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BIODYNAMICS OF ANTHROPOMORPHIC TEST DEVICE NECKS USING A HORIZONTAL IMPULSE ACCELERATOR: HEAD ACCELERATIONS AND NECK LOADS

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Interim Report

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14. ABSTRACT Research was conducted involving a series of impacts on the AFRL Horizontal Impulse Accelerator (HIA), as part of a research collaboration agreement between NASA and AFRL. The purpose of the effort was to evaluate and conduct a comparison of the biodynamic response of different sized ATD head and neck configurations to support the development of computational models used to evaluate crew injury risk and aid in the design of seat and restraint systems for NASA's space vehicles and USAF air vehicles. Testing was completed using a head and neck combination from a 5th Hybrid III female aerospace ATD, a 50th Hybrid III male aerospace ATD, and a 95th Hybrid III male aerospace ATD. A test matrix was developed to assess each ATD as a function of both impact orientation, magnitude of the impact acceleration input pulse (8 to 16 G dependent on impact orientation), and rise-time or time-to-peak of the impact acceleration input pulse (50 or 100 ms). Secondary independent test variables included tests with or with-out a helmet mounted on the head, and tests with or with-out the inclusion of a contact plate that provided impact for the head or head plus helmet. The impact orientations consisted of +X-axis, -X-axis, and Y-axis with the directions relative to the manikin axis reference frame on the inclined test fixture. Free motion of the ATD heads without the contact plate indicated that the head kinematics and neck loads showed a trend to increase as a function of the impact level, and a majority of the data indicated very little difference between the response of the ATD head and necks. Notable exceptions were reduced peak values for the 95th ATD relative to the head kinematics, and reduced peak values for the 5th ATD relative to the neck loads and torques . The data also indicated that the addition of a helmet or a helmet with additional padding successfully reduced kinematic response and inertial neck loads in the three different impact configurations compared to a no-helmet configuration.

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1.0 OVERVIEW

The Aircrew Biodynamics and Protection (ABP) team and their in-house technical support contractor, Infoscitex (IST), conducted an impact study on the Air Force Research Laboratory (AFRL) Horizontal Impulse Accelerator (HIA), as part of a research collaboration with National Aeronautics and Space Administration's (NASA) Johnson Space Center. The purpose of the impact study was to investigate the dynamic response of three different sizes of Anthropomorphic Test Device (ATD) head and necks exposed to different peak impact acceleration levels and different impact acceleration rise times. The experimental data will be used to develop computational biodynamic response models, and to develop crew injury risk criteria that will aid in NASA's and AFRL's design and development of restraint and protection equipment for air and space vehicles.

The impact tests were conducted with the ATD head and necks positioned in +X-axis, -X-axis, and Y-axis orientations (although the test set-up provided some input to the Z-axis of the ATD head and neck), and were conducted with a 5th Hybrid III female ATD head and neck, a 50th Hybrid III male ATD head and neck, and a 95th Hybrid III male ATD head and neck. The ATD head/neck combinations were attached to the HIA sled using specially designed test fixtures. Data collection from the tests on the HIA consisted primarily of head accelerations and angular rates, and both upper and lower neck loads and torques. High speed video from cameras mounted on the HIA sled were also analyzed in addition to the electronic data from the instrumented ATDs.

The horizontal impact facility is located in Building 824, Area B, Wright-Patterson Air Force Base, Ohio, and was operated by the ABP team and IST, under the Aerospace Physiology & Performance Section, Applied Neuroscience Branch, Warfighter Interface Division, 711th Human Performance Wing (711 HPW/RHCPT).

This effort was partially funded by the NASA Engineering and Safety Center (NESC) at the Johnson Space Center, Houston TX. The primary points of contact were Mr. Jeff Somers and Mr. Nate Newby of KBRWyle (subcontractor to NASA), and Mr. Jacob Putnam of NASA.

2.0 BACKGROUND

The United States of America will send a new generation of explorers to the International Space Station and possibly beyond aboard NASA's Orion Crew Exploration Vehicle (CEV). A component of the Vision for Space Exploration, Orion's development is taking place in parallel with missions to complete the International Space Station since Orion will be capable of carrying crew and cargo to the space station. It will be able to rendezvous with a lunar landing module and an Earth departure stage in low-Earth orbit to carry crews to the moon and, one day, to Mars-bound vehicles assembled in low-Earth orbit. Orion could be the Earth entry vehicle for lunar and Mars returns. Orion's design will borrow its shape from the capsules of the past, but takes advantage of 21st century technology in computers, electronics, life support, propulsion, and heat protection systems.

AFRL has had a significant role in the development of NASA's Orion spacecraft through on-going collaborative research (Perry & Buhrman, 2008; Perry, Burneka & Albery, 2013; and Perry, Burneka, & Albery, 2015). The original plan for assessing crew members' injuries during Orion landings was to investigate using the Hybrid III Finite Element (FE) ATD in computational models. The crew member response will be obtained by loading the dummy with landing load acceleration obtained from vehicle landing simulations which are currently performed using LS-Dyna (Livermore Software Technology Corporation, (LSTC)). The landing load accelerations, which are combinations of X, Y, and Z accelerations, will be applied to LS-Dyna models consisting of the Hybrid III FE models placed in the Orion seat designs. Injury criteria will be extracted from the simulations (e.g., neck forces, head accelerations, pelvic motion) and compared against the recommended injury criteria established in the NASA Human Systems Integration Requirements (HSIR) requirements. One issue related to the above approach is that the Hybrid III ATD is normally not used or validated for dynamic multi-axial impacts. While Orion landings generally produce primarily rear and spinal direction loading, there are landing conditions, particularly when vehicle roll is prevalent, where a multi-axial (including lateral impact loading) impact loading occurs.

NASA and the Air Force Research Laboratory previously completed a collaborative evaluation of the Hybrid III 50th % test dummy to support the evaluation of the numerical models intended to simulate the impact responses of the test dummy. Analysis of these tests revealed several results that require additional investigation if the test dummy and numerical models are to be useful to evaluate impacts when the impact vectors are other than the forward-facing direction (-X-axis). First, the loads measured at the shoulder were exceptional high. In part, the high loads have been attributed to the mechanical properties of the Hybrid III dummy shoulder. The Hybrid III is not used by the auto industry to evaluate the likelihood of injury from a multi-axial or sideward impact (Y-axis). An additional collaborative evaluation of a special dummy referred to as the European Side Impact Dummy (EuroSID) dummy, which is typically used for side impact loading scenarios, was also previously completed to evaluate the sideward impact forces occurring at the crew seat occupant's shoulder and hip. However, even though the side impact dummy such as the EuroSID is useful for pure lateral loading, the Orion loading is multi-axial and the EuroSID would not be amenable for use in the LS-Dyna approach described above.

NASA and AFRL also recently completed a collaborative evaluation of the K-version of the Test device for Human Occupant Restraint (THOR) or THOR-K impact test ATD (Perry et al., 2013; Newby et al., 2013; Perry et al., 2015; and Putnam, Somers, Wells, Perry, & Untaroiu, 2015). An extensive number of tests were conducted to evaluate the THOR-K ATD's biodynamic response for potential use in the development of advanced occupant seating systems by NASA and the United States Air Force (USAF). The principle objective of this evaluation was to determine the biodynamic response of the THOR-K with particular emphasis on measuring the spinal and restraint harness loading for various impact orientations and loading conditions. This data would also be compared to the Hybrid III 50th aerospace ATD response data in select test configurations. Testing was completed in three impact orientations: +Z-axis, +Y-axis, and –X-axis, and with input accelerations at various impact levels that ranged from 8 to 20 G peak value (with G being defined as the local gravitational field of earth or the free-fall acceleration, hence, the term "8 G" is a value equal to "8 times the free-fall acceleration"). Testing was also completed to determine the frequency response of the THOR-K ATD by varying the time-to-peak G of the applied input acceleration from 30 milliseconds (ms) to 100 ms. In general, the THOR-K provided good linear response across the various test conditions out to a 20 G input acceleration for the measured test parameters evaluated. The THOR-K response was maximized at the 30 ms time-to-peak input condition. The THOR-K responded in a similar fashion to the Hybrid III ATD in terms of peak values; however, the head and neck responses were consistently lower regardless of peak input acceleration or the input acceleration's time-to-peak value.

NASA and AFRL continued their collaboration after the THOR-K testing and developed a follow-on collaborative program to address NASA's newly adopted vehicle design requirements for Occupant Protection, which specify the use of the Hybrid III ATD. To aid in vehicle development, NESC desired to extend their technical assessment of the Hybrid III ATDs to develop the analytical tools needed to satisfy these new requirements. Two separate studies were conducted in 2014 and 2015 and evaluated the dynamic response of the 5th Hybrid III female and 95th Hybrid III male ATDs respectively (Perry, et.al. 2018)[a]. Impact testing was conducted in multiple axis configurations (combined -X axis and +Z axis, +Z axis only, combined +X axis and +Y axis, +X axis only), and the data analysis focused primarily on the ATD head, chest and lumbar accelerations, and ATD neck and lumbar loads and torques. The NASA space suit used for these tests was representative of the Orion flight suit configuration and was retrofitted with a preliminary design of a helmet occupant restraint device or anchor bar. The function of the device, which was attached to the back of the helmet ring, was to provide helmet stabilization during frontal accelerations and reduce forward rotation or flexion of the helmet and also minimize potential blunt impacts to the crew member's face. The device accomplished this by restricting motion of the helmet during impact by having bars extend out from the helmet attachment point and under the shoulder straps. The bars would engage the restraint harness during forward motion of the helmet and limit rotation relative to the torso. Analysis of these tests revealed several issues that required additional investigation if the test dummy and numerical models are to be useful to evaluate impacts when a space suit is installed onto the Hybrid III test dummy.

