AFRL-RH-WP-TR-2017-0013

CHARACTERIZATION OF VERTICAL IMPACT DEVICE ACCELERATION PULSES USING PARAMETRIC ASSESSMENT: PHASE IV DUAL IMPACT PULSES

Mr. Chris Perry
Mr. Chris Burneka
Mr. Ben Steinhauer
Warfighter Interface Division

Ms. Rachael Christopher
ORISE

Mr. Chris Albery
Infoscitex

Mar 2017
Interim Report

DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.

STINFO COPY

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

NOTICE AND SIGNATURE PAGE

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

//signed//
KRISTOFFER SMITH-RODRIQUEZ, LtCol, USAF
Acting Chief, Applied Neuroscience Branch
Warfighter Interface Division

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

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YY)*
01-04-17

2. REPORT TYPE
Interim

3. DATES COVERED *(From - To)*
Jan 2013 to Sept 2016

4. TITLE AND SUBTITLE
Characterization of Vertical Impact Device Acceleration Pulses Using Parametric Assessment: Phase IV Dual Impact Pulses

5a. CONTRACT NUMBER
FA8650-14-D-6500-0001

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
62202F

5d. PROJECT NUMBER
5329

5e. TASK NUMBER
08

5f. WORK UNIT NUMBER
H0GW (53290812)

6. AUTHOR(S)
Mr. Chris Perry*
Mr. Chris Burneka*
Mr. Ben Steinhauer*
Ms. Rachael Christopher**
Mr. Chris Albery***

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
ORISE**
Oak Ridge Institute for Science and Education
Oak Ridge, TN 37831 USA

Infoscitex Corporation***
Colonel Glenn Hwy, Suite 210
Dayton , Oh 45431-4027

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Materiel Command*
Air Force Research Laboratory
711 Human Performance Wing
Airman Systems Directorate
Warfighter Interface Division
Applied Neuroscience Branch
Wright-Patterson AFB, OH 45433

10. SPONSORING/MONITORING AGENCY ACRONYM(S)
711 HPW/RHCP

11. SPONSORING/MONITORING AGENCY REPORT NUMBER(S)
AFRL-RH-WP-TR-2017-0013

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.

13. SUPPLEMENTARY NOTES
88ABW Cleared 03/30/2017; 88ABW-2017-1403.

14. ABSTRACT Phase IV 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 based on specific seat configurations. The experimental design, consisting of four different seat configurations with a restrained manikin, was evaluated in four different test series. Test Series 1 was conducted to determine the materials and drop heights required for energy attenuation of the seat pan and the foot-rest to generate a 4 m/s velocity with a 5 ms TTP, or a 6 m/s velocity with a 5 ms TTP. Test Series 2 was conducted to determine the materials and drop heights required for energy attenuation of the seat pan to generate a 4 m/s velocity with a 10 ms TTP while the foot-rest was exposed to a 6 m/s velocity with a 5 ms TTP. Test Series 3 was conducted to determine the materials and drop heights required for energy attenuation of the seat pan to generate a 4 m/s velocity with a 20 ms TTP, and the energy attenuation of the foot-rest to generate a 6 m/s velocity with a 10 ms TTP. Test Series 4 was conducted to determine the materials and drop heights required for energy attenuation of the seat pan to generate a 5 m/s velocity with a 25 ms TTP, while the driving input to the foot-rest was 7 m/s velocity with a 2 ms TTP. Data from Test Series 1, evaluating various felt configurations impacted by the VID carriage, determined that the 1.0 inch thick 26S1 felt and the 2.0 inch thick 32S1 felt conditions generated very similar TTP values, and were both very close to the 5 ms requirement at the drop heights found to produce the 4 m/s and 6 m/s velocities. Data from Test Series 2, evaluating the impact characteristics of several material configurations under the seat pan, determined that none of the evaluated materials were able to attenuate the impact acceleration from 6 m/s down to 4 m/s, and that three of the five materials (felt, blue foam, and Stimulite) amplified the response between 10 and 20% at both the 4 m/s and 6 m/s input velocity to the carriage. Data from Test Series 3, evaluating several elastic ball configurations to amplify the foot pan velocity but decrease the velocity TTP, determined that the elastic balls provided some amplification of the velocity but also increased the velocity TTP. Data from Test Series 4 determined that 0.5 inch thick, 32S1 felt would produce a velocity of approximately 7 m/s with a TTP of approximately 3 ms, at a VID carriage drop height of 58 inches. It was also determined that using 10 Hexcel blocks would produce a seat pan velocity of approximately 5 m/s with a TTP of approximately 25 ms at the previously identified drop height of 58 inches.

15. SUBJECT TERMS Vertical Impact Acceleration, High-G impact Acceleration, Felt Programmer, Polyethylene Programmer, Hexcel, Velocity Change, Time to Peak Velocity Change, WIAMan, WIAMan Seat, Hybrid III Manikin, GARD Manikin, IMPAC 3636 machine, Vertical Impact Device

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT:	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON (Monitor)
a. REPORT	b. ABSTRACT	c. THIS PAGE			
Unclassified	Unclassified	Unclassified	SAR	130	Chris Burneka
					19b. TELEPHONE NUMBER *(Include Area Code)*

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

The authors would like to thank the following people for their expertise and assistance during this study in helping to: develop and design test fixtures, install and calibrate instrumentation, set-up and run data collection systems, and process data:

- Mr. Delane “Bull” Bullman, Mr. Greg Thompson, Mr. Glenn Thomas, Mr. Brian Grattan, Mr. Eric Master (Infoscitex Corporation)
- MSgt Clifford Hatch, TSgt James Chase, TSgt Filmon Yosief, SSgt Doug Robson, (Aircrew Biodynamics and Protection Team within the 711 Human Performance Wing)
- Mr. Joseph Strzelecki (Aircrew Biodynamics and Protection Team within the 711 Human Performance Wing)

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) and the Warrior Injury Assessment Manikin (WIAMan) seat. Tests were conducted at different drop heights to evaluate differences in peak acceleration, maximum velocity change, and time-to-peak velocity change with various impact attenuators provided for the VID carriage, the WIAMan seat pan, and WIAMan foot-rest plate. 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, 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. This test phase was the first to determine if the specially designed WIAMan seat structure mounted to the VID drop carriage could be used to generate different velocities and time-to-peak velocities at the seat pan and the foot-rest.

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 WIAMan development program. This test phase was the fourth of multiple phases and focused on the effects the facility's new seat fixture had on the acceleration pulse and calculated velocity change at different locations on the seat structure. Two different WIAMan 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 amoung wounded soldiers and allowing those soldiers 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 curves. This requirement to understand the blast loading environment led to the initiation of the 711 HPW program to determine the impact pulse characteristics that could be generated by 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 and velocity values with a specified time-to-peak (TTP); therefore, the impact characterization research program was initiated.

The first phase of VID research 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 previous work of Childers (Childers, 2002). Red urethane programmers, 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 of greater than or equal to 32 ft/s (≈ 10 m/s).

The second phase of VID research determined the efficacy of using a specially designed 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 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.

The third phase of VID research was conducted to evaluate the facility's performance capabilities with various seat and manikin configurations mounted on the VID impact carriage. Additional program requirements were 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 which became the focus of Phase III (Perry, Burneka, Christopher, Albery, 2016)[3]. 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.

Following the success of Phase I, Phase II, and Phase III testing on the VID, a fourth phase of testing was necessary to address new WIAMan program requirements. The new requirement was for the WIAMan seat configuration to provide different input profile to a seated manikin at the seat pan and at the foot-rest. The seat pan and the foot-rest profiles were defined to be velocity changes in the range of 4 to 7 m/s, and time-to-peak velocity changes in the range of 2 ms to 25 ms. Initially the profiles at the seat pan and foot-rest were the same, but WIAMan program requirements were redefined requiring the seat pan and foot-rest profiles to be different from one another.

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). The program requirements were revised 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. Additional program requirements were then defined to produce seat pan and the foot-rest profiles with velocity changes in the range of 4 to 7 m/s, and time-to-peak (TTP) velocity changes in the range of 2 ms to 25 ms. The test seat configuration was to include a restrained manikin.

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

(1) Determine the materials and drop heights required for energy attenuation of the seat pan and the foot-rest to generate a 4 m/s velocity with a 5 ms TTP, or a 6 m/s velocity with a 5 ms TTP.
(2) Determine the materials and drop heights required for energy attenuation of the seat pan to generate a 4 m/s velocity with a 10 ms TTP, and the energy attenuation of the foot-rest to generate a 6 m/s velocity with a 5 ms TTP.
(3) Determine the materials and drop heights required for energy attenuation of the seat pan to generate a 4 m/s velocity with a 20 ms TTP, and the energy attenuation of the foot-rest to generate a 6 m/s velocity with a 10 ms TTP.
(4) Determine the materials and drop heights required for energy attenuation of the seat pan to generate a 5 m/s velocity with a 25 ms TTP, and the energy attenuation of the foot-rest to generate a 7 m/s velocity with a 2 ms TTP.

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 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 broad range of velocity changes and pulse durations depending on the selected specialized impact programmers initially 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, 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 has a total weight of 1300 lbs. Bronze bearings guide the carriage on two hard chrome-plated guide 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, top of the reaction mass, or both, 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 two sets of a cable, pulley, and lifting tube driven by one hydraulic cylinder, with one set for each guide rail. 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 and then rebounds of of the reaction mass. The Control Console contains all the switches and condition lights for the remote control of the facility, and to initiate the drop of the carriage. The console also houses the hydraulic power for the lifting system. The VID and the VID Control Console (to the right of the VID facility) are 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 always 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.

The drop height of the carriage was determined by measuring the distance between the bottom of the VID drop carriage and the top felt pads 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.

Figure 1. 711 HPW Veritcal Impact Device

4.2 VID Configuration with WIAMan Seat Fixtures

The primary modification to the VID for Phase IV testing was the installation of specially designed seat fixtures mounted to the top of the VID drop carriage. Each VID configuration will be described relative to the set-up for the testing conducted to address the 4 principle objectives that were defined. Testing for each objective will be defined with a corresponding test series identification (Test Series 1 for Objective 1, Test Series 2 for Objective 2 and so on).

4.2.1. Configuration for Test Series 1

Test Series 1 used the WIAMan Seat Two configuration, hereinafter referred to as WS2. WS2 was comprised of four main components; the seat back, the seat pan, the footrest, and a specially designed VID carriage interface plate, and is shown in Figures 2 and 3. The seat was specially designed 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. 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 2. VID with WIAMan Seat Two (WS2) Mounted on Top of Carraige: Front View

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

4.2.2. Configuration for Test Series 2

Test Series 2 used the WIAMan Seat Two configuration with a modified seat pan, hereinafter referred to as WS2ms. WS2ms was comprised of four main components; the seat back, the seat pan plates, the footrest, and a specially designed VID carriage interface plate. The seat pan was modified by the addition of a second plate below the main plate, which served to provide the mounting structure for the seat pan load cells (load cells mounted between the new lower plate and the primary upper seat pan plate). The seat pan plates, shown in Figure 4, allowed the adjustability of the seat pan and footrest height relative to the top of the carriage, and relative to each other and the seatback plate. 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 WS2m was approximately 637 lbs. The test weight of the Hybrid III 50% manikin used in this test series, shown in Figure 5, was approximately 170 lbs, for a total test weight of approximately 807 lbs.

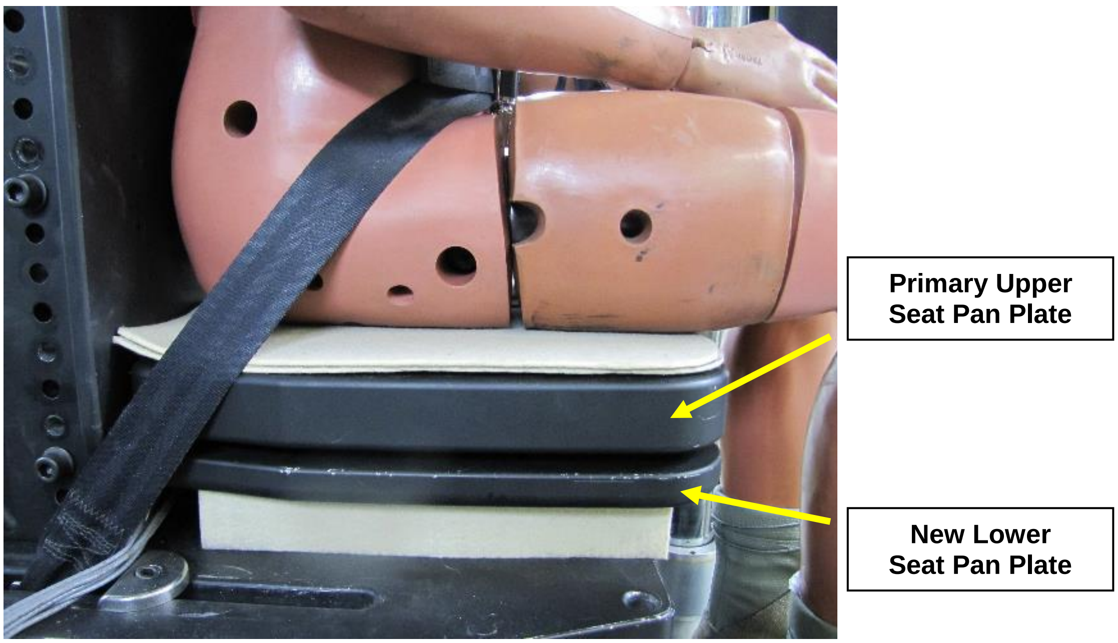


Figure 4. WS2ms Seat Fixture Showing Dual Plates Comprising Seat Pan Structure

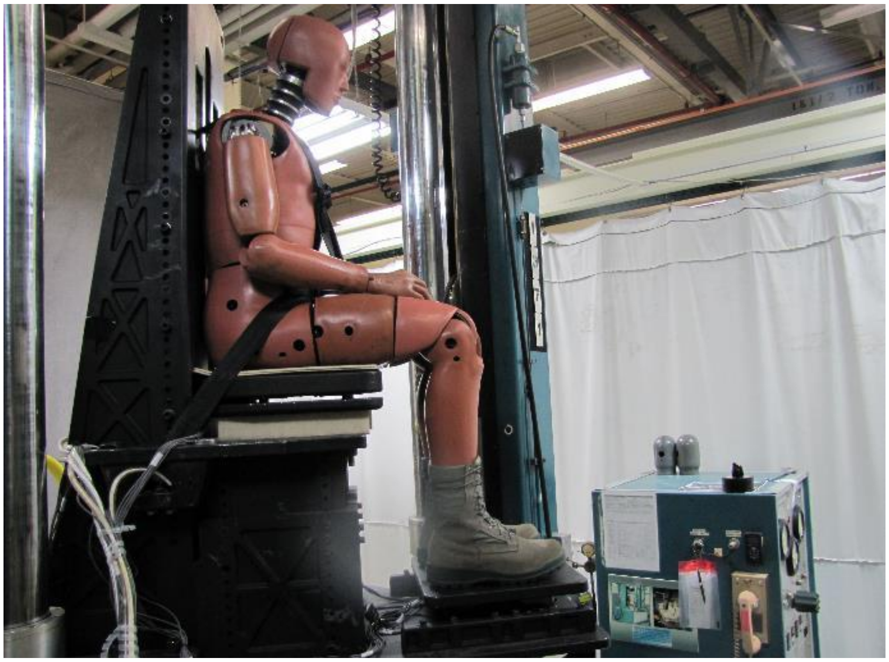


Figure 5. Side View of WS2ms Seat Fixture Showing Hybrid III Manikin

4.2.3. Configuration for Test Series 3

Test Series 3 used the WIAMan Seat Two configuration with a modified foot-rest, hereinafter referred to as WS2mf. WS2mf was comprised of four main components; the seat back, the seat pan plates, the footrest plates, and a specially designed VID carriage interface plate. The foot-rest plate was modified by allowing the plate to slide up and down in the z-axis along 4 centrally mounted guide rods. This allowed energy attenuation materials to be positioned between the foot-rest plate and the riged plate used to mount the seat to the top of the VID carriage. The foot-rest plate and guide rods are shown in Figure 6. The seat still provided adjustability of the seat pan and footrest height relative to the top of the carriage, and relative to each other and the seatback plate. 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 WS2mf was approximately 645 lbs. The test weight of the Hybrid III 50% manikin used in this test series, shown in Figure 5, was approximately 170 lbs, for a total test weight of approximately 815 lbs.

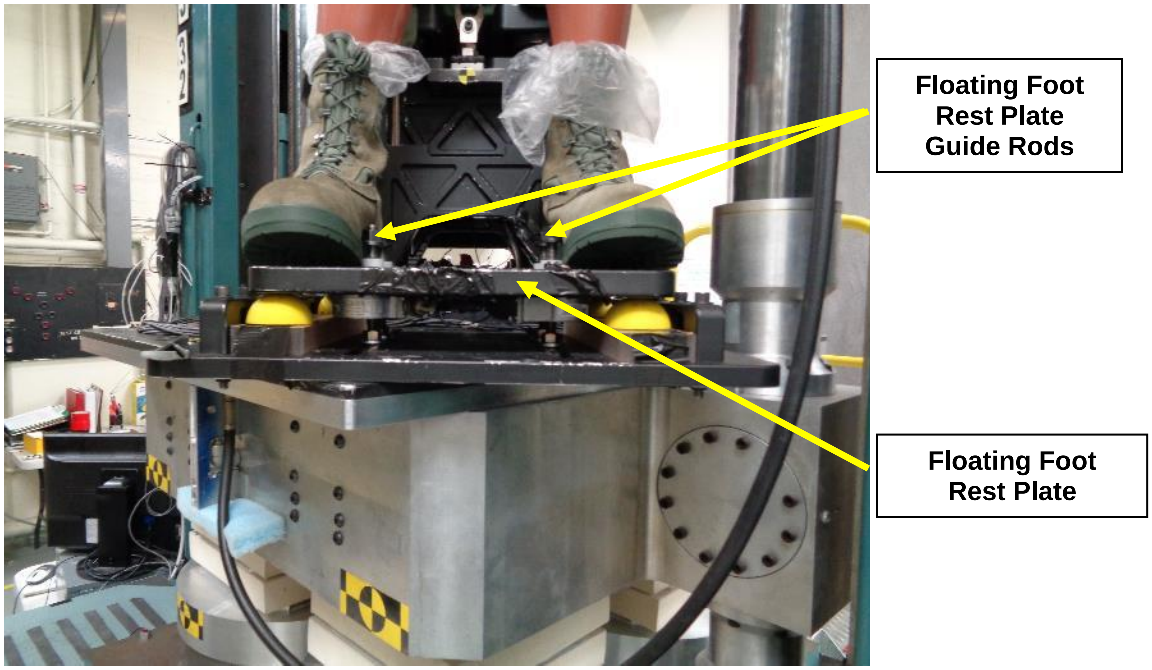


Figure 6. WS2mf Seat Fixture Showing Floating Plate for Foot-Rest Structure

4.2.4. Configuration for Test Series 4

Test Series 4 used the WIAMan Seat Three configuration with a modified foot-rest, hereinafter referred to as WS3. WS3 was comprised of four main components; the seat back, the seat pan plates, the footrest impact structure, and a specially designed VID carriage interface plate. The VID carrige interface plate was rotated from its WS2 postion to a perpendicular orientation on the carraige (Figure 7). This allowed the foot-rest portion of the seat fixture to extend beyond the edge of the VID drop carriage. The foot-rest was completely redesigned to include a separate impact structure that would provide an impact pulse to the foot-rest plate independent of the impact occuring to the main seat structure when the drop carriage contacts the reaction mass (i.e. the VID carriage and the foot-rest impact structure or footrest impact carriage both free-fall together, but impact separate surface areas). A schematic of the design in shown in Figure 8, and a close-up of the structure is shown in Figure 9. It is important to note that the foot-rest impact structure used separate guide rails mounted on the carriage interface plate, and this is what allowed it to react independently of the main carriage during impact.

This design allowed different energy attenuation materials to be positioned between both the VID carriage and reaction mass, and the foot-rest impact structure and an extension plate attached to the reaction mass. The seat still provided adjustability of the seat pan and footrest height relative to the top of the carriage, and relative to each other and the seatback plate. 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 WS3 was approximately 845 lbs. The test weight of the Hybrid III 50% manikin used in this test series, shown in Figure 5, was approximately 170 lbs, for a total test weight of approximately 1015 lbs.

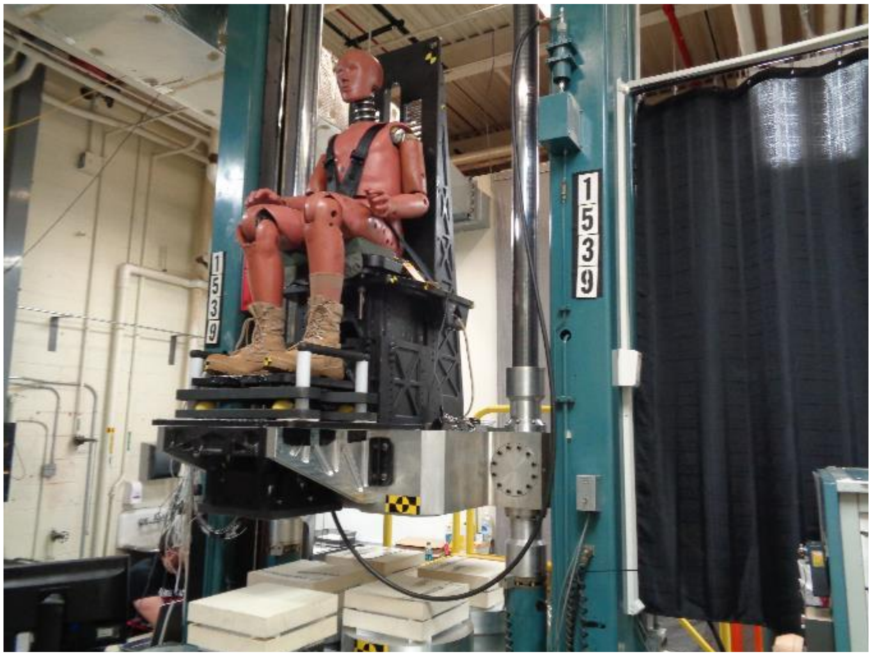


Figure 7. WS3 Seat Fixture Orientation of VID With Hybrid III Manikin

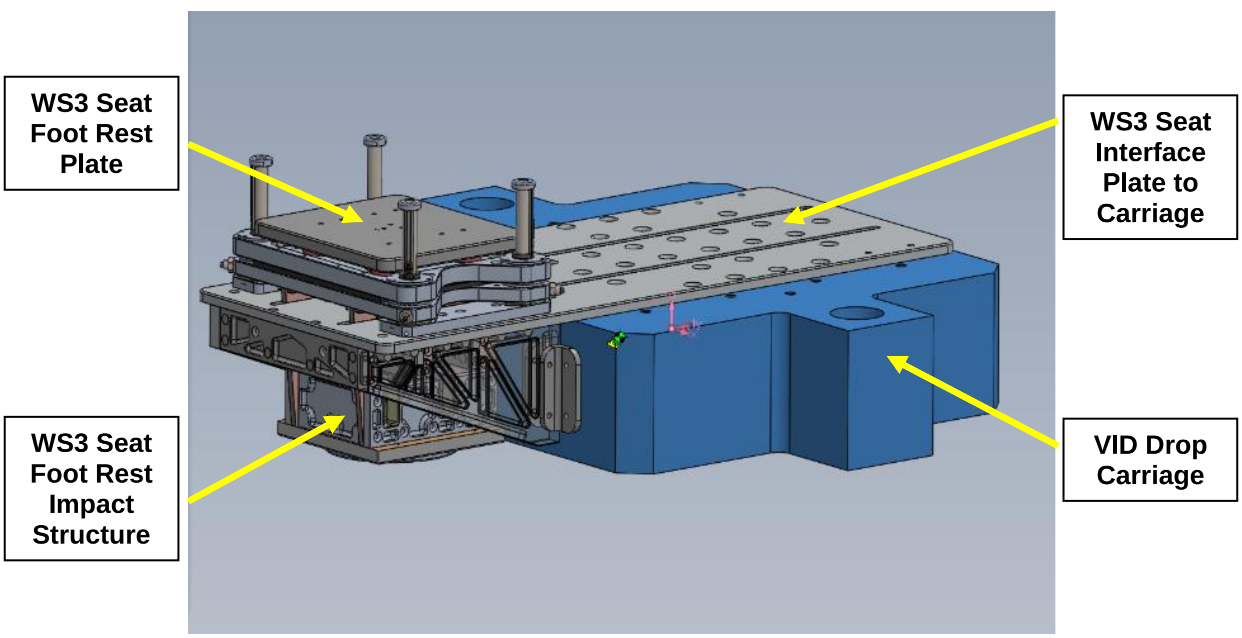


Figure 8. Schematic of Foot-Rest Impact Structure for WS3 Seat

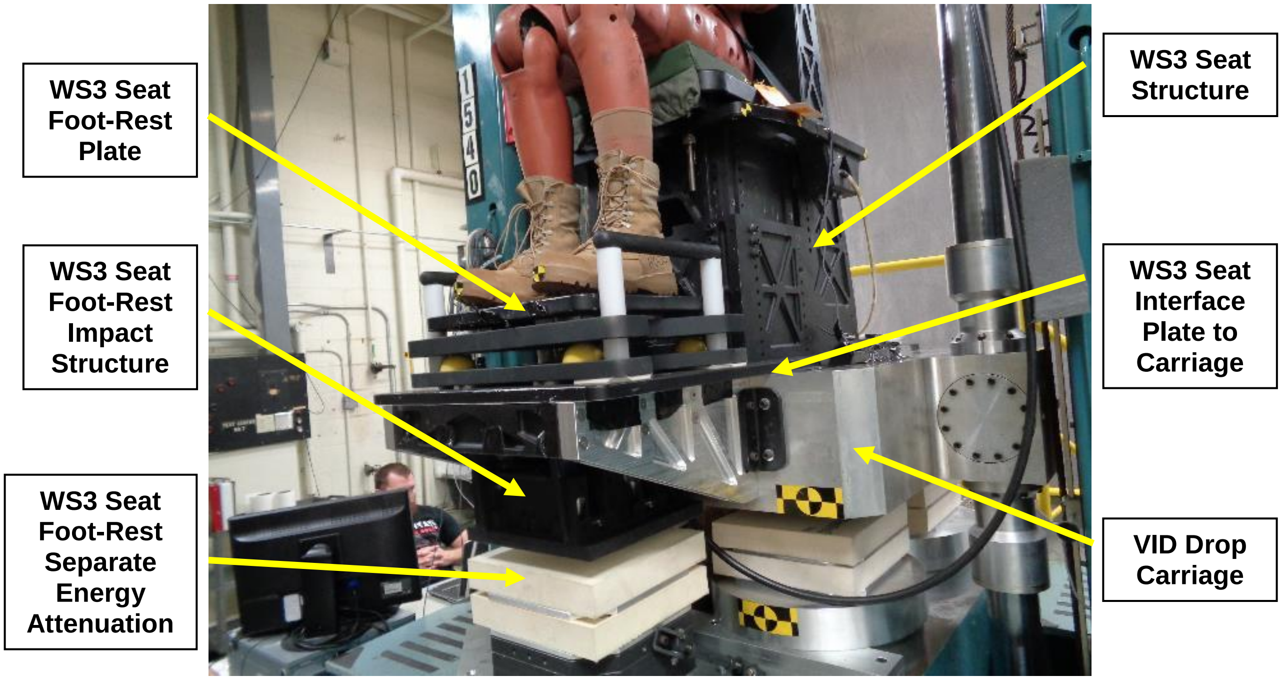


Figure 9. Foot-Rest Impact Structure for WS3 Seat

4.3 Energy Attenuation Programmers

The energy attenuation programmers varied quite dramatically as the program progressed, and therefor will be identified relative to the testing conducted in each Test Series.

4.3.1. Programmers for Test Series 1

Test Series 1 used the WS2 seat configuration. All test set-ups used felt pads positioned between the VID drop carriage and reaction mass. The felt pads were purchased from the Bacon Felt Company in Rochester, NH, and consisted of 1 sq. ft. pads that varied in density and thickness. The densities that were tested were 26 and 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… 26S1 or 32S1). The sample thicknesses tested varied from 0.5 in. up to 2.0 in. thick. The specific combinations of felt used for this phase of testing are identified in the test matrix. The felt programmers are shown in Figure 10.

4.3.2. Programmers for Test Series 2

Test Series 2 used the WS2ms seat configuration with the modified seat pan. All test set-ups in this series used felt pads positioned between the VID drop carriage and reaction mass. The felt pads were purchased from the Bacon Felt Company in Rochester, NH, and consisted of 1 sq. ft.

pads of 1 inch thick 26S1 felt. Five different materials were positioned between the rigid seat structure and the newly designed sliding or floating seat pan plates. The floating seat pan was two rigid plates with load cells sandwiched between to allow measurement of the reaction loads of the manikin into the seat pan plates. The materials that were tested consisted of the following: felt, 3 types of foam, and a honeycomb thermoplastic elastomer (TPE) cushion. Details on each material are provided as follows: (1) Felt Programmers: Two pieces of 16S1 felt from the Bacon Felt Company. Each piece was a 6 x 12 inch rectangle of 2 inch thick, 16 lb/ft^2 (0.11 lb/in^2) density felt; (2) Rigid Foam Programmer: Two pieces of a closed-cell blue packing foam. Each piece was a 6 x 12 inch rectangle of 2 inch thick with a density of approximately 0.027 lb/in^2; (3) Rate-dependent Foam Programmer 1: Two pieces of Blue Confor Foam. Each piece was a 6x12 inch rectangle of 2 inch thick, C-45 rate dependent foam; (4) Rate-dependent Foam Programmer 2: Two pieces of Green Confor Foam. Each piece was a 6x12 inch rectangle of 2 inch thick, C-47 rate dependent foam; and (5) Honeycomb Cushion: Two pieces of Supracor Stimulite Slimline Cushion or Stimulite TPE. Each piece was either a 6x7 inch rectangle or a 3x7 inch rectangle of 2.5 inch thick, 2 layer flexible honeycomb design. Example of seat pan programmer set-up is shown in Figure 11 with the honeycomb TPE.

4.3.3. Programmers for Test Series 3

Test Series 3 used the WS2mf seat configuration with the modified foot-rest plate. All test set-ups in this series used felt pads positioned between the VID drop carriage and reaction mass. The felt pads were purchased from the Bacon Felt Company in Rochester, NH, and consisted of 1 sq. ft. pads of 2 inch thick 16S1 and 2 inch thick 20S1 in a dual felt stack. Several different materials were positioned between the floating foot-rest plate (guided by 4 metal rods) and the base of the rigid seat structure. The materials that were tested consisted of the following: elastic rubber balls and golf balls. General details on each ball are provided as follows: (1) Rubber Ball 1: 1.75 inch diameter eleastic ball manufactured by Wham-O; (2) Rubber Ball 2: 2.5 inch diameter Lacrosse Ball purchased from Dick’s Sporting Goods; (3) Golf Ball 1: Bridgestone golf ball with compression ratio of 35; and (4) Golf Ball 2: Bridgestone golf ball with compression ratio of 110. The type of ball was not mixed with the other ball types during testing. Example of foot-rest programmer set-up is shown in Figure 12 with the lacrosse balls.

4.3.4. Programmers for Test Series 4

Test Series 4 used the WS3 seat configuration with the rotated orientation, and modified foot-rest to allow for separate impacts to the foot-rest independent of the impact to the main seat structure. The tests in this series used either square felt pads or aluminum honeycomb between the VID carriage and the reaction mass. The felt pads were purchased from the Bacon Felt Company in Rochester, NH, and consisted of 1 sq. ft. pads of 2 inch thick 16S1 and 2 inch thick 20S1 in a dual felt stack, or a dual felt pad stack of just the 2 inch thick 16S1. The aluminum honeycomb was Plascore Aluminum Honeycomb PACL-XR2-5.2-1/4-30-P-3003 or Hexcel, cut and pre-crushed into 4x6x6 inch bricks. Example of the VID carriage programmer is shown in Figure 13 with the aluminum honeycomb.

Several different materials were positioned between the foot-rest impact structure and the extension plate attached to the reaction mass (this extension plate provided a surface for placement of energy attentuation materials below the foot-rest impact structure). The materials that were tested consisted of the following: felt, urethane disk, and polyethelene sheets. Details on each material are provided as follows: (1) Felt Programmers 1: Dual felt stack of 16S1 or dual felt stack of 16S1 and 20S1 felt with all felt being 1 sq. ft. pads of 2 inch thick felt; (2) Felt Programmer 2: Single layer of 0.5 inch thick, 1 sq. ft., 32S1 felt; (3) Urethane Disk: Red IMPAC urethane disk supplied with VID with the round disk having a diameter of 11.75 inch, and an edge thickness of 0.5 inch that increased to a thickness of 0.94 inch at the center of the disk ; and (4) Polyethelene Sheets: Black polyethelene sheets with each 0.5 inch thick sheet cut to a 12 inch by 12 inch square for the tests; three different polyethelene materials were tested with durometer values of 75D, 90A, and 95A. Example of the programmer for the foot-rest impact structure is shown in Figure 14.

