JRS Dynamic Rollover Test

2008 Ford Escape Hybrid

Sponsored By:

Automotive Safety Research Institute
Charlottesville, VA.

Vehicle Donated by:
State Farm Insurance Company
Chicago, IL.

Introduction

Center for Injury Research conducted a JRS dynamic rollover test consisting of one roll of a 2008 Ford Escape Hybrid on July 15, 2011. This test report is organized in sections containing test information, data tables and photographs as follows:

Section 1 – Test Procedures and Summaries

Section 2 – Test Results, Data Tables and Selected Comparison Photographs for Roll 1.

Section 3 – Data Graphs

Section 4 – All Test Photographs

Enclosed with this report is a DVD of the video of the test.

2008 Ford Escape Hybrid

Executive Summary

The test was a one roll event. The vehicle was tested at 5 degrees of pitch and 10 degrees of yaw with the roadbed. A Hybrid III dummy was placed in the driver seat tethered "out of position". The "out of position" tether holds the dummy towards the passenger side in a manner similar to how to the dummy would be positioned if it received a 1 g lateral acceleration. The tether was connected to a relay which released the dummy at roughly 30 deg of roll towards the passenger side. The same relay that released the dummy tether also fired the driver side curtain air bag. Table 1 describes the impact conditions. Table 2 shows the injury assessment reference values for the low durometer neck that was used.

The peak lower neck compressive load was 164 N and the peak lower neck moment was 161 N in flexion and 28 Nm in extension. Table 2 describes the lower neck IARV's 10% probability of injury. The peak intrusion speed at the top of the A-Pillar was 8.0 mph with a peak crush of 8.1 inches.

Table 1 Summary of Test Conditions

Roll	Pitch	Road Speed	Contact Angle	Roll Rate	Yaw	Drop Height
1	5.3 deg	14.8 mph	143 deg	176 deg/sec	10 deg	4 in.

Table 2 Lower Neck IARV's for 10% Probability of an AIS ≥ 3 Injury

Neck Type	My (Nm) Flexion	My (Nm) Extension	Mx (Nm)	Axial Fz (N)
Production	380	−156	268	4000
Low Durometer	90-110	−38-−46	59-90	1640-2000
Human/Cadaver	58			1500

1. Test Procedure and Summaries

The following steps were performed as necessary:

1. Inspect the test vehicle for prior damage, rust or other factors that might influence the outcome of the test
2. Prepare the test equipment
3. Install and prepare the instrumentation and video cameras
4. Install the test vehicle in test fixture
5. Perform pre-test measurements
6. Photograph the vehicle
7. Conduct the test
8. Perform post test measurements
9. Photograph the vehicle following the test

The vehicle was tested at 5 degrees of pitch and 10 degrees of yaw.

The test weight of the vehicle was 3,816 pounds. The initial weight of the vehicle was 3630 pounds. The test roll moment of inertia was approximately 556 lb*ft*sec^2 from a referenced value of 572 lb*ft*sec^2.

The vehicle was suspended on mounts at the rear and at the front in a manner that allowed it to roll freely and be dropped, passenger side (the near side) leading.

Due to the shape and location of the center console three string pots measuring the roof crush were mounted 5” lateral towards the passenger side from the longitudinal roll axis of the vehicle. The mounting positions of the string potentiometers resulted in less than 1% error in their measurements as compared to normal mounting locations, which place the string pots on the longitudinal axis. With the location of the driver’s side curtain airbag the roof headliner was removed around the mounting locations of the driver A-pillar and roof header string pots. The

driver B-pillar string pot cable was not able to be mounted without interfering with functionality of the curtain airbag. Static measurements were taken to get the residual crush at the B-Pillar. An instrumented, restrained Hybrid III 50th percentile male test dummy was placed in the driver's seat. The dummy was instrumented with upper and lower neck load cells as well as a triaxial head accelerometer. In addition, seat belt load cells were utilized.

Roll 1 was conducted with a Hybrid III dummy equipped with a more biofidelic (low durometer) neck and lumbar joint, located in the driver's seat which was positioned just reward of the mid seat position. Due to the dummy head interaction with the string pot cable the seat was moved 2" rearward. The dummy was restrained using the vehicle's standard 3 point harness with a non-deployed pre-tensioner. To make the Hybrid III dummy more biofidelic, the two cables in the lower spine of the dummy were removed. The lower neck mounting block was replaced with a block that increased the neck angle forward 30 degrees from the nominal position.

The dummy was tethered "out of position" with a light wire that electronically disconnected at approximately 30° of roll. The "out of position" location of the dummy was found by rotating the vehicle by 90° toward the passenger side. This orientation simulated the dummy accelerating toward the passenger side door at 1 g.

Six vertical and two lateral load cells were placed in the moving roadway to record the impact characteristics of the test.

Two string potentiometers were placed on the fixture support towers to record vehicle vertical motion characteristics during the test. One string potentiometer was located in the front drop tower and the other was located in the rear drop tower.

A roll encoder was placed on the cable pulley which pulls the moving roadway to record the roadway velocity throughout the test. In addition, a roll rate sensor was placed inside the vehicle.

The equipment used to conduct this test is listed in Table 3 and the test vehicle identification data is shown in Table 4 below.

Table 3 Equipment and Instrumentation

Item	MFR./Model
String Potentiometer – Driver's Side A-Pillar	Space Age Control – 301432
String Potentiometer – Driver's Side B-Pillar	Space Age Control – 301432
String Potentiometer – Roof Header	Space Age Control – 301432
String Potentiometer – Passenger's Side A-Pillar	Space Age Control – 301432
String Potentiometer – Front Fixture Support Tower	Space Age Control – 4332-01
String Potentiometer – Rear Fixture Support Tower	Space Age Control – 4332-01
Upper Neck Load Cell	RA Denton 1716A
Lower Neck Load Cell	RA Denton 1794A
Triaxial Head Accelerometer	Endevco, 7264C-2KTZ-2-240
Belt Load Cell - Lap	RADenton 3255
Belt Load Cell - Torso	RADenton 3255
Roll Rate Sensor	DTS ARS
Hybrid III, 50th Percentile Male	Denton 50th Male
Vertical Load Cell 1	Transducer Techniques, SWP-20k – 173372
Vertical Load Cell 2	Transducer Techniques, SWP-20k – 176138
Vertical Load Cell 3	Transducer Techniques, SWP-20k – 176139
Vertical Load Cell 4	Transducer Techniques, SWP-20k – 176140
Vertical Load Cell 5	Transducer Techniques, SWP-20k – 176141
Vertical Load Cell 6	Transducer Techniques, SWP-20k – 176142
Lateral Load Cell 1	Transducer Techniques, DSM-8k – 149806
Lateral Load Cell 2	Transducer Techniques, DSM-8k – 149807
Roadway Velocity Roll Encoder	Contelec – RSC 2201 236 111 106
Vehicle Data Acquisition System	Diversified Technical Systems, TDAS PRO SIM
Roadway Data Acquisition System	Diversified Technical Systems, TDAS PRO SIM
JRS Fixture Acquisition System	Measurement Computing, USB – 1608FS

Table 4 General Test Vehicle Data Test Vehicle: 2008 Ford Escape

Test Vehicle Information:	
Manufacturer: Ford	VIN: 1FMCU49H28KA38925
Gross Weight: 4,680 lb	Curb Weight: 3,667 lb
Sunroof: Yes	2WD/4WD: 2WD
Equivalent Years: 2001-2010	Body Type: 4 Door Multi-Purpose Vehicle

2. Test Results, Data Tables and Selected Comparison Photographs for Roll 1.

The results of the first roll of the JRS Dynamic Rollover Test are presented in this section. In the roll, the vehicle dropped as planned and contacted the vehicle's roof structure.

Roll 1 – 7/15/2011

Summary of Results

Instrument	Peak Value	Residual Intrusion (inches)	Peak Velocity (mph)
Sum of Vertical Load Cells (near side contact)	12,079 lb		
Sum of Vertical Load Cells (far side contact)	15,314 lb		
Sum of Lateral Load Cells (near side contact)	689 lb		
Sum of Lateral Load Cells (far side contact)	776 lb		
Driver's Side A-Pillar String Potentiometer	-8.1 in	-4.5	-8.0
Driver's Side B-Pillar String Potentiometer	NA	-2.5*	NA
Roof Header String Potentiometer	-7.4 in	-4.0	-6.7
Passenger's Side A-Pillar String Potentiometer	-2.1 in	-1.0	-2.5

*Based on static measurements taken pre and post test

Instrument	Maximum Value	Minimum Value
Lap Belt Load	207 lb	-5 lb
Shoulder Belt Load	134 lb	-4 lb
Dummy Head Acceleration Ax	26 g	-27 g
Dummy Head Acceleration Ay	29 g	-17 g
Dummy Head Acceleration Az	7 g	-31 g
Lower Neck Load Cell Fx	926 N	-598 N
Lower Neck Load Cell Fy	96 N	-175 N
Lower Neck Load Cell Fz	164 N	-1,436 N
Lower Neck Load Cell Mx	11 Nm	-28 Nm
Lower Neck Load Cell My	161 Nm	-28 Nm
Upper Neck Load Cell Fz	92 N	-1,913 N
HIC	66	N/A

The vertical load cells mounted on the roadway platform show the near and far side impacts. The vehicle struck the roadway on the near side at approximately 1.77 seconds. The entire roll sequence was completed by approximately 2.1 seconds.

The string potentiometers located on the fixture support towers show the vertical vehicle motion throughout the test. The front of the vehicle dropped 4.5 inches and the rear dropped 3.2 inches prior to initial touchdown. The vehicle was pitched at 5.3 degrees at contact.

The roll encoder located on the cable pulley shows the roadway velocity throughout the roll. The roadway was traveling at 14.8 mph at contact. A roll rate sensor in the vehicle was used to determine the roll angle and rate at impact. The roll angle of the vehicle was 143 degrees and the roll rate was 176 degrees per second at the roadway impact.

