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**CHARACTERIZATION OF VERTICAL IMPACT DEVICE
ACCELERATION PULSES USING PARAMETRIC
ASSESSMENT: PHASE III WIAMAN SEAT**

**Mr. Chris Perry
Mr. Chris Burneka
Warfighter Interface Division**

**Ms. Rachael Christopher
ORISE**

**Mr. Chris Albery
Infoscitex**

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Interim Report**

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711 HUMAN PERFORMANCE WING,
AIRMAN SYSTEMS DIRECTORATE,
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433
AIR FORCE MATERIEL COMMAND
UNITED STATES AIR FORCE**

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//signed//
CHRIS BURNEKA
Work Unit Manager
Applied Neuroscience Branch

//signed//
SCOTT M. GALSTER
Chief, Applied Neuroscience Branch
Warfighter Interface Division

//signed//
WILLIAM E. RUSSELL
Chief, Warfighter Interface Division
Airman Systems Directorate

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14. ABSTRACT Phase III of a research effort using the Vertical Impact Device (VID) located in Bldg 824, Wright-Patterson AFB OH., was conducted to continue research of the facility's performance capabilities. The initial performance requirements for the VID to support the WIAMan program were impact acceleration pulses over 300 G with pulse time-to-peak values in the 5 to 10 ms range, and maximum velocity changes of greater than 32 ft/s or 9.8 m/s (Phase I), and this was followed by a new requirement to exceed 10 m/s (Phase II). Additional program requirements were then defined to produce velocity changes from 13 to 20 ft/s, approximately 4 – 6 m/s, with a time-to-peak velocity change of 5 ms to 10ms as input to a test seat, which became the focus of Phase III. The Phase III test program objectives were to determine the VID pulse characteristics using two specially designed seat fixtures and associated restrained manikins that differed in total weight on the VID carriage. The experimental design consisted of two different seat configurations with a restrained manikin in each configuration. One configuration consisted of a seat structure and a 50% Hybrid III male manikin (159 lb) with a total test weight of 309 lb, and was referred to as the WS1 configuration. The second seat configuration consisted of a seat structure and a GARD manikin (190 lb) with a total test weight of 807 lb, and was referred to as the WS2 configuration. Each seat was tested at different drop heights and using different VID carriage felt attenuators. Test data indicated that the felt attenuators had a greater influence on the carriage acceleration and time-to-peak velocity than the total weight added to the VID carriage. The testing with the WS1 and WS2 set-up showed that the VID facility with either weight configuration produced overall velocity changes and time-to-peak velocity changes with the limits established by the WIAMan program.					
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1.0 OVERVIEW

The Aircrew Biodynamics and Protection (ABP) Team of AFRL (711 HPW/RHCPT) and their in-house technical support contractor, Infoscitex, conducted a series of tests to identify the performance capabilities of the Vertical Impact Device (VID) with additional mounted hardware and a manikin mounted on the top of its drop carriage. The mounted hardware was defined as the first two design iterations of the Warrior Injury Assessment Manikin (WIAMan) seat developed specifically to test instrumented subject responses to various impact pulses. The VID is a Monterey Research Laboratory IMPAC3636 high-G impact test machine with seismic suspension, and is currently situated at the 711 Human Performance Wing (HPW), Airman Systems Directorate in Bldg. 824 at Wright-Patterson AFB, OH. The VID impact test machine is used to generate short duration, very high amplitude impact acceleration profiles to evaluate the effects on human and manikin subjects, and define the effectiveness of operational and prototype protection concepts, for the purpose of improving warfighter performance. The system can provide a maximum acceleration in excess of 1000 G for very short durations, maximum velocity changes of 50 ft/s (15.24 m/s) and pulse durations from 1 to approximately 30 ms using specialized facility adaptors and configurations beyond the standard free-fall set-up. This test phase was the first to have a specially designed seat structure mounted to the VID drop carriage.

The results provided in this report will be used as a reference for future test applications performed within the 711 HPW, as a benchmark for post-refurbishment and post-maintenance performance verification, and to potentially determine the degree of participation in the Army's Warrior Injury Assessment Manikin (WIAMan) development program. This test series was the third of multiple phases and focused on the effects the facility's new seat fixture had on the acceleration pulse and calculated velocity change. Two different seat configurations were tested with a restrained manikin in each configuration.

2.0 BACKGROUND

One of the signature wounds being identified with the war in the Middle East, as increasingly more wounded soldiers return home, is blast injuries. Blast injuries are caused by being in close proximity to an explosive device when it detonates, and which have been seen previously but have been more closely documented on the battlefield since World War I (WWI). Improvements in body armor and battlefield medicine are decreasing fatalities among wounded soldiers and allowing them to return home after suffering a blast injury. Military surgeons are being trained to better understand the pathology of blast injuries and spot the more subtle symptoms in patients enduring treatment. In the war in Iraq, Improvised Explosive Devices, better known as IEDs, are the weapon of choice for insurgents and widely used against our soldiers. The IEDs can cause blast injuries that have the ability to cause compounded catastrophic injuries, as well as the less visually observed or hidden injuries related to brain trauma as a result of a blast wave. As a result, the Army initiated the WIAMan program.

The WIAMan program has the main objective to gain an understanding of the biomechanics of injuries that occur in a combat vehicle underbody blast event involving a landmine or improvised explosive device. This will be accomplished using the data generated during this program to fabricate a specialized manikin that will be used in military Live-Fire Test and Evaluation efforts for the development of injury criteria. The new injury criteria and the new manikin will then be used to develop and evaluate mitigation technologies for ground combat vehicle seating systems. Part of the approach for the WIAMan program will be to define the loading environment which produces the injuries being investigated. The defined loading environment will then be used to measure the applied loads and resultant injuries to test specimens and produce tissue properties, human injury tolerance and response corridors, and ultimately injury risk curve. This requirement to understand the blast loading environment led to the initiation of the 711 HPW program to evaluate the impact pulse characteristics of the VID facility.

Previous research and testing on the VID (Knox, Pellettiere, Perry, Plaga, & Bonfeld, 2008; Veridian Contract Report, CDRL A005, 2002; and Salerno, Brinkley, & Orzech, 1985) focused on application of an energy pulse to either a piece of equipment or a human subject to determine its biodynamic response. The energy pulse was defined by achievement of a maximum peak acceleration value. Very little research has been completed to relate the drop height of the VID to a range of acceleration values with a specified time-to-peak (TTP); therefore, the impact characterization research program was initiated.

The first phase of VID testing determined the efficacy of using the facility to support the WIAMan program which had initial impact acceleration pulse requirements of over 300 G with pulse TTP values in the 5 to 10 ms range (Perry, Burneka, Christopher, Albery, 2016)¹. The test program approach used a parametric analysis with the objective to define and evaluate the performance effect of various impact attenuators on VID impact acceleration. Over 100 impact tests were completed during Phase I, and consisted of varying the energy attenuators, defined as the high-density (red) urethane programmers and industrial felt of varying density and thickness, while progressively increasing the drop height of the VID's drop table. The concept of using felt was leveraged from the work of Childers (Childers, 2002). One red urethane programmer, 4 felt densities, and 4 felt thicknesses were evaluated, and were used as the basis to separate the data

analysis into three sub-phases. The measured response was the acceleration recorded on the VID drop carriage, and the calculated velocity change and TTP velocity change. The data analysis from Phase I indicated that the impact pulses could meet the original 300 G requirement, but had velocity changes that were below recently defined WIAMan program requirements, and a modification to the VID would need to be fabricated to generate velocity changes in excess of 32 ft/s (≈ 10 m/s).

The second phase of VID testing determined the efficacy of using a test fixture (the Accelerated Freefall Device or AFD) designed to increase the velocity change currently generated by the VID facility in order to meet the WIAMan program requirement of 32 ft/s or approximately 10 m/s (Perry, Burneka, Christopher, Albery, 2016)². The AFD interfaced a bungee cord system between the VID free-fall carriage and the reaction mass, which provided an initial velocity to the carriage at the moment it was released into free-fall. This initial velocity would provide for greater impact energy providing higher impact G-levels and velocity changes. The AFD progressively increased the peak acceleration and the velocity change with increasing drop height, compared to the Phase I non-AFD configuration, for various impact attenuation configurations. A maximum velocity change with AFD at 80 inch drop height was found to be 39 ft/s (11.9 m/s). An additional series of tests during this phase evaluated an additional requirement from the WIAMan program to determine whether the VID facility could produce velocity changes above 25 ft/s (7.6 m/s) with time-to-peak values between 5 and 10 ms or greater. The TTP velocity increased about a 3 ms, from approximately 3.5 ms to between 6.5 and 7.0 ms, as a function of using two layers of felt as an impact attenuator. Testing indicated that the AFD provided sufficient additional capability to meet the WIAMan peak velocity change and TTP velocity change requirements.

Despite the success of Phase I and Phase II testing on the VID, a third phase of testing was necessary to meet an additional WIAMan program requirement. The new requirement was for the input energy delivered to a seated manikin to have a velocity change of approximately 13 to 19.5 ft/s (4 to 6 m/s) with a time-to-peak velocity change of 5 to 10ms.

3.0 OBJECTIVES

The initial performance requirements for the VID to support the WIAMan program were impact acceleration pulses over 300 G with pulse time-to-peak values in the 5 to 10 ms range, and a maximum velocity changes of greater than 32 ft/s (9.8 m/s). Additional program requirements were to produce velocity changes in the 13 to 20 ft/s (approximately 4 – 6 m/s) range with a time-to-peak velocity change of 5 ms to 10ms as input to a test seat. The test seat configuration was to include a restrained manikin.

The Phase III test program to determine the VID pulse characteristics using a specially designed seat fixture and a restrained manikin pursued the following objectives:

- (1) Evaluate the range of velocity changes generated with VID-mounted seat fixtures and restrained manikin as a function of progressively increasing drop heights of the VID drop table
- (2) Evaluate the range of time-to-peak velocity change values generated with a VID-mounted seat fixtures and restrained manikin as a function of progressively increasing drop heights of the VID drop table

4.0 TEST FACILITY AND EQUIPMENT

4.1 Vertical Impact Device

The VID or IMPAC 3636 test machine was manufactured in the 1960's, and was given to the AFRL biodynamics facility from the National Aeronautics and Space Administration (NASA). The VID is a high acceleration, shock testing machine capable of providing a maximum acceleration of 1000 G. It is capable of providing a maximum velocity change of 50 ft/s (15.24 m/s) and minimum pulse duration of 1.6 milliseconds depending on the selected specialized impact programmers provided with the system. The maximum drop height is between 8 to 12 feet depending on the mounted test fixture. A test is performed by dropping the carriage supporting the test fixture onto a reaction mass.

The major components of this facility consist of the carriage, reaction mass, elastic impact programmers, lifting and braking system, and control console. The carriage is a single piece high-strength aluminum (7079-T6) forging with machined surfaces carefully designed to provide a uniform load distribution, and weighing 1300 lbs. Bronze bearings guide the carriage on two hard chrome-plated rails. The reaction mass is a 12,000-lb forged steel block mounted on a critically damped, constant force, nitrogen and oil suspension system.

Impact programmers are used to control the shape, peak acceleration, and duration of the shock pulse. The programmers are mounted on the underside of the drop carriage or on the top of the reaction mass, and control the contact surface between the carriage and the reaction mass. Programmers can be combined in various configurations to provide specialized shock pulses. Several programmers initially supplied with the VID facility are no longer functional. The carriage lifting system consists of a cable, pulley, and lifting tube driven by one hydraulic cylinder, for each of the two side supports. Pneumatic friction brakes in the carriage assembly clamp the carriage to the guide rails when the desired drop test height has been reached; the lifting tubes are then lowered to their pre-test position at the bottom of the rails. The carriage is released at test initiation by a fast-acting valve in the brake system. The brakes are again energized to stop any rebound of the carriage after the carriage impacts on the reaction mass. The control console contains all the switches and condition lights for the remote control of the facility. The console also houses the hydraulic power for the lifting system. The VID is shown in Figure 1.

The positive axis of the coordinate system for the test configuration for this program is defined with respect to the top of the carriage, or with respect to the orientation of a manikin positioned in the seat mounted to the VID carriage. The coordinate system is shown for this test configuration in Figure 1. In order to obtain a shock pulse of desired maximum acceleration and duration and to prevent damage to the shock test machine, it is necessary to place a programmer (shock-mitigating material) between the shock table and reaction base. This material has energy-absorbing characteristics, and typical programmers are constructed from felt or urethane materials. Previous research evaluated various combinations of felt pad thickness and density.



Figure 1. 711 HPW Vertical Impact Device

4.2 VID Configuration with WIAMan Seat Fixtures

The primary modification to the VID for this Phase III test series was the installation of specially designed seat fixtures mounted to the top of the VID drop carriage.

The first WIAMan Seat, hereinafter referred to as WIAMan Seat One (WS1) and shown in Figure 2, was comprised of three main components; the seat back, the seat pan, and the footrest. Each component was fabricated from aluminum alloy, and connected to each other and to the top of the carriage via various aluminum alloy plates, blocks, and beams. The total weight of WS1 was approximately 150 lbs. The test weight of the Hybrid III 50th percentile male manikin used in this test series, also shown in Figure 2, was approximately 159 lbs for a total test weight of 309 lbs.



Figure 2. VID with WIAMan Seat One (WS1) Mounted on Top of Drop Carriage

The second WIAMan Seat, hereinafter referred to as WIAMan Seat Two (WS2) and shown in Figures 3 and 4, was comprised of four main components; the seat back, the seat pan, the footrest, and a specially designed VID carriage interface plate. The new design was to provide adjustability of the seat pan and footrest height relative to the top of the carriage, and relative to each other and the seatback plate. In addition, the new seat fixture design provided increased structural integrity. Each component was fabricated from either steel or an aluminum alloy, and connected to each other and to the top of the carriage via various aluminum alloy plates, blocks, and beams. The total weight of WS2 was approximately 617 lbs. The test weight of the Grumman Alderson Research Dummy (GARD) male manikin used in this test series, also shown in Figures 3 and 4, was approximately 190 lbs for a total test weight of approximately 807 lbs.



Figure 3. VID with WIAMan Seat Two (WS2) Mounted on Top of Carriage: Front View



Figure 4. VID with WIAMan Seat Two (WS2) Mounted on Top of Carriage: Side View

The assessment of the effects of the added weight on the performance of the VID in terms of acceleration, velocity change, time-to-peak velocity change, was accomplished by evaluating tests with the seat fixture and comparing them to similar test conditions from the previous parametric evaluation of impact energy attenuators in Phase I. The Phase I parametric evaluation was conducted using different combinations of felt sample thickness and density that were positioned in a four square grid pattern on the top of the reaction mass's 1 ft² steel plates.

The drop height of the carriage determined by measuring the distance between the bottom of the VID drop carriage and the top felt samples using a hand-held laser measurement device with digital read-out (Bosch Model DLR130). The VID reaction mass's suspension system was pressurized to 2000 psi., as directed by the IMPAC 3636 instruction manual, at the beginning of the day for each day of testing. The VID brake system was pressurized to 800 psi for each test.

4.3 Felt Programmers

The felt samples were purchased from the Bacon Felt Company in Rochester, NH, and consisted of 1 sq. ft. samples that varied in density and thickness. The densities available covered the range from 16 to 32 lbs as defined by Bacon Felt for a 3 x 3 ft. square sample that is 1.0 inch thick (the first two numbers of the felt's ID# indicate the density of the material... 16S1, 20S1, 26S1, and 32S1). The sample thicknesses available varied from 0.25 in. up to 2.0 in.

The specific combinations of felt used for this phase of testing are identified in the test matrix.

5.0 INSTRUMENTATION AND DATA COLLECTION

Transducers were chosen to provide the optimum resolution over the expected test acceleration ranges. Full-scale data ranges were selected to provide the expected full-scale range plus 50% to assure the capture of peak signals. All transducer bridges were balanced for optimum output prior to the start of the program. The appropriate accelerometers were adjusted with software for the effect of gravity by adding the component of a 1 G vector in-line with the force of gravity along the accelerometer axis.

The coordinate system (shown in Figure 1) used was the Right-Hand Rule with the z-axis parallel to the VID guide rails, and positive z being defined as up towards the top of the VID facility. The x-axis is perpendicular to the z-axis and points outward away from the VID impact table. The y-axis is perpendicular to the x- and z-axes according to the right-hand rule. The linear accelerometers were wired to provide a positive output voltage when the acceleration experienced by the accelerometer was applied in the +x, +y and +z directions.

5.1 Facility Instrumentation

Acceleration measurements were taken on the VID at different reference point locations on the top surface of the carriage or drop table for each seat configuration (WS1 and WS2). The tests conducted on the VID that provided comparative data points, without mounted seat structures, used just a tri-axial accelerometer package mounted at the center of the VID drop carriage. Load cells were also mounted on each seat structure to record reaction loads of the manikin restraint harness and the various load plates on the seat (seat pan, footrest). The specific instrumentation for each test series relative to the seat are detailed below.

Tests involving WS1 used instrumentation to record accelerations and loads at various points on the test facility and fixture. The tri-axial accelerometer package mounted at the geometric center of the table and behind the seat structure, was composed of two Entran Model EGE-72-200D accelerometers mounted in the x and y-axis, and a single MEAS Model EGCS-S425-2000 accelerometer mounted in the z-axis. The tri-axial accelerometer package mounted at a point on the seat back plate was also composed of two Entran Model EGE-72-200D accelerometers mounted in the x and y-axis, and a single MEAS Model EGCS-S425-2000 accelerometer mounted in the z-axis. These are shown in Figure 5. A tri-axial accelerometer package was also mounted at a point on the bottom of the footrest plate, and was also composed of two Entran Model EGE-72-200D accelerometers mounted in the x and y-axis, and a single MEAS Model EGCS-S425-2000 accelerometer mounted in the z-axis. These are shown in Figure 6. As required by the WIAMan program, two specialized accelerometers were also mounted on the footrest plate. One special accelerometer was an Endevco Model 7270a-60K mounted in the z-axis, and the second special accelerometer was an Endevco Model 2262A-2000 also mounted in the z-axis. Five load cells (Michigan Scientific Model TR3D-B-3K) were mounted on the seat structure to record restraint harness reaction loads at the following harness termination points: right and left lap belts, right and left shoulder belts, and the center crotch strap. Each harness load cell measured reaction loads in the three orthogonal axes, and had a maximum capacity of 3000 lbs.

Tests involving WS2 used instrumentation to record accelerations and loads at various points on the test facility and fixture. The tri-axial accelerometer package mounted at the bottom of the seat fixture (but on top of the main WS2 mounting plate), was composed of two MEAS Model EGCS-S425-250 accelerometers mounted in the x and y-axis, and a single MEAS Model EGCS-S425-250 accelerometer mounted in the z-axis. This is shown in Figure 7. The tri-axial accelerometer package mounted on the seat plate (at a point below where the seat back plate contacted the seat plate) was also composed of two MEAS Model EGCS-S425-250 accelerometers mounted in the x and y-axis, and a single MEAS EGCS-S425-250 accelerometer mounted in the z-axis. This is shown in Figure 8. A second accelerometer package was also mounted on a seat pan which was attached to the seat plate via load cells. This seat pan accelerometer package was composed of the following three single-axis accelerometers mounted in the z-axis: a MEAS Model EGCS-S425-250 accelerometer, an Endevco model 7270a-60K, and an Endevco 2262A-2000. This is shown in Figure 9.

In addition, a tri-axial accelerometer package was mounted on the footrest plate, and was also composed of two MEAS Model EGCS-S425-250 accelerometers mounted in the x and y-axis, and a single MEAS EGCS-S425-250 accelerometer mounted in the z-axis. As required by the WIAMan program, two specialized accelerometers were also mounted on the footrest plate. One special accelerometer was an Endevco model 7270a-60K mounted in the z-axis, and the second special accelerometer was an Endevco 2262A-2000 also mounted in the z-axis. The footrest mounting locations for the tri-axial package and the specialized accelerometers is shown in Figure 10. Five load cells (Michigan Scientific Model TR3D-B-3K) were mounted on the seat structure to record restraint harness reaction loads at the following harness termination points: right and left lap belts, right and left shoulder belts, and the center crotch strap. Each harness load cell measured reaction loads in the three orthogonal axes, and had a maximum capacity of 3000 lbs. In addition to the restraint load cells, the WIAMan program required the contact plates for the manikin (seat pan and footrest) also be instrumented to allow measurement of reaction loads during impact. Each contact plate was instrumented with four Strainert Model FL5(U)-2SGKT with a maximum capacity of 5000 lbs.

Additional testing was conducted on the VID to provide matched-pair impact conditions (felt impact programmer configurations) with and without the WS1 and WS2 seat structures. These additional test conditions are shown in the test matrix later in the report. The tests conducted with no seat structures attached to the top of the VID impact carriage were instrumented with a single tri-axial accelerometer package mounted at the geometric center of the carriage. The tri-axial accelerometer package was composed of two Endevco Model 7264C-500 accelerometers mounted in the x and y-axis, and a single MEAS Model EGCS-S425-1000 accelerometer mounted in the z-axis.

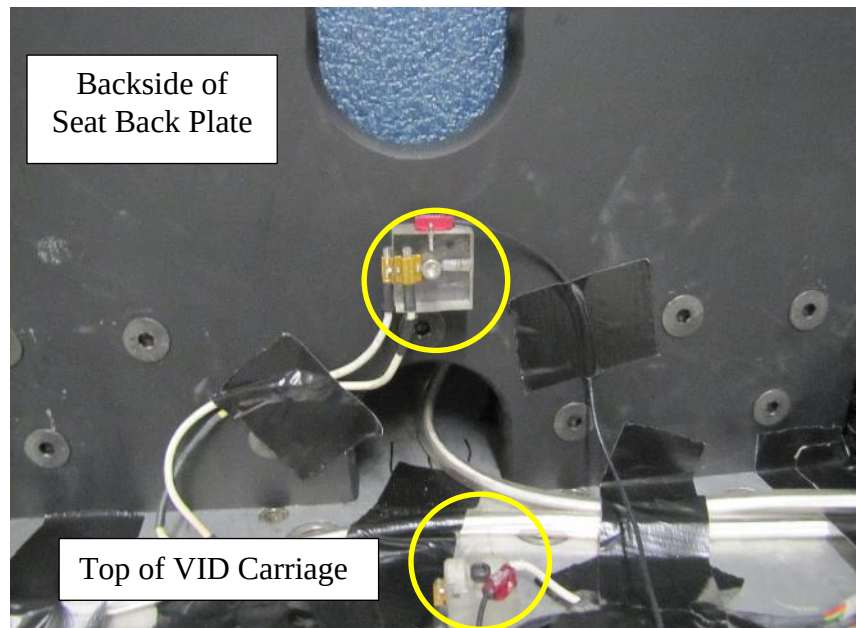


Figure 5. Location of Tri-axial Accel Arrays on VID Drop Carriage and WS1 Seat Back

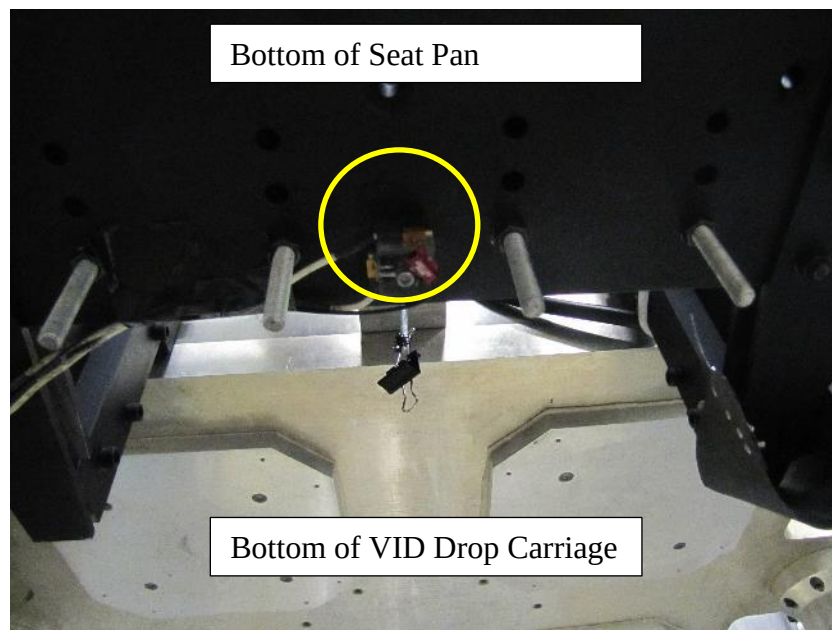


Figure 6. Location of Tri-axial Accel Arrays on the WS1 Footrest Bottom

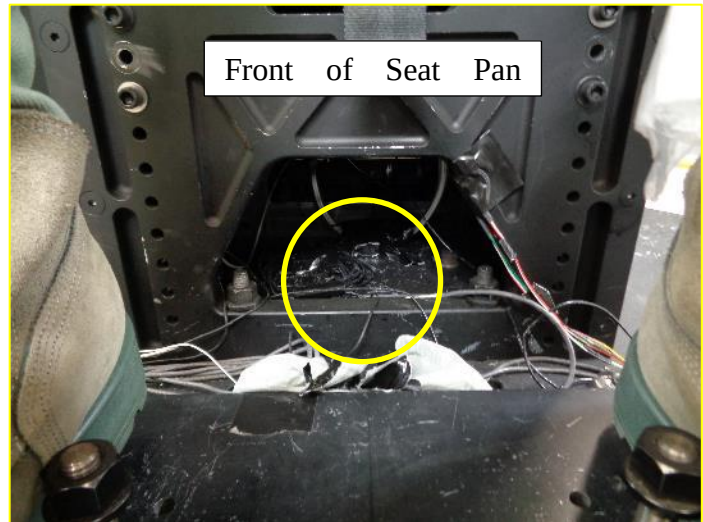


Figure 7. Location of Tri-axial Accel Array on VID Drop Carriage

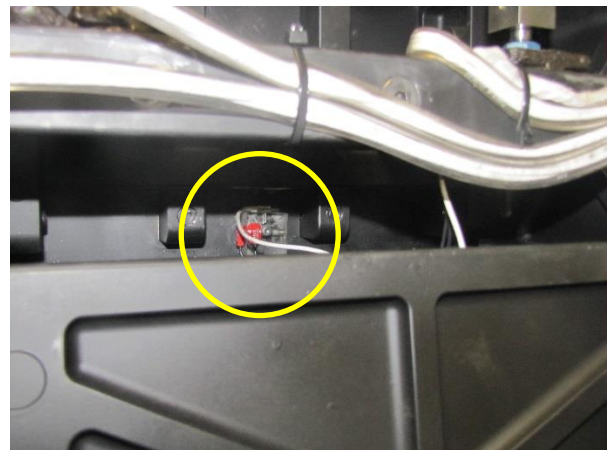
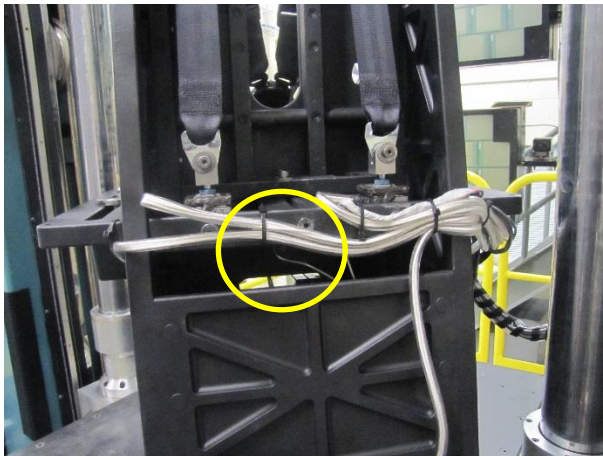


Figure 8. Location of Tri-axial Accel Array on WS2 Seat Plate



Figure 9. Location of Tri-axial Accel Array on WS2 Seat Pan

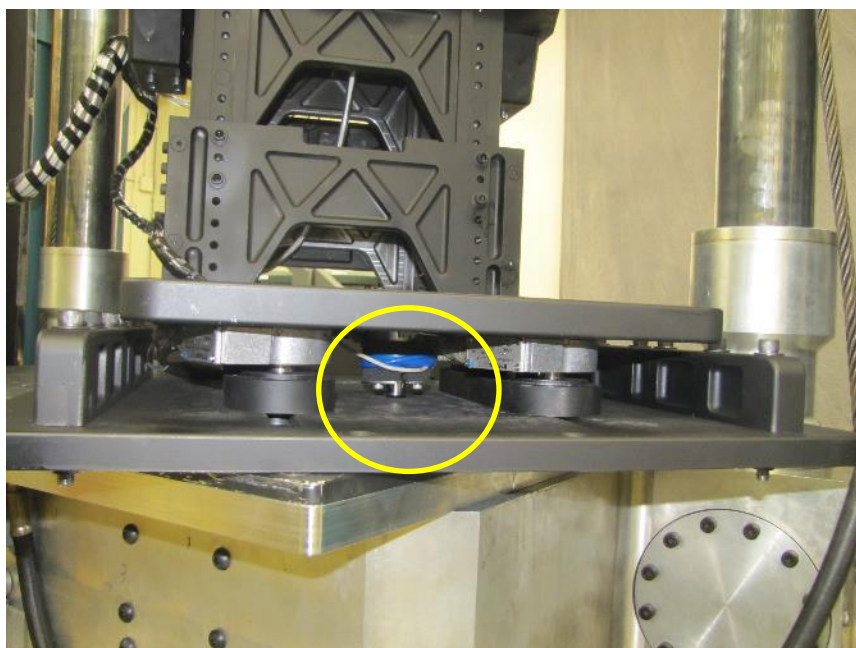


Figure 10. Location of Tri-axial Accel Array on WS2 Footrest

5.2 Transducer Calibration

On-site personnel from Infoscitex, Inc., conducted pre- and post-calibrations on all sensors used on the carriage and seat fixture. Calibration records of individual transducers as well as the Standard Practice Instructions are maintained in the biodynamic facility's Impact Information Center. For this test program, a record was made identifying the data channel, transducer manufacturer, model number, serial number, date and sensitivity of pre-calibration, date and sensitivity of post-calibration, and percentage change. Pre- and post-calibration information is maintained with the program data. The instrumentation used in this study is listed in the Electronic Instrumentation Data Sheets (See Appendix A).