Figure 10. Carriage Felt Programmers (2” Thick Single Layer) used for Test Series 1

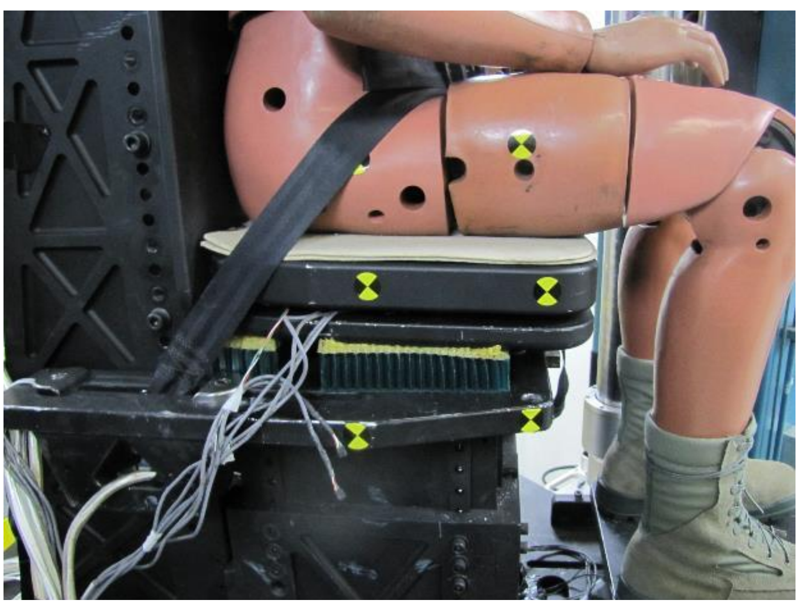


Figure 11. Seat Pan Programmer (Stimulite TPE) Used for Test Series 2

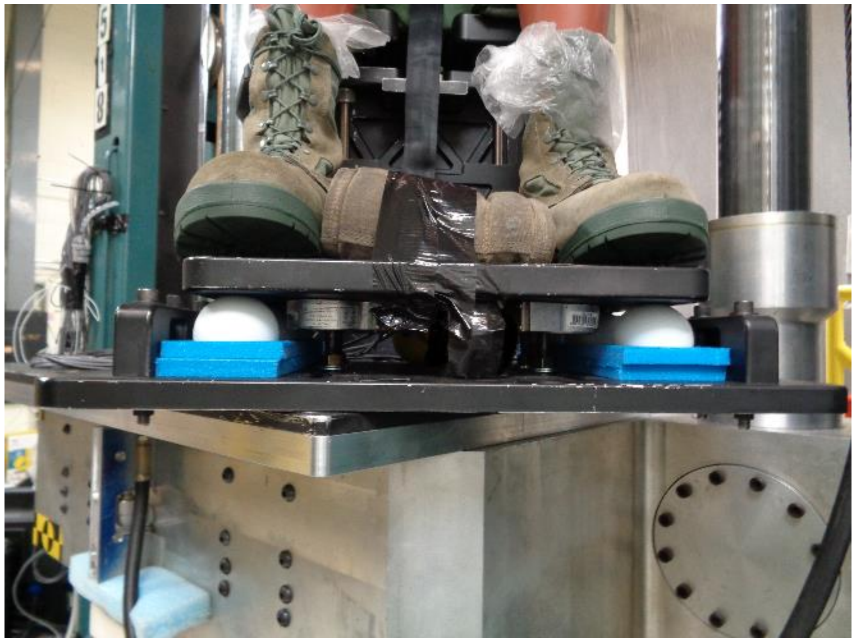


Figure 12. Foot-Rest Programmer (White Elastic Lacrosse Balls) Used for Test Series 3

Figure 13. Carriage Programmer (Hexcel) Used for Test Series 4

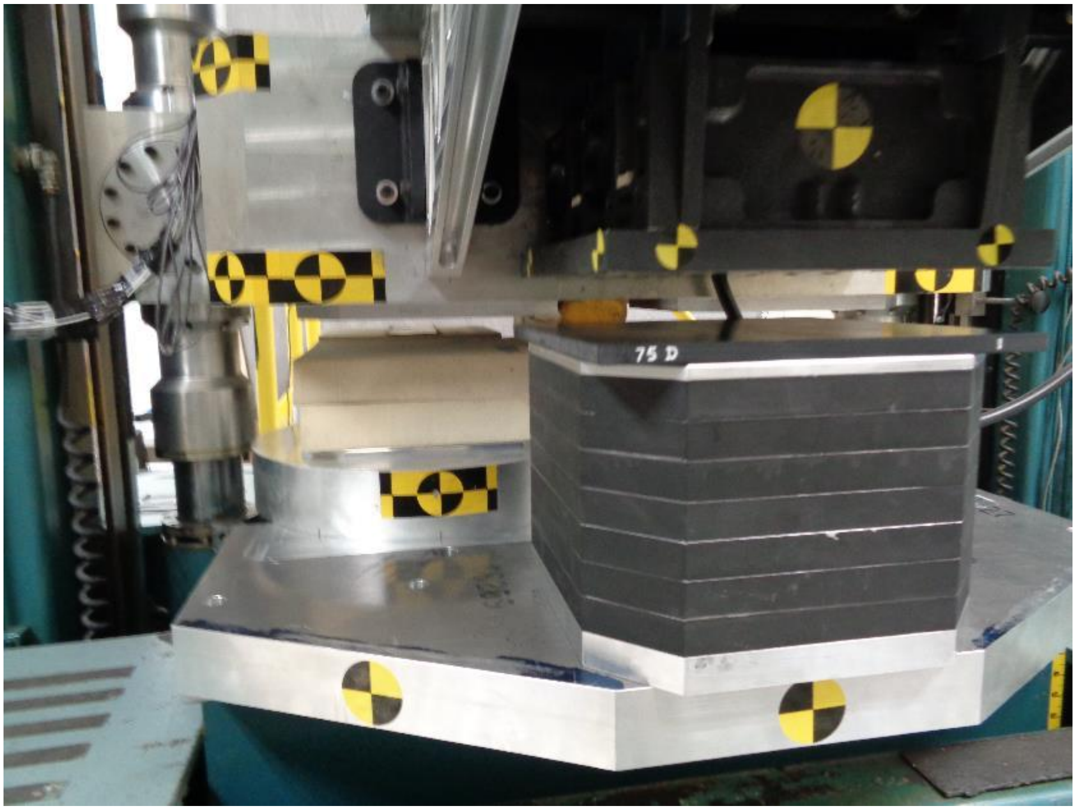


Figure 14. Foot-Rest Impact Structure Programmer (0.5" Thick, Black Polyethelene Sheet With ID of 75D) Used for Test Series 4

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 with positive being 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 and at various locations on the seat structure for each seat configuration. 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.

5.1.1. Instrumentation for Test Series 1

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 three MEAS Model EGCS-425-250 accelerometers mounted in the x, y, and z-axis. This is shown in Figure 15. 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 three MEAS Model EGCS-425-250 accelerometers mounted in the x, y, and z-axis. This is shown in Figure 16. 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 a single MEAS Model EGCS-425-250 accelerometer mounted in the z-axis. This is shown in Figure 17. In addition, a tri-axial accelerometer package was mounted on the footrest plate, and was also composed of three MEAS Model EGCS-425-250 accelerometers mounted in the x, y, and z-axis. This is shown in Figure 18. As required by the WIAMan program, two specialized accelerometers were also mounted on both the seat pan plate and the foot-rest plate (also Figure 18). 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. 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 Strainsert Model FL5(U)-2SGKT.

5.1.2. Instrumentation for Test Series 2

Tests involving WS2ms 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 WS2ms mounting plate), was composed of two MEAS Model EGCS-425-250 accelerometers mounted in the x and y-axis, and a single MEAS Model EGCS-425-1000 mounted in the z-axis. The location is the same as WS2 shown in Figure 15. 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-425-250 accelerometers mounted in the x and y-axis, and a single MEAS Model EGCS-425-1000 mounted in the z-axis. The location is shown in Figure 16. A second accelerometer package was also mounted on the floating seat pan. This floating seat pan accelerometer package was initially composed of three Entran Model EGV3-F-250 accelerometers mounted in the x, y, and z-axis. This package was removed after several tests and replaced with a single MEAS Model EGCS-425-2000 accelerometer mounted in the z-axis. The location is similar to that shown in Figure 17. In addition, an accelerometer package was mounted on the footrest plate, and was composed of a single MEAS Model EGCS-S425-250 accelerometer mounted in the x-axis, and a single MEAS Model EGCS-425-2000 mounted in the z-axis. This location is similar to that shown in Figure 18.

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. 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 Strainsert Model FL5(U)-2SGKT.

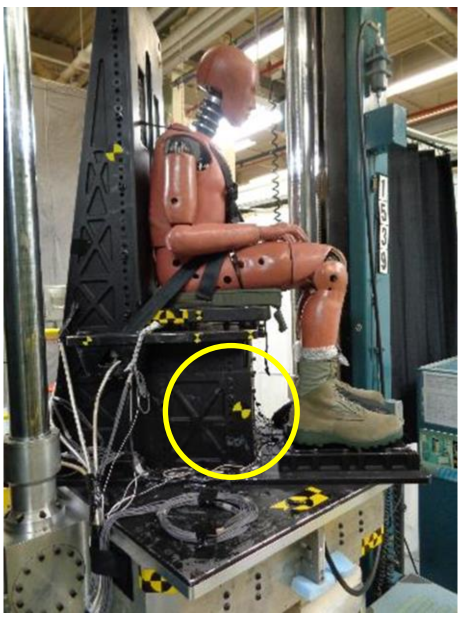
5.1.3. Instrumentation for Test Series 3

Tests involving WS2fm 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 WS2ms mounting plate), was composed of two MEAS Model EGCS-425-250 accelerometers mounted in the x and y-axis, and a single MEAS Model EGCS-425-1000 mounted in the z-axis. The location is the same as WS2 shown in Figure 15. 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-425-250 accelerometers mounted in the x and y-axis, and a single MEAS Model EGCS-425-1000 mounted in the z-axis. The location is shown in Figure 16. A second accelerometer package was also mounted on the seat pan. This seat pan accelerometer package was composed of two MEAS Model EGCS-425-250 in the x and y-axis, and a single MEAS Model EGCS-425-1000 mounted in the z-axis. The location is similar to that shown in Figure 17. In addition, an accelerometer package was mounted on the footrest plate, and was composed of a single MEAS Model EGCS-425-2000 mounted in the z-axis. This location is similar to that shown in Figure 18. As required by the WIAMan program, two specialized accelerometers were also mounted on the foot-rest plate (also Figure 18). One special accelerometer was an Endevco Model 7270A-20K 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. 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 Strainsert Model FL5(U)-2SGKT.

5.1.4. Instrumentation for Test Series 4

Tests involving WS3 used instrumentation to record accelerations and loads at various points on the test facility and fixture. The instrumentation set-up for WS3 is the same as listed for WS2fm used in Test Series 3, even though the seat was rotated 90° and a foot-rest support fixture was added to the seat structure.



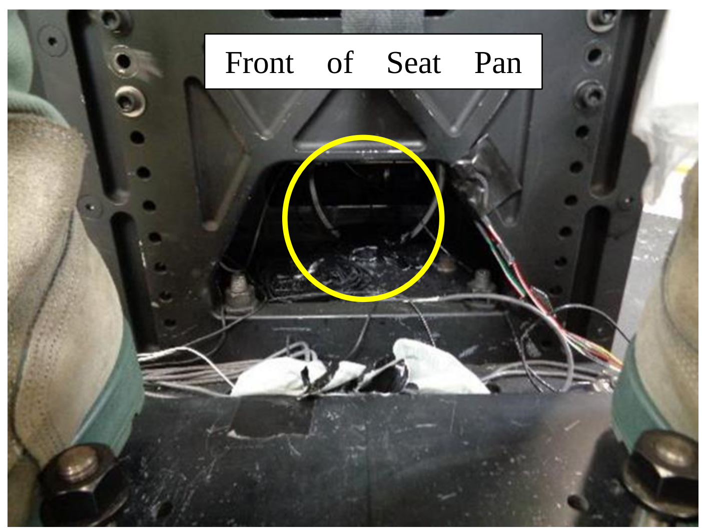


Figure 15. Location of Tri-axial Accel Array on VID Drop Carriage

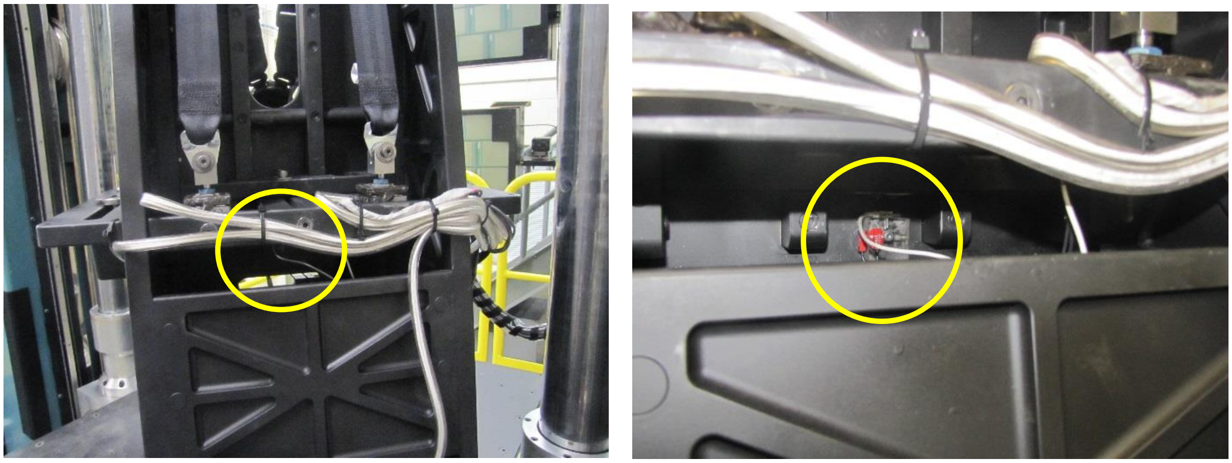


Figure 16. Location of Tri-axial Accel Array on WS2 Seat Plate

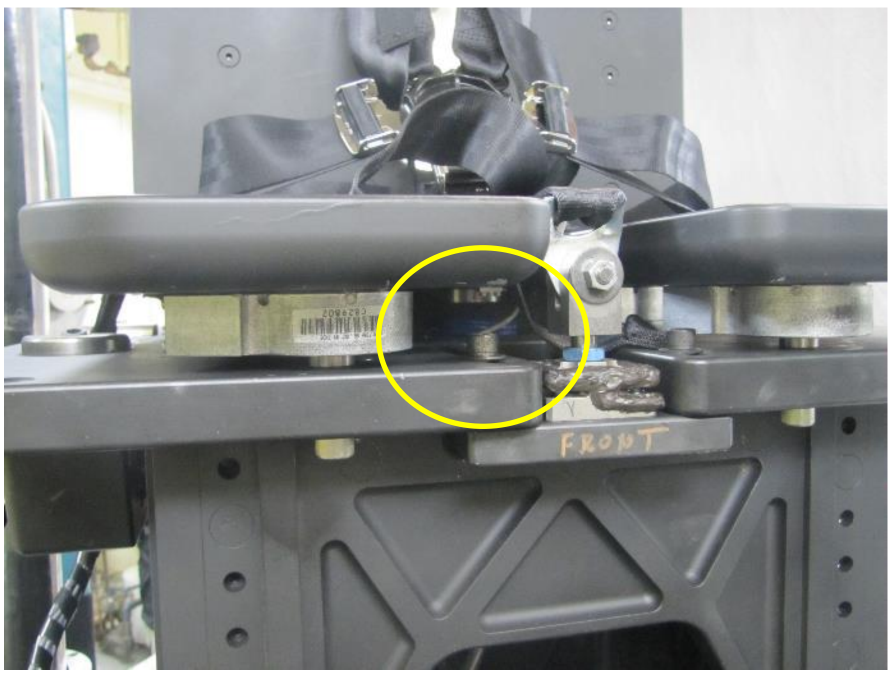


Figure 17. Location of Tri-axial Accel Array on WS2 Seat Pan

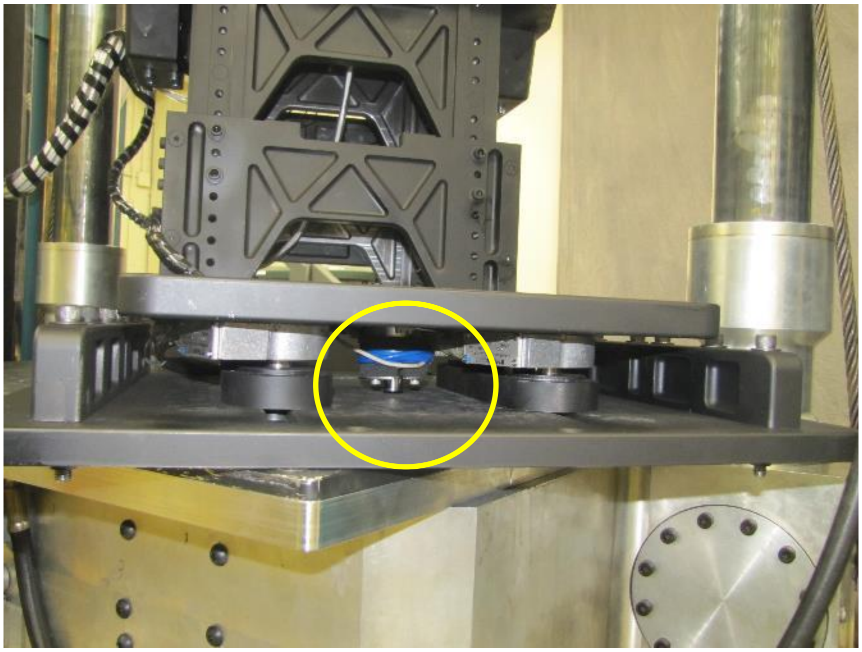


Figure 18. Location of Tri-axial Array and Specialized Accelerometers on WS2 Footrest

5.2 Manikin Instrumentation

Manikins were used for the majority of the testing and were instrumented with accelerometers to record pelvis accelerations, and with load cells to record forces and torques in the lumbar spine and forces in the tibia's. However, the data from the manikins was not part of the analysis for this report; therefore, details on the instrumentation are not included.

5.3 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).

5.4 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. Starting with Test Series 3, contact tape positioned between the drop carriage and the reaction mass (one piece on the carriage and the other on the top of the energy attenuation material positioned on the reaction mass) was used to trigger data collection.

5.5 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 G5 DAS 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 Test Series 1, 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. For Test Series 2, 3, and 4, the DAS collected data at 100K sample rate with a 4Khz anti-aliasing filter. All data was post processed using J211 filtering requirements.

5.6 Quick Look Data Plots

After each test, the filtered data were graphically 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.

5.7 High Speed Video and Photography

One or two Phantom Miro-3 High-Speed digital cameras (Figure 19) 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 Miro-3 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 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 19. Phantom Miro-3 High Speed Digital Camera

6.0 EXPERIMENTAL DESIGN

Specially designed test matrices were developed to address the program requirements 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 to 10 ms as input to a test seat, and also seat pan and the foot-rest profiles with velocity changes in the range of 4 to 7 m/s, and TTP velocity changes in the range of 2 to 25 ms. The test seat configuration included a restrained manikin.

A single matrix was designed for each of the four different Test Series defined as follows: Test Series 1 to produce energy attenuation of the seat pan and the foot-rest to generate a 4 m/s velocity with a 5 ms TTP, or a 6 m/s velocity with a 5 ms TTP; Test Series 2 to produce energy attenuation of the seat pan to generate a 4 m/s velocity with a 10 ms TTP, and the energy attenuation of the foot-rest to generate a 6 m/s velocity with a 5 ms TTP; Test Series 3 to produce energy attenuation of the seat pan to generate a 4 m/s velocity with a 20 ms TTP, and the energy attenuation of the foot-rest to generate a 6 m/s velocity with a 10 ms TTP; and Test Series 4 to produce energy attenuation of the seat pan to generate a 5 m/s velocity with a 25 ms TTP, and the energy attenuation of the foot-rest to generate a 7 m/s velocity with a 2 ms TTP.

6.1 VID Impact Response for Test Series 1

The evaluation of the VID impact response using the WS2 seat structure to address the velocity and TTP velocity requirements was conducted with four different felt programmers configurations identified in Table 1. The felt configurations were selected based on results from previous research on felt impact response. Each configuration was mounted in a four-square grid pattern on the top of the reaction mass. The programmers each impacted a flat, 1 square foot, 0.25 in. thick, steel plate mounted to the bottom of the drop carriage. A Grumman Alderson Research Dummy (GARD) weighing approximately 190 lbs was placed in the seat for all tests with the WS2 seat structure. Two tests were conducted per test cell. The test matrix for this test series is shown in Table 1.

6.2 VID Impact Response for Test Series 2

The evaluation of the VID impact response using the WS2ms seat structure to address the velocity and TTP velocity requirements required for the seatpan was conducted with five different energy attenuation programmers configurations identified in Table 2. The programmer configurations were selected based on evaluations and assessments of the materials from previous research on impact response. Each material configuration was composed of two 6” x 12” blocks mounted beneath the right and left side of the floating seat pan plate (the floating seat pan plate configuration was composed of the top seat pan plate and bottom seat pan plate with the load cells mounted between). The VID drop carriage programmer was 1 inch thick 26S1 felt pads mounted in a four-square grid pattern on the top of the reaction mass. The programmers each impacted a flat, 1 square foot, 0.25 in. thick, steel plate mounted to the bottom of the drop carriage. A Grumman Alderson Research Dummy (GARD) weighing approximately 190 lbs was placed in the seat for all tests with the WS2ms seat structure. Two tests were conducted per test cell. The test matrix for this test series is shown in Table 1.

Table 1. Test Matrix for Test Series 1: VID Response with WS2

Test Cell	Drop Height (in)	Programmer
SK1	10	32S1/Plate/32S1 (0.5 in. thk)
SK2	20	32S1/Plate/32S1 (0.5 in. thk)
SK3	30	32S1/Plate/32S1 (0.5 in. thk)
SK4	40	32S1/Plate/32S1 (0.5 in. thk)
SL1	10	26S1 (1.0 in. thk)
SL2	20	26S1 (1.0 in. thk)
SL3	30	26S1 (1.0 in. thk)
SL4	40	26S1 (1.0 in. thk)
SM1	10	32S1 (2.0 in. thk)
SM2	20	32S1 (2.0 in. thk)
SM3	30	32S1 (2.0 in. thk)
SM4	40	32S1 (2.0 in. thk)
SN1	10	26S1 (2.0 in. thk)
SN2	20	26S1 (2.0 in. thk)
SN3	30	26S1 (2.0 in. thk)
SN4	40	26S1 (2.0 in. thk)

Table 2. Test Matrix for Test Series 2: VID Response with WS2ms

Test Cell	Drop Height (in)	Seat Pan Plate Energy Attenuation Programmer
SO1	18	16S1 Felt (2 in. thk)
SO2	40	16S1 Felt (2 in. thk)
SQ1	18	Blue Packing Foam (2 in. thk)
SQ2	40	Blue Packing Foam (2 in. thk)
SR1	18	C-45 Blue Foam (2 in. thk)
SR2	40	C-45 Blue Foam (2 in. thk)
SS1	18	C-47 Green Foam (2 in. thk)
SS2	40	C-47 Green Foam (2 in. thk)
ST1	18	Stimulite TPE (2.5 in. thk)
ST2	40	Stimulite TPE (2.5 in. thk)

6.3 VID Impact Response for Test Series 3

The evaluation of the VID impact response using the WS2fm seat structure to address the velocity and TTP velocity requirements required for both the seatpan and the foot-rest was conducted with multiple energy attenuation programmers configurations. The VID drop carriage programmer was dual felt pad configuration of 2 inch thick 16S1 and 20S1 or two 20S1 felt samples mounted in a four-square grid pattern on the top of the reaction mass. This configuration was found to provide the required impact specifications at the seat pan of approximately 4 m/s with a 20 ms TTP based on previous testing. The programmers each impacted a flat, 1 square foot, 0.25 in. thick, steel plate mounted to the bottom of the drop carriage. The foot-rest programmer configurations were selected based on evaluations and assessments of the materials from previous research on impact response. The focus was to determine if select impact programmers could increase the input velocity to the foot-pan beyond what the seat structure was exposed to. The required foot-pan velocity was 6 m/s with a 10 ms TTP. There was not a pre-defined test matrix for the foot-pan programmer assessment, and a random test and evalaute approach was used for various easily obtained programmers. The programmers included elastic rubber balls and golf balls (Rubber balls 1.75 inch diameter and 2.5 inch diameter, golf balls with compression ratio of 35 and 110). The type of ball was not mixed with the other ball types during testing. The test conditions with the 1.75 inch diameter elastic balls varied the number of balls tested and included 3, 4, 6, 8, 10, 14, 18, and 20 ball configurations. The test conditions with the 2.5 inch elastic balls varied the number of balls tested and included 2, 4, 6, and 10 whole ball configurations, and some tests with a 4 half-ball configuration. The test conditions with the golf balls that had a compression ratio equal to 35 varied the number of balls tested and included 2, 3, and 4 ball configurations. The test conditions with the golf balls that had a compression ratio equal to 110 only included a 4 ball impact configuration.

6.4 VID Impact Response for Test Series 4

The evaluation of the VID impact response using the WS3 seat structure to address the velocity and TTP velocity requirements required for both the seatpan and the foot-rest was conducted with multiple energy attenuation programmer configurations. The requirement was to produce energy attenuation of the seat pan to generate a 5 m/s velocity with a 25 ms TTP, and to produce energy attenuation of the foot-rest to generate a 7 m/s velocity with a 2 ms TTP. It was determined, based on testing from the previous test series, that the VID drop height would drive the energy profile for the foot-rest requirement, therefore the VID carriage programmer would need to attenuate the energy to achieve a reduced velocity requirement for the seat-pan relative to the foot-rest (5 m/s compared to 7 m/s respectively). The VID carriage programmers were distributed on 4 load plates mounted on the reaction mass, with each programmer impacting a flat, 1 square foot, 0.25 in. thick, steel plate mounted to the bottom of the drop carriage. This configuration controlled the energy delivered to the seat-pan. The test matrix shown in Table 3 reviews the test configurations that were used for data analysis.

The foot-rest programmer configurations were selected based on evaluations and assessments of the materials from previous research on impact response. The focus was to determine if select impact programmers could generate the required velocity TTP since the peak velocity is driven by the drop height of the VID carriage. The foot-rest programmers were distributed on a single load plate with the programmer impact a flat, 1 square foot, 0.25 inch thick, steel plate mounted on the bottom of the foot-rest impact structure. The test matrix shown in Table 4 reviews the test configurations that were used for data analysis.

Table 3. Test Matrix for Test Series 4: VID Response with WS3 (Seat Pan)

Drop Height (in)	VID Carriage Energy Attenuation Programmer
40, 45, 50, 55, 60	16S1 Felt, 2 layers (2.0 in. thk)
55, 60	Plascore Hexcel, 8 blocks, (4 in.)
60	Plascore Hexcel, 10 blocks, (4 in.)
55, 60	Plascore Hexcel, 12 blocks, (4 in.)
60	Plascore Hexcel, 14 blocks, (4 in.)

Table 4. Test Matrix for Test Series 4: VID Response with WS3 (Foot Rest)

Drop Height (in)	Foot Rest Plate Energy Attenuation Programmer
45, 50, 55, 60, 65	32S1 Felt (0.5 in. thk)
40, 45, 50, 55, 60	VID Red Polyurethane Bumper
40, 50, 60	90A Polyethylene (0.5 in. thk)
40, 50, 60	95A Polyethylene (0.5 in. thk)
40, 50, 60	75D Polyethylene (0.5 in. thk)

7.0 RESULTS

A total of 155 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 at two different locations on the seat structure: the seat pan and the foot rest. This forth 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 programmers for both the VID carriage and the seat's footrest.

7.1 VID Impact Response for Test Series 1: 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 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 B.

7.2 VID Impact Response for Test Series 1: Test Data Review

The carriage, seat pan, and foot rest velocity data and TTP velocity data that were collected during impacts with the WS2 seat and the GARD manikin are presented in Tables 4, 5, and 6, and corresponds with the test parameters proposed in Table 1 in the Experimental Design section. The peak velocity and TTP velocity were plotted as a function of progressively increasing drop heights, and are shown in Figures 20 through 25 for the carriage, seat pan, and foot rest respectively.

Table 5. VID Impact Response: Test Series 1 Data Summary for Carriage

Test Cell	VID Carriage Programmer	Drop Ht. (in)	Mean Velocity Change (m/s)	Mean Velocity Change TTP (ms)
SK1	32S1 (0.5 in., 2 layer)	10	2.92 ± 0.04	5.70 ± 0.57
SK2	32S1 (0.5 in., 2 layer)	20	4.18 ± 0.07	4.60 ± 0.00
SK3	32S1 (0.5 in., 2 layer)	30	5.11 ± 0.06	4.35 ± 0.07
SK4	32S1 (0.5 in., 2 layer)	40	5.86 ± 0.09	4.20 ± 0.00
SL1	26S1 (1.0 in., 1 layer)	10	2.92 ± 0.02	6.85 ± 0.07
SL2	26S1 (1.0 in., 1 layer)	20	4.11 ± 0.01	6.20 ± 0.28
SL3	26S1 (1.0 in., 1 layer)	30	5.01 ± 0.00	5.60 ± 0.00
SL4	26S1 (1.0 in., 1 layer)	40	5.69 ± 0.02	5.30 ± 0.00
SM1	32S1 (2.0 in., 1 layer)	10	2.93 ± 0.02	6.45 ± 0.64
SM2	32S1 (2.0 in., 1 layer)	20	4.22 ± 0.02	6.30 ± 0.71
SM3	32S1 (2.0 in., 1 layer)	30	5.19 ± 0.05	6.45 ± 0.07
SM4	32S1 (2.0 in., 1 layer)	40	5.91 ± 0.10	6.20 ± 0.57
SN1	26S1 (2.0 in., 1 layer)	10	2.94 ± 0.01	8.15 ± 0.49
SN2	26S1 (2.0 in., 1 layer)	20	4.16 ± 0.09	7.45 ± 0.07
SN3	26S1 (2.0 in., 1 layer)	30	5.11 ± 0.02	7.10 ± 0.00
SN4	26S1 (2.0 in., 1 layer)	40	5.81 ± 0.08	6.85 ± 0.07

Table 6. VID Impact Response: Test Series 1 Data Summary for Seat Pan

Test Cell	VID Carriage Programmer	Drop Ht. (in)	Mean Velocity Change (m/s)	Mean Velocity Change TTP (ms)
SK1	32S1 (0.5 in., 2 layer)	10	3.12 ± 0.05	5.10 ± 1.41
SK2	32S1 (0.5 in., 2 layer)	20	4.52 ± 0.11	5.60 ± 0.00
SK3	32S1 (0.5 in., 2 layer)	30	5.56 ± 0.06	5.45 ± 0.07
SK4	32S1 (0.5 in., 2 layer)	40	6.40 ± 0.09	2.85 ± 0.07
SL1	26S1 (1.0 in., 1 layer)	10	3.11 ± 0.00	6.50 ± 0.14
SL2	26S1 (1.0 in., 1 layer)	20	4.38 ± 0.02	5.95 ± 0.07
SL3	26S1 (1.0 in., 1 layer)	30	5.34 ± 0.05	5.30 ± 0.28
SL4	26S1 (1.0 in., 1 layer)	40	5.99 ± 0.01	5.15 ± 0.07
SM1	32S1 (2.0 in., 1 layer)	10	3.12 ± 0.02	5.60 ± 0.00
SM2	32S1 (2.0 in., 1 layer)	20	4.45 ± 0.04	5.35 ± 0.07
SM3	32S1 (2.0 in., 1 layer)	30	5.49 ± 0.05	5.20 ± 0.14
SM4	32S1 (2.0 in., 1 layer)	40	6.25 ± 0.00	5.20 ± 0.57
SN1	26S1 (2.0 in., 1 layer)	10	3.09 ± 0.02	8.15 ± 0.07
SN2	26S1 (2.0 in., 1 layer)	20	4.38 ± 0.09	7.45 ± 0.07
SN3	26S1 (2.0 in., 1 layer)	30	5.35 ± 0.02	6.80 ± 0.00
SN4	26S1 (2.0 in., 1 layer)	40	6.08 ± 0.06	6.4 ± 0.00

Table 7. VID Impact Response: Test Series 1 Data Summary for Foot Rest

Test Cell	VID Carriage Programmer	Drop Ht. (in)	Mean Velocity Change (m/s)	Mean Velocity Change TTP (ms)
SK1	32S1 (0.5 in., 2 layer)	10	3.08 ± 0.03	4.40 ± 0.00
SK2	32S1 (0.5 in., 2 layer)	20	4.44 ± 0.05	4.10 ± 0.00
SK3	32S1 (0.5 in., 2 layer)	30	5.44 ± 0.03	4.05 ± 0.07
SK4	32S1 (0.5 in., 2 layer)	40	6.20 ± 0.09	3.70 ± 0.14
SL1	26S1 (1.0 in., 1 layer)	10	3.04 ± 0.01	5.55 ± 0.07
SL2	26S1 (1.0 in., 1 layer)	20	4.29 ± 0.01	5.00 ± 0.00
SL3	26S1 (1.0 in., 1 layer)	30	5.28 ± 0.03	4.90 ± 0.14
SL4	26S1 (1.0 in., 1 layer)	40	6.02 ± 0.03	4.80 ± 0.00
SM1	32S1 (2.0 in., 1 layer)	10	3.13 ± 0.01	5.20 ± 0.00
SM2	32S1 (2.0 in., 1 layer)	20	4.53 ± 0.02	5.00 ± 0.00
SM3	32S1 (2.0 in., 1 layer)	30	5.56 ± 0.06	4.85 ± 0.07
SM4	32S1 (2.0 in., 1 layer)	40	6.37 ± 0.11	4.80 ± 0.00
SN1	26S1 (2.0 in., 1 layer)	10	3.05 ± 0.01	7.85 ± 0.07
SN2	26S1 (2.0 in., 1 layer)	20	4.29 ± 0.11	7.05 ± 0.07
SN3	26S1 (2.0 in., 1 layer)	30	5.27 ± 0.01	6.60 ± 0.00
SN4	26S1 (2.0 in., 1 layer)	40	6.04 ± 0.09	6.60 ± 0.14

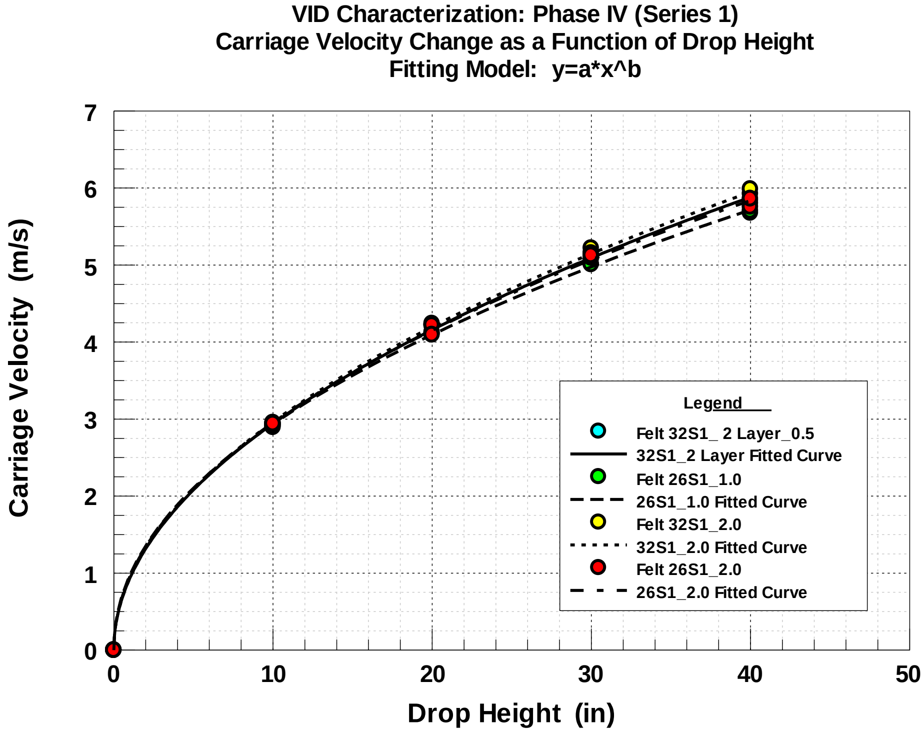


Figure 20. Peak Carriage Velocity as a Function of Drop Height for Test Series 1 (WS2)