During the first roll the windshield fractured and peeled away from the driver side A-pillar. Due to the roof rack mounting location a buckle formed inside of the roof rail on the driver side. The hybrid battery in the rear of the vehicle was undamaged. No side windows failed during test. Figure 1 shows all the windows intact after the impact. A subsequent event following the testing event caused the driver rear window to fail, but did not affect the outcome of the test.

Figure 1. Photo Illustrating No Window Failures During Impact

Pull tests were conducted on both the driver side doors of the vehicle after the first roll. The driver front door required 32lbs of force. The passenger front door required 38lbs to open. Due to the damage of the driver rear door handle a pull test could not be performed. The passenger rear door opened with 18.4lbs and was considered the nominal force required to open the door as no visible damage to the passenger rear door was observed.

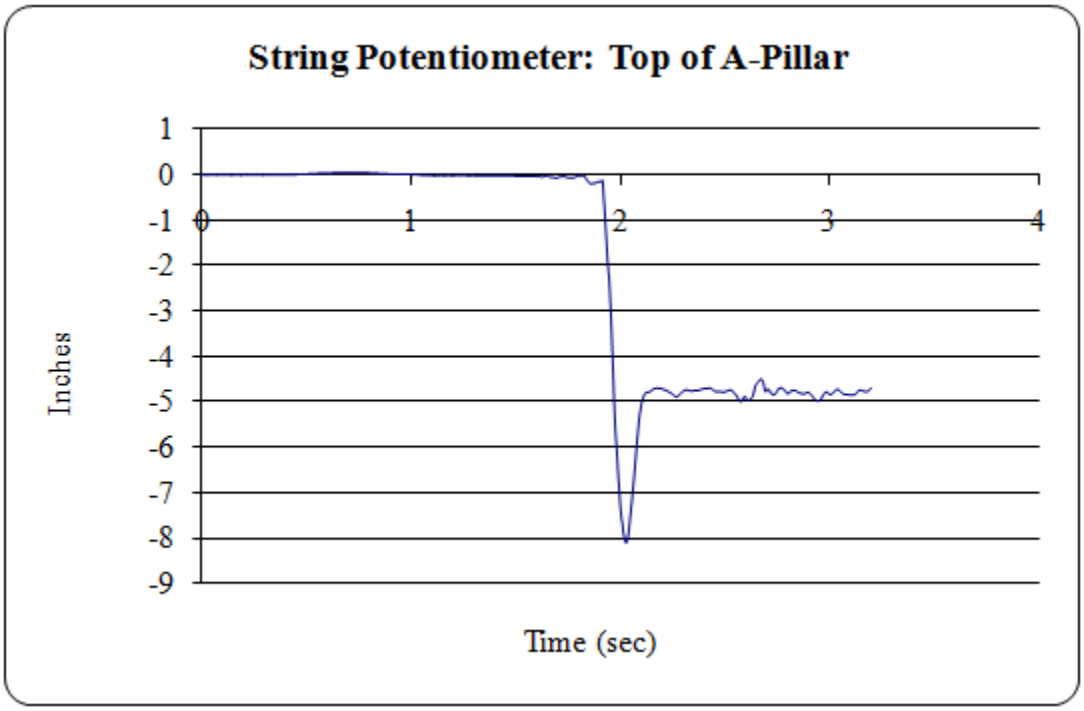
Roll 1 Comparison Photographs

Figure 1: Vehicle Pre Roll 1

Figure 2: Vehicle Post Roll 1

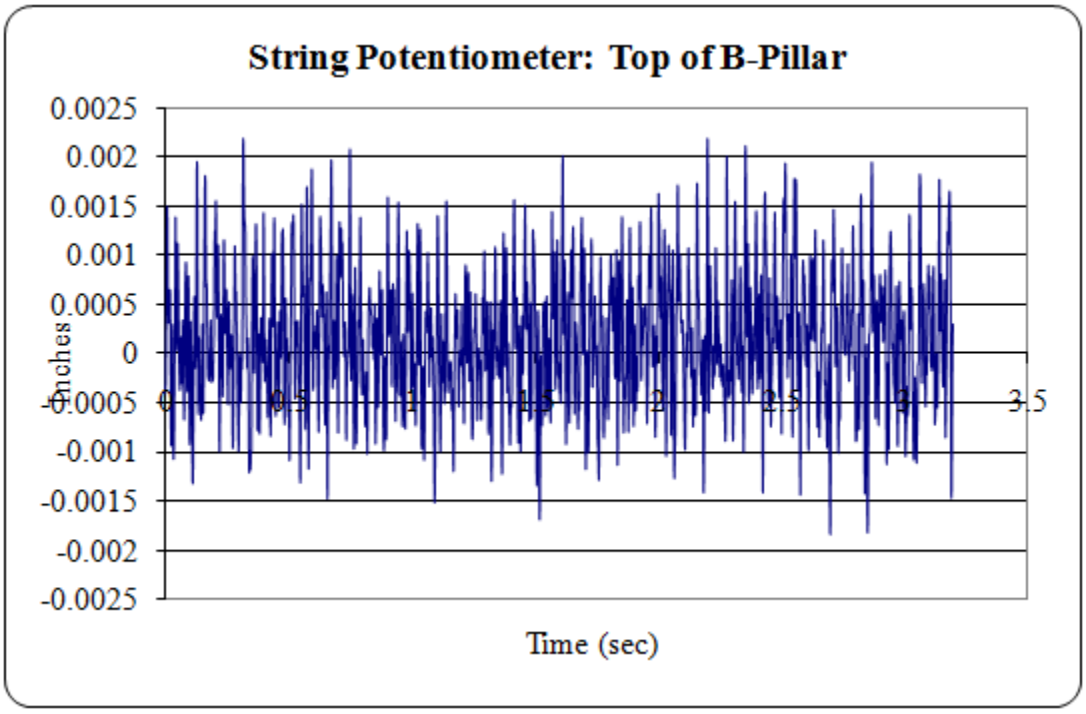
3. Data Graphs

Roll 1 Data Plots – 7/15/2011



Plot 1: String Potentiometer Driver's Side A-Pillar Displacement v. Time

Data Sampling Rate: 10 kHz

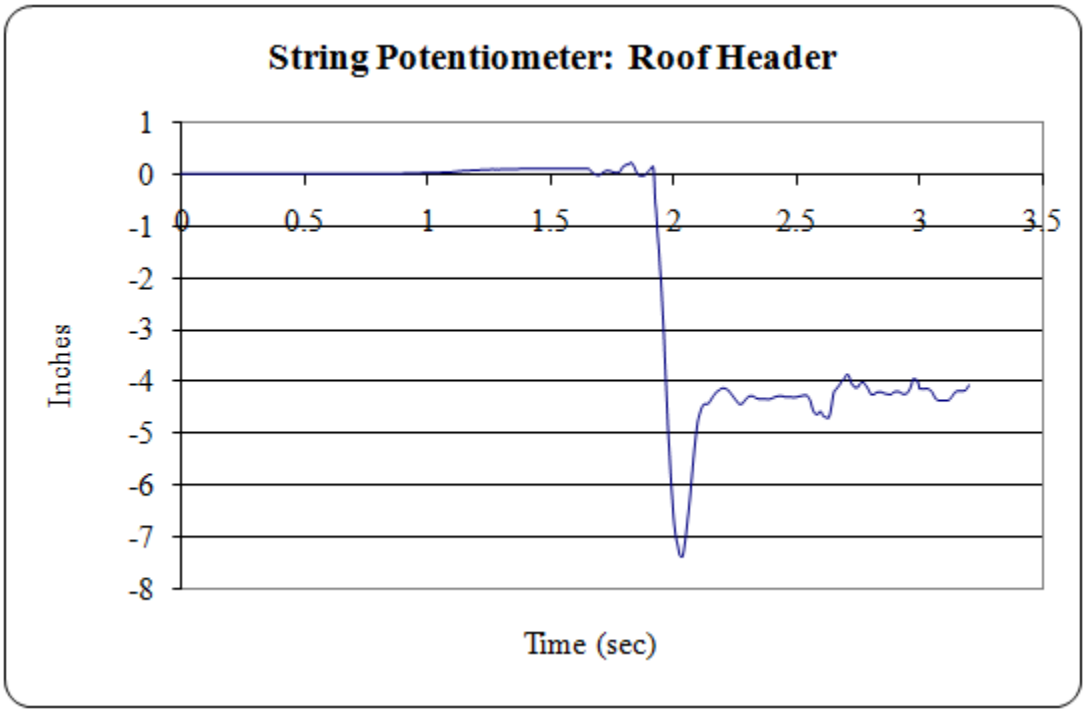


Plot 2: String Potentiometer Driver's Side B-Pillar Displacement v. Time*

*The B-pillar string pot was not used to allow full functionality of the side curtain airbag.