One issue was that the neck load injury metrics were not consistent which may have been attributed to several factors including the communications cap (audio headset device a crew uses to communicate with) used, improper anchor bar and restraint harness interface, and the suit helmet size/mass used. The design aspects of the communications cap such as material type, overall mass of the assembly, thickness of the foam, and foam density were not considered at the time of its design. A second issue was the integration of the anchor bar and the restraint harness, with a suited Hybrid III test dummy in the developmental Orion seat, was cumbersome at times. The test team worked with just a few anchor bar hardware configurations; however, it was determined that additional designs could potentially improve the injury metric data.

An additional effort was recently conducted in 2016 to reduce the amount of free volume inside the suit helmet as well as reduce the overall mass of the helmet (Perry, et.al. 2018)[b]. The NASA Suit team worked with the vendor to develop and utilize existing helmet designs to develop a reduced size helmet, and they also developed several different Advanced Crew Escape Suit (ACES) Non-Conformal Helmet Occupant Restraint (ANCHOR) bar designs. The integration of the light-weight helmet reduced ATD head accelerations and neck loads for both the 5th and 50th ATDs (most notable the Moment about Y-axis (My) neck torque on the 5th), but was not tested on the 95th ATD. The addition of an anchor bar to the back of the helmet reduced neck tension and forward flexion, but tended to shift the primary load path to neck compression and rearward extension which resulted in the loads and torques failing the USAF's Multi-Axial Neck Injury Criteria (MANIC) x-axis injury criteria or MANICx. This result indicated that further research was required on the design of the helmet motion control concept to balance the tension/compression loads and the flexion/extension torques.

Supplementary to the Orion program, NASA currently is also responsible for the occupant protection requirements on the Commercial Crew Program (CCP). The occupant protection standards currently specify the use of the Hybrid III Anthropomorphic Test Device (ATD) for development of related computational models. The Occupant Protection certification approach of the current CCP partners is certification by analysis using finite element models of the Hybrid III ATD. To aid in vehicle certification for Occupant Protection, the NASA Engineering and Safety Center (NESC) is undertaking a technical assessment of the current approach of both CCP partners to demonstrate valid model and results for certification. A research effort was developed to assess and improve the validation of the occupant models (Hybrid III and other components) used by each partner to certify occupant protection requirements through analysis, and to provide data for USAF injury risk criteria.

3.0 OBJECTIVES

The series of tests on the HIA addressed the following primary objectives collaboratively developed by both AFRL and NASA.

Key focus of research effort for AFRL:

1. Dynamically load the 5^{th}, 50^{th}, and 95^{th} ATD head and neck configurations across a variety of accelerations, acceleration rise times, and impact orientations to conduct comparative assessment of their biodynamic response during headfrom free-motion dynamics.

2. Conduct additional data analysis to develop regression models of biodynamic response as a function of input acceleation, to determine limited frequency response analysis based on input acceleration pulses, and develop initial relationship between upper and lower neck load cells responses for potential integration into USAF multi-axial neck injury criteria.

Key focus of research effort for NASA:

1. Dynamically load the 5th, 50th, and 95th ATD head and neck configurations across a variety of accelerations, acceleration rise times, and impact orientations, which were not previously evaluated in past AFRL/NASA research collaborations. Results will be used to enhance the performance of current NASA computational models relative to changes in dynamic loading conditions associated with model input parameters, which will support NASA's continueing development of crew injury critieria for safe operations in spacecraft such as the Orion capsule.

2. Conduct the reasearch effort with better-defined initial conditions and more thorough instrumentation to supplement the development of NASA's computational model uncertainty factors by filling in gaps of uncertainty in model accuracy, through increasing the range of tested conditions.

3. Conduct additional data analysis using impact responses of headform with a fixed, rigid, plate to develop mechanical contact properties for the computational models as a function of impact acceleration and velocity, headform helmet materials, and plate contact materials.

This technical report will only address the portion of the key focus objectives for AFRL relating to a comparative assessment of the biodynamic responses of the three ATD headforms, and the development of regression models of specific biodynamic responses from the ATD headforms. A follow-on technical report will address the remaining key focus objectives for AFRL.

At this time, it is anticipated that NASA will be addressing their key focus objectives in separate NASA developed technical reports.

4.0 TEST FACILITY AND EQUIPMENT

4.1 Horizontal Impulse Accelerator

The HIA (Shaffer, 1976; Strzelecki, 2006) was used to conduct the impacts in multiple axes configurations to evaluate ATD head/neck acceleration response and neck loading during the variouis acceleration exposures while restrained to the top of the HIA sled. The HIA, shown in Figure 1, consists of a thrust pistion, a test sled, and track rails. The 4x8 ft sled was positioned on 160 feet of twin-rail track and was accelerated from a stationary position by a thrust piston housed in a pneumatic actuator. The HIA actuator operates on the principle of differential gas pressures acting on both surfaces of the thrust piston in the actuator (24 inch diameter cylinder). The impact acceleration occurs at the beginning of the experiment as stored high-pressure air was allowed to impinge on the back-side surface of the thrust piston (the thrust piston was held in place by a lock-yoke). At t minus 4 seconds, the lock-yoke was released, and at t = 0 seconds, a 100 psi trigger pressure is applied to the thrust-piston back plate causing the stored high-pressure to move the thrust piston and accelerate the sled down the track. The external push-plate of the thrust piston that was in contact with sled is highlighted in Figure 1 (shown prior to start of the acceleration). As the sled breaks contact with the thrust piston, the sled coasts to a stop or was stopped with a pneumatic brake system mounted beneath the sled. The acceleration pulse imparted to the sled depends on the pressure differential within the actuator (the facility's set pressure and load pressure), the volumes of the pressure chambers within the actuator (the facility's set length and load length), and the shape of the metering pin. It is also possible to increase the onset rate of the acceleration pulse by applying glide brakes following the start of impact. This effort had the HIA configured with the facility's pulse-profile Pin #10 to provide a rise-time of 50 ms, and with the facility's pulse-profile Pin #23 to provide a rise-time of 100 ms.

Figure 1. 711 HPW Horizontal Sled Facility

4.2 HIA Research Configurations

Three specially designed test fixtures to hold the ATD head/necks were rigidly mounted to the top of the HIA sled. The test fixtures with three ATD head/neck configurations are shown in Figure 2. The positive axis of the coordinate system for the test configuration for this program was defined with respect to the base of the ATD head/neck mounted on the test fixture which is mounted on the top of the HIA sled. Therefore, the coordinate system moves with respect to the ATD head as the ATD base and mounting block are adjusted in pitch and yaw (ATD base and mounting block move/rotate together). The coordinate system for this test series is also shown in Figure 2.