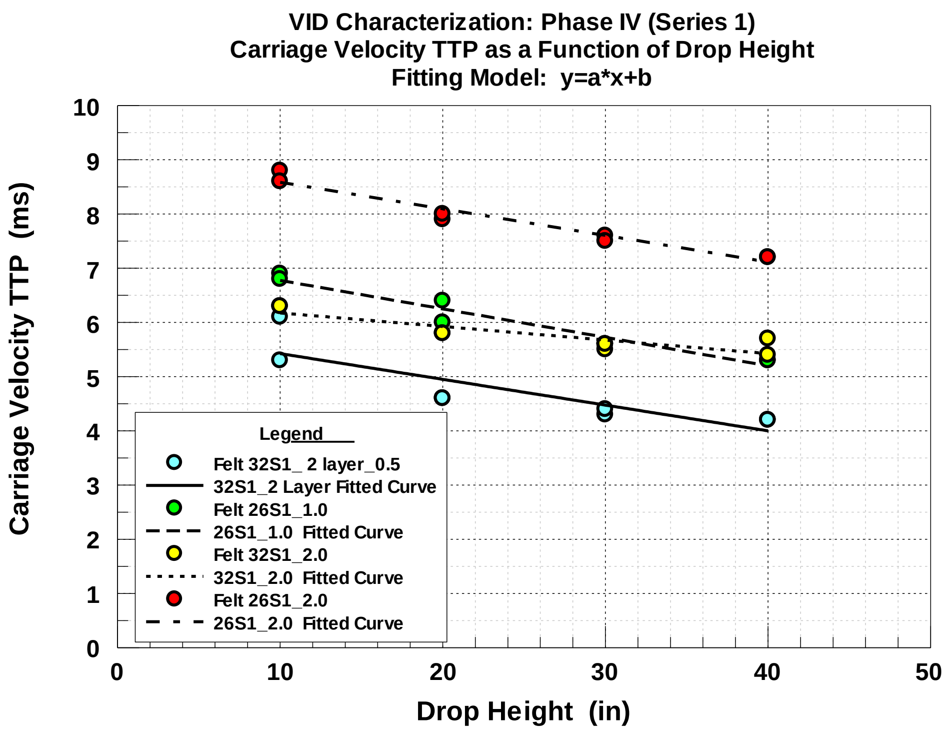


Figure 21. Carriage Velocity TTP as a Function of Drop Height for Test Series 1 (WS2)

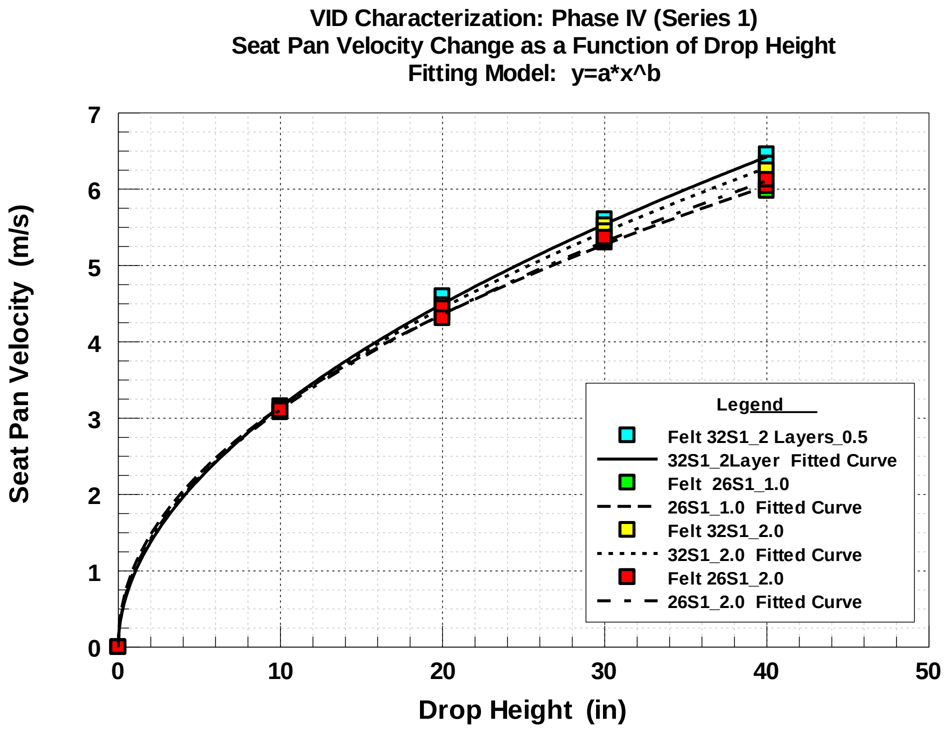


Figure 22. Peak Seat Pan Velocity as a Function of Drop Height for Test Series 1 (WS2)

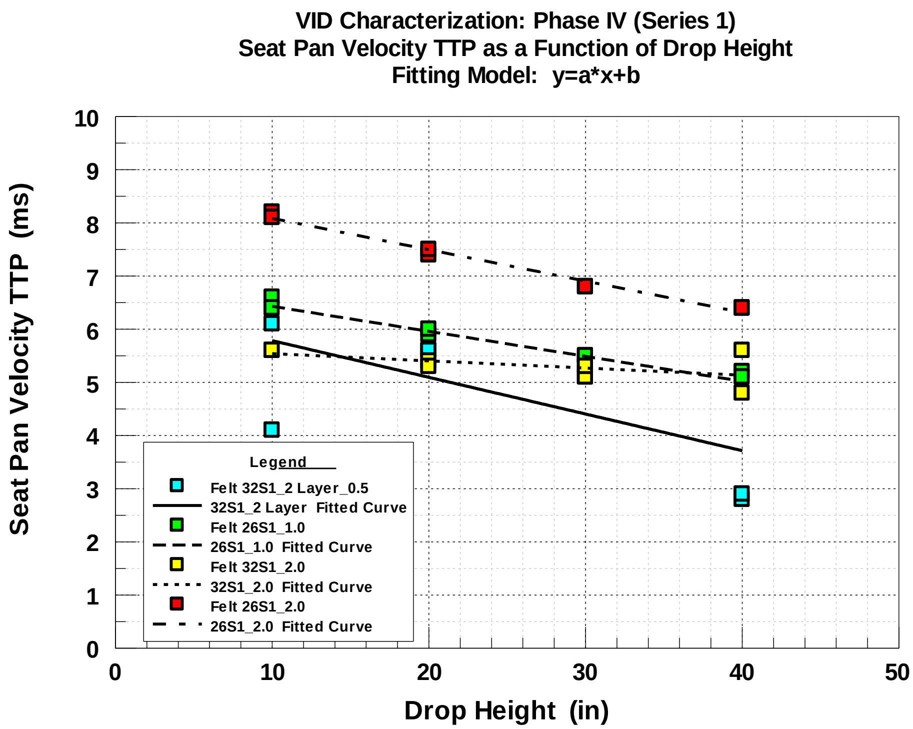


Figure 23. Seat Pan Velocity TTP as a Function of Drop Height for Test Series 1 (WS2)

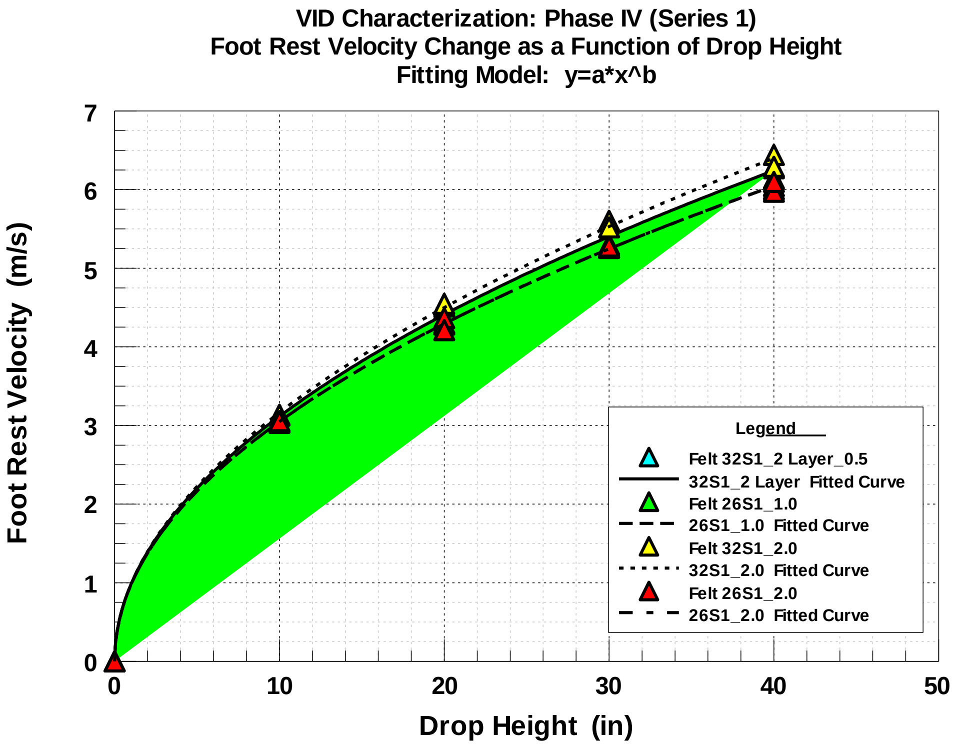


Figure 24. Peak Foot Rest Velocity as a Function of Drop Height for Test Series 1 (WS2)

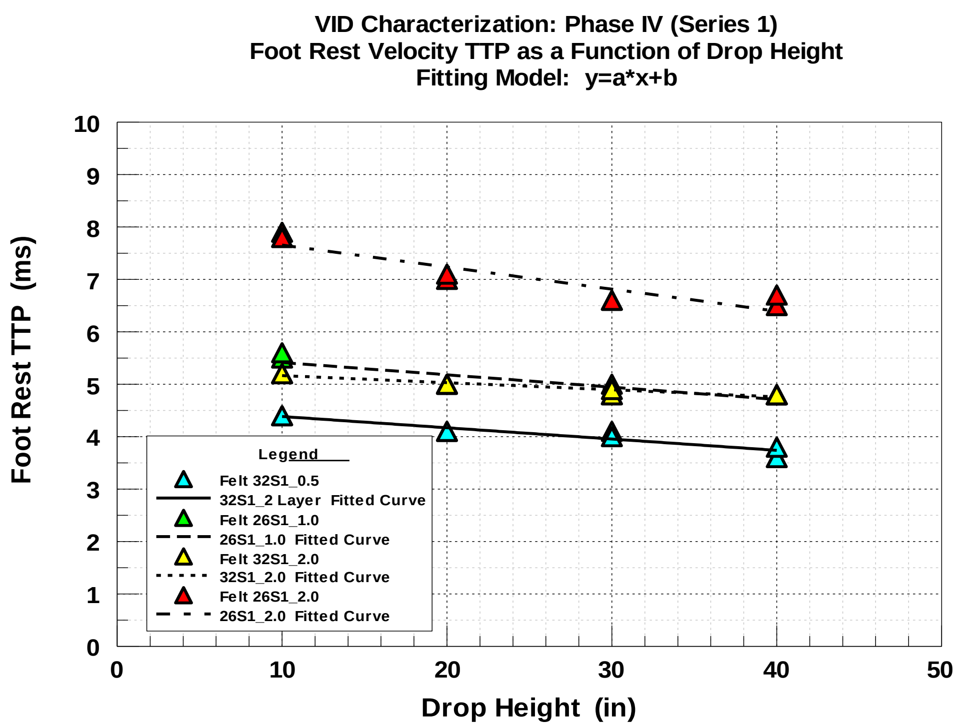


Figure 25. Foot Rest Velocity TTP as a Function of Drop Height for Test Series 1 (WS2)

The data used to calculate the statistical means and standard deviations, for the velocity and velocity TTP data sets, was composed of data from VID tests 1331 through 1362. Testing was successfully completed at all the drop heights (10, 20, 30, and 40 inches) for every VID carriage impact attenuation configuration. The narrow standard deviation values shown in the data tables for the velocity 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 for the velocity data, and a Liner equiation (y=a*x+b) provided the best fit regression for the velocity TTP data. Coefficient of Determination (COD) for the velocity data sets was 0.99 or better, and the COD for the Velocity TTP data varied between 0.7 and 0.8 for the majority of the data sets. Higher levels of noise in the seat pan data attributed to the lower correlations for those data sets. In general, the COD values for all the data sets (the velocity data in particular) allows the regression models to be used for estimation of required test parameters.

The velocity test data indicates the consistent trend to increase as a function of drop height, and was predicted with the Power Series equation, which is consistent with the previous research phases. The test data also highlights the limited variation in velocity response between the four felt impact configurations as the drop height increases independent of the measurement location. The peak velocity values for the seat pan and foot rest were both slightly attenuated relative to the carriage values, and were very close at the tested drop heights. The drop heights to generate 4 and 6 m/s ranged from 16 to 17 inches for 4 m/s, and ranged from 35 to 40 inches for 6 m/s. The larger variance for the 6 m/s requirement indicates the influence of felt characteristics at the higher energy input conditions.

The velocity TTP test data indicates a slight trend to decrease as a function of drop height, and was consistently predicted with a Linear equation. The velocity TTP data showed a broader range of response as a function of the impact felt as compared to the peak velocity data. The 2 layer, 0.5 inch thick 32S1 felt condition consistently provided the lower TTP values, while the 2.0 inch thick 26S1 felt condition consistently provided the highest TTP values. The 1.0 inch thick 26S1 felt and the 2.0 inch thick 32S1 felt conditions generated very similar TTP values, and were both very close to the 5 ms requirement at the drop heights found to produce the 4 m/s and 6 m/s velocities. This can be shown in Figures 26 and 27 which are time history plots of the calculated velocity changes for several locations on the seat structure using the 1.0 inch thick 26S1 felt as the carriage attenuation material.

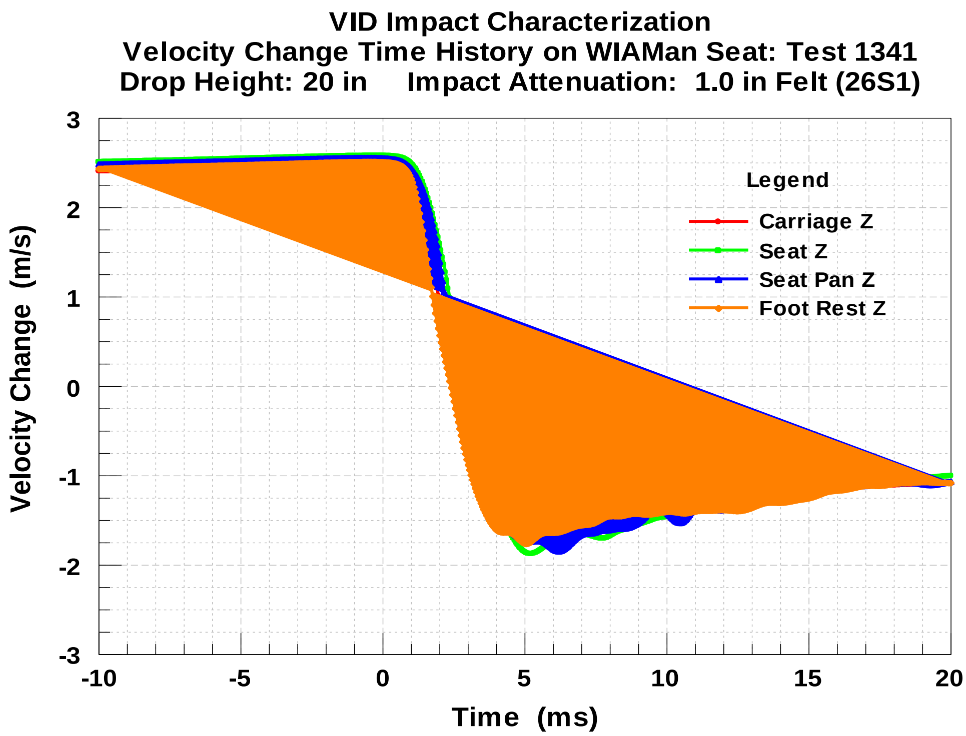


Figure 26. Velocity Change Time History at Various Seat Locations: Velocity ≈ 4 m/s

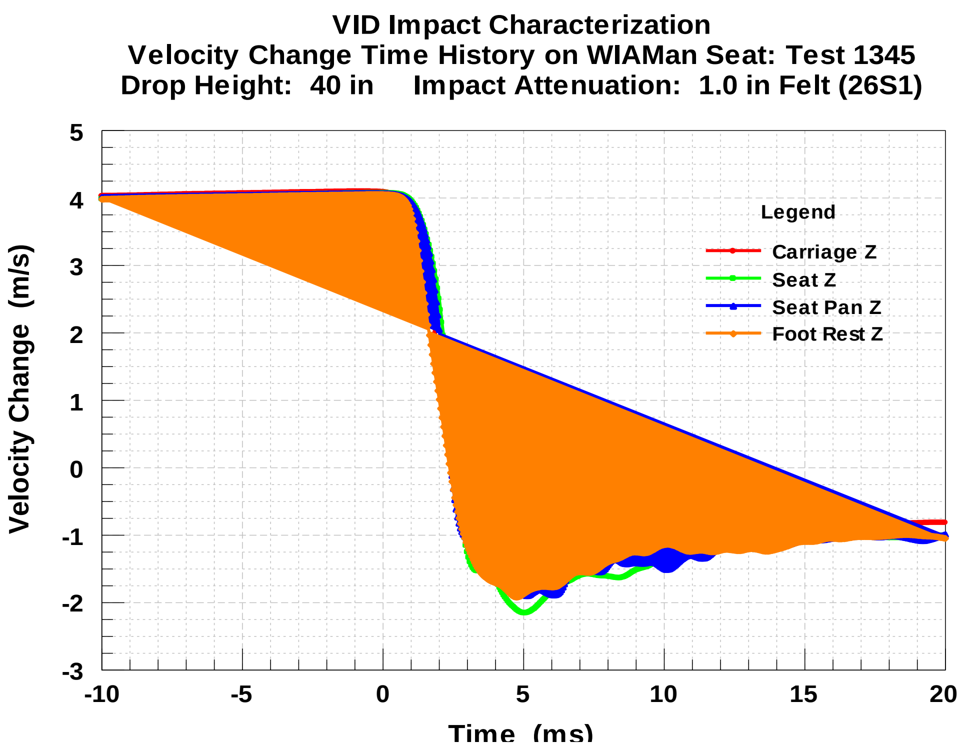


Figure 27. Velocity Change Time History at Various Seat Locations: Velocity ≈ 6 m/s

7.3 VID Impact Response for Test Series 2: Test by Test Summary

A review of the specific test configuration for each of the impact tests conducted on the VID with the WS2ms 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 for Test Series 2: Test Data Review

The seat pan velocity data and TTP velocity data that were collected during impacts with the WS2ms seat and the GARD manikin are presented in Table 8, and corresponds with the test parameters proposed in Table 2 in the Experimental Design section. The peak velocity and TTP velocity were plotted as a function of progressively increasing drop heights, and are shown in Figures 28 and 29. The plots are identified by what impact attenuation material was used for the floating seat pan.

Table 8. VID Impact Response: Floating Seat Test Data for Test Series 2

Test Cell	Seat Pan Plate Energy Attenuation Programmer	Drop Height (in)	Mean Velocity Change (m/s)	Mean Velocity Change TTP (ms)
SO1	16S1 Felt	18	4.72 ± 0.06	12.20 ± 0.57
SO2	16S1 Felt	40	6.72 ± 0.12	9.45 ± 0.21
SQ1	Blue Packing Foam	18	4.88 ± 0.05	26.40 ± 0.42
SQ2	Blue Packing Foam	40	6.78 ± 0.08	16.70 ± 0.28
SR1	C-45 Blue Foam	18	4.17 ± 0.20	6.90 ± 3.54
SR2	C-45 Blue Foam	40	6.32	3.8
SS1	C-47 Green Foam	18	4.16 ± 0.06	14.25 ± 2.47
SS2	C-47 Green Foam	40	6.03 ± 0.14	11.30 ± 0.42
ST1	Stimulite TPE	18	4.33 ± 0.02	20.10 ± 0.14
ST2	Stimulite TPE	40	7.34 ± 0.28	13.10 ± 0.14

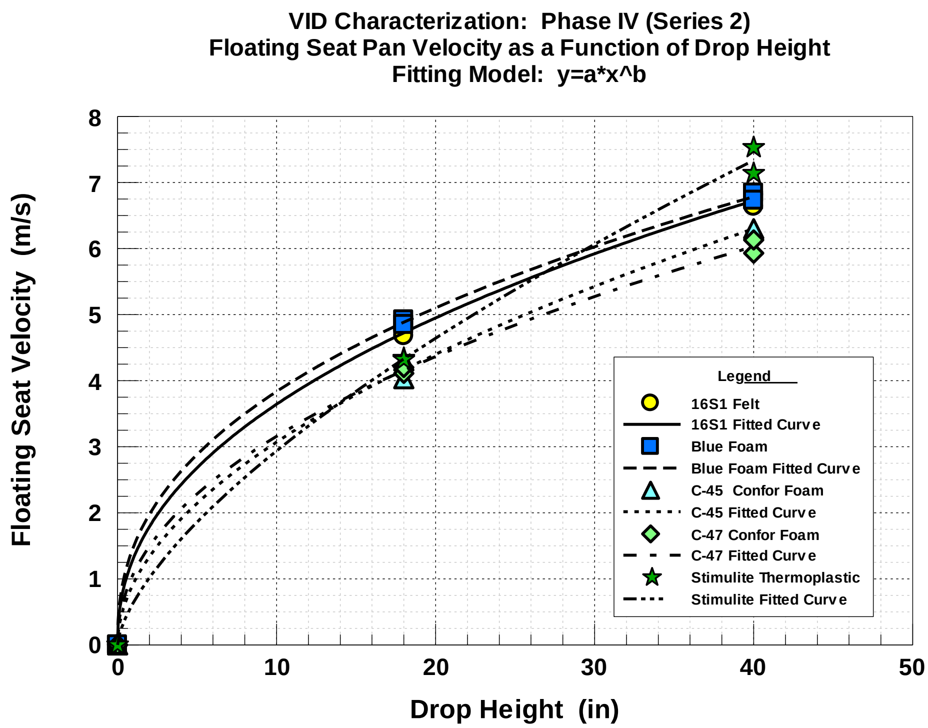


Figure 28. Peak Floating Seat Velocity as a Function of Drop Height:Test Series 2 (WS2ms)

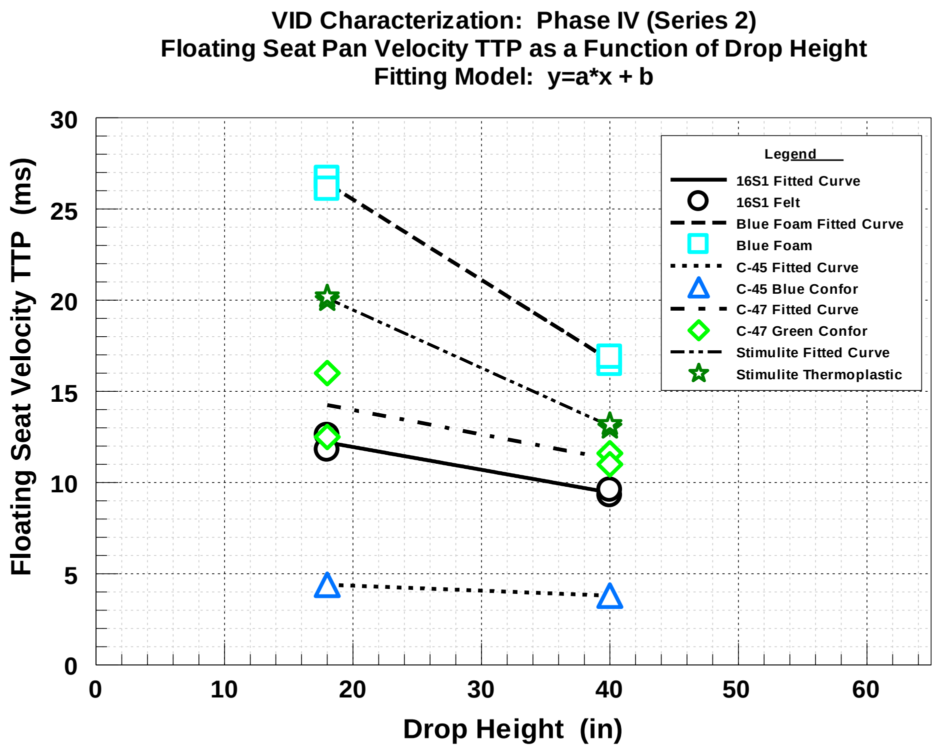


Figure 29. Floating Seat Velocity TTP as a Function of Drop Height:Test Series 2 (WS2ms)

The data used to calculate the statistical means and standard deviations, for the velocity and velocity TTP data sets, was composed of data from VID tests 1371 through 1401. Testing was successfully completed at all the drop heights (18 and 40 inches) for every VID carriage impact attenuation configuration. These drop heights were selected to provide the 4m/s and 6 m/s input velocity requirements based on testing from Test Series 1. The narrow standard deviation values shown in the data tables for the velocity 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 for the velocity data, and a Liner equiation (y=a*x+b) provided the best fit regression for the velocity TTP data which was consistent with previoius data sets. Coefficient of Determination (COD) for the velocity data sets was 0.99 or better, and the COD for the Velocity TTP data varied between 0.6 and 0.99 with the majority of the data sets being greater than 0.9. Higher levels of noise in the seat pan data attributed to the large range of correlation values for the TTP data sets. In general, the COD values for all the data sets allows the regression models to be used for estimation of required test parameters.

The velocity test data indicates the consistent trend to increase as a function of drop height, and was predicted with the Power Series equation, which is consistent with the previous research phases and Test Series 1. The test data also highlights the limited variation in floating seat velocity response between the five impact material configurations as the drop height increases. The peak velocity values for the seat pan were amplified by three of the five materials (felt, blue foam, and Stimulite TPE) between 10 and 20% at both the 4 m/s and 6 m/s input velocity to the carriage. The Confor foam samples (C-45 and C-47) were both able to control the dynamic overshoot of the floating seat pan and manikin test subject. The Stimulite TPE had a similar response to the Confor foam at the 4 m/s input velocity, but had the highest dynamic overshoot (largest velocity response) at the 6 m/s input velocity.

The velocity TTP test data indicates a trend to decrease as a function of drop height. The velocity TTP data showed a much broader range of response as a function of the impact attenuation material as compared to the peak velocity data. The 16S1 felt and the Confor foam condition consistently provided the lower TTP values, while the Blue foam and the Stimulite TPE consistently provided the higher TTP values with the Blue foam generating the largest values. The TTP values at 4 m/s input ranged from approximately 4 ms to 26 ms, and the TTP values at the 6 m/s input ranged from approximately 4 ms to 17 ms. The 16S1 felt pads generated a TTP of approximately 12 ms at the 4 m/s input which was the closest response to the requirement of 10 ms TTP.

7.5 VID Impact Response for Test Series 3: Test by Test Summary

A review of the specific test configuration for each of the impact tests conducted on the VID with the WS2fm and the 50th percentile 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 D.

7.6 VID Impact Response for Test Series 3: Test Data Review

The seat pan and foot rest velocity and TTP velocity data that were collected during impacts with the WS2fm seat and the Hybrid III manikin are presented in Table 9, and corresponds with the test parameters proposed in Table 2 in the Experimental Design section. The peak velocity and TTP velocity mean values and associated standard deviations are shown collectively for all the different foot rest attenuators that were tested due to observed limited range of response. Tests were conducted at two different drop heights to access the affect on the seat pan velocity requirement of 4 m/s at 20 ms TTP.

Table 9. VID Impact Response: Seat Pan and Foot Rest Data for Test Series 3

Drop Ht. (in)	Seat Pan Velocity (m/s)	Seat Pan TTP (ms)	Foot Rest Velocity (m/s)	Foot Rest TTP (ms)
18	3.83 ± 0.17	21.38 ± 0.68	4.56 ± 0.26	24.58 ± 3.36
20	4.00 ± 0.05	20.87 ± 0.77	4.99 ± 0.26	25.42 ± 3.48

The data used to calculate the statistical means and standard deviations, for the velocity and velocity TTP data sets, was composed of data from VID tests 1510 through 1538. Testing was successfully completed at all the drop heights (18 and 20 inches) for every VID carriage impact attenuation configuration. These drop heights were selected to provide the 4m/s velocity requirements based on testing from Test Series 1 and 2. The narrow standard deviation values shown in the data tables for the velocity highlight the repeatability of the VID test facility over the various test conditions. The 20 inch drop height gave the best seat pan velocity and seat pan velocity TTP response using either the dual felt pad configuration of 20S1/20S1 or 16S1/20S1 as the VID carriage impact attenuation system.

In general, the data shows that the various combinations of elastic balls provided some increase in foot rest velocity (approximately 1 m/s higher), but also increased the associated TTP. There were a few ball combinations (10+ elastic balls of either 1.75 inch or 2.25 inch diameter) that maximized the velocity upto approximately 5.5 m/s, but at the expense of having the TTP be very high as well. It should be noted that the elastic balls that generated the higher velocity values generated a double peak in the velocity pulse. The first peak had a TTP in the range of 13 to 15 ms, and the larger second peak had a TTP over 20 ms, and these second peak TTP values were used in the data calculations shown in Table 9.

7.7 VID Impact Response for Test Series 4: Test by Test Summary

A review of the specific test configuration for each of the impact tests conducted on the VID with the WS3 and the 50^{th} percentile 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 E.

7.8 VID Impact Response for Test Series 4: Test Data Review

The seat pan and foot rest velocity and TTP velocity data that were collected during impacts with the WS3 seat and the Hybrid III manikin are presented in Table 10 and 11, and correspond with the test parameters proposed in Table 3 and 4 in the Experimental Design section. The peak velocity and TTP velocity mean values and associated standard deviations are shown collectively for all the different seat pan and foot rest attenuators that were tested due to observed limited range of response. Tests were conducted at different drop heights to characterize the material affects on the seat pan and foot rest velocity and TTP velocity.

The foot rest velocity requirement of 7 m/s, 2 ms TTP was the driving requirement to determine the carriage height since the seat pan velocity requirement was less than the foot rest requirement (5 m/s, 25 ms TTP). Therefore, the foot rest data are shown first to assess the required carriage drop height to achieve 7 m/s, and are shown in Table 10. The peak velocity and TTP velocity were plotted as a function of progressively increasing drop heights, and are shown in Figures 30 and 31 for the foot rest.

Table 10. VID Impact Response: Foot Rest Data for Series 4

Foot Rest Plate Energy Attenuation Programmer	Drop Height (in)	Mean Velocity Change (m/s)	Mean Velocity Change TTP (ms)
32S1 Felt (0.5 in. thick)	45	6.25	2.9
32S1 Felt (0.5 in. thick)	50	6.65	3.0
32S1 Felt (0.5 in. thick)	55	6.8	2.8
32S1 Felt (0.5 in. thick)	60	7.2	3.2
32S1 Felt (0.5 in. thick)	65	7.39	3.8
VID Red Polyurethane Bumper	40	6.21	4.3
VID Red Polyurethane Bumper	45	6.63	4.3
VID Red Polyurethane Bumper	50	6.92	4.2
VID Red Polyurethane Bumper	55	7.26	4.1
VID Red Polyurethane Bumper	60	7.59	4.1
90A Polyethylene Sheet (0.5 in.)	40	6.13 ± 0.52	3.4 ± 0.26
90A Polyethylene Sheet (0.5 in.)	50	6.52 ± 0.06	3.2 ± 0.0
90A Polyethylene Sheet (0.5 in.)	55	6.59	3.2
90A Polyethylene Sheet (0.5 in.)	60	7.21 ± 0.03	3.3 ± 0.0
95A Polyethylene Sheet (0.5 in.)	40	5.73 ± 0.02	3.3 ± 0.14
95A Polyethylene Sheet (0.5 in.)	50	6.39 ± 0.04	3.2 ± 0.35
95A Polyethylene Sheet (0.5 in.)	55	6.50	2.9
95A Polyethylene Sheet (0.5 in.)	60	6.80 ± 0.06	3.1 ± 0.28
75D Polyethylene Sheet (0.5 in.)	40	5.59 ± 0.03	2.95 ± 0.07
75D Polyethylene Sheet (0.5 in.)	50	5.85 ± 0.02	3.45 ± 0.35
75D Polyethylene Sheet (0.5 in.)	55	6.53	2.5

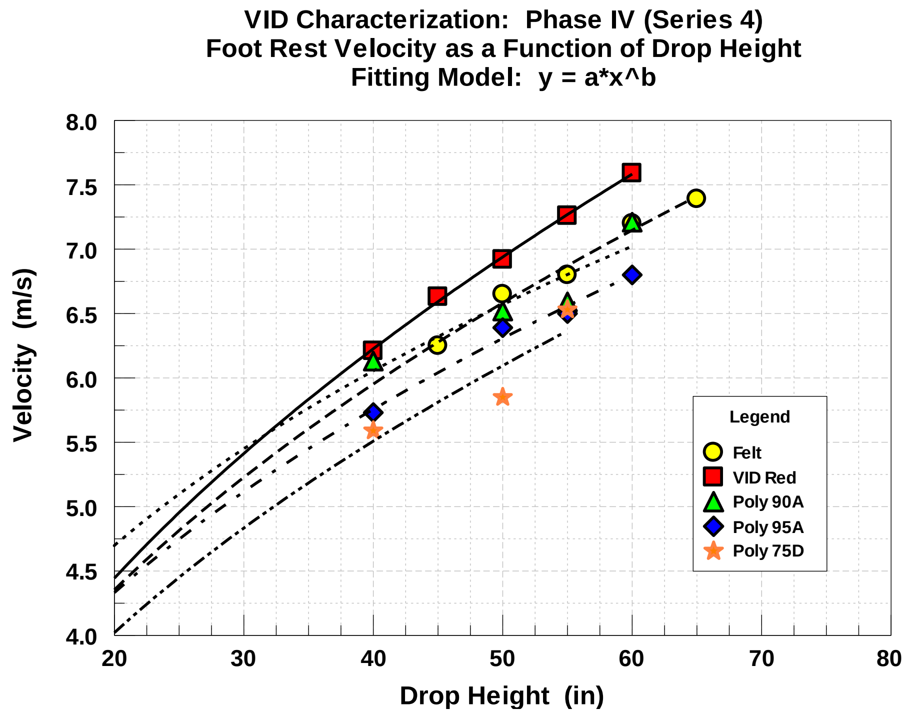


Figure 30. Peak Foot Rest Velocity as a Function of Drop Height:Test Series 4 (WS3)

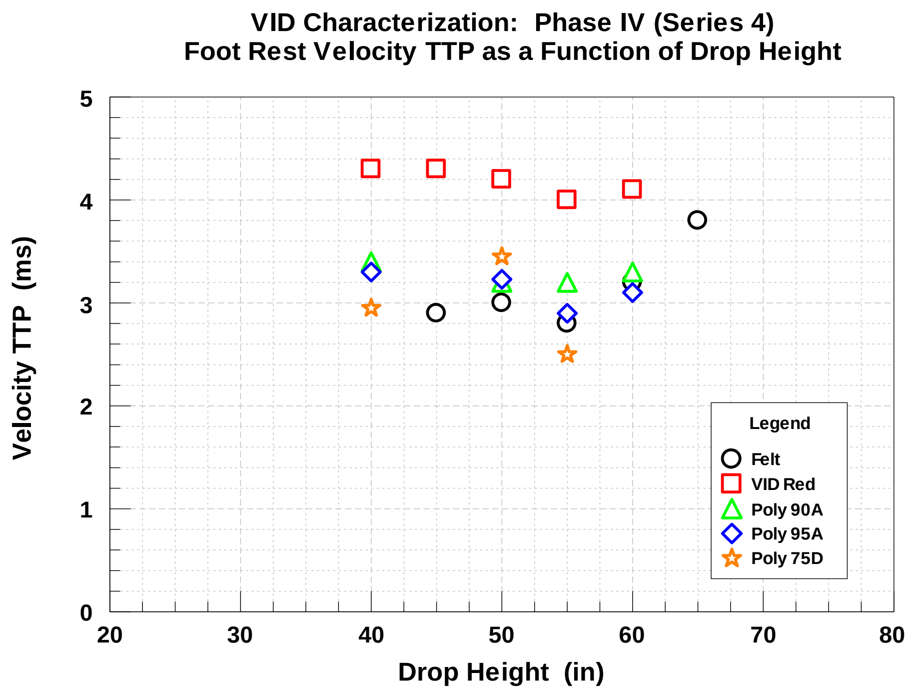


Figure 31. Foot Rest Velocity TTP as a Function of Drop Height: Test Series 4 (WS3)

The data used to calculate the statistical means and standard deviations, from the velocity and velocity TTP data sets for the foot rest, was composed of data from VID tests 1592 through 1643. Testing was successfully completed at all the drop heights (40 through 65 inches) for every VID carriage impact attenuation configuration. The VID impacts provided narrow standard deviation values for the carriage velocity calculations (less than 2%), and highlight the repeatability of the VID test facility over the various test conditions. The plots generated from foot rest data (Figures 30 and 31) showed that a Power Series equation (y=a*x^b) provided the best fit regression for the peak velocity data with a Coefficient of Determination (COD) of 0.99 or better. In general, the COD values for these foot rest data sets allows the regression models to be used for estimation of required test parameters for the materials that were evelauated.