5.3 Data Acquisition Control

The data collection process was controlled by a technician seated at the VID's Master Station Control located on the side of the VID facility. A test was initiated when the technician initiated a verbal countdown. The technician then initiated the data collection and the video collection with separate hand-held switches at $t = -2$ sec. Software was used to establish a zero reference for all transducers prior to table impact.

5.4 Data Acquisition System

Transducer excitation, signal amplification, filtering, digitizing, and transmission was provided off-board the VID carriage by a computer-controlled data acquisition system (DAS). This research program used the G5 DAS manufactured by Diversified Technical Systems (DTS), Inc., to collect all the fixture data for each test as defined by the test matrix. The 32-channel G5 was mounted off-board the VID next to the Master Station Control laptop. The G5 is a ruggedized, DC powered, fully programmable signal conditioning and recording systems for transducers and events. The TDAS G5 was designed to withstand a 100 G shock.

The signal conditioning accepts a variety of transducers including full and partial bridges, voltage, and piezo-resistive sensors. Transducer signals are amplified, filtered, digitized and recorded in onboard solid-state memory. The data acquisition system is controlled through an Ethernet interface using the Ethernet instruction language. A laptop PC with an Ethernet board configures the G5 before testing and retrieves the data after each test. For this program, the DAS collected data at a 20K sample rate with a 4 Khz anti-aliasing filter, and then used a 2Khz post processing filter when the data was downloaded into Excel files.

5.5 Quick Look Data Plots

After each test, the filtered data was plotted in a portrait format of 4-6 plots per page, and grouped with similar channels. The spreadsheet of plots also contained pertinent maxima, minima, and respective times of each occurrence. For all data, time = 0 was at initial carriage motion. The plots arranged in this fashion included: displacement versus time, force (load) versus time, and acceleration versus time.

5.6 High Speed Video and Photography

One or two Phantom Miro-3 High-Speed digital cameras (Figure 11) were used to collect video of each test. The cameras were mounted off-board the VID facility at perpendicular and/or oblique angles relative to the front of the facility.

The Phantom Micro line is a compact, light-weight, rugged family of cameras targeted at industrial applications ranging from biometric research to automotive crash testing. Rated to survive 100 G acceleration, this rugged camera can take 512 x 512 images at up to 2200 frames-per-second (fps). Reduce the resolution to 32 x 32 and achieve frame rates greater than 95,000 fps. With an ISO rating of 4800 (monochrome, saturation-based ISO 12232), the camera has the light sensitivity for the most demanding applications. With shutter speeds as low as 2 microseconds, the user can freeze objects in motion, eliminate blur, and bring out the image detail needed for successful motion analysis. The camera accepts any standard 1" C-mount lens. The Phantom Miro-3 member of the family is optimized for applications such as Hydraulically Controlled, Gas Energized (HYGE) crash simulations used in the automotive industry. Selectable 8-, 10- or 12-bit pixel depth allows the user to choose the dynamic range that best meets the demands of the application. The Miro-3 has a number of external control signals allowing for external triggering, camera synchronization, and time-stamping. The camera has both dynamic RAM and internal flash memory for non-volatile storage. Internal battery power allows the camera to be used in an un-tethered mode and ensures data survivability in case of loss of power.

The images for this study were collected at 1000 frames per second (fps). The video files were downloaded and converted to Audio Visual Interleave (AVI) format, and stored in the RH Collaborative Biomechanics Data Bank. Photographs were taken of the test set-up prior to each test. Photographic and video data were stored on an internal network for downloads as requested.



Figure 11. Phantom Miro-3 High Speed Digital Camera

6.0 EXPERIMENTAL DESIGN

Specially designed test matrices were developed to address the program objectives assessing the effects of different weight seat structures on the acceleration and velocity change at impact on the VID. Tests were conducted at different drop heights and with various combinations of high-density felt thickness and density.

6.1 VID Impact Response with WS1

The evaluation of the VID impact response using the WS1 seat structure was conducted with dual felt sample programmers (2.0 inch felt/steel plate/2.0 inch felt) mounted in a four-square grid pattern on the top of the reaction mass. The dual felt sample programmer configuration was composed of a 2.0 inch thick piece of 26S1 felt on the top, a 1 square foot, 0.25 inch thick steel plate, and a 2.0 inch thick piece of 32S1 felt on the bottom. The programmers each impacted a flat, 1 square foot, 0.25 in. thick, steel plate mounted to the bottom of the drop carriage. A Hybrid III 50% male manikin was placed in the seat for all tests with the WS1 seat structure. Two tests were conducted per test cell. The test matrix for this test series is shown in Table 1. The test set-up is shown in Figure 12.

Table 1. Test Matrix for VID Response with WS1

Test Cell	Drop Height (in)	Programmer	Seat Structure	Manikin
SH1	20	26S1/Plate/32S1	WS1	Hybrid III 50th
SH2	30	26S1/Plate/32S1	WS1	Hybrid III 50th
SH3	40	26S1/Plate/32S1	WS1	Hybrid III 50th
SH4	50	26S1/Plate/32S1	WS1	Hybrid III 50th
SH5	10	26S1/Plate/32S1	None	None
SH6	20	26S1/Plate/32S1	None	None
SH7	30	26S1/Plate/32S1	None	None
SH8	40	26S1/Plate/32S1	None	None



Figure 12. VID Facility with Installation of WS1 and Hybrid III Manikin

6.2 VID Impact Response with WS2

The evaluation of the VID impact response using the WS2 seat structure was conducted with dual felt sample programmers (2.0 inch felt/steel plate/2.0 inch felt) mounted in a four-square grid pattern on the top of the reaction mass. The dual felt sample programmer configuration was composed of a 2.0 inch thick piece of 26S1 felt on the top, a 1 square foot, 0.25 inch thick steel plate, and a 2.0 inch thick piece of 32S1 felt on the bottom. In addition, several tests were conducted with single layer programmers consisting of 2.0 inch thick 2621 and 2.0 inch thick 32S1 felt samples. All the programmer configurations impacted a flat, 1 square foot, 0.25 in. thick, steel plate mounted to the bottom of the drop carriage. A GARD manikin was placed in the seat for all tests with the WS2 seat structure. Two or three tests were conducted per test cell. The test matrix for this test series is shown in Table 2. The test set-up is shown in Figure 13.

Table 2. Test Matrix for VID Response with WS2

Test Cell	Drop Height (in)	Programmer	Seat Structure	Manikin
SI2	20	26S1/Plate/32S1	WS2	GARD
SI3	30	26S1/Plate/32S1	WS2	GARD
SI4	40	26S1/Plate/32S1	WS2	GARD
SH6	20	26S1/Plate/32S1	None	None
SH7	30	26S1/Plate/32S1	None	None
SH8	40	26S1/Plate/32S1	None	None
SM1	10	32S1	WS2	GARD
SM2	20	32S1	WS2	GARD
SM3	30	32S1	WS2	GARD
SM4	40	32S1	WS2	GARD
SM5	10	32S1	None	None
SM6	20	32S1	None	None
SM7	30	32S1	None	None
SM8	40	32S1	None	None
SN1	10	26S1	WS2	GARD
SN2	20	26S1	WS2	GARD
SN3	30	26S1	WS2	GARD
SN4	40	26S1	WS2	GARD
SN5	10	26S1	None	None
SN6	20	26S1	None	None
SN7	30	26S1	None	None
SN8	40	26S1	None	None



Figure 13. VID Facility with Installation of WS2 and GARD Manikin

The test configurations in Table 1 and Table 2 that did not include the seat structure and the manikin were additional tests added during the analysis phase of the data to provide the necessary data sets for a comparative analysis of the effects of the added weight to the VID carriage. The impact attenuation configurations for these additional tests were driven by the configurations used during the testing of the two seat structures.

7.0 RESULTS

A total of 66 impact tests were completed on the VID in support of this effort to characterize the impact acceleration pulses and velocity changes generated by the VID carriage with additional weight due to seat structures and manikins. This third phase of VID characterization testing consisted of altering the drop height to observe the effects on peak acceleration, velocity change and other variables with two different configurations of seat structure and manikin, and with different impact attenuation felt programmers.

7.1 VID Impact Response with WS1: Test by Test Summary

A review of the specific test configuration for each of the impact tests conducted on the VID with the WS1 and Hybrid III manikin is shown with a test-by-test summary documenting test conditions and a brief summary of the key data. The summary is shown in Appendix B.

7.2 VID Impact Response with WS1: Test Data Review

The carriage acceleration data collected from testing with the WS1 and Hybrid III manikin is presented in Table 3, and corresponds with the test parameters proposed in Table 1 in the Experimental Design section. Both the peak acceleration and the resulting integrated velocity change in ft/s were plotted as a function of progressively increasing drop heights, shown in Figures 14 and 15.

Table 3. VID Impact Response: WS1 Data Summary

Test Cell	Seat Configuration	Drop Ht. (in)	Mean Peak Acceleration (G)	Mean Velocity Change (ft/s)
SH1	WS1	20	80.08 ± 3.71	13.54 ± 0.49
SH2	WS1	30	97.30 ± 0.90	15.90 ± 0.13
SH3	WS1	40	114.55 ± 1.56	18.15 ± 0.16
SH4	WS1	50	133.95 ± 2.82	20.32 ± 0.23
SH5	None	10	56.61 ± 0.02	9.96 ± 0.01
SH6	None	20	84.54 ± 0.03	14.23 ± 0.01
SH7	None	30	104.80 ± 1.98	17.48 ± 0.00
SH8	None	40	124.05 ± 0.64	20.03 ± 0.10

VID Characterization: Phase III
 Impact Assessment with Additional Carriage Weight
 Added Weight: 309 lb; Impact Attenuation: 26S1/Plate/32S1 Felt, 2.0 in Thk
 Fitting Model: $y=a*x^b$

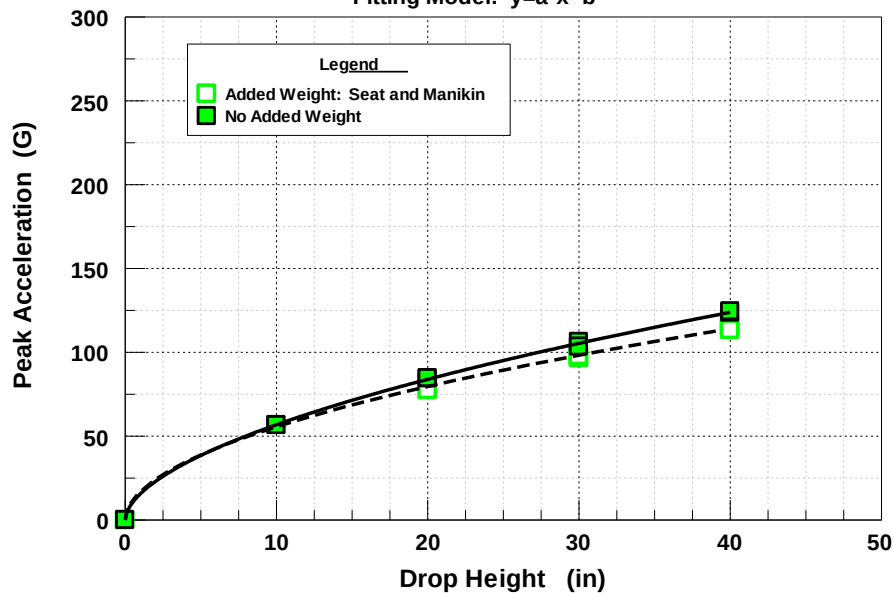


Figure 14. Peak Acceleration as a Function Drop Height for WS1 Configuration

VID Characterization: Phase III
 Impact Assessment with Additional Carriage Weight
 Added Weight: 309 lb; Impact Attenuation: 26S1/Plate/32S1 Felt, 2.0 in Thk
 Fitting Model: $y=a*x^b$

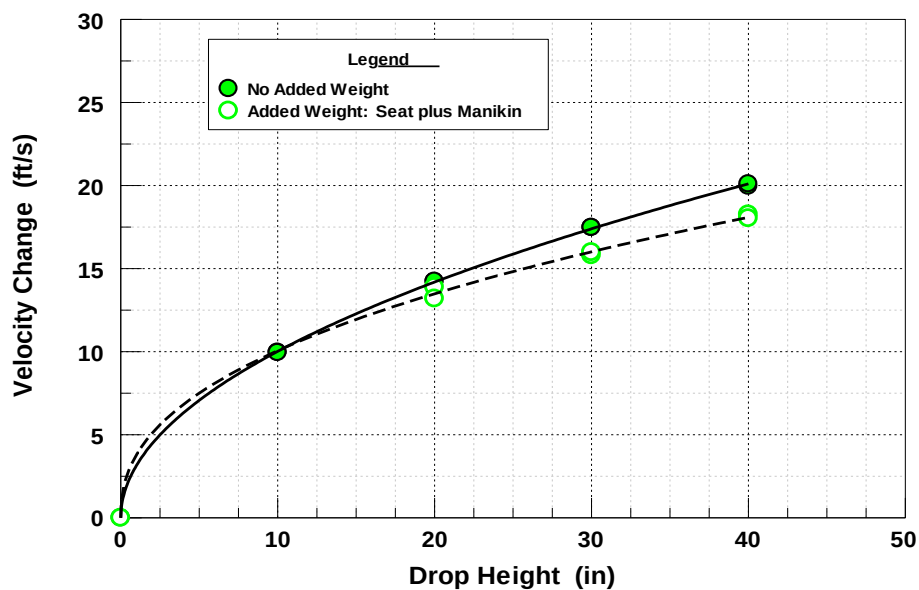


Figure 15. Velocity Change as a Function of Drop Height for WS1 Configuration

The data used to calculate the statistical means and standard deviations, for the acceleration and calculated velocity change data sets, was composed of data from all the VID tests 1260 through 1267, and tests 1673 through 1680. Testing stopped at the 40 inch drop height for the No-Weight Configurations (no seat structure) due to time constraints and facility configuration management. The narrow standard deviation values shown in the data table highlight the repeatability of the VID test facility over the various test conditions. The plots generated from test data showed that a Power Series equation ($y=a*x^b$) provided the best fit regression line for both the acceleration and velocity change plots. Coefficient of Determination (COD) for all the data sets (both acceleration and velocity change) was 0.99 or better. The excellent COD values for all the data sets also highlight the repeatability of the VID test facility, and allows the model to be used for estimation of required test parameters.

One aspect of the test data that Figure 14 and 15 highlight is the limited variation in response with and with-out the added weight to the VID drop carriage as the drop height increases. Examination of the data in Table 3 and the plots in Figure 14 and 15 show that the additional weight of 309 lbs had minimal effect on both the acceleration and the velocity change while using the defined impact attenuation set-up (dual felt configuration). It appears that the weight may be decreasing the peak acceleration and the velocity change as the drop height increases, but additional testing at greater drop heights would need to be conducted to verify. This trend can be observed by calculating the percent difference in the response based on added weight to the VID. In order to calculate percent difference between data points collected at the drop heights with and without the added weight, the percent difference was always referenced to a baseline value, and for this study, the baseline value or $value_b$ was equal to the acceleration or velocity change without the added weight (no seat structure). The following equation was used to calculate the percent difference or Pd the addition of weight had on the facility acceleration and velocity change:

$$Pd = \frac{value - value_b}{value_b} \times 100$$

where $value$ is the acceleration or velocity change data collected with the added weight, and $value_b$ is the baseline reference value which is the acceleration or velocity change data value when there was no seat on the VID carriage. A positive Pd value indicates that the data values increased with the addition of the weight. The percent difference calculations are shown in Table 4 and 5.

Table 4. Percent Difference in Peak Acceleration as a Function of the WS1

Drop Height (in)	Peak Acceleration No Seat (G)	Peak Acceleration WS1 Seat (G)	Percent Difference (Pd)
20	84.5	80.1	- 4.8%
30	104.8	97.3	- 7.2%
40	124.1	114.6	- 7.7%

Table 5. Percent Difference in Velocity Change as a Function of the WS1

Drop Height (in)	Velocity Change No Seat (ft/s)	Velocity Change WS1 (ft/s)	Percent Difference (Pd)
20	14.23	13.54	- 5.8%
30	17.48	15.90	- 9.0%
40	20.03	18.15	- 9.4%

The percent difference values for the peak acceleration and velocity change data indicate that the added weight to the VID impact carriage had a minor effect on the facility acceleration and velocity change as the drop height increased. The percent differences, for the peak acceleration and the velocity change, are negative values that are becoming greater as the drop height increased, with a maximum percent difference of approximately 7 and 9% respectively at the 40 inch drop. These values are considered minor and inconclusive since the standard deviation of the data from tests with the seat had values in the 2 to 5% range relative to the mean.

7.3 VID Impact Response with WS2: Test by Test Summary

A review of the specific test configuration for each of the impact tests conducted on the VID with the WS2 and the GARD manikin is shown with a test-by-test summary documenting test conditions and a brief summary of the key data. The summary is shown in Appendix C.

7.4 VID Impact Response with WS2: Test Data Review

The carriage acceleration and velocity change data collected from testing with the WS2 and GARD manikin is presented in Table 6, and corresponds with the test parameters proposed in Table 2 in the Experimental Design section. The summary data is divided into three groups based on the felt configurations used as the impact attenuators. Both the peak acceleration and the resulting integrated velocity change in ft/s were plotted as a function of progressively increasing drop heights, shown in Figures 16 through 21. The plots are identified by what felt density was used for carriage impact attenuation by the annotation at the end of the figure title (26/32 for the 26S1/32S1 dual felt configuration, 32S1 for the single 32S1 felt, and 26S1 for the 26S1 felt). The felt configuration is also indicated at the top of each plot in the plot description.

Table 6. Test Matrix for VID Response with WS2

Test Cell	Seat (Felt) Configuration	Drop Ht. (in)	Mean Peak Acceleration (G)	Mean Velocity Change (ft/s)
SI2	WS2 (26S1/32S1)	20	87.55 ± 2.47	13.31 ± 0.23
SI3	WS2 (26S1/32S1)	30	110.80 ± 1.37	16.09 ± 0.51
SI4	WS2 (26S1/32S1)	40	134.74 ± 1.73	19.10 ± 0.78
SH6	None (26S1/32S1)	20	84.54 ± 0.03	14.23 ± 0.01
SH7	None (26S1/32S1)	30	104.80 ± 1.98	17.48 ± 0.00
SH8	None (26S1/32S1)	40	124.05 ± 0.64	20.03 ± 0.10
SM1	WS2 (32S1)	10	106.23 ± 0.46	9.53 ± 0.04
SM2	WS2 (32S1)	20	167.01 ± 0.46	13.75 ± 0.06
SM3	WS2 (32S1)	30	213.79 ± 3.06	16.89 ± 0.13
SM4	WS2 (32S1)	40	247.31 ± 6.53	19.22 ± 0.28
SM5	None (32S1)	10	73.68 ± 0.50	10.00 ± 0.11
SM6	None (32S1)	20	107.35 ± 0.07	14.35 ± 0.03
SM7	None (32S1)	30	133.80 ± 0.42	17.49 ± 0.45
SM8	None (32S1)	40	154.60 ± 0.42	20.44 ± 0.06
SN1	WS2 (26S1)	10	75.61 ± 0.86	9.56 ± 0.04
SN2	WS2 (26S1)	20	117.74 ± 3.10	13.58 ± 0.29
SN3	WS2 (26S1)	30	155.18 ± 1.13	16.70 ± 0.08
SN4	WS2 (26S1)	40	184.56 ± 3.11	18.99 ± 0.24
SN5	None (26S1)	10	65.36 ± 0.24	10.03 ± 0.11
SN6	None (26S1)	20	95.15 ± 0.07	14.17 ± 0.02
SN7	None (26S1)	30	117.65 ± 0.07	17.26 ± 0.01
SN8	None (26S1)	40	136.50 ± 0.28	19.82 ± 0.02

VID Characterization: Phase III
 Impact Assessment with Additional Carriage Weight
 Added Weight: 807 lb; Impact Attenuation: 26S1/Plate/32S1 Felt, 2.0 in Thk
 Fitting Model: $y=a*x^b$

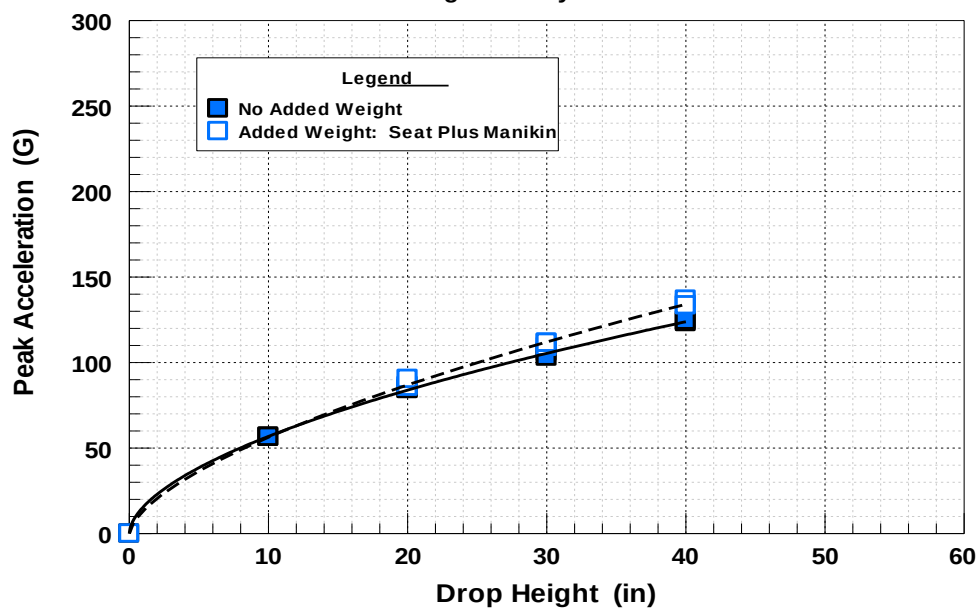


Figure 16. Peak Acceleration as a Function of Drop Height for WS2 Configuration (26/32)

VID Characterization: Phase III
 Impact Assessment with Additional Carriage Weight
 Added Weight: 807 lb; Impact Attenuation: 26S1/Plate/32S1 Felt, 2.0 in Thk
 Fitting Model: $y=a*x^b$

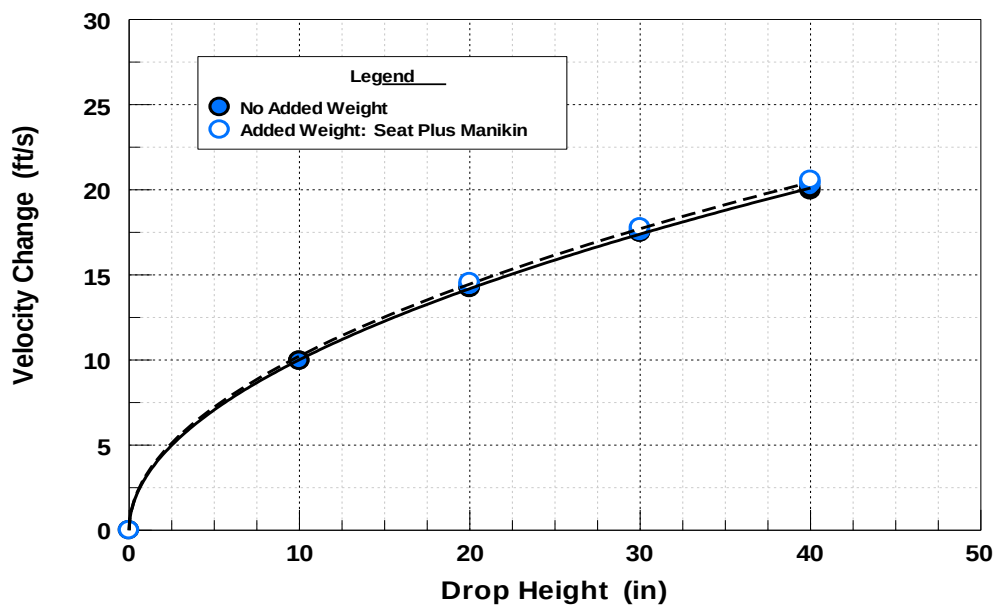


Figure 17. Velocity Change as a Function of Drop Height for WS2 Configuration (26/32)