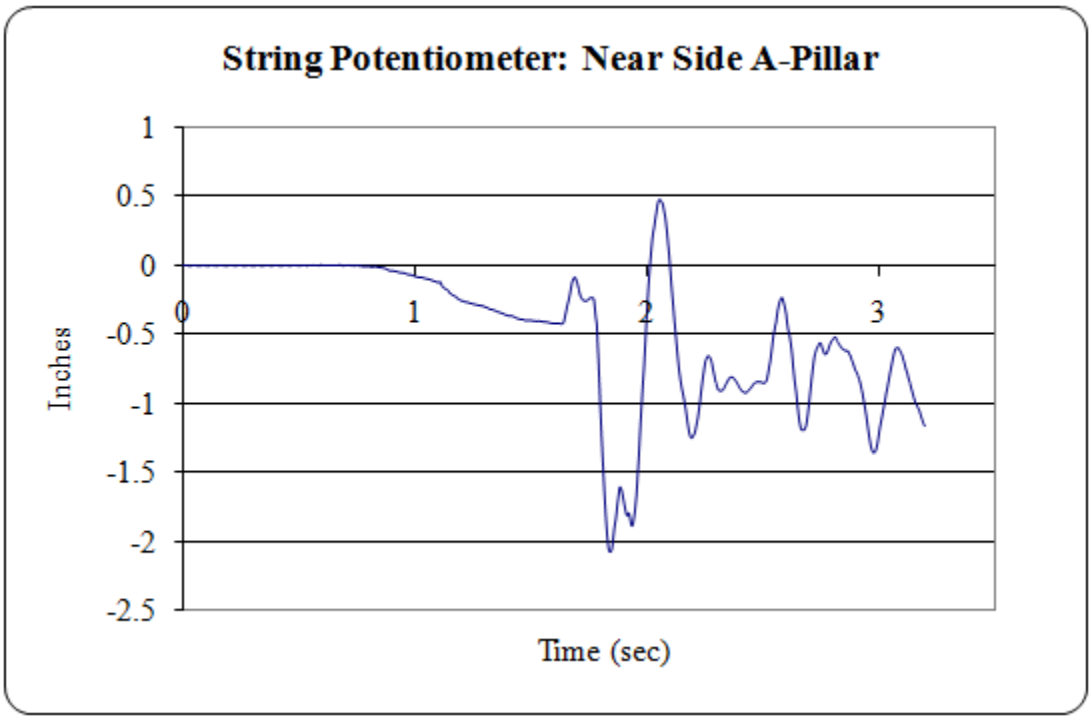
Data Sampling Rate: 10 kHz

Roll 1



Plot 3: String Potentiometer Driver's Side Roof Header Displacement v. Time

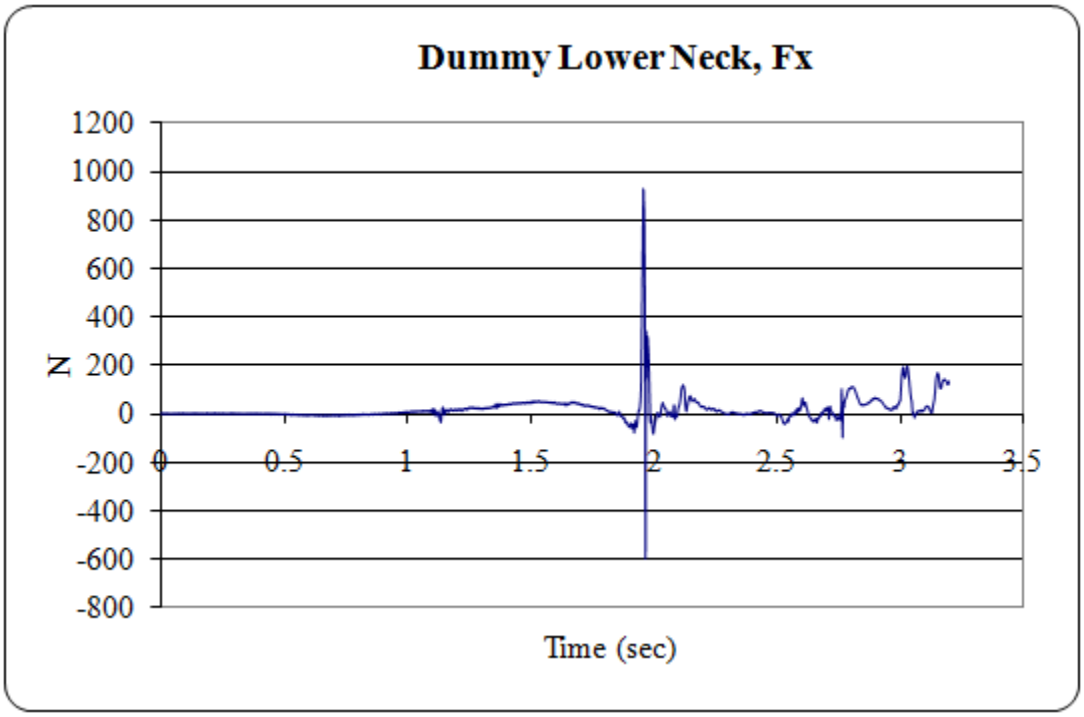
Data Sampling Rate: 10 kHz



Plot 4: String Potentiometer Passenger's Side A-Pillar Displacement v. Time

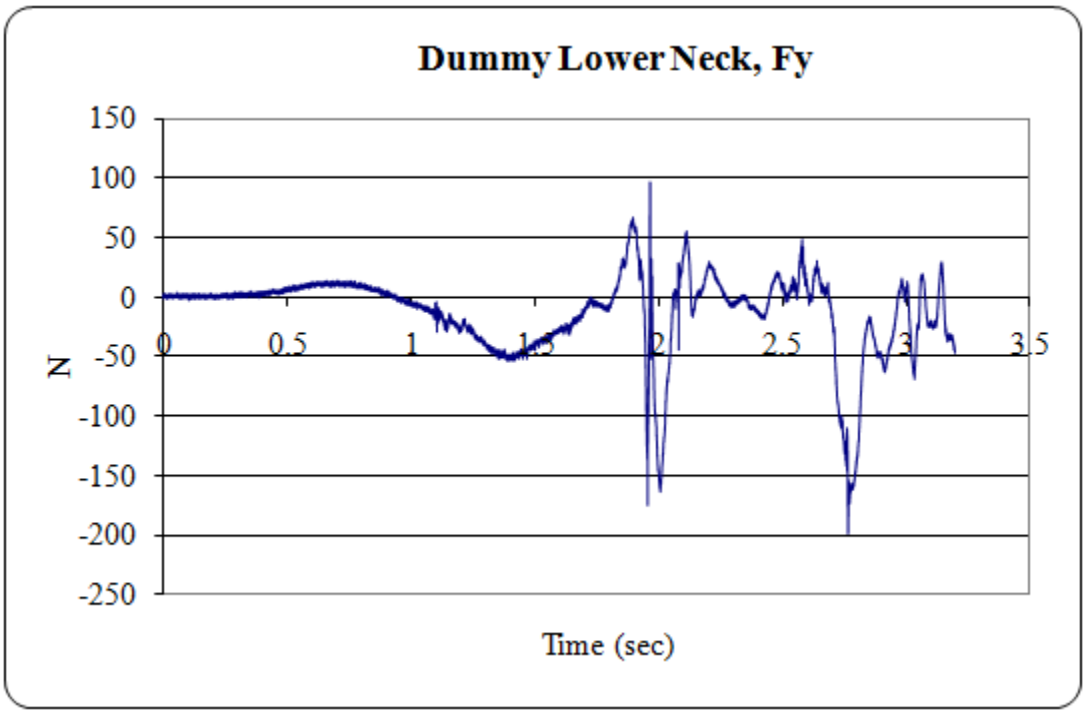
Data Sampling Rate: 10 kHz

Roll 1



Plot 5: Lower Neck Load, Fx, v. Time

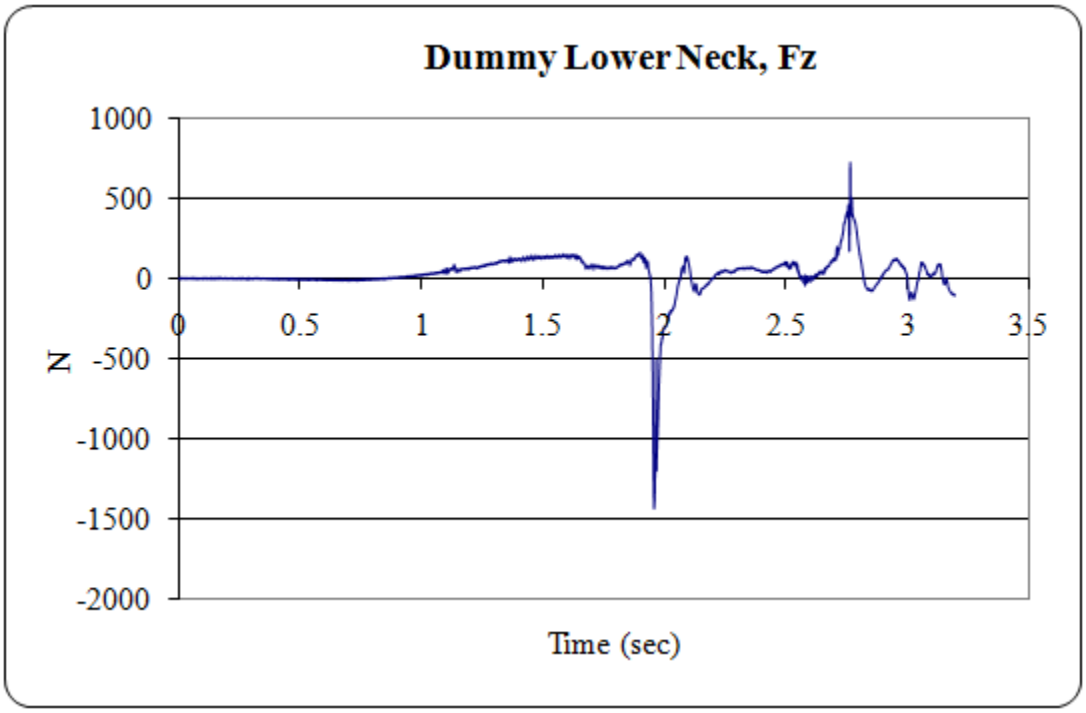