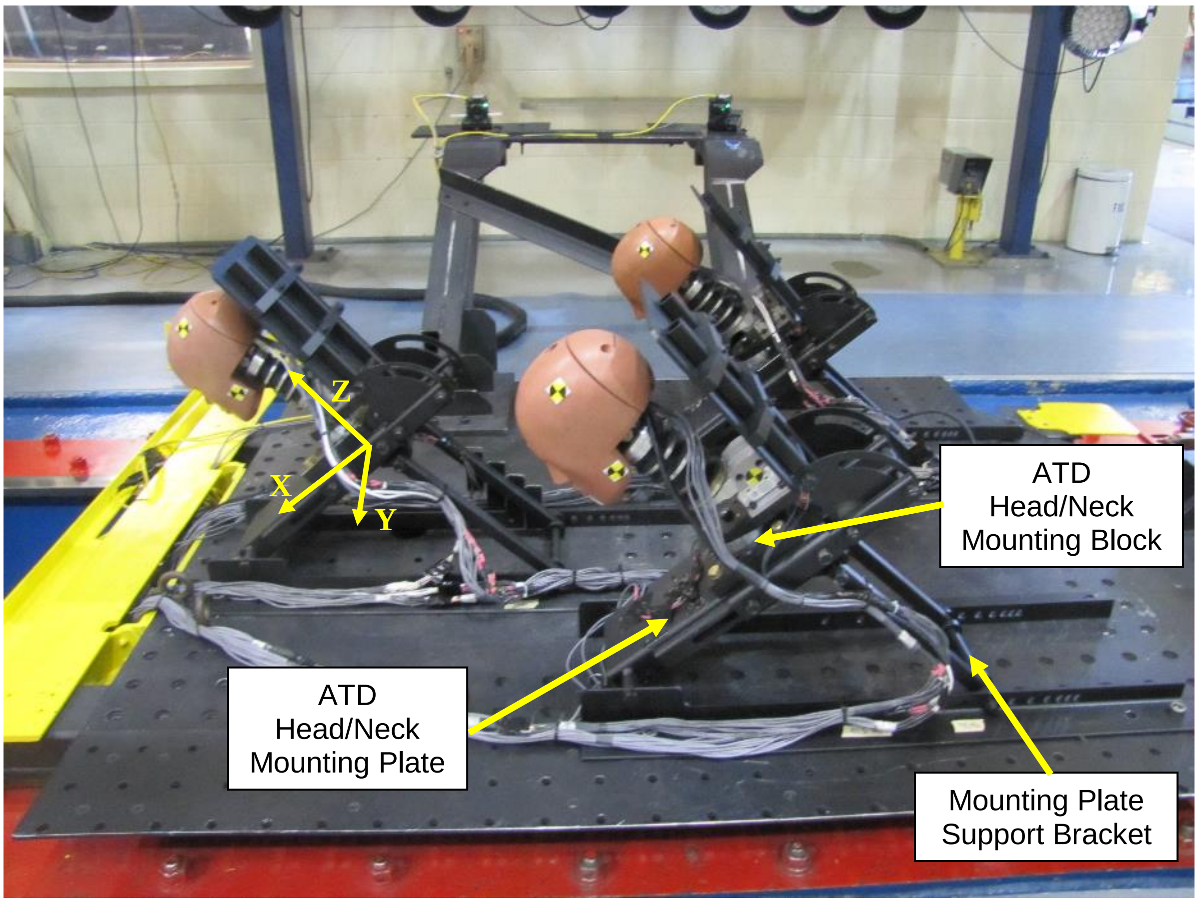

Figure 2. ATD Head/Necks Mounted on Specialized Test Fixtures on HIA Sled

The ATD head/neck fixtures were designed to allow the head/necks to be positioned at multiple angles in both yaw (0° to 180°) and pitch (0° to 90°) relative to the top of the sled. The variation in pitch of the ATD head/neck fixtures was allowed by the adjustability of the ATD head/neck mounting plate's support bracket. The variation in yaw of the ATD head/neck fixtures was allowed by the adjustability of the ATD head/neck mount block on the top the mounting plate (head/neck mounting block could be rotated to different mounting locations on the mounting plate). A few of these variations are shown in Figures 3 through 6. Figure 3 also identifies the location of the three different sized heads which was consistant throughout the test series.

The ATD head/neck fixtures were also designed with an adjustable impact plate which could be configured to allow or not-allow the head to strike the plate during the impact event. This is shown in Figures 7 and 8.

The rotation of the ATD head/neck mounting block on top of the mounting plate allowed the head/neck configuration to be rotated into various angles relative to the top of the mounting plate. The rotation of the mounting block 90° allowed the head/neck configuration to be subjected to a lateral, +Y-axis impact acceleration as shown in Figure 5. The rotation of the mounting block 180° allowed the head/neck configuration to be subjected to a -X-axis impact acceleration as shown in Figure 6. The three primary test fixtures composed of the mounting plate, support bracket, strike plate, and various interface components that interfaced the fixtures to the sled, were not moved or rotated following the start of the program.