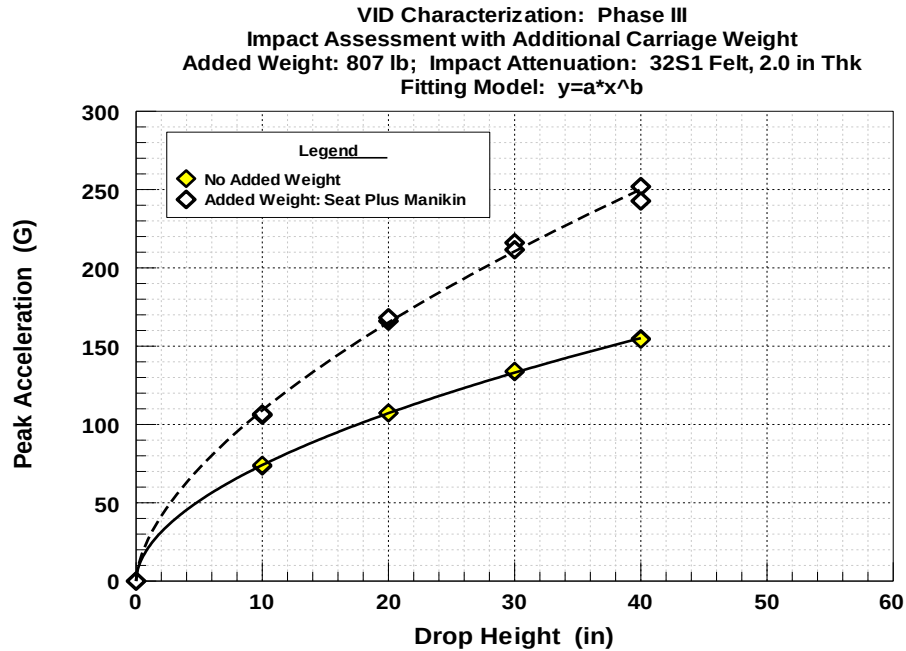


Figure 18. Peak Acceleration as a Function of Drop Height for WS2 Configuration (32S1)

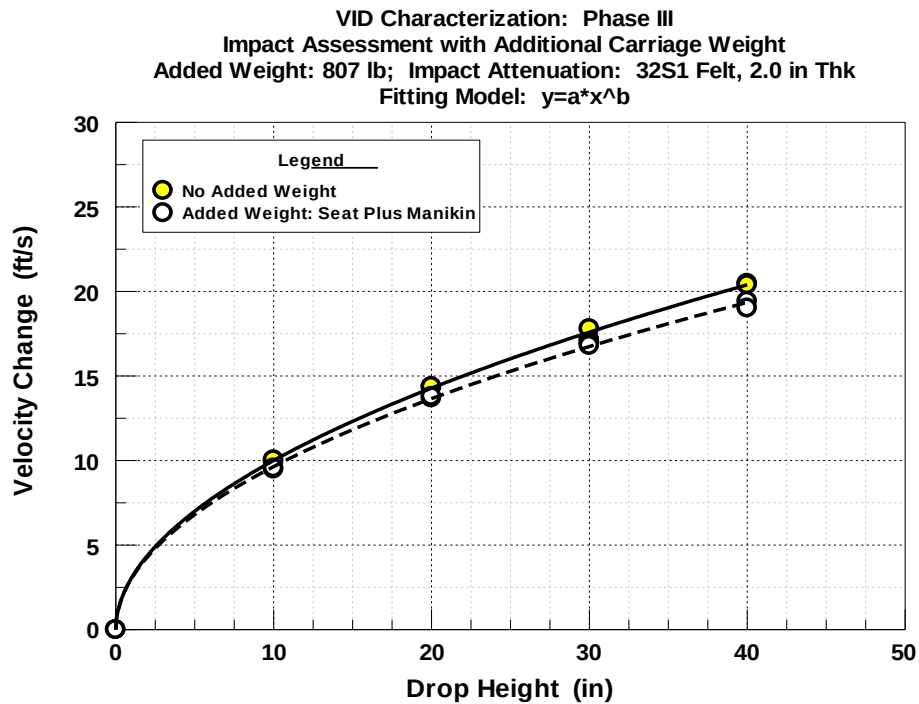


Figure 19. Velocity Change as a Function of Drop Height for WS2 Configuration (32S1)

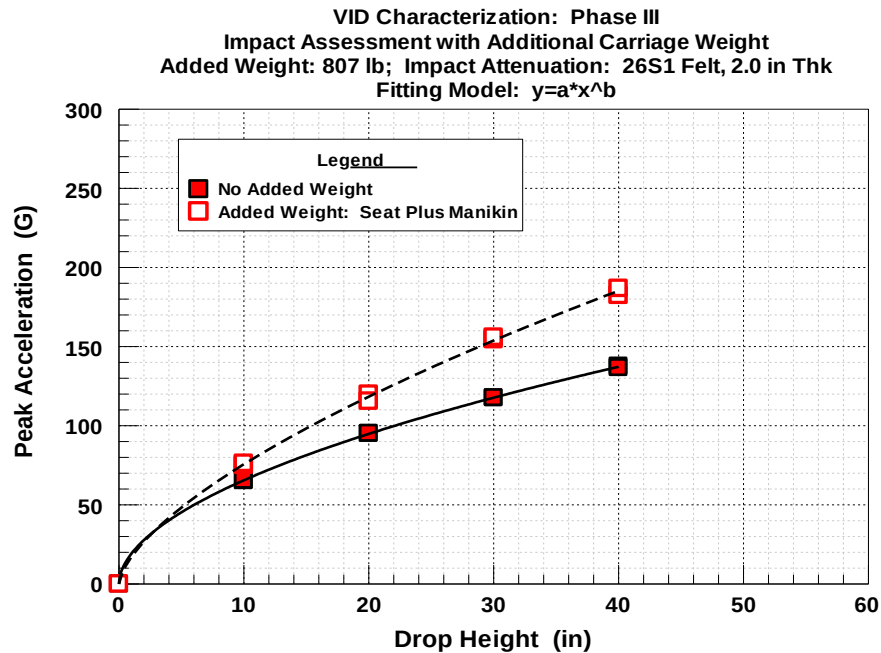


Figure 20. Peak Acceleration as a Function of Drop Height for WS2 Configuration (26S1)

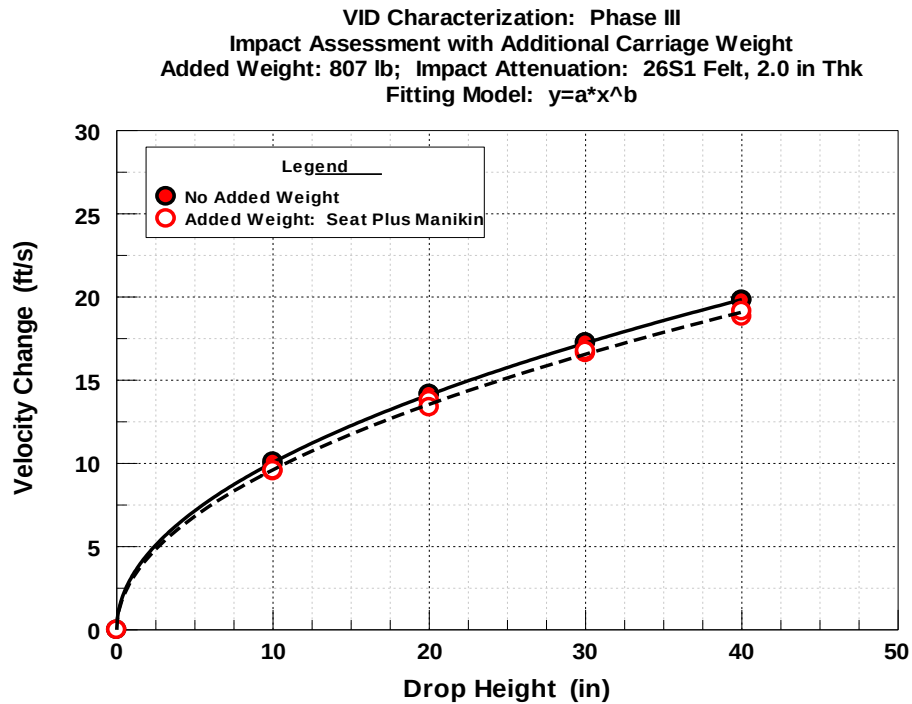


Figure 21. Velocity Change as a Function of Drop Height for WS2 Configuration (26S1)

The data used to calculate the statistical means and standard deviations, for the acceleration and calculated velocity change data sets, was composed of data from the following sets of VID tests: Data analysis with the 26S1/32S1 felt combination impact attenuation was conducted with tests 1260 through 1267 (WS1), 1281 through 1290 (WS2), and 1673 through 1680 (no seat); data analysis with the 32S1 felt impact attenuation was conducted with tests 1347 through 1354 (WS2) and 1657 through 1664 (no seat); and data analysis with the 26S1 felt impact attenuation was conducted with tests 1355 through 1362 (WS2) and 1665 through 1672 (no seat). The additional tests that were conducted with no added weight to the VID carriage (no seat structure) were completed upto a maximum drop height of 40 inches due to time constraints and facility configuration management. The narrow standard deviation values shown in the data table for all three impact attenuation configurations highlight the repeatability of the VID test facility over the various test conditions.

The plots generated from test data showed that a Power Series equation ($y=a*x^b$) provided the best fit regression line for both the acceleration and velocity change plots. Coefficient of Determination (COD) for all the data sets (both acceleration and velocity change) was 0.99 or better. The excellent COD values for all the data sets also highlight the repeatability of the VID test facility, and allows the model to be used for estimation of required test parameters.

One aspect of the test data that Figure 16 through 21 highlight is the limited variation in response with and with-out the added weight to the VID drop carriage as the drop height increases. Examination of the data in Table 6 and the plots in Figure 16 through 21 shows that the additional weight of 807 lbs had minimal effect on the velocity change while the effect on the acceleration was dependent on the carriage impact attenuation configuration. Interestingly, the higher density felt configurations increased the peak acceleration with the tested weight.

This can be observed by calculating the percent difference in the acceleration response based on added weight to the VID as a function of the felt configurations or based on the felt configuration. The percent differences were calculated using data from the 40 inch drop height as this shows the greatest difference based on the plots in Figures 14, 16, 18, and 20. In order to calculate percent difference between data points collected, the percent difference was always referenced to a baseline value, and for this assessment, the baseline value or $value_b$ was equal to the acceleration without the added weight, or the felt configuration with the smallest stiffness (26S1/32S1 dual felt configuration). The following equation was used to calculate the percent difference or Pd the addition of weight had on the facility acceleration:

$$Pd = \frac{value - value_b}{value_b} \times 100$$

where $value$ is the acceleration data collected with the added weight, and $value_b$ is the baseline reference value which is the acceleration data value when for the defined baseline depending on the comparison. A positive Pd value indicates that the data values increased with the addition of the weight. The percent difference calculations shown in Table 7 are based on added weight with a constant felt configuration (26S1/32S1), and included data from the WS1 seat analysis. The percent difference calculations shown in Table 8 are based on felt configuration with a constant carriage weight (WS2).

Table 7. Percent Difference in Peak Acceleration as a Function if the Weight at 40 in Drop and 26S1/32S1 Impact Felt Configuration

Peak Acceleration (No Seat) (G)	Peak Acceleration (WS1) (G)	Peak Acceleration (WS2) (G)	Percent Difference (Pd)
124.1	114.6		-7.7%
	114.6	134.7	18%
124.1		134.7	8.5%

Table 8. Percent Difference in Peak Acceleration as a Function of the Felt at 40 in Drop and Carriage Weight of 807 lb (WS2)

Peak Acceleration (26S1/32S1) (G)	Peak Acceleration (26S1) (G)	Peak Acceleration (32S1) (G)	Percent Difference (Pd)
134.7	184.6		37%
	184.6	247.3	34%
134.7		247.3	84%

The data plots for the peak acceleration data indicate that both added weight to the VID impact carriage and the felt impact configuration had an effect on the facility acceleration as the drop height increased. The effect was more pronounced as a function of the felt impact configuration. The percent difference table highlights this effect comparing the data from the 40 inch drop height tests. The percent differences for the peak acceleration showed an increase with the heaviest test condition (WS2) with a maximum percent difference of approximately 18%. The percent difference for the peak acceleration was even greater when the comparison was made between the data from 26S1/32S1 felt configuration and the data from the 32S1 felt configuration with a percent difference of 84%. Since the velocity change for the three different felt configurations did not change noticeably across the drop heights tested, the acceleration pulse shape must have changed to account for the peak acceleration differences. This is shown in Figure 22 which aptly demonstrates that the pulse duration changed from approximately 9 to 5 ms when the impact felt configuration was changed.

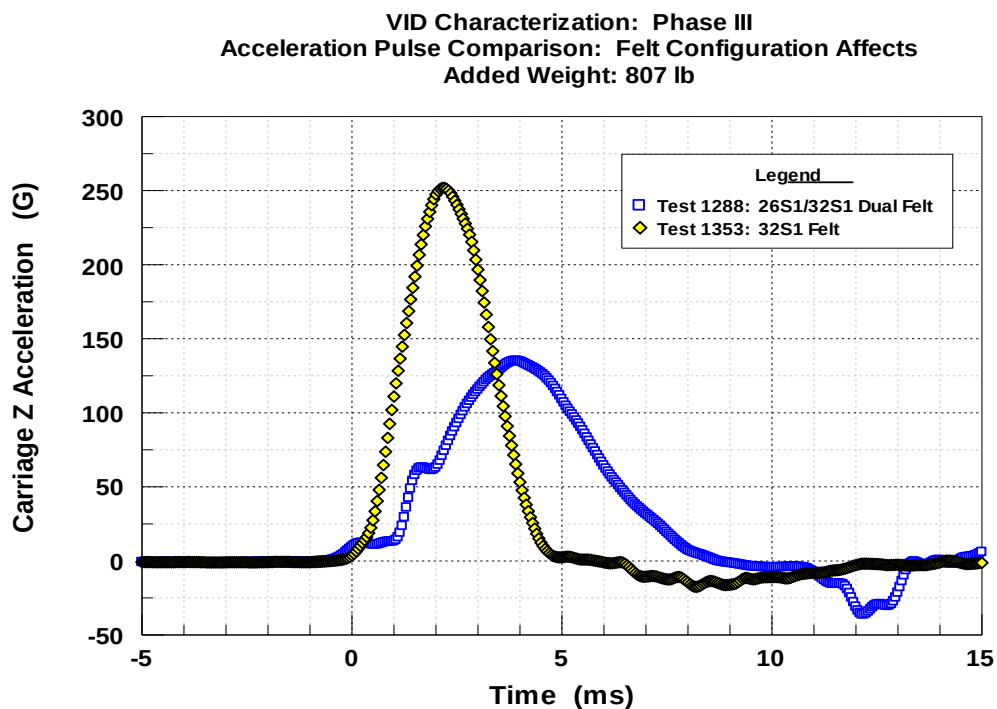


Figure 22. Variation of Acceleration Pulse Shape as a Function of Felt Configuration

Since the stiffness of the felt affected the pulse shape significantly, additional analysis was completed to evaluate the effect of increased carriage weight on peak acceleration and acceleration pulse shape using the felt configuration with the greatest stiffness. Data from Table 6, using 32S1 impact felt configuration, indicates that the Percent Difference between peak acceleration with no weight (baseline) and with the WS2 mounted on the VID carriage would be approximately 60% increase in the acceleration value at the 40 inch drop height. As before, since the velocity change for this configuration did not change noticeably, the acceleration pulse shape must have changed to account for the peak acceleration difference. This is shown in Figure 23 which aptly demonstrates that the pulse duration changed from approximately 9 to 5 ms when the VID carriage weight was increased.

VID Characterization: Phase III
Acceleration Pulse Comparison: Additional Carriage Weight Affects
Impact Felt Configuration: 32S1

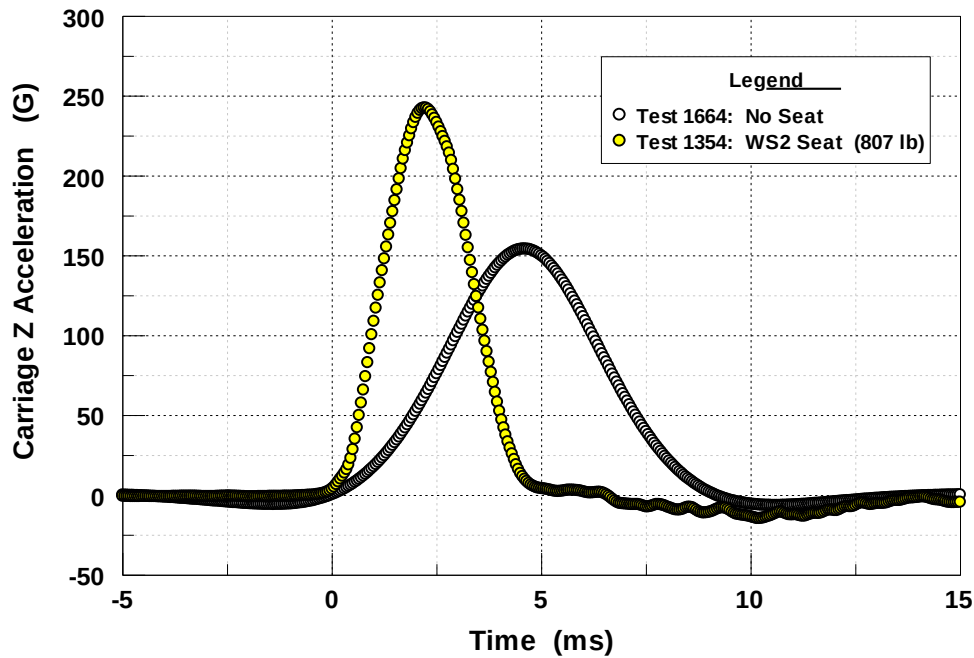


Figure 23. Variation of Acceleration Pulse Shape as a Function of VID Carriage Weight

7.5 VID Impact Response with Weighted Carriage: Time to Peak Velocity Review

The data collected from testing with WS2 and the various felt programmers is presented in Table 6, and corresponds with the test parameters proposed in Table 2 in the Experimental Design section. One of the objectives of the program was to determine carriage response with added weight and to determine if this effected the time-to-peak velocity change requirement of 5 to 10 ms. The plots in Figures 20 and 21 show that for the extremes of weight configurations (no weight to WS2) and of felt stiffness (26S1/32S1 to 32S1), the estimate of time-to-peak velocity change using acceleration pulse duration falls with the 5 to 10 ms boundary condition.

8.0 SUMMARY AND CONCLUSIONS

Research was conducted involving a series of impact tests to identify the performance capabilities of the Vertical Impact Device (VID) with additional mounted hardware or seat structure, and a manikin, mounted on the top of its drop carriage. The mounted hardware was defined as the first two design iterations of the Warrior Injury Assessment Manikin (WIAMan) seat developed specifically to test instrumented subject responses to various impact pulses. This test series was the third of multiple phases of a larger research effort, and focused on the effect the installed seat fixture had on the acceleration pulse and calculated velocity change.

The initial performance requirements for the VID to support the WIAMan program were impact acceleration pulses over 300 G with pulse time-to-peak values in the 5 to 10 ms range, and a maximum velocity changes of greater than 32 ft/s (9.8 m/s). Additional program requirements were to produce velocity changes in the 13 to 20 ft/s (approximately 4 – 6 m/s) range with a time-to-peak velocity change of 5 ms to 10 ms as input to a test seat. The test seat configuration was to include a restrained manikin. Therefore, the objectives of the Phase III test program were to determine the VID pulse characteristics using a specially designed seat fixture and a restrained manikin to evaluate the range of velocity changes and the range of time-to-peak velocity change values generated with a VID-mounted seat fixture and restrained manikin as a function of progressively increasing drop heights of the VID drop table.

The experimental design consisted of two different seat configurations with a restrained manikin in each configuration. One configuration consisted of a seat structure and a 50% Hybrid III male manikin (159 lb) with a total test weight of 309 lb, and was referred to as the WS1 configuration. The second seat configuration consisted of a seat structure and a GARD manikin (190 lb) with a total test weight of 807 lb, and was referred to as the WS2 configuration. The WS1 set-up was tested using a single impact attenuation configuration consisting of 26S1/plate/32S1 dual felt pads. The WS2 set-up was tested using three different impact attenuation configurations consisting of 26S1 felt, 32S1 felt, and the 26S1/plate/32S1 dual felt pads. Each seat configuration was compared to a non-weighted VID carriage configuration at different drop heights ranging from 10 to 50 inches.

The test data from the evaluation of the WS1 configuration showed that the additional weight of 309 lb had minimal effect on both the acceleration and the velocity change while using the dual felt impact configuration compared to the non-weighted carriage set-up. The percent differences for the peak acceleration and the velocity change showed only maximum values of 7 and 9% respectively at the 40 inch drop, and these values were considered very minor and inconclusive since the standard deviation of the data from tests with seat had values in the 2 to 5% range relative to the mean.

The test data from the evaluation of the WS2 configuration showed that the additional weight of 807 lb had minimal effect on the velocity change regardless of the impact attenuation configuration, but had a major effect on the peak acceleration relative to the felt attenuator. The peak acceleration increased by 84% with the stiffest impact felt configuration (32S1). The WS2 configuration did show some change in the peak acceleration compared to the WS1 configuration when the impact attenuation was the same as the WS1 test set-up (18% increase),

but this was minor compared to the affect the impact attenuator had on the peak acceleration. The increase in peak acceleration with very little change in the velocity was due to the duration of the acceleration time history pulse decreasing. The decrease for the pulse duration was measurable with either an increase in carriage weight, or an increase in the stiffness of the carriage attenuation.

The testing with the WS1 and WS2 set-up showed that the VID facility with either weight configuration produced overall velocity changes and time-to-peak velocity changes with the limits established by the WIAMan program (approximately 13 to 20 ft/s, and 5 to 10 ms respectively).

