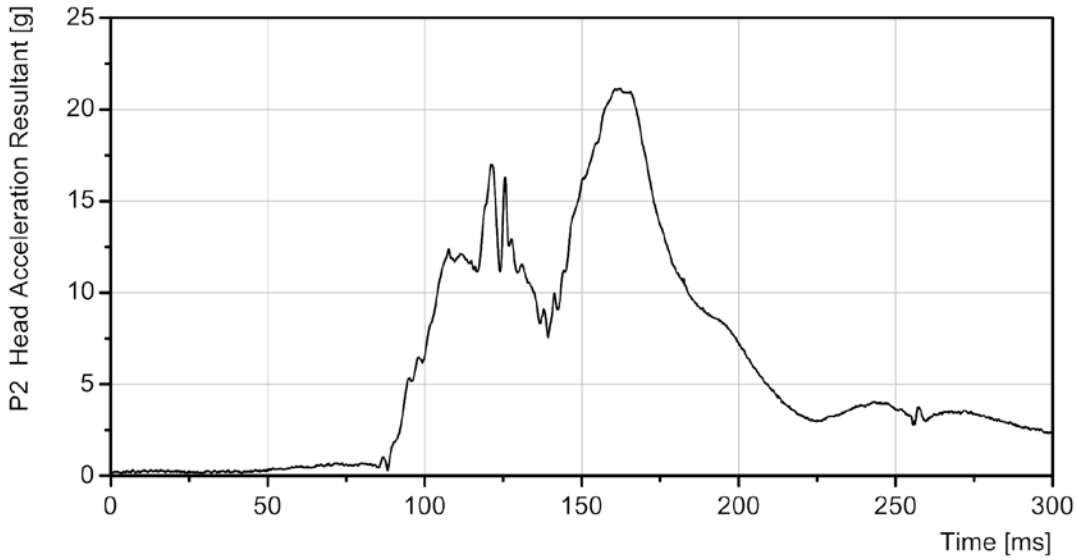


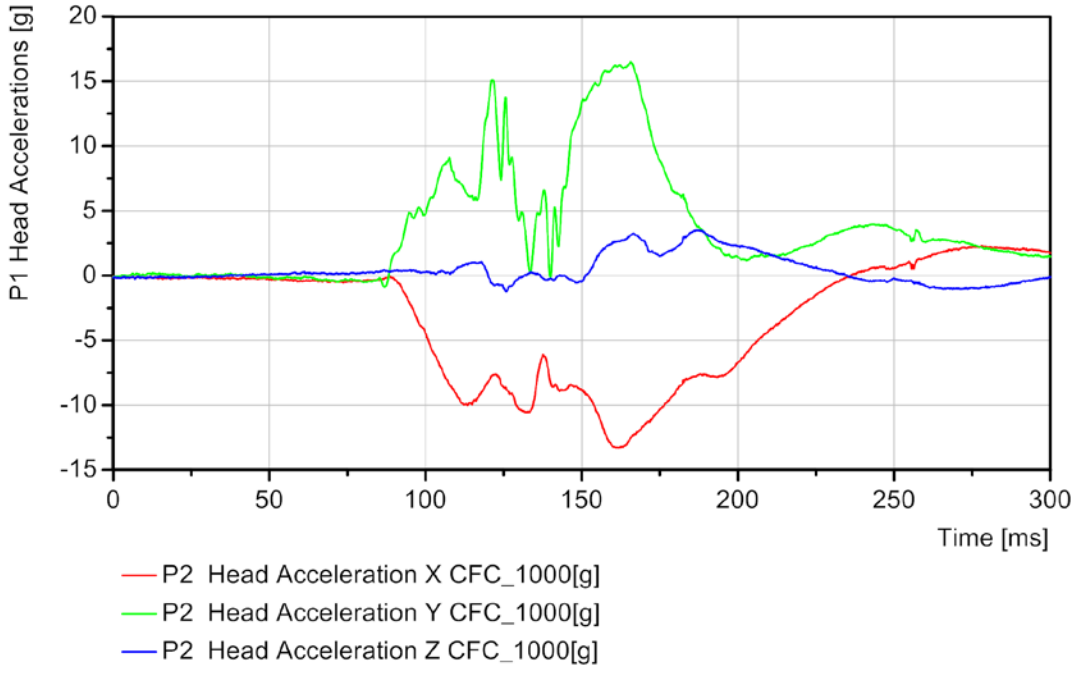
Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF



Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

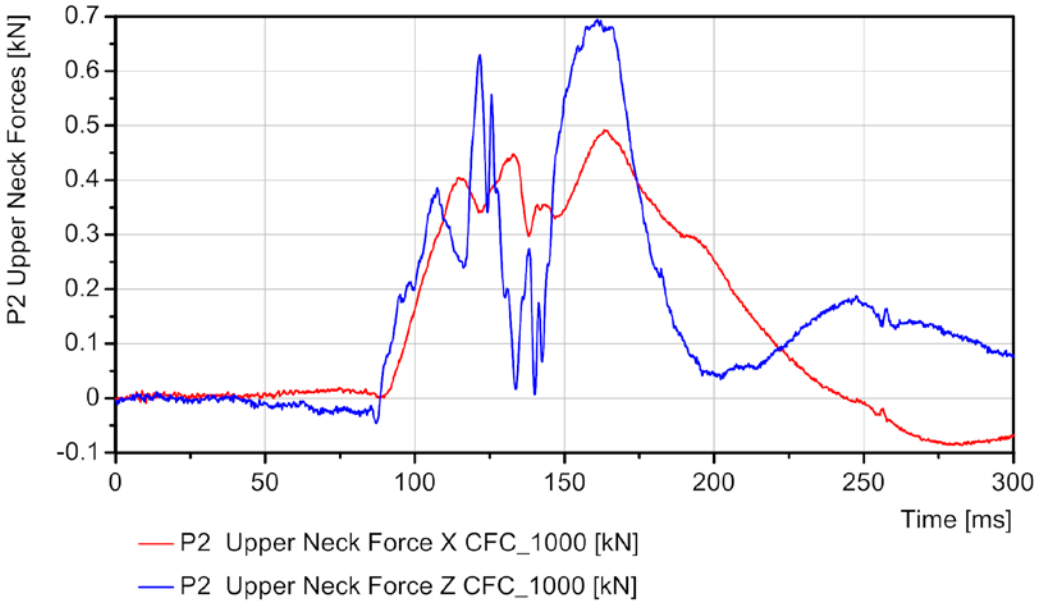
Head Accelerations and Injury Criteria



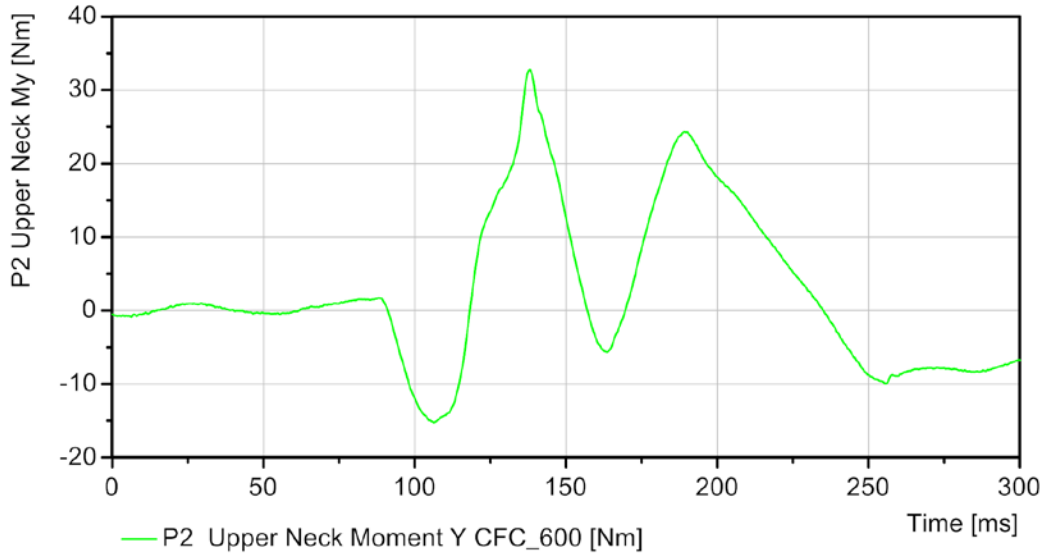


Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Upper Neck Forces

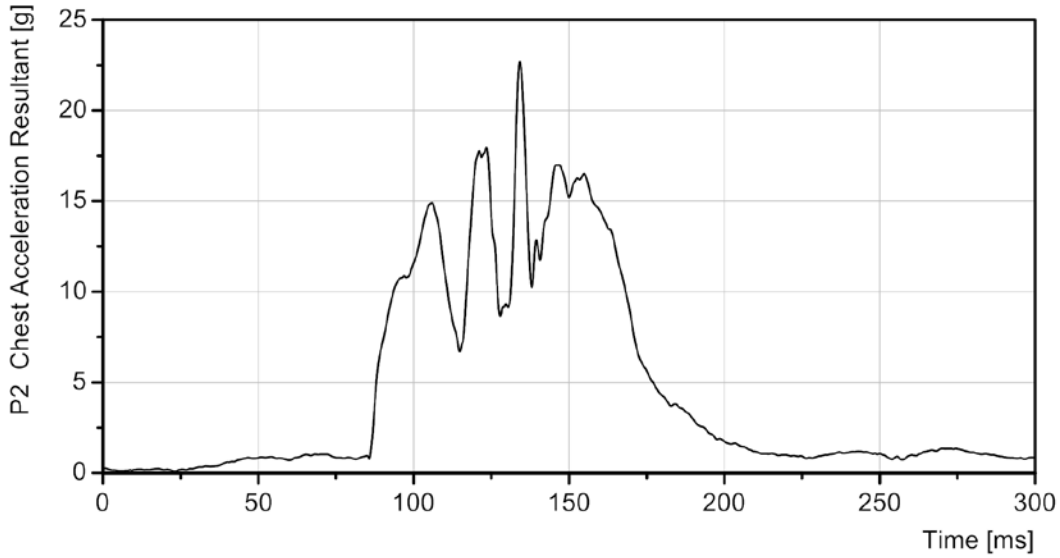


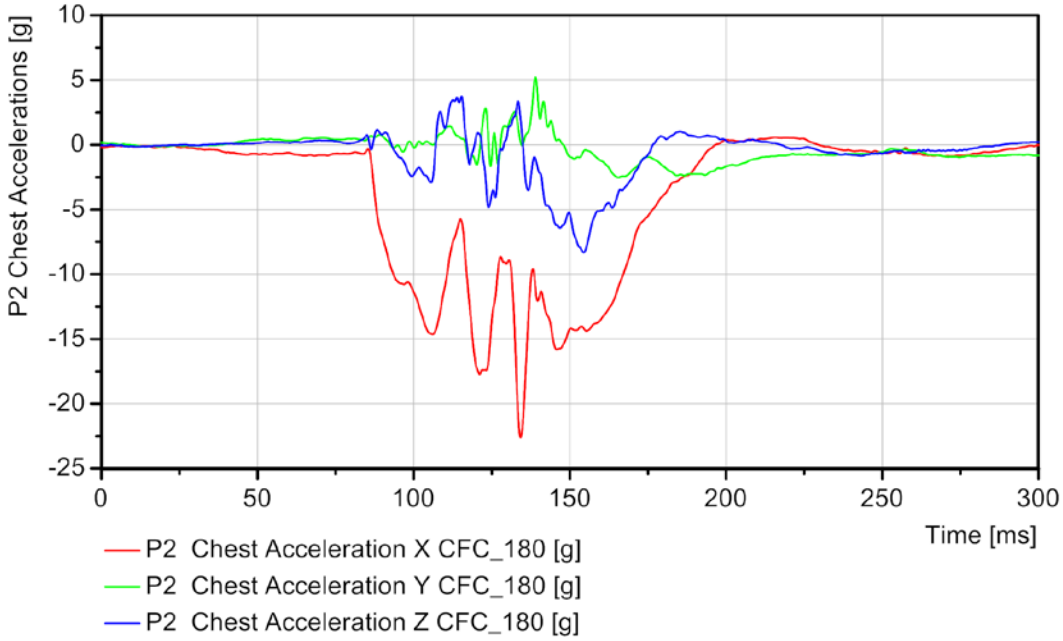
Upper Neck Moments



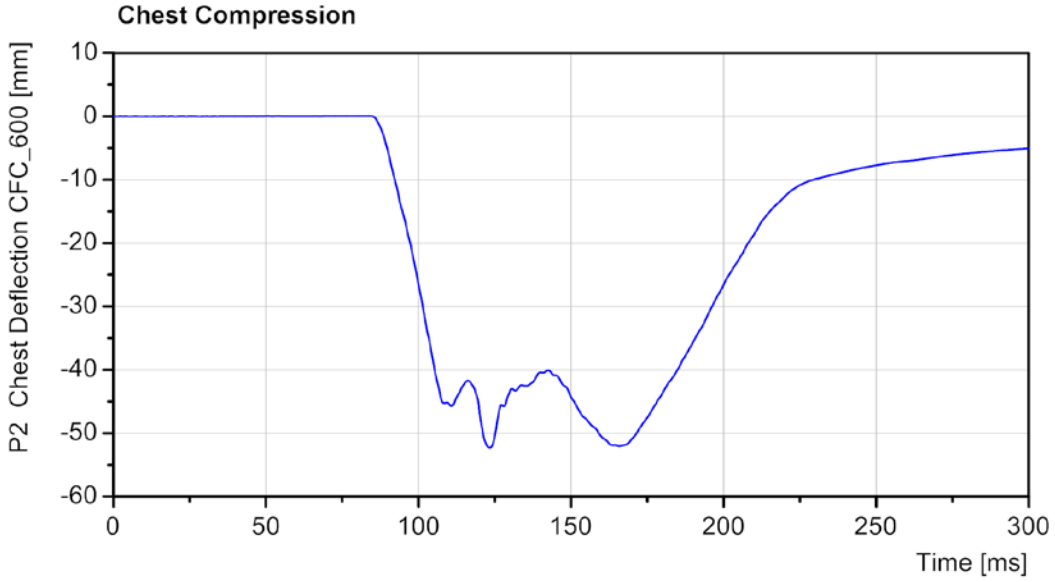
Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Chest Accelerations and Injury Criteria

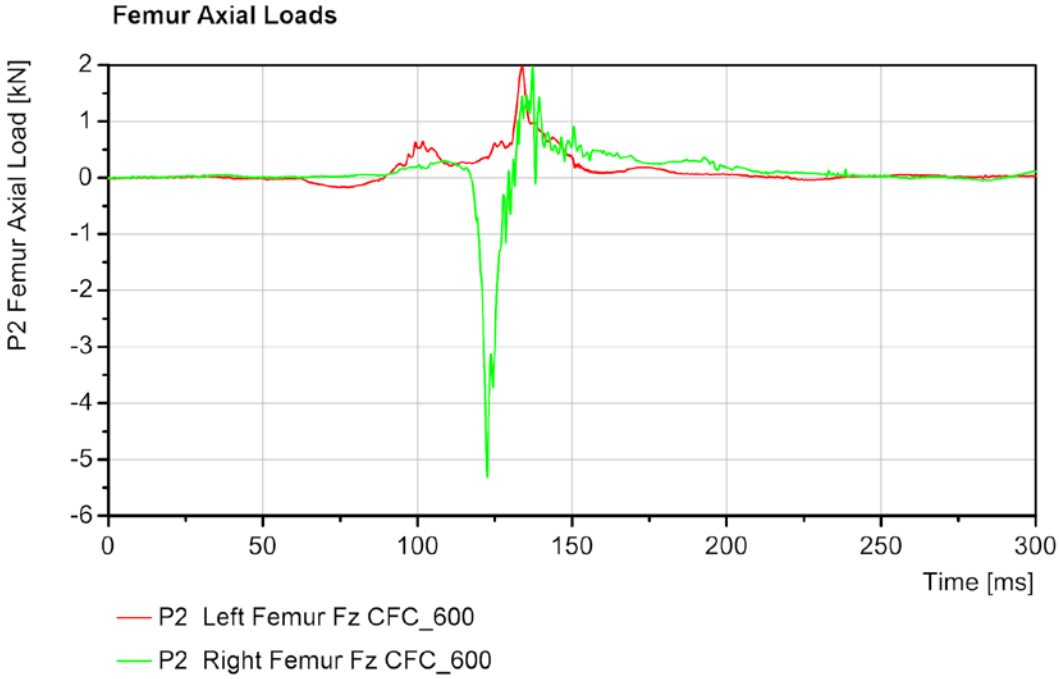




Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



Test Number: G300I03; Test Type: APTA PR-CS-S-018-13; Date: 23/07/15
Customer: Volpe Center; Speed: 8.96 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



A.4 Test 4

Test Number	G300I04
Configuration	Forward Facing
Test Type	APTA-PR-CS-S-018-13 Table Test
Dummies	Hybrid III RS and Hybrid III both 50th Percentile
Result	Failure of upper right abdomen deflection, H3-RS (wall-side ATD)

A.4.1 Test 4: Summary

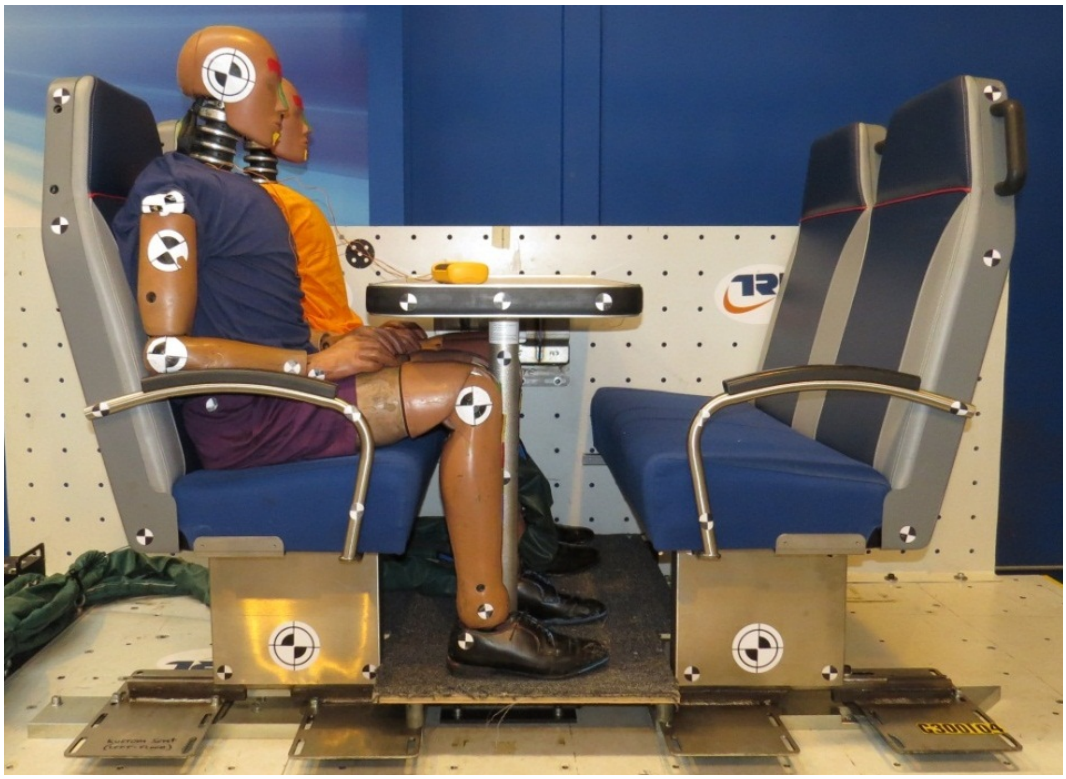


Figure A.4.1: Pre-Test

This injury test was for the seat configuration depicted above. The seat design was 'Seat 1' and the table design was 'Table 3.' As the seats and table were not intended to be installed together, the table was installed asymmetrically (per the installation drawing) in order to give a representative distance between the seat back and table edge, and between the ATD knees and opposing seats. The installation of seats and table was carried out by TRL test staff, and all mountings and interface plates were designed and fabricated by TRL.

Figure A.4.2: Post-Test

The test pulse is plotted in Figure A.4.3; the calibration run pulse obtained prior to testing is plotted in Figure A.4.4, demonstrating that the test conforms as far as possible to the requirements of the standard.

The test was filmed from several viewpoints using high-speed digital cameras running at 1000 fps. Still photographs were used to document the set-up and record any seat deformation and contact points post-test. 2D point measurements have been used to compare seat and dummy positions before and after the test; this allows survival space and deformation to be quantified. A checklist was completed during testing to ensure compliance with the requirements of APTA-PR-CS-S-018-13.