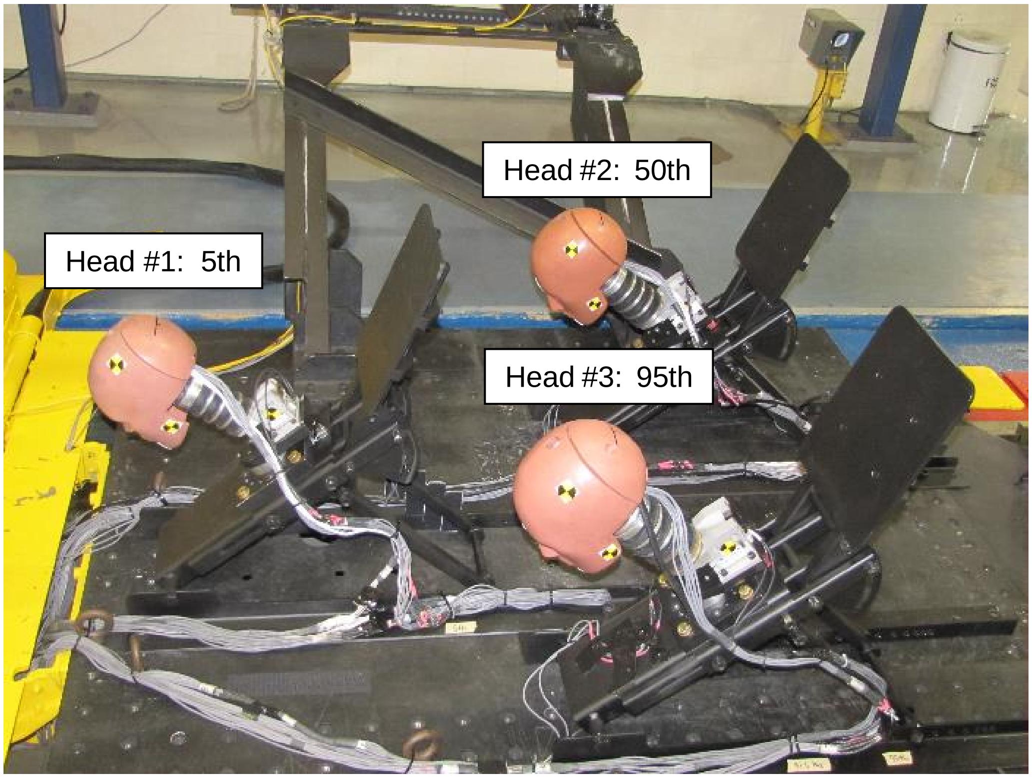

Figure 3. ATD Head/Necks Mounted in +X-Axis Configuration: 40° Pitch, 0° Yaw

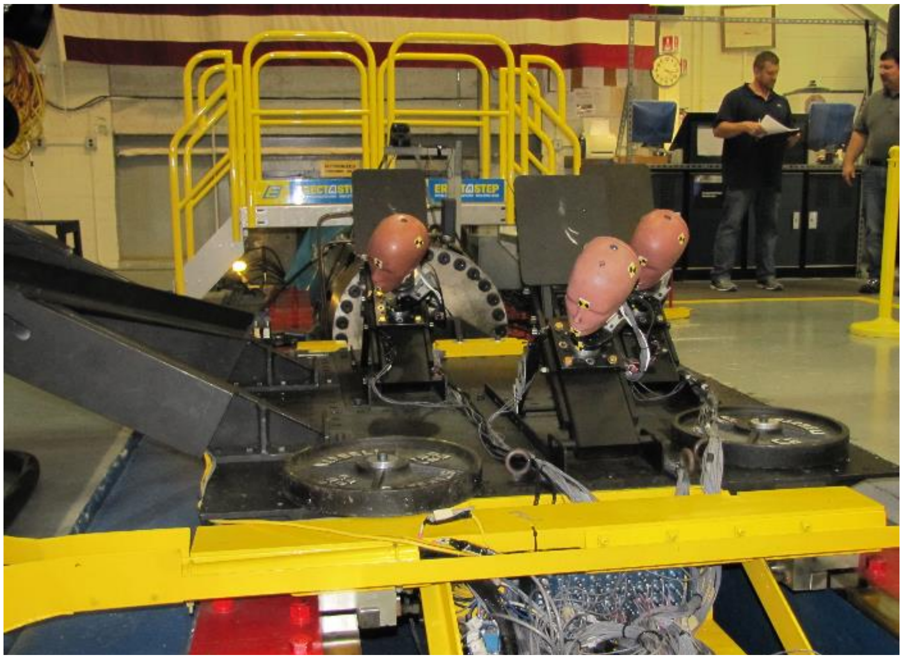

Figure 4. ATD Head/Necks Mounted in +X-Axis Configuration: 40° Pitch, 45° Yaw

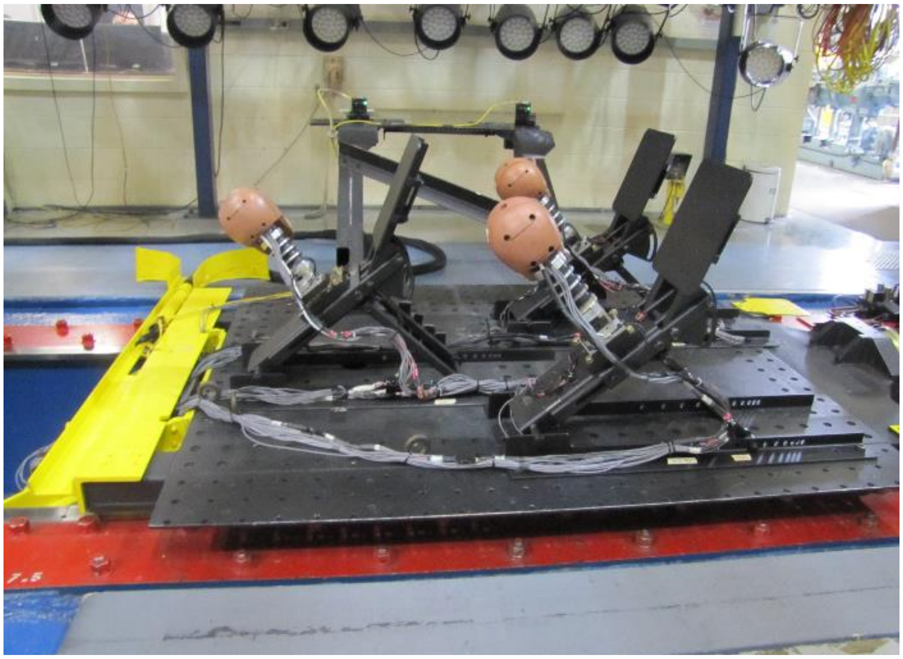

Figure 5. ATD Head/Necks Mounted in +Y-Axis Configuration: 40° Pitch, 90° Yaw

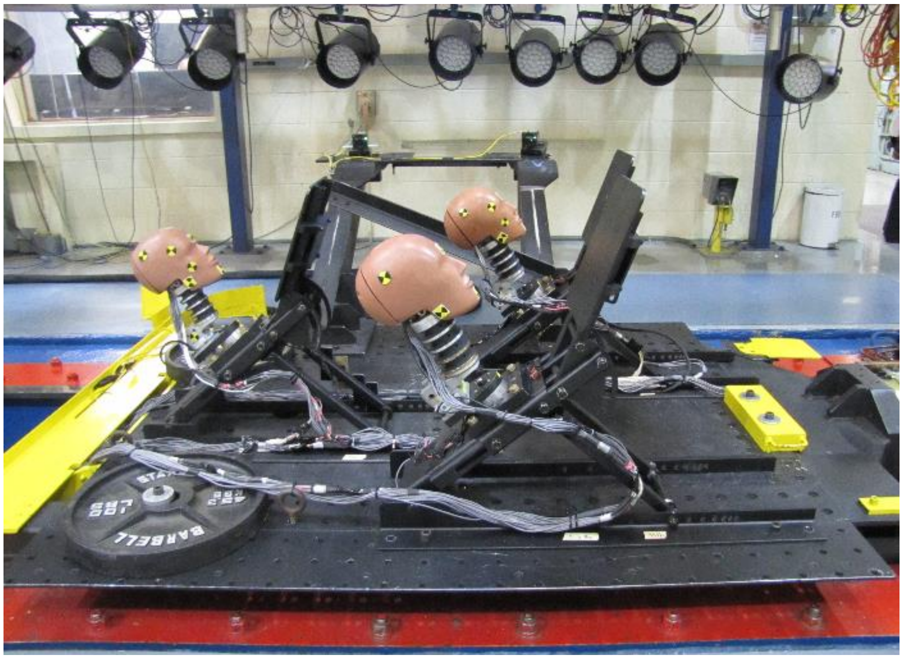

Figure 6. ATD Head/Necks Mounted in -X-Axis Configuration: 40° Pitch, 0° Yaw

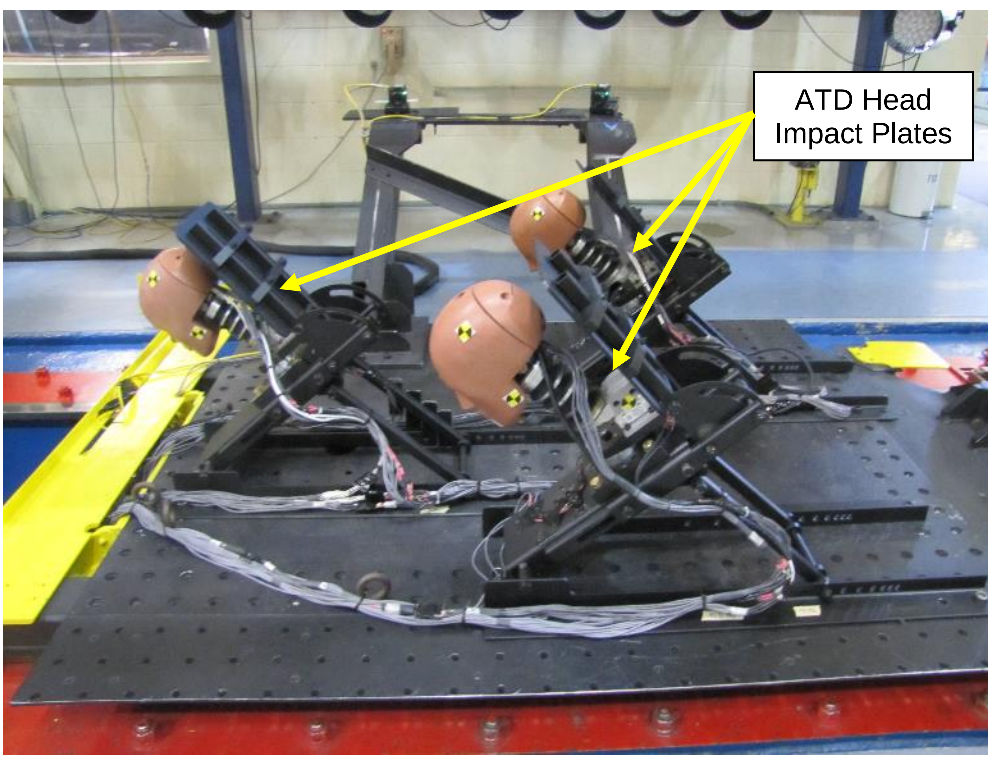

Figure 7. ATD Head/Necks in +X-Axis Configuration <u>Allowing</u> Plate Contact

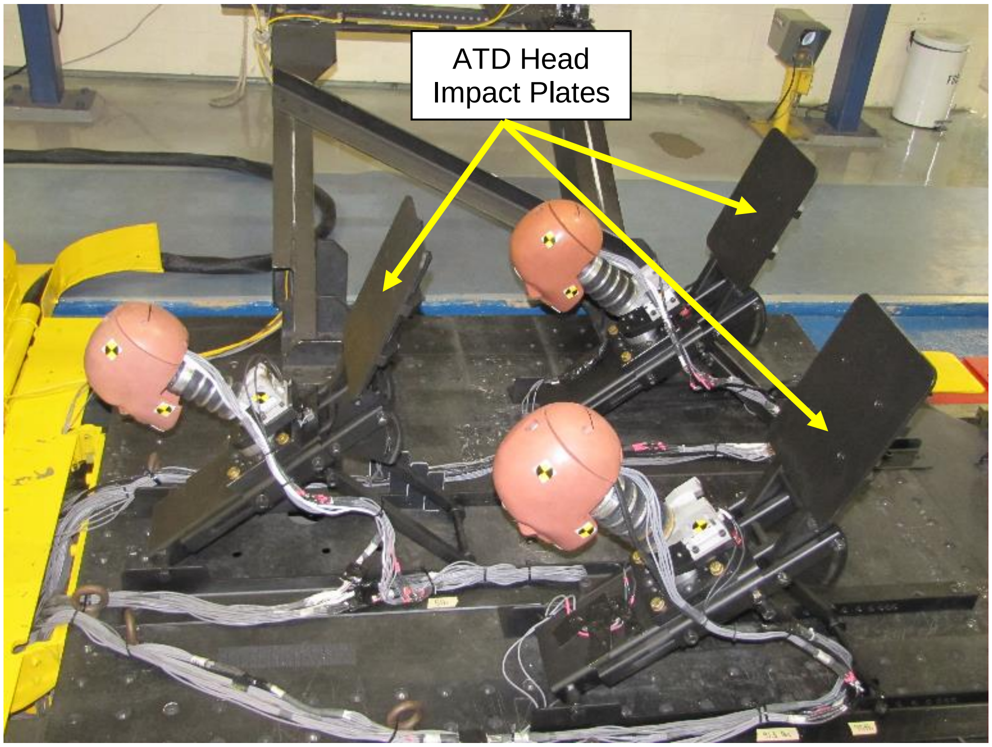

Figure 8. ATD Head/Necks in +X-Axis Configuration Not Allowing Plate Contact

4.3 ATD Head and Necks

All tests were conducted with three instrumented ATD head/neck configurations which consisted of a 5th Hybrid III female head/neck, a 50th Hybrid III male head/neck, and a 95th Hybrid III male head/neck. The three ATD configurations were all tested simulataniously for this effort.

5.0 INSTRUMENTATION AND DATA COLLECTION

The transducers for this effort 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 depending on head/neck orientation (process referred to as “zero’d out” as part of pre-test procedures).

This research effort used the Right-Hand Rule coordinate system (shown in Figure 2 on the test fixture) for the facility sensors. The X-axis is defined as parallel to the head/neck mounting plate with positive pointing outward away from the front of the head/neck mounting block (front of mounting block cooresponds to face or front of ATD head). The Z-axis is defined as being perpendicular to the X-axis with positive pointing upward through the head/neck mounting block (along the ATD neck and the ATD head). The Y-axis is defined as perpendicular to the X- and Z-axes according to the right-hand rule with positive pointing towards the left relative to the face of the ATD head. The coordinate systems rotates with the ATD head/neck orienation. The facility 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.

The ATD sensors used the Society of Automotive Engineers (SAE) J211 system (positive Z-axis is down) coordinate system. The following critical parameters were measured as follows: Neck tension load was measured as positive and neck compression load was measured as negative, forward shear load was measured as negative and rearward shear load was measured as positive, flexion (head rotation forward relative to the neck) was measured as positive, and extension (head rotation rearward relative to the neck) was measured as negative.