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GLOSSARY

ABP	Aircrew Biodynamics and Protection
AFRL	Air Force Research Laboratory
AFD	Accelerated Free-fall Device
CBDN	Collaborative Biomechanics Data Network
COD	Coefficient of Determination
DAS	Data Acquisition System
DC	Direct Current
DoD	Department of Defense
DTS	Diversified Technical Systems
GARD	Grumman Alderson Research Dummy
IED	Improvised Explosive Device
HPW	Human Performance Wing
MEAS	Measurement Specialties
NASA	National Aeronautics and Space Administration
TTP	Time to Peak
USAF	United States Air Force
VID	Vertical Impact Device
WIAMan	Warrior Injury Assessment Manikin
WPAFB	Wright-Patterson Air Force Base
WS1	WIAMan Seat One
WS2	WIAMan Seat Two
WWI	World War I

APPENDIX A. ELECTRONIC DATA CHANNEL DESCRIPTIONS

Test Numbers 1260 - 1267: Cells SH1 through SH4

Test Numbers 1281 - 1290: Cells SI1 through SI4

Test Numbers 1347 – 1354: Cells SM1 through SM4

Test Numbers 1355 – 1362: Cells SN1 through SN4

Test Numbers 1657 – 1664: Cells SM5 through SM8

Test Numbers 1665 – 1672: Cells SN5 through SN8

Test Numbers 1673 – 1680: Cells SH5/SI5 through SH8/SI8

CHARACTERIZATION OF VERTICAL IMPACT DEVICE ACCELERATION PULSES USING PARAMETRIC ASSMENT (PHASE III)						TEST DATES:15-16 Jan 2014; 24-28 Feb 2014; 4-11 Mar 2014; 1-23 Apr 2014						
STUDY NUMBER: 201306						TEST NUMBERS: 1252-1267; 1268-1306; 1307-1315; 1316-1369						
FACILITY: VID						SAMPLE RATE: 20K						
DATA COLLECTION SYSTEM: TDAS G5 sr# 5M0022						FILTER FREQUENCY: 2K						
						TRANSDUCER RANGE (VOLTS): +/- 5V						
DATA CHANNEL	DATA POINT	TRANSDUCER MFG. & MODEL	SERIAL NUMBER	PRE-CAL		POST-CAL		% Δ	DAS SENSITIVITY	BRIDGE	FULL SCALE	NOTES
				DATE	SENS	DATE	SENS					
1	CARRIAGE X ACCCEL (G)	MEAS SPEC EGCS-S425-250	R130NQ	03-Jul-13	.5746 mv/g at 10V exc	15-Aug-14	.5800 mv/g at 10V exc	0.9	.05746 mv/v/g	FULL	200 G	
2	CARRIAGE Y ACCCEL (G)	MEAS SPEC EGCS-S425-250	R130NP	03-Jul-13	.6097 mv/g at 10V exc	15-Aug-14	.6142 mv/g at 10V exc	0.7	.06097 mv/v/g	FULL	200 G	
3	CARRIAGE Z ACCCEL (G)	MEAS SPEC EGCS-S425-2000	A011331	24-Jan-14	.0857 mv/g at 10V exc	15-Aug-14	.0846 mv/g at 10V exc	1.4	.00857 mv/v/g	FULL	2000 G	Used on tests 1268 thru 1295
3	CARRIAGE Z ACCCEL (G)	MEAS SPEC EGCS-S425-250	R130NV	03-Jul-13	.6292 mv/g at 10V exc	15-Aug-14	.64178 mv/g at 10V exc	2	.06292 mv/v/g	FULL	250 G	Used on tests 1296 thru 1369
4	SEAT X ACCEL (G)	MEAS SPEC EGCS-S425-250	T13132	10-Jan-14	.6154 mv/g at 10V exc	15-Aug-14	.5976 mv/g at 10V exc	-2.9	.06154 mv/v/g	FULL	200 G	
5	SEAT Y ACCEL (G)	MEAS SPEC EGCS-S425-250	R1103Y	19-May-13	.5410 mv/g at 10V exc	15-Aug-14	.5546 mv/g at 10V exc	2.5	.05410 mv/v/g	FULL	200 G	
6	SEAT Z ACCEL (G)	ENDEVCO 7264C-2000	P57979	22-May-13	.1813 mv/g at 10V exc	07-Mar-14	.1851 mv/g at 10V exc	2.1	.01813 mv/v/g	FULL	2000 G	Used on tests 1268 thru 1295
6	SEAT Z ACCEL (G)	MEAS SPEC EGCS-S425-250	R130NT	03-Jul-14	.5891 mv/g at 10V exc	15-Aug-14	.5930 mv/g at 10V exc	0.7	.05891 mv/v/g	FULL	250 G	Used on tests 1296 thru 1369
7	SEAT PAN Z ACCEL (G)	MEAS SPEC EGCS-S425-2000	A012954	26-Jun-13	.0809 mv/g at 10V exc	15-Aug-14	.0826 mv/g at 10V exc	0.8	.00809 mv/v/g	FULL	2000 G	Used on tests 1268 thru 1295
7	SEAT PAN Z ACCEL (G)	MEAS SPEC EGCS-S425-250	R130NR	03-Jul-14	.5871 mv/g at 10V exc	15-Aug-14	.5922 mv/g at 10V exc	0.9	.05871 mv/v/g	FULL	250 G	Used on tests 1296 thru 1369
8	SEAT PAN Z2 ACCEL (G)	ENDEVCO 2262A-2000	L16923	15-Oct-12	.3376 mv/g at 10V exc	NA	NA	NA	.03376 mv/v/g	FULL	1000 G	Customer owned. Customer will calibrate.
9	SEAT PAN Z3 ACCEL (G)	ENDEVCO 7270A-60K	F41161	19-Sep-13	2.758 uv/g at 10V exc	NA	NA	NA	.0002758 mv/v/g	FULL	1000 G	Customer owned. Customer will calibrate.
10	FOOT REST X ACCEL (G)	MEAS SPEC EGCS-S425-250	T13130	10-Jan-14	.6700 mv/g at 10V exc	15-Aug-14	.6507 mv/g at 10V exc	-2.9	.06700 mv/v/g	FULL	200 G	
11	FOOT REST Y ACCEL (G)	MEAS SPEC EGCS-S425-250	T13131	10-Jan-14	.6015 mv/g at 10V exc	15-Aug-14	.5845 mv/g at 10V exc	-2.8	.06015 mv/v/g	FULL	200 G	
12	FOOT REST Z ACCEL (G)	ENDEVCO 7264C-2000	P56419	22-May-13	.2200 mv/g at 10V exc	07-Mar-14	.2257 mv/g at 10V exc	2.6	.02200 mv/v/g	FULL	2000 G	Used on tests 1268 thru 1295
12	FOOT REST Z ACCEL (G)	MEAS SPEC EGCS-S425-250	R130NU	03-Jul-14	.5707 mv/g at 10V exc	15-Aug-14	.5867 mv/g at 10V exc	2.8	.05707 mv/v/g	FULL	250 G	Used on tests 1296 thru
13	FOOT REST Z2 ACCEL (G)	ENDEVCO 2262A-2000	L17037	15-Oct-13	.4166 mv/g at 10V exc	NA	NA	NA	.04166 mv/v/g	FULL	1000 G	Customer owned. Customer will calibrate.
14	FOOT REST Z3 ACCEL (G)	ENDEVCO 7270A-60K	F41085	22-Aug-13	2.706 uv/g at 10V exc	NA	NA	NA	.0002706 mv/v/g	FULL	1000 G	Customer owned. Customer will calibrate. 10 SEPT. 2014

15	VELOCITY GATE 1 (V)	NEULOG NUL-209	26	NA	1000 mv/v at 5v exc	NA	NA	NA	1000 mv/v/v	FULL	5 V	
16	VELOCITY GATE 2 (V)	NEULOG NUL-209	40	NA	1000 mv/v at 5v exc	NA	NA	NA	1000 mv/v/v	FULL	5 V	
17	LEFT FRONT SEAT PAN Z FORCE (LB)	STRAINSERT FL5(U)-2SGKT	Q-19794-2	14-Aug-13	4.00 uv/lb at 10V exc	2-Sep-14	4.0 uv/lb at 10V exc	0.0	.0004 mv/v/lb	FULL	5000 LB	
18	RIGHT FRONT SEAT PAN Z FORCE (LB)	STRAINSERT FL5(U)-2SGKT	Q-19794-1	22-Aug-13	3.99 uv/lb at 10V exc	2-Sep-14	4.0 uv/lb at 10V exc	0.3	.0004 mv/v/lb	FULL	5000 LB	
19	LEFT REAR SEAT PAN Z FORCE (LB)	STRAINSERT FL5(U)-2SGKT	Q-22614-6	31-Jan-14	4.00 uv/lb at 10V exc	28-Aug-14	4.00 uv/lb at 10V exc	0.0	.0004 mv/v/lb	FULL	5000 LB	
20	RIGHT REAR SEAT PAN Z FORCE (LB)	STRAINSERT FL5(U)-2SGKT	Q-22614-5	31-Jan-14	4.00 uv/lb at 10V exc	29-Aug-14	4.00 uv/lb at 10V exc	0.0	.0004 mv/v/lb	FULL	5000 LB	
21	LEFT FRONT FOOT REST PAN Z FORCE (LB)	STRAINSERT FL5(U)-2SGKT	Q-22614-4	31-Jan-14	4.00 uv/lb at 10V exc	29-Aug-14	3.99 uv/lb at 10V exc	-0.3	.0004 mv/v/lb	FULL	5000 LB	
22	RIGHT FRONT FOOT REST PAN Z FORCE (LB)	STRAINSERT FL5(U)-2SGKT	Q-22614-3	31-Jan-14	4.00 uv/lb at 10V exc	28-Aug-14	4.01 uv/lb at 10V exc	0.3	.0004 mv/v/lb	FULL	5000 LB	
23	LEFT REAR FOOT REST PAN Z FORCE (LB)	STRAINSERT FL5(U)-2SGKT	Q-22614-2	31-Jan-14	4.00 uv/lb at 10V exc	27-Aug-14	4.03 uv/lb at 10V exc	0.8	.0004 mv/v/lb	FULL	5000 LB	
24	RIGHT REAR FOOT REST PAN Z FORCE (LB)	STRAINSERT FL5(U)-2SGKT	Q-22614-1	31-Jan-14	4.00 uv/lb at 10V exc	27-Aug-14	3.99 uv/lb at 10V exc	-0.3	.0004 mv/v/lb	FULL	5000 LB	
25	LEFT LAP X FORCE (LB)	MICH SCI TR3D-B-3K	3 X	27-Jan-14	14.77 uv/lb at 10V exc	18-Aug-14	14.43 uv/lb at 10V exc	-2.3	.001477 mv/v/lb	FULL	1500 LB	Used for all tests
26	LEFT LAP Y FORCE (LB)	MICH SCI TR3D-B-4K	3 Y	27-Jan-14	14.63 uv/lb at 10V exc	18-Aug-14	15.04 uv/lb at 10V exc	2.8	.001463 mv/v/lb	FULL	1500 LB	Used for all tests
27	LEFT LAP Z FORCE (LB)	MICH SCI TR3D-B-4K	3 Z	27-Jan-14	11.79 uv/lb at 10V exc	18-Aug-14	12.12 uv/lb at 10V exc	2.8	.001179 mv/v/lb	FULL	1500 LB	Used for all tests
28	RIGHT LAP X FORCE (LB)	MICH SCI TR3D-B-4K	447 Y	27-Jan-14	14.50 uv/lb at 10V exc	18-Aug-14	14.89 uv/lb at 10V exc	2.7	.001450 mv/v/lb	FULL	1500 LB	Used for all tests
29	RIGHT LAP Y FORCE (LB)	MICH SCI TR3D-B-4K	447 X	27-Jan-14	14.74 uv/lb at 10V exc	18-Aug-14	15.15 uv/lb at 10v exc	2.8	.001474 mv/v/lb	FULL	1500 LB	Used for all tests
30	RIGHT LAP Z FORCE (LB)	MICH SCI TR3D-B-4K	447 Z	27-Jan-14	11.79 uv/lb at 10V exc	18-Aug-14	12.04 uv/lb at 10V exc	2.1	.001179 mv/v/lb	FULL	1500 LB	Used for all tests
31	LEFT SHOULDER X FORCE (LB)	MICH SCI TR3D-B-4K	5 Y	27-Jan-14	14.46 uv/lb at 10V exc	18-Aug-14	14.84 uv/lb at 10V exc	2.6	.001446 mv/v/lb	FULL	1500 LB	Used for all tests
32	LEFT SHOULDER Y FORCE (LB)	MICH SCI TR3D-B-4K	5 X	27-Jan-14	14.61 uv/lb at 10V exc	18-Aug-14	14.92 uv/lb at 10V exc	2.1	.001461 mv/v/lb	FULL	1500 LB	Used for all tests
33	LEFT SHOULDER Z FORCE (LB)	MICH SCI TR3D-B-4K	5 Z	27-Jan-14	11.71 uv/lb at 10V exc	18-Aug-14	12.01 uv/lb at 10V exc	2.6	.001171 mv/v/lb	FULL	1500 LB	Used for all tests

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34	RIGHT SHOULDER X FORCE (LB)	MICH SCI TR3D-B-4K	381 Y	14-Feb-14	12.83 uv/lb at 10V exc	18-Aug-14	12.87 uv/lb at 10V exc	0.3	.001283 mv/v/lb	FULL	1500 LB	Used for all tests
35	RIGHT SHOULDER Y FORCE (LB)	MICH SCI TR3D-B-4K	381 X	14-Feb-14	12.60 uv/lb at 10V exc	18-Aug-14	12.60 uv/lb at 10V exc	0.0	.001260 mv/v/lb	FULL	1500 LB	Used for all tests
36	RIGHT SHOULDER Z FORCE (LB)	MICH SCI TR3D-B-4K	381 Z	14-Feb-14	10.84 uv/lb at 10V exc	18-Aug-14	10.90 uv/lb at 10V exc	0.5	.001084 mv/v/lb	FULL	1500 LB	Used for all tests
37	CROTCH X FORCE (LB)	MICH SCI TR3D-B-4K	2 Y	27-Jan-14	14.70 uv/lb at 10V exc	18-Aug-14	14.70 uv/lb at 10V exc	2.6	.001470 mv/v/lb	FULL	1500 LB	Used for tests 1288 thru 1310
38	CROTCH Y FORCE (LB)	MICH SCI TR3D-B-4K	2 X	27-Jan-14	14.89 uv/lb at 10V exc	18-Aug-14	15.20 uv/lb at 10V exc	2.1	.001489 mv/v/lb	FULL	1500 LB	Used for tests 1288 thru 1310
39	CROTCH Z FORCE (LB)	MICH SCI TR3D-B-4K	2 Z	27-Jan-14	11.78 uv/lb at 10V exc	18-Aug-14	11.78 uv/lb at 10V exc	2.5	.001178 mv/v/lb	FULL	1500 LB	Used for tests 1288 thru 1310
40	LEFT SHOULDER FORCE (LB)	DENTON 1910	319	21-Mar-13	6.56 uv/lb at 10V exc	4-Jun-14	6.51 uv/lb at 10V exc	-0.8	.000651 mv/v/lb	FULL	1500 LB	Used for all tests
41	RIGHT SHOULDER FORCE (LB)	DENTON 1910	320	3-Apr-13	6.57 uv/lb at 10V exc	27-May-14	6.54 uv/lb at 10V exc	-0.5	.000654 mv/v/lb	FULL	1500 LB	Used for all tests
42	LEFT LAP FORCE (LB)	DENTON 1910	318	21-Mar-13	6.60 uv/lb at 10V exc	4-Jun-14	6.62 uv/lb at 10V exc	0.3	.000662 mv/v/lb	FULL	1500 LB	Used for all tests
43	RIGHT LAP FORCE (LB)	DENTON 1910	321	21-Mar-13	6.50 uv/lb at 10V exc	09-Jun-14	6.52 uv/lb at 10V exc	0.3	.000652 mv/v/lb	FULL	1500 LB	Used for all tests

10 SEPT 2014

PROGRAM: VID WIAMAN_Test Plan Addendum_Phase III_Baseline Data:Addendum to Test Plan for Program/Study Number: 201304						TEST DATES: 24 May 2016 - 25 May 2016						
STUDY NUMBER: 201604						TEST NUMBERS: 1656 - 1680						
FACILITY: VID						SAMPLE RATE: 20k						
DATA COLLECTION SYSTEM: TDAS G5						FILTER FREQUENCY: 4k						
						TRANSDUCER RANGE (VOLTS): +/- 5V						
DATA CHANNEL	DATA POINT	TRANSDUCER MFG. & MODEL	SERIAL NUMBER	PRE-CAL		POST-CAL		% Δ	DAS SENSITIVITY	BRIDGE	FULL SCALE	NOTES
				DATE	SENS	DATE	SENS					
1	CARRIAGE X ACCEL (G)	ENDEVCO 7264C-500	P11256	29-Mar-16	.6971 mv/g at 10V exc	06-Jun-16	.6934 mv/g at 10V exc	-0.5	.06971 mv/v/g	FULL	100 G	
2	CARRIAGE Y ACCEL (G)	ENDEVCO 7264C-500	P10500	29-Mar-16	.5568 mv/g at 10V exc	06-Jun-16	.5546 mv/g at 10V exc	-0.4	.05568 mv/v/g	FULL	100 G	
3	CARRIAGE Z ACCEL (G)	MEAS SPEC EGCS-S425-1000	N04741	29-Mar-16	.1158 mv/g at 10V exc	06-Jun-16	.1165 mv/g at 10V exc	0.6	.01158 mv/v/g	FULL	500 G	

APPENDIX B. VID ASSESSMENT WITH WS1: TEST BY TEST SUMMARY

The following is a review of the test configuration for each of the impact tests conducted on the VID with a test-by-test summary. The tests are for the WS1 seat configuration and the comparison tests with no added weight to the VID carriage. The WS1 Configuration consisted of a 150 lb seat fixture with 159 lb Hybrid III 50% male manikin.

A breakout of the tests per cell are as follows: Test Numbers 1260 - 1267: Cells SH1 through SH4 (WS1 Seat and Manikin Configuration); and Test Numbers 1673 – 1680: Cells SH5 through SH8 (No Weight on VID Carriage)

- **Test 1260:** Cell SH1, Test 1; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 20 in., Peak Acceleration = 82.7 G, Integrated Velocity Change = 13.89 ft/s (4.23 m/s), Measured Velocity Change = 10.85 ft/s (3.31 m/s), Measured Total Velocity Change = 14.24 ft/s (4.34 m/s), Time-to-Peak Acceleration = 5.2 ms, Time-to-Peak Velocity = 14.2 ms. **Successful Test – All electronic data channels were present and continuous, data was successfully collected, and desired test condition was achieved for testing WIAMAN I Seat. Note: This test included the presence of the Honda Hybrid III manikin and the addition of the ACES seat cushion.**
- **Test 1261:** Cell SH1, Test 2; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 20 in., Peak Acceleration = 77.46 G, Integrated Velocity Change = 13.19 ft/s (4.02 m/s), Measured Velocity Change = 10.33 ft/s (3.15 m/s), Measured Total Velocity Change = 13.39 ft/s (4.08 m/s), Time-to-Peak Acceleration = 5.3 ms, Time-to-Peak Velocity = 14.3 ms. **Successful Test – All electronic data channels were present and continuous, data was successfully collected, and desired test condition was achieved for testing WIAMAN I Seat. Note: This test included the presence of the Honda Hybrid III manikin and the addition of the ACES seat cushion.**
- **Test 1262:** Cell SH2, Test 1; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 30 in., Peak Acceleration = 96.66 G, Integrated Velocity Change = 15.8 ft/s (4.81 m/s), Measured Velocity Change = 12.5 ft/s (3.81 m/s), Measured Total Velocity Change = 16.46 ft/s (5.02 m/s), Time-to-Peak Acceleration = 5.4 ms, Time-to-Peak Velocity = 14 ms. **Successful Test – All electronic data channels were present and continuous, data was successfully collected, and desired test condition was achieved for testing WIAMAN I Seat. Note: This test included the presence of the Honda Hybrid III manikin and the addition of the ACES seat cushion.**
- **Test 1263:** Cell SH2, Test 2; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 30 in., Peak Acceleration = 97.93 G, Integrated Velocity Change = 15.99 ft/s (4.87 m/s), Measured Velocity Change = 12.62 ft/s (3.85 m/s), Measured Total Velocity Change = 16.39 ft/s (5 m/s), Time-to-Peak Acceleration = 5.4 ms, Time-to-Peak Velocity = 13.9 ms. **Successful Test – All electronic data channels were present and continuous, data was successfully collected, and desired test condition was achieved for testing WIAMAN I Seat. Note: This test included the presence of the Honda Hybrid III manikin and the addition of the ACES seat cushion.**

- **Test 1264:** Cell SH3, Test 1; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 40 in., Peak Acceleration = 115.65 G, Integrated Velocity Change = 18.26 ft/s (5.57 m/s), Measured Velocity Change = 14.58 ft/s (4.44 m/s), Measured Total Velocity Change = 19.5 ft/s (5.94 m/s), Time-to-Peak Acceleration = 4.6 ms, Time-to-Peak Velocity = 13.8 ms. **Successful Test – All electronic data channels were present and continuous, data was successfully collected, and desired test condition was achieved for testing WIAMAN I Seat. Note: This test included the presence of the Honda Hybrid III manikin and the addition of the ACES seat cushion.**
- **Test 1265:** Cell SH3, Test 2; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 40 in., Peak Acceleration = 113.44 G, Integrated Velocity Change = 18.03 ft/s (5.5 m/s), Measured Velocity Change = 14.42 ft/s (4.4 m/s), Measured Total Velocity Change = 19.06 ft/s (5.81 m/s), Time-to-Peak Acceleration = 4.8 ms, Time-to-Peak Velocity = 13.7 ms. **Successful Test – All electronic data channels were present and continuous, data was successfully collected, and desired test condition was achieved for testing WIAMAN I Seat. Note: This test included the presence of the Honda Hybrid III manikin and the addition of the ACES seat cushion.**
- **Test 1266:** Cell SH4, Test 1; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 50 in., Peak Acceleration = 135.94 G, Integrated Velocity Change = 20.48 ft/s (6.24 m/s), Measured Velocity Change = 16.61 ft/s (5.06 m/s), Measured Total Velocity Change = 22.24 ft/s (6.78 m/s), Time-to-Peak Acceleration = 4.8 ms, Time-to-Peak Velocity = 13.4 ms. **Successful Test – All electronic data channels were present and continuous, data was successfully collected, and desired test condition was achieved for testing WIAMAN I Seat. Note: This test included the presence of the Honda Hybrid III manikin and the addition of the ACES seat cushion.**
- **Test 1267:** Cell SH4, Test 2; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 50 in., Peak Acceleration = 131.95 G, Integrated Velocity Change = 20.15 ft/s (6.14 m/s), Measured Velocity Change = 16.2 ft/s (4.94 m/s), Measured Total Velocity Change = 21.79 ft/s (6.64 m/s), Time-to-Peak Acceleration = 4.8 ms, Time-to-Peak Velocity = 13.4 ms. **Successful Test – All electronic data channels were present and continuous, data was successfully collected, and desired test condition was achieved for testing WIAMAN I Seat. Note: This test included the presence of the Honda Hybrid III manikin and the addition of the ACES seat cushion.**

APPENDIX C. VID ASSESSMENT WITH WS2: TEST BY TEST SUMMARY

The following is a review of the test configuration for each of the impact tests conducted on the VID with a test-by-test summary. The tests are for the WS2 seat configuration and the comparison tests with no added weight to the VID carriage. The WS2 Configuration consisted of a 617 lb seat fixture with 190 lb GARD male manikin.

A breakout of the tests per cells are as follows: Test Numbers 1281 - 1290: Cells SI1 through SI4; Test Numbers 1347 – 1354: Cells SM1 through SM4; Test Numbers 1355 – 1362: Cells SN1 through SN4; Test Numbers 1657 – 1664: Cells SM5 through SM8; Test Numbers 1665 – 1672: Cells SN5 through SN8; and Test Numbers 1673 – 1680: Cells SH5 through SH8.

- **Test 1281:** Cell SI2, Test 2; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 20 in., Peak Acceleration = 86.46 G. **Integrated Velocity Change:** Carriage Z = 13.39 ft/s (4.08 m/s), Seat Pan Reference = 14.42 ft/s (4.39 m/s), Foot Rest Reference = 13.3 ft/s (4.05 m/s). Measured Velocity Change = 9.87 ft/s (3.01 m/s), Measured Total Velocity Change = 12.83 ft/s (3.91 m/s); Time-to-Peak Acceleration = 5 ms, Time-to-Peak Velocity = 13.8 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject. First test using new felt.
- **Test 1282:** Cell SI2, Test 3; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 20 in., Peak Acceleration = 85.81 G. **Integrated Velocity Change:** Carriage Z = 13.05 ft/s (3.97 m/s), Seat Pan Reference = 14.43 ft/s (4.4 m/s), Foot Rest Reference = 13.32 ft/s (4.06 m/s). Measured Velocity Change = 9.79 ft/s (2.99 m/s), Measured Total Velocity Change = 12.89 ft/s (3.93 m/s); Time-to-Peak Acceleration = 5 ms, Time-to-Peak Velocity = 13.6 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.
- **Test 1283:** Cell SI2, Test 4; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 20 in., **No Test – Bad test; no data was recorded for this test.**
- **Test 1284:** Cell SI2, Test 5; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 20 in., Peak Acceleration = 90.38 G. **Integrated Velocity Change:** Carriage Z = 13.49 ft/s (4.11 m/s), Seat Pan Reference = 14.57 ft/s (4.44 m/s), Foot Rest Reference = 13.49 ft/s (4.11 m/s). Measured Velocity Change = 9.87 ft/s (3.01 m/s), Measured Total Velocity Change = 13.02 ft/s (3.97 m/s); Time-to-Peak Acceleration = 4.6 ms, Time-to-Peak Velocity = 13.1 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.

- **Test 1285:** Cell SI3, Test 1; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 30 in., Peak Acceleration = 109.22 G. **Integrated Velocity Change:** Carriage Z = 16.67 ft/s (5.09 m/s), Seat Pan Reference = 17.57 ft/s (5.36 m/s), Foot Rest Reference = 16.32 ft/s (4.97 m/s). Measured Velocity Change = 11.93 ft/s (3.64 m/s), Measured Total Velocity Change = 16.02 ft/s (4.88 m/s); Time-to-Peak Acceleration = 5 ms, Time-to-Peak Velocity = 13.9 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject; Velocity Gate= delta V.
- **Test 1286:** Cell SI3, Test 2; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Height = 30 in., Peak Acceleration = 111.59 G. **Integrated Velocity Change:** Carriage Z = 15.72 ft/s (4.79 m/s), Seat Pan Reference = 17.71 ft/s (5.4 m/s), Foot Rest Reference = 16.46 ft/s (5.02 m/s). Measured Velocity Change = 11.93 ft/s (3.64 m/s), Measured Total Velocity Change = 16.08 ft/s (4.9 m/s); Time-to-Peak Acceleration = 3 ms, Time-to-Peak Velocity = 10.7 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject; Velocity Gate= delta V.
- **Test 1287:** Cell SI3, Test 3; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 30 in., Peak Acceleration = 111.58 G. **Integrated Velocity Change:** Carriage Z = 15.88 ft/s (4.84 m/s), Seat Pan Reference = 17.79 ft/s (5.43 m/s), Foot Rest Reference = 16.46 ft/s (5.02 m/s). Measured Velocity Change = 11.93 ft/s (3.64 m/s), Measured Total Velocity Change = 16.06 ft/s (4.89 m/s); Time-to-Peak Acceleration = 4 ms, Time-to-Peak Velocity = 13.1 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject; Velocity Gate= delta V.
- **Test 1288:** Cell SI4, Test 1; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 40 in., Peak Acceleration = 134.03 G. **Integrated Velocity Change:** Carriage Z = 19.27 ft/s (5.88 m/s), Seat Pan Reference = 20.35 ft/s (6.2 m/s), Foot Rest Reference = 18.84 ft/s (5.75 m/s). Measured Velocity Change = 13.53 ft/s (4.12 m/s), Measured Total Velocity Change = 18.54 ft/s (5.65 m/s); Time-to-Peak Acceleration = 5 ms, Time-to-Peak Velocity = 12.6 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject; Velocity Gate= delta V.

- Test 1289:** Cell SI4, Test 2; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 40 in., Peak Acceleration = 136.72 G. **Integrated Velocity Change:** Carriage Z = 18.25 ft/s (5.56 m/s), Seat Pan Reference = 20.44 ft/s (6.22 m/s), Foot Rest Reference = 18.95 ft/s (5.77 m/s). Measured Velocity Change = 13.81 ft/s (4.21 m/s), Measured Total Velocity Change = 18.86 ft/s (5.75 m/s); Time-to-Peak Acceleration = 5 ms, Time-to-Peak Velocity = 12.9 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject; Velocity Gate= delta V.
- Test 1290:** Cell SI4, Test 3; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 40 in., Peak Acceleration = 133.48 G. **Integrated Velocity Change:** Carriage Z = 19.78 ft/s (6.02 m/s), Seat Pan Reference = 20.58 ft/s (6.27 m/s), Foot Rest Reference = 18.94 ft/s (5.77 m/s). Measured Velocity Change = 13.96 ft/s (4.26 m/s), Measured Total Velocity Change = 19.17 ft/s (5.84 m/s); Time-to-Peak Acceleration = 5 ms, Time-to-Peak Velocity = 12.5 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject; Velocity Gate= delta V.
- Test 1347:** Cell SM2, Test 1; Felt Density 3251 (2.0 in.), Drop Height = 20 in., Peak Acceleration = 165.97 G. **Integrated Velocity Change:** Carriage Z = 13.71 ft/s (4.18 m/s), Seat Pan Reference = 14.42 ft/s (4.39 m/s). Measured Velocity Change = 10.17 ft/s (3.1 m/s), Measured Total Velocity Change = 13.19 ft/s (4.02 m/s); Time-to-Peak Acceleration = 2.3 ms, Time-to-Peak Velocity = 6.8 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject.
- Test 1348:** Cell SM2, Test 2; Felt Density 3251 (2.0 in.), Drop Height = 20 in., Peak Acceleration = 168.05 G. **Integrated Velocity Change:** Carriage Z = 13.79 ft/s (4.2 m/s), Seat Pan Reference = 14.55 ft/s (4.44 m/s). Measured Velocity Change = 10.17 ft/s (3.1 m/s), Measured Total Velocity Change = 13.23 ft/s (4.03 m/s); Time-to-Peak Acceleration = 2.3 ms, Time-to-Peak Velocity = 6.7 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject.
- Test 1349:** Cell SM1, Test 1; Felt Density 3251 (2.0 in.), Drop Height = 10 in., Peak Acceleration = 105.9 G. **Integrated Velocity Change:** Carriage Z = 9.5 ft/s (2.9 m/s), Seat Pan Reference = 10.26 ft/s (3.13 m/s). Measured Velocity Change = 6.98 ft/s (2.13 m/s), Measured Total Velocity Change = 12.47 ft/s (3.8 m/s); Time-to-Peak Acceleration = 2.4 ms, Time-to-Peak Velocity = 6.8 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject.