Data Sampling Rate: 10 kHz



Plot 6: Lower Neck Load, Fy, v. Time

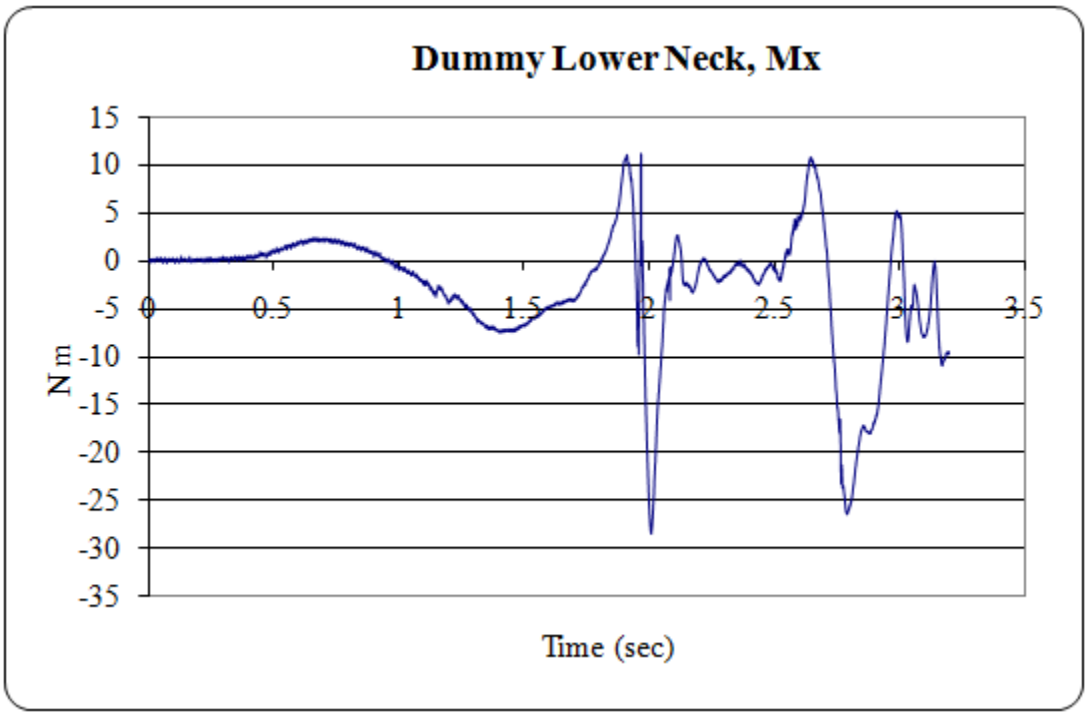
Data Sampling Rate: 10 kHz

Roll 1



Plot 7: Lower Neck Load, Fz, v. Time

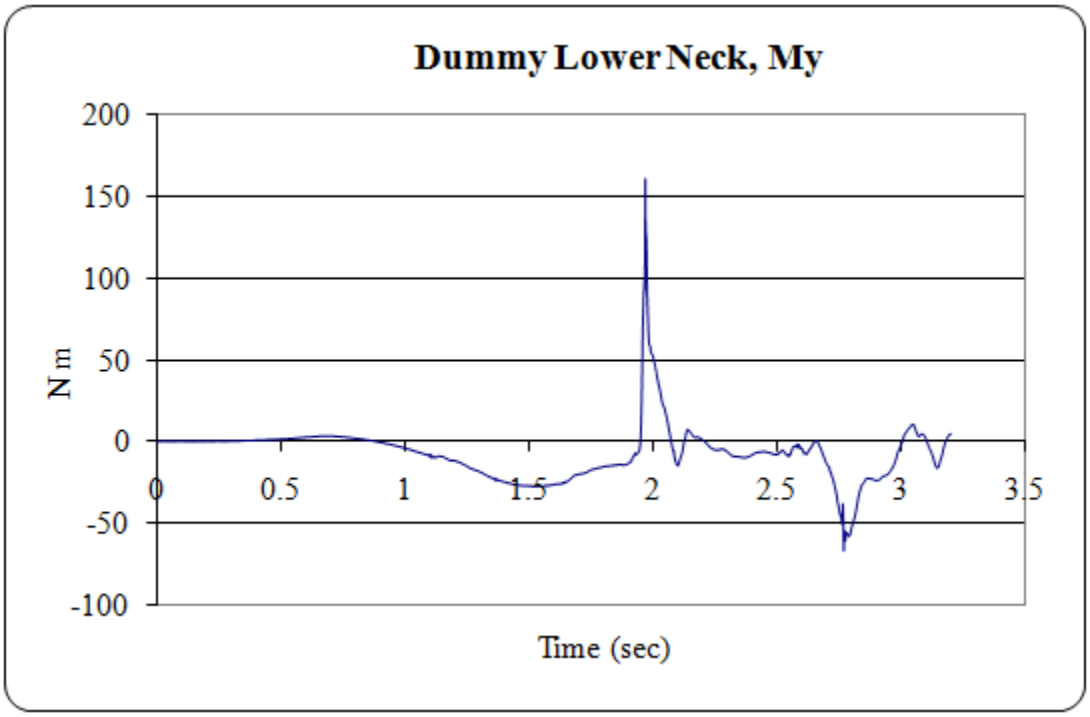
Data Sampling Rate: 10 kHz



Plot 8: Lower Neck Load, Mx, v. Time

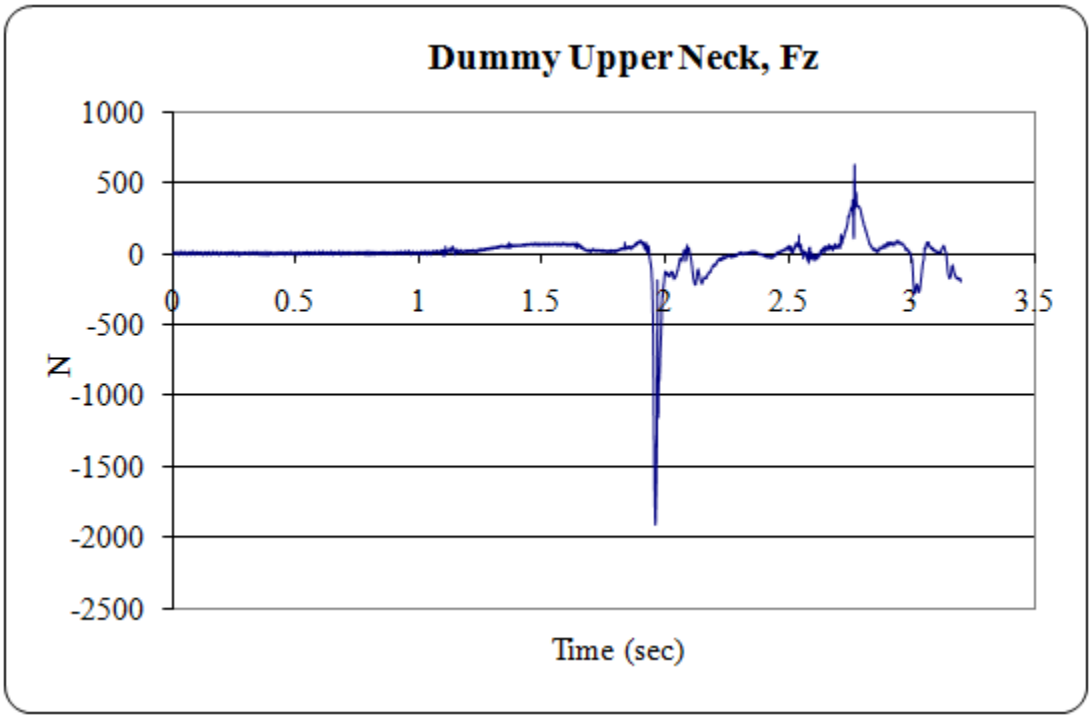
Data Sampling Rate: 10 kHz

Roll 1



Plot 9: Lower Neck Load, My, v. Time

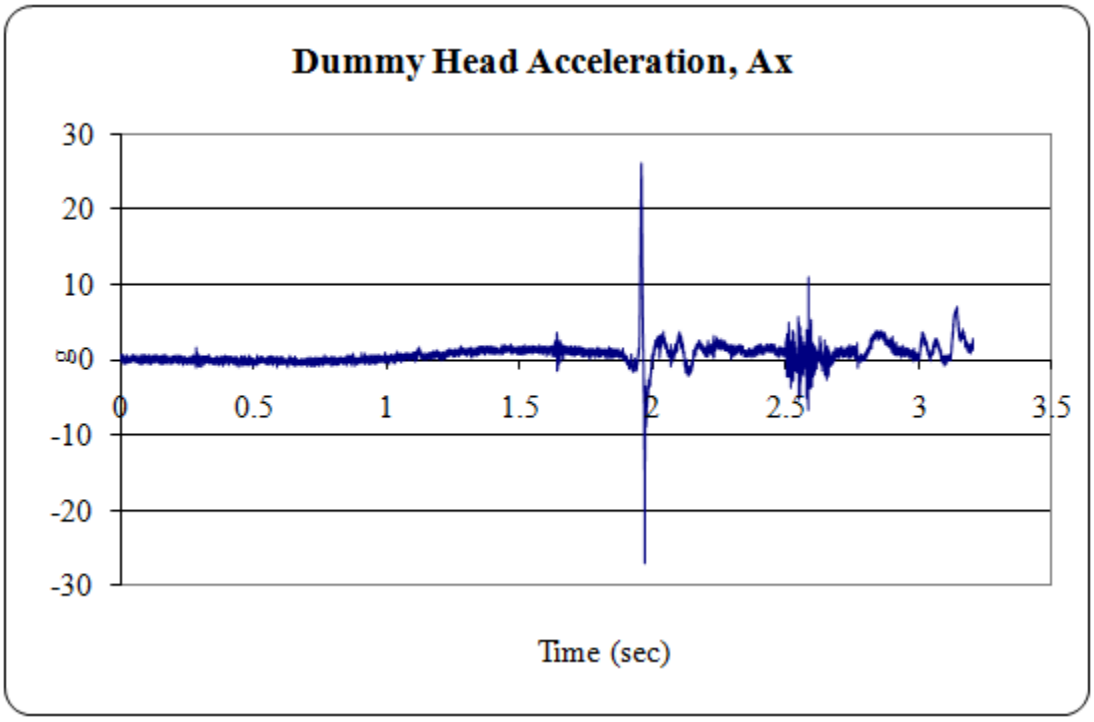