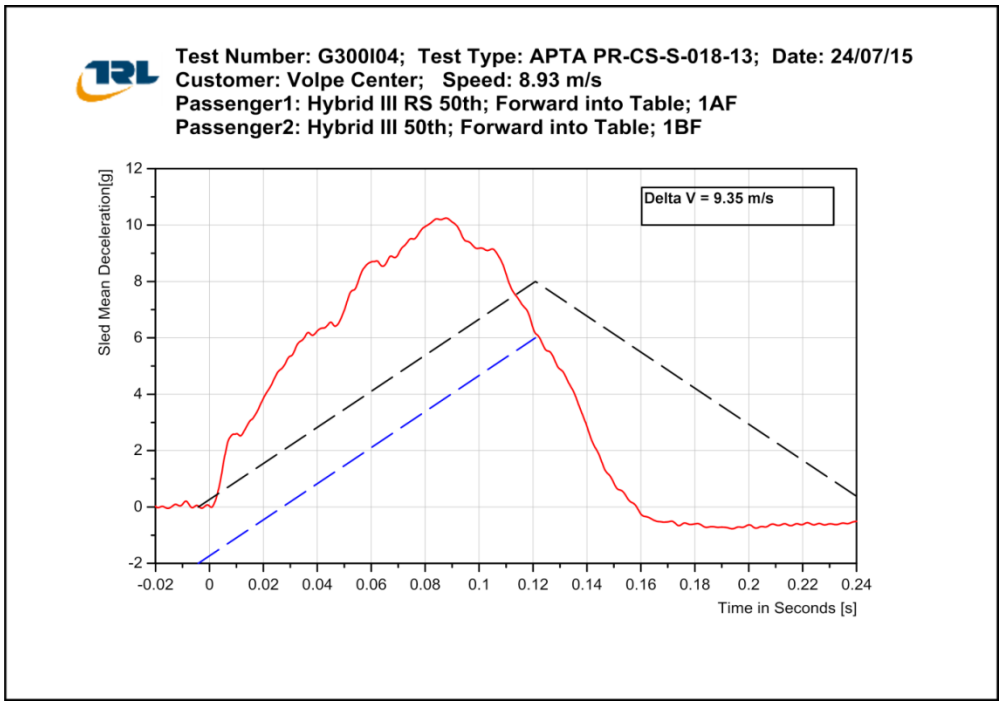


Figure A.4.3: Test G300I04 Deceleration Pulse

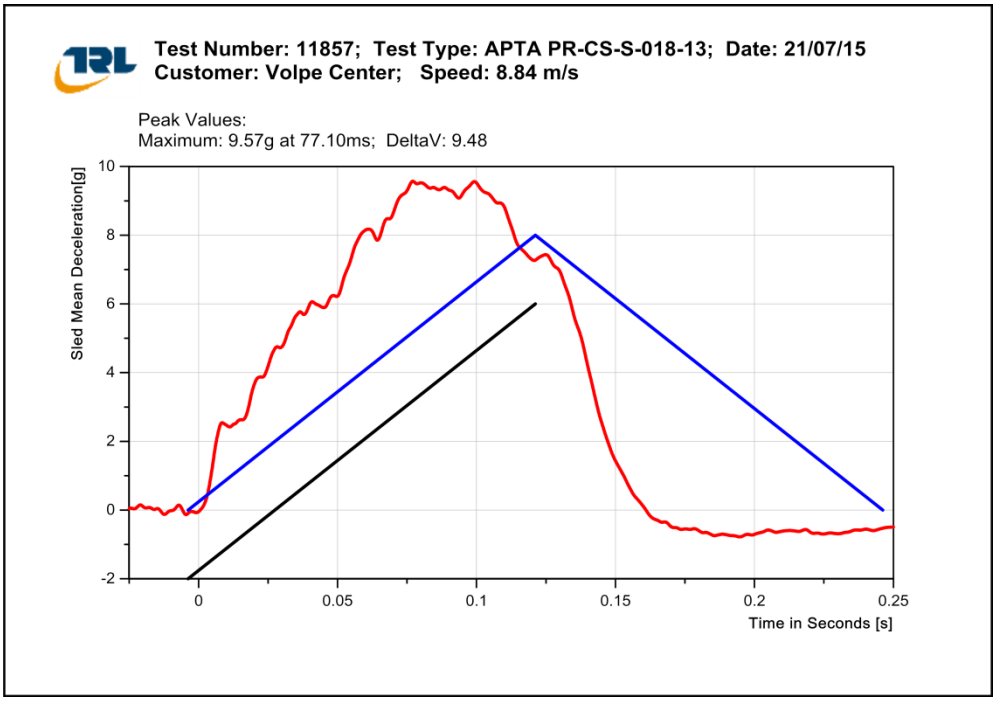
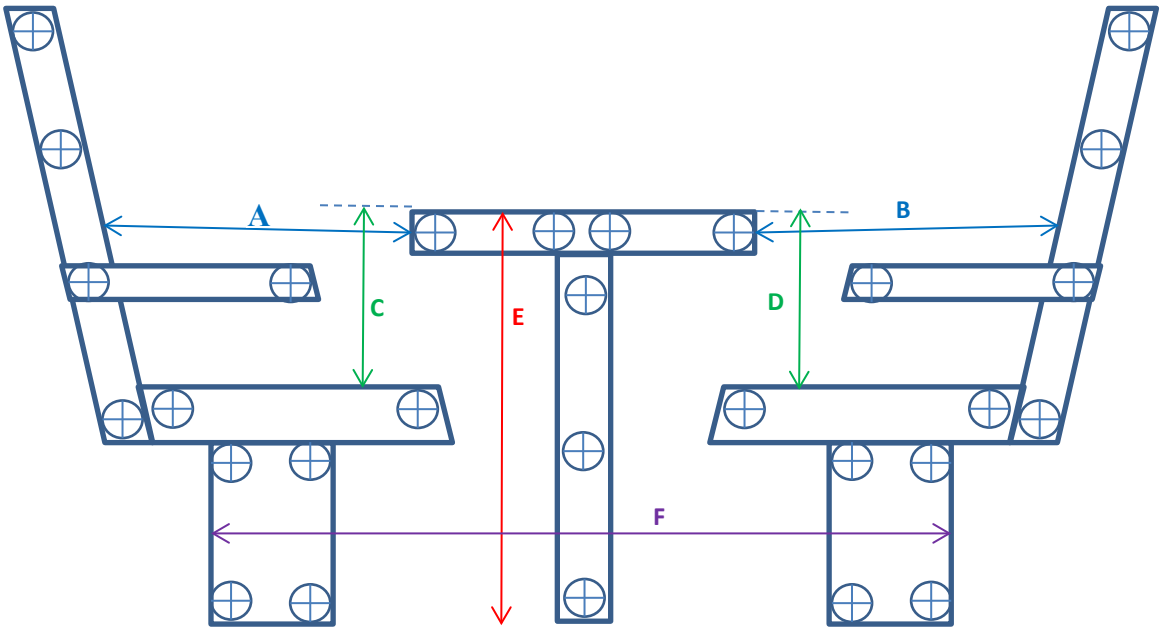
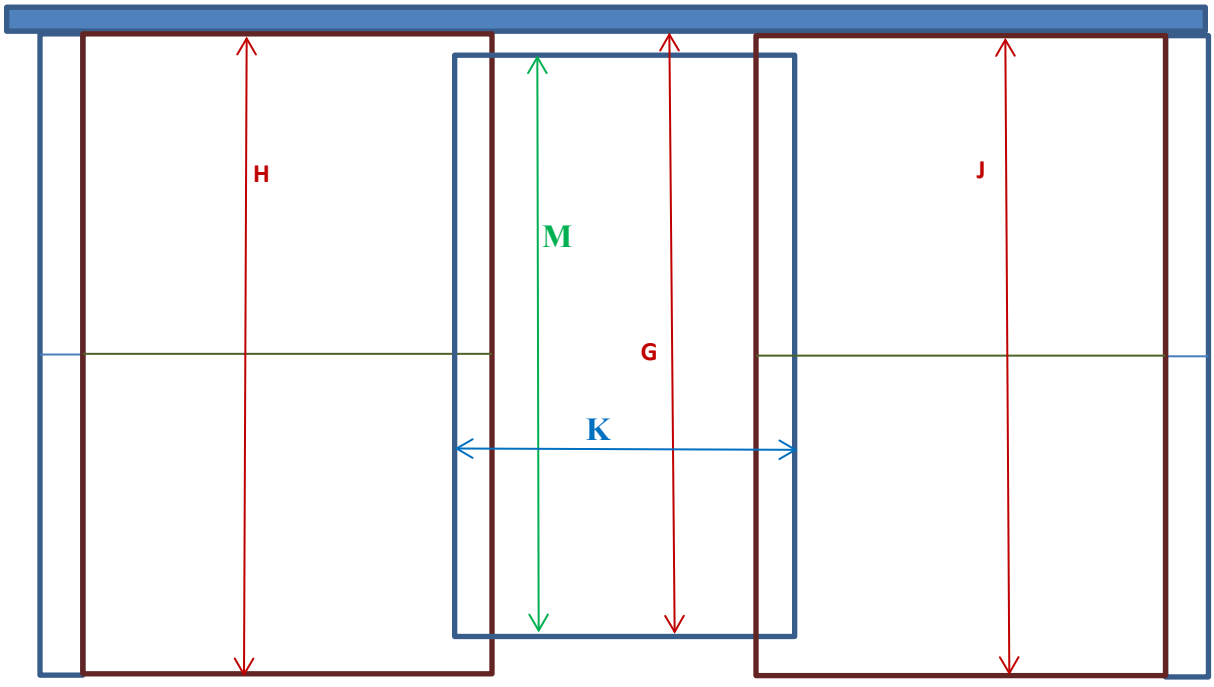


Figure A.4.4: Calibration Run Deceleration Pulse

A.4.2 Test 4: Pre and Post Test Measurements



Overhead View



Measurement	Pre-Test Value (mm)	Post-Test Value (mm)
Longitudinal Distance between the front edge of the table top and the seat back (ATD 1) A	425	560
Longitudinal Distance between the front edge of the table top and the seat back (ATD 2) A	420	570
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 1) B	515	485
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 2) B	515	455
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 1) C	304	315
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 2) C	301	310
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 1) D	304	305
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 2) D	300	285
Vertical Distance from Table Top to Floor E	735	760
Longitudinal Distance from outside Rear Pedestal Base to outside of Front Pedestal Base F	1225	1223
Lateral Distance from Wall to Edge of Table G	1080	1080
Lateral Distance from Wall to Edge of Forward Facing Seats H	1120	1115
Lateral Distance from Wall to Edge of Rear Facing Seats J	1115	1115
Table Top Thickness	60	65
Table Top Lateral (width) K	505	470(edge)/ 375(middle)
Table Top Longitudinal (depth) M	1025	1025

A.4.3 Test 4: Injury Criteria Summary

Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 1

Body Region	APTA Limit	HII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Head - HIC 15	700	103.82	Pass	26.44	Pass
Neck Peak Axial Tension	4.17kN	0.91kN	Pass	0.72kN	Pass
Neck Peak Axial Compression	-4kN	-1.62kN	Pass	-0.04kN	Pass
Neck - Nij NTE	1.0	0.21	Pass	0.14	Pass
Neck- Nij NTF	1.0	0.21	Pass	0.12	Pass
Neck - Nij NCE	1.0	0.90	Pass	0.02	Pass
Neck - Nij NCF	1.0	0.19	Pass	0.05	Pass
Chest - 3ms Exceedence	60g	25.05g	Pass	22.62g	Pass
Upper Left Chest Max Deflection	-63mm	-40.06mm	Pass	N/A	N/A
Upper Right Chest Max Deflection	-63mm	-42.43mm	Pass	N/A	N/A
Lower Left Chest Max Deflection	-63mm	-58.38mm	Pass	N/A	N/A
Lower Right Chest Max Deflection	-63mm	-58.24mm	Pass	N/A	N/A
Chest Max Deflection (HIII)	-63mm	N/A	N/A	-50.35	Pass
Upper Left Chest Viscous Criterion	1.0m/s	0.30m/s	Pass	N/A	N/A
Upper Right Chest Viscous Criterion	1.0m/s	0.30m/s	Pass	N/A	N/A
Lower Left Chest Viscous Criterion	1.0m/s	0.62m/s	Pass	N/A	N/A
Lower Right Chest Viscous Criterion	1.0m/s	0.67m/s	Pass	N/A	N/A
Chest Viscous Criterion (HIII)	1.0m/s	N/A	N/A	0.35	Pass
Upper Left Abdomen Deflection	-67mm	-53.54mm	Pass	N/A	N/A
Upper Right Abdomen Deflection	-67mm	-67.91mm	Fail	N/A	N/A
Lower Left Abdomen Deflection	-67mm	-22.71mm	Pass	N/A	N/A
Lower Right Abdomen Deflection	-67mm	-21.41mm	Pass	N/A	N/A

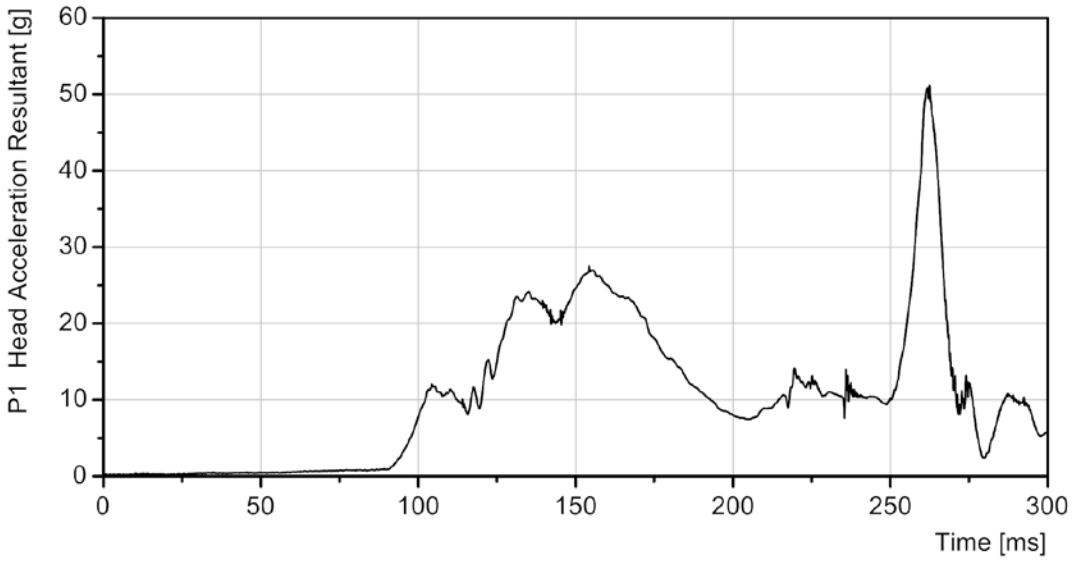
Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

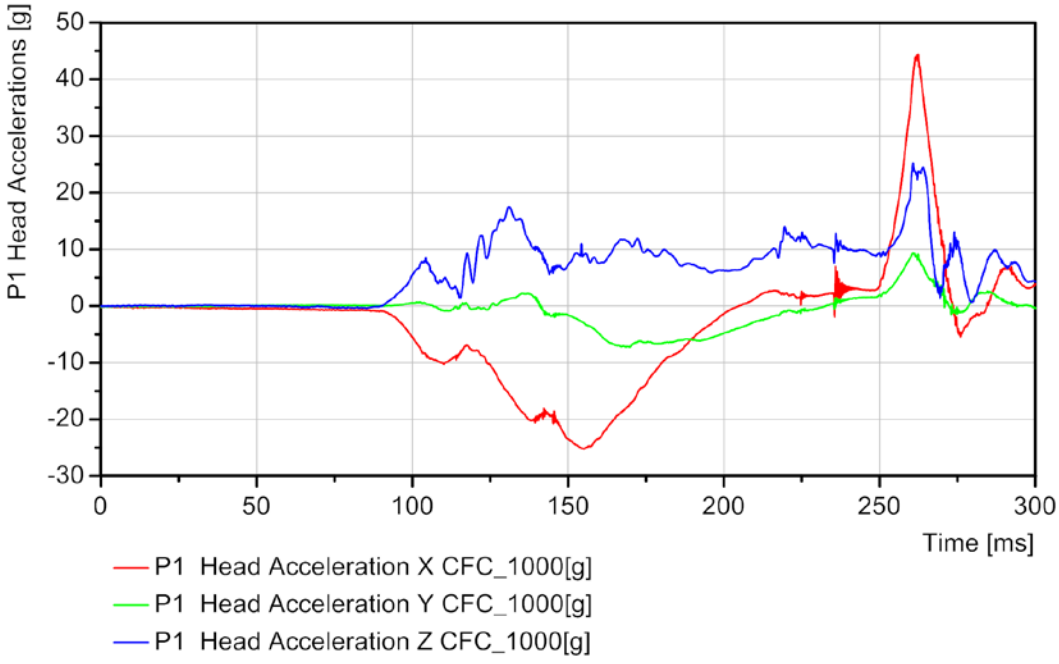
APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 2

Body Region	APTA Limit	HIII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Upper Abdomen Left VC	1.98m/s	0.52m/s	Pass	N/A	N/A
Upper Abdomen Right VC	1.98m/s	0.69m/s	Pass	N/A	N/A
Lower Abdomen Left VC	1.98m/s	0.12m/s	Pass	N/A	N/A
Lower Abdomen Right VC	1.98m/s	0.14m/s	Pass	N/A	N/A
Left Femur Peak Compression	-7kN	-3.81kN	Pass	-0.35kN	Pass
Right Femur Peak Compression	-7kN	-4.29kN	Pass	-5.51kN	Pass

Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

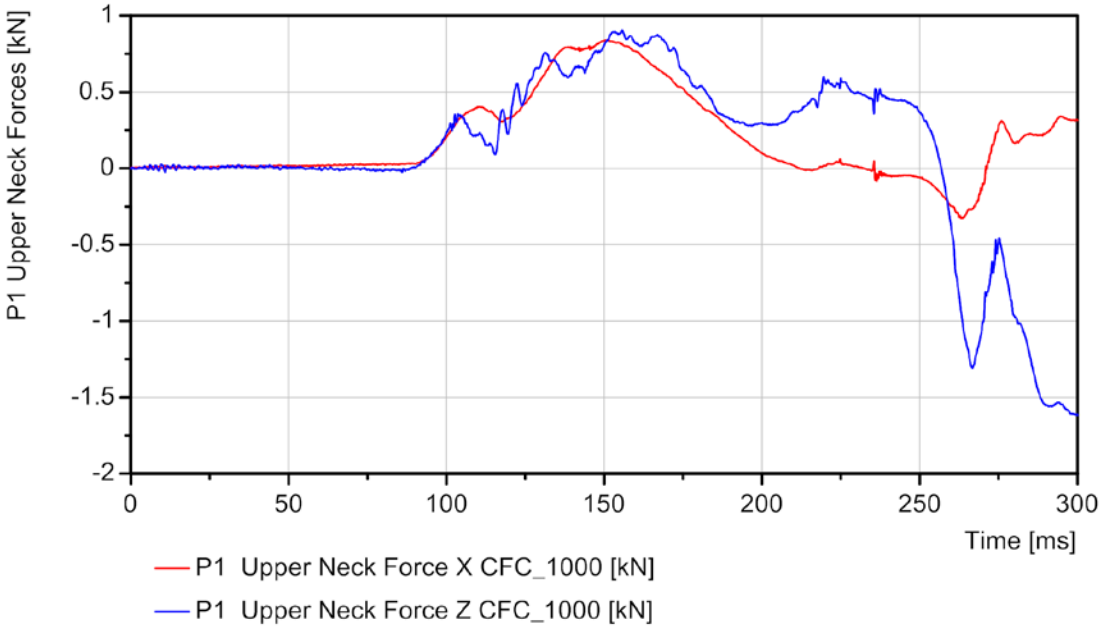
Head Accelerations and Injury Criteria

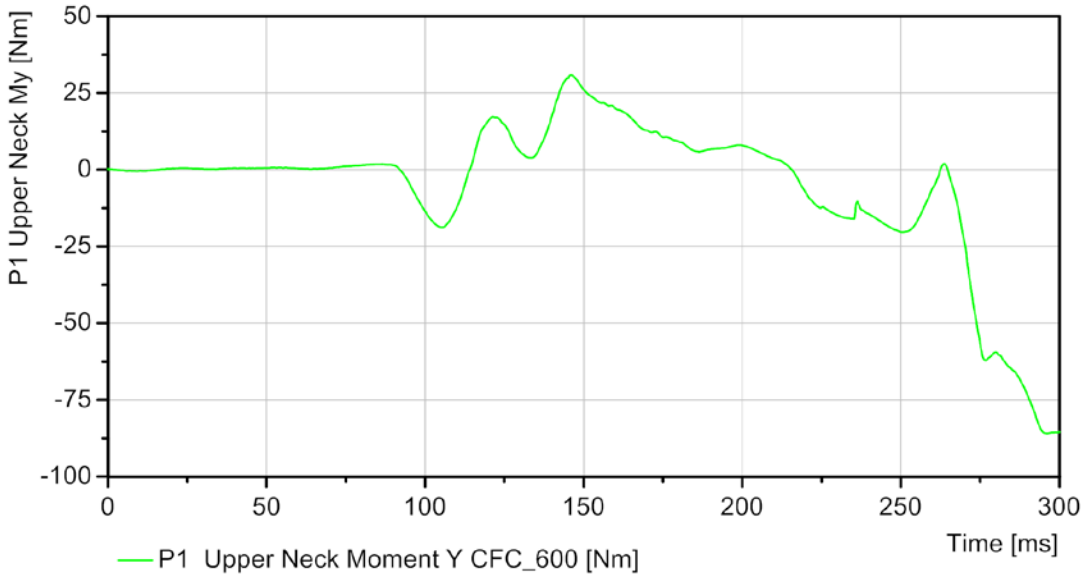




Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

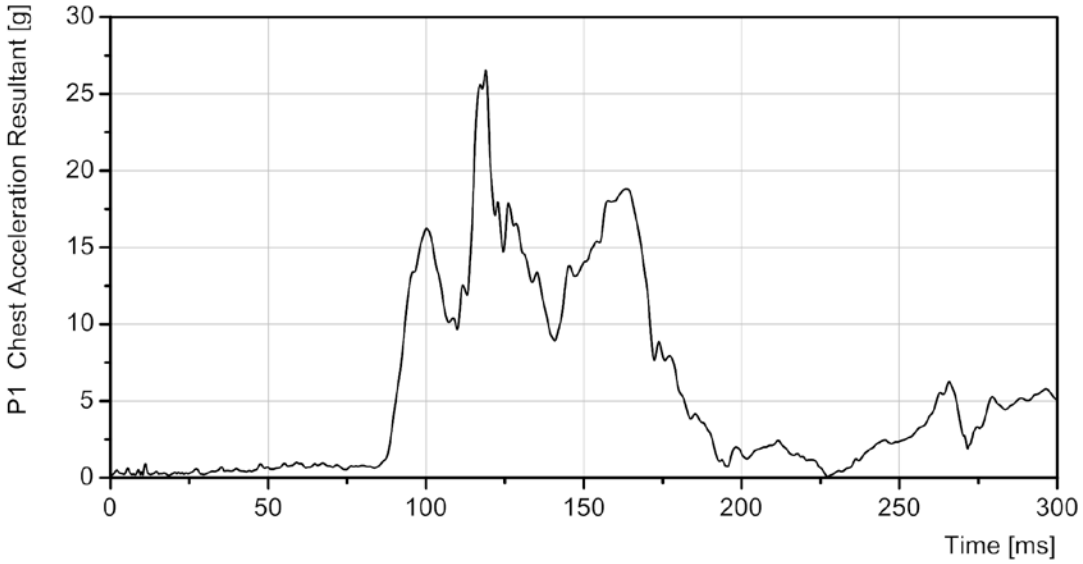
Upper Neck Forces

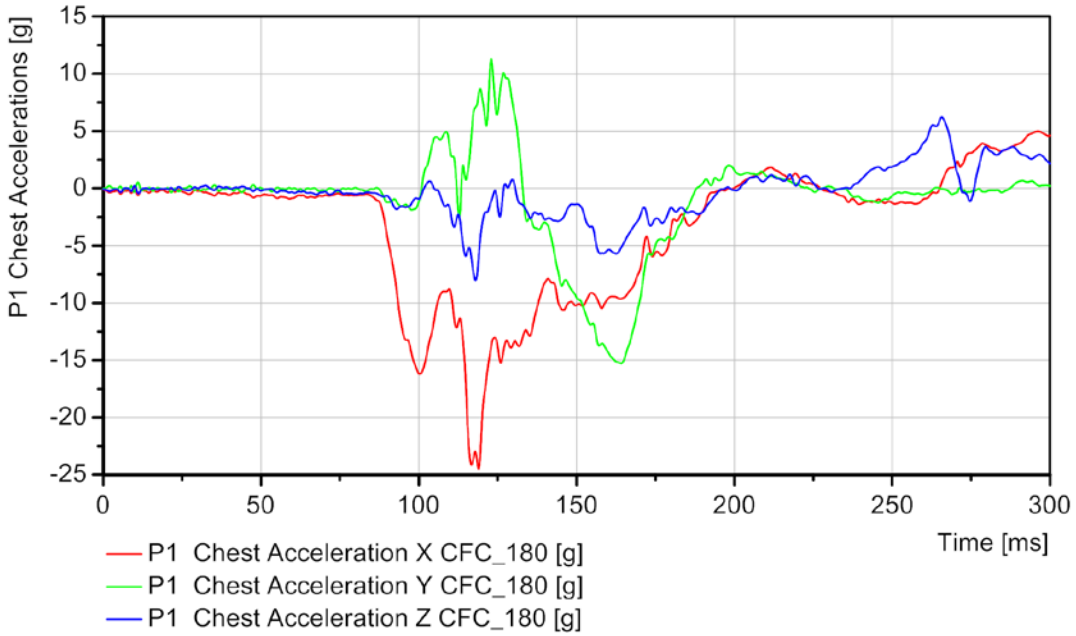




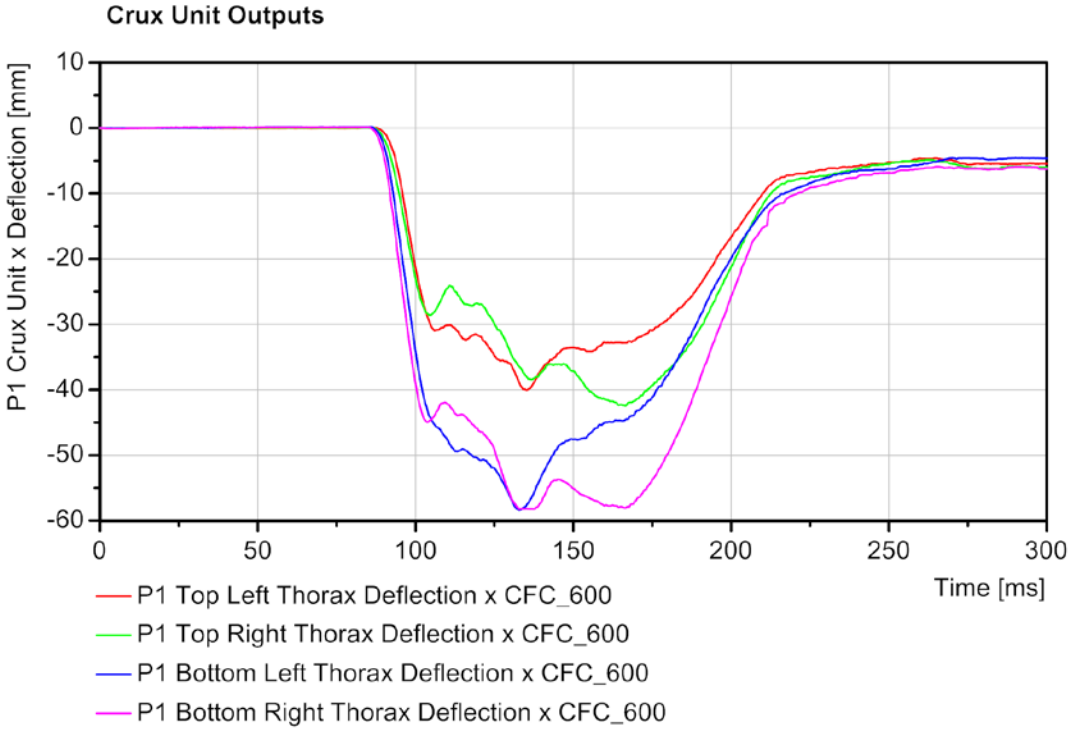
Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

Chest Accelerations and Injury Criteria



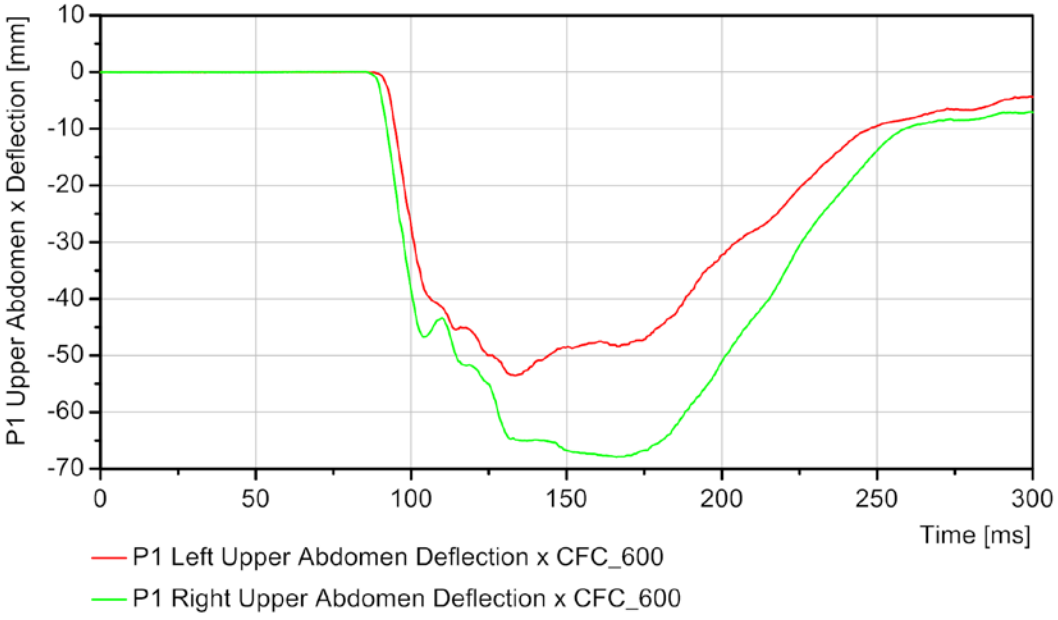


Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

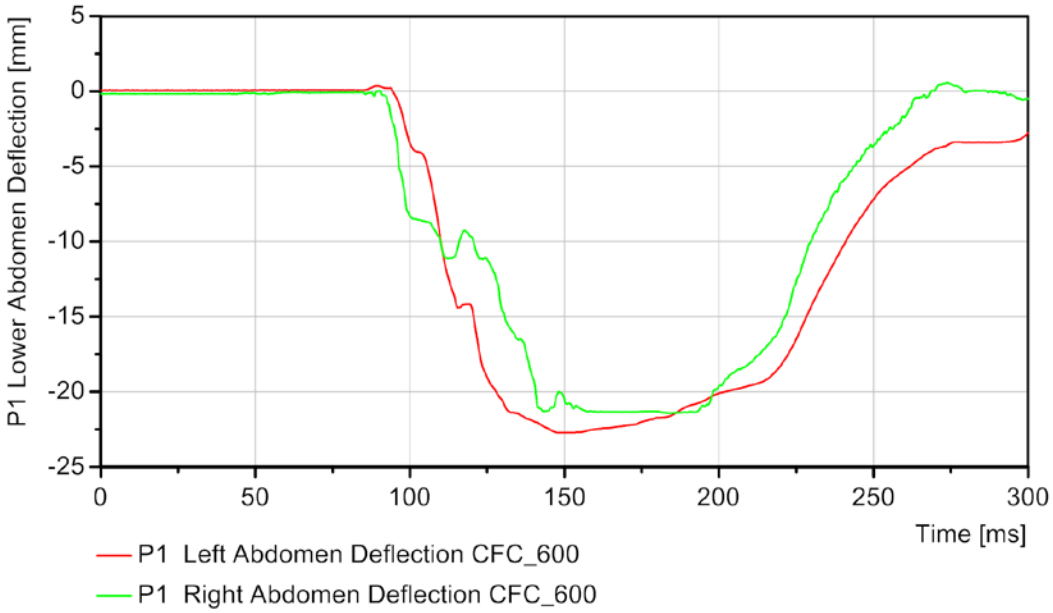


Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

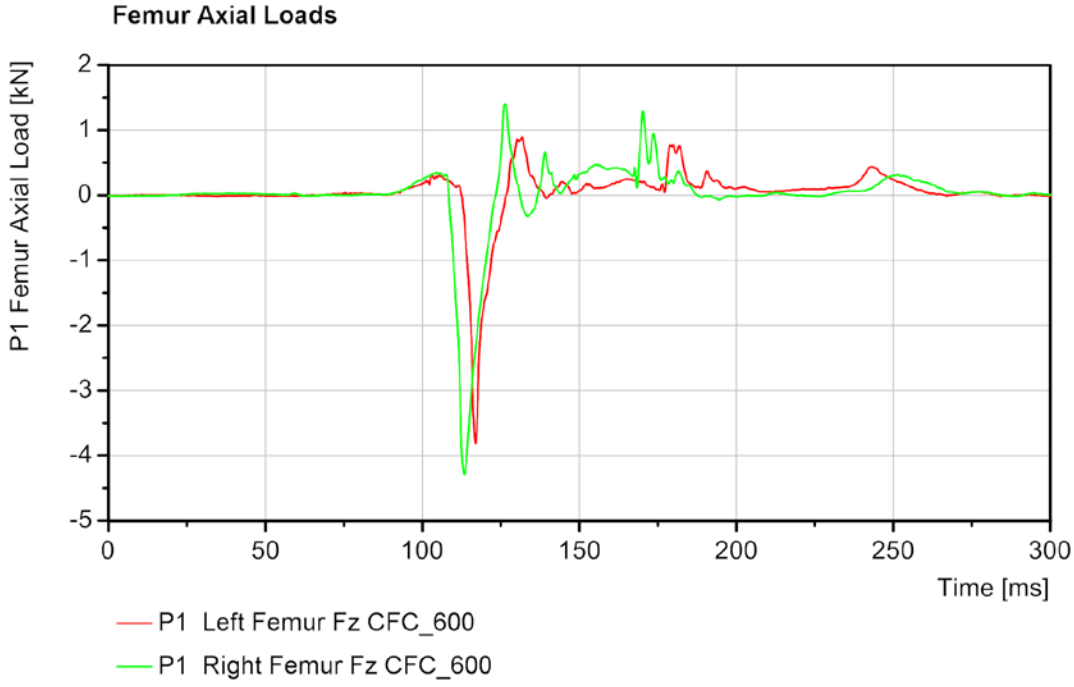
DGSP Unit Outputs



Lower Abdomen Deflections

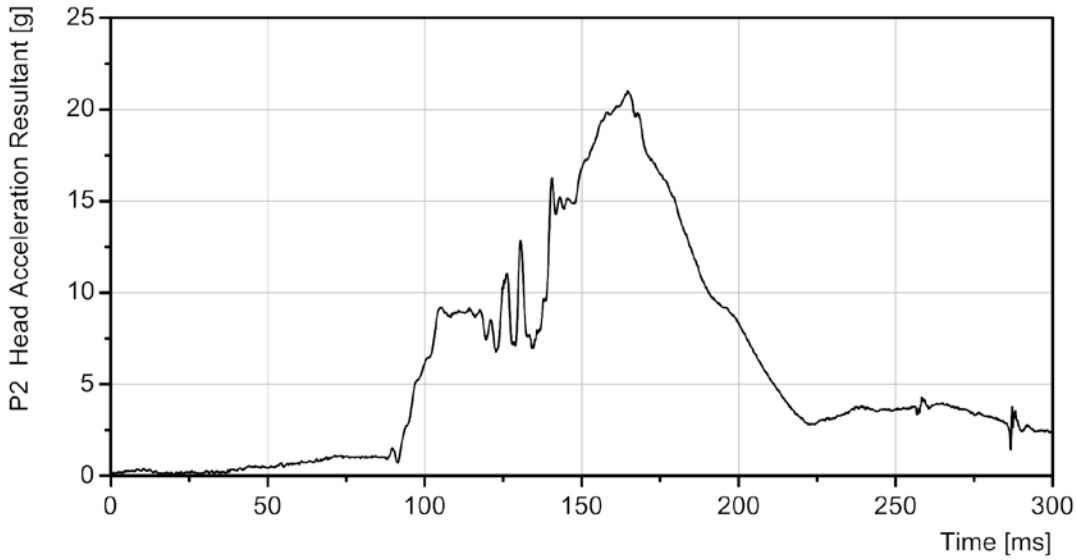


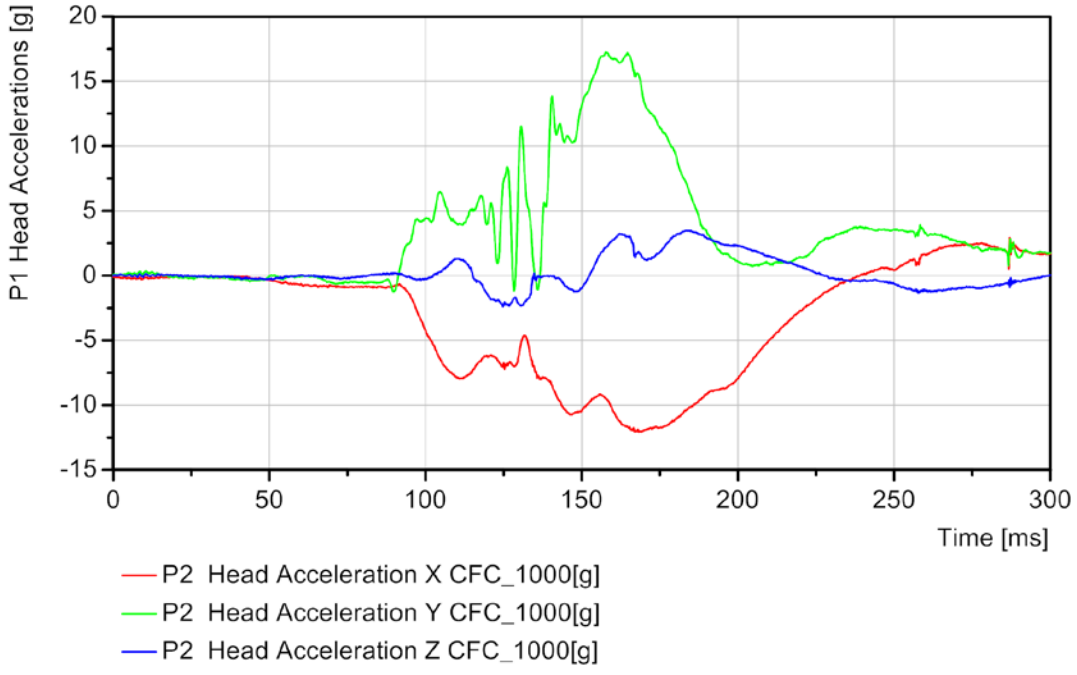
Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF



Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

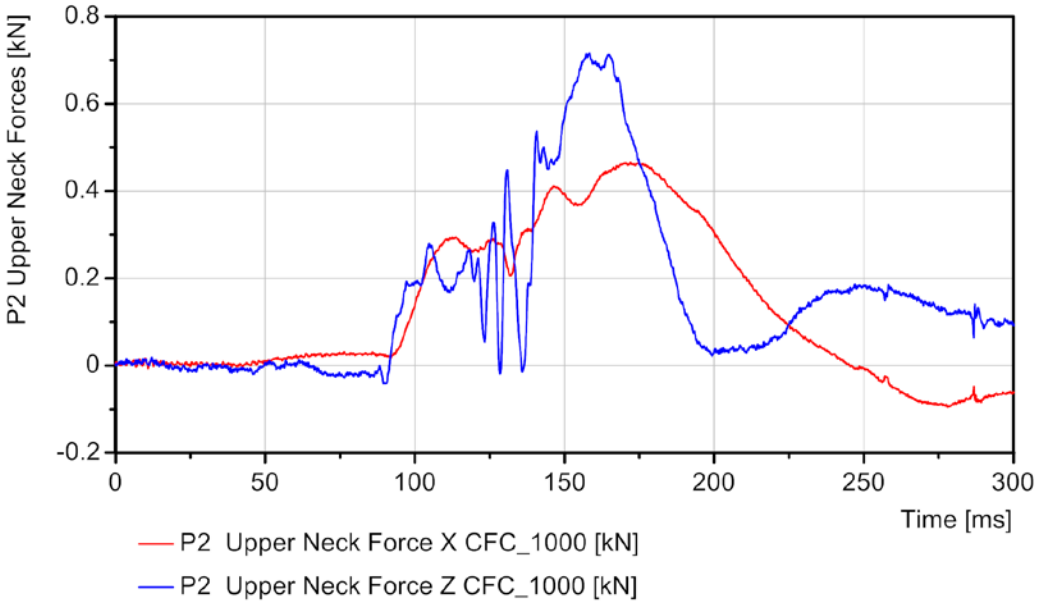
Head Accelerations and Injury Criteria



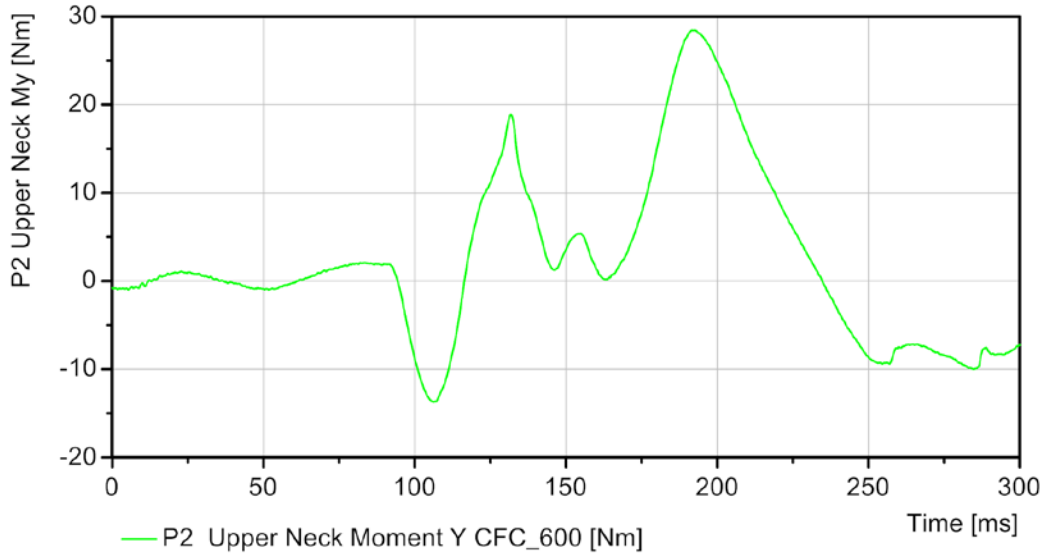


Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Upper Neck Forces

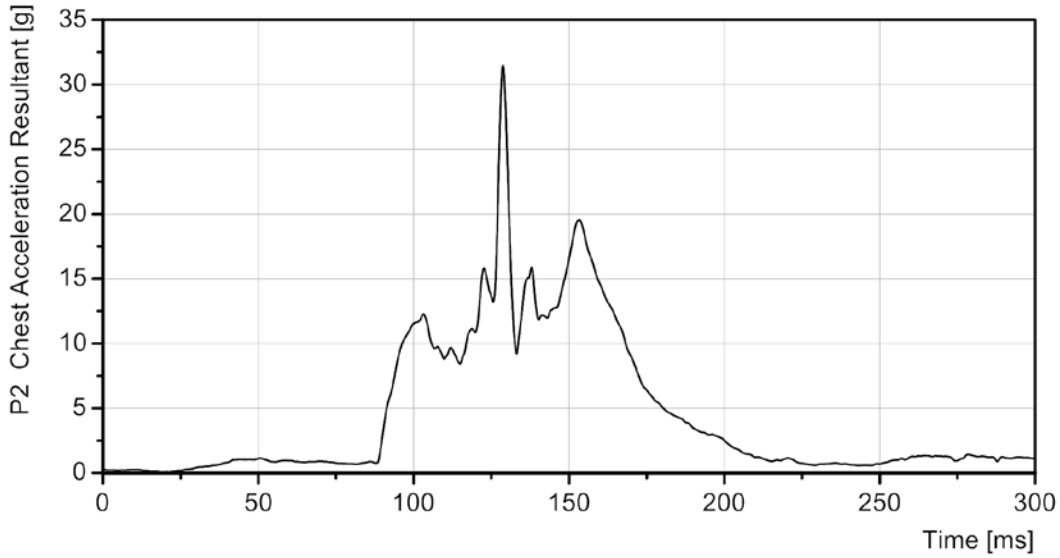


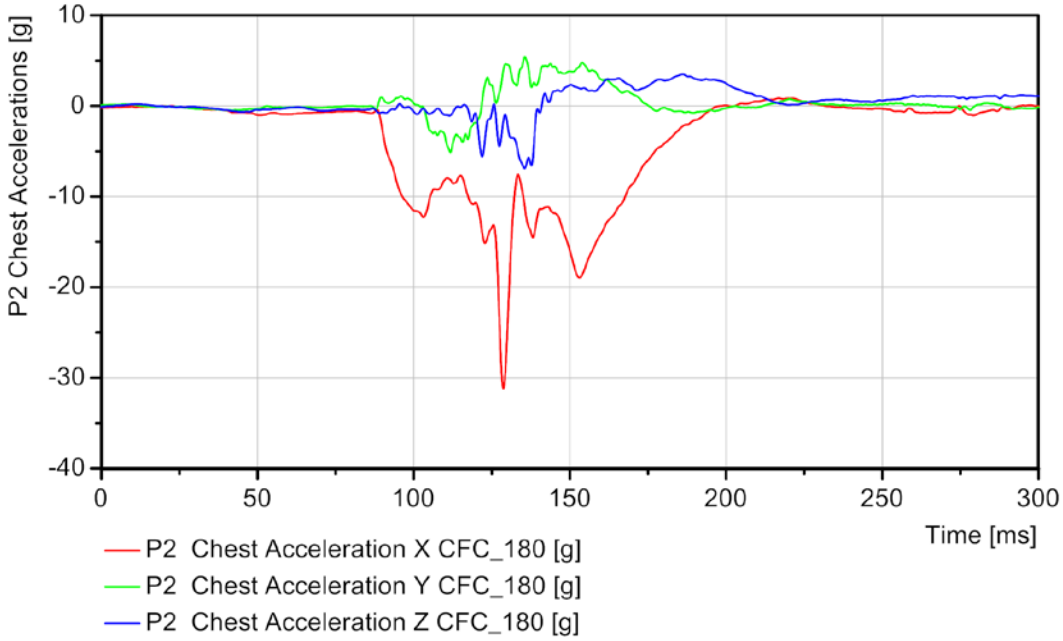
Upper Neck Moments



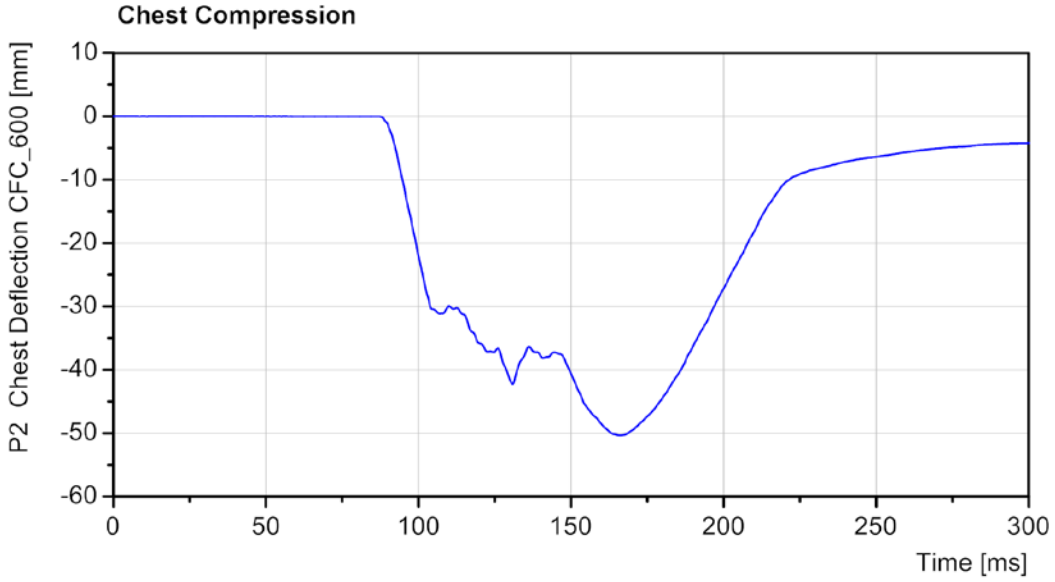
Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Chest Accelerations and Injury Criteria