The velocity test data indicates the consistent trend to increase as a function of drop height, and was predicted with the Power Series equation, which is consistent with the previous research phases using different materials to attentuate either the VID carriage or different componenets of the seat structure (seat pan, foot rest for example). The test data also highlights the limited variation in velocity response between the felt impact configuration and several polyethylene sheets as the drop height increases. The VID red urethane programmers generated the greatest velocity values at the tested drop heights, and the 75D polyethylene sheet generated the lowest velocity values. The drop heights to achieve the required 7 m/s ranged from 51 in. for the VID red urethane programmer, to an estimated 67.5 in. for the 75D polyethylene sheet.

The velocity TTP test data indicates a slight trend to decrease as a function of drop height, but in general the TTP was not significantly affected by the drop height for the 5 materials that were evaluated. The velocity TTP data showed a broader range of response as a function of the materials as compared to the peak velocity data. The VID red urethane programmers consistently generated the largest TTP values of approximately 4.2 ms on average, while the felt and polyethylene sheets provided lower TTP values of approximately 3.1 ms on average. None of the test materials were able to generate the required TTP value of 2.0 ms; however the 32S1 felt sheet consistently generated TTP values of around 3.0 ms with the exception of an outlier data point at the 65 inch drop of 3.8 ms.

Based on the above analysis, if the 32S1 felt is used as the foot rest attenuation material, then the VID carriage would be need to be dropped at approximately 58 inches to produce the 7 m/s velocity change, and this would be used to determine the attenuation material needed to meet the seat pan requirements. The seat pan data are shown to assess the required material to achieve 5 m/s at 25 ms TTP, and are shown in Table 11. The peak velocity and TTP velocity were plotted as a function of progressively increasing drop heights, and are shown in Figures 32 and 33 for the seat pan.

Table 11. VID Impact Response: Seat Pan Data for Series 4

Seat Pan Plate Energy Attenuation Programmer	Drop Height (in)	Mean Velocity Change (m/s)	Mean Velocity Change TTP (ms)
16S1 Felt (2.0 in. thick), 2 Layers	40	5.66 ± 0.09	21.98 ± 0.85
16S1 Felt (2.0 in. thick), 2 Layers	45	6.00 ± 0.04	22.20 ± 1.27
16S1 Felt (2.0 in. thick), 2 Layers	50	6.29 ± 0.12	20.03 ± 2.70
16S1 Felt (2.0 in. thick), 2 Layers	55	6.53 ± 0.04	21.60 ± 1.98
16S1 Felt (2.0 in. thick), 2 Layers	60	6.91 ± 0.11	19.88 ± 1.03
16S1 Felt (2.0 in. thick), 2 Layers	65	7.03	21.00
Hexcel (4.0 in height), 8 blocks	55	5.03	34.9
Hexcel (4.0 in height), 8 blocks	60	5.41 ± 0.01	26.50 ± 0.57
Hexcel (4.0 in height), 10 blocks	60	4.74	18.6
Hexcel (4.0 in height), 12 blocks	55	5.08 ± 0.00	28.2 ± 0.14
Hexcel (4.0 in height), 12 blocks	60	4.65	14.9
Hexcel (4.0 in height), 14 blocks	60	5.32	26.1

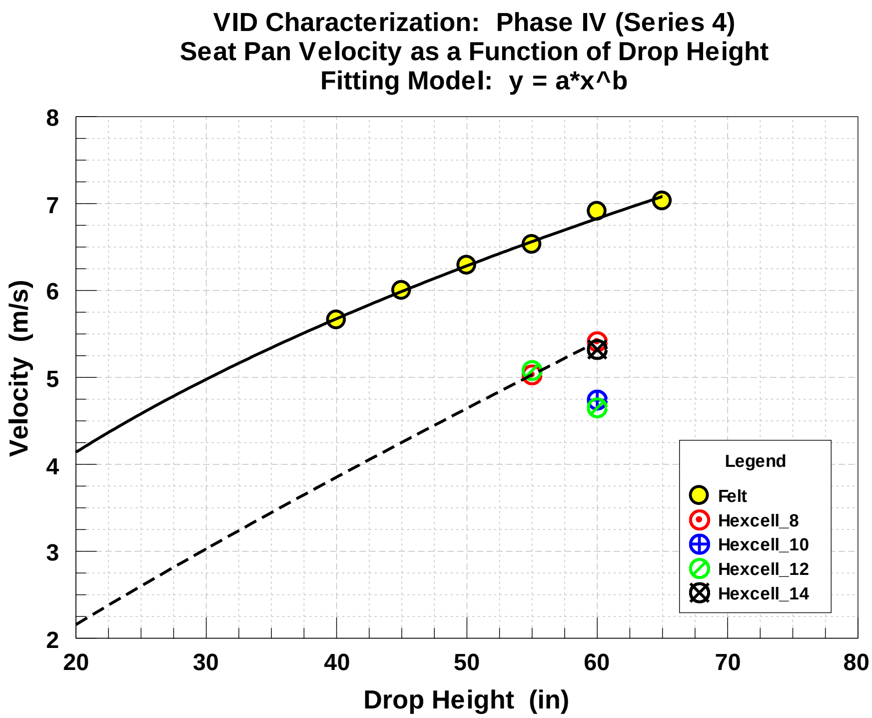


Figure 32. Peak Seat Pan Velocity as a Function of Drop Height:Test Series 4 (WS3)

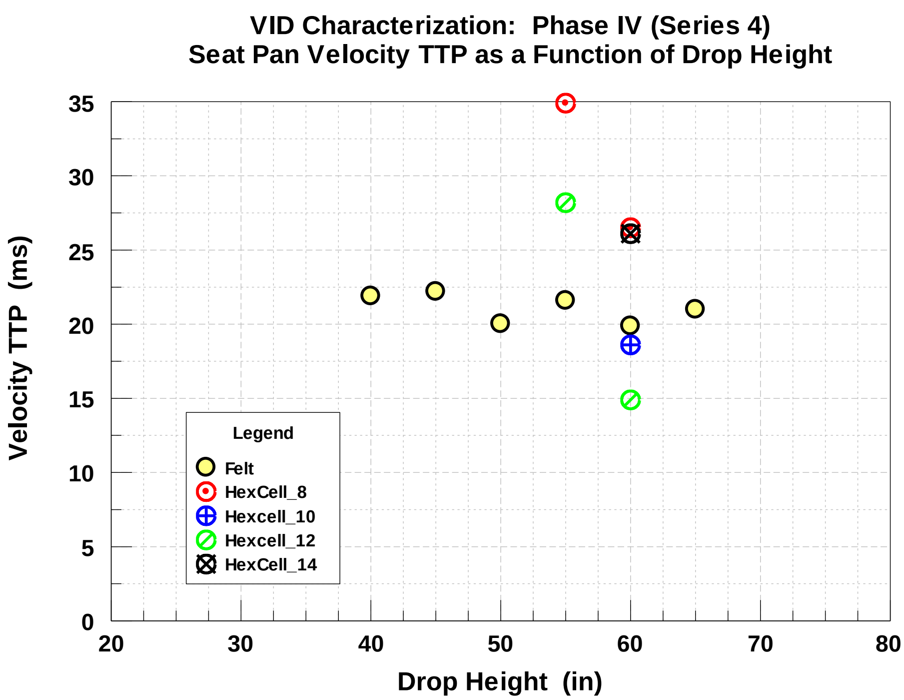


Figure 33. Seat Pan Velocity TTP as a Function of Drop Height: Test Series 4 (WS3)

The data used to calculate the statistical means and standard deviations, from the velocity and velocity TTP data sets for the seat pan, was composed of data from VID tests 1592 through 1643. The plots generated from seat pan data (Figures 32 and 33) showed that a Power Series equation ($y=a*x^b$) provided the best fit regression for the peak velocity data with a Coefficient of Determination (COD) of 0.99 or better. Only velecity data from the felt and the Hexcel_8 configurations were fitted with Power Series equations. The limited amount of Hexcel available during testing contributed to the small number of impact tests with with Hexcel material configurations. In general, the COD values for these seat pan data sets allows the regression models to be used for estimation of required test parameters for the materials that were evelauated.

The velocity test data indicates the consistent trend to increase as a function of drop height, and was predicted with the Power Series equation, which is consistent with the previous research phases using different materials to attentuate either the VID carriage or different componenets of the seat structure (seat pan, foot rest for example). The test data also highlights the large variation in velocity response between the felt impact configuration and the Hexcel configurations as the drop height increases. The felt was clearly not able to attenuate the energy of the VID carriage drop compared to the attenuation capability of the blocks of Hexcel. For example, at the required drop height of 58 inches to achieve 7 m/s at the foot rest, the felt attenuated the carriage to achieve a seat pan velocity of approximately 6.8 m/s. In comparison, the Hexcel attenuated the carriage to achieve a seat pan velocity of approximately 5.2 m/s, which is closer to the desired 5.0 m/s.

The velocity TTP test data indicates a very slight trend to decrease as a function of drop height, but in general the TTP was not significantly affected by the drop height for the either the felt or the Hexcel configurations. The velocity TTP data showed a broader range of response as a function of the Hexcel as as compared to the felt. The data indicates that the number of Hexcel blocks used in a test did not have a consistent affect on the Velocity TTP. The two Hexcel configurations used at multiple drop heights (Hexcel_8 and Hexcel_12) appeard to indicate a decrease in TTP as the drop height increased, and based on this assumption, the use of Hexcel_10 would produce a TTP of around 25 ms at a 58 inch drop, but additional testing would need to be conducted to verify this assumption.

The seat pan requirements were to have an attenuated seat pan velocity of 5 m/s with a velocity TTP of 25 ms. Based on the above data analysis, using 10 Hexcel blocks would produce a seat pan velocity very close to 5 m/s and also achieve a velocity TTP of approximately 25 ms. Impact data with the Hexcel configurations is limited, therefore additional impact testing of the attenuation capability of Hexcel would need to be completed for more accurate characterization of its velocity response as a function of drop height.

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 design iterations of the WIAMan seat developed specifically to test the biodynamic response of instrumented manikins. The research effort was the fourth of multiple phases of a larger research effort, and focused on the effect of different energy attenuation materials on the velocity and velocity TTP at various locations on the WIAMan seat fixture.

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 then defined to produce seat pan and foot rest profiles that were independent of each other.

The experimental design, consisting of four different seat configurations with a restrained manikin, was evaluated in four different test series. Test Series 1 was conducted to determine the materials and drop heights required for energy attenuation of the seat pan and the foot-rest to generate a 4 m/s velocity with a 5 ms TTP, or a 6 m/s velocity with a 5 ms TTP. The seat fixture (WS2) was mounted over the center of the VID carriage. Test Series 2 was conducted to determine the materials and drop heights required for energy attenuation of the seat pan to generate a 4 m/s velocity with a 10 ms TTP while the foot-rest was exposed to a 6 m/s velocity with a 5 ms TTP. The seat fixture was the same as for Test Series 1. Test Series 3 was conducted to determine the materials and drop heights required for energy attenuation of the seat pan to generate a 4 m/s velocity with a 20 ms TTP, and the energy attenuation of the foot-rest to generate a 6 m/s velocity with a 10 ms TTP. The seat fixture from Test Series 2 was modified allowing for the foot rest to stroke following impact. Test Series 4 was conducted to determine the materials and drop heights required for energy attenuation of the seat pan to generate a 5 m/s velocity with a 25 ms TTP, while the driving input to the foot-rest was 7 m/s velocity with a 2 ms TTP. A new seat fixture, designed with the foot rest positioned off the side of the carriage, allowed the stroking foot rest to impact a base separate from the VID carraige’s impact base.

Data from Test Series 1, evaluating various felt configurations impacted by the VID carriage, showed that the velocity test data indicated the consistent trend to increase as a function of drop height, and was predicted with the Power Series equation, which is consistent with the previous research phases. The drop heights to generate 4 and 6 m/s ranged from 16 to 17 inches for 4 m/s, and ranged from 35 to 40 inches for 6 m/s. The velocity TTP test data indicated a slight trend to decrease as a function of drop height, and was consistently predicted with a Linear equation. The 1.0 inch thick 26S1 felt and the 2.0 inch thick 32S1 felt conditions generated very similar TTP values, were both very close to the 5 ms requirement at the drop heights found to produce the 4 m/s and 6 m/s velocities.

Data from Test Series 2, evaluating the impact characteristics of several material configurations under the seat pan, showed the velocity test data indicated the consistent trend to increase as a function of drop height, and was predicted with the Power Series equation, which is consistent with the previous research phases and Test Series 1. None of the evaluated materials were able to attenuate the impact acceleration from 6 m/s down to 4 m/s. In fact, the peak velocity values for the seat pan were amplified by three of the five materials (felt, blue foam, and Stimulite) between 10 and 20% at both the 4 m/s and 6 m/s input velocity to the carriage. The velocity TTP values at 4 m/s input ranged from approximately 4 ms to 26 ms, and the TTP values at the 6 m/s input ranged from approximately 4 ms to 17 ms. However, the 16S1 felt pads generated a velocity TTP of approximately 11 ms across the range of drop heights tested, which was the closest response to the requirement of 10 ms TTP.

Data from Test Series 3, evaluating several material configurations to amplify the foot rest using a baseline input to the seat pan of 4 m/s but also decrease the velocity TTP, showed that the various combinations of elastic balls under the foot rest increased the foot rest velocity, but also increased the corresponding TTP as well. There were a few ball combinations (10+ elastic balls of either 1.75 inch or 2.25 inch diameter) that maximized the velocity upto approximately 5.5 m/s, which was close to the required 6 m/s. However, these same combinations also generated velocity TTP values around 25ms, which was double the required TTP value of 10 ms.

Data from Test Series 4 was evaluated to first determine what drop height and material would be used to achieve the required velocity and TTP at the foot rest (7 m/s velocity with a 2 ms TTP), and then use the determined drop height to evalute attenuating materials placed under the VID carriage to achieve the required velocity and TTP at the seat pan (5 m/s velocity with a 25 ms TTP). Data analysis of the foot rest data indicated that using 0.5 inch thick, 32S1 felt would produce a velocity of approximately 7 m/s with a TTP of approximately 3 ms, at a VID carriage drop height of 58 inches. Data with the attenuating Hexcel materials under the carriage was limited due to lack of sufficient materials for testing, however, it was determined that using 10 Hexcel blocks would produce a seat pan velocity of approximately 5 m/s with a TTP of approximately 25 ms at a drop height of 58 inches.

Overall, Test Series 1 continued to show the versitility of using various felt densities and thicknesses to generate required peak velocities and velocity TTP. Test Series 2 highlighted the limitations of the current seat fixture to allow the integration of material to attenuate the seat pan structure. Future seat fixture modifications could include the ability to integrate Hexcel under the seat pan and evaluate the response similar to the testing using Hexcel under the VID impact carriage. Test Series 3 highlighted that the current seat fixture design necessitates the requirement to attenuate the carriage impact in order to have a seat pan velocity lower than the foot rest. Test Series 4 indicated that additional testing be conducted with Hexcel configurations to improve the characterization of the seat pan responses to achieve required velocity and TTP velocity values that are different from the foot rest fixture.

BIBLIOGRAPHY/REFERENCES

Perry, C. E., Burneka, C., Christopher, R., Albery, C., (2016)[3]. Characterization of Vertical Impact Device Acceleration Pulses using Parametric Assessment: Phase III Accelerated WIAMan Seat. USAF Technical Report: AFRL-RH-WP-TR-2016-0056. Wright Patterson AFB: Human Effectiveness Directorate, 711 Human Performance Wing, Air Force Research Laboratory.

Perry, C., Burneka, C., Christopher, R., Albery, C. (2016)[2]. Characterization of Vertical Impact Device Acceleration Pulses Using Parametric Assessment: Phase II Accelerated Free-Fall. USAF Technical Report : AFRL-RH-WP-TR-2016-0048. Wright-Patterson AFB: Airman Systems Directorate, 711 Human Performance Wing, Air Force Research Laboratory.

Perry, C., Burneka, C., Christopher, R., Albery, C. (2016)[1]. Characterization of Vertical Impact Device Acceleration Pulses Using Parametric Assessment: Phase I. USAF Technical Report : AFRL-RH-WP-TR-2015-0014. Wright-Patterson AFB: Airman Systems Directorate, 711 Human Performance Wing, Air Force Research Laboratory.

Knox, T., Pellettiere, J., Perry, C., Plaga, J., Bonfeld, J. (2008). New Sensors to Track Head Acceleration During Possible Injurious Events. SAE International: Journal of Passenger Cars – Electronic Electrical Systems, Vol. 1(1): 652-663

Childers, M.A. (2002). Evaluation of the IMPAC66 Shock Test machine, Serial Number 118 (Technical Report ARL-TR-2840). Aberdeen Proving Ground: Weapons and Materials Research Directorate, Army Research Laboratory.

Veridian Contract Report (2002). Test Configuration and Data Acquisition System for Evaluation for Ejection Data Acquisition and Recorder Module (Veridian Engineering Division, CDRL A005 under Contract F41624-97-D-6004). Wright-Patterson AFB: Human Effectiveness Directorate, Human Performance Wing, Air Force Research Laboratory.

Salerno, Capt. M.D., Brinkley, J.W., Orzech, Capt. M.A. (1985). Dynamic Response of the Human Head to +Gx Impact. SAFE Journal, Vol. 17 (4): 36-42.

GLOSSARY

ABP	Aircrew Biodynamics and Protection
ABW	Air Base Wing
AFRL	Air Force Research Laboratory
AFD	Accelerated Free-fall Device
CBDN	Collaborative Biomechanics Data Network
CDRL	Contract Data Requirements List
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
ORISE	Oak Ridge Institue for Science and Education
TPE	Thermoplastic Elastomer
TTP	Time to Peak
RH	Airman Systems Directorate under HPW
USAF	United States Air Force
VID	Vertical Impact Device
WIAMan	Warrior Injury Assessment Manikin
WPAFB	Wright-Patterson Air Force Base
WS1	WIAMan Seat configuration One
WS2	WIAMan Seat configuration Two
WS3	WIAMan Seat configuraton Three
WWI	World War I

APPENDIX A. ELECTRONIC DATA CHANNEL DESCRIPTIONS

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 thru1369
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

10 SEPT 2014

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 10Vexc	-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: CHARACTERIZATION OF VERTICAL IMPACT DEVICE ACCELERATION PULSES USING PARAMETRIC ASSESSMENT : MODIFICATION TO SEA PAN FOR WIAMAN SEAT FIXTURE

TEST DATES:

STUDY NUMBER: 201407 (Addendum to 201304)

TEST NUMBERS: 1371-1448, 1449 PMHS, 1450-1457, 1468-1655

FACILITY: VID

SAMPLE RATE: 100 Khz

DATA COLLECTION SYSTEM: TDAS G5 sr# 5M0022 & SlicePro sr# SP0014

FILTER FREQUENCY: NONE

G5: 1371-1401, SP: 1402- , G5+SP: 1449

TRANSDUCER RANGE (VOLTS): +/- 5V

DATA CHANNEL	DATA POINT	TRANSDUCER MFG. & MODEL	SERIAL NUMBER	PRE-CAL DATE	PRE-CAL SENS	POST-CAL DATE	POST-CAL SENS	% Δ	DAS SENSITIVITY	BRIDGE	FULL SCALE	NOTES
1	CARRIAGE X ACCCEL (G)	MEAS SPEC EGCS-425-250	R130NW	15-Aug-14	.6035 mv/g at 10V exc				.06035 mv/v/g	FULL	100 G	
2	CARRIAGE Y ACCCEL (G)	MEAS SPEC EGCS-425-250	R130NX	15-Aug-14	.5877 mv/g at 10V exc				.05877 mv/v/g	FULL	100 G	
3	CARRIAGE Z ACCCEL (G)	MEAS SPEC EGCS-425-1000	N04741	22-May-14	.1148 mv/g at 10V exc				.01148 mv/v/g	FULL	500 G	
4	FOOT REST X ACCEL (G)	MEAS SPEC EGCS-425-250	R130NT	15-Aug-14	.5930 mv/g at 10V exc				.05930 mv/v/g	FULL	100 G	Used on tests 1371-1448
	FOOT REST Z ACCEL (G)	MEAS SPEC EGCS-425-2000	A011337	15-Aug-14	.0837 mv/g at 10V exc				.00837 mv/v/g	FULL	500 G	Used on tests 1468-
5	FOOT REST Z ACCEL (G)	MEAS SPEC EGCS-425-2000	A011337	15-Aug-14	.0837 mv/g at 10V exc				.00837 mv/v/g	FULL	500 G	Used on tests 1371-1457
	SEAT BACK Z ACCEL (G)	MEAS SPEC EGCS-425-1000	N04732	22-May-14	.1148 mv/g at 10V exc				.01148 mv/v/g	FULL	500 G	Used on tests 1468-
6	SEAT BACK Z ACCEL (G)	MEAS SPEC EGCS-425-1000	N04732	22-May-14	.1148 mv/g at 10V exc				.01148 mv/v/g	FULL	500 G	Used on tests 1371-1457
	SEAT PAN X ACCEL (G)	MEAS SPEC EGCS-S425-250	T13131	15-Aug-14	.5845 mv/g at 10V exc				.05825 mv/v/g	FULL	100 G	Used on tests 1468-
7	SEAT PAN X ACCEL (G)	MEAS SPEC EGCS-425-250	R130NZ	15-Aug-14	.5927 mv/g at 10V exc				.05927 mv/v/g	FULL	100 G	Used on tests 1371-1407
	SEAT PAN X ACCEL (G)	MEAS SPEC EGCS-S425-250	T13131	15-Aug-14	.5845 mv/g at 10V exc				.05825 mv/v/g	FULL	100 G	Used on tests 1408-1457
	SEAT PAN Y ACCEL (G)	MEAS SPEC EGCS-425-250	R130NY	15-Aug-14	.5826 mv/g at 10V exc				.05826 mv/v/g	FULL	100 G	Used on tests 1468-
8	SEAT PAN Y ACCEL (G)	MEAS SPEC EGCS-425-250	R130NY	15-Aug-14	.5826 mv/g at 10V exc				.05826 mv/v/g	FULL	100 G	Used on tests 1371-1457
	SEAT PAN Z ACCEL (G)	MEAS SPEC EGCS-425-1000	N04742	22-May-14	.1148 mv/g at 10V exc				.01148 mv/v/g	FULL	500 G	Used on tests 1468-

9	SEAT PAN Z ACCEL (G)	MEAS SPEC EGCS-425-1000	N04742	22-May-14	.1148 mv/g at 10V exc				.01148 mv/v/g	FULL	500 G	Used on tests 1371-1401.
	SEAT PAN Z ACCEL (G)	ENDEVCO 2262-A 2000	L16923	17-Sep-14	.3307 mv/g at 10V exc				.03307 mv/v/g	FULL	500 G	Used on tests 1402-1448
	SEAT PAN (2262A) Z ACCEL	ENDEVCO 2262-A 2000	L16923	17-Sep-14	.3307 mv/g at 10V exc				.03307 mv/v/g	FULL	500 G	Used on tests 1450-1476
	FLOATING SEAT PAN (2262A) Z	ENDEVCO 2262-A 2000	L16923	17-Sep-14	.3307 mv/g at 10V exc				.03307 mv/v/g	FULL	500 G	Used on tests 1477-
10	FLOATING SEAT PAN X ACCEL (G)	ENTRAN EGV3-F-250	M110KX (Y)	08-Oct-14	.7243 mv/g at 10V exc	15-Dec-14	.8015 mv/g at 10V exc	-0.3	.07243 mv/v/g	FULL	100 G	Used on tests 1371-1379
	FOOT REST (LOFFI) Z ACCEL	ENDEVCO 2262-A 2000	L17511	16-Dec-14	.4321 mv/g at 10V exc				.0431 mv/v/g	FULL	1000 G	Used on tests 1450-
11	FLOATING SEAT PAN Y ACCEL (G)	ENTRAN EGV3-F-250	M110KX (X)	08-Oct-14	.7508 mv/g at 10V exc	15-Dec-14	.8193 mv/g at 10V exc	-0.3	.07508 mv/v/g	FULL	100 G	Used on tests 1371-1379
	SEAT PAN (7270) Z ACCEL (G)	ENDEVCO-7270A-20K	F40503	17-Sep-14	8.419 uV/g at 10V exc				.0008419 mv/v/g	FULL	20000 G	Used on tests 1450-1476
	FLOATING SEAT PAN (7270) Z ACCEL (G)	ENDEVCO-7270A-20K	F40503	17-Sep-14	8.419 uV/g at 10V exc				.0008419 mv/v/g	FULL	20000 G	Used on tests 1477-
12	FLOATING SEAT PAN Z ACCEL (G)	ENTRAN EGV3-F-250	M110KX (Z)	08-Oct-14	.6929 mv/g at 10V exc	15-Dec-14	.7339 mv/g at 10V exc	-0.2	.06929 mv/v/g	FULL	250 G	Used on tests 1371-1379
	FLOATING SEAT PAN Z ACCEL (G)	MEAS SPEC EGCS-S425-2000	A011338	15-Aug-14	.0874 mv/g at 10V exc				.00874 mv/v/g	FULL	500 G	Used on tests 1380-1401
	FLOATING SEAT PAN Z ACCEL (G)	ENDEVCO 2262-A 2000	L17511	16-Dec-14	.4321 mv/g at 10V exc				.0431 mv/v/g	FULL	1000 G	Used on tests 1402-1448
	FOOT REST (7270) Z ACCEL	ENDEVCO-7270A-20K	F40504	17-Sep-14	8.617 uV/g at 10V exc				.0008617 mv/v/g	FULL	20000 G	Used on tests 1450-1476
	FOOT REST (7270) Z ACCEL	ENDEVCO-7270A-20K	F40465	17-Sep-14	8.418 uV/g at 10V exc				.0008418 mv/v/g	FULL	20000 G	Used on tests 1477-
13	LEFT FRONT SEAT PAN Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-22614-3	27-Aug-14	4.01 uv/lb at 10V exc				.000401 mv/v/lb	FULL	5000 LB	Used on tests 1371-1401.
	LEFT FRONT SEAT PAN Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-19794-4	04-Mar-14	2.00 uv/lb at 10V exc				.000200 mv/v/lb	FULL	5000 LB	Used on tests 1402-1434
	LEFT FRONT SEAT PAN Z FORCE (LB)	STRAINSERT FL10U©-2SGKT	Q-23179-5	19-Jan-15	2.00 uv/lb at 10V exc				.000200 mv/v/lb	FULL	10000 LB	Used on tests 1435-
14	RIGHT FRONT SEAT PAN Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-22614-4	29-Aug-14	3.99 uv/lb at 10V exc				.000399 mv/v/lb	FULL	5000 LB	Used on tests 1371-1401.
	RIGHT FRONT SEAT PAN Z FORCE (LB)	STRAINSERT FL10U©-2SGKT	Q-4742-1	06-May-14	2.00 uv/lb at 10V exc				.000200 mv/v/lb	FULL	10000 LB	Used onn tests 1402-1476
	RIGHT FRONT SEAT PAN Z FORCE (LB)	STRAINSERT FL10U©-2SGKT	Q-23179-4	19-Jan-15	2.00 uv/lb at 10V exc				.000200 mv/v/lb	FULL	10000 LB	Used on tests 1477-

15	LEFT REAR SEAT PAN Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-22614-1	27-Aug-14	3.99 uv/lb at 10V exc				.000399 mv/v/lb	FULL	5000 LB	Used on tests 1371-1401.
	LEFT REAR SEAT PAN Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-19794-3	04-Mar-14	2.00 uv/lb at 10V exc				.000200 mv/v/lb	FULL	5000 LB	Used on tests 1402-1434
	LEFT REAR SEAT PAN Z FORCE (LB)	STRAINSERT FL10U©-2SGKT	Q-23179-6	19-Jan-15	2.00 uv/lb at 10V exc				.000200 mv/v/lb	FULL	10000 LB	Used on tests 1435-
16	RIGHT REAR SEAT PAN Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-22614-2	27-Aug-14	4.03 uv/lb at 10V exc				.000403 mv/v/lb	FULL	5000 LB	Used on tests 1371-1401.
	RIGHT REAR SEAT PAN Z FORCE (LB)	STRAINSERT FL10U©-2SGKT	Q-4742-4	04-Sep-14	1.99 uv/lb at 10V exc				.000199 mv/v/lb	FULL	10000 LB	Used onn tests 1402-1476
	RIGHT REAR SEAT PAN Z FORCE (LB)	STRAINSERT FL10U©-2SGKT	Q-23179-9	19-Jan-15	2.00 uv/lb at 10V exc				.000200 mv/v/lb	FULL	10000 LB	Used on tests 1477-
17	LEFT FRONT FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-19794-1	02-Sep-14	4.00 uv/lb at 10V exc				.000400 mv/v/lb	FULL	5000 LB	Used on tests 1371-1476. Broke on 1373 but continued using as
	LEFT FRONT FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-22614-1	27-Aug-14	3.992 uv/lb at 10V exc				.0003992 mv/v/lb	FULL	5000 LB	Used on tests 1477-1538
	LEFT FRONT FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-19794-1	6-May-15	3.9966 uv/lb at 10V exc				.00039966 mv/v/lb	FULL	5000 LB	Used on tests 1539-
18	RIGHT FRONT FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-22614-6	29-Aug-14	4.00 uv/lb at 10V exc				.000400 mv/v/lb	FULL	5000 LB	Used onn tests 1371-1476
	RIGHT FRONT FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-22614-4	12-Dec-14	4.00 uv/lb at 10V exc				.000400 mv/v/lb	FULL	5000 LB	Used on tests 1477-1538
	RIGHT FRONT FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-19794-2	11-May-15	4.0014 uv/lb at 10V exc				.00040014 mv/v/lb	FULL	5000 LB	Used on tests 1539-
19	LEFT REAR FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-22614-5	28-Aug-14	4.00 uv/lb at 10V exc				.000400 mv/v/lb	FULL	5000 LB	Used onn tests 1371-1476
	LEFT REAR FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-23179-1	15-Jan-15	4.00 uv/lb at 10V exc				.000400 mv/v/lb	FULL	5000 LB	Used on tests 1477-
20	RIGHT REAR FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-19794-2	02-Sep-14	4.00 uv/lb at 10V exc				.000400 mv/v/lb	FULL	5000 LB	Used onn tests 1371-1476
	RIGHT REAR FOOT REST Z FORCE (LB)	STRAINSERT FL5U©-2SGKT	Q-23179-3	15-Jan-15	4.00 uv/lb at 10V exc				.000400 mv/v/lb	FULL	5000 LB	Used on tests 1477-

21	LEFT LAP X FORCE (LB)	MICH SCI TR3D-B-3K	112 (X)	05-Nov-14	12.12 uv/lb at 10V exc				.001212 mv/v/lb	FULL	1500 LB	
22	LEFT LAP Y FORCE (LB)	MICH SCI TR3D-B-3K	112 (Y)	05-Nov-14	12.14 uv/lb at 10V exc				.001214 mv/v/lb	FULL	1500 LB	
23	LEFT LAP Z FORCE (LB)	MICH SCI TR3D-B-3K	112 (Z)	05-Nov-14	10.08 uv/lb at 10V exc				.001008 mv/v/lb	FULL	1500 LB	
24	RIGHT LAP X FORCE (LB)	MICH SCI TR3D-B-3K	4 (Y)	18-Aug-14	13.32 uv/lb at 10V exc				.001332 mv/v/lb	FULL	1500 LB	
25	RIGHT LAP Y FORCE (LB)	MICH SCI TR3D-B-3K	4 (X)	18-Aug-14	13.40 uv/lb at 10V exc				.001340 mv/v/lb	FULL	1500 LB	
26	RIGHT LAP Z FORCE (LB)	MICH SCI TR3D-B-3K	4 (Z)	18-Aug-14	10.97 uv/lb at 10V exc				.001097 mv/v/lb	FULL	1500 LB	
27	LEFT SHOULDER X FORCE (LB)	MICH SCI TR3D-B-3K	113 (X)	17-Apr-14	13.17 uv/lb at 10V exc				.001317 mv/v/lb	FULL	1500 LB	
28	LEFT SHOULDER Y FORCE (LB)	MICH SCI TR3D-B-3K	113 (Y)	17-Apr-14	12.97 uv/lb at 10V exc				.001297 mv/v/lb	FULL	1500 LB	
29	LEFT SHOULDER Z FORCE (LB)	MICH SCI TR3D-B-3K	113 (Z)	17-Apr-14	10.93 uv/lb at 10V exc				.001093 mv/v/lb	FULL	1500 LB	
30	RIGHT SHOULDER X FORCE (LB)	MICH SCI TR3D-B-3K	4335 (X)	17-Apr-14	13.27 uv/lb at 10V exc				.001327 mv/v/lb	FULL	1500 LB	
31	RIGHT SHOULDER Y FORCE (LB)	MICH SCI TR3D-B-3K	4335 (Y)	17-Apr-14	12.83 uv/lb at 10V exc				.001283 mv/v/lb	FULL	1500 LB	
32	RIGHT SHOULDER Z FORCE (LB)	MICH SCI TR3D-B-3K	4335 (Z)	17-Apr-14	10.80 uv/lb at 10V exc				.001080 mv/v/lb	FULL	1500 LB	
33	PELVIS X ACCEL (G)	ENDEVCO EGCS S425-250	R130P0	15-Aug-14	.5746 mv/g at 10V exc				.05746 mv/v/g	FULL	250 G	Used on tests 1402-1538
	LEFT LAP IN-LINE (LB)	HUMANETICS 1910	319	4-Jun-14	6.50886 uv/lb at 10V exc				.000650886 mv/v/lb	FULL	250 LB	Used on tests 1539-1541
34	PELVIS Y ACCEL (G)	ENDEVCO EGCS S425-2000	A012954	15-Aug-14	.0826 mv/g at 10V exc				.00826 mv/v/g	FULL	2000 G	Used on tests 1402-1412
	PELVIS Y ACCEL (G)	ENDEVCO 7264-2000	P57979	15-Aug-14	.1968 mv/g at 10V exc				.01968 mv/v/g	FULL	2000 G	Used on tests 1413
	PELVIS Y ACCEL (G)	ENDEVCO EGCS S425-250	R13085	15-Dec-14	.6168 mv/g at 10V exc				.06168 mv/v/g	FULL	250 G	Used on tests 1414-1538
	RIGHT LAP IN-LINE (LB)	HUMANETICS 1910	318	20-Jun-14	6.61606 uv/lb at 10V exc				.000661606 mv/v/lb	FULL	250 LB	Used on tests 1539-1541
35	PELVIS Z ACCEL (G)	ENDEVCO 7264-2000	P57979	15-Aug-14	.1968 mv/g at 10V exc				.01968 mv/v/g	FULL	2000 G	Used on tests 1402-1412
	PELVIS Z ACCEL (G)	ENDEVCO EGCS S425-2000	A012954	15-Aug-14	.0826 mv/g at 10V exc				.00826 mv/v/g	FULL	2000 G	Used on tests 1413-1538
	LEFT SHOULDER IN-LINE (LB)	HUMANETICS 3255LN2	318	5-Jan-15	6.55677 uv/lb at 10V exc				.000655677 mv/v/lb	FULL	250 LB	Used on tests 1539-1541
36	LUBMAR X FORCE (LB)	HUMANETICS DP1102	1842 (FX)	03-Dec-13	.0003253 mv/v/lbf				.0003253 mv/v/lbf	FULL	1000 LB	Used on tests 1402-1538
	RIGHT SHOULDER IN-LINE (LB)	HUMANETICS 1910	321	18-Dec-14	6.50405 uv/lb at 10V exc				.000650405 mv/v/lb	FULL	250 LB	Used on tests 1539-1541

37	LUMBER Z FORCE (LB)	HUMANETICS DP1102	1842 (FZ)	03-Dec-13	.0003253 mv/v/lbf				.0003253 mv/v/lbf	FULL	1000 LB	Used on tests 1402-1538
	FLOATING SEAT PAN Z ACCEL (G)	MEAS SPEC EGCS-S425-2000	A011338	15-Aug-14	.0874 mv/g at 10V exc				.00874 mv/v/g	FULL	500 G	Used on tests 1539-1541
38	LUMBER MY TORQUE (IN-LB)	HUMANETICS DP1102	1842 (MY)	03-Dec-13	.0003637 mv/v/in-lbf				.0003637 mv/v/in-lbf	FULL	2500 IN-LB	Used on tests 1402-1538
	SEISMIC BASE ACCEL (G)	MEAS SPEC EGCS-S425-250	R1103W	4-May-15	.6038 mv/g at 10V exc				.06038 mv/v/g	FULL	250 G	Used on tests 1539-1541
39	LEFT TIBIA X FORCE (LB)	HUMANETICS 3466	186 (FX)	20-Dec-13	.0007548 mv/v/lbf				.0007548 mv/v/lbf	FULL	1000 LB	Used on tests 1407-1538
	SEISMIC BASE POT (IN)	CELESCO MT2A-30E-14-10K-M1	B1801457B	11-May-15	306.5212121 mv/in at 10V				30.65212121 mv/v/in	FULL	15 IN	Used on tests 1539-1541
40	LEFT TIBIA Z FORCE (LB)	HUMANETICS 3466	186 (FZ)	20-Dec-13	.0004238 mv/v/lbf				.0004238 mv/v/lbf	FULL	1000 LB	Used on tests 1407-1538
41	LEFT TIBIA MY TORQUE (IN-LB)	HUMANETICS 3466	186 (MY)	20-Dec-13	.0008329 mv/v/in-lbf				.0008329 mv/v/in-lbf	FULL	2500 IN-LB	Used on tests 1407-1538
42	RIGHT TIBIA X FORCE (LB)	HUMANETICS 3466	185 (FX)	20-Dec-13	.0007528 mv/v/lbf				.0007528 mv/v/lbf	FULL	1000 LB	Used on tests 1407-1538
43	RIGHT TIBIA Z FORCE (LB)	HUMANETICS 3466	185 (FZ)	20-Dec-13	.0004218 mv/v/lbf				.0004218 mv/v/lbf	FULL	1000 LB	Used on tests 1407-1538
44	RIGHT TIBIA MY TORQUE (IN-LB)	HUMANETICS 3466	185 (MY)	20-Dec-13	.0008347 mv/v/in-lbf				.0008347 mv/v/in-lbf	FULL	2500 IN-LB	Used on tests 1407-1538
45	SEAT PAN Z ACCEL 2 (G)	MEAS SPEC EGCS-425-1000	N04742	22-May-14	.1148 mv/g at 10V exc				.01148 mv/v/g	FULL	500 G	Used on tests 1407-1457
	SEAT PAN Z ACCEL 2 (G)	MEAS SPEC EGCS-S425-2000	A011338	15-Aug-14	.0874 mv/g at 10V exc				.00874 mv/v/g	FULL	500 G	Used on tests 1468-1476
	FLOATING SEAT PAN Z ACCEL (G)	MEAS SPEC EGCS-S425-2000	A011338	15-Aug-14	.0874 mv/g at 10V exc				.00874 mv/v/g	FULL	500 G	Used on tests 1477-1538
46	FLOATING SEAT PAN Z ACCEL 2 (G)	MEAS SPEC EGCS-S425-2000	A011338	15-Aug-14	.0874 mv/g at 10V exc				.00874 mv/v/g	FULL	500 G	Used on tests 1407-1457
	SEISMIC BASE ACCEL (G)	MEAS SPEC EGCS-S425-250	R1103W	4-May-15	.6038 mv/g at 10V exc				.06038 mv/v/g	FULL	250 G	Used on tests 1488-1538
47	SEISMIC BASE POT (IN)	CELESCO MT2A-30E-14-10K-M1	B1801457B	11-May-15	306.5212121 mv/in at 10V exc				30.65212121 mv/v/in	FULL	15 IN	Used on tests 1488-1538

APPENDIX B. VID ASSESSMENT FOR TEST SERIES I: 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 for the different VID carriage impact attenuation configurations. The WS2 seat configuration consisted of a 617 lb seat fixture with 190 lb GARD male manikin.