Data Sampling Rate: 10 kHz



Plot 10: Upper Neck Load, Fz, v. Time

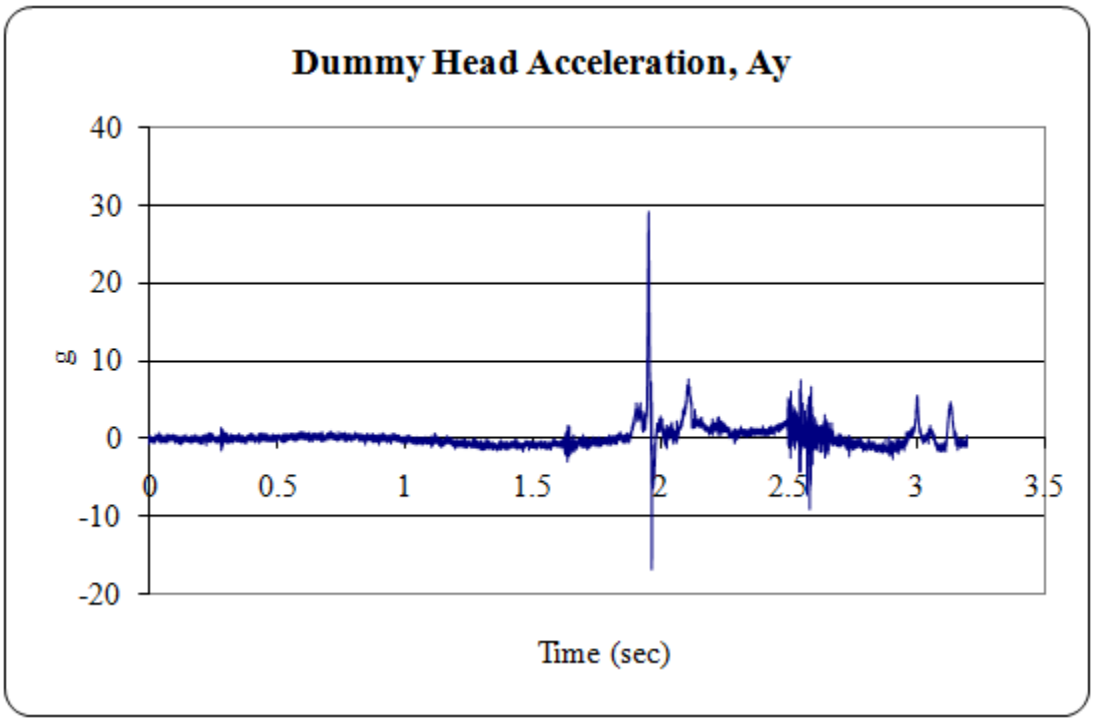
Data Sampling Rate: 10 kHz

Roll 1



Plot 11: Head Acceleration, Ax, vs. Time

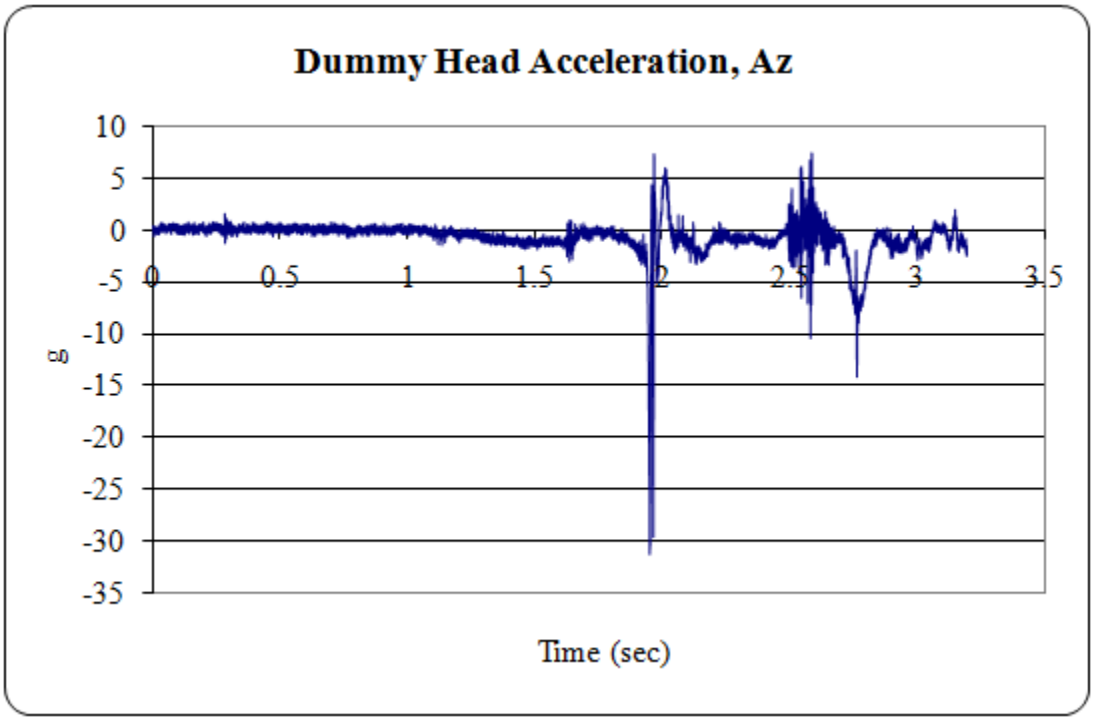
Data Sampling Rate: 10 kHz



Plot 12: Head Acceleration, Ay, vs. Time

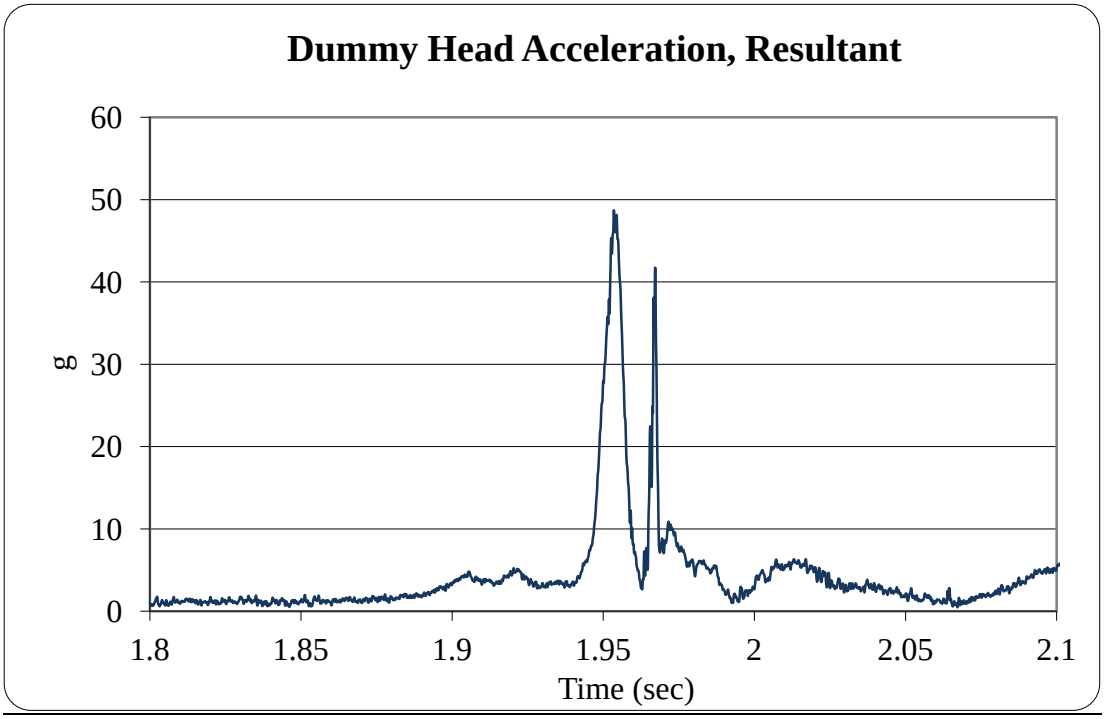
Data Sampling Rate: 10 kHz

Roll 1



Plot 13: Head Acceleration, Az, vs. Time

Data Sampling Rate: 10 kHz