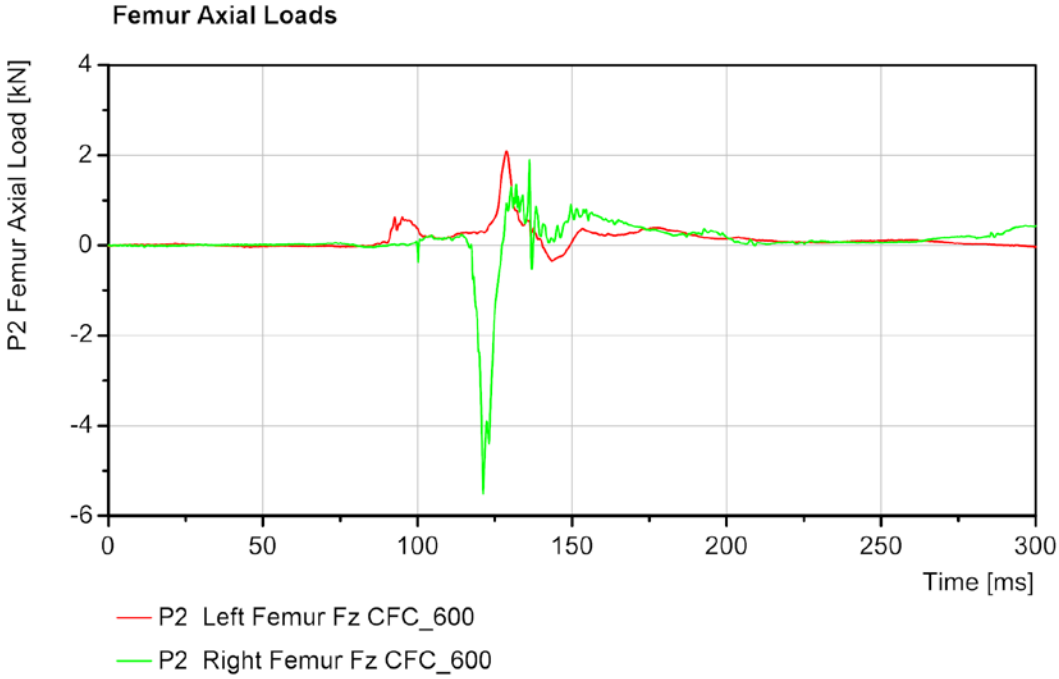




Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



Test Number: G300I04; Test Type: APTA PR-CS-S-018-13; Date: 24/07/15
Customer: Volpe Center; Speed: 8.93 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



A.5 Test 5

Test Number	G300I05
Configuration	Forward Facing
Test Type	APTA-PR-CS-S-018-13 Table Test
Dummies	Hybrid III RS and Hybrid III both 50th Percentile
Result	Failure of lower left and right chest deflections and VC; and upper right abdomen deflection, H3-RS (wall-side ATD)

A.5.1 Test 5: Summary

Figure A.5.1: Pre-Test

This injury test was for the seat configuration depicted above. The seat design was 'Seat 1' and the table design was 'Table 4.' The installation of seats and table was carried out by TRL test staff, and all mountings and interface plates were designed and fabricated by TRL.

The test pulse is plotted in Figure A.5.3; the calibration run pulse obtained prior to testing is plotted in Figure A.5.4, demonstrating that the test conforms as far as possible to the requirements of the standard.

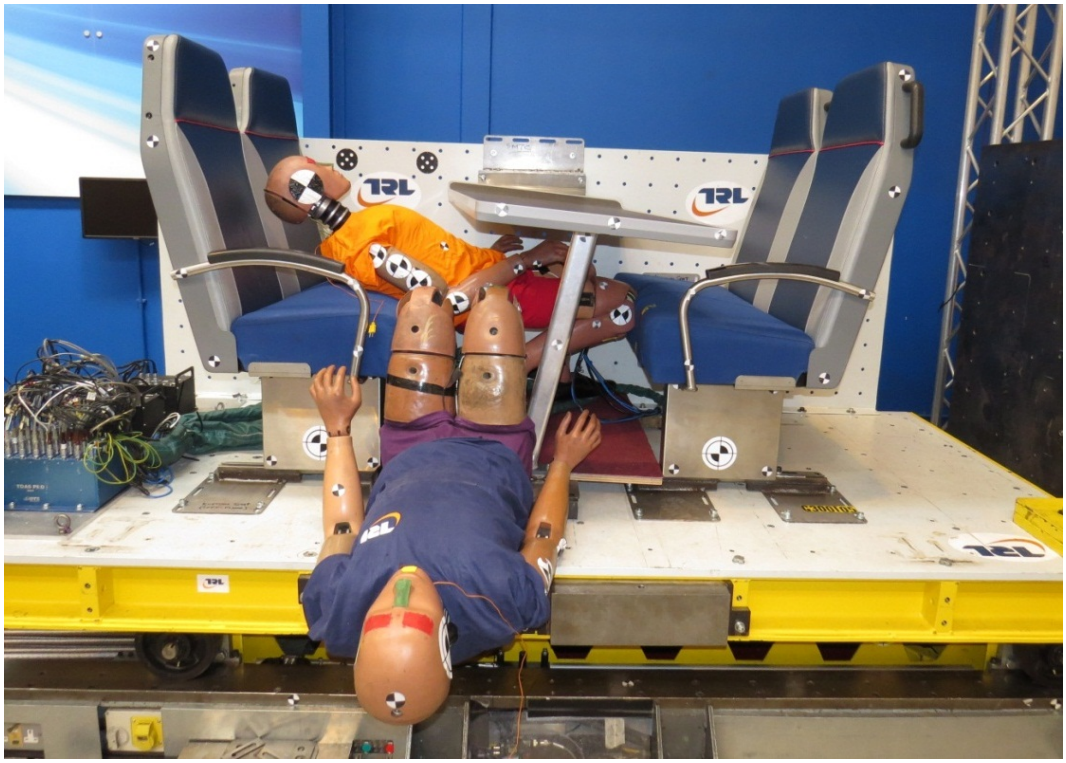


Figure A.5.2 Post-Test

The test was filmed from several viewpoints using high-speed digital cameras running at 1000 fps. Still photographs were used to document the set-up and record any seat deformation and contact points post-test. 2D point measurements have been used to compare seat and dummy positions before and after the test; this allows survival space and deformation to be quantified.

A checklist was completed during testing to ensure compliance with the requirements of APTA-PR-CS-S-018-13.

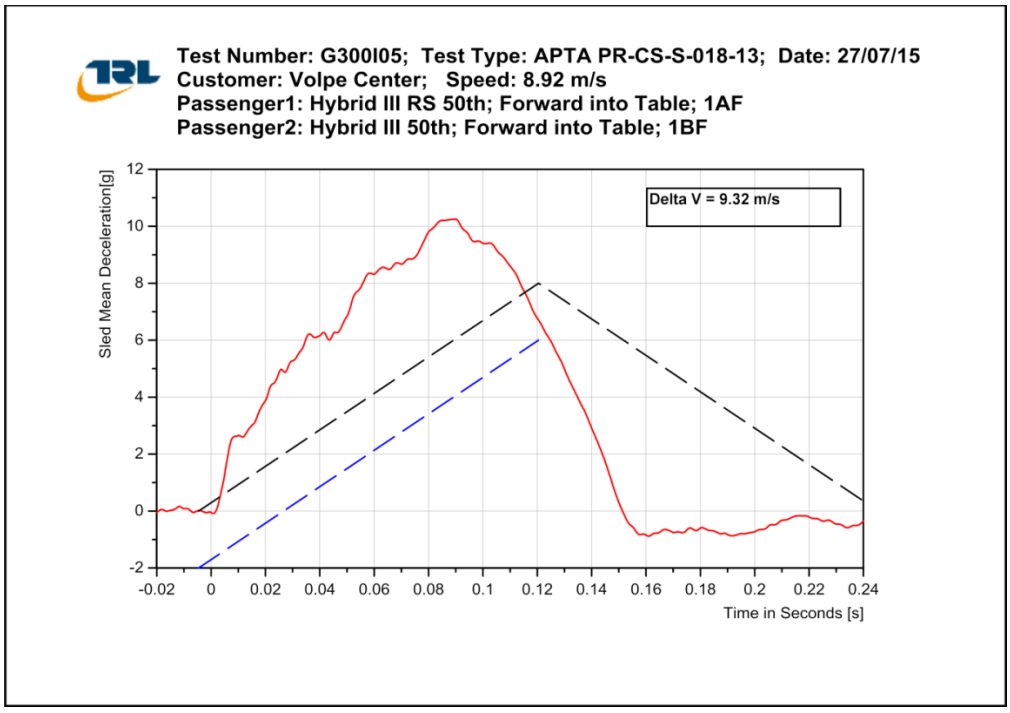


Figure A.5.3: Test G300I05 Deceleration Pulse

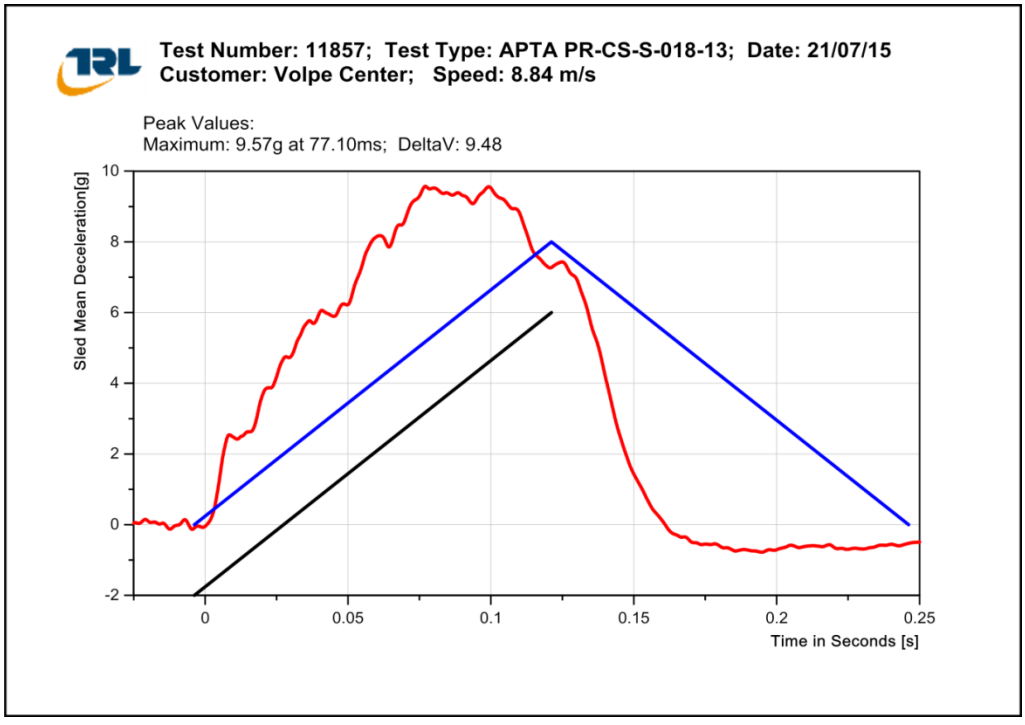
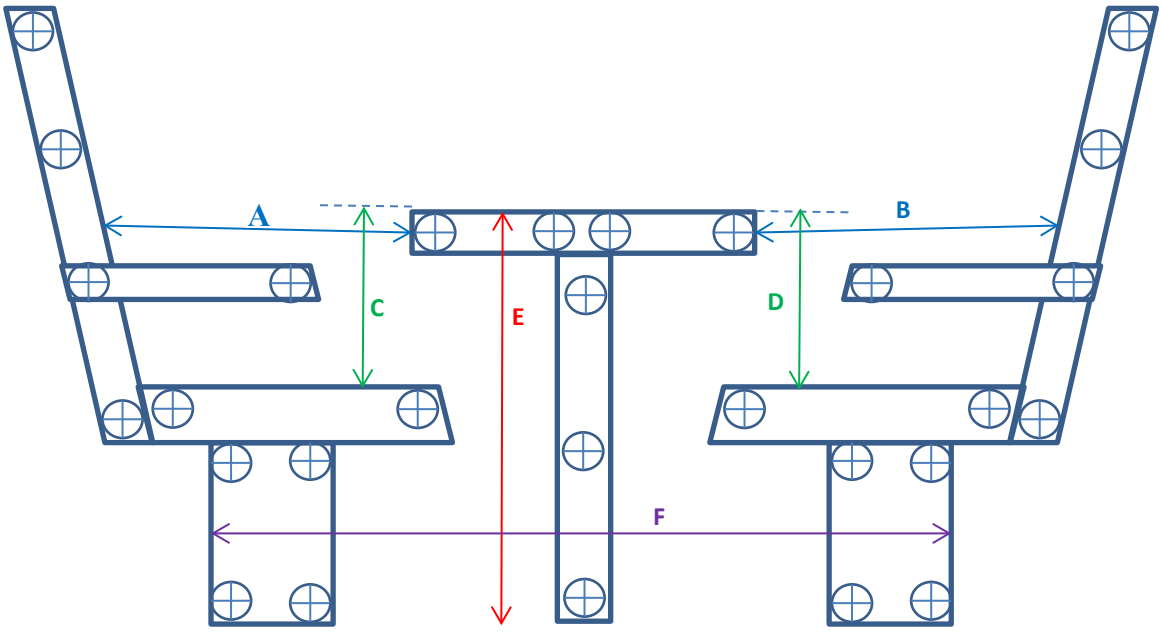
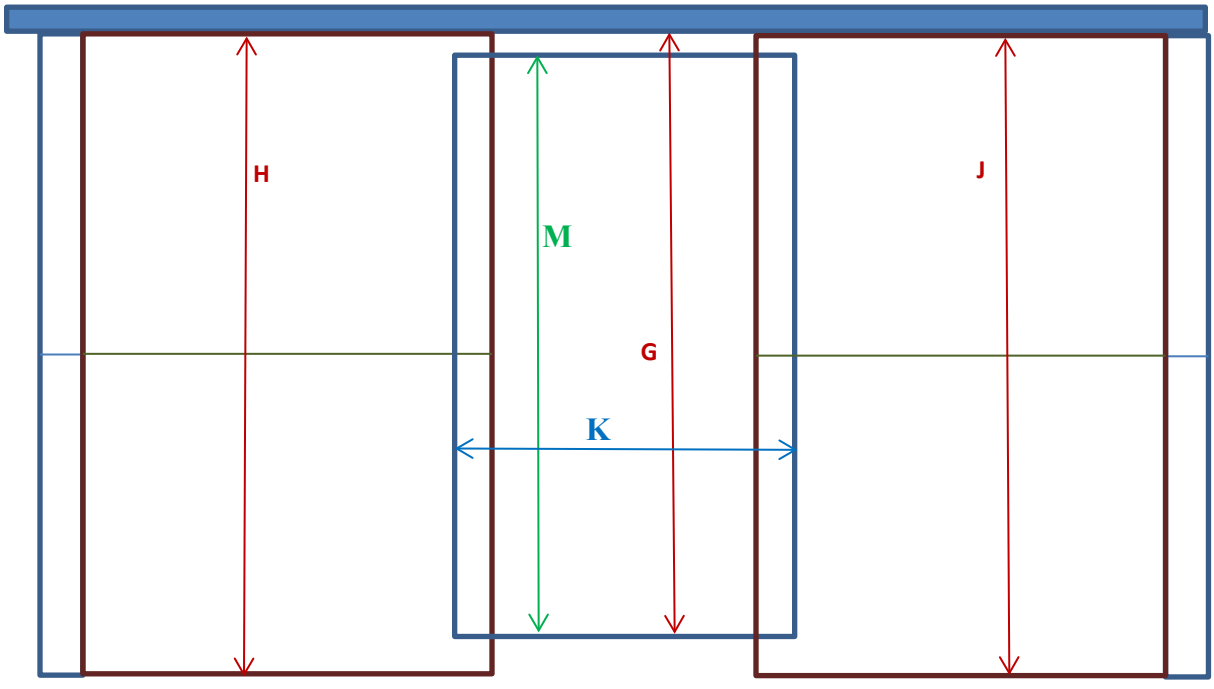


Figure A.5.4: Calibration Run Deceleration Pulse

A.5.2 Test 5: Pre and Post Test Measurements



Overhead View



Measurement	Pre-Test Value (mm)	Post-Test Value (mm)
Longitudinal Distance between the front edge of the table top and the seat back (ATD 1) A	500	560
Longitudinal Distance between the front edge of the table top and the seat back (ATD 2) A	504	650
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 1) B	498	435
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 2) B	497	360
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 1) C	278	320
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 2) C	276	305
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 1) D	276	248
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 2) D	278	240
Vertical Distance from Table Top to Floor E	730	760/740
Longitudinal Distance from outside Rear Pedestal Base to outside of Front Pedestal Base F	1450	1455
Lateral Distance from Wall to Edge of Table G	1259	1302
Lateral Distance from Wall to Edge of Forward Facing Seats H	1120	1145
Lateral Distance from Wall to Edge of Rear Facing Seats J	1124	1123
Table Top Thickness	46	45
Table Top Lateral (width) K	634	635
Table Top Longitudinal (depth) M	1210	1210

A.5.3 Test 5: Injury Criteria Summary

Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 1

Body Region	APTA Limit	HII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Head - HIC 15	700	252.43	Pass	48.72	Pass
Neck Peak Axial Tension	4.17kN	2.32kN	Pass	1.13kN	Pass
Neck Peak Axial Compression	-4kN	-2.3kN	Pass	-0.06kN	Pass
Neck - Nij NTE	1.0	0.69	Pass	0.16	Pass
Neck- Nij NTF	1.0	0.67	Pass	0.24	Pass
Neck - Nij NCE	1.0	0.73	Pass	0.01	Pass
Neck - Nij NCF	1.0	0.45	Pass	0.02	Pass
Chest - 3ms Exceedence	60g	47.5g	Pass	29.34g	Pass
Upper Left Chest Max Deflection	-63mm	-51.01mm	Pass	N/A	N/A
Upper Right Chest Max Deflection	-63mm	-45.19mm	Pass	N/A	N/A
Lower Left Chest Max Deflection	-63mm	-90.43mm	Fail	N/A	N/A
Lower Right Chest Max Deflection	-63mm	-80.45mm	Fail	N/A	N/A
Chest Max Deflection (HIII)	-63mm	N/A	N/A	*	*
Upper Left Chest Viscous Criterion	1.0m/s	0.55m/s	Pass	N/A	N/A
Upper Right Chest Viscous Criterion	1.0m/s	0.32m/s	Pass	N/A	N/A
Lower Left Chest Viscous Criterion	1.0m/s	1.41m/s	Fail	N/A	N/A
Lower Right Chest Viscous Criterion	1.0m/s	1.19m/s	Fail	N/A	N/A
Chest Viscous Criterion (HIII)	1.0m/s	N/A	N/A	*	*
Upper Left Abdomen Deflection	-67mm	-61.4mm	Pass	N/A	N/A
Upper Right Abdomen Deflection	-67mm	-75.95mm	Fail	N/A	N/A
Lower Left Abdomen Deflection	-67mm	-17.41mm	Pass	N/A	N/A
Lower Right Abdomen Deflection	-67mm	-31.67mm	Pass	N/A	N/A