Test Objective: Determine the materials and drop heights required for energy attenuation of the seat pan and the foot-rest to generate a 4 m/s velocity with a 5 ms TTP, or a 6 m/s velocity with a 5 ms TTP.

A breakout of the tests per cell are as follows:

Test Numbers 1331 – 1338	Cells SK1 through SK4
Test Numbers 1339 – 1346	Cells SL1 through SL4
Test Numbers 1347 – 1354	Cells SM1 through SM4
Test Numbers 1355 – 1362	Cells SN1 through SN4

- **<u>Test 1331</u>:** Cell SK1, Test 1; Felt Density 3251, Programmer: 0.5 in. / 0.5 in. Drop Height = 10 in., Peak Acceleration = 147.97 G. **Integrated Velocity Change**: Carriage Z = 9.38 ft/s (2.86 m/s), Seat Pan Reference = 10.26 ft/s (3.13 m/s). Measured Velocity Change = 7.02 ft/s (2.14 m/s); Time-to-Peak Acceleration = 2.1 ms, Time-to-Peak Velocity = 5.5 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.

- **<u>Test 1332</u>:** Cell SK1, Test 2; Felt Density 3251, Programmer: 0.5 in. / 0.5 in. Drop Height = 10 in., Peak Acceleration = 151.08 G. **Integrated Velocity Change**: Carriage Z = 9.59 ft/s (2.92 m/s), Seat Pan Reference = 10.44 ft/s (3.18 m/s). Measured Velocity Change = 7.09 ft/s (2.16 m/s), Measured Total Velocity Change = 8.21 ft/s (2.5 m/s); Time-to-Peak Acceleration = 2 ms, Time-to-Peak Velocity = 6.2 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.

- **<u>Test 1333</u>:** Cell SK2, Test 1; Felt Density 3251, Programmer: 0.5 in. / 0.5 in. Drop Height = 20 in., Peak Acceleration = 233.64 G. **Integrated Velocity Change**: Carriage Z = 13.34 ft/s (4.06 m/s), Seat Pan Reference = 14.63 ft/s (4.46 m/s). Measured Velocity Change = 10.02 ft/s (3.05 m/s), Measured Total Velocity Change = 12.9 ft/s (3.93 m/s); Time-to-Peak Acceleration = 1.8 ms, Time-to-Peak Velocity = 5.9 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.

- **<u>Test 1334</u>:** Cell SK2, Test 2; Felt Density 3251, Programmer: 0.5 in. / 0.5 in. Drop Height = 20 in., Peak Acceleration = 239.67 G. **Integrated Velocity Change**: Carriage Z = 13.67 ft/s (4.17 m/s), Seat Pan Reference = 15.15 ft/s (4.62 m/s). Measured Velocity Change = 10.25 ft/s (3.13 m/s), Measured Total Velocity Change = 13.3 ft/s (4.05 m/s); Time-to-Peak Acceleration = 1.9 ms, Time-to-Peak Velocity = 5.9 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.

- **<u>Test 1335</u>:** Cell SK3, Test 1; Felt Density 3251, Programmer: 0.5 in. / 0.5 in. Drop Height = 30 in., Peak Acceleration = 303.56 G. **Integrated Velocity Change**: Carriage Z = 16.62 ft/s (5.06 m/s), Seat Pan Reference = 18.87 ft/s (5.75 m/s). Measured Velocity Change = 12.62 ft/s (3.85 m/s), Measured Total Velocity Change = 16.48 ft/s (5.02 m/s); Time-to-Peak Acceleration = 1.8 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.

- **<u>Test 1336</u>:** Cell SK3, Test 2; Felt Density 3251, Programmer: 0.5 in. / 0.5 in. Drop Height = 30 in., Peak Acceleration = 299.18 G. **Integrated Velocity Change**: Carriage Z = 16.4 ft/s (4.99 m/s), Seat Pan Reference = 18.33 ft/s (5.59 m/s). Measured Velocity Change = 12.38 ft/s (3.77 m/s), Measured Total Velocity Change = 16.18 ft/s (4.93 m/s); Time-to-Peak Acceleration = 1.8 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.

- **<u>Test 1337</u>:** Cell SK4, Test 1; Felt Density 3251, Programmer: 0.5 in. / 0.5 in. Drop Height = 40 in., Peak Acceleration = 361.49 G. **Integrated Velocity Change**: Carriage Z = 19.03 ft/s (5.8 m/s), Seat Pan Reference = 21.98 ft/s (6.7 m/s). Measured Velocity Change = 14.58 ft/s (4.44 m/s), Measured Total Velocity Change = 18.96 ft/s (5.78 m/s); Time-to-Peak Acceleration = 1.6 ms, Time-to-Peak Velocity = 5.5 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.

- **<u>Test 1338</u>:** Cell SK4, Test 2; Felt Density 3251, Programmer: 0.5 in. / 0.5 in. Drop Height = 40 in., Peak Acceleration = 352.06 G. **Integrated Velocity Change**: Carriage Z = 18.68 ft/s (5.7 m/s), Seat Pan Reference = 21.38 ft/s (6.52 m/s). Measured Velocity Change = 14.26 ft/s (4.35 m/s), Measured Total Velocity Change = 18.64 ft/s (5.68 m/s); Time-to-Peak Acceleration = 1.7 ms, Time-to-Peak Velocity = 5.6 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.

- **<u>Test 1339</u>:** Cell SL1, Test 1; Felt Density 2651 (1.0 in.), Drop Height = 10 in., Peak Acceleration = 106.46 G. **Integrated Velocity Change**: Carriage Z = 9.48 ft/s (2.88 m/s), Seat Pan Reference = 10.25 ft/s (3.12 m/s). Measured Velocity Change = 7.06 ft/s (2.15 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.

- **<u>Test 1340</u>:** Cell SL1, Test 2; Felt Density 2651 (1.0 in.), Drop Height = 10 in., Peak Acceleration = 106.9 G. **Integrated Velocity Change**: Carriage Z = 9.54 ft/s (2.91 m/s), Seat Pan Reference = 10.23 ft/s (3.12 m/s). Measured Velocity Change = 7.02 ft/s (2.14 m/s); Time-to-Peak Acceleration = 2.5 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.

- **<u>Test 1341</u>:** Cell SL2, Test 1; Felt Density 2651 (1.0 in.), Drop Height = 20 in., Peak Acceleration = 166.64 G. **Integrated Velocity Change**: Carriage Z = 13.35 ft/s (4.07 m/s), Seat Pan Reference = 14.38 ft/s (4.38 m/s). Measured Velocity Change = 10.09 ft/s (3.08 m/s), Measured Total Velocity Change = 12.74 ft/s (3.88 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.

- **<u>Test 1342</u>:** Cell SL2, Test 2; Felt Density 2651 (1.0 in.), Drop Height = 20 in., Peak Acceleration = 167.53 G. **Integrated Velocity Change**: Carriage Z = 13.35 ft/s (4.08 m/s), Seat Pan Reference = 14.46 ft/s (4.41 m/s). Measured Velocity Change = 10.17 ft/s (3.1 m/s), Measured Total Velocity Change = 12.87 ft/s (3.92 m/s); Time-to-Peak Acceleration = 2.2 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.

- **<u>Test 1343</u>:** Cell SL3, Test 1; Felt Density 2651 (1.0 in.), Drop Height = 30 in., Peak Acceleration = 222.58 G. **Integrated Velocity Change**: Carriage Z = 16.29 ft/s (4.97 m/s), Seat Pan Reference = 17.66 ft/s (5.39 m/s). Measured Velocity Change = 12.5 ft/s (3.81 m/s), Measured Total Velocity Change = 16.05 ft/s (4.89 m/s); Time-to-Peak Acceleration = 2.1 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.

- **<u>Test 1344</u>:** Cell SL3, Test 2; Felt Density 2651 (1.0 in.), Drop Height = 30 in., Peak Acceleration = 222.73 G. **Integrated Velocity Change**: Carriage Z = 16.25 ft/s (4.96 m/s), Seat Pan Reference = 17.51 ft/s (5.34 m/s). Measured Velocity Change = 12.5 ft/s (3.81 m/s), Measured Total Velocity Change = 15.82 ft/s (4.82 m/s); Time-to-Peak Acceleration = 2 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.

- **<u>Test 1345</u>:** Cell SL4, Test 1; Felt Density 2651 (1.0 in.), Drop Height = 40 in., Peak Acceleration = 266.71 G. **Integrated Velocity Change**: Carriage Z = 18.4 ft/s (5.61 m/s), Seat Pan Reference = 19.55 ft/s (5.96 m/s). Measured Velocity Change = 14.26 ft/s (4.35 m/s), Measured Total Velocity Change = 18.17 ft/s (5.54 m/s); Time-to-Peak Acceleration = 2 ms, Time-to-Peak Velocity = 5.4 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.

- **<u>Test 1346</u>:** Cell SL4, Test 2; Felt Density 2651 (1.0 in.), Drop Height = 40 in., Peak Acceleration = 268.54 G. **Integrated Velocity Change**: Carriage Z = 18.48 ft/s (5.64 m/s), Seat Pan Reference = 19.48 ft/s (5.94 m/s). Measured Velocity Change = 14.26 ft/s (4.35 m/s), Measured Total Velocity Change = 18.18 ft/s (5.54 m/s); Time-to-Peak Acceleration = 2 ms, Time-to-Peak Velocity = 5.3 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.

- **<u>Test 1347</u>:** 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.

- **<u>Test 1348</u>:** 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.

- **<u>Test 1349</u>:** 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.

- **<u>Test 1350</u>:** 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.

- **<u>Test 1351</u>:** 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.

- **<u>Test 1352</u>:** 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.

- **<u>Test 1353</u>:** 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.

- **<u>Test 1354</u>:** 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.

- **<u>Test 1355</u>:** 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.

- **<u>Test 1356</u>:** 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.

- **<u>Test 1357</u>:** 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.

- **<u>Test 1358</u>:** 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.

- **<u>Test 1359</u>:** 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.

- **<u>Test 1360</u>:** 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.

- **<u>Test 1361</u>:** 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.

- **<u>Test 1362</u>:** 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.

APPENDIX C. VID ASSESSMENT FOR TEST SERIES 2: 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 WS2ms seat configuration and the comparison tests for the different VID carriage impact attenuation configurations. The WS2ms seat configuration consisted of a 617 lb seat fixture with 190 lb GARD male manikin. This test series was composed of tests 1371 through 1401.

Test Ojective: Determine the materials and drop heights required for energy attenuation of the seat pan to generate a 4 m/s velocity with a 10 ms TTP, and the energy attenuation of the foot-rest to generate a 6 m/s velocity with a 5 ms TTP. .

A breakout of the tests per cell are as follows:

Test Numbers 1371 – 1375	Cells SO1 through SO2
Test Numbers 1387 – 1389	Cells SR1 through SR2
Test Numbers 1390 – 1393	Cells SS1 through SS2
Test Numbers 1394 – 1397	Cells ST1 through ST2
Test Numbers 1398 – 1401	Cells SQ1 through SQ2

- **<u>Test 1371</u>:** Cell SO1, Test 1 ; Drop Height = 18 in., VID carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 16S1 (2.0 in.),
  Non-Successful Test – All electronic data channels were not present and continuous, error collecting the data.

- **<u>Test 1372</u>:** Cell SO1, Test 2; Drop Height = 18 in., VID carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 16S1 (2.0 in.), Peak Acceleration = 160.48 G. Integrated Velocity Change: Seat Pan = 4.26 m/s, Foot Rest = 4.19 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1373</u>:** Cell SO1, Test 3; Drop Height = 18 in., VID carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 16S1 (2.0 in.), Peak Acceleration = 159.06 G. Integrated Velocity Change: Seat Pan = 4.22 m/s, Foot Rest = 4.16 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1374</u>:** Cell SO2, Test 1; Drop Height = 40 in., VID carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 16S1 (2.0 in.), Peak Acceleration = 263.48 G. Integrated Velocity Change: Seat Pan = 6.07 m/s, Foot Rest = 6.02 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1375</u>:** Cell SO2, Test 2; Drop Height = 40 in., VID carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 16S1 (2.0 in.), Peak Acceleration = 262.77 G. Integrated Velocity Change: Seat Pan = 6.14 m/s, Foot Rest = 6.01 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1381 through 1386</u>:** Cells SP1 and SP2, Drop Heights = 18, 40 inches, VID carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 16S1 (2.0 in., 6 x 6 blocks)
  Un-Successful Tests – Integration of felt under seat pan produced an unstable fixture generating very inconsistent data.

- **<u>Test 1387:</u>** Cell SR1, Test 1; Drop Height = 18 in., VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: C-45 Blue Confor Foam (2.0 in.), Peak Acceleration = 151.73 G, Integrated Velocity: Seat Pan = 4.10 m/s, Foot Rest = 3.97 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1388</u>:** Cell SR1, Test 2; Drop Height = 18 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: C-45 Blue Confor Foam (2.0 in.), Peak Acceleration = 152.77 G, Integrated Velocity: Seat Pan = 4.15 m/s, Foot Rest = 3.98 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1389</u>:** Cell SR2, Test 1; Drop Height = 40 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: C-45 Blue Confor Foam (2.0 in.) Peak Acceleration = 260.00 G, Integrated Velocity: Seat Pan = 6.16 m/s, Foot Rest = 5.87 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1390</u>:** Cell SS1, Test 1; Drop Height = 18 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: C-47 Green Confor Foam (2.0 in.), Peak Acceleration = 156.67 G, Integrated Velocity: Seat Pan = 4.20 m/s, Foot Rest = 4.06 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1391</u>:** Cell SS1, Test 2; Drop Height = 18 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: C-47 Green Confor Foam (2.0 in.), Peak Acceleration = 156.43 G, Integrated Velocity: Seat Pan = 4.20 m/s, Foot Rest = 4.02 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1392</u>:** Cell SS2, Test 1; Drop Height = 40 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: C-47 Green Confor Foam (2.0 in.), Peak Acceleration = 259.40 G, Integrated Velocity: Seat Pan = 6.09 m/s, Foot Rest = 5.86 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1393</u>:** Cell SS2, Test 2; Drop Height = 40 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: C-47 Green Confor Foam (2.0 in.), Peak Acceleration = 257.27 G, Integrated Velocity: Seat Pan = 6.06 m/s, Foot Rest = 5.82 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1394</u>:** Cell ST1, Test 1; Drop Height = 18 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 2-Layer Stimulite,; Peak Acceleration = 149.25 G, Integrated Velocity: Seat Pan = 4.22 m/s, Foot Rest = 4.15 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1395</u>:** Cell ST1, Test 2; Drop Height = 18 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 2-Layer Stimulite,; Peak Acceleration = 148.50 G, Integrated Velocity: Seat Pan = 4.21 m/s, Foot Rest = 4.10 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1396</u>:** Cell ST2, Test 1; Drop Height = 40 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 2-Layer Stimulite,; Peak Acceleration = 242.88 G, Integrated Velocity: Seat Pan = 6.16 m/s, Foot Rest = 5.96 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1397</u>:** Cell ST2, Test 2; Drop Height = 40 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: 2-Layer Stimulite,; Peak Acceleration = 243.23 G, Integrated Velocity: Seat Pan = 6.18 m/s, Foot Rest = 5.96 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1398</u>:** Cell SQ1,Test 1; Drop Height = 18 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: Blue Package Foam (Density = 0.027 lb/in^2),; Peak Acceleration = 148.37 G, Integrated Velocity: Seat Pan = 4.24 m/s, Foot Rest = 4.11 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1399</u>:** Cell SQ1,Test 2; Drop Height = 18 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: Blue Package Foam (Density = 0.027 lb/in^2),; Peak Acceleration = 146.68 G, Integrated Velocity: Seat Pan = 4.18 m/s, Foot Rest = 4.04 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1400</u>:** Cell SQ2,Test 1; Drop Height = 40 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: Blue Package Foam (Density = 0.027 lb/in^2),; Peak Acceleration = 242.75 G, Integrated Velocity: Seat Pan = 6.12 m/s, Foot Rest = 6.03 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

- **<u>Test 1401</u>:** Cell SQ2,Test 2; Drop Height = 40 in.; VID Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: Blue Package Foam (Density = 0.027 lb/in^2),; Peak Acceleration = 243.50 G, Integrated Velocity: Seat Pan = 6.13 m/s, Foot Rest = 6.06 m/s
  Successful Test – All electronic data channels were present and continuous, data was successfully collected, desired test condition was achieved for testing seat pan attenuation.

APPENDIX D. VID ASSESSMENT FOR TEST SERIES 3: 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 WS2fm seat configuration and the comparison tests for the different VID carriage impact attenuation configurations. The WS2fm seat configuration consisted of a 645 lb seat fixture with 170 lb 50th percentile Hybrid III male manikin. This test series was composed of tests 1501 through 1538; however, tests 1501 through 1509 did not include a manikin and were not analyzed.

Test Objective: Determine the materials and drop heights required for energy attenuation of the seat pan to generate a 4 m/s velocity with a 20 ms TTP, and the energy attenuation of the foot-rest to generate a 6 m/s velocity with a 10 ms TTP.

- **Test 1510:** Drop Height: 20 in.; Foot rest Attenuation: 18 Elastic Balls (1.75" Dia.) Test with 50th percentile Hybrid III manikin plus Boots
- **Test 1511**: Drop Height: 20 in.; Foot rest Attenuation: 18 Elastic Balls (1.75" Dia.) All "WHAM-O" balls, Test with 50th percentile Hybrid III manikin plus Boots
- **Test 1512**: Drop Height: 20 in.; Foot rest Attenuation: 18 Elastic Balls (1.75" Dia.) All "WHAM-O" balls, Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest
- **Test 1513**: Drop Height: 20 in., Foot rest Attenuation: 20 Elastic Balls (1.75" Dia.) All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus boots; 20 lbs added to foot rest
- **Test 1514:** Drop Height: 20 in., Foot rest Attenuation: 4 Golf Balls (CR = 35); Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest
- **Test 1515**: Drop Height: 18 in., Foot rest Attenuation: 4 Golf Balls (CR = 35); Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest
- **Test 1516:** Drop Height: 18 in., Foot rest Attenuation: 2 Golf Balls (CR = 35) and 2 Elastic Balls (1.75 in. Dia., "WHAM-O"); Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest
- **Test 1517:** Drop Height: 18 in., Foot rest Attenuation: 4 Golf Balls (CR = 110); Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest
- **Test 1518**: Drop Height: 20 in., Foot rest Attenuation: 10 Lacrosse Balls (2.5” Dia.); Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest

- **Test 1519**: Drop Height: 20 in., Foot rest Attenuation: 2 Lacrosse Balls (2.5" Dia.); Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest

- **Test 1520**: Drop Height: 20 in., Foot rest Attenuation: 4 Elastic Balls (1.75" Dia.), All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest

- **Test 1521**: Drop Height: 20 in., Foot rest Attenuation: 6 Elastic Balls (1.75" Dia.), All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest

- **Test 1522**: Drop Height: 20 in., Foot rest Attenuation: 8 Elastic Balls (1.75" Dia.), All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest

- **Test 1523**: Drop Height: 20 in., Foot rest Attenuation: 10 Elastic Balls (1.75" Dia.), All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest

- **Test 1524**: Drop Height: 20 in., Foot rest Attenuation: 10 Elastic Balls (1.75" Dia.), All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest

- **Test 1525**: Drop Height: 20 in., Foot rest Attenuation: 4 Elastic Balls (1.75" Dia.), All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest; Spacer Bars (1" thk) added below ball rack

- **Test 1526**: Drop Height: 20 in., Foot rest Attenuation: 4 Elastic Balls (1.75" Dia.), All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus Boots; 40 lbs added to foot rest; Spacer Bars (1" thk) added below ball rack

- **Test 1527**: Drop Height: 20 in., Foot rest Attenuation: 4 Elastic Balls (1.75" Dia.), All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest; Spacer Bars (1" thk) added below ball rack

- **Test 1528**: Drop Height: 20 in., Foot rest Attenuation: 3 Elastic Balls (1.75" Dia.), All "WHAM-O" balls; Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest; Spacer Bars (1" thk) added below ball rack

- **Test 1529**: Drop Height: 20 in., Foot rest Attenuation: 3 Golf Balls (CR=35); Test with 50^{th} percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest; Spacer Bars (1" thk) added below ball rack

- **Test 1530**: Drop Height: 20 in., Foot rest Attenuation: 3 Golf Balls (CR=35); Test with 50^{th} percentile Hybrid III manikin plus Boots; 40 lbs added to foot rest; Spacer Bars (1" thk) added below ball rack

- **Test 1531**: Drop Height: 20 in., Foot rest Attenuation: 4 Lacrosse Balls (2.5” Dia.) using only half sections of the balls; Test with 50^{th} percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest; Spacer Bars (1" thk) added below ball rack

APPENDIX E. VID ASSESSMENT FOR TEST SERIES 4: 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 WS3 seat configuration and the comparison tests for the different VID carriage and footrest carriage impact attenuation configurations. The foot-rest was a separate impact structure that would provide an impact pulse to the foot-rest plate independent of the impact occuring to the main seat structure when the drop carriage contacts the reaction mass (i.e. the VID carriage and the foot-rest impact structure or footrest impact carriage both free-fall together, but impact separate surface areas). The foot-rest impact structure used separate guide rails allowing it to react independently of the main carriage during impact. The WS3 seat configuration had a total weight of approximately 845 lbs. The test weight of the Hybrid III 50% manikin used in this test series was approximately 170 lbs, for a total test weight of approximately 1015 lbs. This test series was composed of tests 1585 through 1643.

Test Objective: Determine the materials and drop heights required for energy attenuation of the seat pan to generate a 5 m/s velocity with a 25 ms TTP, and the energy attenuation of the foot-rest to generate a 7 m/s velocity with a 2 ms TTP.

- **<u>Test 1585</u>:** Drop Height = 35 in.; Carriage Programmer: Manikin Neck Hexcel - 16 blocks; Footrest Programmer: 26S1 Felt, 1 inch thick; No Test - Instrumentation error.
- **<u>Test 1586</u>:** Drop Height = 20 in.; Carriage Programmer: Manikin Neck Hexcel - 16 blocks; Footrest Programmer: 26S1 Felt, 1inch thick; Carriage Velocity = 4.09 m/s
- **<u>Test 1587</u>:** Drop Height = 20 in.; Carriage Programmer: Manikin Neck Hexcel - 16 blocks; Footrest Programmer: 26S1 Felt, 1 inch thick; Carriage Velocity = 4.04 m/s
- **<u>Test 1588</u>:** Drop Height = 40 in.; Carriage Programmer: Manikin Neck Hexcel - 16 blocks; Footrest Programmer: 26S1 Felt, 1 inch thick; Carriage Velocity = 5.54 m/s
- **<u>Test 1589</u>:** Drop Height = 40 in.; Carriage Programmer: 3.25 inch Hexcel - 8 blocks; Footrest Programmer: 26S1 Felt, 1 inch thick; Carriage Velocity = 3.88 m/s
- **<u>Test 1590</u>**: Drop Height = 60 in.; Carriage Programmer: 3.50 inch Hexcel - 8 blocks; Footrest Programmer: Red urethane bumper; Carriage Velocity = 4.71 m/s
- **<u>Test 1591</u>**: Drop Height = 54 in.; Carriage Programmer: 3.00 inch Hexcel - 6 blocks; Footrest Programmer: Red urethane bumper; Carriage Velocity = 4.41 m/s
- **<u>Test 1592</u>**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2" thick pads (2); Footrest Programmer: Red urethane bumper; Carriage Velocity = 6.09 m/s
- **<u>Test 1593</u>**: Drop Height = 50 in.; Carriage Programmer: 3.00 inch Hexcel - 8 blocks; Footrest Programmer: Red urethane bumper; Carriage Velocity = 4.35 m/s

- **Test 1594**: Drop Height = 60 in.; Carriage Programmer: 3.50 inch Hexcel - 8 blocks; Footrest Programmer: 32S1 Felt, 0.5” thick; Carriage Velocity = 4.27 m/s

- **Test 1595**: Drop Height = 45 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 32S1 Felt, 0.5” thick; Carriage Velocity = 5.99 m/s

- **Test 1596**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 32S1 Felt, 0.5” thick; Carriage Velocity = 6.30 m/s

- **Test 1597**: Drop Height = 55 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 32S1 Felt, 0.5” thick; Carriage Velocity = 6.50 m/s

- **Test 1598**: Drop Height = 60 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 32S1 Felt, 0.5” thick; Carriage Velocity = 6.75 m/s

- **Test 1599**: Drop Height = 65 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 32S1 Felt, 0.5” thick; Carriage Velocity = 6.96 m/s

- **Test 1600**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Red urethane bumper; Carriage Velocity = 5.59 m/s

- **Test 1601**: Drop Height = 45 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Red urethane bumper; Carriage Velocity = 5.97 m/s

- **Test 1602**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Red urethane bumper; Carriage Velocity = 6.19 m/s

- **Test 1603**: Drop Height = 55 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Red urethane bumper; Carriage Velocity = 6.43 m/s

- **Test 1604**: Drop Height = 60 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Red urethane bumper; Carriage Velocity = 6.67 m/s

- **Test 1605**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.25” thick; Carriage Velocity = 5.58 m/s

- **Test 1606**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.25” thick with 10” impact disk; Carriage Velocity = 5.57 m/s

- **Test 1607**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.25” thick with 8” impact disk; Carriage Velocity = 5.69 m/s

- **Test 1608**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.25” thick with 6” impact disk; Carriage Velocity = 5.63 m/s

- **Test 1609**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.25” thick with 4” impact disk; Carriage Velocity = 5.57 m/s

- **Test 1610**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.25” thick with 3” impact disk; Carriage Velocity = 5.60 m/s

- **Test 1611**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.375” thick with 3” impact disk; Carriage Velocity = 5.61 m/s

- **Test 1612**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.375” thick; Carriage Velocity = 5.61 m/s

- **Test 1613**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.375” thick; Carriage Velocity = 6.22 m/s

- **Test 1614**: Drop Height = 60 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: Polyethelene, 0.375” thick; Carriage Velocity = 6.74 m/s

- **Test 1615**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 90 A Polyethelene, 0.5” thick; Carriage Velocity = 5.57 m/s

- **Test 1616**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 90 A Polyethelene, 0.5” thick; Carriage Velocity = 5.54 m/s

- **Test 1617**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 90 A Polyethelene, 0.5” thick; Carriage Velocity = 6.21 m/s

- **Test 1618**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 90 A Polyethelene, 0.5” thick; Carriage Velocity = 6.18 m/s

- **Test 1619**: Drop Height = 60 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 90 A Polyethelene, 0.5” thick; Carriage Velocity = 6.96 m/s

- **Test 1620**: Drop Height = 60 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 90 A Polyethelene, 0.5” thick; Carriage Velocity = 6.94 m/s

- **Test 1621**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 90 A Polyethelene, 0.5” thick; Carriage Velocity = 5.64 m/s

- **Test 1622**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 90 A Polyethelene, 0.5” thick; Carriage Velocity = 5.73 m/s

- **Test 1623**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 5.57 m/s

- **Test 1624**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 5.68 m/s

- **Test 1625**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 6.41 m/s

- **Test 1626**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 6.37 m/s

- **Test 1627**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 6.40 m/s

- **Test 1628**: Drop Height = 60 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 6.97 m/s

- **Test 1629**: Drop Height = 60 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 6.95 m/s

- **Test 1630**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 75 D Polyethelene, 0.5” thick; Carriage Velocity = 5.57 m/s

- **Test 1631**: Drop Height = 40 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 75 D Polyethelene, 0.5” thick; Carriage Velocity = 5.73 m/s

- **Test 1632**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 75 D Polyethelene, 0.5” thick; Carriage Velocity = 6.28 m/s

- **Test 1633**: Drop Height = 50 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 75 D Polyethelene, 0.5” thick; Carriage Velocity = 5.41 m/s

- **Test 1634**: Bad Test

- **Test 1635**: Bad Test

- **Test 1636**: Drop Height = 60 in.; Carriage Programmer: 4 “ Hexcel, 10 Blocks; Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 4.72 m/s

- **Test 1637**: Drop Height = 60 in.; Carriage Programmer: 4 “ Hexcel, 12 Blocks; Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 4.57 m/s

- **Test 1638**: Drop Height = 60 in.; Carriage Programmer: 4 “ Hexcel, 8 Blocks; Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 5.35 m/s

- **Test 1639**: Drop Height = 60 in.; Carriage Programmer: 4 “ Hexcel, 8 Blocks; Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 5.38 m/s

- **Test 1640**: Drop Height = 55 in.; Carriage Programmer: 4 “ Hexcel, 8 Blocks; Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 4.88 m/s

- **Test 1641**: Drop Height = 55 in.; Carriage Programmer: 4 “ Hexcel, 12 Blocks; Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 5.04 m/s

- **Test 1642**: Drop Height = 55 in.; Carriage Programmer: 4 “ Hexcel, 12 Blocks; Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 5.11 m/s

- **Test 1643**: Drop Height = 60 in.; Carriage Programmer: 4 “ Hexcel, 14 Blocks; Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 5.31 m/s

APPENDIX F. SAMPLE DATA SHEETS: TEST SERIES 1, TEST SERIES 2, TEST SERIES 3, TEST SERIES 4

Examples of test data collected during the program will show the post-test processed data for the four different test series evaluating different seat and impact material configurations. Two tests will be shown for each test series, and are identified below.

TEST SERIES 1. Carriage attenuation material assessment.

- **Test 1338:** Cell SK4; Drop Height: 40 inches; Carriage Programmer: Felt Density 3251, (0.5 in. / 0.5 in.); Peak Acceleration = 352.06 G. **Integrated Velocity Change**: Carriage Z = 18.68 ft/s (5.7 m/s), Seat Pan Reference = 21.38 ft/s (6.52 m/s); Time-to-Peak Acceleration = 1.7 ms, Time-to-Peak Velocity = 5.6 ms.

- **Test 1362:** Cell SN4; Drop Height: 40 inches; Carrige Programmer: 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); Time-to-Peak Acceleration = 3.1 ms, Time-to-Peak Velocity = 6.8 ms.

TEST SERIES 2. Seat pan attenuation material assessment.