- **Test 1350:** Cell SM1, Test 2; Felt Density 3251 (2.0 in.), Drop Height = 10 in., Peak Acceleration = 106.55 G. **Integrated Velocity Change:** Carriage Z = 9.56 ft/s (2.91 m/s), Seat Pan Reference = 10.37 ft/s (3.16 m/s). Measured Velocity Change = 7.02 ft/s (2.14 m/s), Measured Total Velocity Change = 8.25 ft/s (2.51 m/s); Time-to-Peak Acceleration = 2.4 ms, Time-to-Peak Velocity = 6.9 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.
- **Test 1351:** Cell SM3, Test 1; Felt Density 3251 (2.0 in.), Drop Height = 30 in., Peak Acceleration = 215.95 G. **Integrated Velocity Change:** Carriage Z = 16.98 ft/s (5.17 m/s), Seat Pan Reference = 17.93 ft/s (5.46 m/s). Measured Velocity Change = 12.74 ft/s (3.88 m/s), Measured Total Velocity Change = 16.75 ft/s (5.11 m/s); Time-to-Peak Acceleration = 2.3 ms, Time-to-Peak Velocity = 6.5 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.
- **Test 1352:** Cell SM3, Test 2; Felt Density 3251 (2.0 in.), Drop Height = 30 in., Peak Acceleration = 211.62 G. **Integrated Velocity Change:** Carriage Z = 16.8 ft/s (5.11 m/s), Seat Pan Reference = 17.77 ft/s (5.41 m/s). Measured Velocity Change = 12.38 ft/s (3.77 m/s), Measured Total Velocity Change = 16.36 ft/s (4.99 m/s); Time-to-Peak Acceleration = 2.3 ms, Time-to-Peak Velocity = 6.3 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.
- **Test 1353:** Cell SM4, Test 1; Felt Density 3251 (2.0 in.), Drop Height = 40 in., Peak Acceleration = 251.92 G. **Integrated Velocity Change:** Carriage Z = 19.42 ft/s (5.92 m/s), Seat Pan Reference = 20.16 ft/s (6.14 m/s). Measured Velocity Change = 14.58 ft/s (4.44 m/s), Measured Total Velocity Change = 19.08 ft/s (5.81 m/s); Time-to-Peak Acceleration = 2.2 ms, Time-to-Peak Velocity = 5.8 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.
- **Test 1354:** Cell SM4, Test 2; Felt Density 3251 (2.0 in.), Drop Height = 40 in., Peak Acceleration = 242.69 G. **Integrated Velocity Change:** Carriage Z = 19.02 ft/s (5.8 m/s), Seat Pan Reference = 20.49 ft/s (6.25 m/s). Measured Velocity Change = 14.11 ft/s (4.3 m/s), Measured Total Velocity Change = 18.56 ft/s (5.66 m/s); Time-to-Peak Acceleration = 2.2 ms, Time-to-Peak Velocity = 6.6 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.

- **Test 1355:** Cell SN1, Test 1; Felt Density 2651 (2.0 in.), Drop Height = 10 in., Peak Acceleration = 75 G. **Integrated Velocity Change:** Carriage Z = 9.53 ft/s (2.9 m/s), Seat Pan Reference = 10.1 ft/s (3.08 m/s). Measured Velocity Change = 6.94 ft/s (2.12 m/s), Measured Total Velocity Change = 8.18 ft/s (2.49 m/s); Time-to-Peak Acceleration = 3.3 ms, Time-to-Peak Velocity = 8.4 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject.
- **Test 1356:** Cell SN1, Test 2; Felt Density 2651 (2.0 in.), Drop Height = 10 in., Peak Acceleration = 76.21 G. **Integrated Velocity Change:** Carriage Z = 9.58 ft/s (2.91 m/s), Seat Pan Reference = 10.19 ft/s (3.1 m/s). Measured Velocity Change = 6.98 ft/s (2.13 m/s), Measured Total Velocity Change = 8.23 ft/s (2.51 m/s); Time-to-Peak Acceleration = 3.3 ms, Time-to-Peak Velocity = 7.7 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject.
- **Test 1357:** Cell SN2, Test 1; Felt Density 2651 (2.0 in.), Drop Height = 20 in., Peak Acceleration = 119.93 G. **Integrated Velocity Change:** Carriage Z = 13.78 ft/s (4.2 m/s), Seat Pan Reference = 14.64 ft/s (4.46 m/s). Measured Velocity Change = 10.25 ft/s (3.13 m/s), Measured Total Velocity Change = 13.4 ft/s (4.08 m/s); Time-to-Peak Acceleration = 3.3 ms, Time-to-Peak Velocity = 7.4 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject.
- **Test 1358:** Cell SN2, Test 2; Felt Density 2651 (2.0 in.), Drop Height = 20 in., Peak Acceleration = 115.54 G. **Integrated Velocity Change:** Carriage Z = 13.37 ft/s (4.08 m/s), Seat Pan Reference = 14.23 ft/s (4.33 m/s). Measured Velocity Change = 9.87 ft/s (3.01 m/s), Measured Total Velocity Change = 12.82 ft/s (3.91 m/s); Time-to-Peak Acceleration = 3.3 ms, Time-to-Peak Velocity = 7.4 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject.
- **Test 1359:** Cell SN3, Test 1; Felt Density 2651 (2.0 in.), Drop Height = 30 in., Peak Acceleration = 154.38 G. **Integrated Velocity Change:** Carriage Z = 16.64 ft/s (5.07 m/s), Seat Pan Reference = 17.6 ft/s (5.36 m/s). Measured Velocity Change = 12.5 ft/s (3.81 m/s), Measured Total Velocity Change = 16.45 ft/s (5.01 m/s); Time-to-Peak Acceleration = 3.3 ms, Time-to-Peak Velocity = 7.1 ms.

Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.

Note: This test was conducted with GARD as the test subject.

- **Test 1360:** Cell SN3, Test 2; Felt Density 2651 (2.0 in.), Drop Height = 30 in., Peak Acceleration = 155.98 G. **Integrated Velocity Change:** Carriage Z = 16.76 ft/s (5.11 m/s), Seat Pan Reference = 17.7 ft/s (5.4 m/s). Measured Velocity Change = 12.5 ft/s (3.81 m/s), Measured Total Velocity Change = 16.46 ft/s (5.02 m/s); Time-to-Peak Acceleration = 3.3 ms, Time-to-Peak Velocity = 7.1 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.
- **Test 1361:** Cell SN4, Test 1; Felt Density 2651 (2.0 in.), Drop Height = 40 in., Peak Acceleration = 182.36 G. **Integrated Velocity Change:** Carriage Z = 18.82 ft/s (5.74 m/s), Seat Pan Reference = 19.92 ft/s (6.08 m/s). Measured Velocity Change = 14.11 ft/s (4.3 m/s), Measured Total Velocity Change = 18.61 ft/s (5.67 m/s); Time-to-Peak Acceleration = 3.1 ms, Time-to-Peak Velocity = 6.8 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.
- **Test 1362:** Cell SN4, Test 2; Felt Density 2651 (2.0 in.), Drop Height = 40 in., Peak Acceleration = 186.76 G. **Integrated Velocity Change:** Carriage Z = 19.16 ft/s (5.84 m/s), Seat Pan Reference = 20.21 ft/s (6.16 m/s). Measured Velocity Change = 14.42 ft/s (4.4 m/s), Measured Total Velocity Change = 19.09 ft/s (5.82 m/s); Time-to-Peak Acceleration = 3.1 ms, Time-to-Peak Velocity = 6.8 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing WIAMAN II Seat.
Note: This test was conducted with GARD as the test subject.
- **Test 1657:** Cell SM5, Test 1; Programmer: 2" Felt 32S1. Drop Height = 10 in., Peak G level = 73.32, Velocity Change = 9.95 ft/s, Time-to-Peak Acceleration = 4.9 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1658:** Cell SM5, Test 2; Programmer: 2" Felt 32S1. Drop Height = 10 in., Peak G level = 74.03, Velocity Change = 10.04 ft/s, Time-to-Peak Acceleration = 4.9 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1659:** Cell SM6, Test 1; Programmer: 2" Felt 32S1. Drop Height = 20 in., Peak G level = 107.29, Velocity Change = 14.33 ft/s, Time-to-Peak Acceleration = 4.7 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1660:** Cell SM6, Test 2; Programmer: 2" Felt 32S1. Drop Height = 20 in., Peak G level = 107.43, Velocity Change = 14.37 ft/s, Time-to-Peak Acceleration = 4.7 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.

- **Test 1661:** Cell SM7, Test 1; Programmer: 2" Felt 32S1. Drop Height = 30 in., Peak G level = 133.47, Velocity Change = 17.71 ft/s, Time-to-Peak Acceleration = 4.6 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1662:** Cell SM7, Test 2; Programmer: 2" Felt 32S1. Drop Height = 30 in., Peak G level = 134.06, Velocity Change = 17.8 ft/s, Time-to-Peak Acceleration = 4.7 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1663:** Cell SM8, Test 1; Programmer: 2" Felt 32S1. Drop Height = 40 in., Peak G level = 154.91, Velocity Change = 20.48 ft/s, Time-to-Peak Acceleration = 4.6 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1664:** Cell SM8, Test 2; Programmer: 2" Felt 32S1. Drop Height = 40 in., Peak G level = 154.3, Velocity Change = 20.4 ft/s, Time-to-Peak Acceleration = 4.6 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1665:** Cell SN5, Test 1; Programmer: 2" Felt 26S1. Drop Height = 10 in., Peak G level = 65.19, Velocity Change = 9.95 ft/s, Time-to-Peak Acceleration = 5.3 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1666:** Cell SN5, Test 2; Programmer: 2" Felt 26S1. Drop Height = 10 in., Peak G level = 65.53, Velocity Change = 10.01 ft/s, Time-to-Peak Acceleration = 5.4 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1667:** Cell SN6, Test 1; Programmer: 2" Felt 26S1. Drop Height = 20 in., Peak G level = 95.04, Velocity Change = 14.15 ft/s, Time-to-Peak Acceleration = 5.0 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1668:** Cell SN6, Test 2; Programmer: 2" Felt 26S1. Drop Height = 20 in., Peak G level = 95.21, Velocity Change = 14.18 ft/s, Time-to-Peak Acceleration = 5.1 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1669:** Cell SN7, Test 1; Programmer: 2" Felt 26S1. Drop Height = 30 in., Peak G level = 117.58, Velocity Change = 17.25 ft/s, Time-to-Peak Acceleration = 5.0 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.

- **Test 1670:** Cell SN7, Test 2; Programmer: 2" Felt 26S1. Drop Height = 30 in., Peak G level = 117.74, Velocity Change = 17.27 ft/s, Time-to-Peak Acceleration = 5.0 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1671:** Cell SN8, Test 1; Programmer: 2" Felt 26S1. Drop Height = 40 in., Peak G level = 136.69, Velocity Change = 19.83 ft/s, Time-to-Peak Acceleration = 5.0 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1672:** Cell SN8, Test 2; Programmer: 2" Felt 26S1. Drop Height = 40 in., Peak G level = 136.28, Velocity Change = 19.8 ft/s, Time-to-Peak Acceleration = 5.0 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1673:** Cell SH5, Test 1; Programmer: 2" Felt 26S1/ Plate/ 2" Felt 32S1. Drop Height = 10 in., Peak G level = 56.62, Velocity Change = 9.97 ft/s, Time-to-Peak Acceleration = 6.3 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1674:** Cell SH5, Test 2; Programmer: 2" Felt 26S1/ Plate/ 2" Felt 32S1. Drop Height = 10 in., Peak G level = 56.59, Velocity Change = 9.95 ft/s, Time-to-Peak Acceleration = 6.3 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1675:** Cell SH6, Test 1; Programmer: 2" Felt 26S1/ Plate/ 2" Felt 32S1. Drop Height = 20 in., Peak G level = 84.52, Velocity Change = 14.22 ft/s, Time-to-Peak Acceleration = 5.8 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1676:** Cell SH6, Test 2; Programmer: 2" Felt 26S1/ Plate/ 2" Felt 32S1. Drop Height = 20 in., Peak G level = 84.56, Velocity Change = 14.24 ft/s, Time-to-Peak Acceleration = 5.9 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1677:** Cell SH7, Test 1; Programmer: 2" Felt 26S1/ Plate/ 2" Felt 32S1. Drop Height = 30 in., Peak G level = 106.22, Velocity Change = 17.48 ft/s, Time-to-Peak Acceleration = 5.6 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.

- **Test 1678:** Cell SH7, Test 2; Programmer: 2" Felt 26S1/ Plate/ 2" Felt 32S1. Drop Height = 30 in., Peak G level = 103.36, Velocity Change = 17.48 ft/s, Time-to-Peak Acceleration = 5.6 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1679:** Cell SH8, Test 1; Programmer: 2" Felt 26S1/ Plate/ 2" Felt 32S1. Drop Height = 40 in., Peak G level = 123.56, Velocity Change = 19.96 ft/s, Time-to-Peak Acceleration = 5.5 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.
- **Test 1680:** Cell SH8, Test 2; Programmer: 2" Felt 26S1/ Plate/ 2" Felt 32S1. Drop Height = 40 in., Peak G level = 124.47, Velocity Change = 20.09 ft/s, Time-to-Peak Acceleration = 5.5 ms.
Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved.

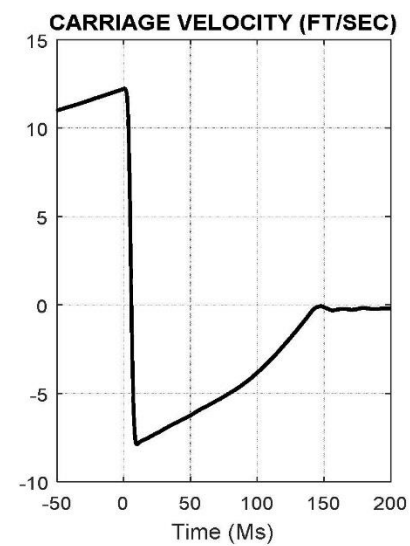
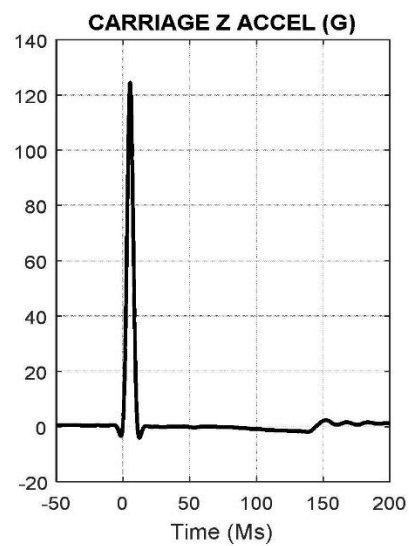
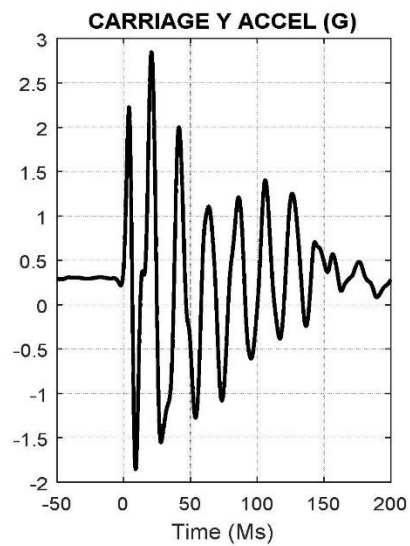
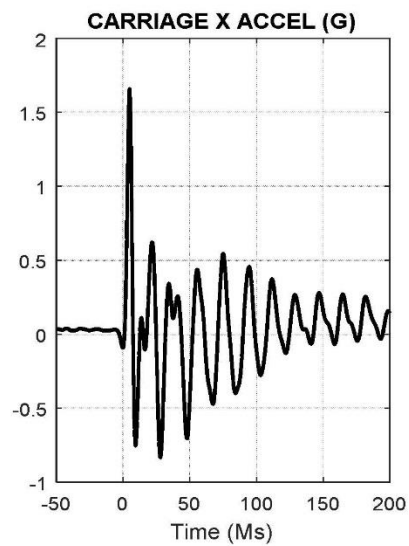
APPENDIX D. SAMPLE DATA SHEETS: NO WEIGHT, WS1, WS2 CARRIAGE CONFIGURATIONS

Examples of test data collected during the program will show the post-test processed data for the three different carriage weight configurations: No Weight, WS1 seat and manikin configuration (309 lb total), and WS2 seat and manikin configuration (807 lb total). The first three tests will be for the 26S1/32S1 dual felt impact attenuation. The fourth test will be for the 32S1 felt impact attenuation with WS2. All tests are at the 40 inch drop height to highlight the difference in the data sets. Test identification is summarized below:

- **Test 1680:** Cell SH8, **No Weight**, Test 2; Programmer: 2" Felt 26S1/ Plate/ 2" Felt 32S1. Drop Height = 40 in., Peak G level = 124.47, Velocity Change = 20.09 ft/s, Time-to-Peak Acceleration = 5.5 ms.
- **Test 1264:** Cell SH3, **WS1 Seat**, Test 1; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 40 in., Peak Acceleration = 115.65 G, Integrated Velocity Change = 18.26 ft/s (5.57 m/s), Time-to-Peak Acceleration = 4.6 ms.
- **Test 1290:** Cell SI4, **WS2 Seat**, Test 3; Felt Density 2651/3251, Programmer: 2 in./ plate/ 2 in. Drop Height = 40 in., Peak Acceleration = 133.48 G. Integrated Velocity Change: Carriage Z = 19.78 ft/s (6.02 m/s), Seat Pan Reference = 20.58 ft/s (6.27 m/s), Foot Rest Reference = 18.94 ft/s (5.77 m/s), Time-to-Peak Acceleration = 5 ms.
- **Test 1354:** Cell SM4, **WS2 Seat**, Test 2; Felt Density 3251 (2.0 in.), Drop Height = 40 in., Peak Acceleration = 242.69 G, Integrated Velocity Change: Carriage Z = 19.02 ft/s (5.8 m/s), Seat Pan Reference = 20.49 ft/s (6.25 m/s), Time-to-Peak Acceleration = 2.2 ms.

Test: VID1680 Date: 05-25-2016 Cell: SH8 Nom G: 40

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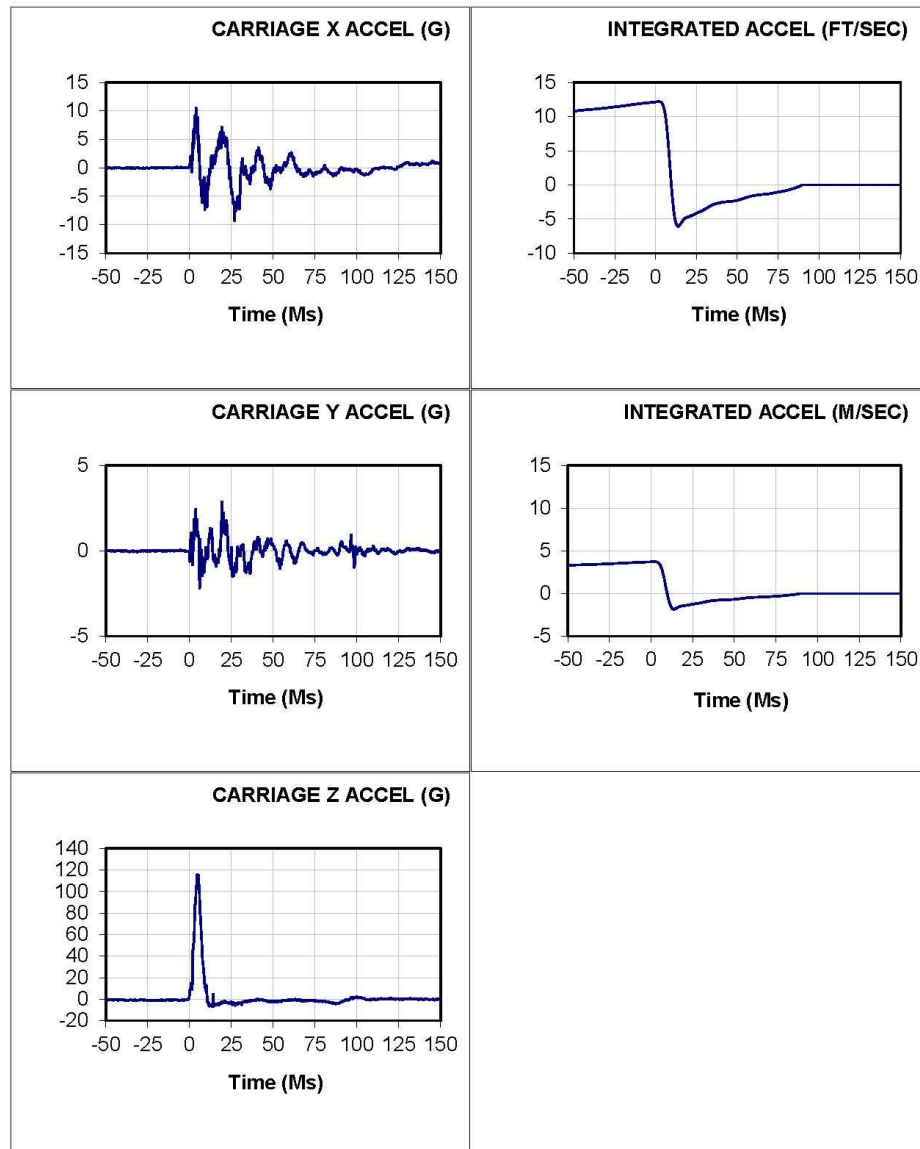


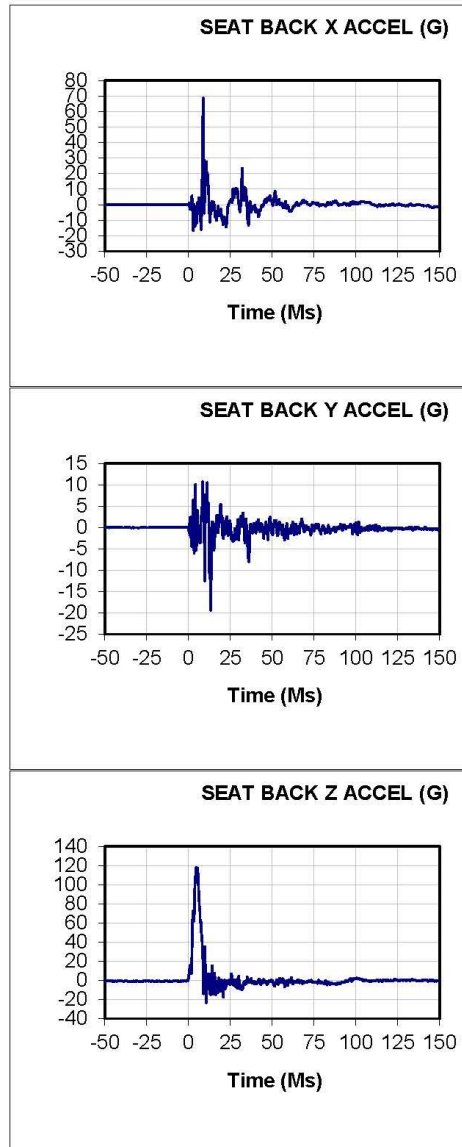
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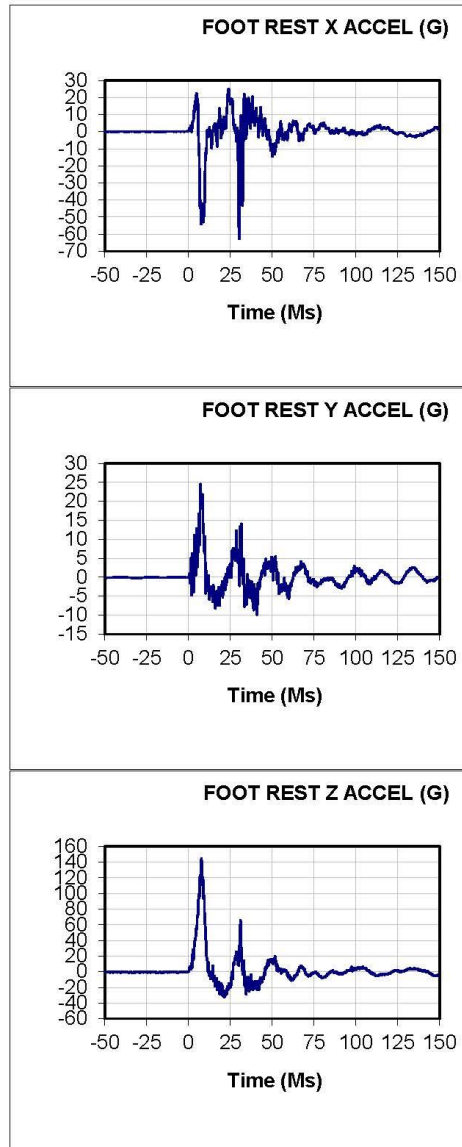
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				0.1	
Drop Height (In)		40.00			
Impact Rise Time (Ms)				4.6	
Impact Duration (Ms)				10.7	
Velocity Change (Ft/Sec)		12.19			
GATE 1 PREIMPACT VEL (M/SEC)		4.44		-0.6	-5.1
GATE 1 PREIMPACT VEL (FT/SEC)		14.58		-0.6	-5.1
GATE 1 POST-IMPACT VEL (M/SEC)		1.50		30.9	17.5
GATE 1 POST-IMPACT VEL (FT/SEC)		4.92		30.9	17.5
GATE 1 VELOCITY SUM (M/SEC)		5.94		-0.6	-5.1
GATE 1 VELOCITY SUM (FT/SEC)		19.50		-0.6	-5.1
GATE 2 PREIMPACT VEL (M/SEC)		3.74		-31.3	-36.7
GATE 2 PREIMPACT VEL (FT/SEC)		12.26		-31.3	-36.7
CARRIAGE X ACCEL (G)	-0.01	10.58	-9.32	3.9	27.0
CARRIAGE Y ACCEL (G)	0.00	2.88	-2.21	19.4	6.1
CARRIAGE Z ACCEL (G)	-0.90	115.65	-6.69	4.6	11.7
INTEGRATED ACCEL (M/SEC)	3.55	3.72	-1.85	1.8	13.8
INTEGRATED ACCEL (FT/SEC)	11.66	12.19	-6.07	1.8	13.8
SEAT BACK X ACCEL (G)	-0.05	68.56	-16.96	8.9	2.8
SEAT BACK Y ACCEL (G)	-0.01	10.75	-19.43	8.4	13.3
SEAT BACK Z ACCEL (G)	-0.81	117.72	-23.70	4.6	10.6
FOOT REST X ACCEL (G)	0.09	24.97	-62.81	24.0	30.2
FOOT REST Y ACCEL (G)	-0.07	24.56	-9.92	7.2	41.0
FOOT REST Z ACCEL (G)	-0.69	144.26	-32.39	7.8	21.4
TOP LEFT RETRACTION FORCE (LB)	8.51	136.67	-15.51	14.1	14.4
TOP RIGHT RETRACTION FORCE (LB)	0.11	142.85	-32.97	14.1	14.4
GATE 1 VOLTAGE (VOLTS)	0.00	2.48	-0.27	17.9	31.0
GATE 2 VOLTAGE (VOLTS)	0.00	0.00	0.00	19.5	76.6
LEFT LAP X FORCE (LB)	-5.82	17.89	-255.27	3.8	72.1
LEFT LAP Y FORCE (LB)	-1.25	165.11	-23.93	74.3	22.5
LEFT LAP Z FORCE (LB)	-4.60	100.81	-335.52	5.3	66.5
LEFT LAP RES	7.56	433.10	3.87	66.2	20.6
RIGHT LAP X FORCE (LB)	-4.51	18.48	-218.82	5.3	67.2
RIGHT LAP Y FORCE (LB)	-1.94	25.31	-126.72	10.0	76.9
RIGHT LAP Z FORCE (LB)	-5.37	95.42	-286.76	4.4	67.8
RIGHT LAP RES	7.31	369.39	0.67	67.7	25.7