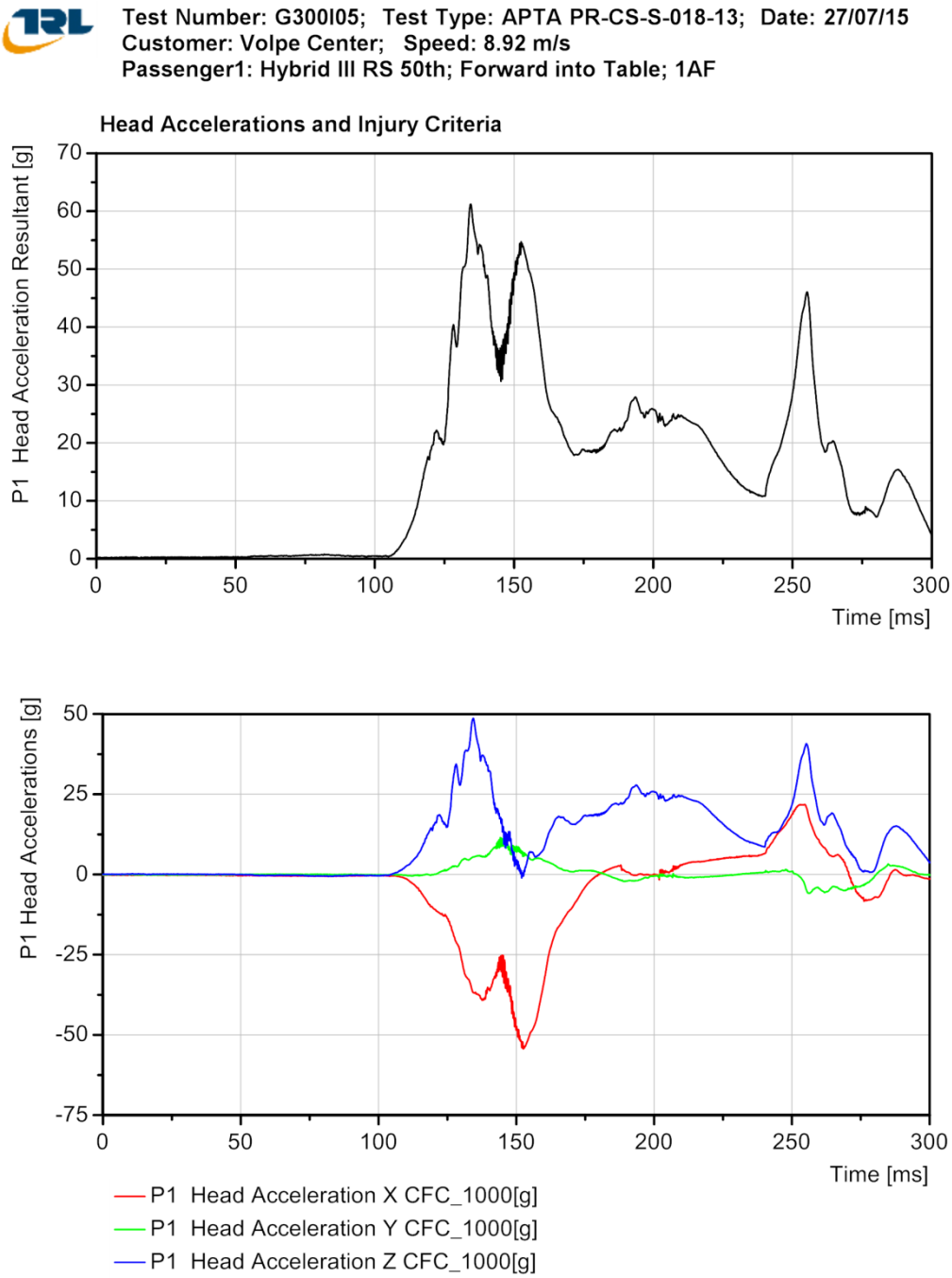
*The Hybrid III Chest Slider came out of its groove during the test and hence these results are not valid

Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 2

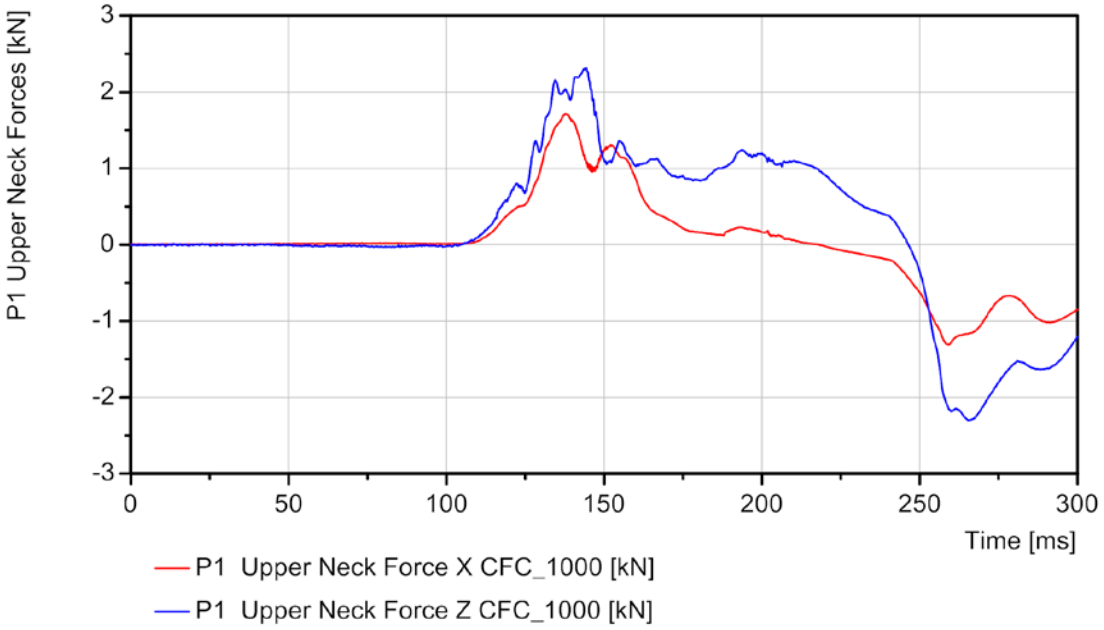
Body Region	APTA Limit	HIII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Upper Abdomen Left VC	1.98m/s	0.94m/s	Pass	N/A	N/A
Upper Abdomen Right VC	1.98m/s	1.14m/s	Pass	N/A	N/A
Lower Abdomen Left VC	1.98m/s	0.05m/s	Pass	N/A	N/A
Lower Abdomen Right VC	1.98m/s	0.27m/s	Pass	N/A	N/A
Left Femur Peak Compression	-7kN	-1.58kN	Pass	-5.2kN	Pass
Right Femur Peak Compression	-7kN	-3.72kN	Pass	-5.01kN	Pass

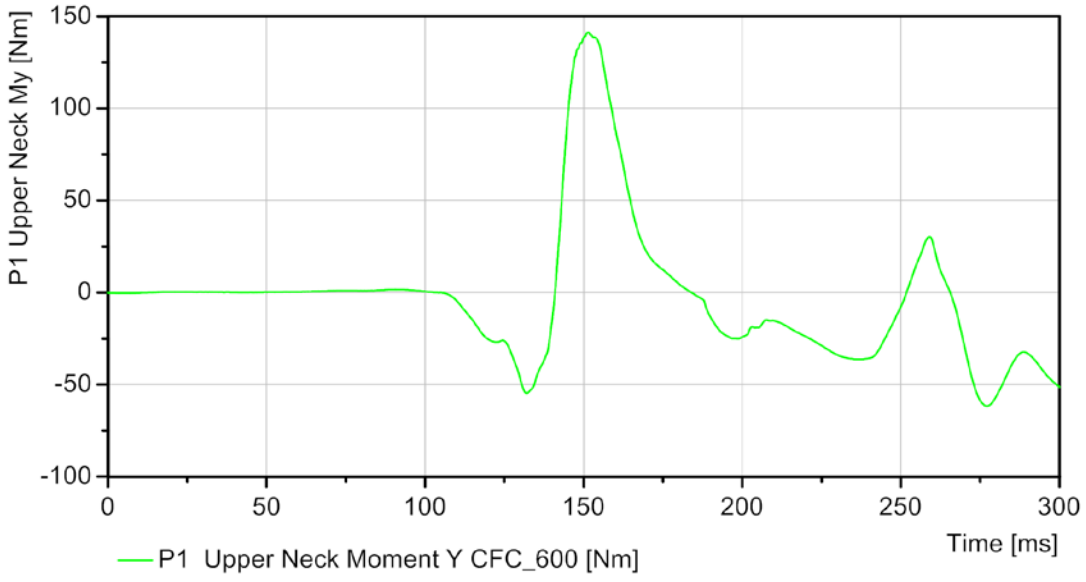
A.5.4 Test 5: ATD Sensor Data



Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

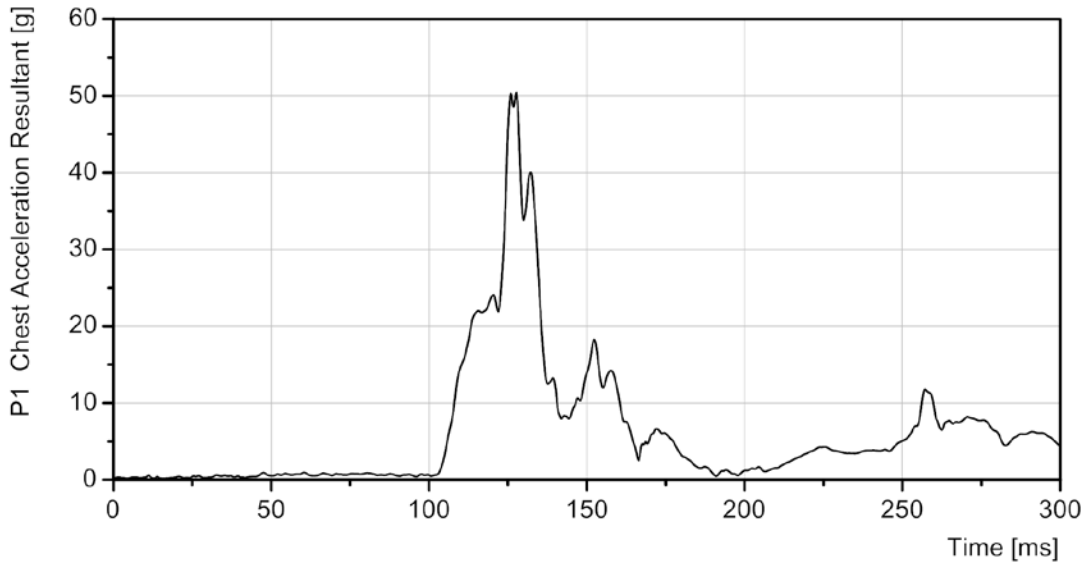
Upper Neck Forces

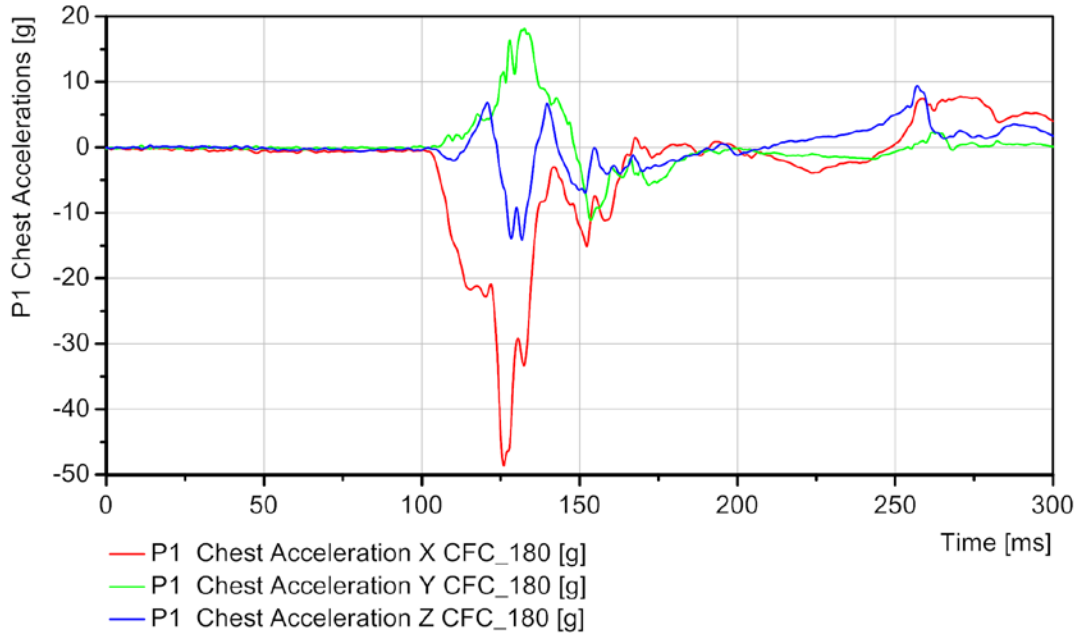




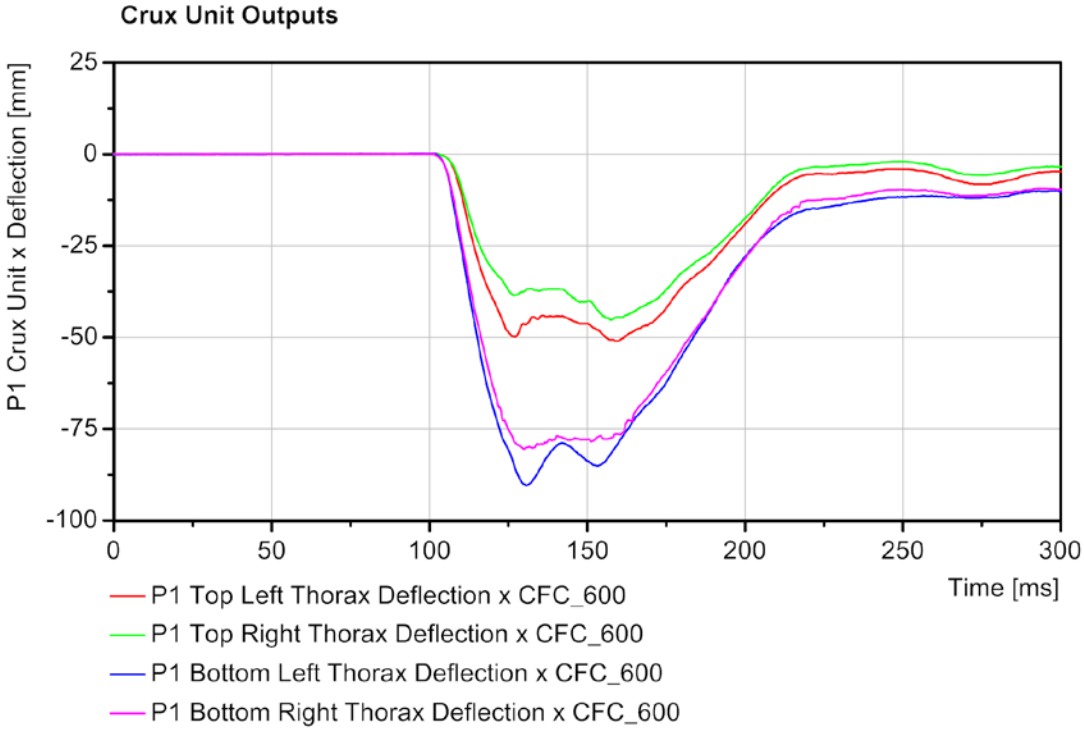
Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

Chest Accelerations and Injury Criteria



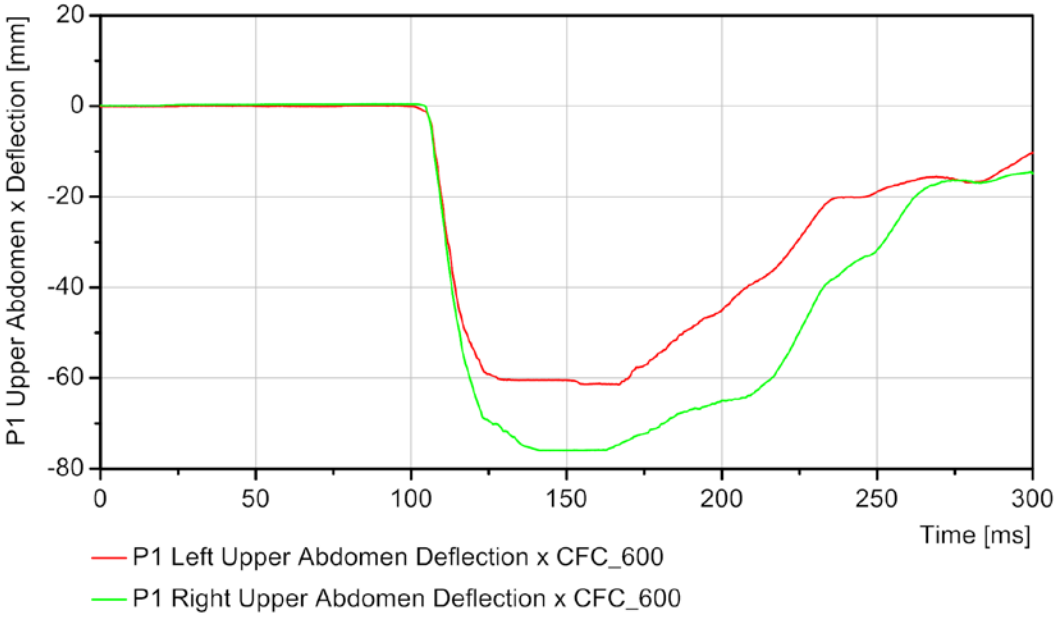


Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

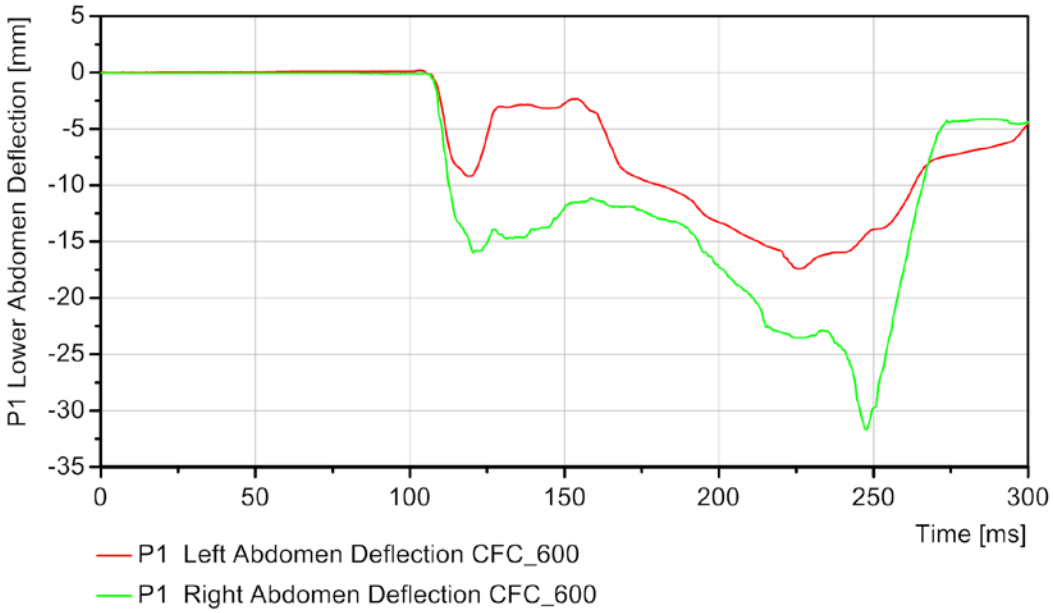


Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

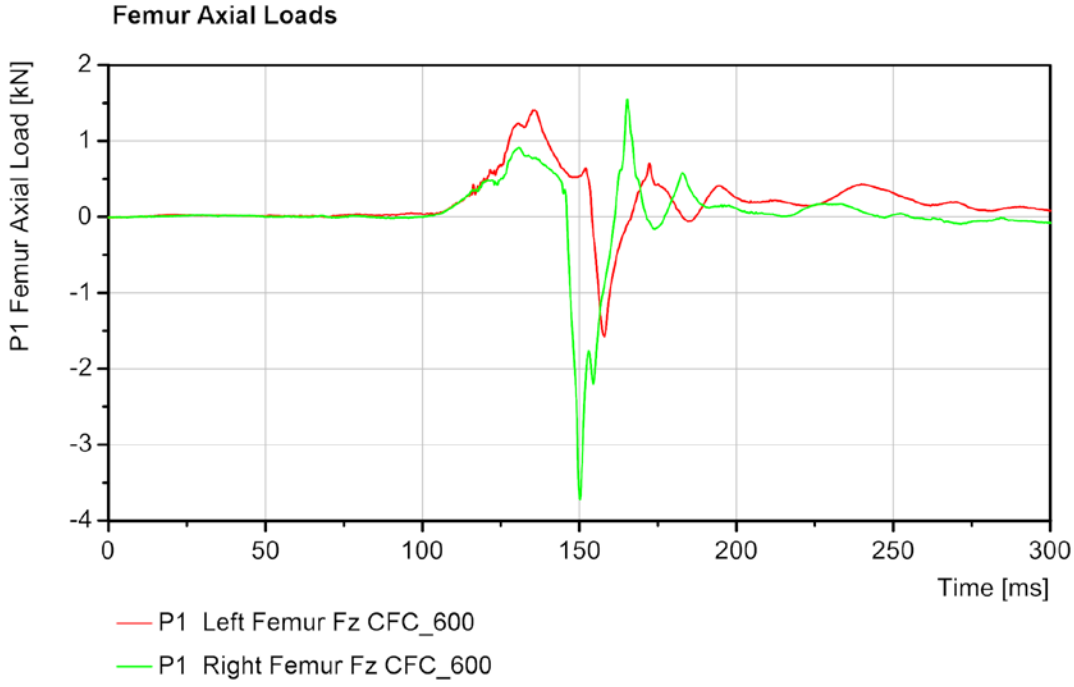
DGSP Unit Outputs



Lower Abdomen Deflections

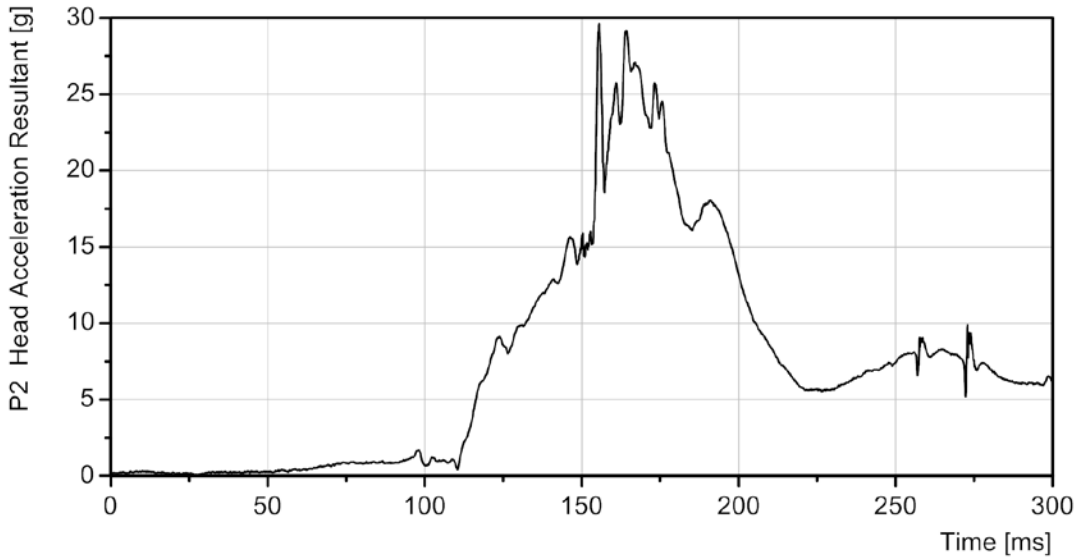


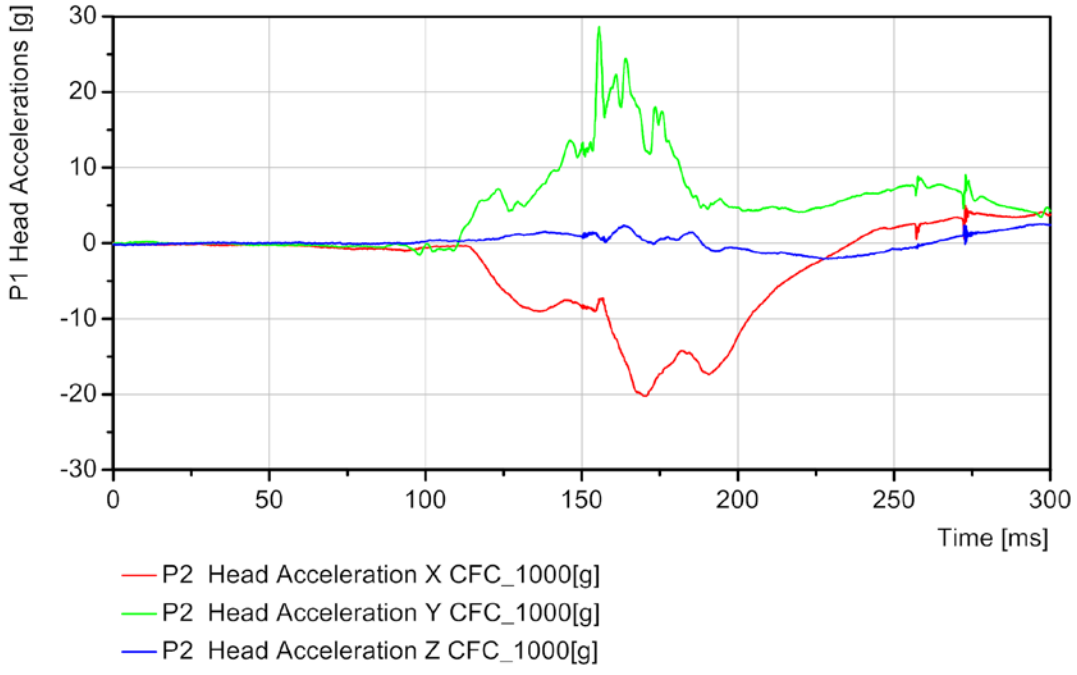
Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF



Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

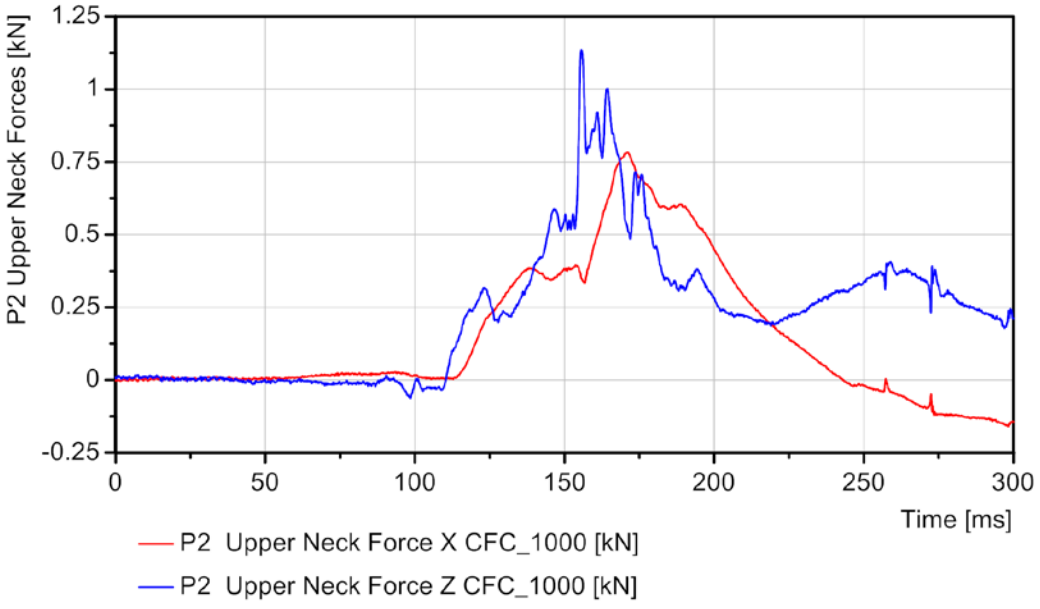
Head Accelerations and Injury Criteria



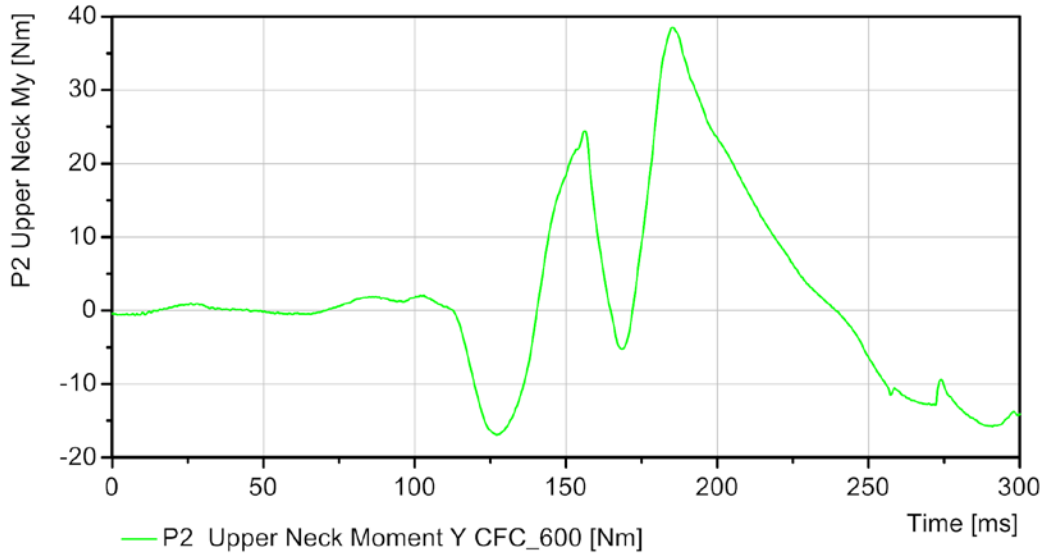


Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Upper Neck Forces

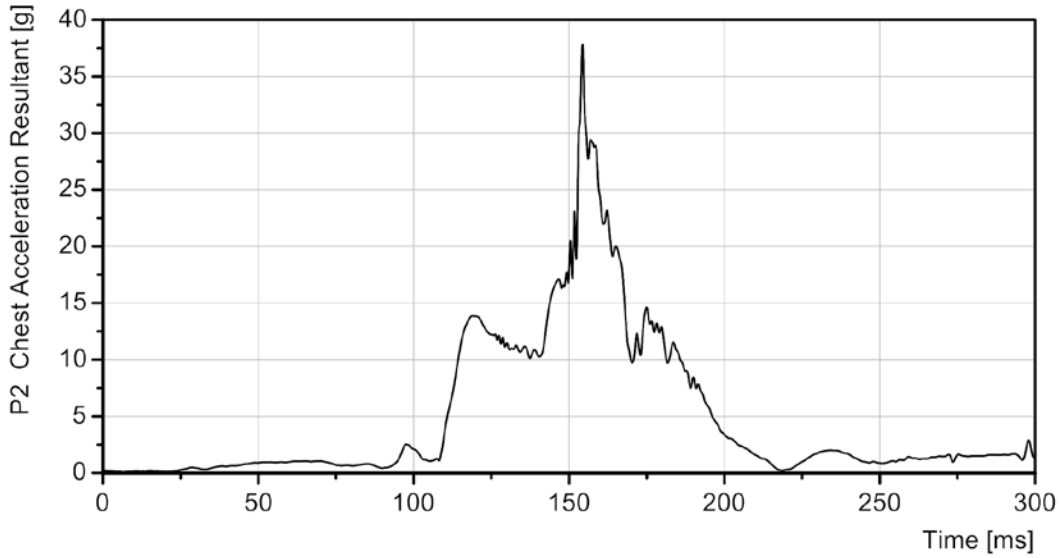


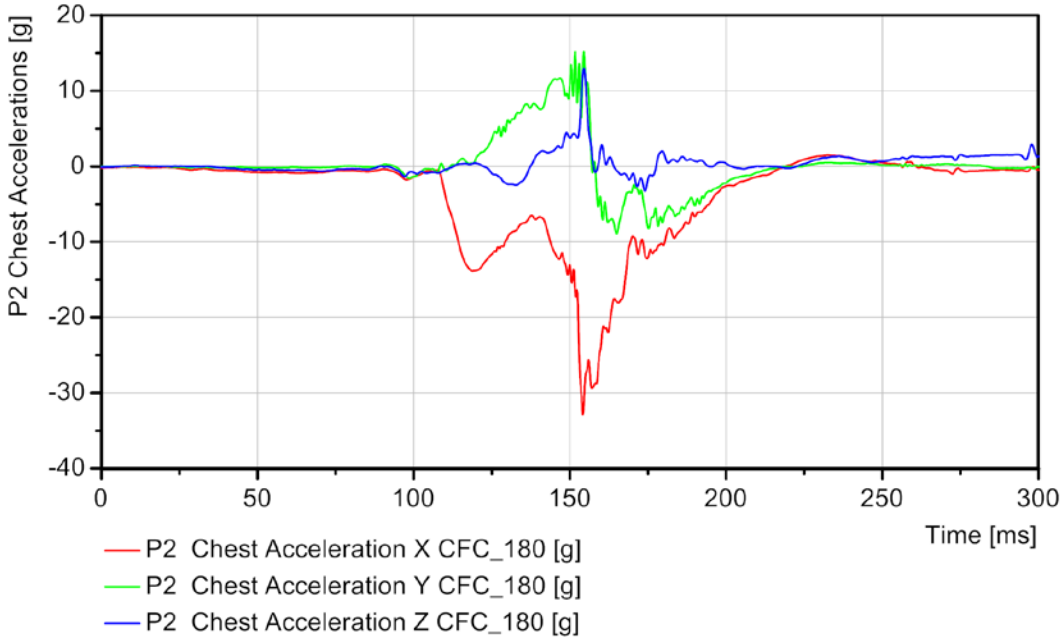
Upper Neck Moments



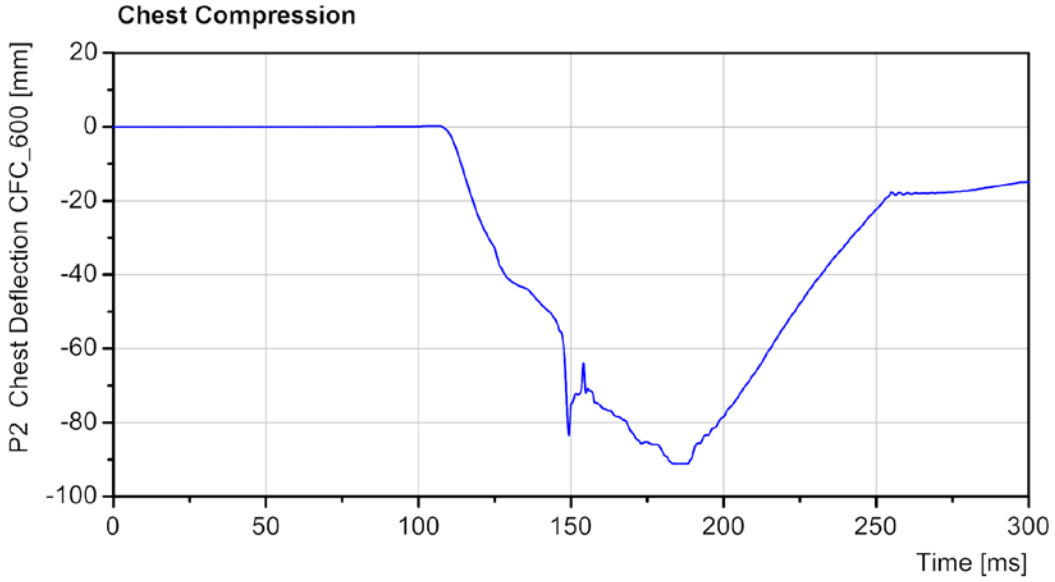
Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Chest Accelerations and Injury Criteria

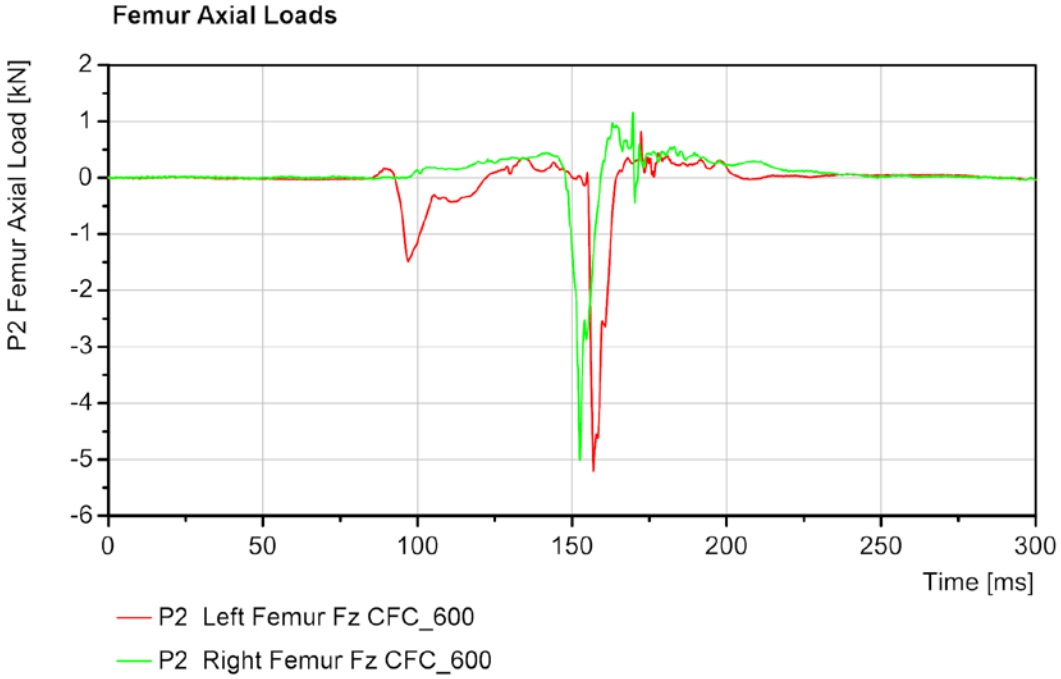




Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



Test Number: G300I05; Test Type: APTA PR-CS-S-018-13; Date: 27/07/15
Customer: Volpe Center; Speed: 8.92 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



A.6 Test 6

Test Number	G300I06
Configuration	Forward Facing
Test Type	APTA-PR-CS-S-018-13 Table Test
Dummies	Hybrid III RS and Hybrid III both 50th Percentile
Result	Failure of lower left and right chest deflection, H3-RS (wall-side ATD); failure of chest VC and right femur compression, HIII (aisle-side ATD)

A.6.1 Test 6: Summary

Figure A.6.1: Pre-Test

This injury criteria test was for a pair of double seats facing each other across a cantilever mounted table, as depicted above. The seat design was 'Seat 1' and the table design was 'Table 5.' The installation of seats and table was carried out by TRL test staff; all mountings and interface plates were designed and fabricated by TRL to be representative, as far as reasonable, real-world installation.

The calibration pulse obtained prior to testing is plotted in Figure A.6.4 and the test pulse achieved is plotted in Figure A.6.3. For both, the test conforms to the requirements of the APTA standard.

Figure A.6.2: Post-Test

The test was filmed from several viewpoints using high-speed digital cameras running at 1000 fps. Still photographs were used to document the set-up and record any seat deformation and contact points post-test.

2D reference point measurements have been used to compare seat and dummy positions before and after the test. This allows component deformation to be quantified and the integrity of survival space to be assessed.

A checklist was completed during testing to ensure compliance with the requirements of APTA-PR-CS-S-018-13.

Significant forward deformation of the table was observed during the impact event resulting from loading by the HIII RS and HIII 50th ATDs. The cantilevered mountings were distorted but did recover somewhat and no parts of the table were ejected.

During the impact both ATDs' knees became wedged beneath the table and the opposite seat pan cushion. Both motions would have severely compromised the occupant survival space of any occupant on the opposing seat.

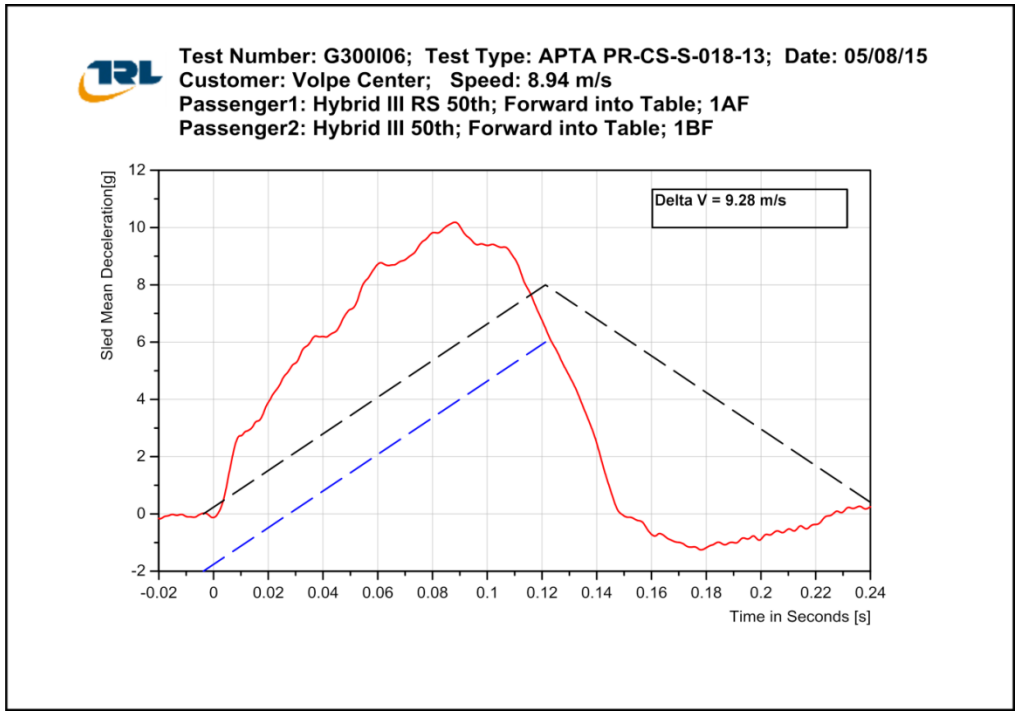


Figure A.6.3: Test G300I06 Deceleration Pulse

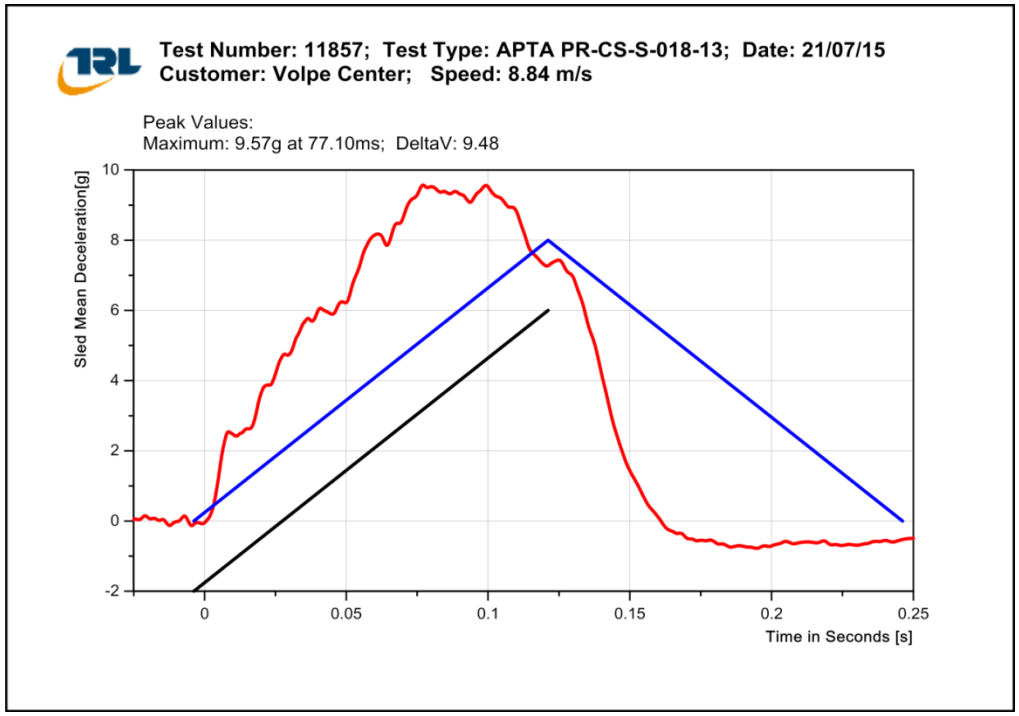
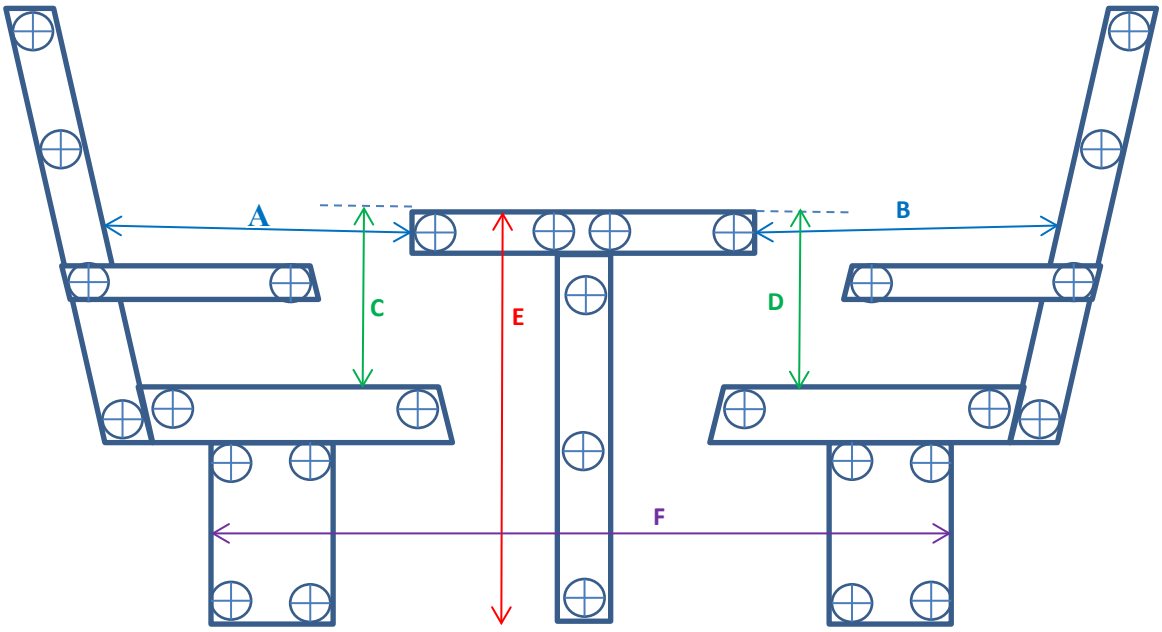
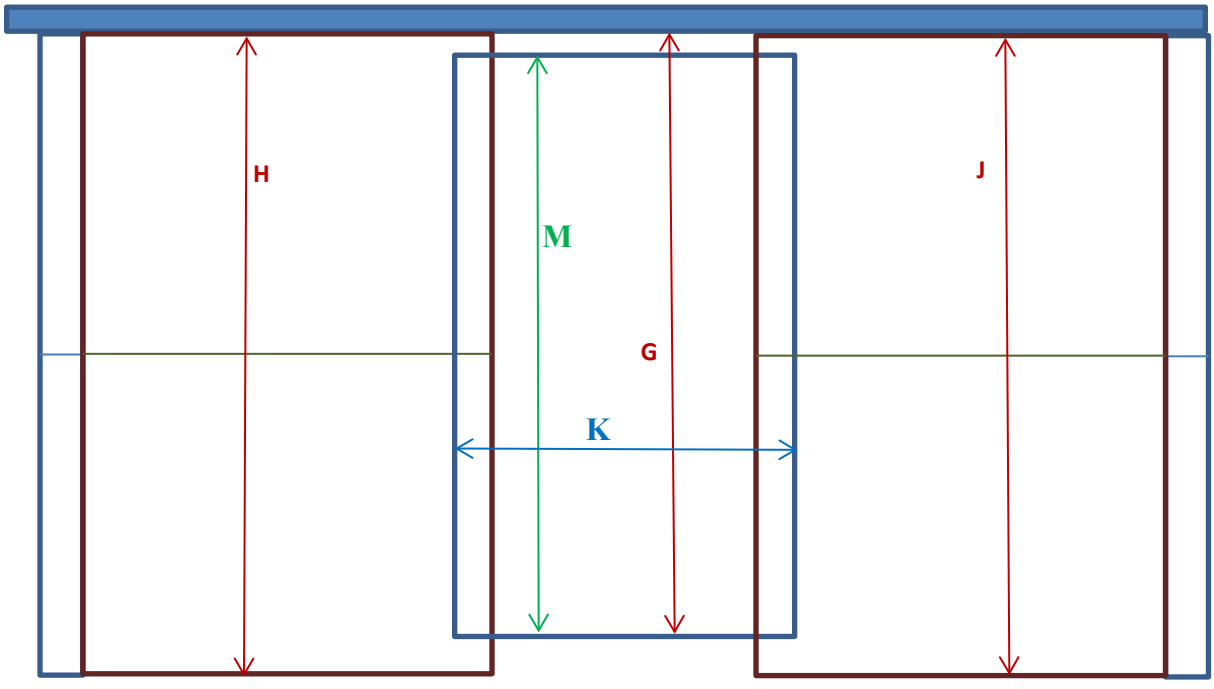