5.1 Facility and Test Fixture Instrumentation

The HIA sled was instrumented with a tri-axial linear accelerometer package mounted on the bottom of the sled deck which consisted of an Entran Model EGE-72-200 accelerometer in the X-axis, and two Entran Model EGA-125F-110D accelerometers in the Y-axis and the Z-axis.

Tri-axial accelerometer packages were also mounted on each ATD head/neck test fixture. The tri-axial accelerometer package on one fixture consisted of three Entran Model EGV3-F-250 linear accelerometers. The tri-axial accelerometer packages on the other two fixtures consisted of three Measurement Specialists Model EGCS-S425-250 linear accelerometers. The location of the tri-axial accelerometer package on the ATD head/neck test fixture is shown in Figure 9 (highlighted by the yellow circle), and was consistent across each test fixture.

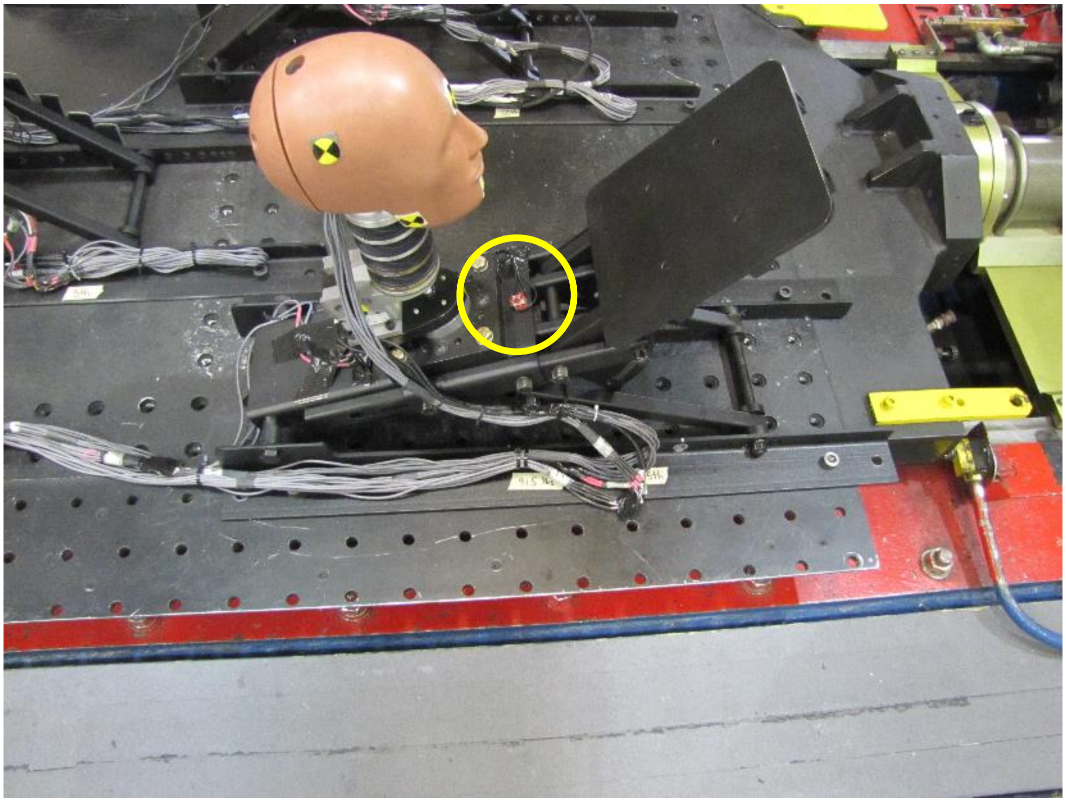

Figure 9. Location of Tri-axial Accelerometer Package on the ATD head/neck test fixture

5.2 ATD Instrumentation

The ATD head/neck configurations were all instrumented with a tri-axial accelerometer package located in the head, and with 6-axis load cells (3 orthogonal linear forces, 3 orthogonal moments) in the upper neck and in the lower neck. In addition, the ATD heads were instrumented with tri-axial package of angular rate sensors. The critical accelerations for this effort were the head z acceleration, head x acceleration, and the head angular rate. The critical loads and moments for this effort were the Z-axis axial loads and the X-axis shear loads, and the My bending moment that measured flexion and extension of the head on the neck.

The ATD heads were all instrumented with a tri-axial linear accelerometer package and a tri-axial angular rate sensor package measuring rotational rate around the head X, Y, and Z-axis. The tri-axial linear accelerometer packages were composed of three Measurement Specialties Model EGCS-S425-250 linear accelerometers. The tri-axial angular rate sensor package for one ATD head was composed of three Diversified Technical Systems (DTS) Model ARS-8K angular rate sensors. The tri-axial angular rate sensor packages for the remaining two ATD heads were composed of a combination of DTS Model ARS-8K and Model ARS-1500 angular rate sensors. The 95^{th} ATD head was also instrumented with a single Endevco Model 73202BM4 angular accelerometer to measure the angular acceleration in Ry.

The ATD upper necks were all instrumented with Humanetics Model 1716A 6-axis load cells which measured the axial loads and angular torques in the three orthogonal axes. The 5th ATD lower neck was instrumented with a Humanetics Model 5045 6-axis load cell. The 50th ATD lower neck and the 95th ATD lower neck were each instrumented with a Humanetics Model 5832 6-axis load cell.

5.3 Transducer Calibration

On-site personnel from Infoscitex, Inc., conducted pre- and post-calibrations on all sensors used on the HIA sled and test fixtures; however, some ATD load cells were required to be sent back to the manufacturer for calibration. Calibration records of individual transducers as well as the Standard Practice Instructions are maintained in the 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. Detailed information on the specific instrumentation used in this study is listed in the Electronic Instrumentation Data Sheet shown in Appendix A.

5.4 Data Acquisition Control

The Master Instrumentation Control Unit in the Instrumentation Room located between the HIA and the Vertical Deceleration Tower (VDT) impact facilities controlled the data acquisition. A test was initiated when the countdown clock reached zero using a comparator circuit. The comparator circuit was set to start data collection at a pre-selected time based on a positive reading of multiple safety inter-lock sensors used by the facility to protect the facility operators and for when human test subjects were used. Data were recorded to establish a zero reference for all transducers prior to start the test. The reference data were stored separately from the test data and were used in the processing of the test data. A reference mark pulse was generated to mark the electronic data at a pre-selected time after test initiation to place the reference mark close to the impact point. The reference mark time was used as the start time for data processing of the electronic data.

5.5 Data Acquisition System

This research program used the 64-channel Test Data Analysis System (TDAS) Pro data collection systems manufactured by DTS, Inc., to collect all the facility, test fixture and ATD data for each test. The TDAS was mounted on-board the HIA at the back of the sled (Figure 10). The TDAS is a ruggedized, DC powered, fully programmable signal conditioning and recording systems for transducers and events, and 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 were amplified, filtered, digitized and recorded in onboard solid-state memory. The data acquisition system was controlled through an Ethernet interface using the Ethernet instruction language. A desktop Personal Computer (PC) with an Ethernet board configures the TDAS before testing and retrieves the data after each test.

For this program, the TDAS collected data at a 10K sample rate with a 2.9 KHz anti-alias filter. The data was post-filtered digitally per SAE-J211 as indicated by the following.

- Class 1K (1650 Hz filter): Internal Head Liner Accelerations, Internal Head Rotational Accelerations, Internal Neck Forces
- Class 600 (1000 Hz filter): Internal Neck Moments
- Class 60 (100 Hz filter): HIA Sled Accelerations, Test Fixture Accelerations

Figure 10. Location of TDAS Pro Data Collection System Mounted on HIA Sled

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 sled motion. The plots arranged in this fashion included: force (load) versus time, and acceleration versus time.

5.7 High Speed Video and Photography

Two Phantom Miro-C210/C210J High-Speed digital cameras (Figure 11) were used to collect video of each test. The cameras were mounted on-board the HIA sled in a lateral test fixture. These locations are shown in Figure 12.

The Phantom Micro-C210/C210J line is a compact, light-weight, rugged camera targeted at industrial applications ranging from biometric research to automotive crash testing. The cameras weigh just over 1 lb, and are just slightly larger than a 3 inch cube. The cameras come standard with an internal battery and internal, non-removable Phantom Cine-Flash for 128 Giga-Byte (GB) storage. The Miro-C series can be used individually or grouped together to create multi-camera configurations, and they will also work with other Phantom Miro family of cameras and accessories. The Miro-C cameras have a 12-bit 1.3 Megapixel Complementary Metal–Oxide–Semiconductor (CMOS) sensor, can achieve 1800 frames per second (fps) at a resolution of 1280 x 1024, and are rated to survive 170g shocks. The camera accepts any standard 1" C-mount lens. The Phantom Miro family of cameras is optimized for applications such as Hydraulically Controlled, Gas Energized (HYGE) crash simulations used in the automotive industry. They have a number of external control signals allowing for external triggering, camera synchronization, and time-stamping. 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 fps. The video files were downloaded and converted to either a MP4 or AVI format, and stored in the Collaborative Biomechanics Data Network (CBDN). Photographs were taken of the test set-up prior to each test. Photographic and video data were stored on an internal network for downloads as requested.