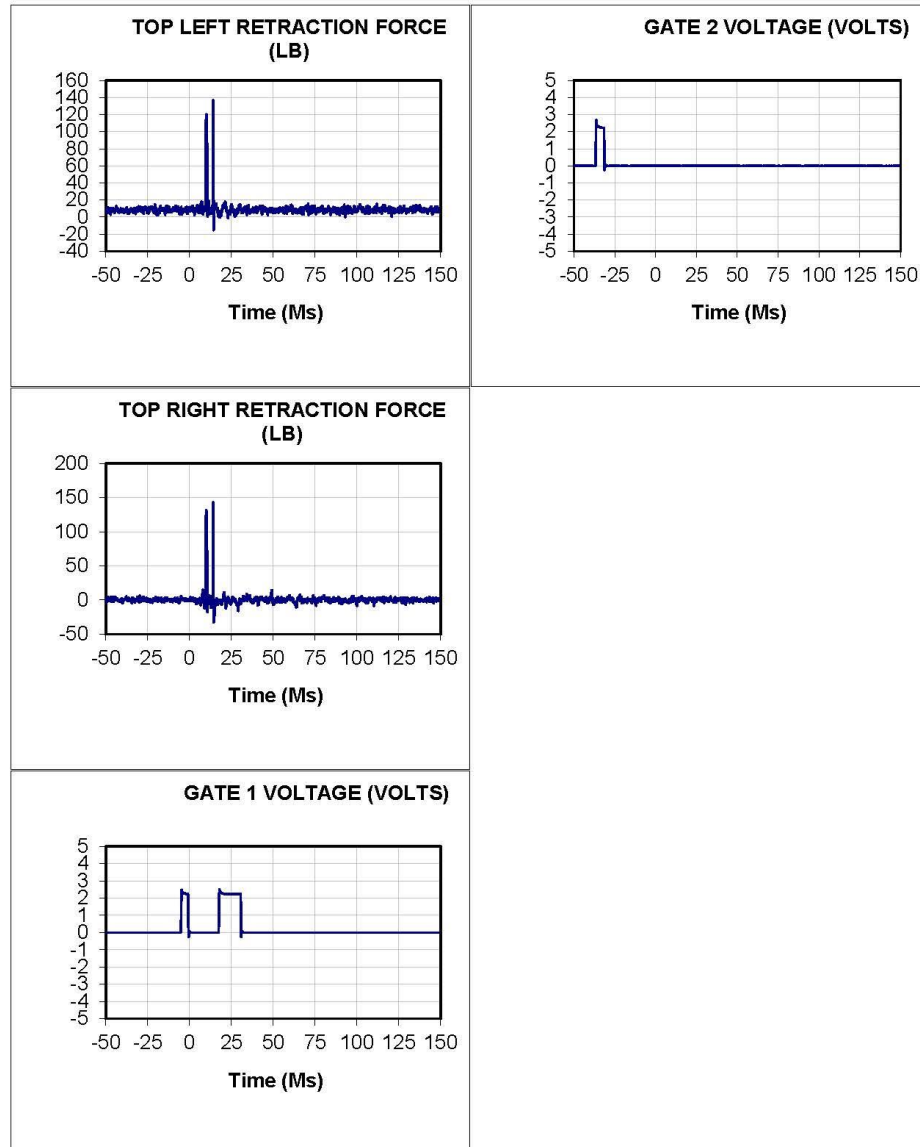
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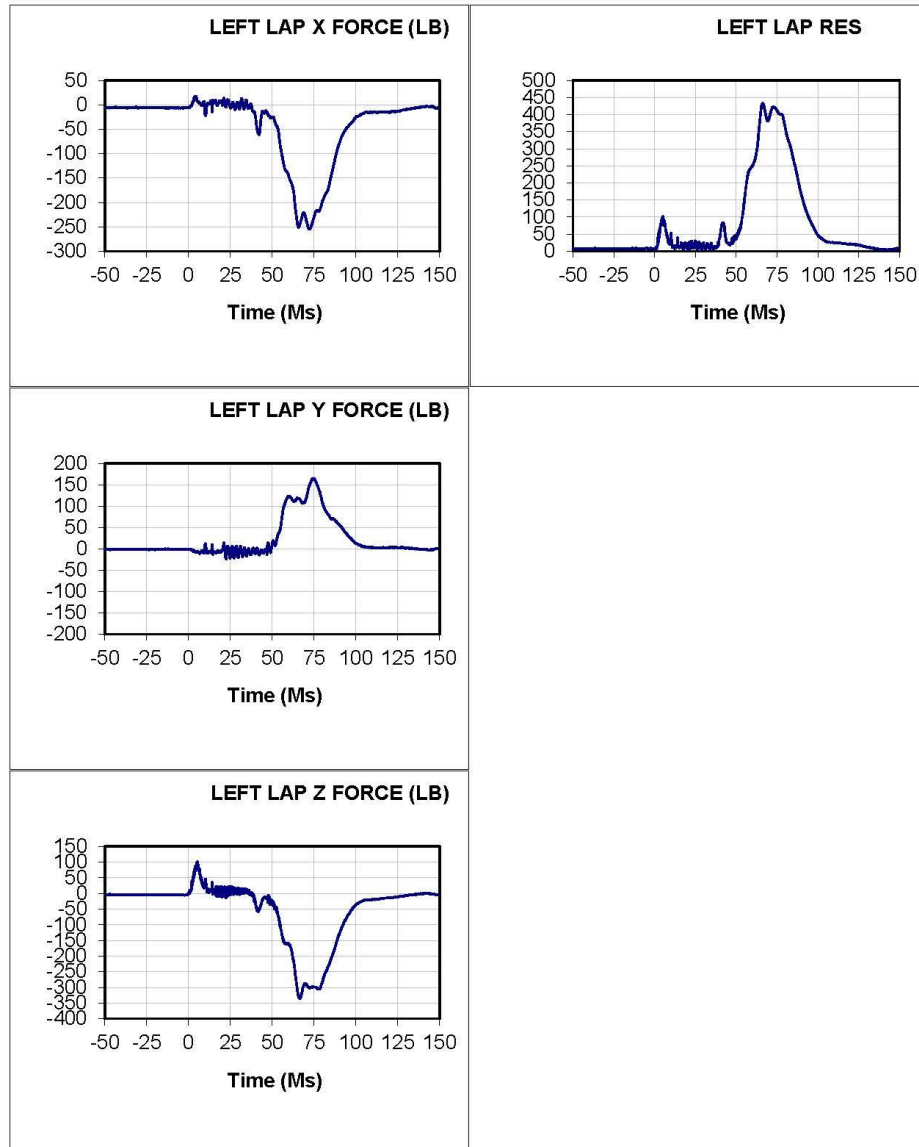
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
LEFT SHOULDER X FORCE (LB)	2.74	65.73	-364.55	7.5	64.3
LEFT SHOULDER Y FORCE (LB)	-1.49	113.78	-99.96	5.1	70.9
LEFT SHOULDER Z FORCE (LB)	1.41	27.51	-102.35	6.4	65.6
LEFT SHOULDER RES	3.51	383.52	0.23	64.8	134.4
RIGHT SHOULDER X FORCE (LB)	3.86	104.64	-412.58	7.5	64.0
RIGHT SHOULDER Y FORCE (LB)	-1.53	27.36	-35.10	61.8	10.0
RIGHT SHOULDER Z FORCE (LB)	-0.31	154.33	-130.95	6.4	68.5
RIGHT SHOULDER RES	4.21	424.07	0.57	64.0	140.0
CROTCH X FORCE (LB)	0.87	124.41	-45.18	72.4	9.0
CROTCH STRAP Y FORCE (LB)	0.57	32.23	-26.55	14.1	83.6
CROTCH STRAP Z FORCE (LB)	-7.89	134.33	-624.81	4.5	73.9
CROTCH STRAP RES	7.98	636.58	1.49	73.9	2.0
CARRIAGE Z4 ACCEL (G)	0.90	5.84	-3.68	17.5	137.6
CARRIAGE Z5 ACCEL (G)	-1.30	363.98	-167.86	8.4	20.3
FOOT REST Z2 ACCEL (G)	-0.73	153.49	-74.58	6.7	12.1
FOOT REST Z3 ACCEL (G)	-0.61	149.38	-66.45	9.1	14.1