Figure A.6.4: Calibration Run Deceleration Pulse

A.6.2 Test 6: Pre and Post Test Measurements



Overhead View



Measurement	Pre-Test Value (mm)	Post-Test Value (mm)‡
Longitudinal Distance between the front edge of the table top and the seat back (ATD 1) A	505	
Longitudinal Distance between the front edge of the table top and the seat back (ATD 2) A	540	
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 1) B	536	
Longitudinal Distance between the front edge of the table top and the seat back (Seat Facing ATD 2) B	564	
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 1) C	294	
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (ATD 2) C	287	
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 1) D	282	
Vertical Distance between the top of the table top and the highest point of the seat bottom cushion (Seat facing ATD 2) D	285	
Vertical Distance from Table Top to Floor E	725	
Longitudinal Distance from outside Rear Pedestal Base to outside of Front Pedestal Base F	1433	
Lateral Distance from Wall to Edge of Table G	1078	
Lateral Distance from Wall to Edge of Forward Facing Seats H	1137	
Lateral Distance from Wall to Edge of Rear Facing Seats J	1121	
Table Top Thickness	65	
Table Top Lateral (width) K	1045	
Table Top Longitudinal (depth) M	590	

‡ The post-test longitudinal survival space measurements were not collected

A.6.3 Test 6: Injury Criteria Summary

Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 1

Body Region	APTA Limit	HII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Head - HIC 15	700	40.48	Pass	17.78	Pass
Neck Peak Axial Tension	4.17kN	0.99kN	Pass	1.06kN	Pass
Neck Peak Axial Compression	-4kN	-0.06kN	Pass	-0.20kN	Pass
Neck - Nij NTE	1.0	0.24	Pass	0.39	Pass
Neck- Nij NTF	1.0	0.17	Pass	0.22	Pass
Neck - Nij NCE	1.0	0.01	Pass	0.04	Pass
Neck - Nij NCF	1.0	0.15	Pass	0.14	Pass
Chest - 3ms Exceedence	60g	20.74g	Pass	26.84g	Pass
Upper Left Chest Max Deflection	-63mm	-51.84mm	Pass	N/A	N/A
Upper Right Chest Max Deflection	-63mm	-44.43mm	Pass	N/A	N/A
Lower Left Chest Max Deflection	-63mm	-72.14mm	Fail	N/A	N/A
Lower Right Chest Max Deflection	-63mm	-69.03mm	Fail	N/A	N/A
Chest Max Deflection (HIII)	-63mm	N/A	N/A	-59.19	Pass
Upper Left Chest Viscous Criterion	1.0m/s	0.28m/s	Pass	N/A	N/A
Upper Right Chest Viscous Criterion	1.0m/s	0.29m/s	Pass	N/A	N/A
Lower Left Chest Viscous Criterion	1.0m/s	0.69m/s	Pass	N/A	N/A
Lower Right Chest Viscous Criterion	1.0m/s	0.73m/s	Pass	N/A	N/A
Chest Viscous Criterion (HIII)	1.0m/s	N/A	N/A	1.49	Fail
Upper Left Abdomen Deflection	-67mm	-58.66mm	Pass	N/A	N/A
Upper Right Abdomen Deflection	-67mm	*	*	N/A	N/A
Lower Left Abdomen Deflection	-67mm	-17.57mm	Pass	N/A	N/A
Lower Right Abdomen Deflection	-67mm	-23.36mm	Pass	N/A	N/A

*The Right DGSP Unit had an instrumentation failure and will be excluded

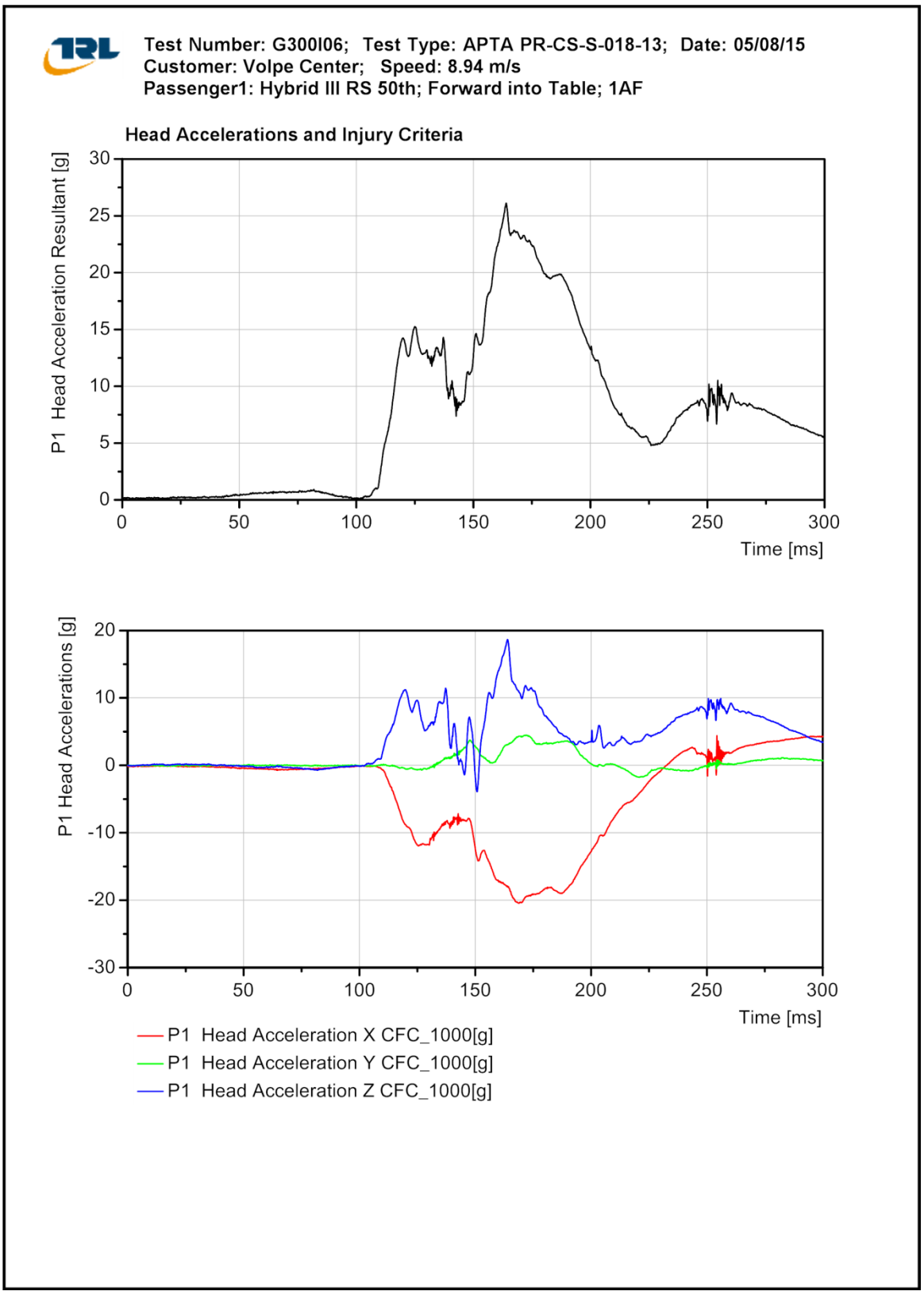
Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF
Passenger2: Hybrid III 50th; Forward into Table; 1BF

APTA PR-CS-S-018-13 Rev 1 Injury Criteria Summary Table Part 2

Body Region	APTA Limit	HIII-RS Value	HIII-RS Pass/Fail	Std HIII Value	Std HIII Pass/Fail
Upper Abdomen Left VC	1.98m/s	0.77m/s	Pass	N/A	N/A
Upper Abdomen Right VC	1.98m/s	*	*	N/A	N/A
Lower Abdomen Left VC	1.98m/s	0.08m/s	Pass	N/A	N/A
Lower Abdomen Right VC	1.98m/s	0.13m/s	Pass	N/A	N/A
Left Femur Peak Compression	-7kN	-3.93kN	Pass	-0.51kN	Pass
Right Femur Peak Compression	-7kN	-4.12kN	Pass	-5.94kN	Pass

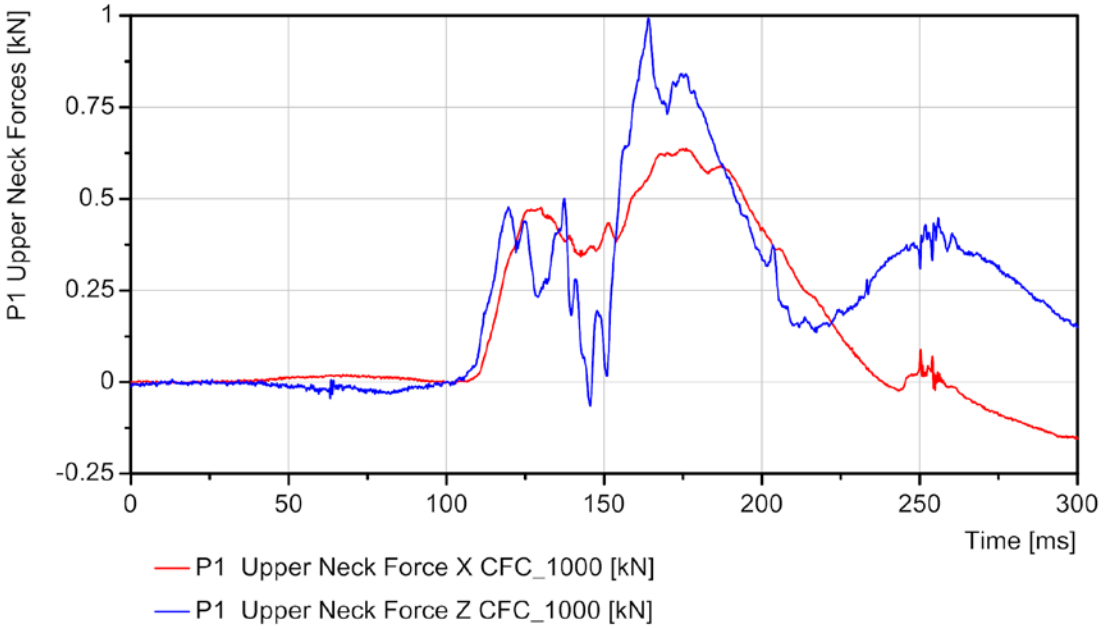
* Right DGSP Unit had an instrumentation failure and has been excluded

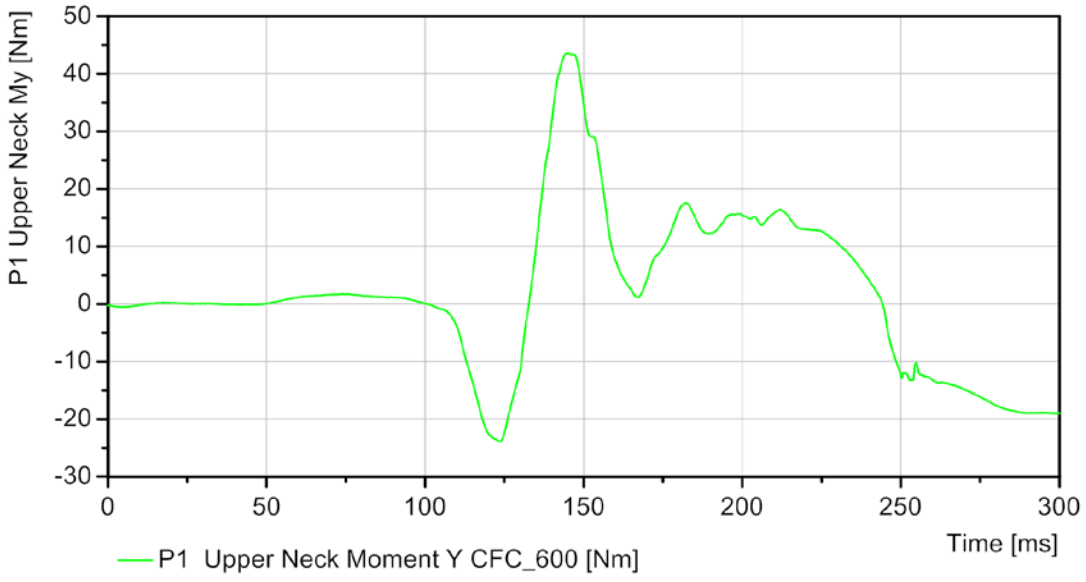
A.6.4 Test 6: ATD Sensor Data



Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

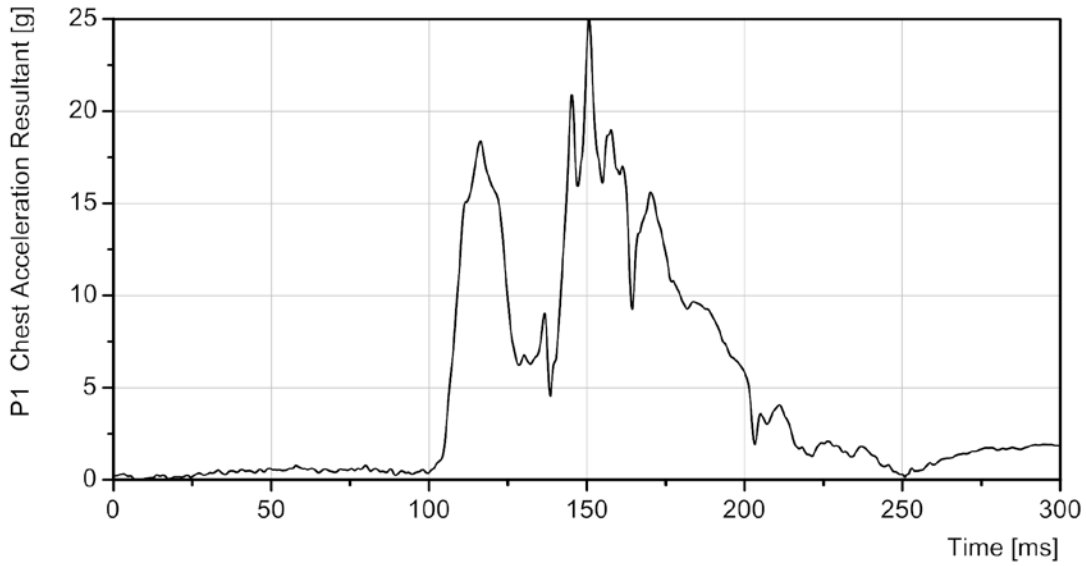
Upper Neck Forces

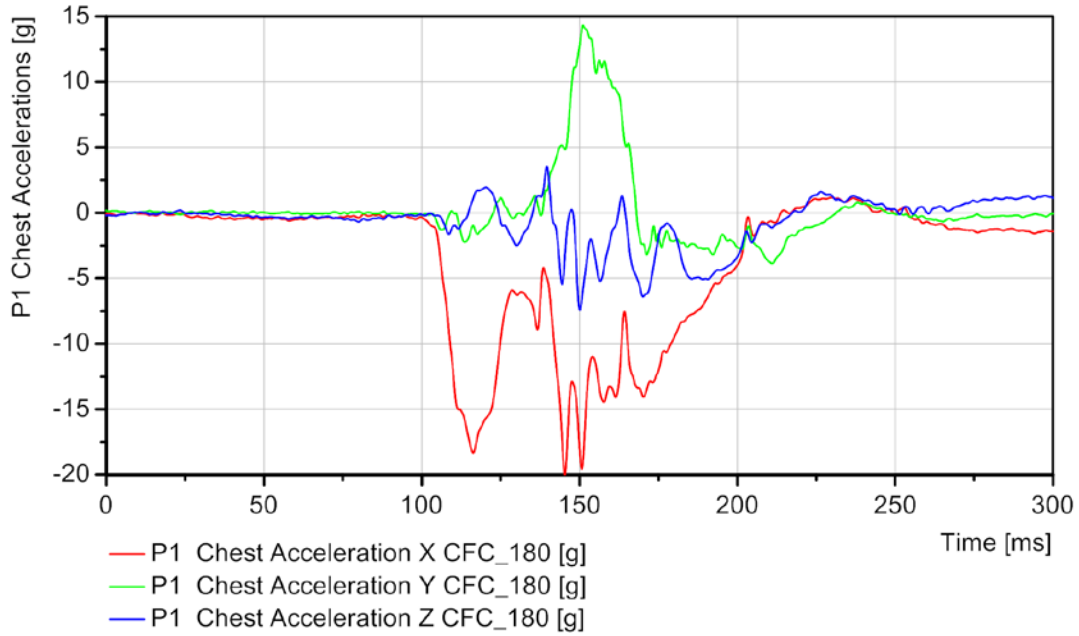




Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

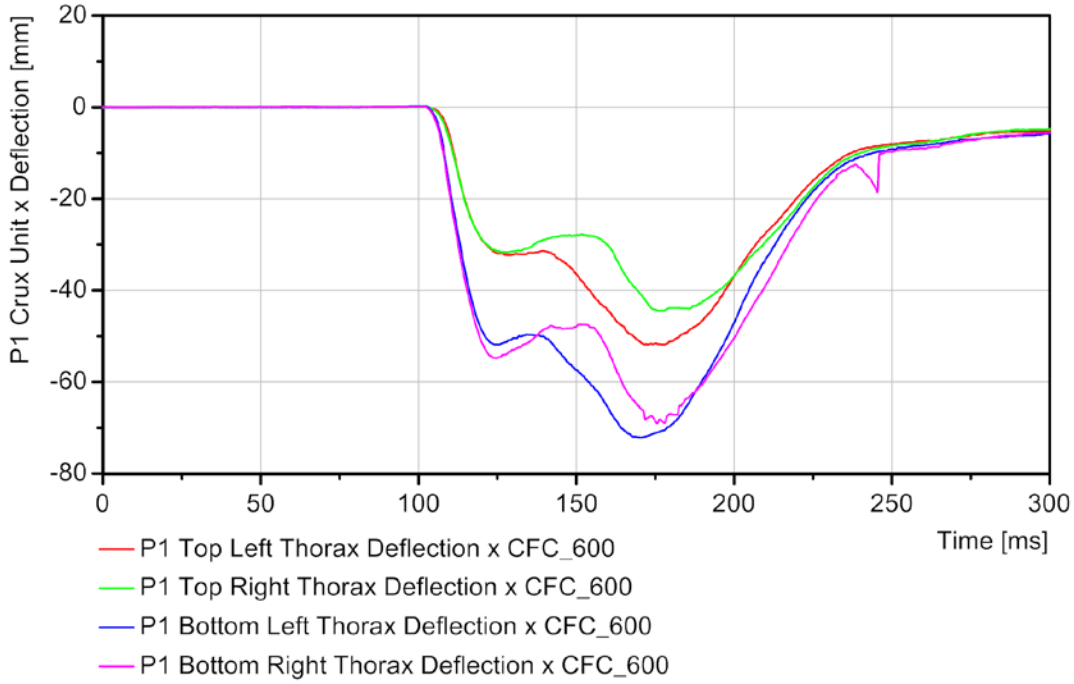
Chest Accelerations and Injury Criteria





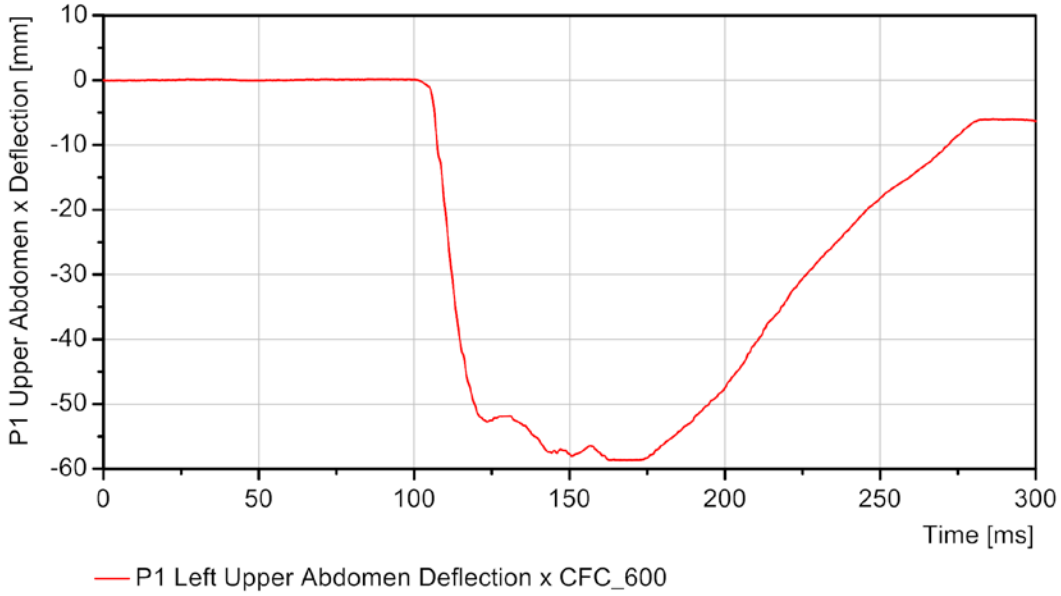
Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