- **Test 1389:** Cell SR2; Drop Height = 40 in.; Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: C-45 Blue Confor Foam (2.0 in.); Peak Acceleration = 260.00 G, Integrated Velocity: Seat Pan = 6.16 m/s, Foot Rest = 5.87 m/s

- **Test 1401:** Cell SQ2; Drop Height = 40 in.; Carriage Attenuation: Felt Density 26S1 (1.0 in.), Seat Pan Attenuation: Blue Package Foam (Density = 0.027 lb/in^2); Peak Acceleration = 243.50 G, Integrated Velocity: Seat Pan = 6.13 m/s, Foot Rest = 6.06 m/s

TEST SERIES 3. Foot rest attenuation material assessment.

- **Test 1514:** Drop Height: 20 in., Foot rest Attenuation: 4 Golf Balls (CR = 35); Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest

- **Test 1518**: Drop Height: 20 in., Foot rest Attenuation: 10 Lacrosse Balls (2.5” Dia.); Test with 50th percentile Hybrid III manikin plus Boots; 20 lbs added to foot rest

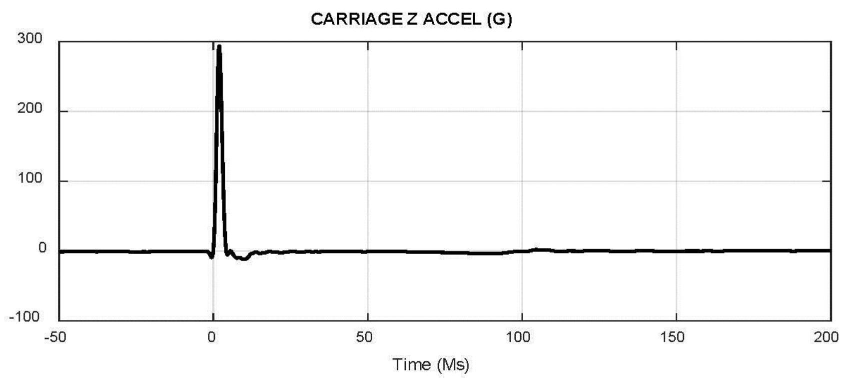
TEST SERIES 4. Carriage and foot rest attenuation material assessment.

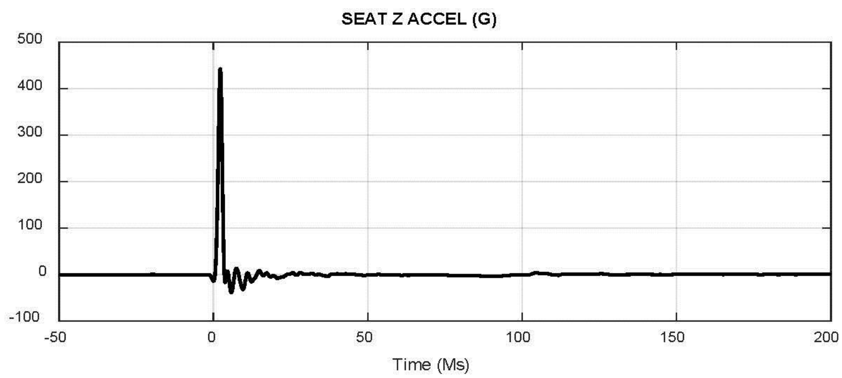
- **Test 1598**: Drop Height = 60 in.; Carriage Programmer: Felt Stack - 16S1 Felt, 2” thick pads (2); Footrest Programmer: 32S1 Felt, 0.5” thick; Carriage Velocity = 6.75 m/s

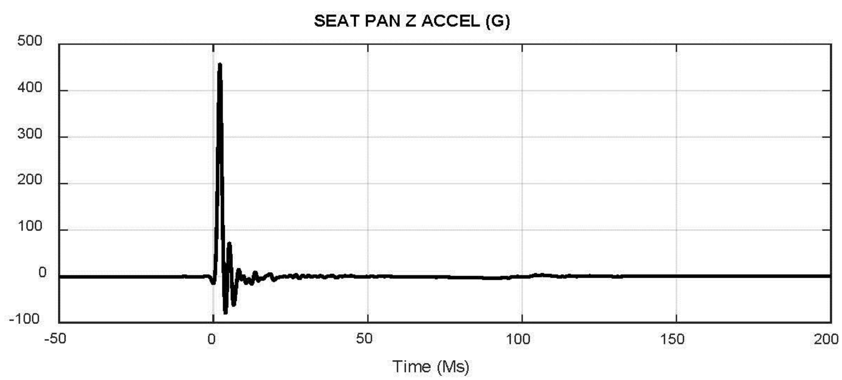
- **Test 1636**: Drop Height = 60 in.; Carriage Programmer: 4 “ Hexcel, 10 Blocks; Footrest Programmer: 95 A Polyethelene, 0.5” thick; Carriage Velocity = 4.72 m/s

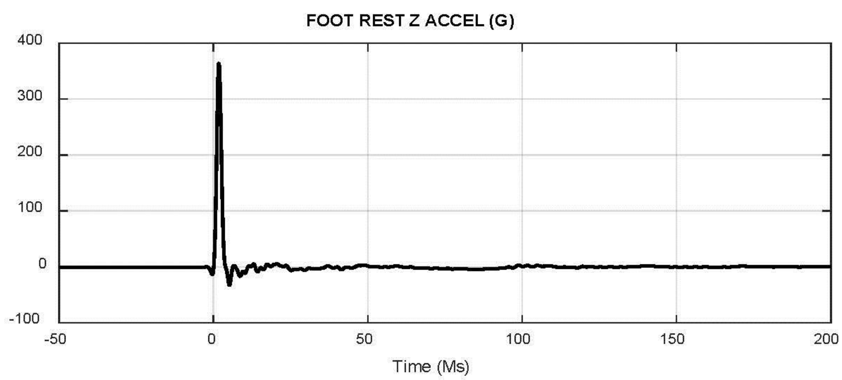
Test: VID1338 Date: 04-11-2014 Cell: SK4 Nom G: 350

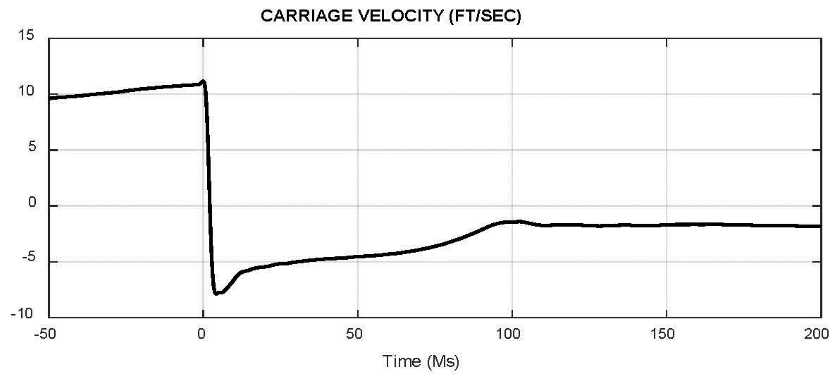
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Impact Rise Time (Ms)				1.9	
Impact Duration (Ms)				4.2	
CARRIAGE Z ACCEL (G)		293.99	-11.57	1.9	10.0
SEAT Z ACCEL (G)		442.35	-39.26	2.2	5.8
SEAT PAN Z ACCEL (G)		455.81	-78.98	2.1	3.9
FOOT REST Z ACCEL (G)		363.97	-33.05	1.8	5.2
CARRIAGE VELOCITY (FT/SEC)		11.17	-7.87	0.0	4.2
SEAT VELOCITY (FT/SEC)		12.87	-7.97	0.5	3.5
SEAT PAN VELOCITY (FT/SEC)		13.23	-7.55	0.5	3.3
FOOT REST VELOCITY (FT/SEC)		14.57	-5.57	0.1	3.9
		DeltaV		T2P	
CARRIAGE VELOCITY (FT/SEC)		19.04		4.2	
SEAT VELOCITY (FT/SEC)		20.84		3.0	
SEAT PAN VELOCITY (FT/SEC)		20.79		2.9	
FOOT REST VELOCITY (FT/SEC)		20.14		3.8	

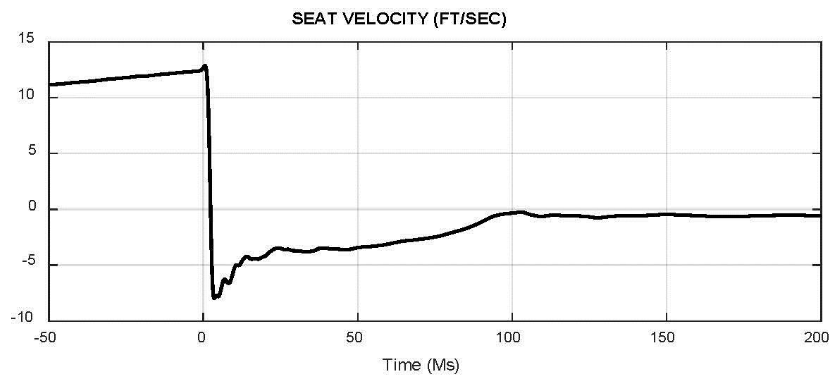

CARRIAGE Z ACCEL (G)
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)

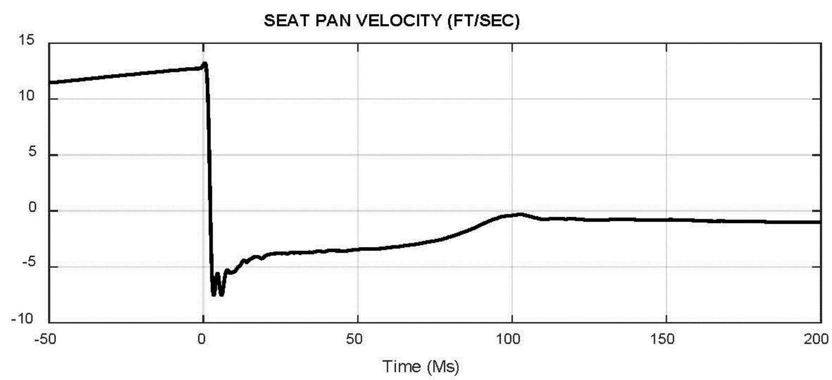

SEAT Z ACCEL (G)
500
400
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)

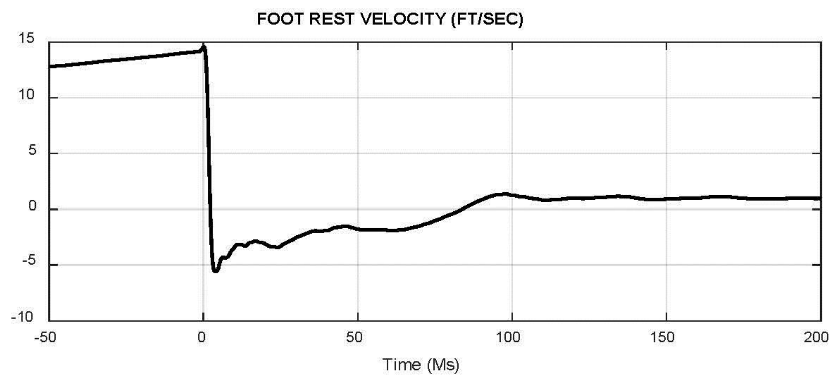

SEAT PAN Z ACCEL (G)
500
400
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)


FOOT REST Z ACCEL (G)
400
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)


CARRIAGE VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

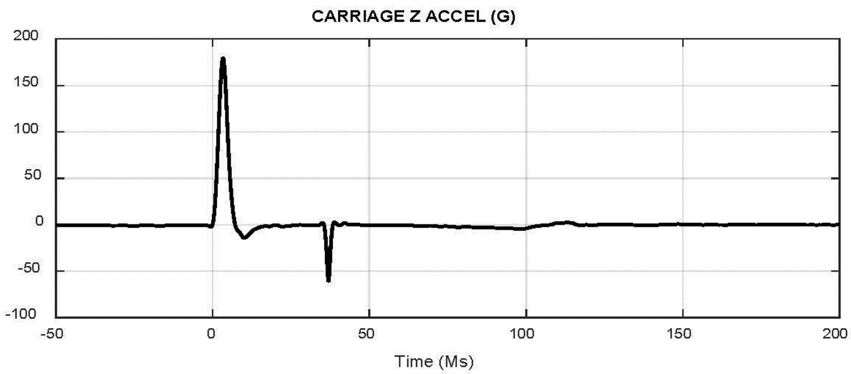

SEAT VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

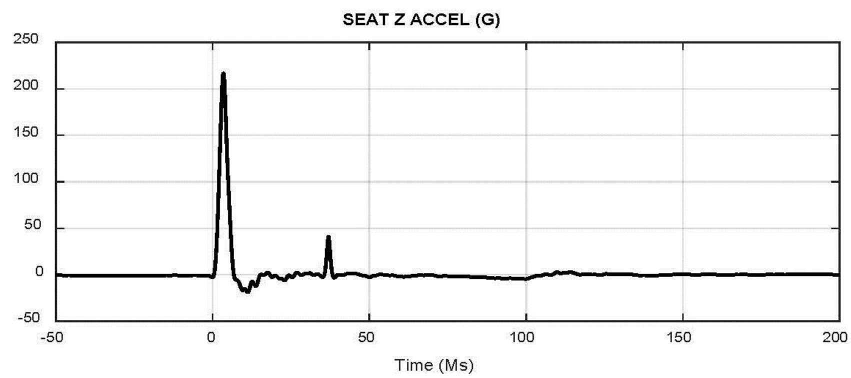

SEAT PAN VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

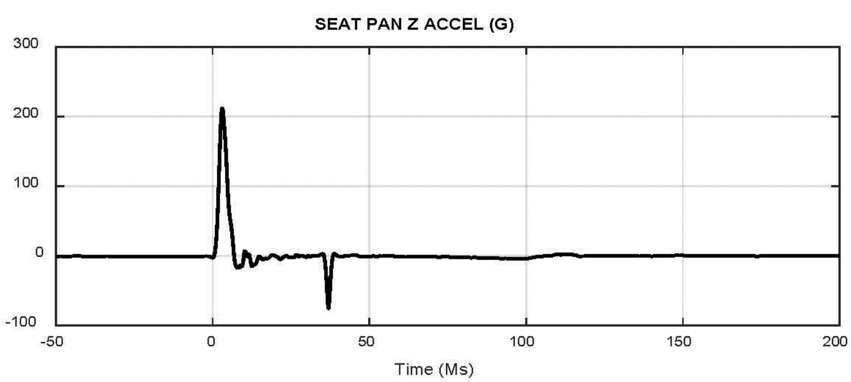

FOOT REST VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

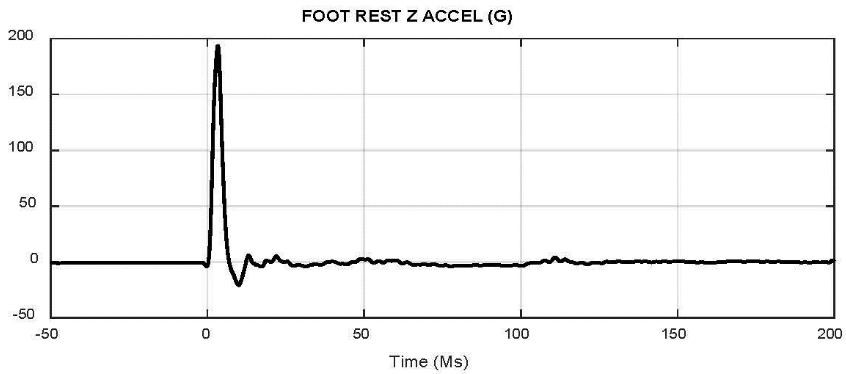
Test: VID1362 Date: 04-15-2014 Cell: SN4 Nom G: 175

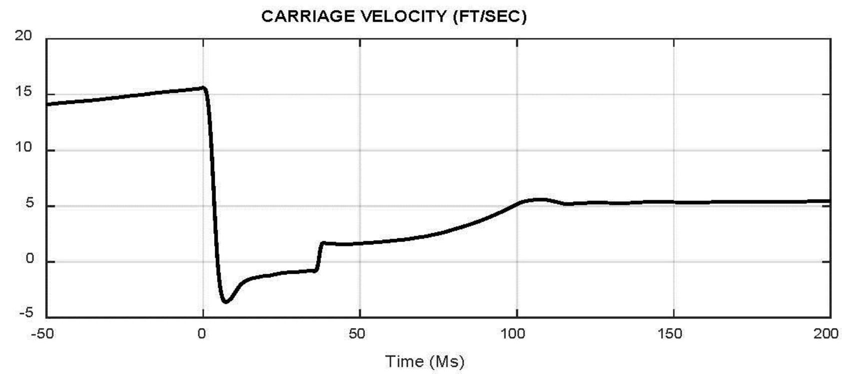
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Impact Rise Time (Ms)				3.3	
Impact Duration (Ms)				7.2	
CARRIAGE Z ACCEL (G)		179.33	-60.65	3.3	37.0
SEAT Z ACCEL (G)		216.67	-18.79	3.5	11.2
SEAT PAN Z ACCEL (G)		211.99	-75.29	3.0	37.0
FOOT REST Z ACCEL (G)		193.67	-20.83	3.4	10.0
CARRIAGE VELOCITY (FT/SEC)		15.62	-3.61	0.0	7.1
SEAT VELOCITY (FT/SEC)		9.60	-10.69	0.4	6.8
SEAT PAN VELOCITY (FT/SEC)		15.06	-5.03	0.5	6.9
FOOT REST VELOCITY (FT/SEC)		14.64	-5.37	0.3	7.0
		DeltaV		T2P	
CARRIAGE VELOCITY (FT/SEC)		19.23		7.2	
SEAT VELOCITY (FT/SEC)		20.29		6.4	
SEAT PAN VELOCITY (FT/SEC)		20.09		6.4	
FOOT REST VELOCITY (FT/SEC)		20.01		6.7	

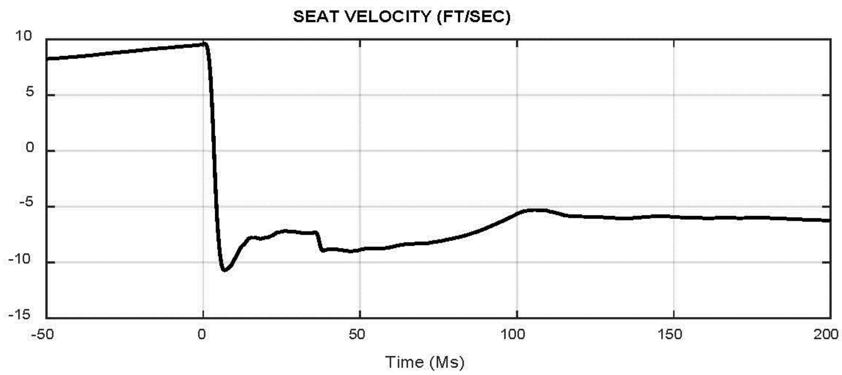

CARRIAGE Z ACCEL (G)
200
150
100
50
0
-50
-100
-50
0
50
100
150
200
Time (Ms)

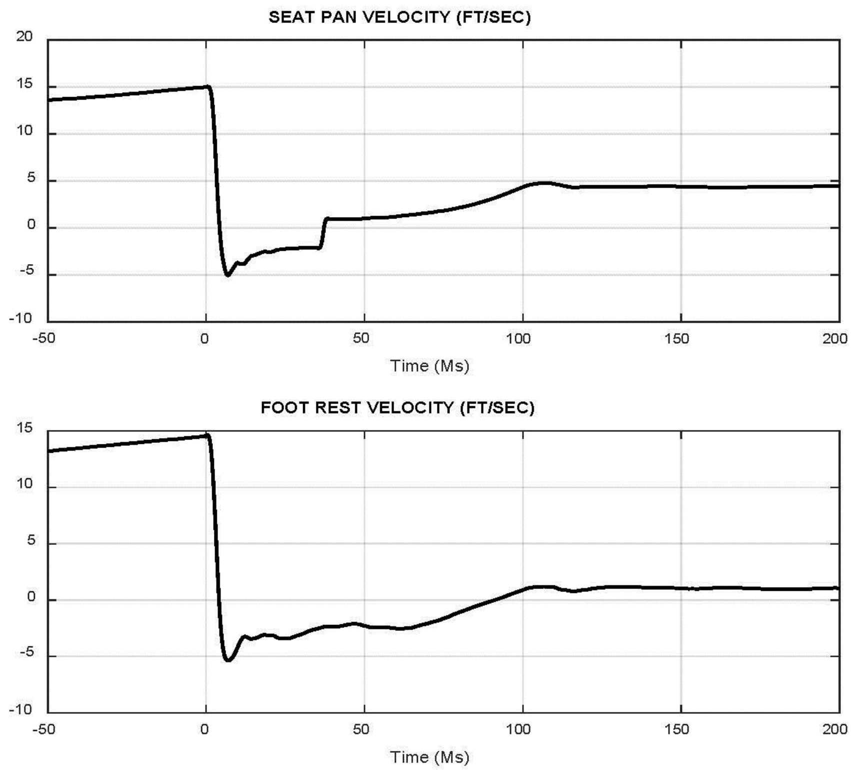

SEAT Z ACCEL (G)
250
200
150
100
50
0
-50
-50
0
50
100
150
200
Time (Ms)


SEAT PAN Z ACCEL (G)
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)


FOOT REST Z ACCEL (G)
200
150
100
50
0
-50
-50
0
50
100
150
200
Time (Ms)

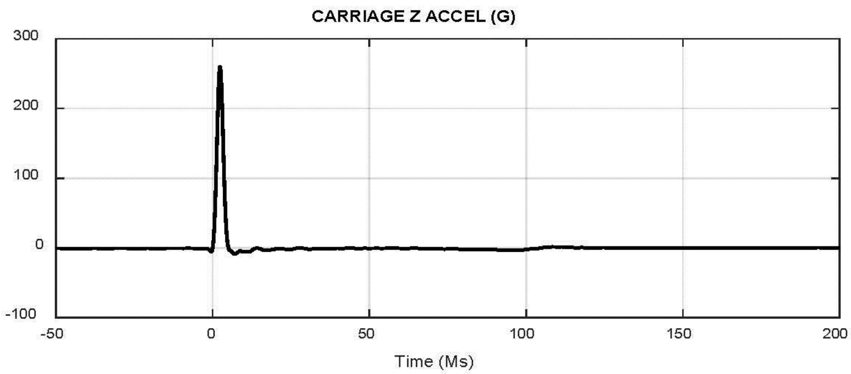

CARRIAGE VELOCITY (FT/SEC)
20
15
10
5
0
-5
-50
0
50
100
150
200
Time (Ms)

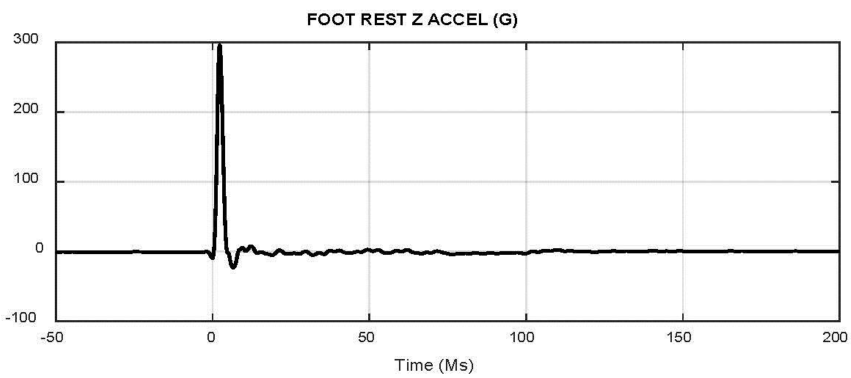

SEAT VELOCITY (FT/SEC)
10
5
0
-5
-10
-15
-50
0
50
100
150
200
Time (Ms)

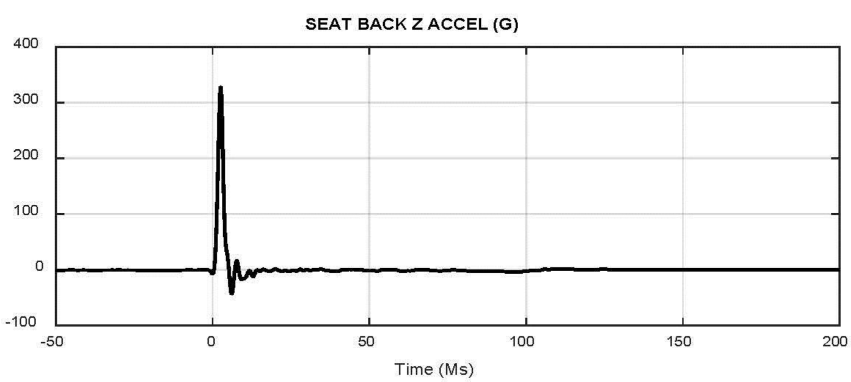

SEAT PAN VELOCITY (FT/SEC)
20
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)
FOOT REST VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

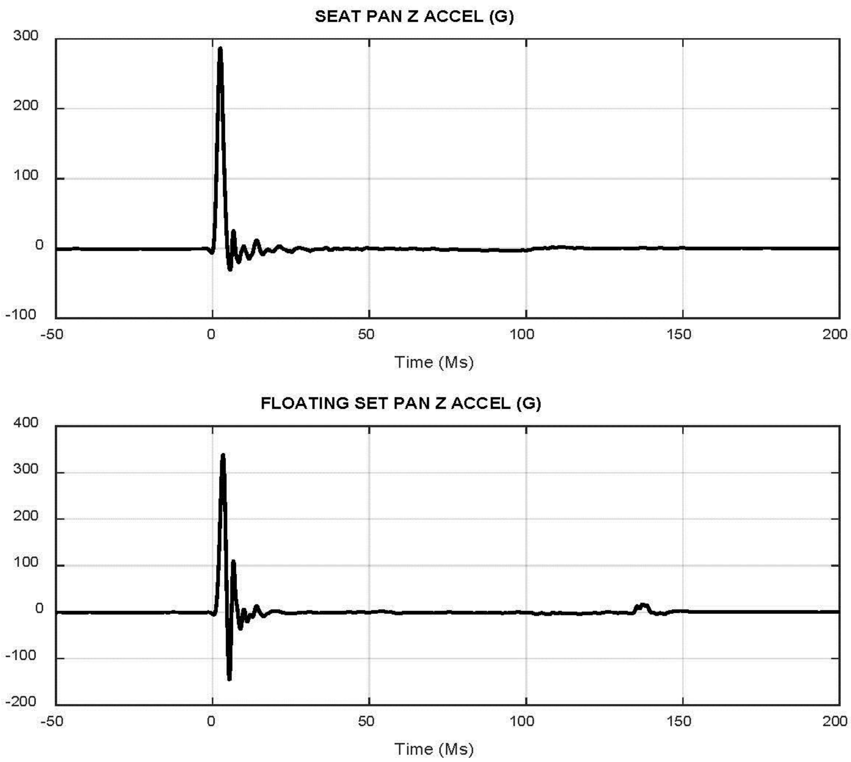
Test: VID1389 Date: 12-11-2014 Cell: SR2 Nom G: 400

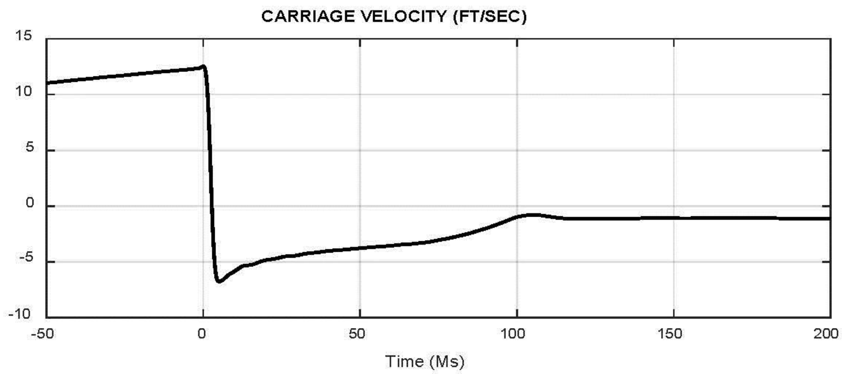
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Impact Rise Time (Ms)				2.4	
Impact Duration (Ms)				5.1	
CARRIAGE Z ACCEL (G)		260.00	-8.58	2.3	7.0
FOOT REST Z ACCEL (G)		295.74	-23.12	2.3	6.5
SEAT BACK Z ACCEL (G)		327.52	-43.06	2.5	6.0
SEAT PAN Z ACCEL (G)		286.98	-31.07	2.4	5.6
FLOATING SET PAN Z ACCEL (G)		338.38	-144.97	3.3	5.3
CARRIAGE VELOCITY (FT/SEC)		12.54	-6.77	0.0	5.0
FOOT REST VELOCITY (FT/SEC)		11.72	-7.54	0.4	4.6
SEAT BACK VELOCITY (FT/SEC)		12.22	-8.55	0.4	5.1
SEAT PAN VELOCITY (FT/SEC)		12.19	-8.03	0.2	4.7
FLOATING SET PAN VELOCITY (FT/SEC)		12.66	-8.06	0.8	4.6
		DeltaV		T2P	
CARRIAGE VELOCITY (FT/SEC)		19.31		5.0	
FOOT REST VELOCITY (FT/SEC)		19.26		4.2	
SEAT BACK VELOCITY (FT/SEC)		20.77		4.7	
SEAT PAN VELOCITY (FT/SEC)		20.22		4.5	
FLOATING SET PAN VELOCITY (FT/SEC)		20.72		3.8	


CARRIAGE Z ACCEL (G)
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)

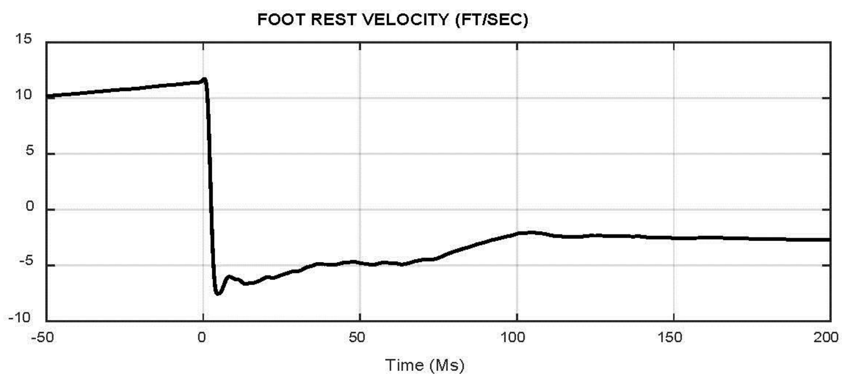

FOOT REST Z ACCEL (G)
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)


SEAT BACK Z ACCEL (G)
400
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)

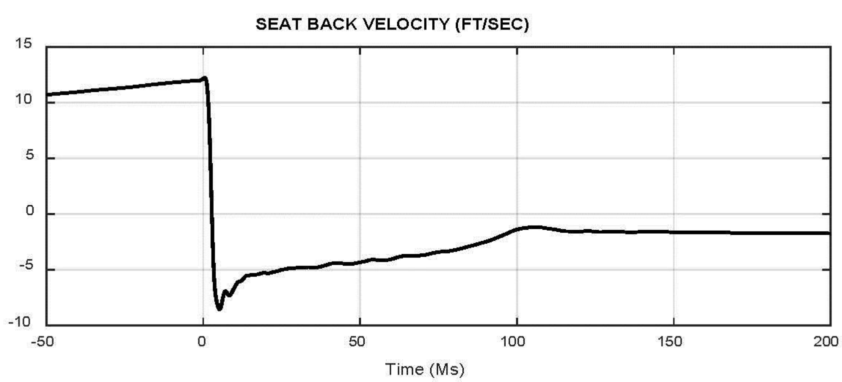

SEAT PAN Z ACCEL (G)
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)
FLOATING SET PAN Z ACCEL (G)
400
300
200
100
0
-100
-200
-50
0
50
100
150
200
Time (Ms)



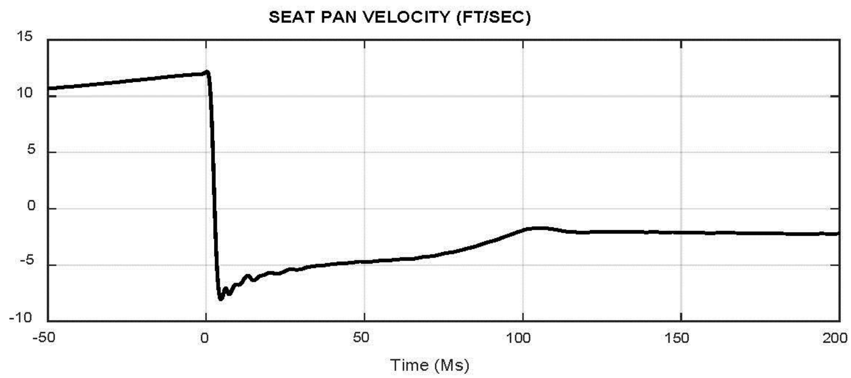
CARRIAGE VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

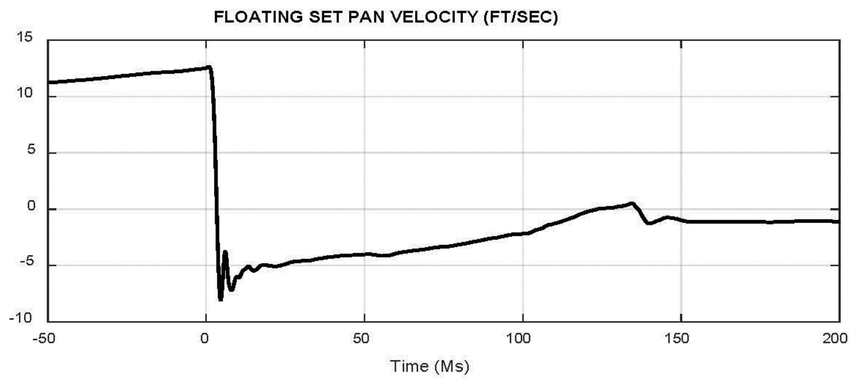


FOOT REST VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)



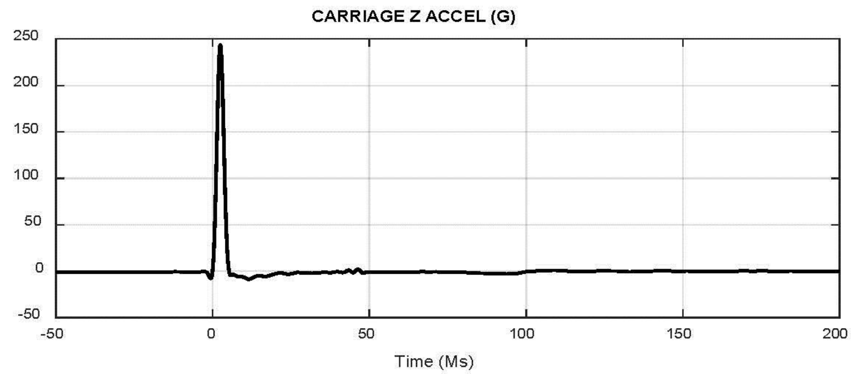
SEAT BACK VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