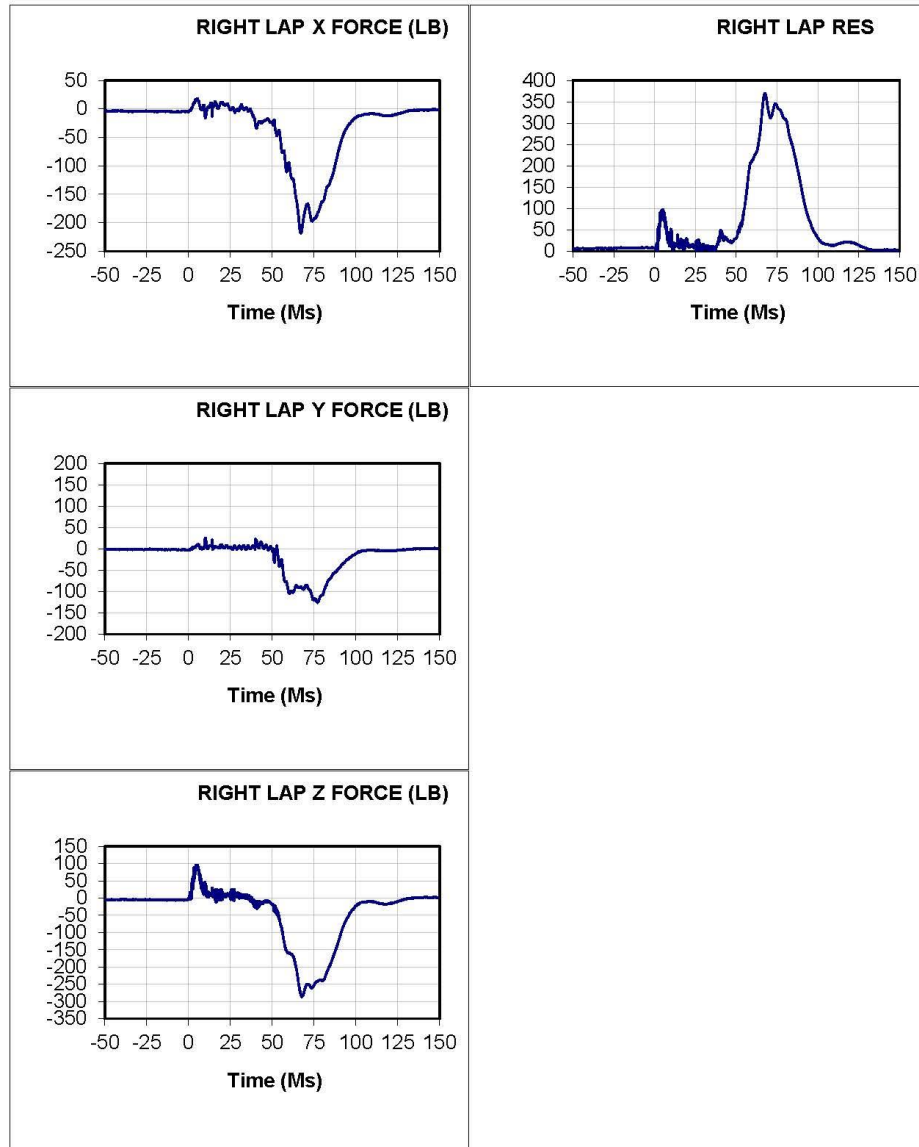


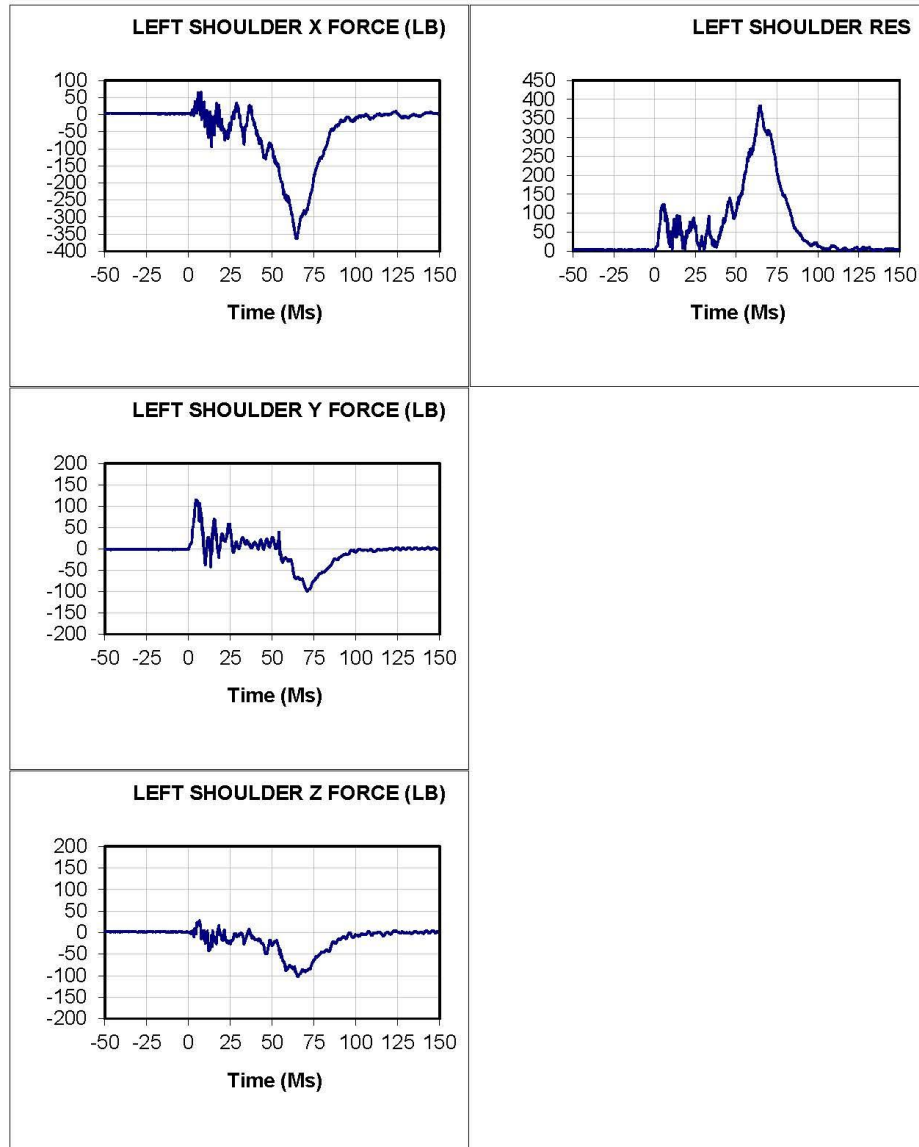


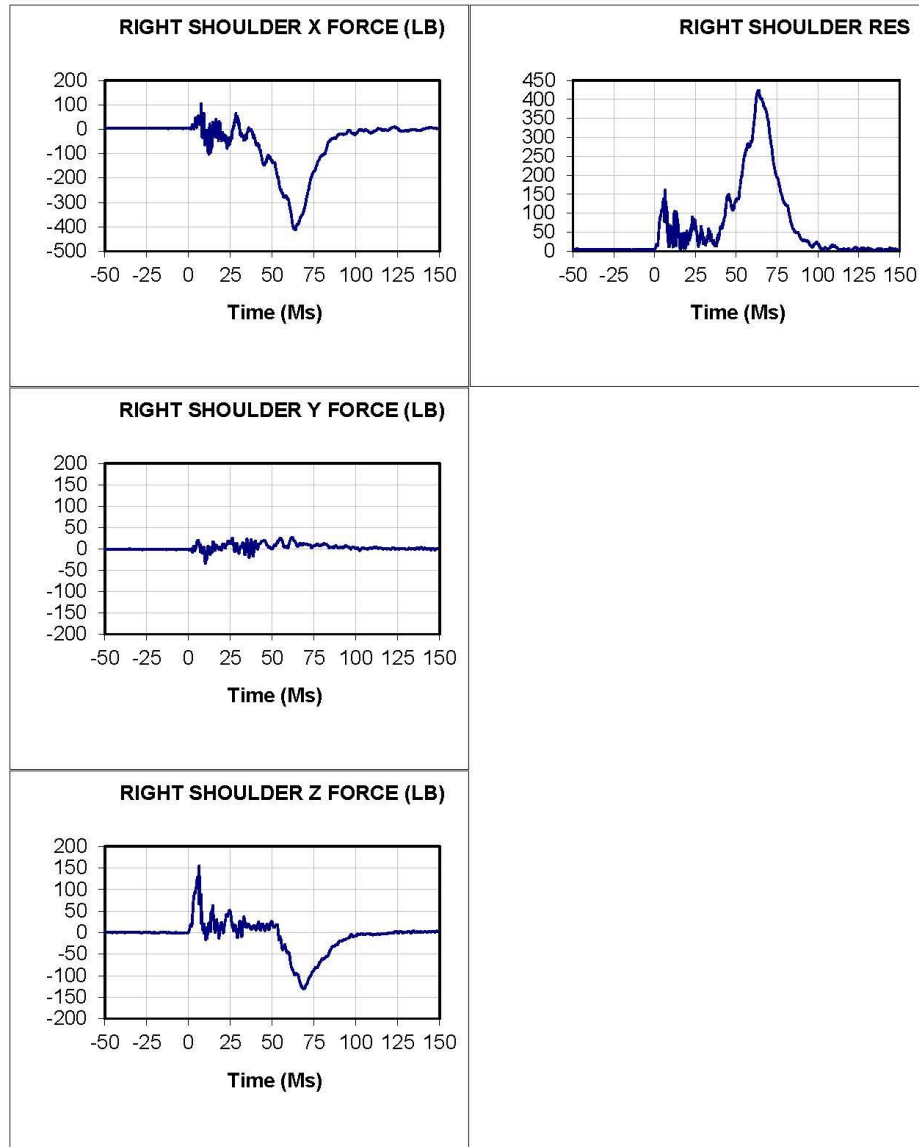


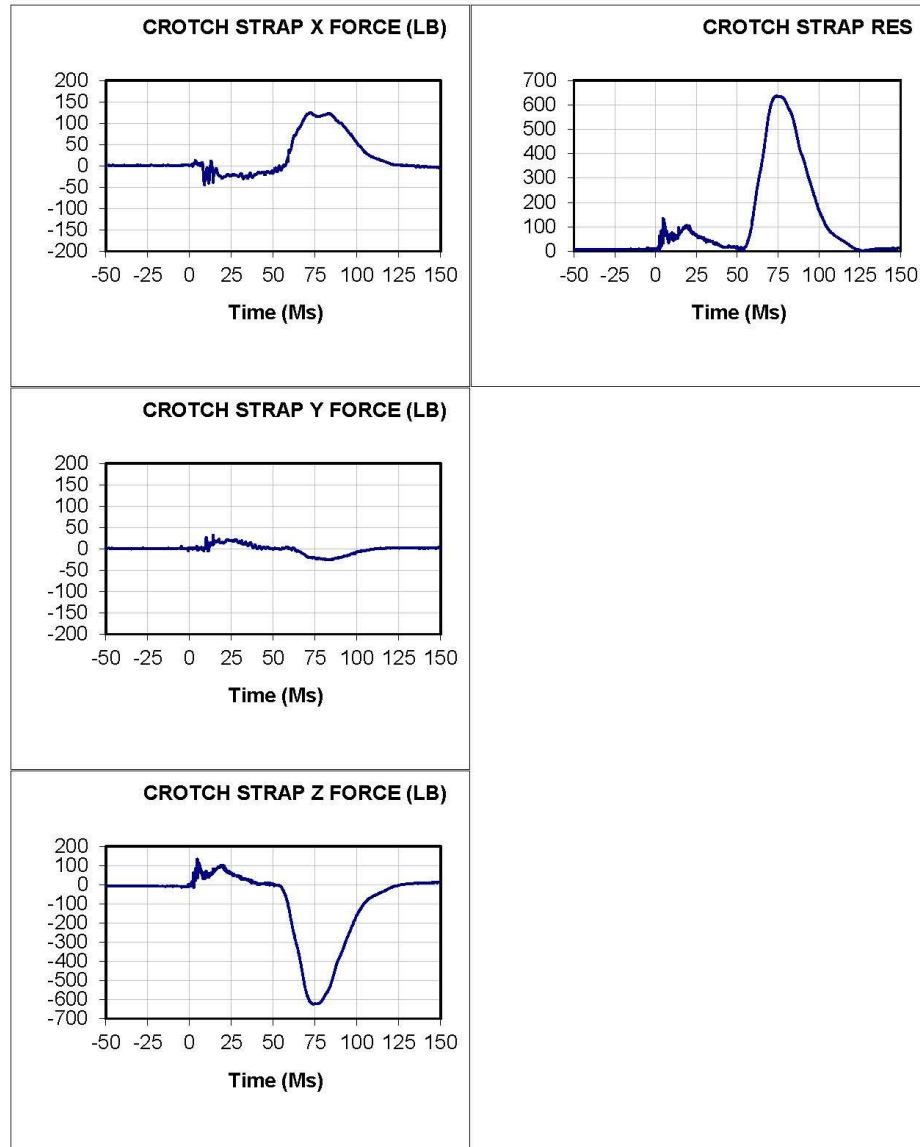


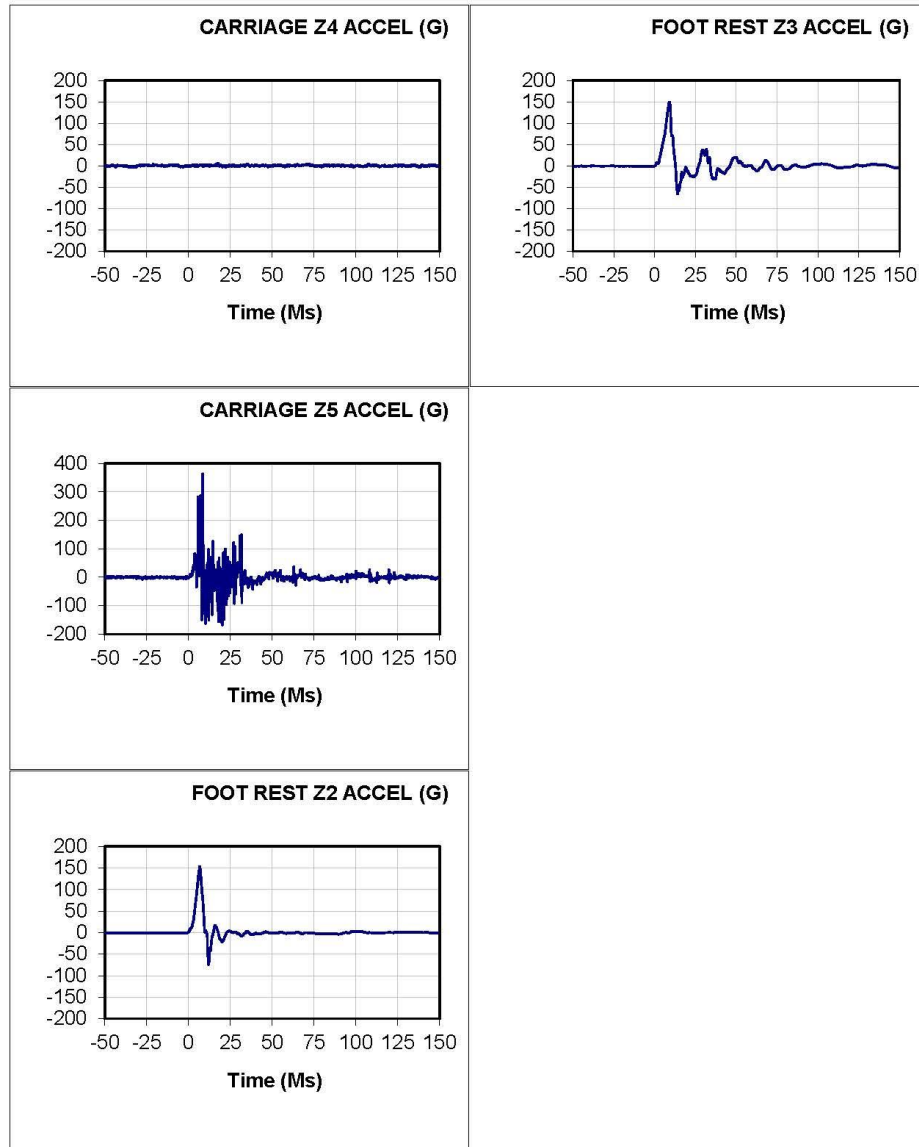










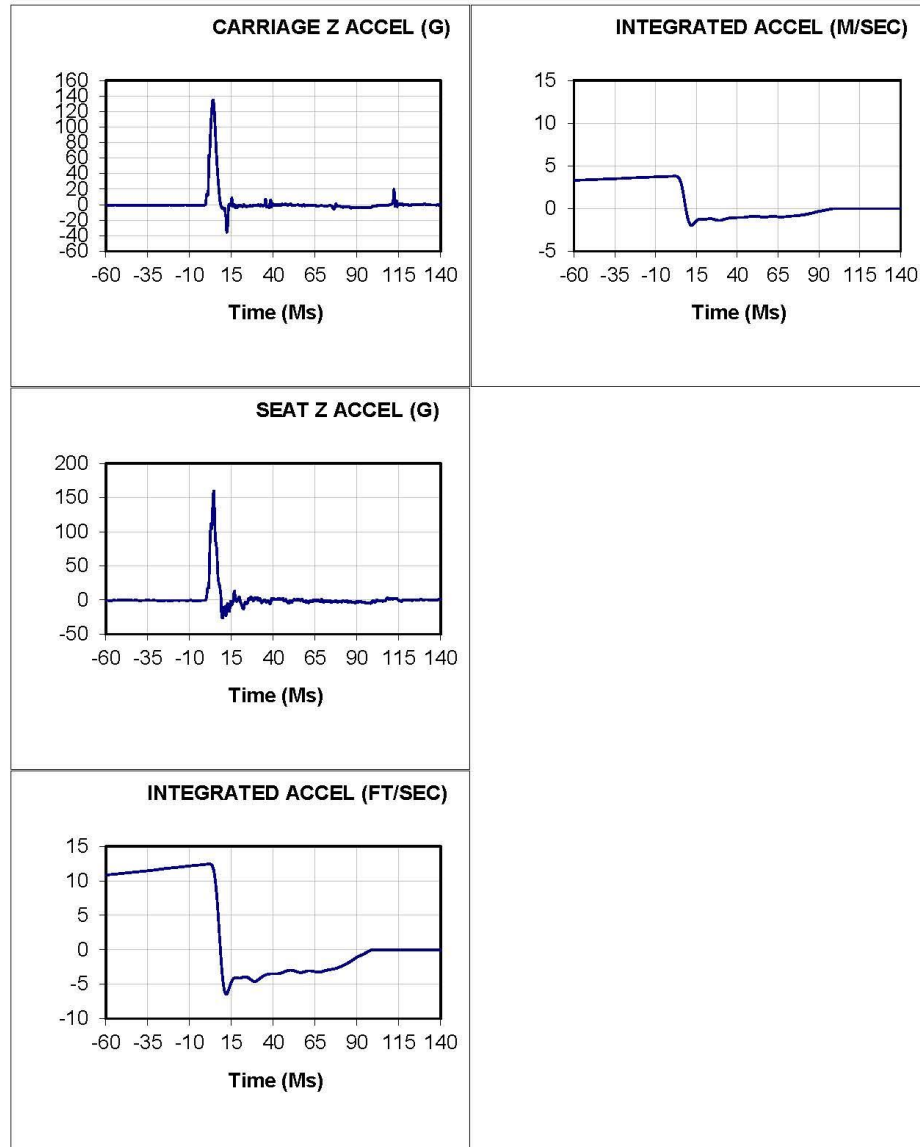


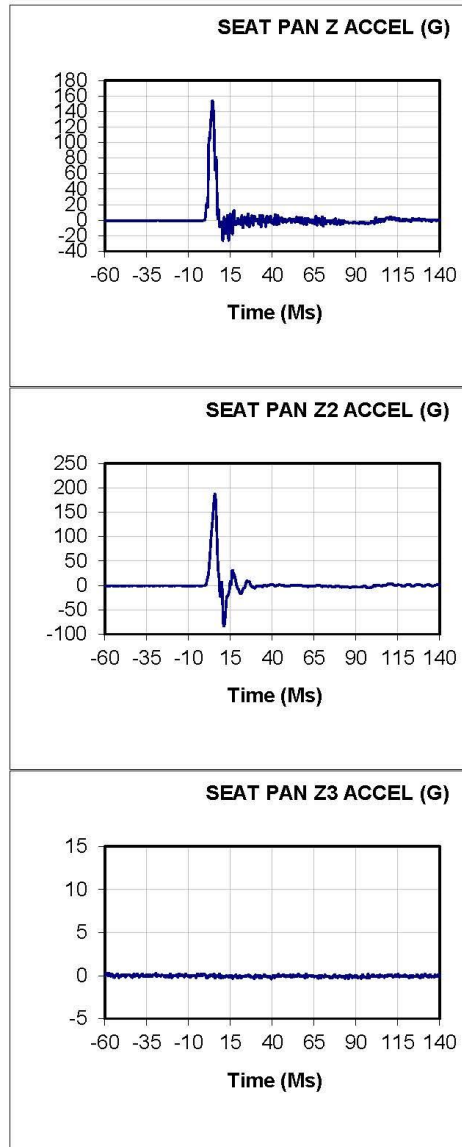
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 Nom G: 150.0 Cell: S14

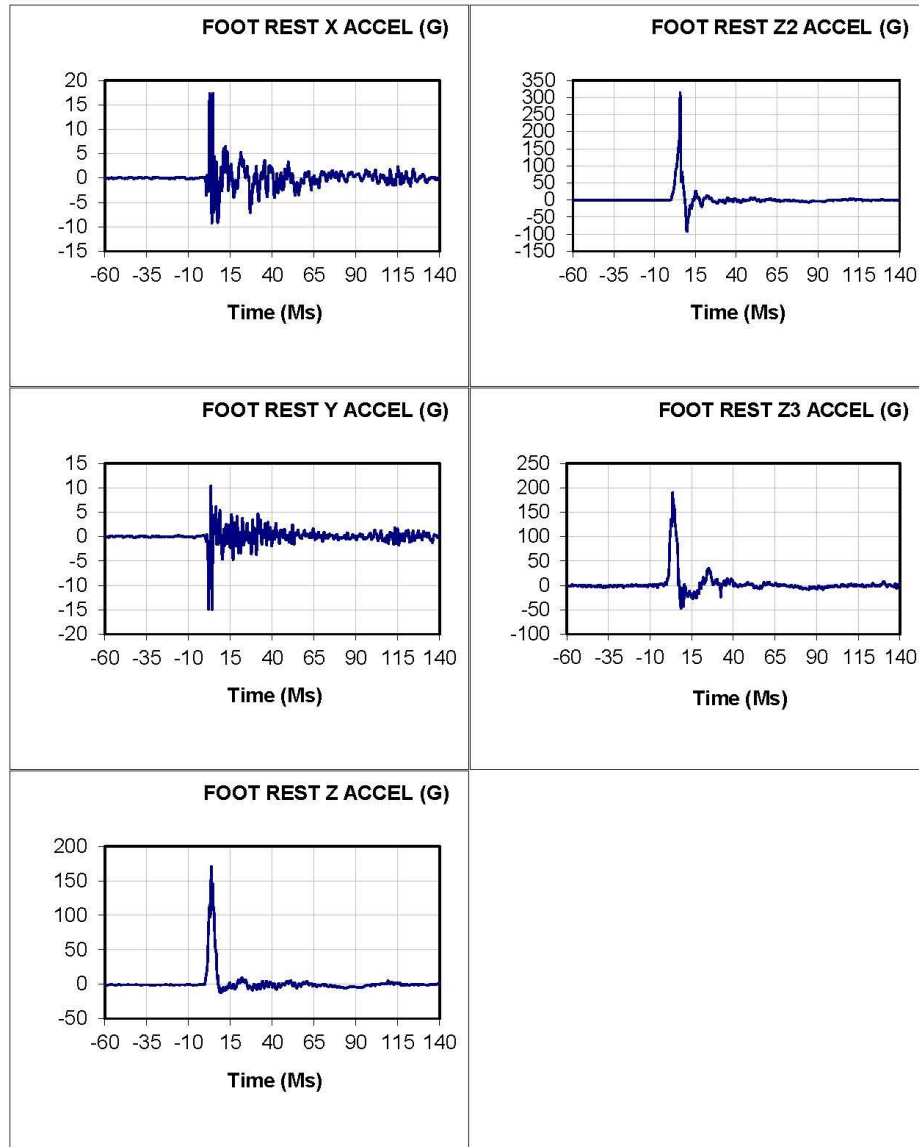
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Reference Mark Time (Ms)				-0.5	
Drop Height (In)		40.00			
Impact Rise Time (Ms)				3.6	
Impact Duration (Ms)				7.9	
Velocity Change (Ft/Sec)		12.44			
GATE 1 PREIMPACT VEL (M/SEC)		4.26		-1.3	-6.0
GATE 1 PREIMPACT VEL (FT/SEC)		13.96		-1.3	-6.0
GATE 1 POST-IMPACT VEL (M/SEC)		1.59		27.9	15.3
GATE 1 POST-IMPACT VEL (FT/SEC)		5.21		27.9	15.3
GATE 1 VELOCITY SUM (M/SEC)		5.84		-1.3	-6.0
GATE 1 VELOCITY SUM (FT/SEC)		19.17		-1.3	-6.0
GATE 2 PREIMPACT VEL (M/SEC)		5.71		-28.0	-31.5
GATE 2 PREIMPACT VEL (FT/SEC)		18.75		-28.0	-31.5
CARRIAGE Z ACCEL (G)	-0.82	135.11	-35.69	4.0	12.3
SEAT Z ACCEL (G)	-0.81	159.54	-26.53	4.4	9.9
INTEGRATED ACCEL (FT/SEC)	11.96	12.44	-6.46	1.6	11.9
INTEGRATED ACCEL (M/SEC)	3.65	3.79	-1.97	1.6	11.9
SEAT PAN Z ACCEL (G)	-0.78	153.80	-26.39	4.3	10.4
SEAT PAN Z2 ACCEL (G)	-0.91	186.50	-84.09	5.8	11.1
SEAT PAN Z3 ACCEL (G)	-0.01	0.21	-0.41	8.6	39.3
FOOT REST X ACCEL (G)	-0.03	17.37	-9.28	4.6	4.0
FOOT REST Y ACCEL (G)	-0.01	10.33	-15.01	3.3	4.1
FOOT REST Z ACCEL (G)	-0.85	170.96	-12.45	3.6	9.5
FOOT REST ACCEL RES	0.86	171.03	0.07	3.6	136.5
FOOT REST Z2 ACCEL (G)	-0.89	313.77	-93.02	5.7	9.7
FOOT REST Z3 ACCEL (G)	-0.81	190.27	-47.44	3.6	8.6
GATE 1 VOLTAGE (VOLTS)	0.05	2.56	-0.24	16.1	28.6
GATE 2 VOLTAGE (VOLTS)	0.21	0.00	0.00	23.6	103.6
LEFT FRONT SEAT PAN Z FORCE (Lb)	-20.92	3857.36	-95.53	11.4	28.5
RIGHT FRONT SEAT PAN Z FORCE (Lb)	-41.42	6421.32	-154.69	10.8	28.5
LEFT REAR SEAT PAN Z FORCE (Lb)	-11.63	567.62	-133.32	11.5	16.1
RIGHT REAR SEAT PAN Z FORCE (Lb)	-38.76	5962.75	-175.05	11.4	72.2
SEAT PAN RES	61.61	9566.97	13.08	11.4	0.1
LEFT FRONT FOOT REST Z FORCE (Lb)	-11.64	1004.28	-135.01	4.5	27.3
RIGHT FRONT FOOT REST Z FORCE (Lb)	-3.90	1361.56	-120.19	4.5	31.9

201306 Test: 1290 Test Date: 140227 Subj: GARD Wt: 797.0
 Nom G: 150.0 Cell: S14

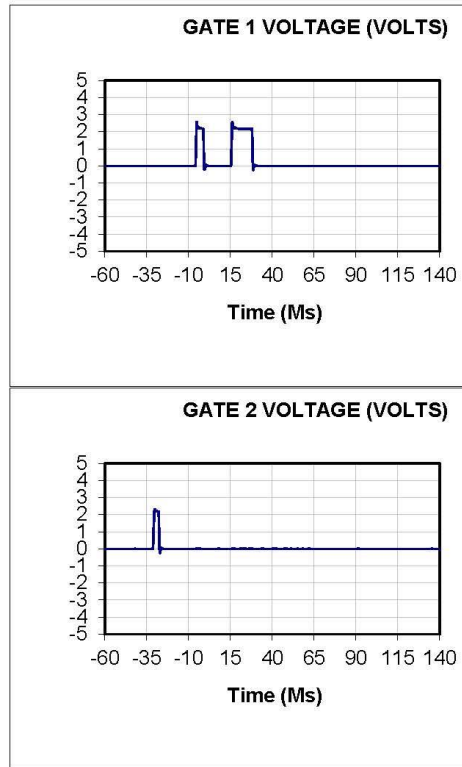
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LEFT REAR FOOT REST Z FORCE (LB)	-18.57	2050.35	-141.34	8.5	30.4
RIGHT REAR FOOT REST Z FORCE (LB)	-26.50	2234.49	-110.77	7.8	35.3
FOOT REST RES	34.67	2937.86	13.16	8.4	116.3
LEFT LAP X FORCE (LB)	-6.26	37.93	-259.77	5.8	43.3
LEFT LAP Y FORCE (LB)	4.09	110.62	-20.84	48.3	7.2
LEFT LAP Z FORCE (LB)	-9.05	132.95	-431.64	4.5	46.0
LEFT LAP RES	11.75	504.64	4.45	46.1	106.4
RIGHT LAP X FORCE (LB)	-3.16	65.70	-329.76	7.8	44.8
RIGHT LAP Y FORCE (LB)	-0.56	16.41	-93.28	19.3	48.5
RIGHT LAP Z FORCE (LB)	-7.83	133.76	-571.56	4.4	46.5
RIGHT LAP RES	8.49	665.42	2.97	46.5	0.9
LEFT SHOULDER X FORCE (LB)	0.18	47.46	-38.64	5.6	52.0
LEFT SHOULDER Y FORCE (LB)	1.40	45.36	-57.37	10.3	10.9
LEFT SHOULDER Z FORCE (LB)	0.27	136.72	-149.93	5.0	51.9
LEFT SHOULDER RES	1.60	154.98	0.47	51.9	131.6
RIGHT SHOULDER X FORCE (LB)	1.24	63.68	-96.67	11.7	10.9
RIGHT SHOULDER Y FORCE (LB)	-0.46	26.27	-40.59	22.6	10.9
RIGHT SHOULDER Z FORCE (LB)	2.27	171.81	-143.25	4.5	49.0
RIGHT SHOULDER RES	2.70	172.09	0.86	4.4	134.1