Figure 11. Phantom Miro-C210 High Speed Digital Camera

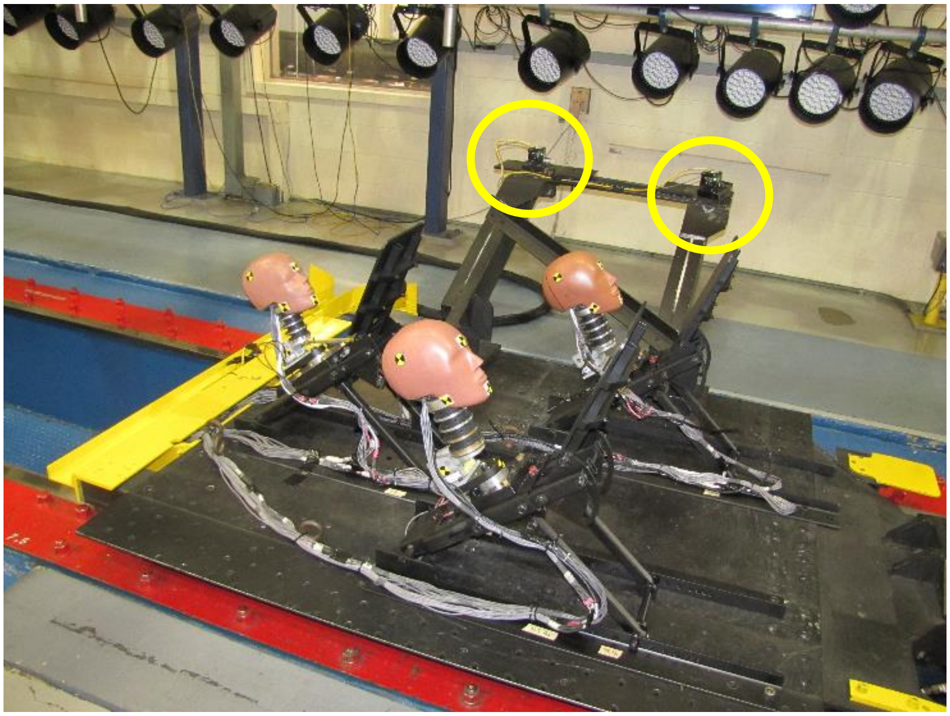

Figure 12. Locations of Phantom Miro-C210 Cameras Mounted On-Board HIA Sled

6.0 EXPERIMENTAL DESIGN

A specially designed test matrix was developed addressing the program requirement to conduct an assessment of the biodynamic response of three different sized ATDs based on the various head supported mass configurations (with and with-out helmets), and head impact configurations (with and with-out impact of adjustable impact plate). The primary biodynamic response parameters of interest were head accelerations, head rotational response, and neck loads and torques used to calculate neck injury risk. The response data was collected and analyzed to primarily feed computational models for both NASA and AFRL, but some additional risk analysis was also conducted.

The HIA was set-up to generate a half-sine acceleration waveform for all test configurations using Pin #10 and Pin #23. Pin #10 was used to generate acceleration rise-times of approximately 50 ms, and Pin #23 was used to generate rise-times of approximately 100 ms. Plots of the rise-times for each pin at the 12 G impact level is shown in Figure 13. The test matrix was devided into two sections based on the rise-time used for the impact tests. The initial impact levels were selected to expose the ATD head/necks to input accelerations across a broad range of peak values (6, 10, and 16 G) for the selected three primary impact orientations of –X-axis, +X-axis, and Y-axis. It should be noted that the test fixtures used for the ATD head/neck configurations held them at a pitch angle of 40° off the top of the sled, so each impact had some component of the accelration applied to the Z-axis of each ATD configuration. These impact levels and impact orientations were conducted using both rise-times. The other variable that was added into the matrix was the inclusion of a soft helmet configuration from Boeing and SpaceX who were part of NASA's CCP. The initial test matrix for this effort is shown in Table 1.

NASA was unavailable to obtain a soft helmet from SpaceX, therefore, the test matrix was completely redesigned after consulting with ABP personnel and adjusting impact levels based on impact orientation. Several other paramaters were also added to some of the test cells including the addition of Confor foam padding to the helmet shell (Pink Confor CF42AC), the impact plate, and variation of the initial distance between the bare ATD head or helmet shell and the impact plate. Some of the test cells had different variations of these new parameters for each of the three ATD head/neck configurations. The final test matrix is shown in Table 2, and the changes (highlighted in light blue in the second matrix) are summarized as follows:

- Relative to the section of the test matrix with Pin 10 and Rise-time of 50 ms…
    - Cells with impact levels of 6 G and 10 G were increased to 8 G and 12 G respectively (Cells A, B, D, E, G, H, J, K, M, N, P, Q)
    - The impact in the lateral orientation or Y-axis at 16 G was lowered to 10 G due to the orientation or use of the strike plate without a helmet (Cells F, L)
    - Several new cells were added to – X-axis and +X-axis impact orientations which positioned the ATD head/neck in 45° yaw (A1, B1, C1, G1, H1, I1)
    - Cells using strike plate and no helmet had an offset distance between head and strike plate of 2" (Cells J, K, L)
    - Cells with initial impact orientation of +X-axis and using the Boeing helmet had different variables set up for each of the three ATD head/necks relative to: use of a helmet, helmet/strike-plate off-set distance, thickness of Confor foam insert in

helmet, addition of Confor foam to strike plate, and impact orientation (Cells M, N, O, P, Q, R)

- Relative to the section of the test matrix with Pin 23 and Rise-time of 100 ms…
    - Cells with impact level of 16 G were decreased to 12 G due to the large velocity change of the impact (Cells U, X, AA, DD, GG); <u>Cell JJ was NOT run</u>
    - A new cell was added to the –X-axis, No Helmet, No Plate configuration to conduct an impact at 8 G (Cell S2)
    - Cells using strike plate and no helmet had an offset distance between head and strike plate of 2” (Cells BB, CC, DD)
    - Cells with initial impact orientation of +X-axis and using the Boeing helmet had different variables set up for each of the three ATD head/necks relative to: use of a helmet, helmet/strike-plate off-set distance, and impact orientation (Cells EE, FF, GG, GG1, GG2, HH, II)

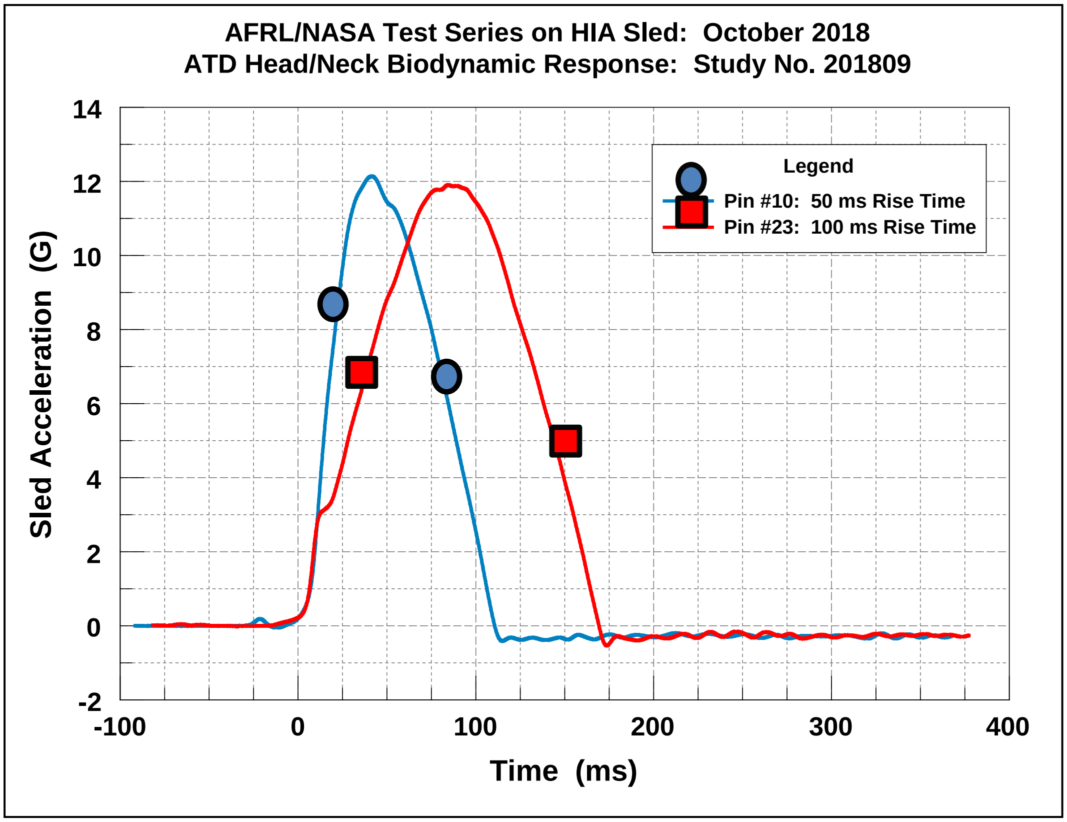

Figure 13. HIA Sled Pulses Comparing HIA-Pin Rise Times for 12 G Pulse

Table 1. Original Test Matrix for Isolated ATD Head/Neck Configurations

Cell	HIA Pin	Impact Rise Time (ms)	Impact Level (G)	Impact Orientation	Headplate	Helmet
A	10	50	6	-X	No	No
B	10	50	10	-X	No	No
C	10	50	16	-X	No	No
D	10	50	6	Y	No	No
E	10	50	10	Y	No	No
F	10	50	16	Y	No	No
G	10	50	6	+X	No	No
H	10	50	10	+X	No	No
I	10	50	16	+X	No	No
J	10	50	6	+X	Yes	No
K	10	50	10	+X	Yes	No
L	10	50	16	+X	Yes	No
M	10	50	6	+X	Yes	Boeing
N	10	50	10	+X	Yes	Boeing
O	10	50	16	+X	Yes	Boeing
P	10	50	6	+X	Yes	SpaceX
Q	10	50	10	+X	Yes	SpaceX
R	10	50	16	+X	Yes	SpaceX
S	23	100	6	-X	No	No
T	23	100	10	-X	No	No
U	23	100	16	-X	No	No
V	23	100	6	Y	No	No
W	23	100	10	Y	No	No
X	23	100	16	Y	No	No
Y	23	100	6	+X	No	No
Z	23	100	10	+X	No	No
AA	23	100	16	+X	No	No