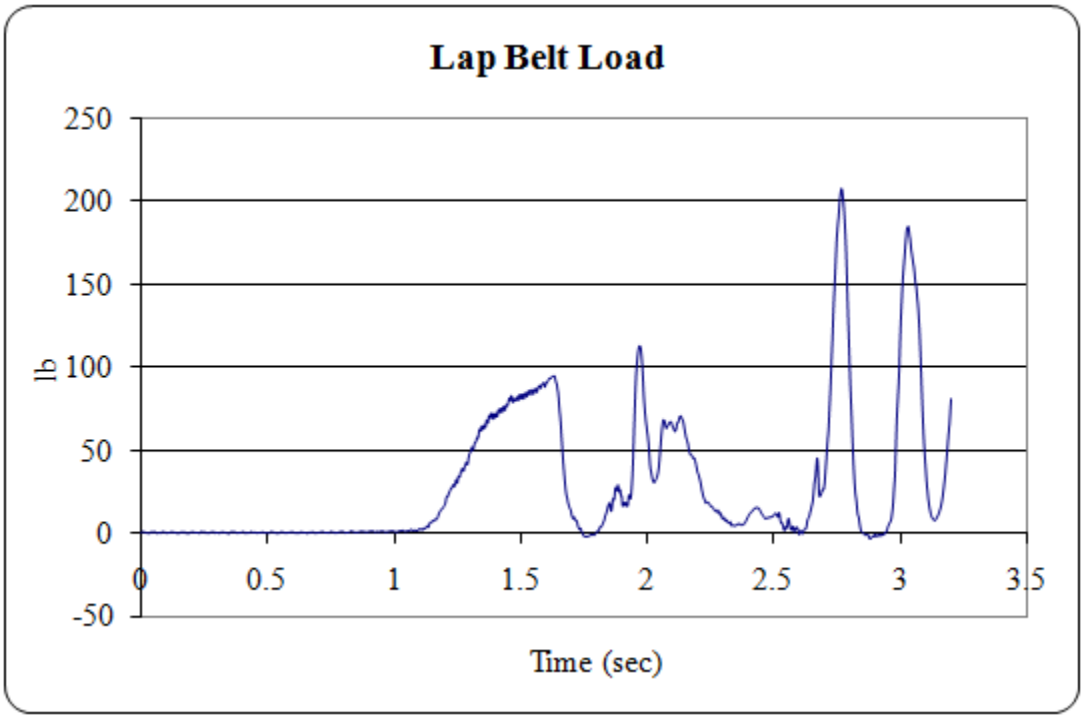


Plot 14: Resultant Head Acceleration vs. Time

HIC = 66

Data Sampling Rate: 10 kHz

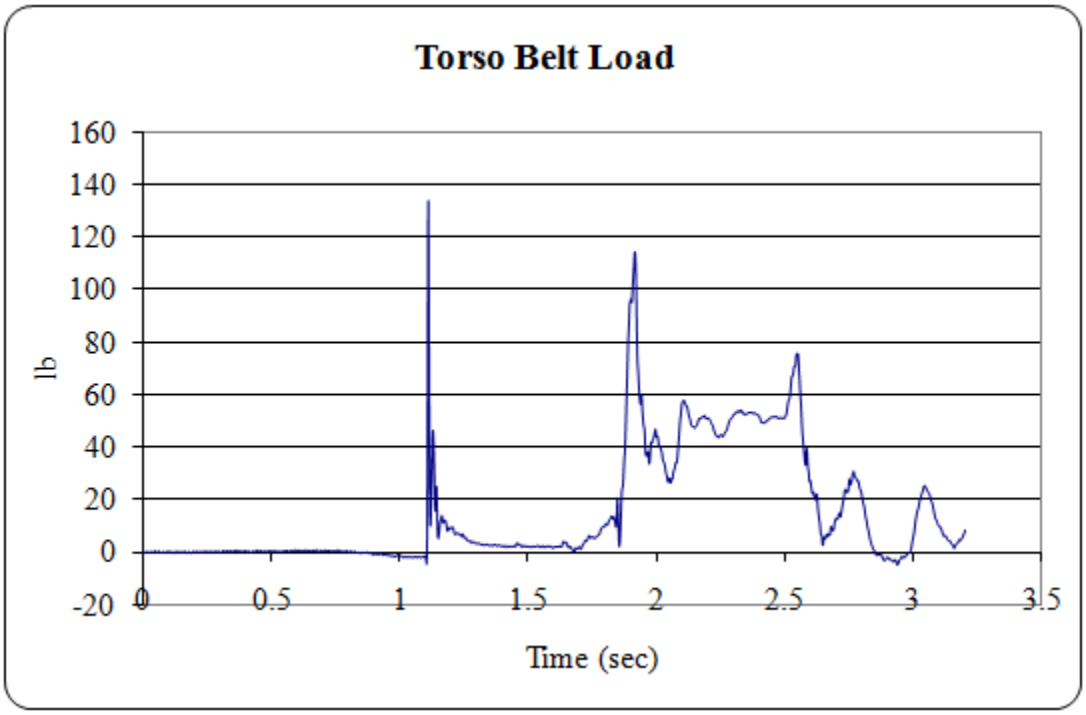
Roll 1



Plot 15: Lap Belt Load* vs. Time

*Measured on one side of the belt

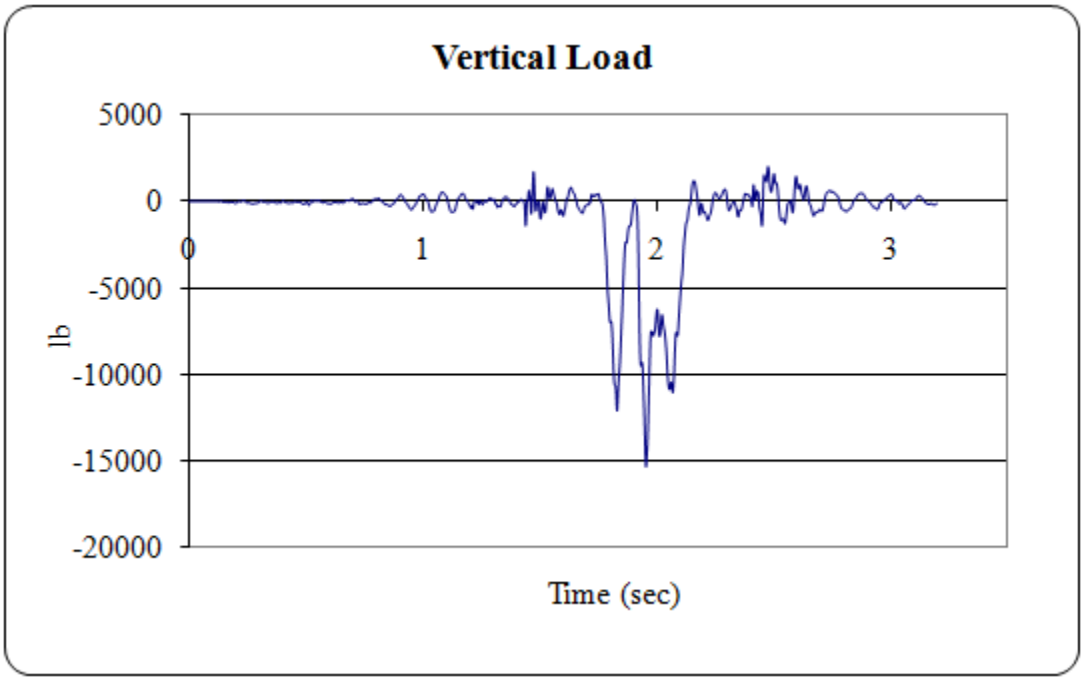
Data Sampling Rate: 10 kHz



Plot 16: Torso Belt Load* vs. Time

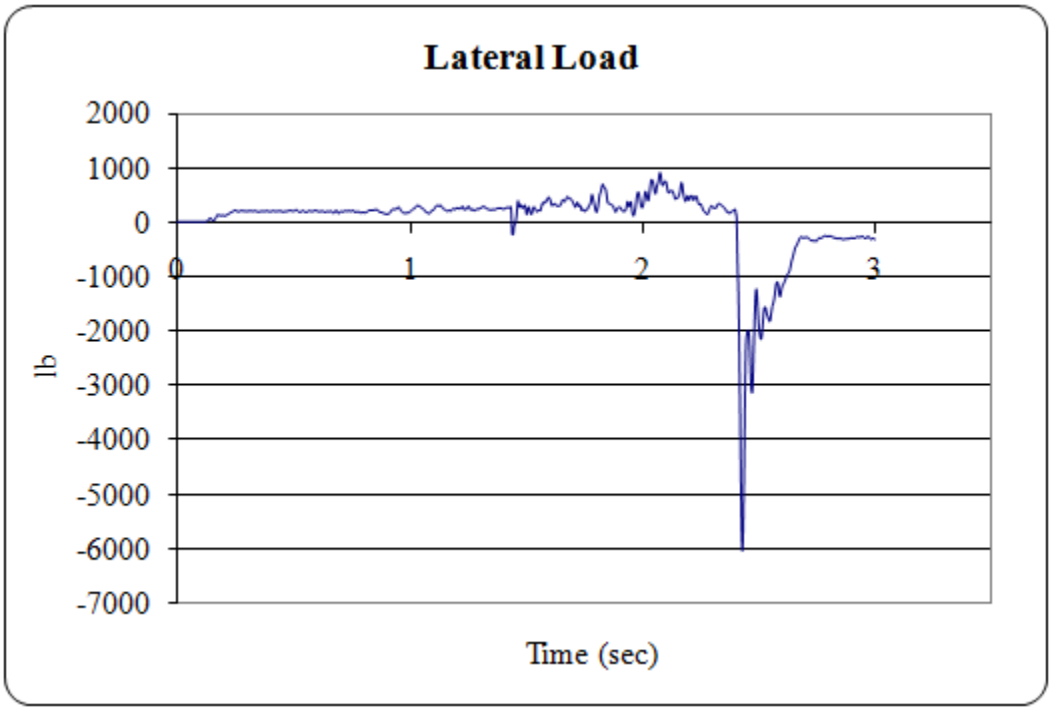
*Measured on one side of the belt
Data Sampling Rate: 10 kHz