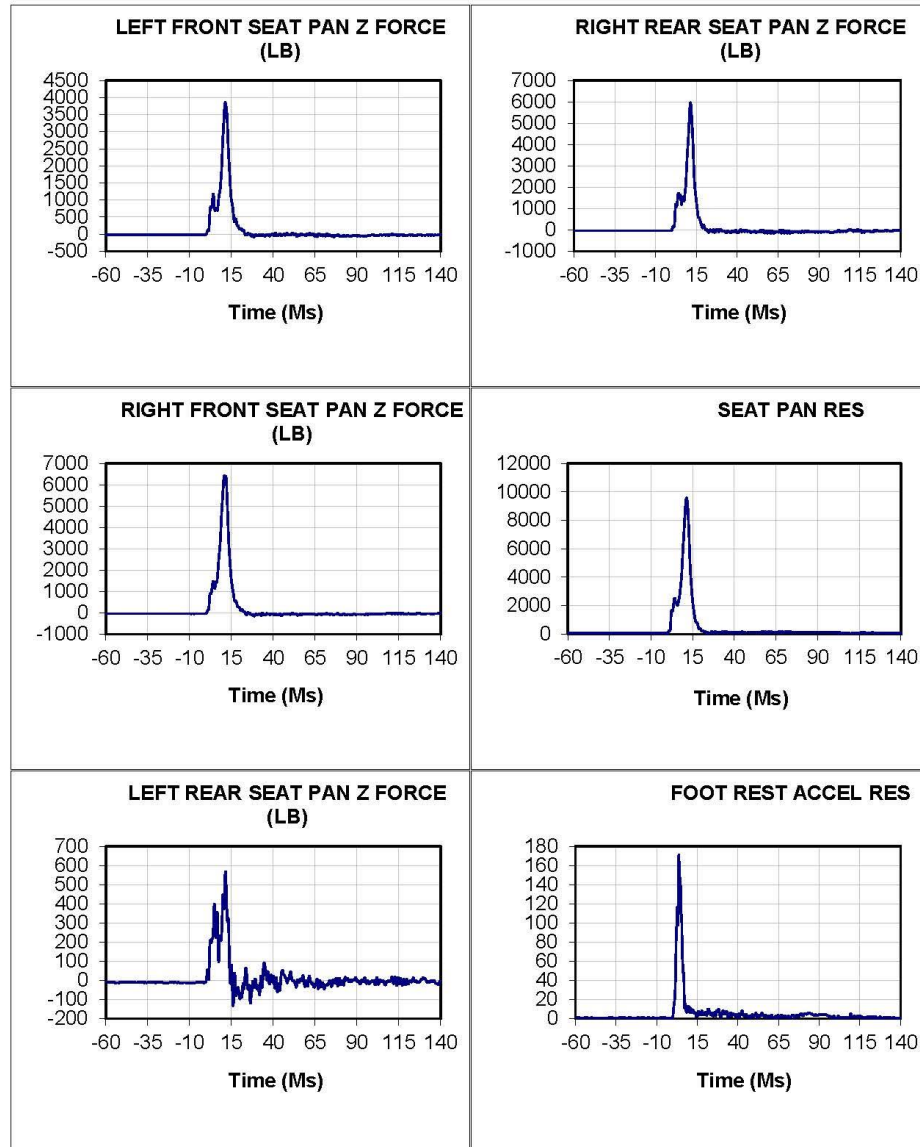


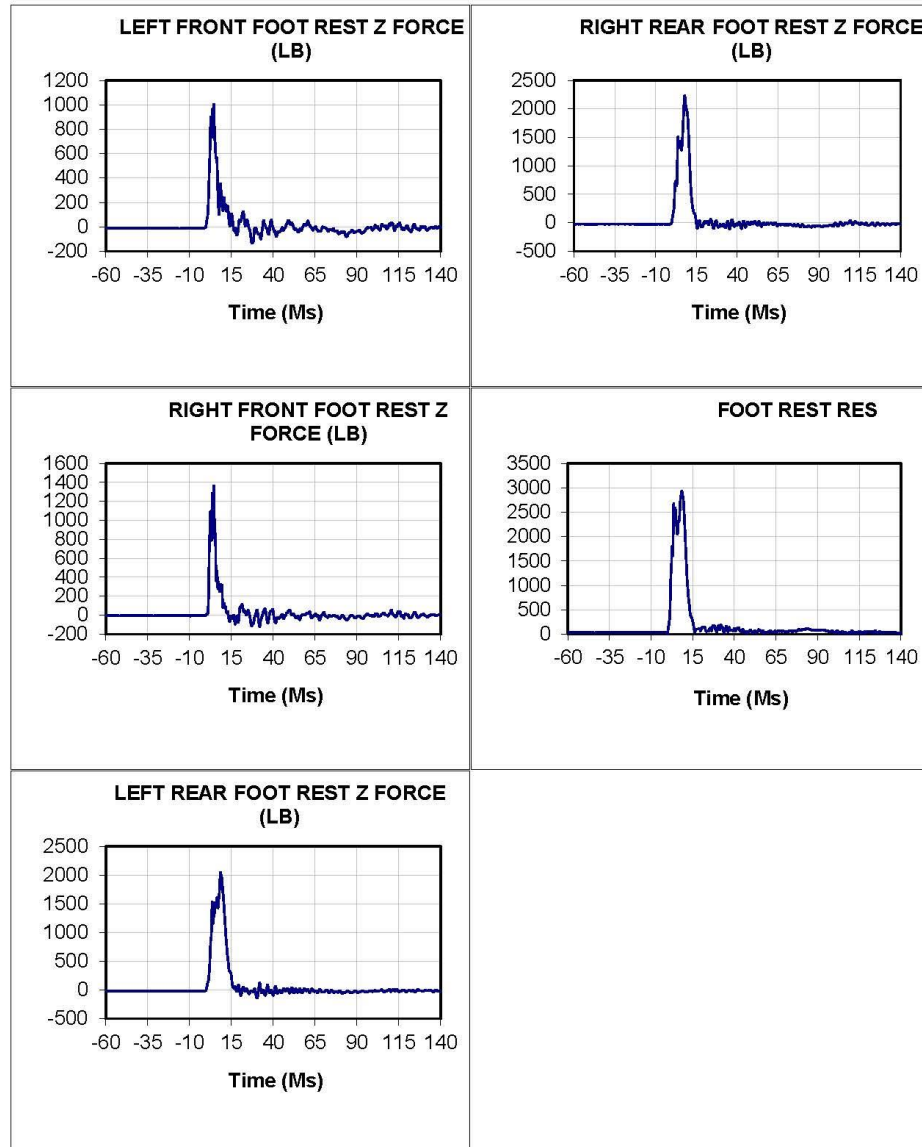


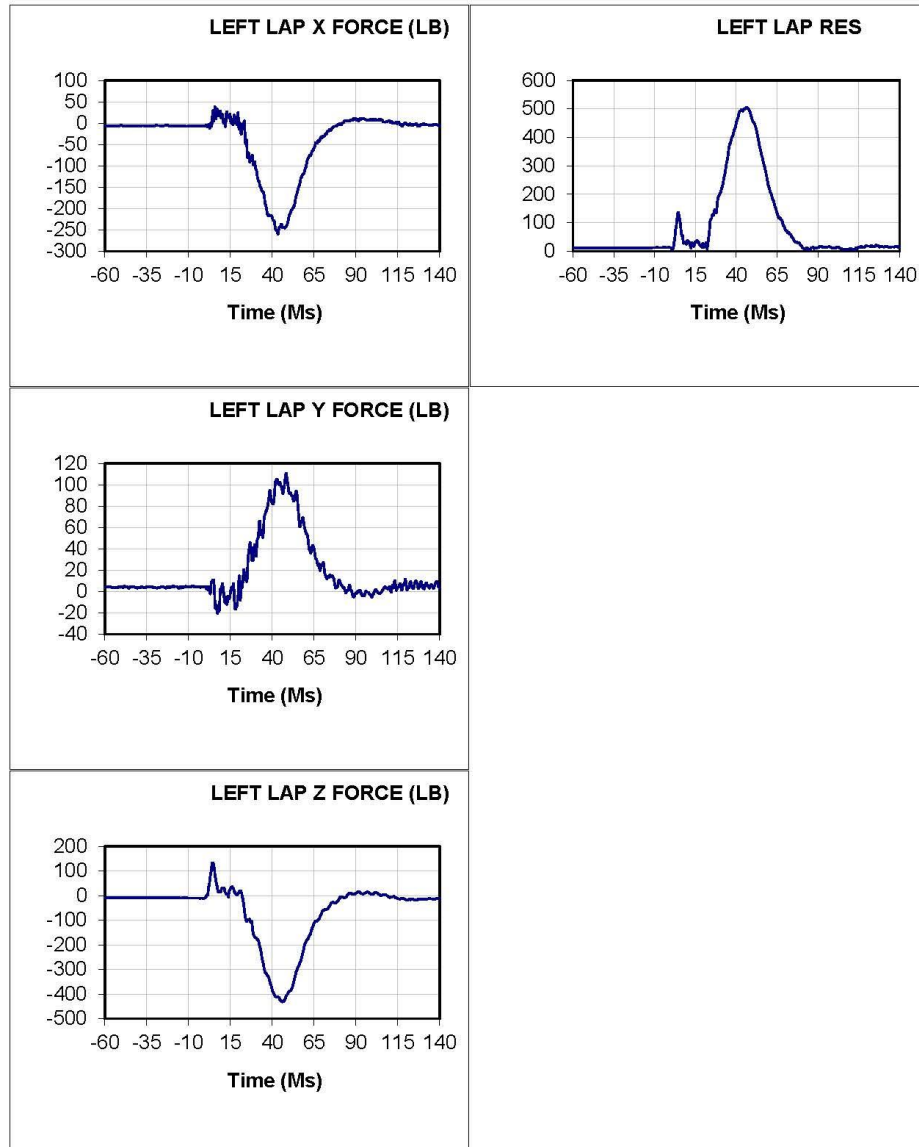


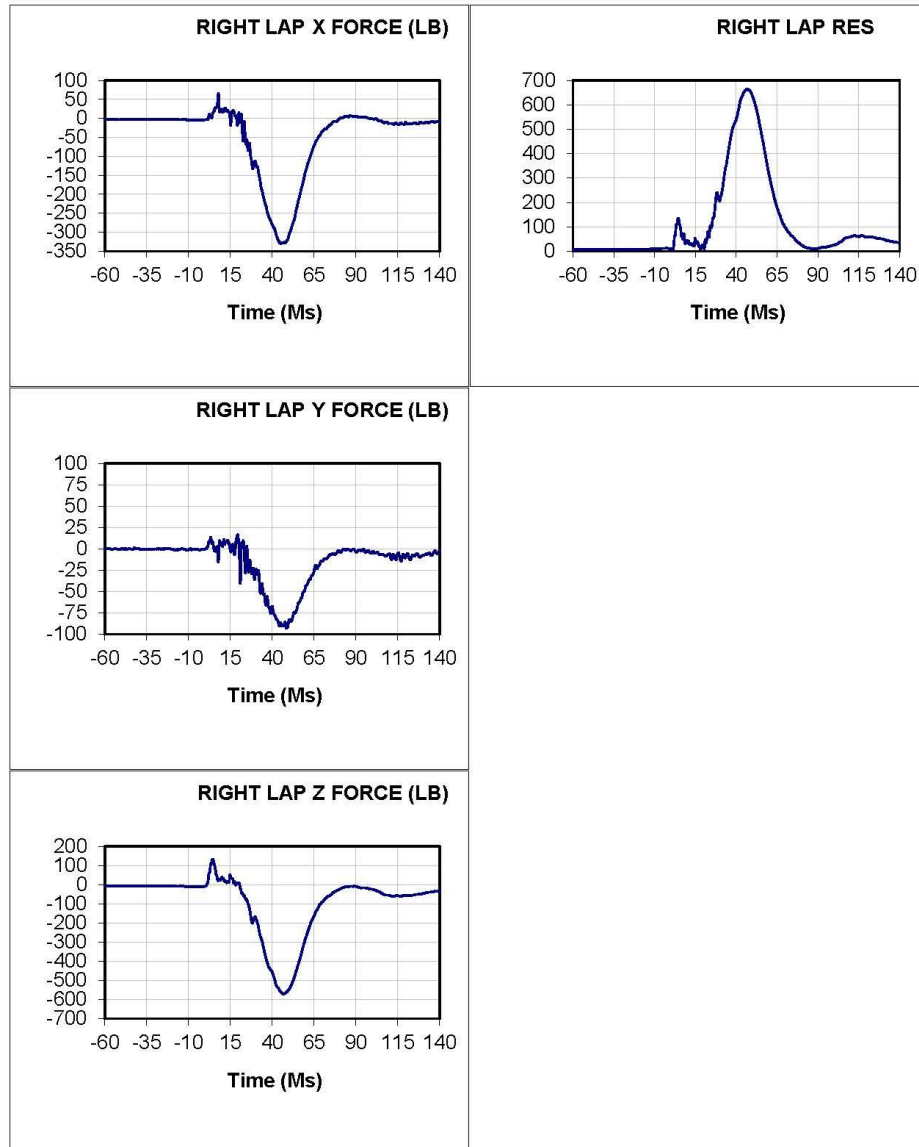
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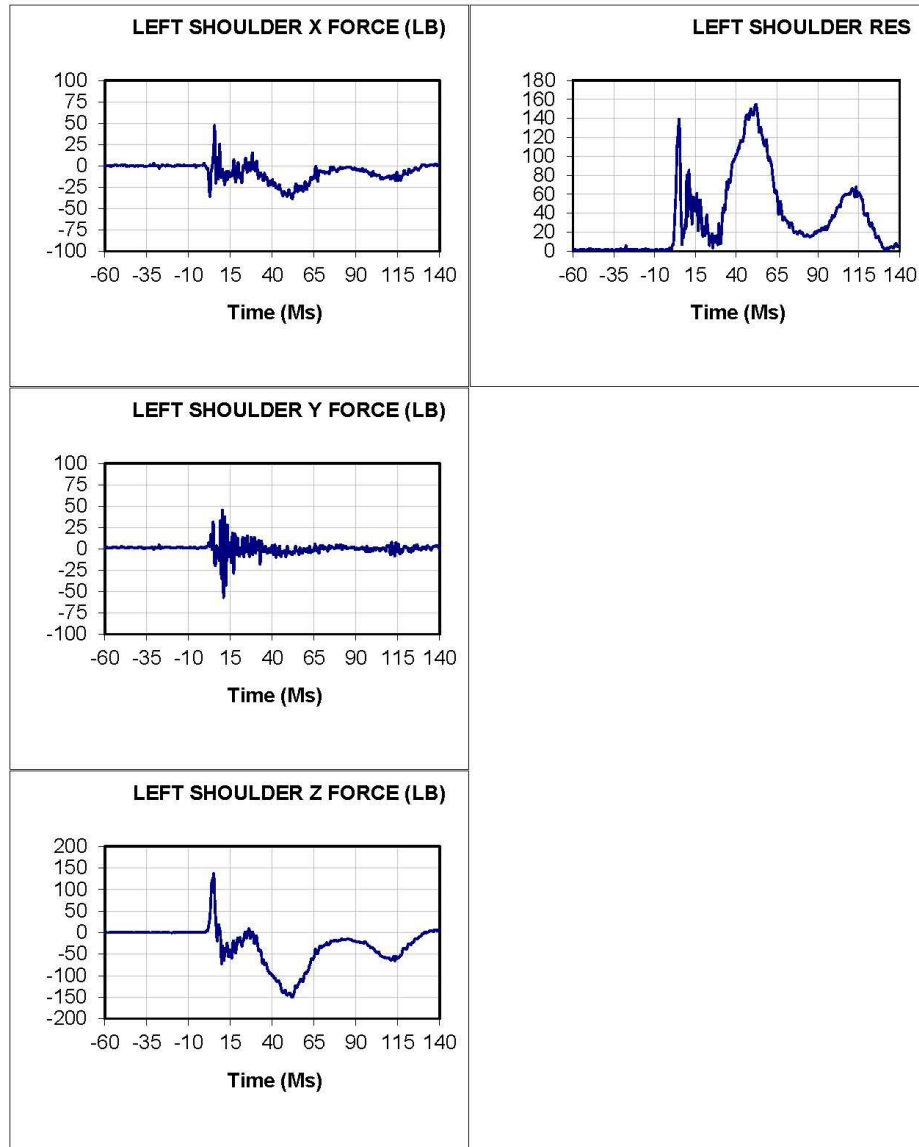


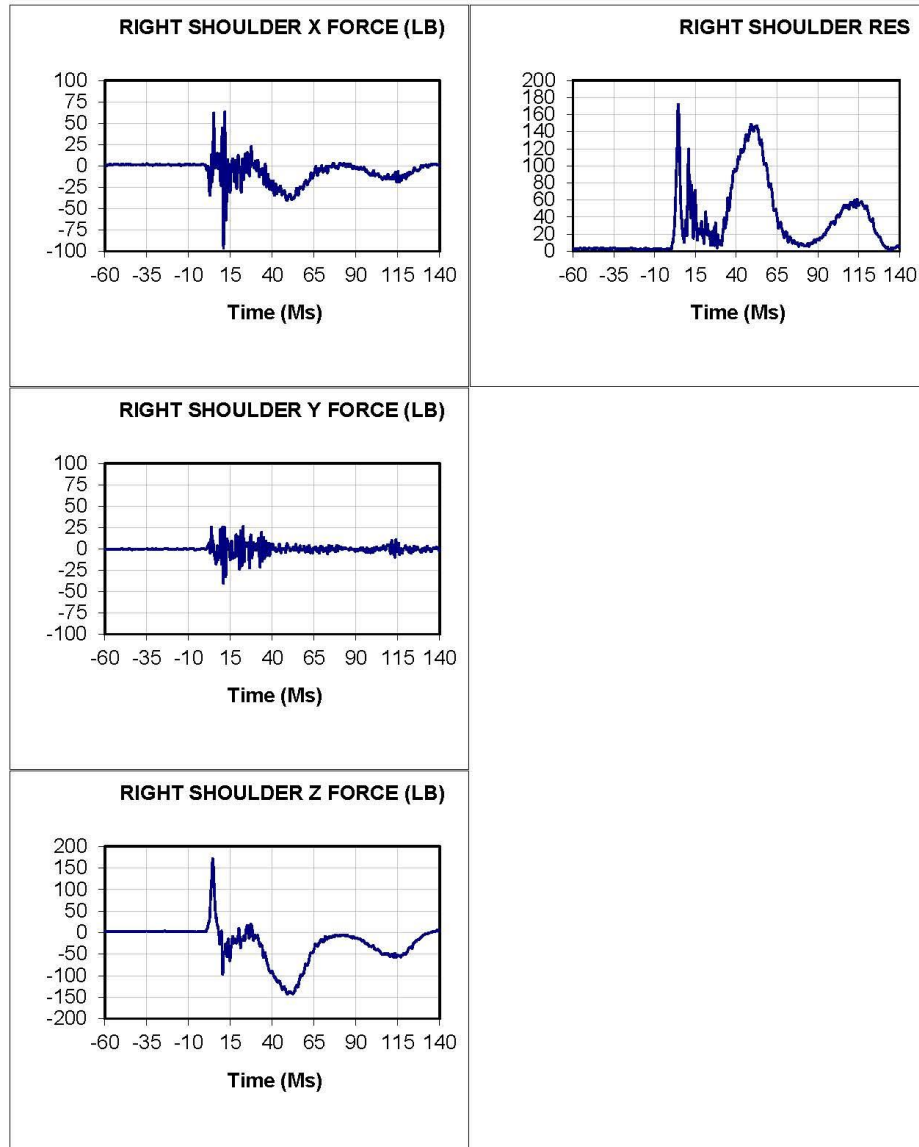










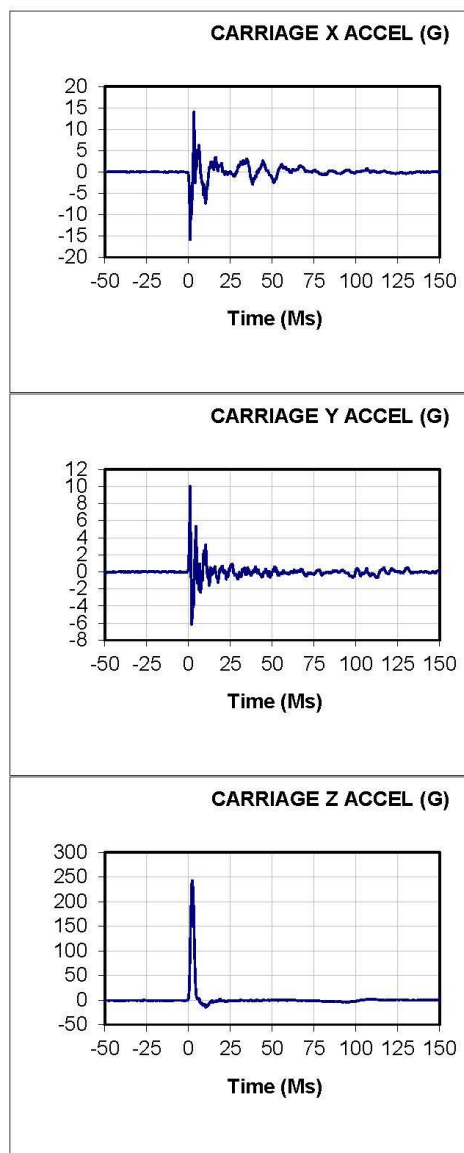


201306 Test: 1354 Test Date: 140415 Subj: GARD Wt: 190.0
 Nom G: 250.0 Cell: SM4

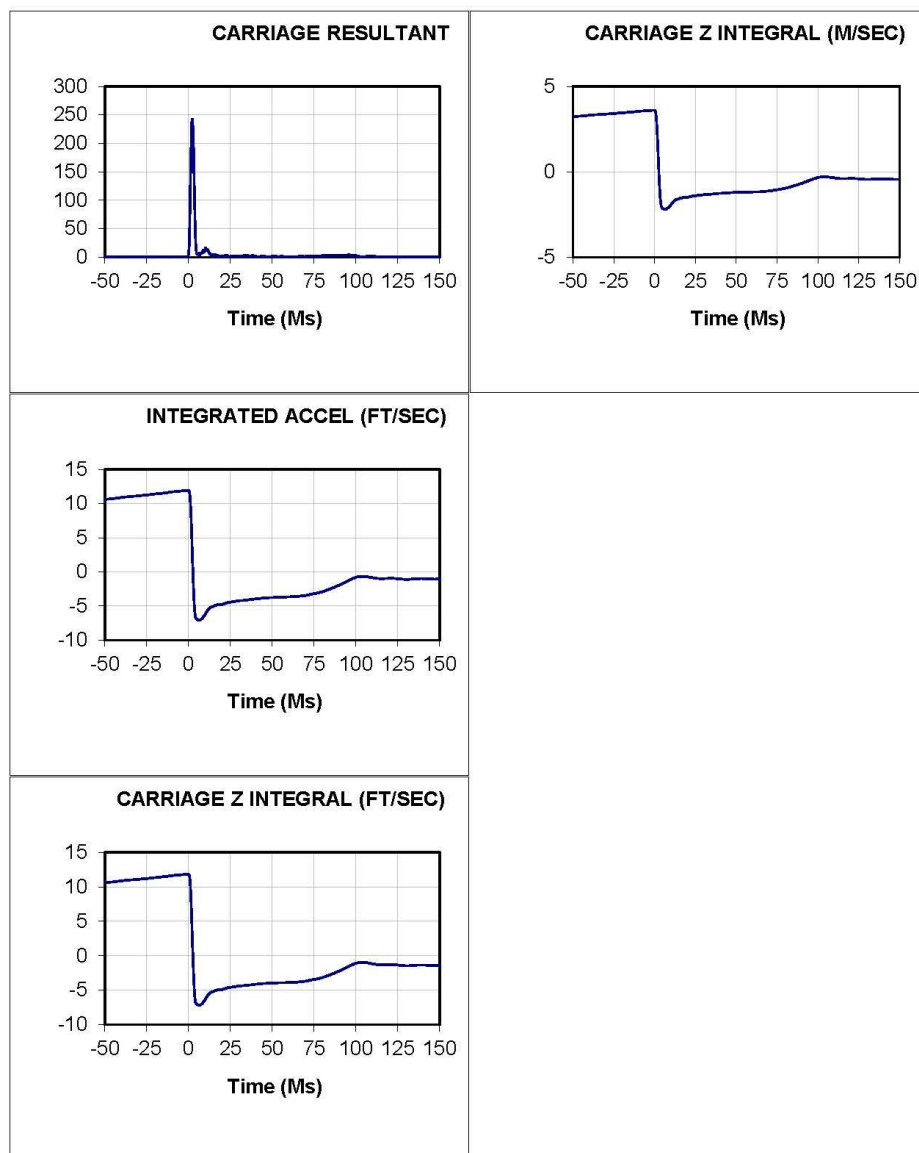
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Drop Height (In)		40.00			
Impact Rise Time (Ms)				2.2	
Impact Duration (Ms)				6.6	
Velocity Change (Ft/Sec)		11.93			
Velocity Change (M/Sec)		3.64			
Total Velocity Change (Ft/Sec)		19.03			
Total Velocity Change (M/Sec)		5.80			
GATE 1 PREIMPACT VEL (M/SEC)		4.30		-1.6	-6.3
GATE 1 PREIMPACT VEL (FT/SEC)		14.11		-1.6	-6.3
GATE 1 POST-IMPACT VEL (M/SEC)		1.36		24.0	9.3
GATE 1 POST-IMPACT VEL (FT/SEC)		4.45		24.0	9.3
GATE 1 VELOCITY SUM (M/SEC)		5.66		-1.6	-6.3
GATE 1 VELOCITY SUM (FT/SEC)		18.56		-1.6	-6.3
GATE 2 PREIMPACT VEL (M/SEC)		4.49		-29.2	-33.7
GATE 2 PREIMPACT VEL (FT/SEC)		14.75		-29.2	-33.7
CARRIAGE X ACCEL (G)	-0.03	14.09	-15.95	3.3	0.9
CARRIAGE Y ACCEL (G)	0.01	10.03	-6.17	0.9	2.0
CARRIAGE Z ACCEL (G)	-0.79	242.69	-14.56	2.2	10.2
CARRIAGE RESULTANT	0.80	242.81	0.06	2.2	146.4
INTEGRATED ACCEL (M/SEC)	3.50	3.63	-2.17	0.0	6.6
INTEGRATED ACCEL (FT/SEC)	11.48	11.91	-7.11	0.0	6.6
CARRIAGE Z INTEGRAL (FT/SEC)	11.42	11.81	-7.21	0.0	6.6
CARRIAGE Z INTEGRAL (M/SEC)	3.48	3.60	-2.20	0.0	6.6
SEAT BACK Z INTEGRAL (FT/SEC)	11.42	11.86	-9.36	0.0	5.2
SEAT BACK Z INTEGRAL (M/SEC)	3.48	3.61	-2.85	0.0	5.2
SEAT BACK X ACCEL (G)	0.01	128.74	-186.97	3.3	4.7
SEAT BACK Y ACCEL (G)	-0.02	45.27	-23.65	3.8	2.7
SEAT BACK Z ACCEL (G)	-0.82	424.08	-53.89	2.5	5.7
SEAT BACK RESULTANT	0.82	428.31	0.09	2.5	124.6
SEAT PAN Z INTEGRAL (FT/SEC)	11.52	12.01	-8.50	0.0	6.2
SEAT PAN Z INTEGRAL (M/SEC)	3.51	3.66	-2.59	0.0	6.2
SEAT PAN Z ACCEL (G)	-0.93	498.03	-74.28	2.3	6.8
SEAT PAN Z2 ACCEL (G)	-0.86	390.37	-189.77	3.7	6.1
SEAT PAN Z3 ACCEL (G)	0.72	56.00	-547.64	6.9	2.3
FOOT REST Z INTEGRAL (FT/SEC)	11.52	11.92	-8.65	0.0	4.8

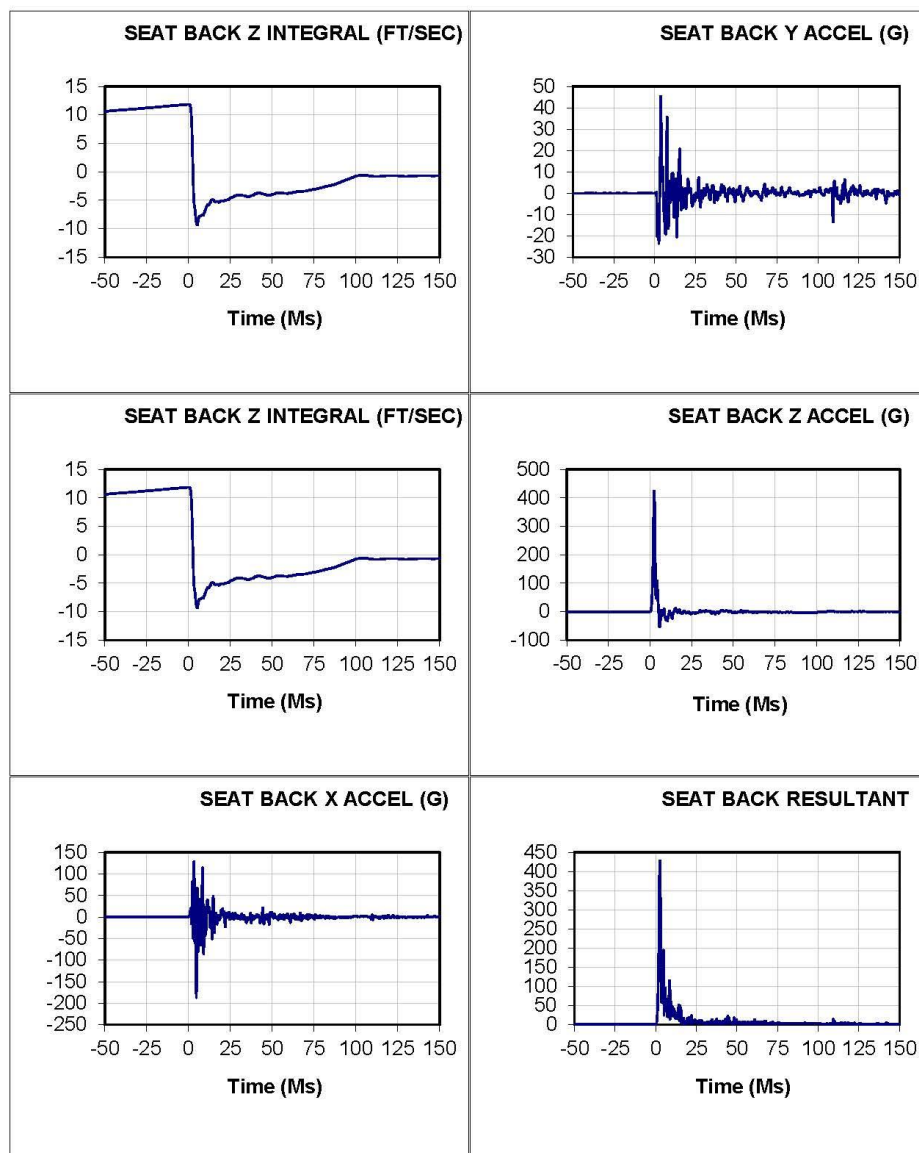
201306 Test: 1354 Test Date: 140415 Subj: GARD Wt: 190.0
Nom G: 250.0 Cell: SM4

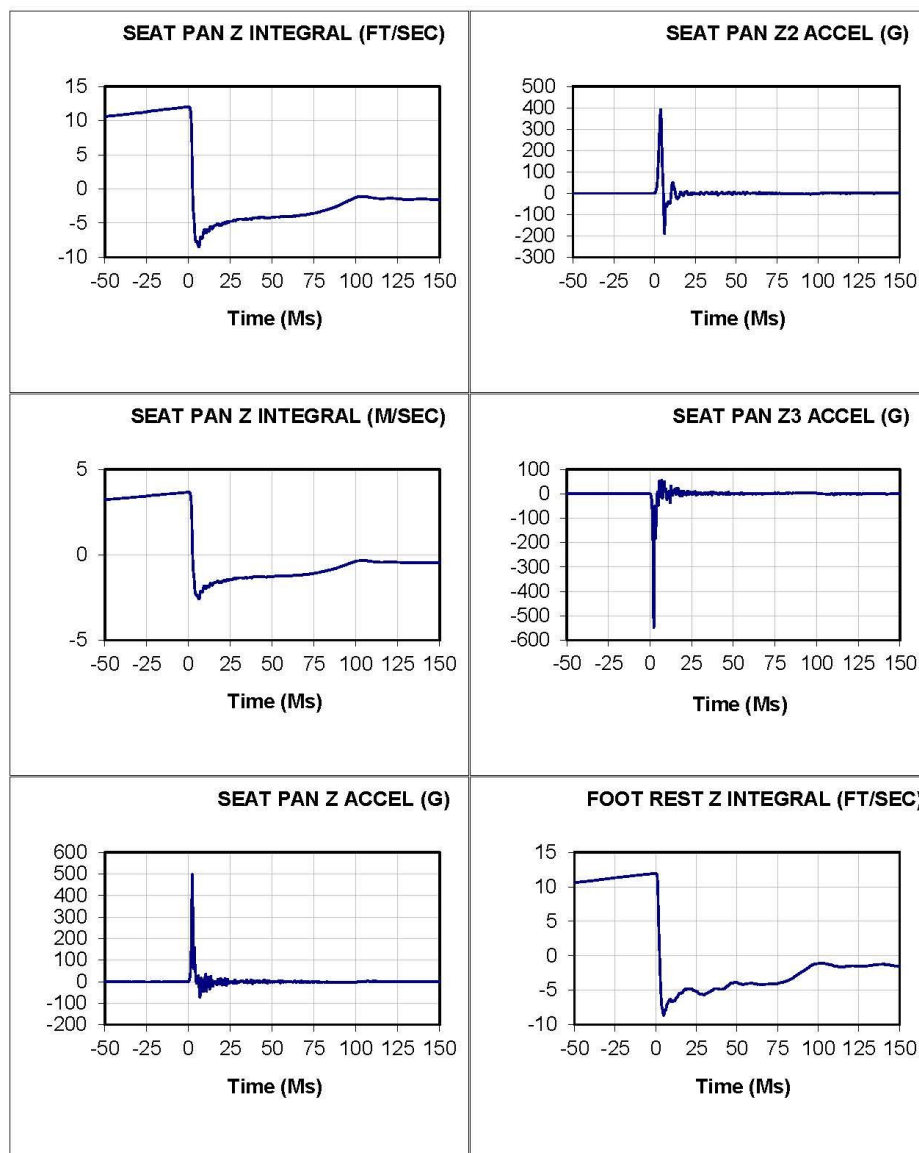
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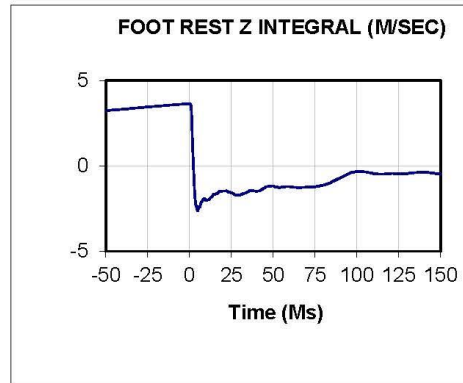
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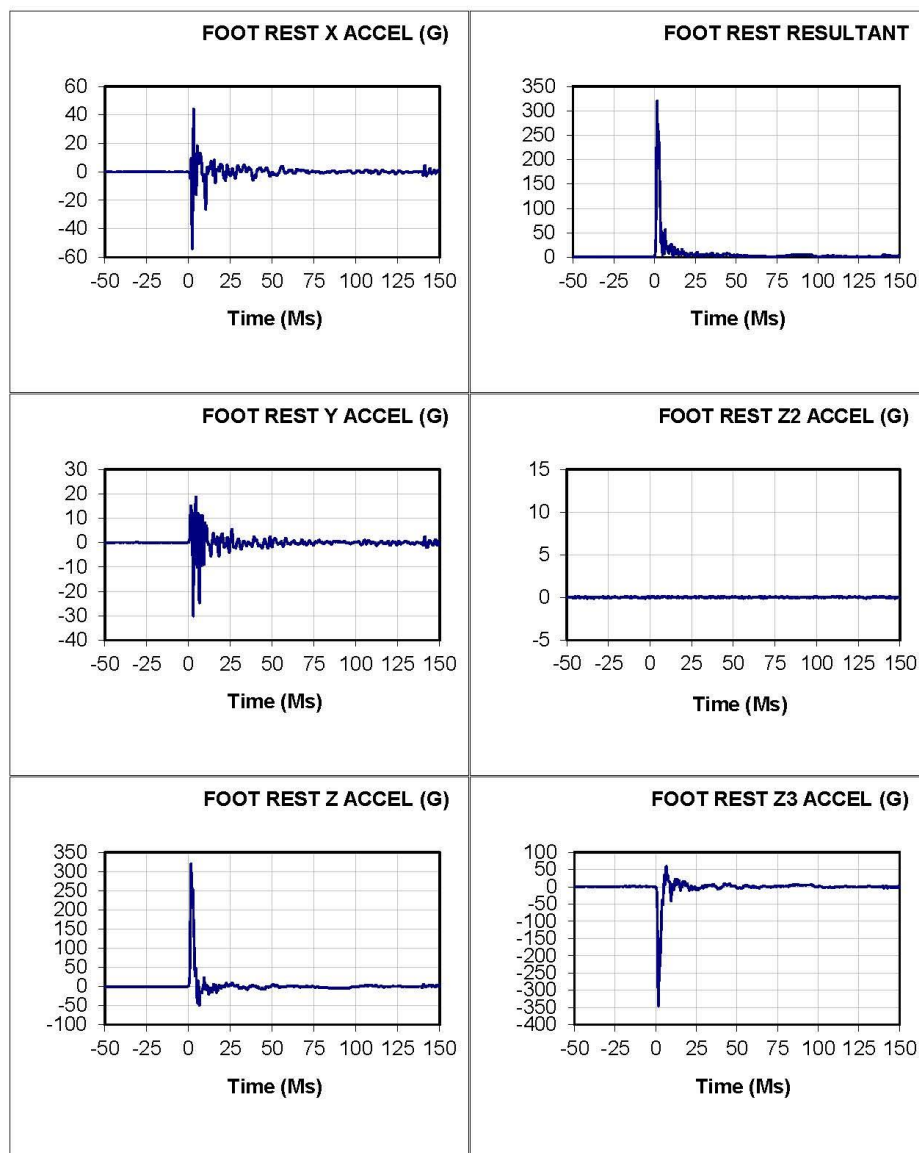






201306 Test: 1354 Test Date: 140415 Subj: GARD Cell: SM4





201306 Test: 1354 Test Date: 140415 Subj: GARD Cell: SM4