BB	**23**	**100**	**6**	**+X**	**Yes**	**No**
CC	**23**	**100**	**10**	**+X**	**Yes**	**No**
DD	**23**	**100**	**16**	**+X**	**Yes**	**No**
EE	**23**	**100**	**6**	**+X**	**Yes**	**Boeing**
FF	**23**	**100**	**10**	**+X**	**Yes**	**Boeing**
GG	**23**	**100**	**16**	**+X**	**Yes**	**Boeing**
HH	**23**	**100**	**6**	**+X**	**Yes**	**SpaceX**
II	**23**	**100**	**10**	**+X**	**Yes**	**SpaceX**
JJ	**23**	**100**	**16**	**+X**	**Yes**	**SpaceX**

Table 2. Updated Test Matrix for Isolated ATD Head/Neck Configurations

Cell	HIA Pin	Impact Rise Time (ms)	Impact Level (G)	Impact Orientation	Headplate	Helmet
A	10	50	8	+X	No	No
A1	10	50	8	+X	No	No
B	10	50	12	+X	No	No
B1	10	50	12	+X	No	No
C	10	50	16	+X	No	No
C1	10	50	16	+X	No	No
D	10	50	8	Y	No	No
E	10	50	12	Y	No	No
F	10	50	10	Y	No	No
G	10	50	8	-X	No	No
G1	10	50	8	-X	No	No
H	10	50	12	-X	No	No
H1	10	50	12	-X	No	No
I	10	50	16	-X	No	No
I1	10	50	16	-X	No	No
J	10	50	8	+X	Yes	No
K	10	50	12	+X	Yes	No
L	10	50	10	+X	Yes	No
M	10	50	8	+X	Yes	Boeing
N	10	50	12	+X	Yes	Boeing
O	10	50	16	+X	Yes	Boeing
P	10	50	8	Y	Yes	No
Q	10	50	12	Y	Yes	No/Boeing
R	10	50	16	Y	Yes	No/Boeing
S	23	100	6	+X	No	No
S1	23	100	8	+X	No	No
T	23	100	10	+X	No	No
U	23	100	12	+X	No	No

V	**23**	**100**	**6**	**Y**	**No**	**No**
W	**23**	**100**	**10**	**Y**	**No**	**No**
X	**23**	**100**	**12**	**Y**	**No**	**No**
Y	**23**	**100**	**6**	**-X**	**No**	**No**
Z	**23**	**100**	**10**	**-X**	**No**	**No**
AA	**23**	**100**	**12**	**-X**	**No**	**No**
BB	**23**	**100**	**6**	**+X**	**Yes**	**No**
CC	**23**	**100**	**10**	**+X**	**Yes**	**No**
DD	**23**	**100**	**12**	**+X**	**Yes**	**No**
EE	**23**	**100**	**6**	**+X**	**Yes**	**Boeing**
FF	**23**	**100**	**10**	**+X**	**Yes**	**Boeing**
GG	**23**	**100**	**12**	**+X**	**Yes**	**Boeing**
GG1	**23**	**100**	**12**	**+X**	**Yes**	**Boeing**
GG2	**23**	**100**	**15**	**+X**	**Yes**	**Boeing**
HH	**23**	**100**	**6**	**Y**	**Yes**	**Boeing**
II	**23**	**100**	**10**	**Y**	**Yes**	**Boeing**

7.0 RESULTS AND OBSERVATIONS

The test results will cover the impact tests conducted with all three ATDs, and will focus on the head acceleration and velocity data, and the neck loads and torques measured at the occipital condyle of the ATD's head/neck junction. The data analysis will be separated into sections based on the acceleration pulse time-to-peak, with the focus centering on the ATD head response in free motion (no impact plate) or the ATD head response with the various plate and helmet configurations.

7.1 HIA Test by Test Summary

A review of the specific test configuration for each of the impact tests conducted on the HIA with the three ATD Hybrid III head/neck configurations was documented with a test-by-test summary. Test numbers 9695 through 9700 were "Proof Tests" conducted to determine the key facility parameters to meet the required acceleration levels. Tests 9701 through 9794 were conducted to address the test matrix. The test-by-test summary is shown in Appendix B.

Examples of the quick look data plots for specific tests from this summary are shown in Appendix C, and the specific tests are identified below with the impact level and orientation constant at 12 G and +X-axis respectively.

- 50 ms Time-to-Peak Input Acceleration
  - Free-Motion:
    - Test # 9735 Cell B Plate/Helmet: No/No
  - Contact Plate:
    - Test # 9732 Cell K Plate/Helmet: Yes/No
    - Test # 9726 Cell N Plate/Helmet: Yes/Yes

- 100 ms Time-to-Peak Input Acceleration
  - Free-Motion:
    - Test # 9711 Cell U Plate/Helmet: No/No
  - Contact Plate:
    - Test # 9710 Cell DD Plate/Helmet: Yes/No
    - Test # 9715 Cell GG Plate/Helmet: Yes/Yes

7.2 HIA Repeatability

Forty nine impact tests (this includes the tests considered a NO TEST) were completed in support of this effort to characterize the biodynamic response of the three different sized Hybrid III ATD head/neck configurations exposed to impact acceleration in the –X-axis, +X-axis, and Y-axis configurations relative to the top of the ATD head/neck mounting plates. One test per cell was conducted with noted differences in either the input acceleration, acceleration rise-time, the incorporation of the strike plate, the use of a helmet, and the use of helmet or strike plate padding.

The repeatability of the HIA impacts was calculated using the input data from all the tests related to the test matrix (proof test data not included), and the results are shown in Table 3. The data is seperated as a function of the desired input acceleration and the desired time-to-peak acceleration since the ATD head/neck configurations were tested concurently.

Table 3. HIA Repeatability for Desired Peak Input Accelerations and Time-to-Peak

Peak Input Acceleration (G)	Number of Tests	Facility Peak Sled Acceleration (G)	Facility Time to Peak Acceleration (ms)
6 (50 ms)	0		
6 (100 ms)	6	6.07 ± 0.03	97.23 ± 1.14
8 (50 ms)	8	8.14 ± 0.13	43.09 ± 1.25
8 (100 ms)	1	8.09	88.50
10 (50 ms)	2	10.30 ± 0.24	42.30 ± 0.28
10 (100 ms)	6	9.92 ± 0.09	84.72 ± 0.64
12 (50 ms)	8	12.20 ± 0.27	40.91 ± 1.20
12 (100 ms)	6	11.85 ± 0.07	87.20 ± 3.19
16 (50 ms)	6	15.89 ± 0.24	38.98 ± 1.11
16 (100 ms)	0		

The peak acceleration level and time-to-peak summaries shown in Table 3 for the 50 ms pulse with Pin 10 indicate that the HIA facility and impact environment was well controlled during the duration of the program. The peak acceleration values had a variation of less than 2.5 %, and the time-to-peak values had a variation of less than 3.0%. It is interesting to note that as the impact level increased from 8 to 16 G, the corresponding time-to-peak values steadily decreased from the desired value of 50 ms (to a minimum of approximately 39 ms).

The peak acceleration level and time-to-peak summaries shown in Table 3 for the 100 ms pulse with Pin 23 indicate that the HIA facility and impact environment was well controlled during the duration of the program. The peak acceleration values had a variation of less than 1.0 %, and the time-to-peak values had a variation of less than 4.0%. It is again interesting to note that as the impact level increased from 6 to 12 G, the corresponding time-to-peak values showed a slight trend to decrease down from the desired 100 ms value (to a minimum of approximately 85 ms).

The time-to-peak data demonstrated slightly higher variability for both pulses, and this is due to the slight noise variation at the top of the acceleration half-sine pulse which caused the software to select a peak acceleration value which may not have been at a point in time that was equal to half the total pulse duration. The variation at the top of the pulse is due to the intrinsic facility noise on the signal due to the design of the HIA system (thrust pin shape, internal wall friction, fluid friction and dynamics, etc.) which is beyond the capability to control for an experiment.

7.3 ATD Head and Neck Fixture Acceleration Response

Accelerometer packs were mounted on each of the three test fixtures supporting the ATD head and neck configurations (previously identified in Figure 3). This was completed to ensure that the fixtures did not produce a significant amplification of the input acceleration that was provided to the HIA sled.