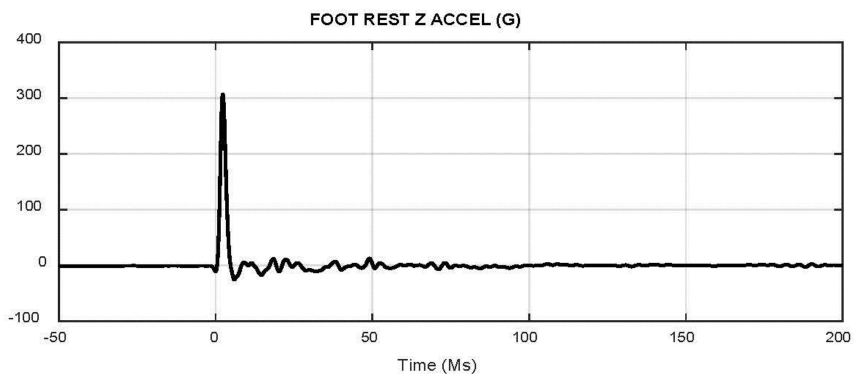

SEAT PAN VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

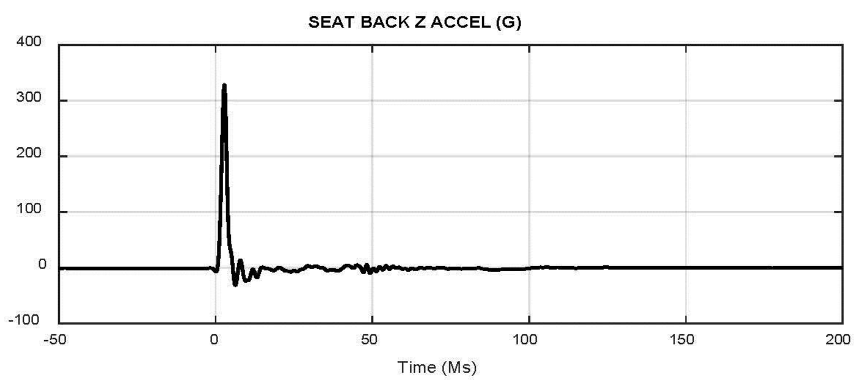

FLOATING SET PAN VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

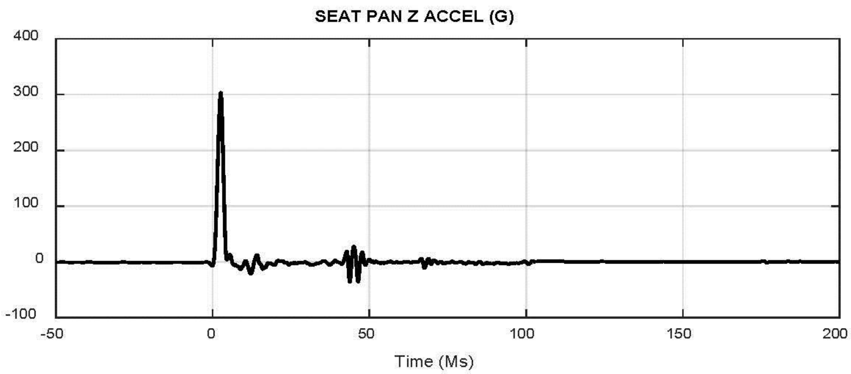
Test: VID1401 Date: 12-15-2014 Cell: SQ2 Nom G: 400

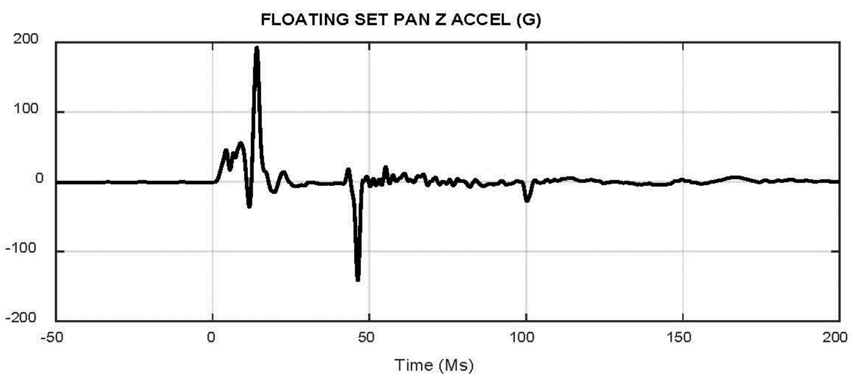
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Impact Rise Time (Ms)				2.5	
Impact Duration (Ms)				5.2	
CARRIAGE Z ACCEL (G)		243.50	-8.80	2.5	11.5
FOOT REST Z ACCEL (G)		307.04	-25.24	2.3	6.0
SEAT BACK Z ACCEL (G)		328.43	-31.29	2.8	6.3
SEAT PAN Z ACCEL (G)		303.33	-35.71	2.6	43.8
FLOATING SET PAN Z ACCEL (G)		192.61	-141.14	14.1	46.3
CARRIAGE VELOCITY (FT/SEC)		12.12	-7.70	0.0	5.2
FOOT REST VELOCITY (FT/SEC)		13.86	-6.01	0.5	4.8
SEAT BACK VELOCITY (FT/SEC)		14.23	-6.78	0.6	5.5
SEAT PAN VELOCITY (FT/SEC)		13.48	-6.63	0.4	6.2
FLOATING SET PAN VELOCITY (FT/SEC)		14.53	-7.54	0.9	17.8
		DeltaV		T2P	
CARRIAGE VELOCITY (FT/SEC)		19.82		5.3	
FOOT REST VELOCITY (FT/SEC)		19.87		4.3	
SEAT BACK VELOCITY (FT/SEC)		21.01		4.8	
SEAT PAN VELOCITY (FT/SEC)		20.11		5.8	
FLOATING SET PAN VELOCITY (FT/SEC)		22.07		16.9	

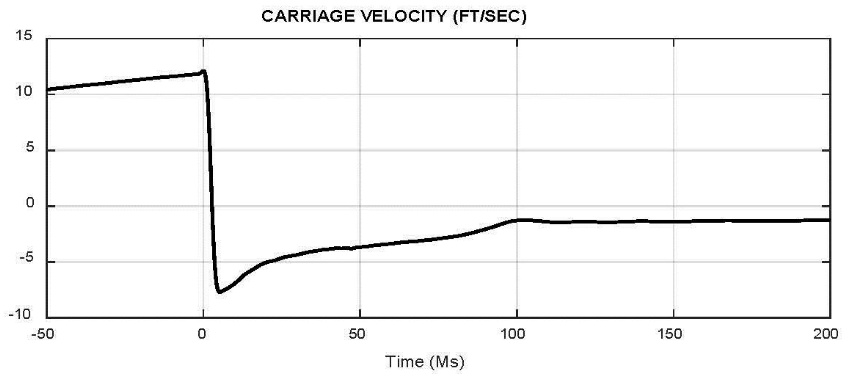

CARRIAGE Z ACCEL (G)
250
200
150
100
50
0
-50
-50
0
50
100
150
200
Time (Ms)

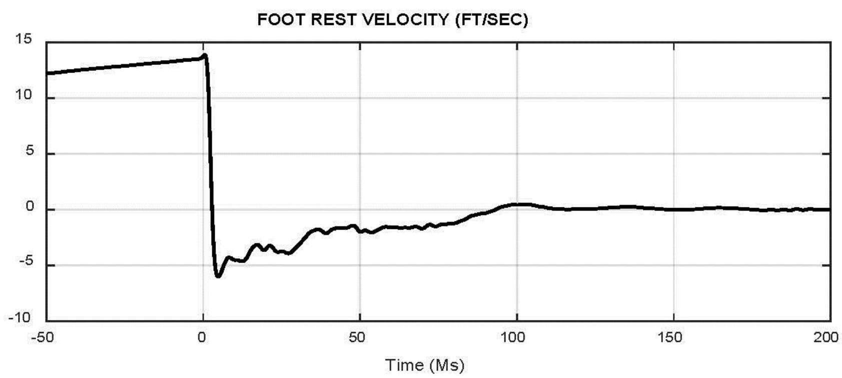

FOOT REST Z ACCEL (G)
400
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)

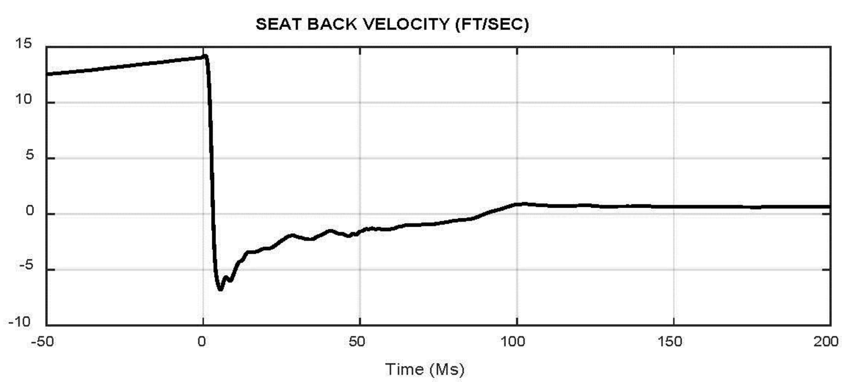

SEAT BACK Z ACCEL (G)
400
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)

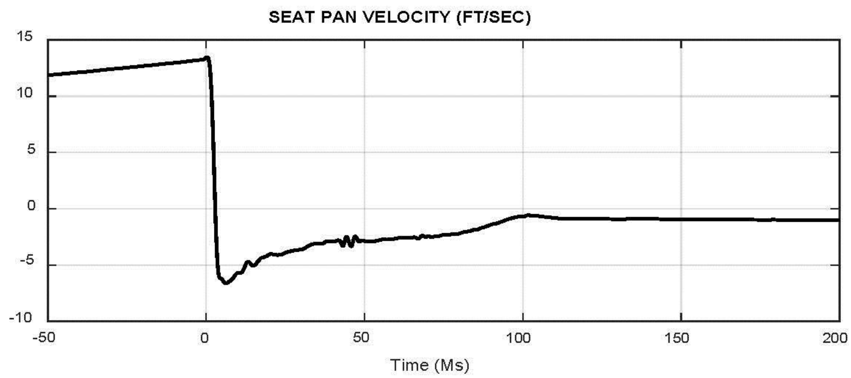

SEAT PAN Z ACCEL (G)
400
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)

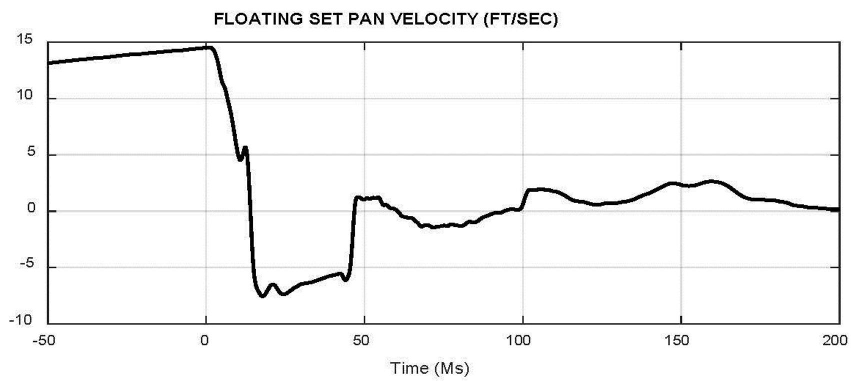

FLOATING SET PAN Z ACCEL (G)
200
100
0
-100
-200
-50
0
50
100
150
200
Time (Ms)


CARRIAGE VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)


FOOT REST VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

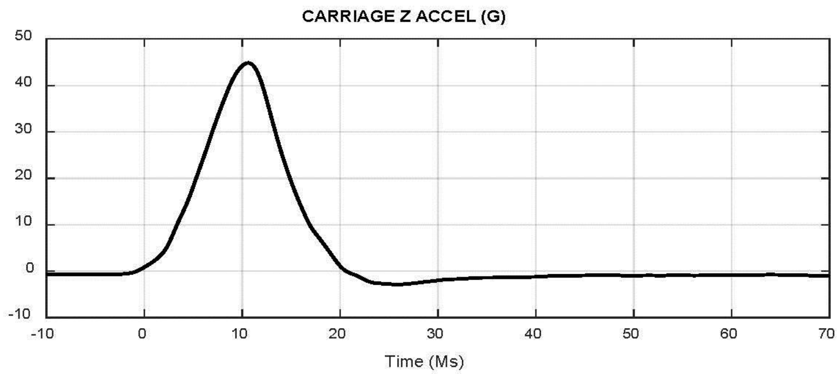

SEAT BACK VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

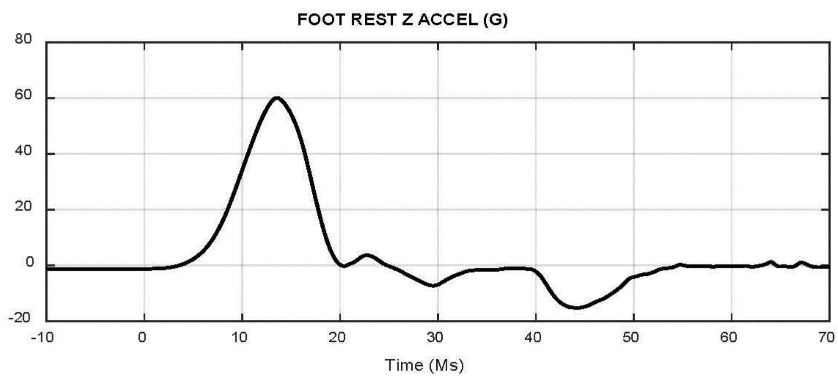

SEAT PAN VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

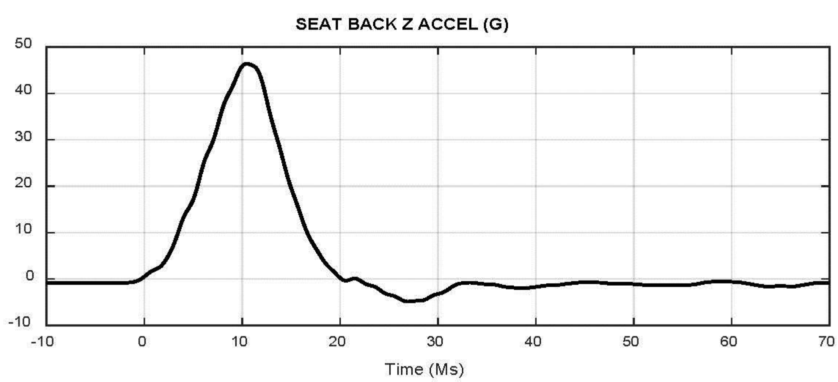

FLOATING SET PAN VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

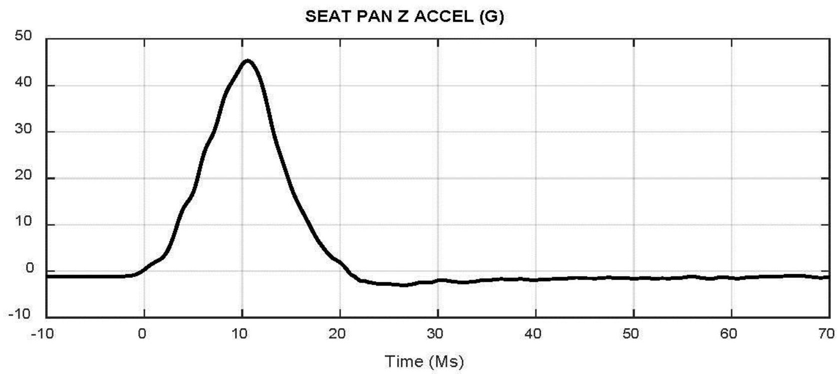
Test: 1514 Facility: VID Date: 05/29/15 Cell: FZ2 Subject: HB3-50

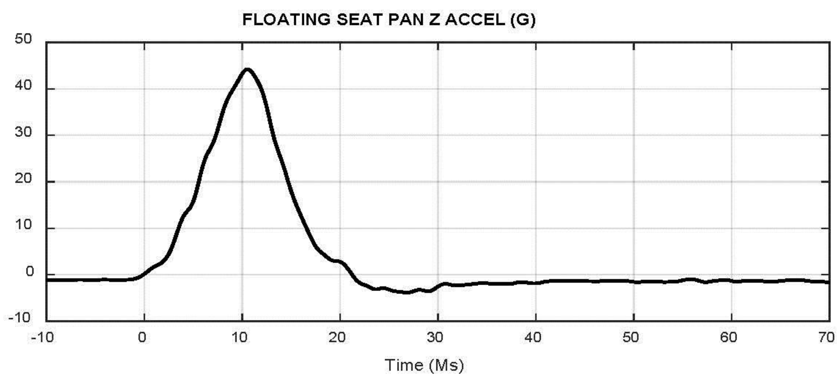
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
CARRIAGE Z ACCEL (G)		44.85	-2.89	10.6	25.9
FOOT REST Z ACCEL (G)		60.06	-15.22	13.5	44.2
SEAT BACK Z ACCEL (G)		46.36	-4.87	10.5	26.9
SEAT PAN Z ACCEL (G)		45.32	-3.03	10.6	26.6
FLOATING SEAT PAN Z ACCEL (G)		44.19	-3.87	10.5	26.8
CARRIAGE Z VELOCITY (FT/SEC)		2.28	-11.25	-0.8	20.6
FOOT REST Z VELOCITY (FT/SEC)		22.35	7.30	3.6	24.8
SEAT BACK Z VELOCITY (FT/SEC)		8.32	-5.23	-0.3	20.1
SEAT PAN Z VELOCITY (FT/SEC)		18.37	5.11	-0.2	20.8
FLOATING SEAT PAN Z VELOCITY (FT/SEC)		17.83	4.97	-0.1	21.2
		DeltaV		T2P	
CARRIAGE Z VELOCITY (FT/SEC)		13.54		21.4	
FOOT REST Z VELOCITY (FT/SEC)		15.06		21.2	
SEAT BACK Z VELOCITY (FT/SEC)		13.55		20.5	
SEAT PAN Z VELOCITY (FT/SEC)		13.26		21.0	
FLOATING SEAT PAN Z VELOCITY (FT/SEC)		12.85		21.4	

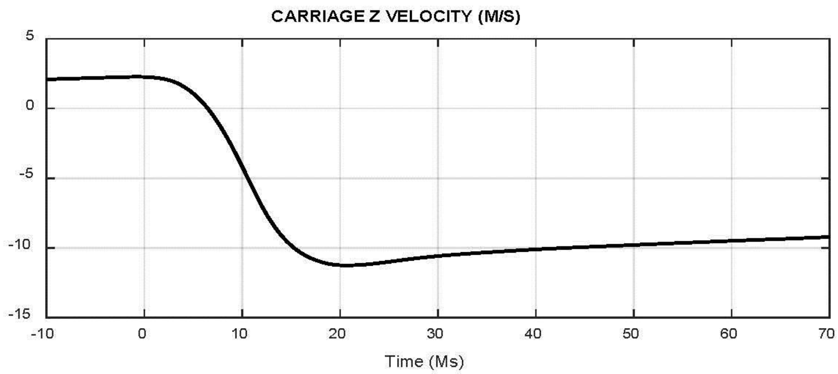

CARRIAGE Z ACCEL (G)
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)

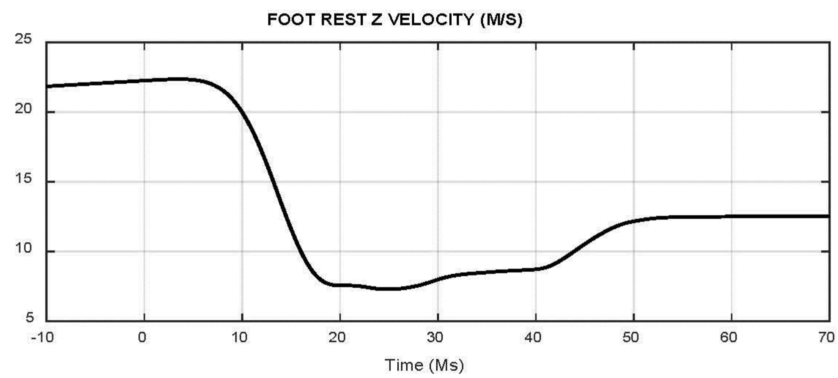

FOOT REST Z ACCEL (G)
80
60
40
20
0
-20
-10
0
10
20
30
40
50
60
70
Time (Ms)

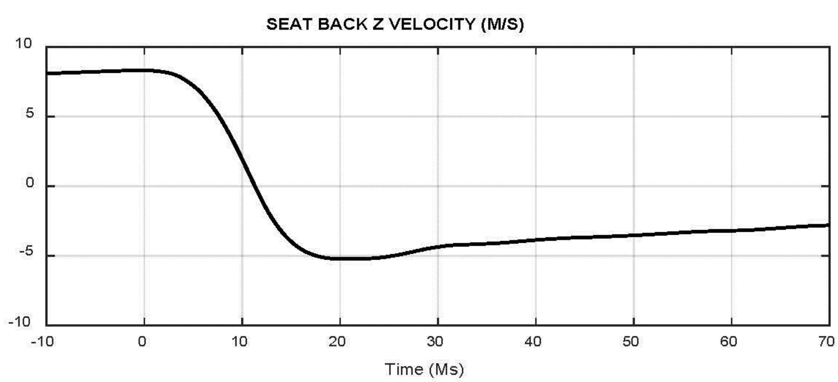

SEAT BACK Z ACCEL (G)
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)

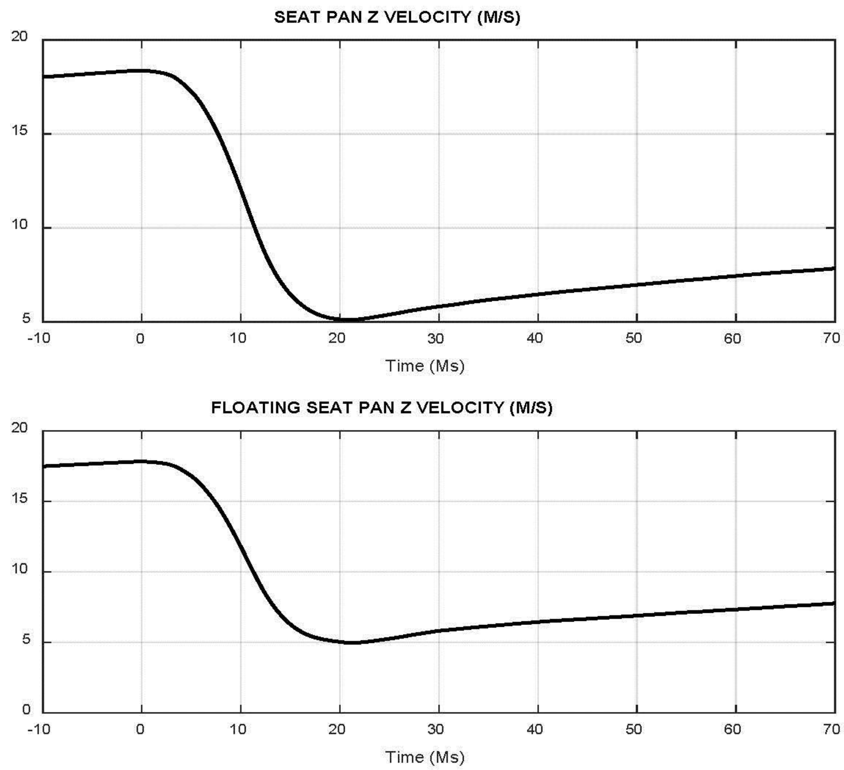

SEAT PAN Z ACCEL (G)
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)


FLOATING SEAT PAN Z ACCEL (G)
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)


CARRIAGE Z VELOCITY (M/S)
5
0
-5
-10
-15
-10
0
10
20
30
40
50
60
70
Time (Ms)

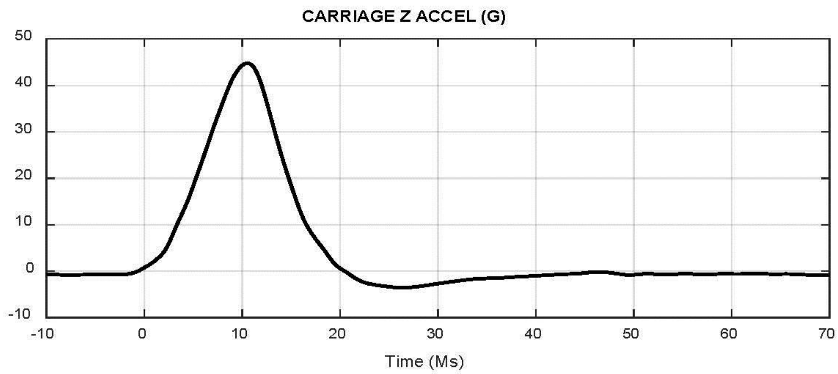

FOOT REST Z VELOCITY (M/S)
25
20
15
10
5
-10
0
10
20
30
40
50
60
70
Time (Ms)

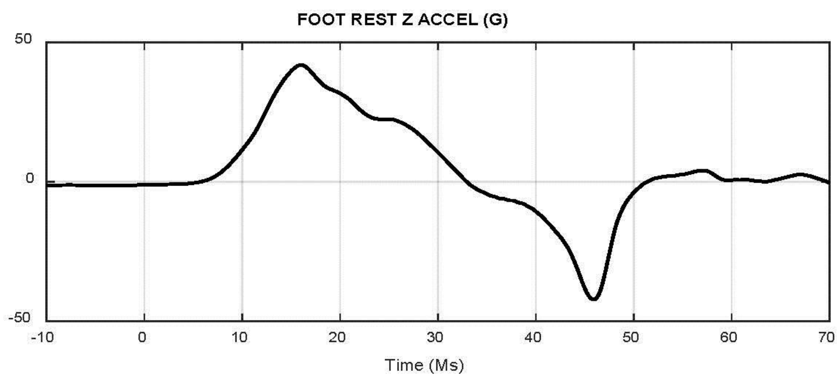

SEAT BACK Z VELOCITY (M/S)
10
5
0
-5
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)

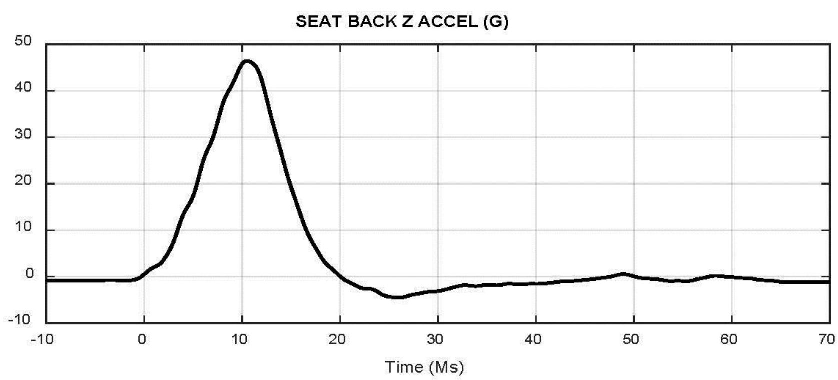

SEAT PAN Z VELOCITY (M/S)
20
15
10
5
-10
0
10
20
30
40
50
60
70
Time (Ms)
FLOATING SEAT PAN Z VELOCITY (M/S)
20
15
10
5
0
-10
0
10
20
30
40
50
60
70
Time (Ms)

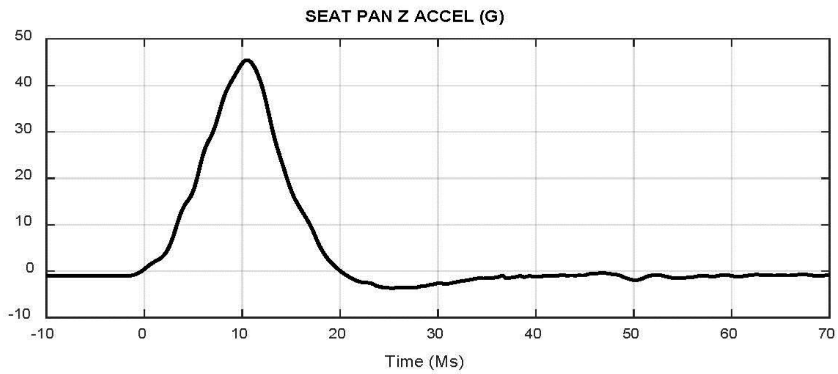
Test: 1518 Facility: VID Date: 06/03/15 Cell: FA20 Subject: HB3-50

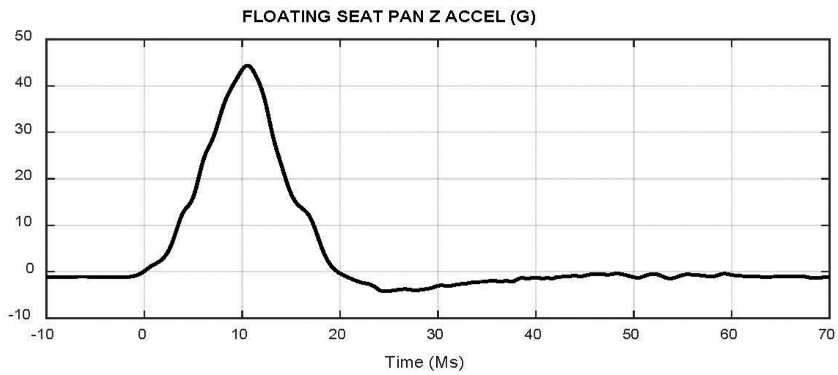
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
CARRIAGE Z ACCEL (G)		44.78	-3.55	10.5	26.2
FOOT REST Z ACCEL (G)		41.83	-42.25	16.0	45.9
SEAT BACK Z ACCEL (G)		46.38	-4.51	10.5	26.0
SEAT PAN Z ACCEL (G)		45.45	-3.67	10.5	25.3
FLOATING SEAT PAN Z ACCEL (G)		44.34	-4.19	10.5	24.5
CARRIAGE Z VELOCITY (FT/SEC)		6.16	-7.15	-0.6	20.5
FOOT REST Z VELOCITY (FT/SEC)		18.81	0.61	5.8	32.9
SEAT BACK Z VELOCITY (FT/SEC)		6.95	-6.53	-0.3	20.0
SEAT PAN Z VELOCITY (FT/SEC)		13.96	0.78	-0.3	20.0
FLOATING SEAT PAN Z VELOCITY (FT/SEC)		16.56	3.78	-0.1	19.7
		DeltaV		T2P	
CARRIAGE Z VELOCITY (FT/SEC)		13.31		21.1	
FOOT REST Z VELOCITY (FT/SEC)		18.19		27.2	
SEAT BACK Z VELOCITY (FT/SEC)		13.48		20.3	
SEAT PAN Z VELOCITY (FT/SEC)		13.18		20.3	
FLOATING SEAT PAN Z VELOCITY (FT/SEC)		12.79		19.8	

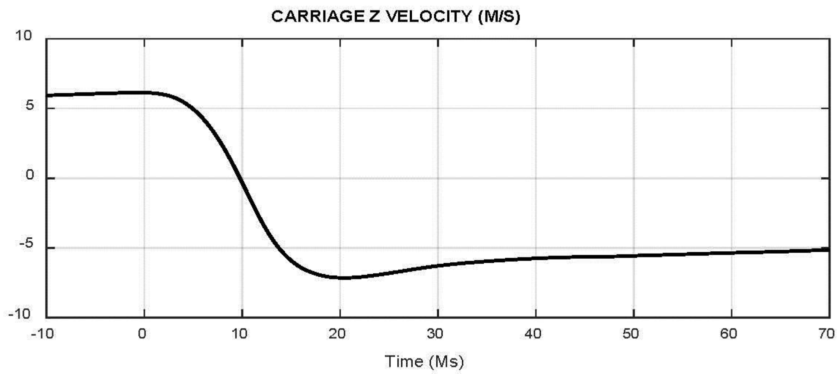

CARRIAGE Z ACCEL (G)
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)

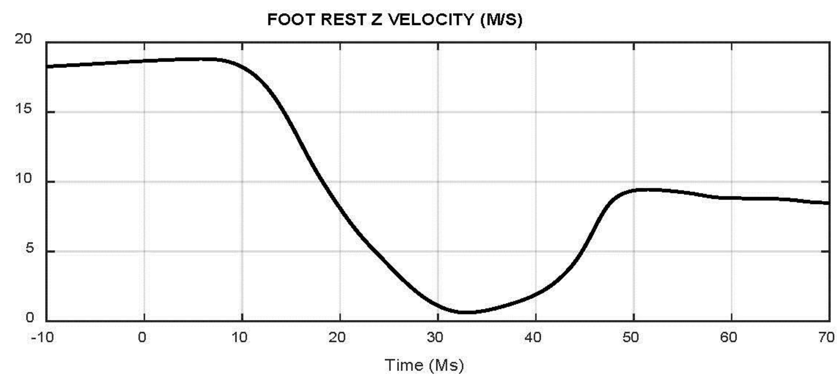

FOOT REST Z ACCEL (G)
50
0
-50
-10
0
10
20
30
40
50
60
70
Time (Ms)

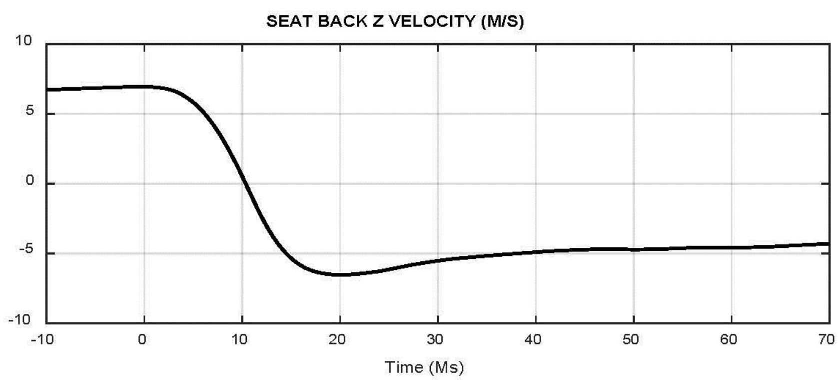

SEAT BACK Z ACCEL (G)
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)

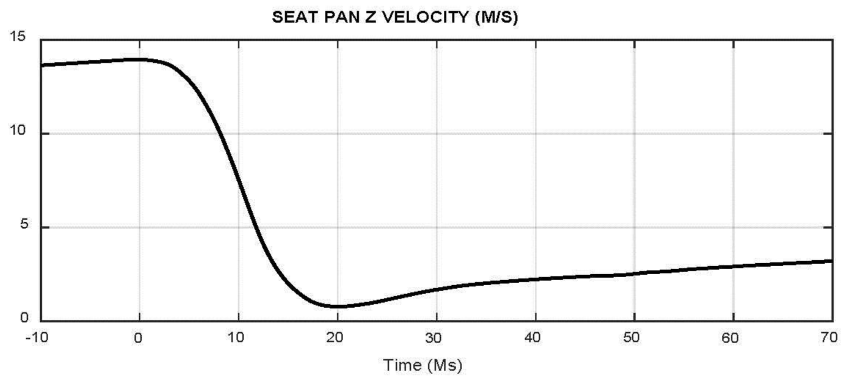

SEAT PAN Z ACCEL (G)
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)

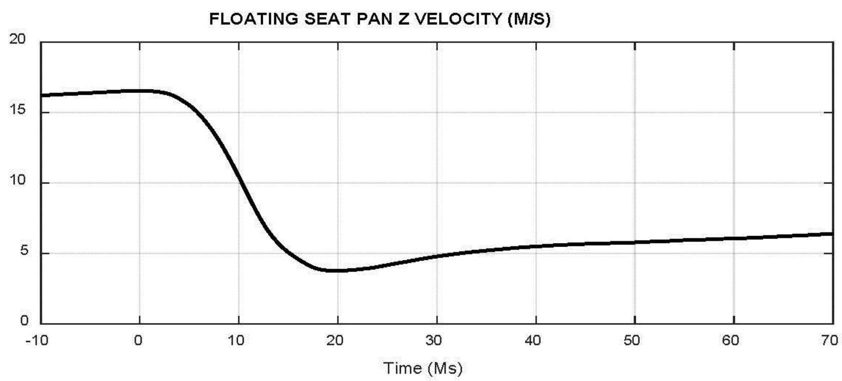

FLOATING SEAT PAN Z ACCEL (G)
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)