Roll 1



Plot 17: Total Vertical Load v. Time

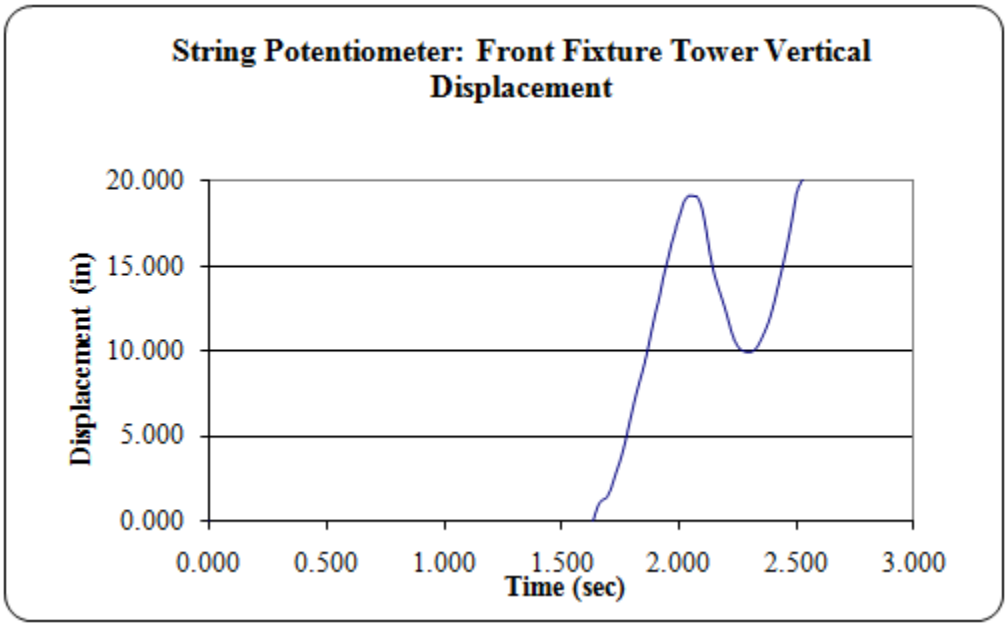
Data Sampling Rate: 10 kHz



Plot 18: Total Lateral Load v. Time

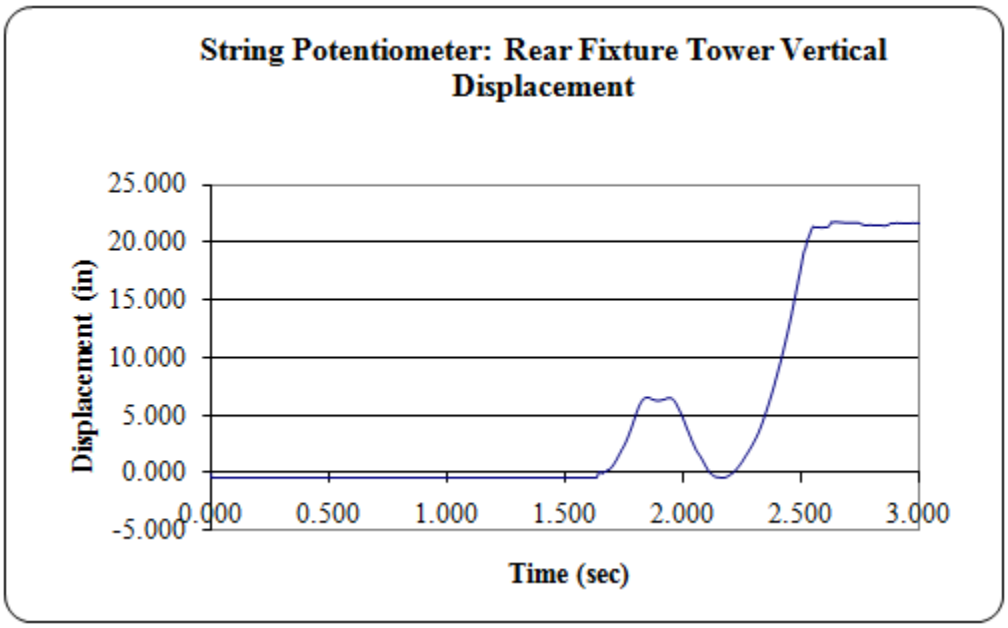
Data Sampling Rate: 10 kHz

Roll 1



Plot 19: String Potentiometer Front Fixture Support Tower Displacement vs. Time

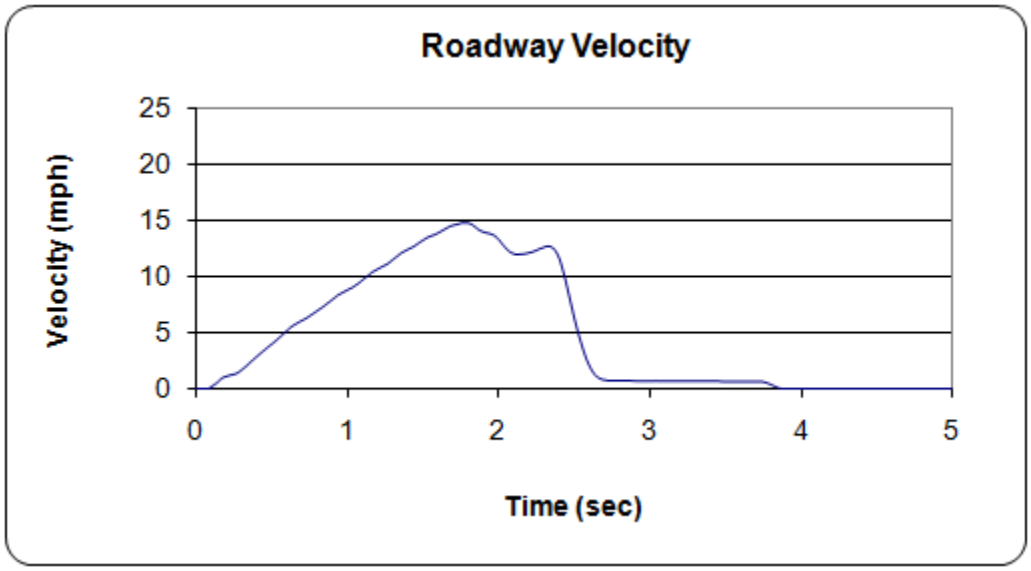
Data Sampling Rate: 1 kHz



Plot 20: String Potentiometer Rear Fixture Support Tower Displacement vs. Time

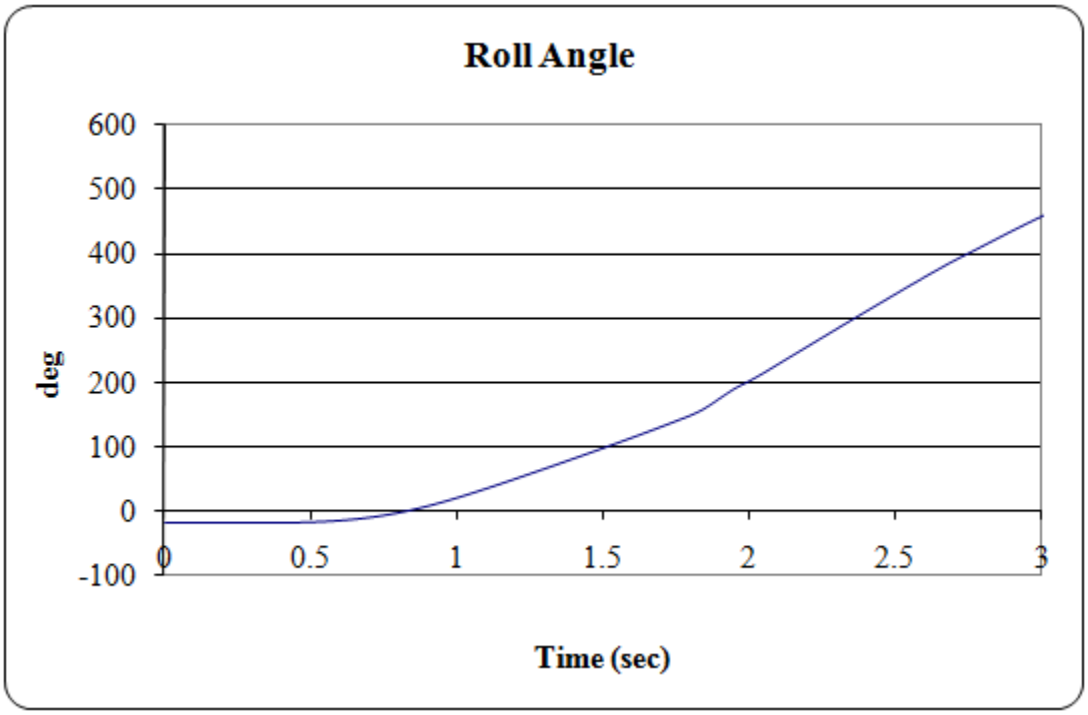
Data Sampling Rate: 1 kHz

Roll 1



Plot 21: Roll Encoder on Roadway Velocity vs. Time

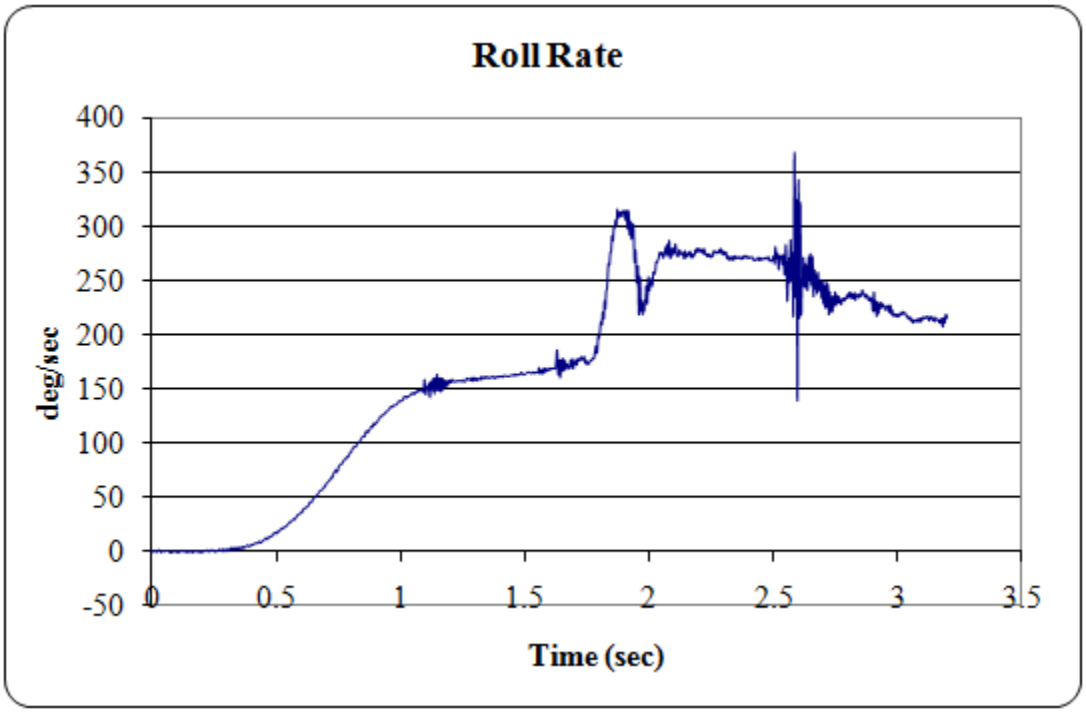
Data Sampling Rate: 1 kHz



Plot 22: Roll Angle vs. Time

Data Sampling Rate: 10 kHz

Roll 1

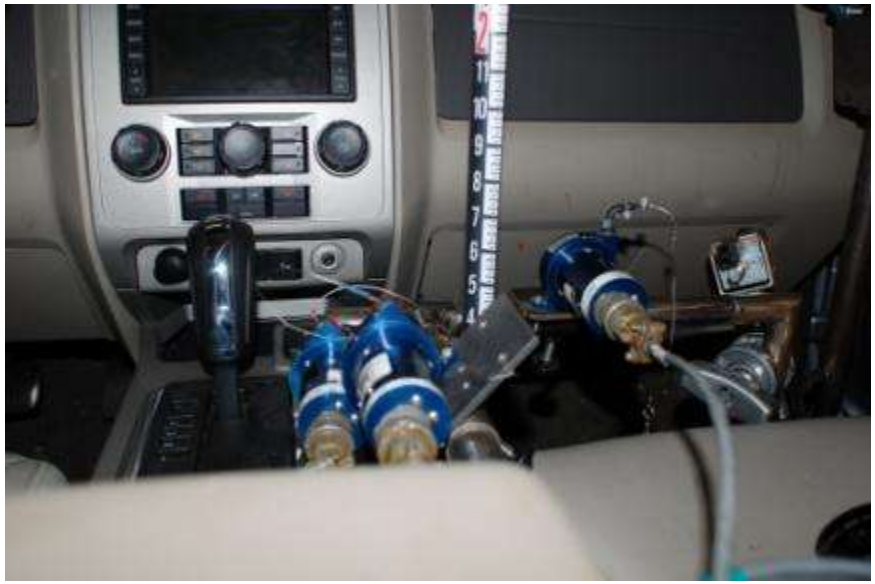