Crux Unit Outputs

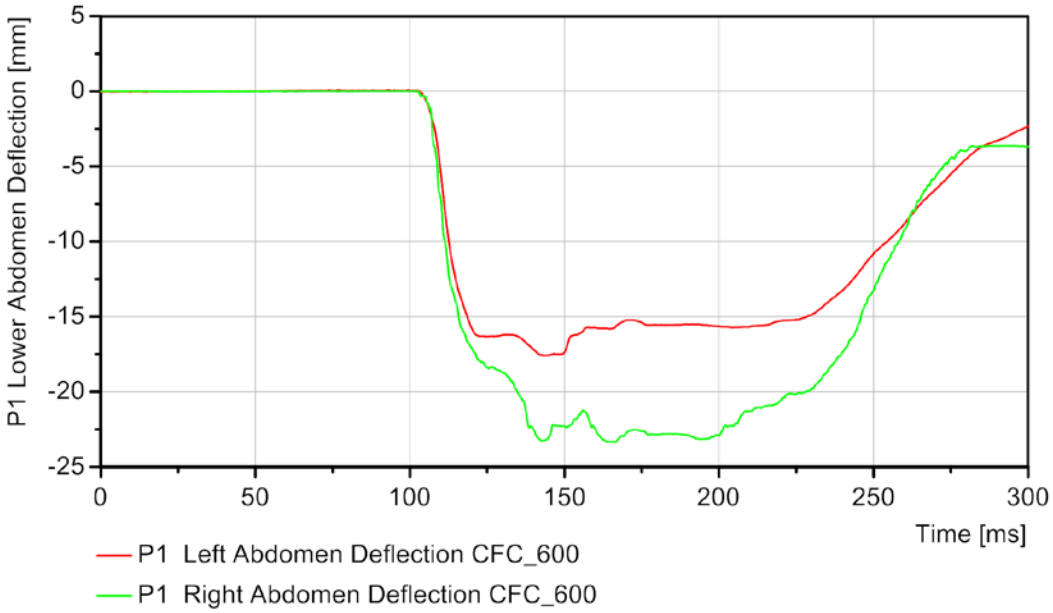


Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

DGSP Unit Outputs

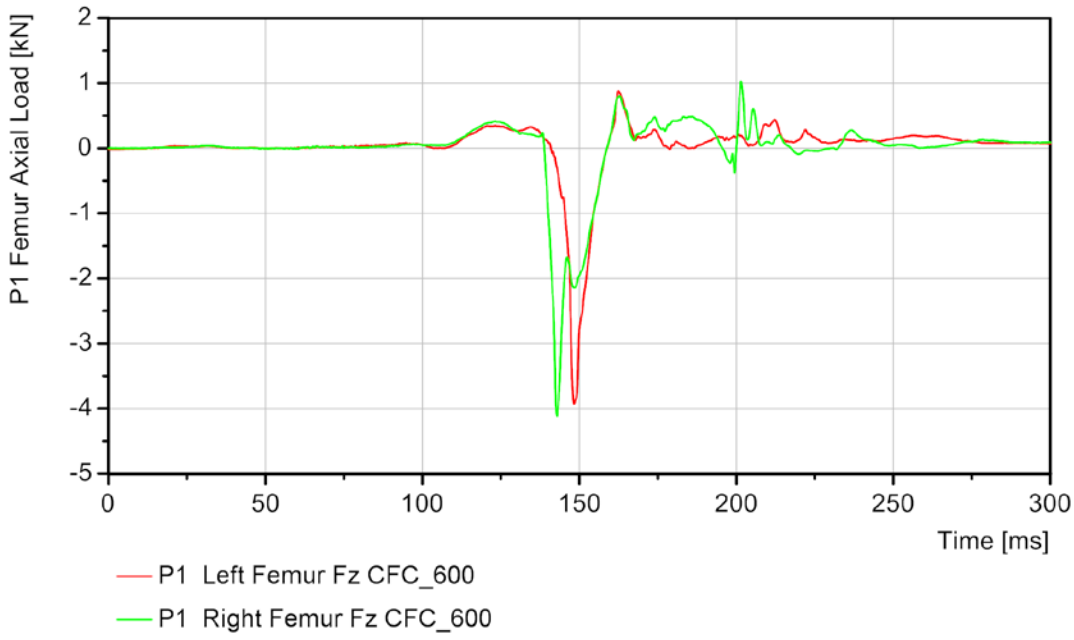


Lower Abdomen Deflections



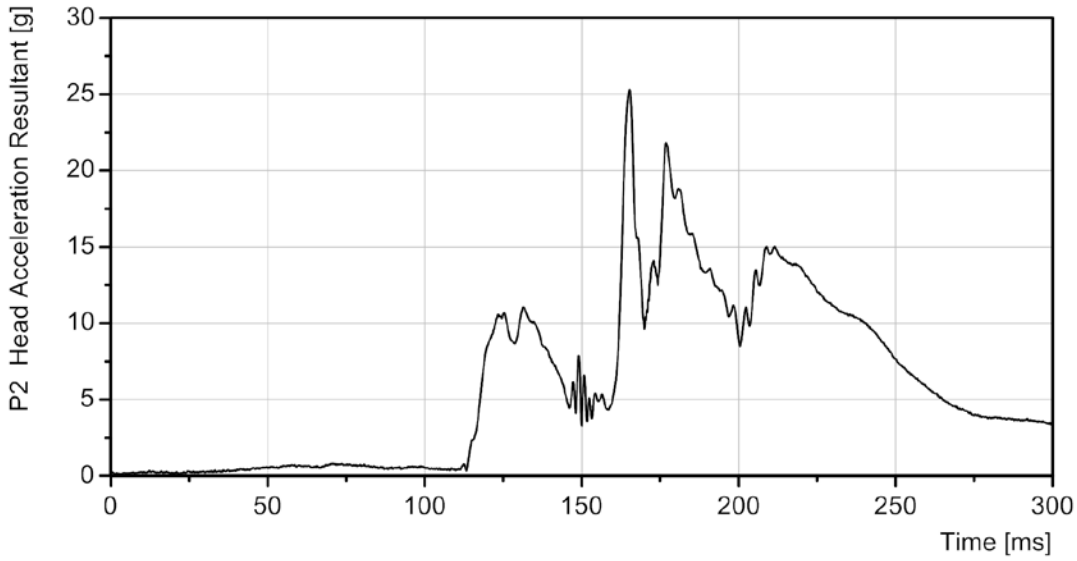
Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger1: Hybrid III RS 50th; Forward into Table; 1AF

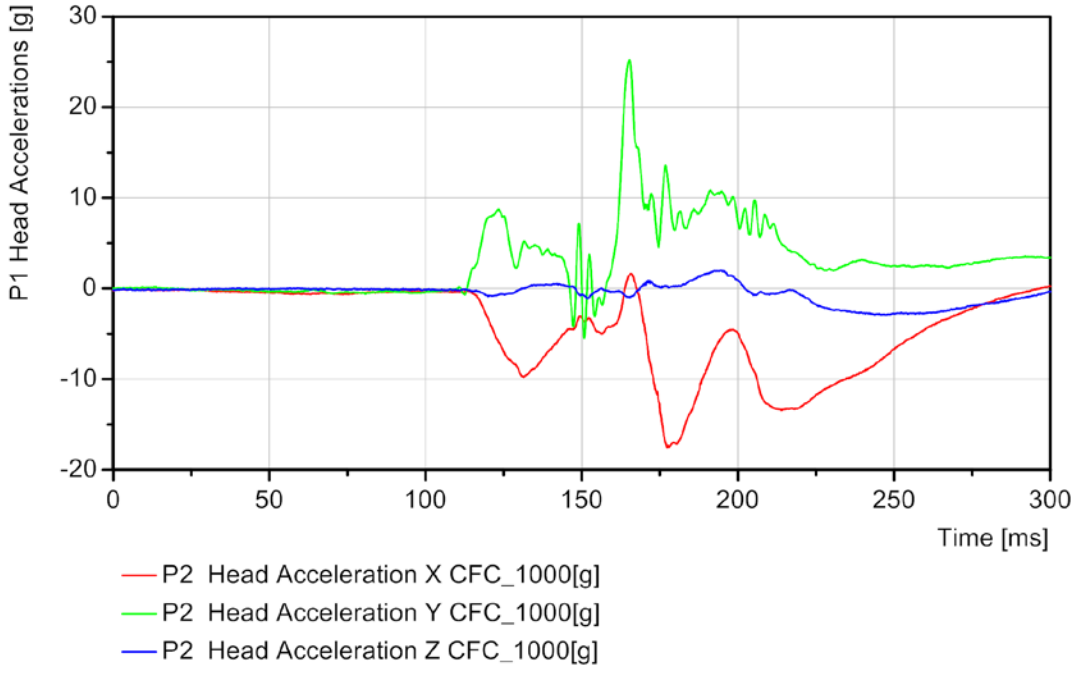
Femur Axial Loads



Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

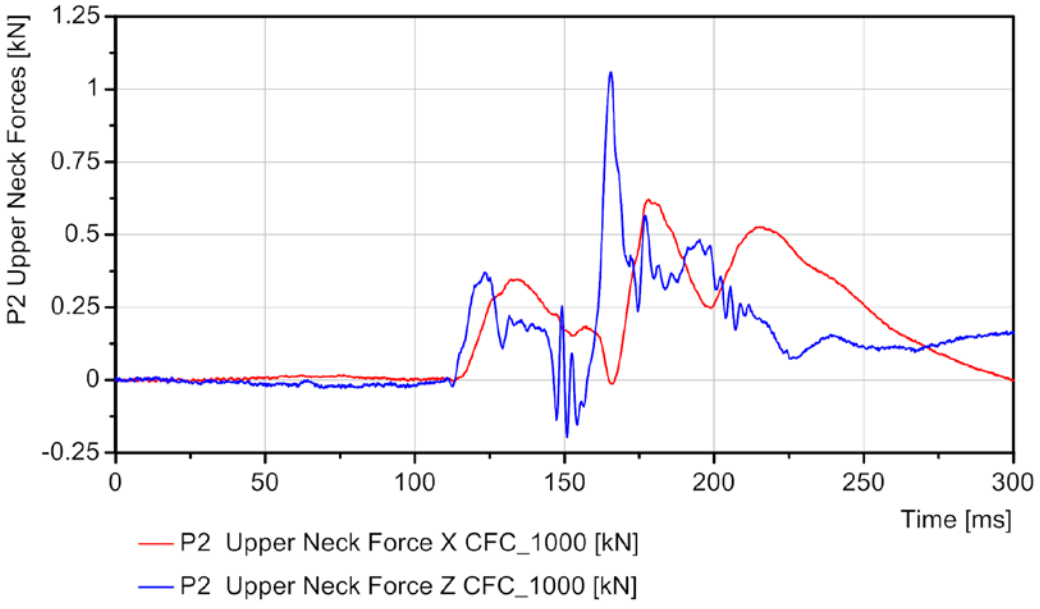
Head Accelerations and Injury Criteria



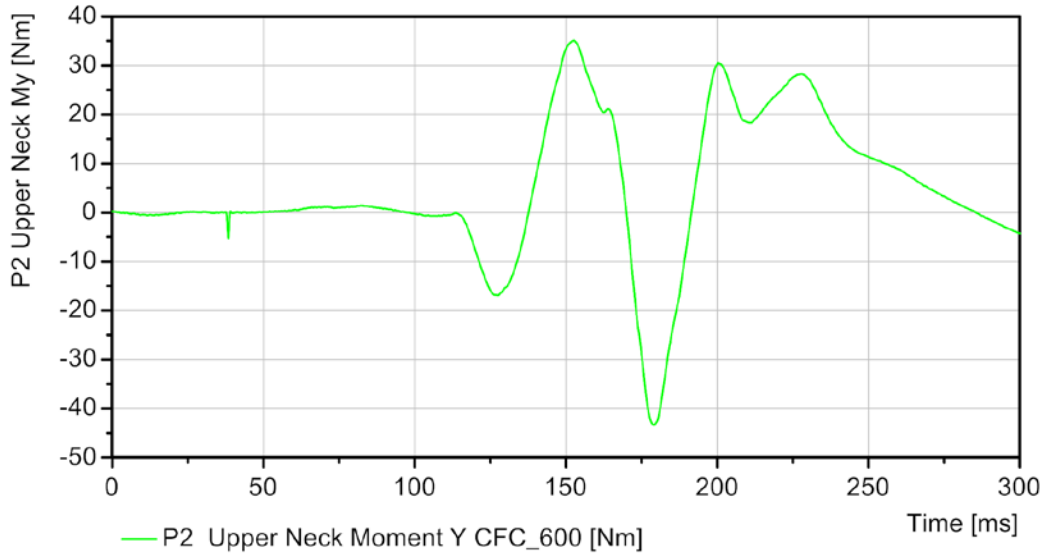


Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Upper Neck Forces

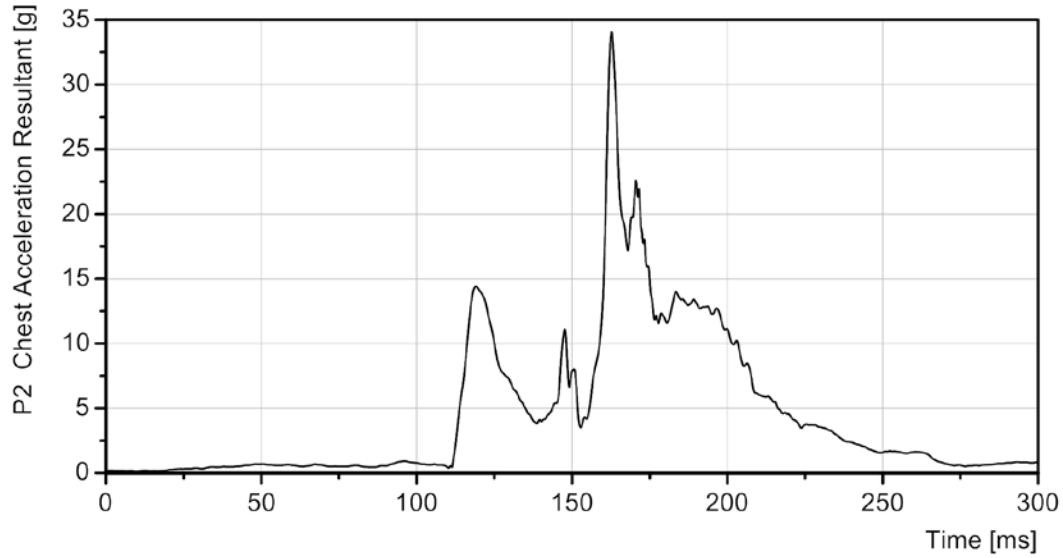


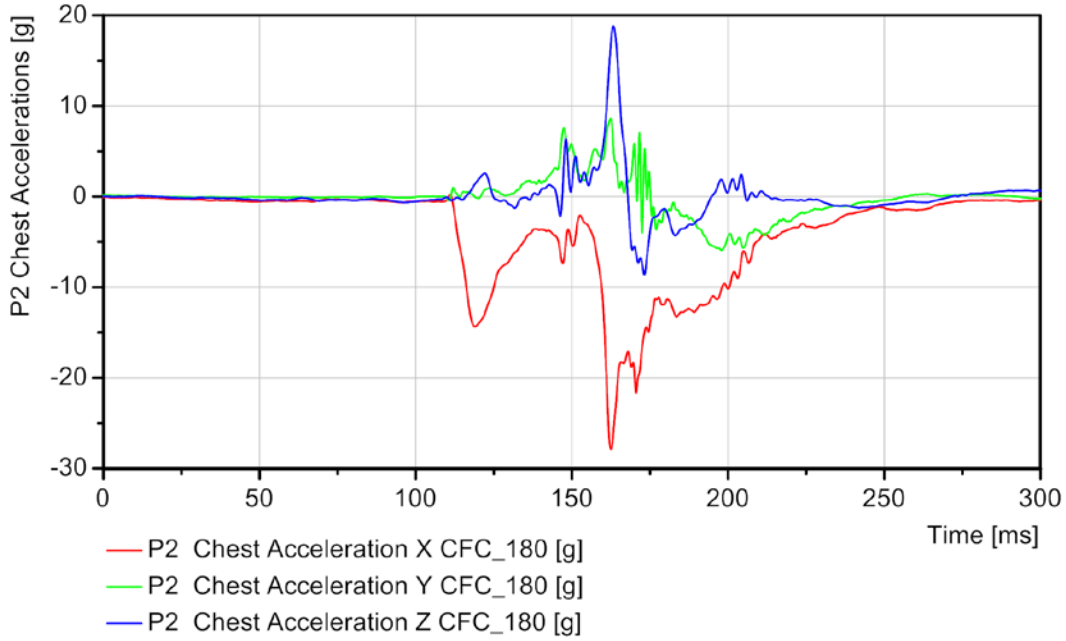
Upper Neck Moments



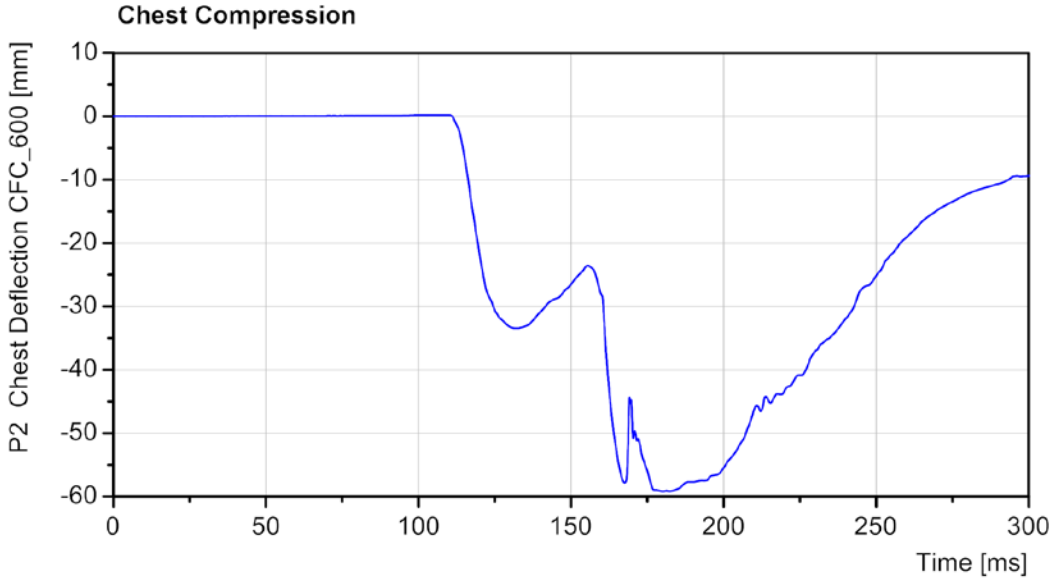
Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF

Chest Accelerations and Injury Criteria

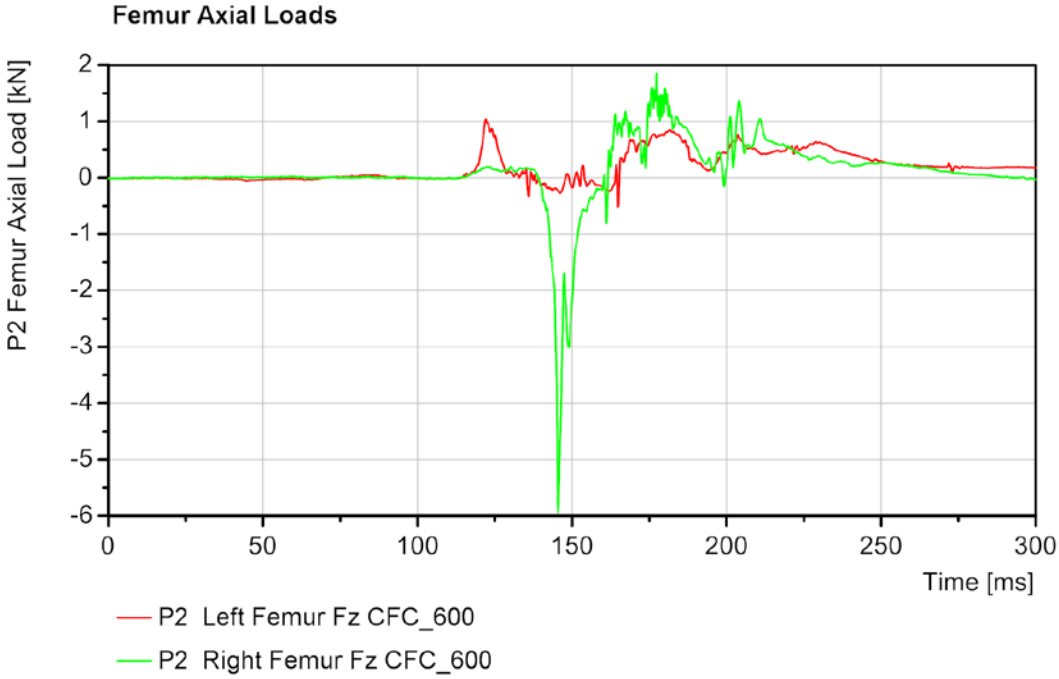




Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



Test Number: G300I06; Test Type: APTA PR-CS-S-018-13; Date: 05/08/15
Customer: Volpe Center; Speed: 8.94 m/s
Passenger2: Hybrid III 50th; Forward into Table; 1BF



Abbreviations and Acronyms

APTA	American Public Transportation Association
ATD	Anthropomorphic Test Device
H3-RS	Hybrid III Rail Safety ATD
NHTSA	National Highway Traffic Safety Administration
THOR	Test-device for Human Occupant Restraint (an ATD)