CARRIAGE Z VELOCITY (M/S)
10
5
0
-5
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)


FOOT REST Z VELOCITY (M/S)
20
15
10
5
0
-10
0
10
20
30
40
50
60
70
Time (Ms)

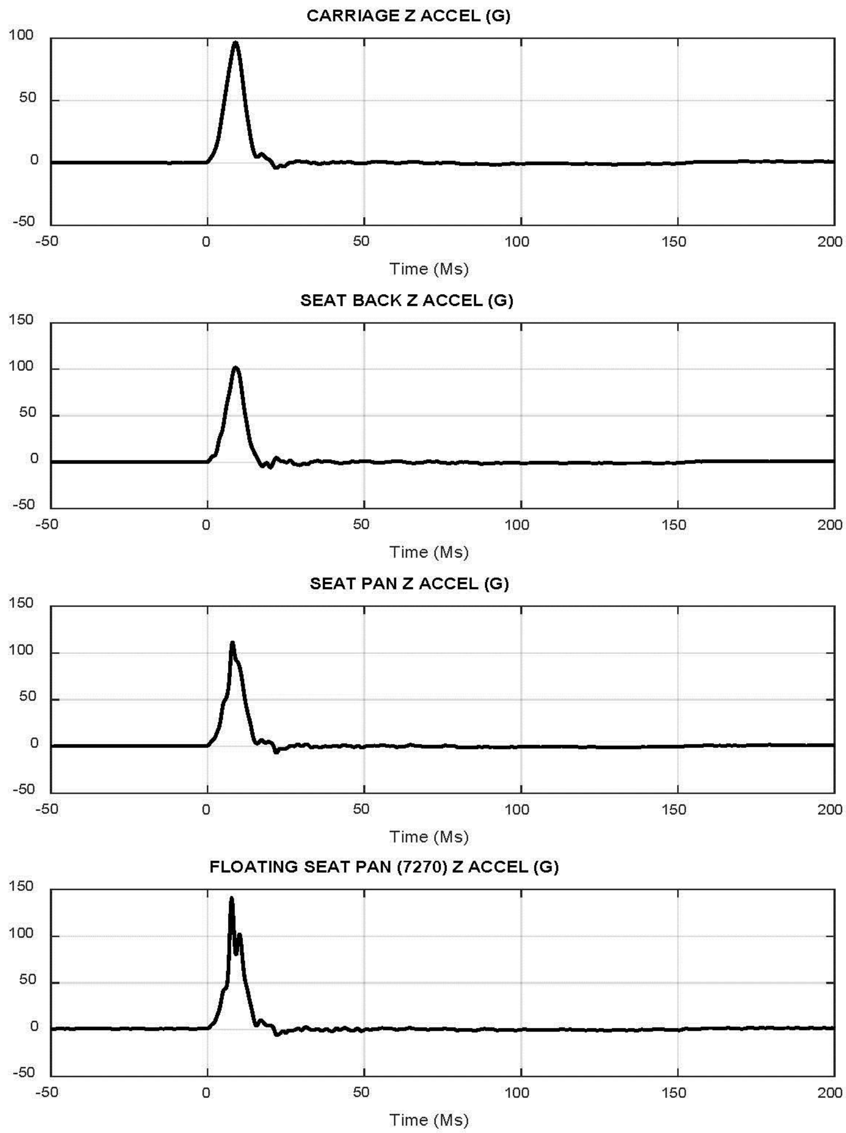

SEAT BACK Z VELOCITY (M/S)
10
5
0
-5
-10
-10
0
10
20
30
40
50
60
70
Time (Ms)

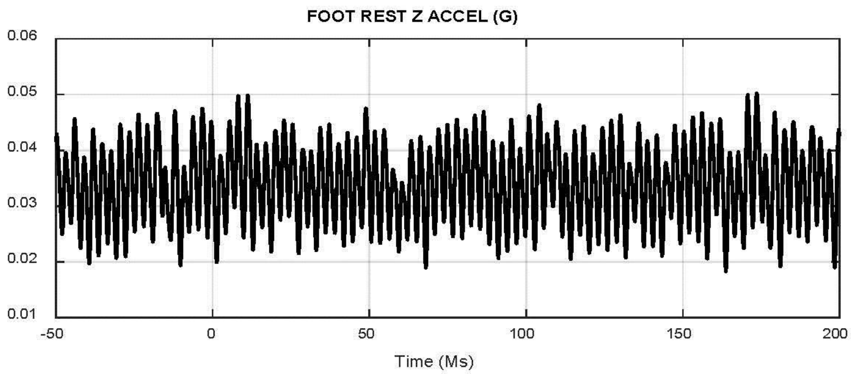

SEAT PAN Z VELOCITY (M/S)
15
10
5
0
-10
0
10
20
30
40
50
60
70
Time (Ms)

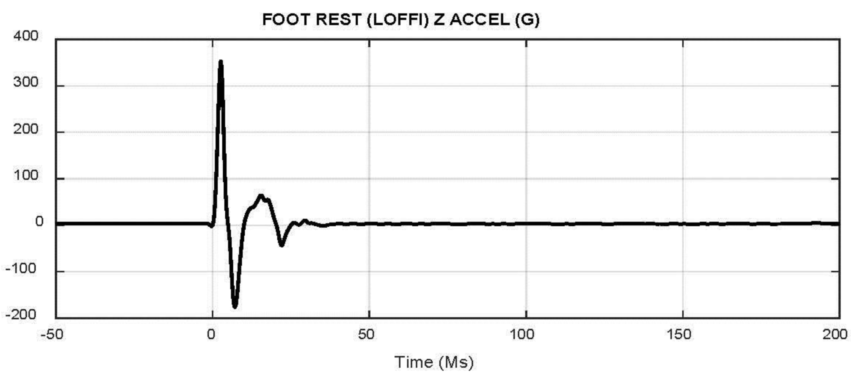

FLOATING SEAT PAN Z VELOCITY (M/S)
20
15
10
5
0
-10
0
10
20
30
40
50
60
70
Time (Ms)

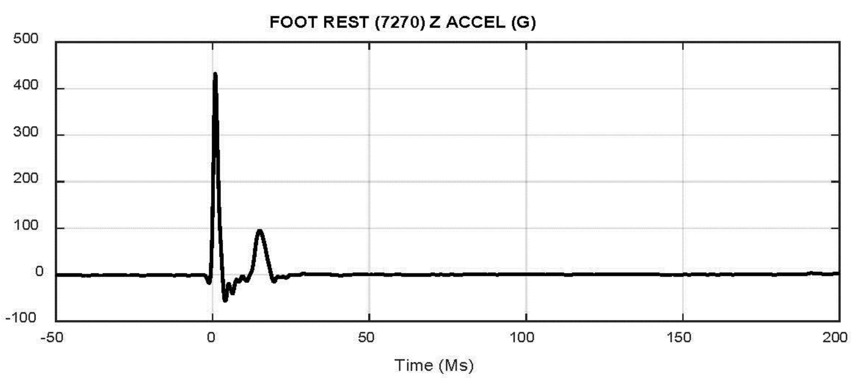
Test: VID1598 Date: 01-21-2016 Cell: PROOF60 Nom G: 60

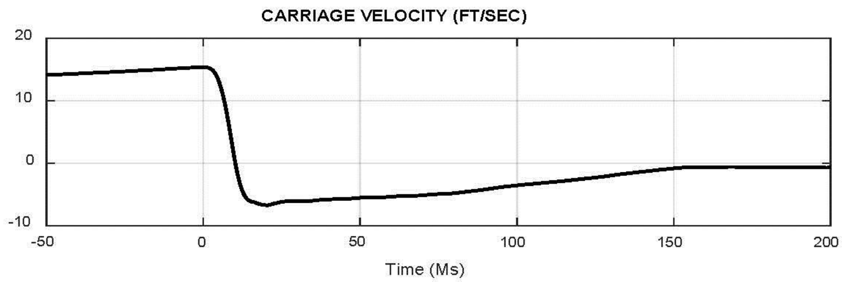
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Impact Rise Time (Ms)				8.9	
Impact Duration (Ms)				20.3	
CARRIAGE Z ACCEL (G)		96.77	-4.03	8.9	21.9
SEAT BACK Z ACCEL (G)		101.92	-5.86	8.9	20.0
SEAT PAN Z ACCEL (G)		111.52	-7.01	7.9	22.0
FLOATING SEAT PAN (7270) Z ACCEL (G)		140.91	-6.09	7.7	22.1
FOOT REST Z ACCEL (G)		0.05	0.02	173.6	163.7
FOOT REST (LOFFI) Z ACCEL (G)		353.24	-176.22	2.6	7.1
FOOT REST (7270) Z ACCEL (G)		431.69	-56.31	0.8	4.0
CARRIAGE VELOCITY (FT/SEC)		15.42	-6.72	0.0	20.3
SEAT BACK VELOCITY (FT/SEC)		16.27	-6.04	0.3	16.3
SEAT PAN VELOCITY (FT/SEC)		15.85	-6.48	0.2	20.9
FLOATING SEAT PAN (7270) VELOCITY (FT/SEC)		15.81	-8.13	0.3	21.0
FOOT REST VELOCITY (FT/SEC)		0.03	0.02	-27.1	194.9
FOOT REST (LOFFI) VELOCITY (FT/SEC)		15.15	-9.26	0.2	4.9
FOOT REST (7270) VELOCITY (FT/SEC)		15.63	-14.86	-0.6	200.0
		DeltaV		T2P	
CARRIAGE VELOCITY (FT/SEC)		22.14		20.3	
		21.52		29.7	
		21.52		31.8	
SEAT BACK VELOCITY (FT/SEC)		22.31		16.1	
		21.90		23.4	
		21.89		26.6	
SEAT PAN VELOCITY (FT/SEC)		22.33		20.7	
		21.62		29.1	
		21.62		32.0	
FLOATING SEAT PAN (7270) VELOCITY (FT/SEC)		23.95		20.7	
		22.89		31.6	
		22.19		43.7	
FOOT REST VELOCITY (FT/SEC)		0.00		1.6	
		0.00		4.5	
		0.00		7.2	
FOOT REST (LOFFI) VELOCITY (FT/SEC)		24.41		4.7	
		20.38		20.0	
		16.50		26.4	
FOOT REST (7270) VELOCITY (FT/SEC)		23.62		3.8	
		28.79		19.3	
		27.55		26.0	

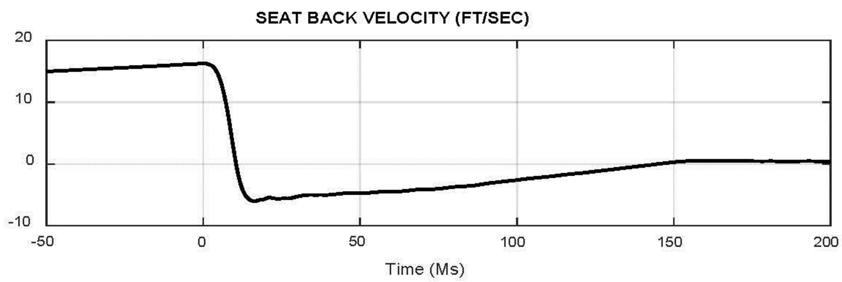

CARRIAGE Z ACCEL (G)
100
50
0
-50
-50
0
50
100
150
200
Time (Ms)
SEAT BACK Z ACCEL (G)
150
100
50
0
-50
-50
0
50
100
150
200
Time (Ms)
SEAT PAN Z ACCEL (G)
150
100
50
0
-50
-50
0
50
100
150
200
Time (Ms)
FLOATING SEAT PAN (7270) Z ACCEL (G)
150
100
50
0
-50
-50
0
50
100
150
200
Time (Ms)

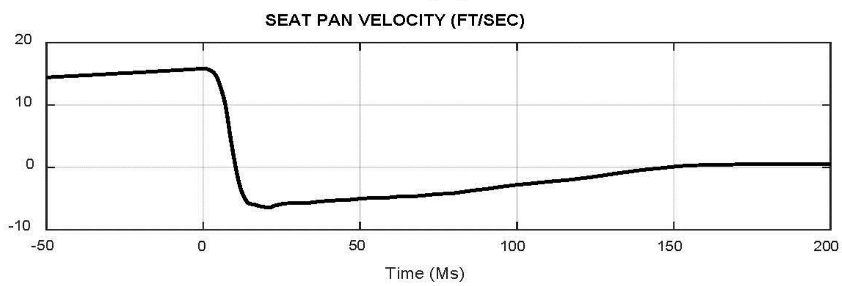

FOOT REST Z ACCEL (G)
0.06
0.05
0.04
0.03
0.02
0.01
-50
0
50
100
150
200
Time (Ms)

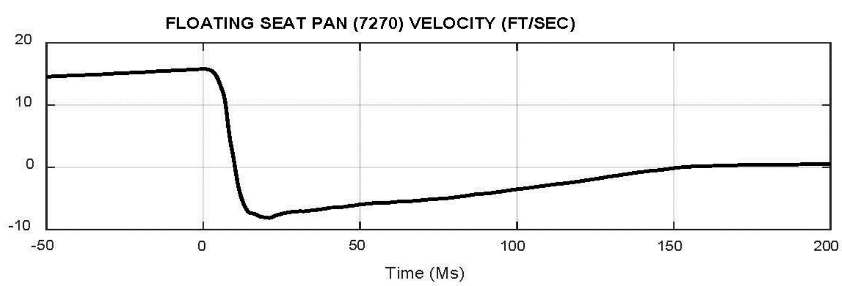

FOOT REST (LOFFI) Z ACCEL (G)
400
300
200
100
0
-100
-200
-50
0
50
100
150
200
Time (Ms)

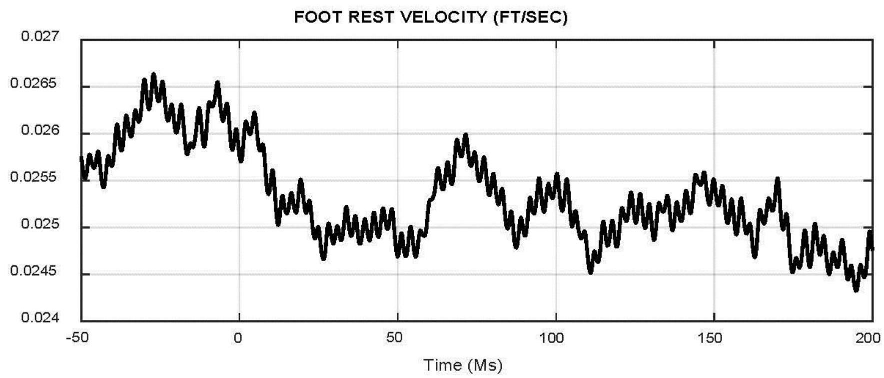

FOOT REST (7270) Z ACCEL (G)
500
400
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)

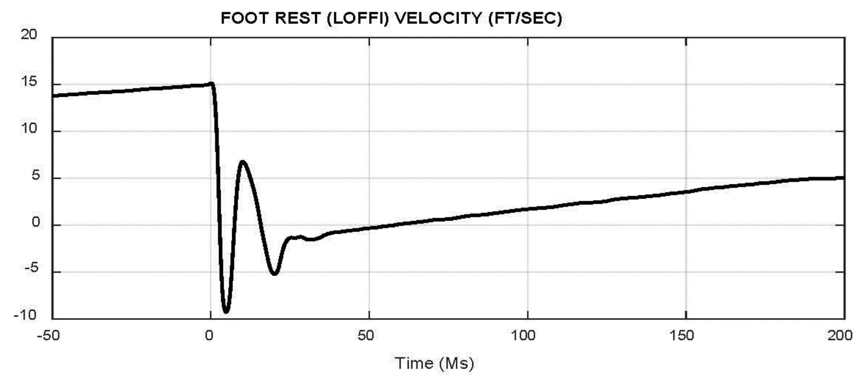

CARRIAGE VELOCITY (FT/SEC)
20
10
0
-10
-50
0
50
100
150
200
Time (Ms)

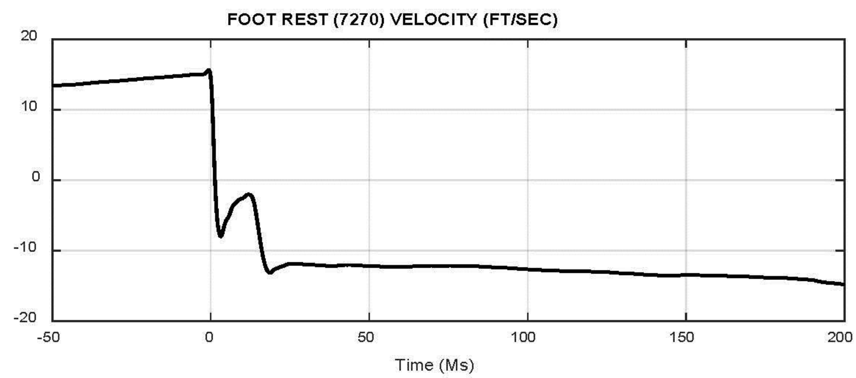

SEAT BACK VELOCITY (FT/SEC)
20
10
0
-10
-50
0
50
100
150
200
Time (Ms)


SEAT PAN VELOCITY (FT/SEC)
20
10
0
-10
-50
0
50
100
150
200
Time (Ms)


FLOATING SEAT PAN (7270) VELOCITY (FT/SEC)
20
10
0
-10
-50
0
50
100
150
200
Time (Ms)

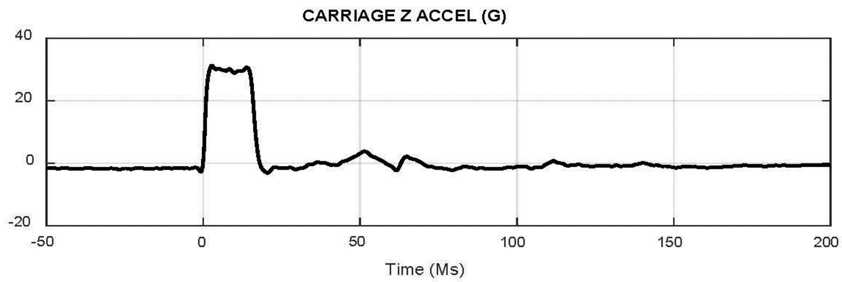

FOOT REST VELOCITY (FT/SEC)
0.027
0.0265
0.026
0.0255
0.025
0.0245
0.024
-50
0
50
100
150
200
Time (Ms)

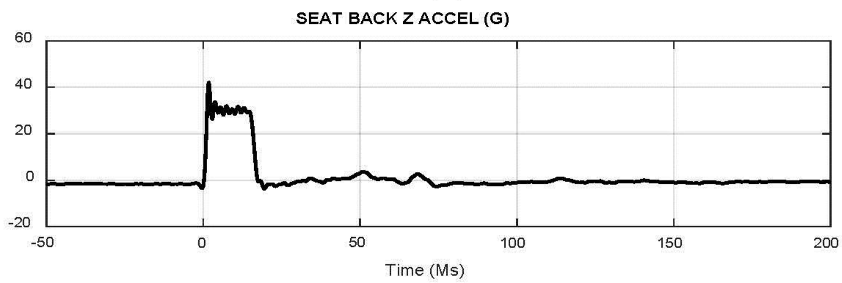

FOOT REST (LOFFI) VELOCITY (FT/SEC)
20
15
10
5
0
-5
-10
-50
0
50
100
150
200
Time (Ms)

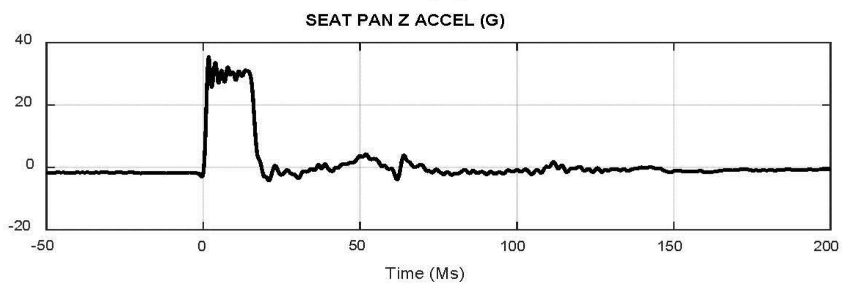

FOOT REST (7270) VELOCITY (FT/SEC)
20
10
0
-10
-20
-50
0
50
100
150
200
Time (Ms)

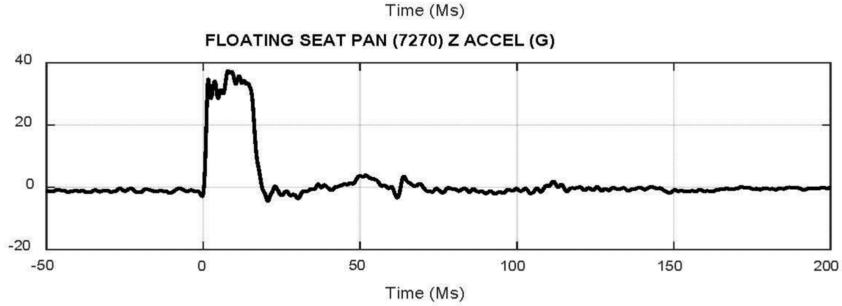
Test: VID1636 Date: 02-18-2016 Cell: PROOF60 Nom G: 60

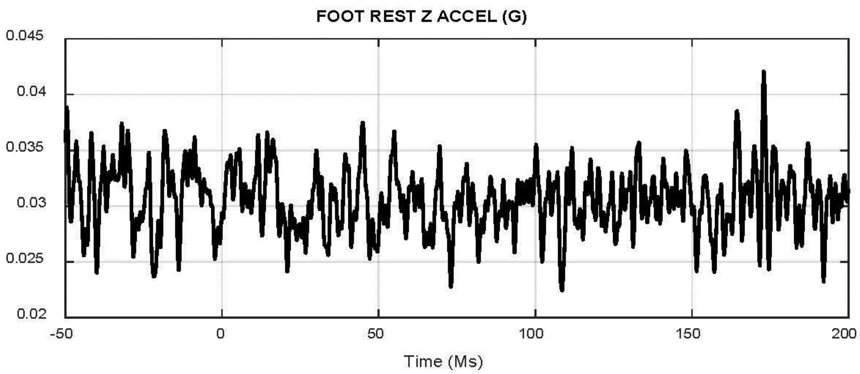
Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Impact Rise Time (Ms)				2.8	
Impact Duration (Ms)				17.8	
CARRIAGE Z ACCEL (G)		31.32	-3.08	2.8	20.5
SEAT BACK Z ACCEL (G)		42.11	-3.75	1.7	19.5
SEAT PAN Z ACCEL (G)		35.46	-4.20	1.7	20.9
FLOATING SEAT PAN (7270) Z ACCEL (G)		37.43	-4.49	7.9	20.6
FOOT REST Z ACCEL (G)		0.04	0.02	172.9	108.5
FOOT REST (LOFFI) Z ACCEL (G)		342.50	-196.57	2.5	6.9
FOOT REST (7270) Z ACCEL (G)		390.30	-62.08	0.7	4.0
CARRIAGE VELOCITY (FT/SEC)		15.52	-1.43	-0.2	71.0
SEAT BACK VELOCITY (FT/SEC)		15.04	-2.14	0.2	72.3
SEAT PAN VELOCITY (FT/SEC)		16.55	-0.36	0.1	70.9
FLOATING SEAT PAN (7270) VELOCITY (FT/SEC)		15.80	-1.89	0.2	70.4
FOOT REST VELOCITY (FT/SEC)		0.00	-0.01	-50.0	17.7
FOOT REST (LOFFI) VELOCITY (FT/SEC)		12.40	-11.73	0.1	4.8
FOOT REST (7270) VELOCITY (FT/SEC)		19.06	-3.12	-0.7	3.0
		DeltaV		T2P	
CARRIAGE VELOCITY (FT/SEC)		15.49		18.4	
		16.55		60.0	
		16.95		71.2	
SEAT BACK VELOCITY (FT/SEC)		15.60		18.4	
		15.38		37.5	
		16.79		62.0	
SEAT PAN VELOCITY (FT/SEC)		15.56		18.6	
		15.36		23.6	
		15.00		35.0	
FLOATING SEAT PAN (7270) VELOCITY (FT/SEC)		17.08		18.6	
		16.84		23.3	
		16.34		39.7	
FOOT REST VELOCITY (FT/SEC)		0.00		1.3	
		0.00		5.0	
		0.00		9.3	
FOOT REST (LOFFI) VELOCITY (FT/SEC)		24.14		4.7	
		11.98		16.6	
		12.09		25.6	
FOOT REST (7270) VELOCITY (FT/SEC)		22.18		3.7	
		16.74		23.4	
		16.21		57.1	

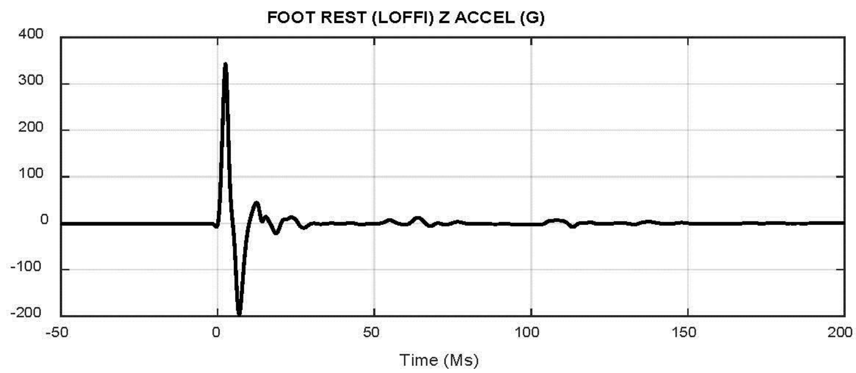

CARRIAGE Z ACCEL (G)
40
20
0
-20
-50
0
50
100
150
200
Time (Ms)

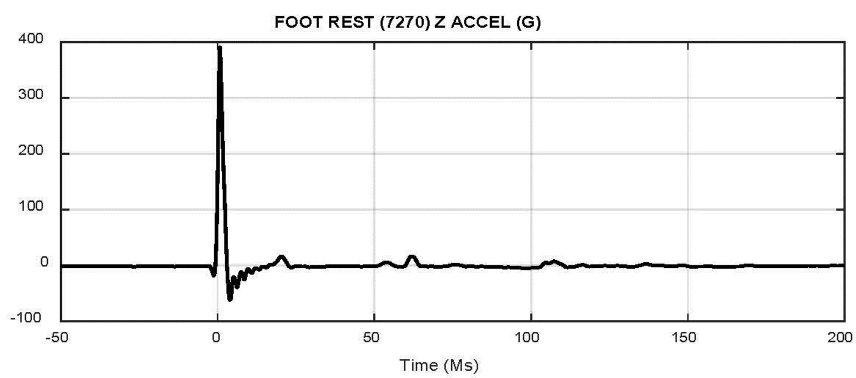

SEAT BACK Z ACCEL (G)
60
40
20
0
-20
-50
0
50
100
150
200
Time (Ms)

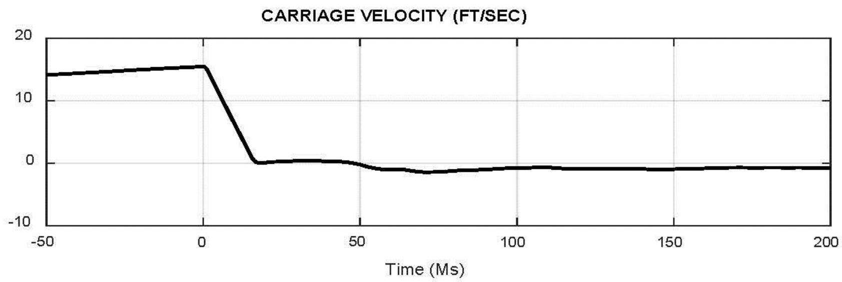

SEAT PAN Z ACCEL (G)
40
20
0
-20
-50
0
50
100
150
200
Time (Ms)

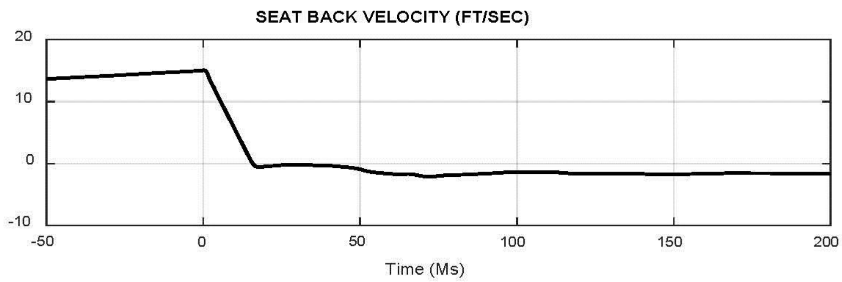

FLOATING SEAT PAN (7270) Z ACCEL (G)
40
20
0
-20
-50
0
50
100
150
200
Time (Ms)

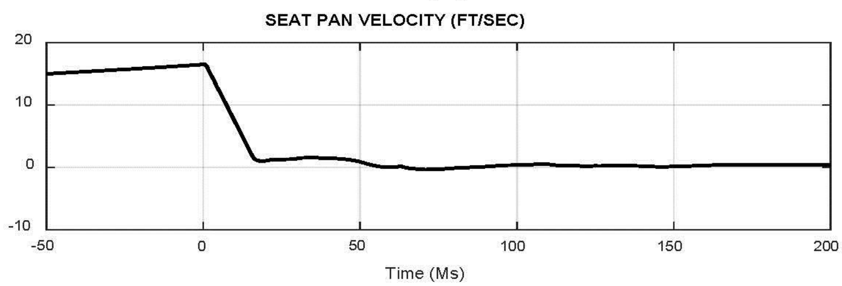

FOOT REST Z ACCEL (G)
0.045
0.04
0.035
0.03
0.025
0.02
-50
0
50
100
150
200
Time (Ms)

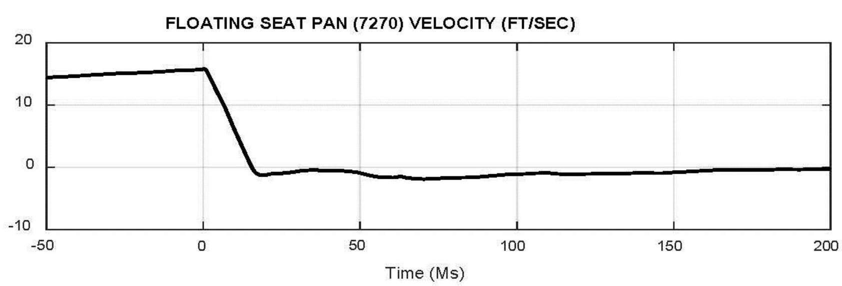

FOOT REST (LOFFI) Z ACCEL (G)
400
300
200
100
0
-100
-200
-50
0
50
100
150
200
Time (Ms)

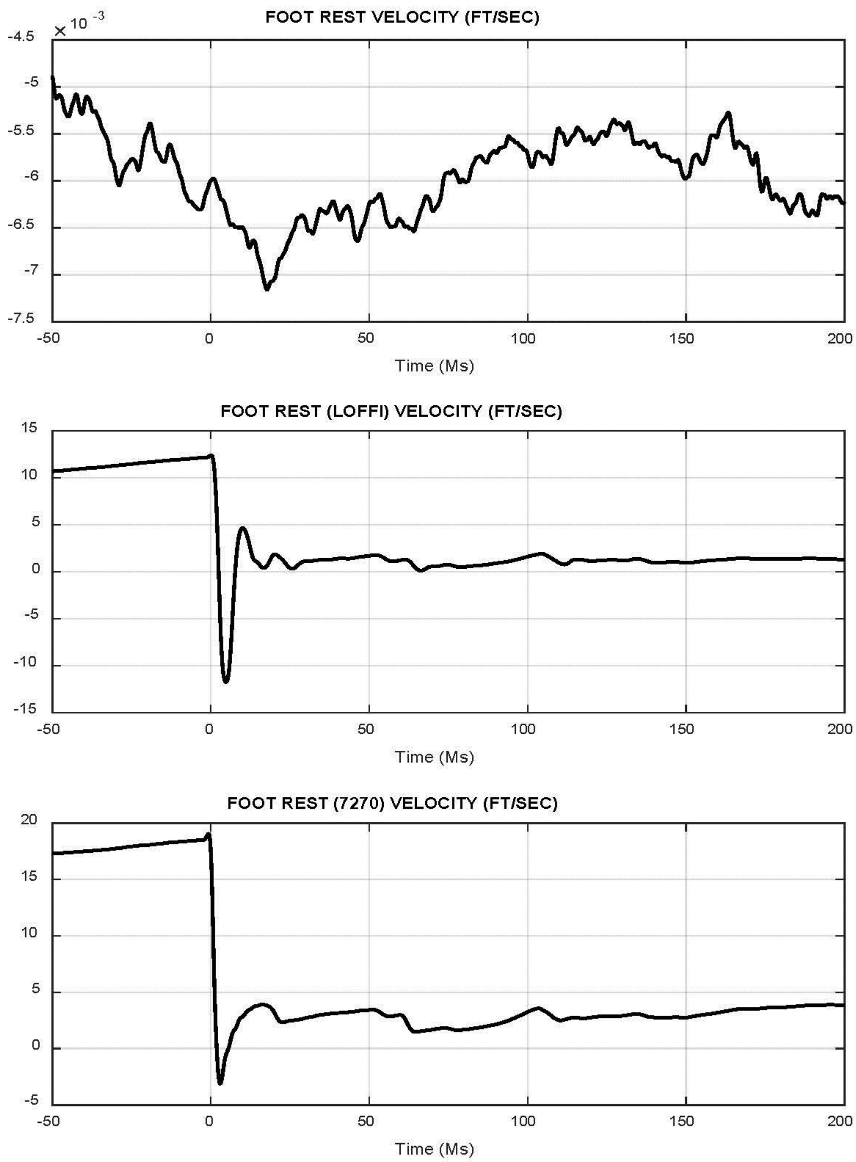

FOOT REST (7270) Z ACCEL (G)
400
300
200
100
0
-100
-50
0
50
100
150
200
Time (Ms)


CARRIAGE VELOCITY (FT/SEC)
20
10
0
-10
-50
0
50
100
150
200
Time (Ms)


SEAT BACK VELOCITY (FT/SEC)
20
10
0
-10
-50
0
50
100
150
200
Time (Ms)


SEAT PAN VELOCITY (FT/SEC)
20
10
0
-10
-50
0
50
100
150
200
Time (Ms)


FLOATING SEAT PAN (7270) VELOCITY (FT/SEC)
20
10
0
-10
-50
0
50
100
150
200
Time (Ms)


FOOT REST VELOCITY (FT/SEC)
× 10^-3
-4.5
-5
-5.5
-6
-6.5
-7
-7.5
-50
0
50
100
150
200
Time (Ms)
FOOT REST (LOFFI) VELOCITY (FT/SEC)
15
10
5
0
-5
-10
-15
-50
0
50
100
150
200
Time (Ms)
FOOT REST (7270) VELOCITY (FT/SEC)
20
15
10
5
0
-5
-50
0
50
100
150
200
Time (Ms)