Plot 23: Roll Rate vs. Time

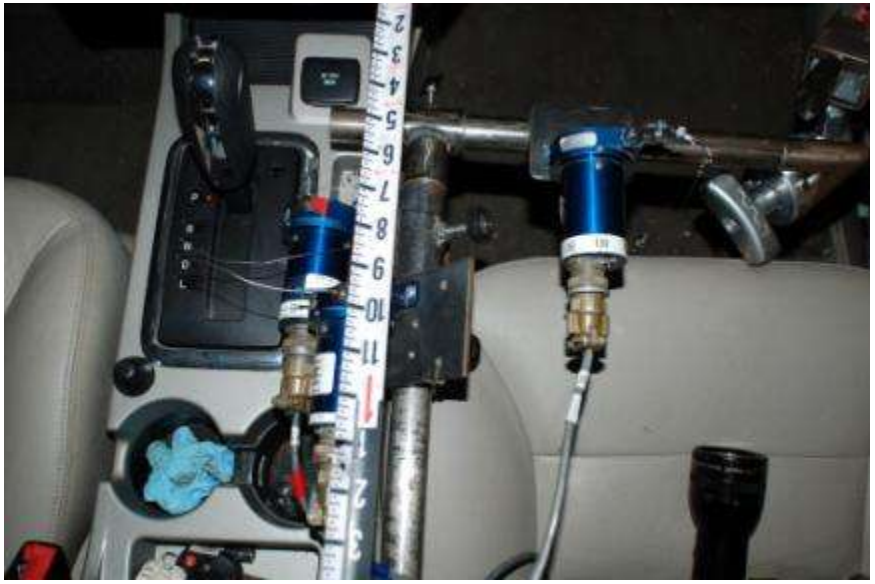
Data Sampling Rate: 10 kHz

4. All Test Photographs – Test Setup

Test Setup and Vehicle Instrumentation



Vehicle Instrumentation

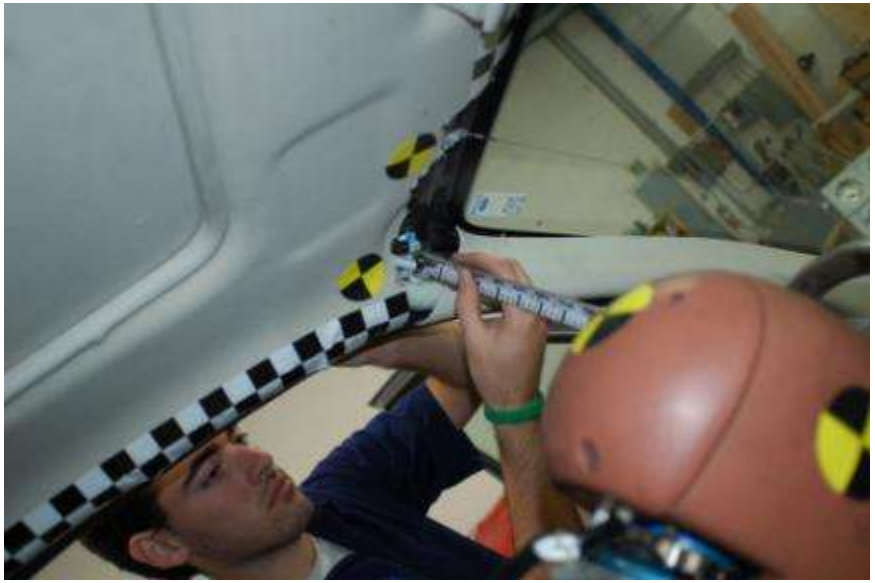


Vehicle Instrumentation

Vehicle Instrumentation




Vehicle Instrumentation

Vehicle Instrumentation




Vehicle Instrumentation

Roll 1 Photographs –7/15/2011 – Dummy Inspection

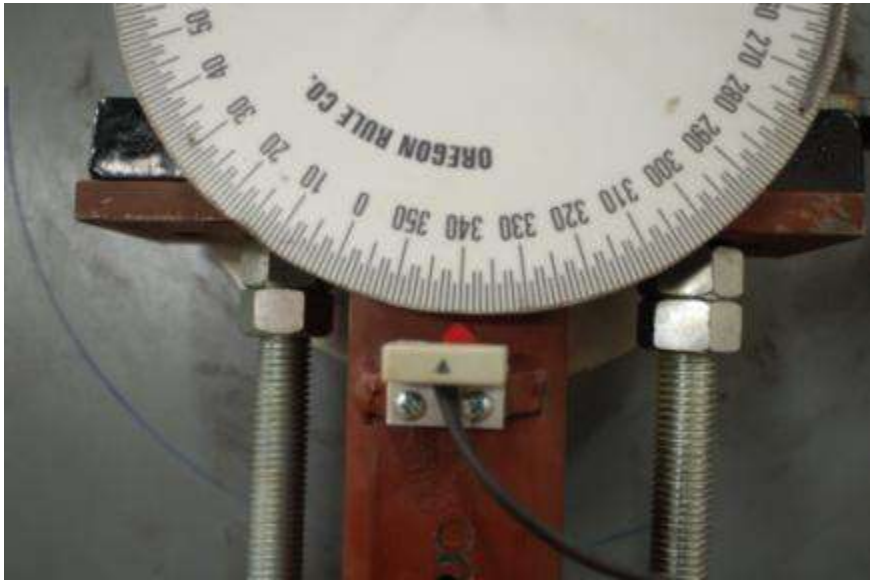
Dummy Inspection

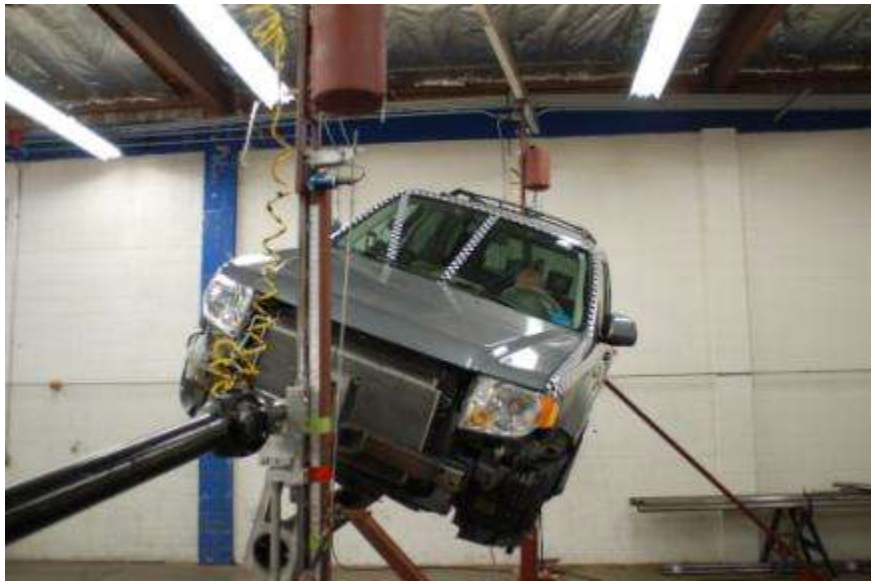
Dummy Inspection

Roll 1 Photographs – 7/15/2010 – Pre-Roll




Pre-Roll 1


OREGON RULE CO.
0 10 20 30 40 50
270 280 290 300 310 320 330 340 350 0



Pre-Roll 1

Pre-Roll 1

Roll 1 Photographs – 7/15/2010 – Post-Roll 1

Post-Roll 1

Pre-Test

Pre-Test

Post-Test

Post-Test