Table 4 presents the resultant acceleration at the base of the head/neck mounting block for each ATD. The data is seperated as a function of the desired input acceleration and the desired time-to-peak acceleration since the ATD head/neck configurations were tested concurently.

Table 4. ATD Head Fixture Repeatability for Desired Peak Input Accelerations

Peak Input Acceleration (G)	Number of Tests	Facility Peak Sled Acceleration (G)	Head #1: 5th ATD Fixture Acceleration (G)	Head #2: 50th ATD Fixture Acceleration (G)	Head #3: 95th ATD Fixture Acceleration (G)
6 (50 ms)	0				
6 (100 ms)	6	6.07 ± 0.03	6.45 ± 0.14	6.21 ± 0.08	6.26 ± 0.04
8 (50 ms)	8	8.14 ± 0.13	8.45 ± 0.13	8.25 ± 0.13	8.42 ± 0.27
8 (100 ms)	1	8.09	8.48	8.20	8.32
10 (50 ms)	2	10.30 ± 0.24	10.75 ± 0.23	10.46 ± 0.28	10.66 ± 0.15
10 (100 ms)	6	9.92 ± 0.09	10.64 ± 0.30	10.28 ± 0.25	10.60 ± 0.32
12 (50 ms)	8	12.20 ± 0.27	12.75 ± 0.31	12.33 ± 0.31	12.55 ± 0.36
12 (100 ms)	6	11.85 ± 0.07	12.76 ± 0.31	12.42 ± 0.34	12.50 ± 0.46
16 (50 ms)	6	15.89 ± 0.24	16.68 ± 0.25	16.13 ± 0.28	16.35 ± 0.24
16 (100 ms)	0				

The test fixture peak acceleration levels shown in Table 4 for the for the 50 ms pulse with Pin 10 indicate that all the fixtures slightly amplified the sled acceleration by approximately 5% or less. The variability of the fixture accelerations was very similar to the variability of the sled acceleration at each impact acceleration from 8 through 16 G. The fixture for the 5th ATD head/neck was the greatest of the three fixtures at all the impact accelerations from 8 through 16 G. This was due to this fixture's mounting location being located at the opposite end of the HIA sled from the initiation of the impact pulse and reacting to a slight upward jump of the sled. This was validated by noting a much larger component of the sled acceleration being measured by the Z-axis accelerometer of the mounting fixture for the 5th ATD head/neck compared to the Z-axis accelerometer of the mounting fixtures for both the 50th ATD and 95th ATD head/neck.

The test fixture peak acceleration levels shown in Table 4 for the for the 100 ms pulse with Pin 23 indicate that all the fixtures also slightly amplified the sled acceleration by approximately 5% or less. The variability of the fixture accelerations was very similar to the variability of the sled acceleration at each impact acceleration from 6 through 12 G. The fixture for the 5th ATD head/neck was also the greatest of the three fixtures at all the impact accelerations from 6 through 12 G, and was also due to the much larger component of the sled acceleration being measured by the Z-axis accelerometer of the mounting fixture.

The test fixture peak acceleration levels shown in Table 4 for both the 50 ms and the 100 ms pulses indicate that the HIA facility and impact environment was well controlled during the duration of the program. It also indicates that the input accelerations to all the head/neck configurations was consistent throughout the study.

7.4 ATD Head/Neck Response: 50 ms Pulse

The ATD head and neck responses for the tests completed with the impact acceleration consisting of the 50 ms pulse were addressed by analyzing both the kinematic and inertial reactions. The kinematic reactions consisted of the assessment of the measured head acceleration and rotational velocity including any calculated resultant values. The inertial reactions consisted of the assessment upper neck loads and torques including any calculated resultant values.

The head and neck kinematic reactions are addressed first, and are followed by the upper neck loads and torques in following sections using the same data presentation method as shown for the kinematic response parameters.

7.4.1 Kinematic Response (50 ms): No Head Impact Plates

The ATD head and neck responses with the 50 ms input pulse were analyzed with respect to the head kinimatic response based on calculated resultant head acceleration and calculated resultant rotational velocity from all the test cells that were set-up with the impact plate positioned away from the ATD heads and also that were set-up without using a helmet. The data are shown in Tables 5 and 6 for each impact orientation at the assessed impact levels for both calculated response parameters.

Table 5. ATD Head Acceleration Response: 50 ms Pulse with No Plate/Helmet

Peak Input (G)	Test Set-Up (Impact Orientation)	5th ATD Resultant Head Acceleration (G)	50th ATD Resultant Head Acceleration (G)	95th ATD Resultant Head Acceleration (G)
8	+X-Axis	7.47	6.98	7.35
	+X-Axis (45° Yaw)	6.78	6.71	7.57
	Y-Axis	8.50	8.91	9.38
	-X-Axis	9.33	10.16	10.71
	-X-Axis (45° Yaw)	9.29	9.68	10.08
12	+X-Axis	10.81	10.06	10.25
	+X-Axis (45° Yaw)	9.59	9.91	10.47
	Y-Axis	13.27	13.62	13.89
	-X-Axis	15.76	16.05	16.33
	-X-Axis (45° Yaw)	14.90	15.27	15.56
16	+X-Axis	13.94	12.66	13.25
	+X-Axis (45° Yaw)	12.85	15.52	14.40
	-X-Axis	22.93	23.50	23.53
	-X-Axis (45° Yaw)	21.97	22.43	22.36

The ATD resultant head accelerations all show a trend to increase as a function of the impact level and as a function of the impact orientation (impact direction). The majority of the data indicates minor differences between the response of the ATD head sizes as a function of impact orientation at a given impact level. It is interesting to note that the resultant head acceleration increased as the impact orientation changed from +X-axis to Y-axis to -X-axis, with the -X-axis response being the greatest at each impact level. In addition, the repeat tests at the indicated impact orientations had the head at a yaw angle of 45°; however, the head yaw angle did not make a noticable difference in the overall response compared to the differences observed between the impact orientations.

The data plot in Figure 14 demonstrates the relationship between the data sets across the three different impact orientations, and the limited variation in the response across the three different ATD head and necks. The identification of the ATD data sets (data point shapes) and the cooresponding impact orientation (data point colors) are shown in the plot title, and this is carried on for all the plots in this report. The data sets were fit with a Power Function ($y=a*x^b$) regression model versus a Liner Function because it provided a higher COD or R^2 value, and this indicates a better prediction of the portion of the head acceleration variance (dependent variable) based on the input acceleration (independent variable). A single Power Function regression model is shown for each impact orientation for clarity on the plot using data from the 50th ATD. The Correlation (r) and the Coefficient of Determination (COD or R^2) for the regression models in each group was a minimum 0.997 and 0.997 respectively, highlighting a strong model fit.

Table 6. ATD Head Velocity Response: 50 ms Pulse with No Plate/Helmet

Peak Input (G)	Test Set-Up (Impact Orientation)	5th ATD Resultant Head Rotational Velocity (Rad/S)	50th ATD Resultant Head Rotational Velocity (Rad/S)	95th ATD Resultant Head Rotational Velocity (Rad/S)
8	+X-Axis	9.49	11.67	9.24
	+X-Axis (45° Yaw)	5.80	11.62	7.28
	Y-Axis	14.58	13.77	7.81
	-X-Axis	15.79	15.76	12.14
	-X-Axis (45° Yaw)	9.29	15.32	10.14
12	+X-Axis	16.20	18.63	15.17
	+X-Axis (45° Yaw)	15.75	16.36	11.03
	Y-Axis	21.10	19.71	13.26
	-X-Axis	21.58	22.02	18.19
	-X-Axis (45° Yaw)	21.68	21.58	16.04
16	+X-Axis	23.22	24.46	19.59
	+X-Axis (45° Yaw)	23.42	20.9	15.22
	-X-Axis	28.17	27.42	23.08
	-X-Axis (45° Yaw)	27.50	26.56	21.06

The ATD resultant head rotational velocity all show a trend to increase as a function of the impact level and as a function of the impact orientation (impact direction). The majority of the data indicates minor differences between the response of the 5th and 50th ATD head and necks as a function of impact orientation at each of the three impact levels; however, the 95th ATD head and neck rotational velocity had smaller peak values compared to the other two ATD head and necks at each impact orientation and impact level. It should be noted that the majority of the resultant head rotational velocity for the +X-axis and the –X-axis impacts is composed of the Ry rotational velocity, and for the Y-axis impacts is composed of the Rx rotational velocity. It is again interesting to note that the resultant head rotational velocity increased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis, but not to the same degree as was demonstrated by the resultant head acceleration data. The head yaw angle data showed similar results as indicated with the resultant head acceleration.

The data plot in Figure 15 demonstrates the relationship between the data sets across the three different impact directions, and the variation in the response across the three different ATD head and necks. The data sets were fit with a Power Function ($y=a*x^b$) regression model versus a Liner Function because it provided a higher COD or R^2 value, and this indicates a better prediction of the portion of the rotational velocity (dependent variable) based on the input acceleration (independent variable). A single Power Function regression model is shown for each impact orientation for clarity on the plot using data from the 5th or 50th ATD. The r and R^2 for the regression models in each group was a minimum 0.999 and 0.997 respectively, highlighting a strong model fit.

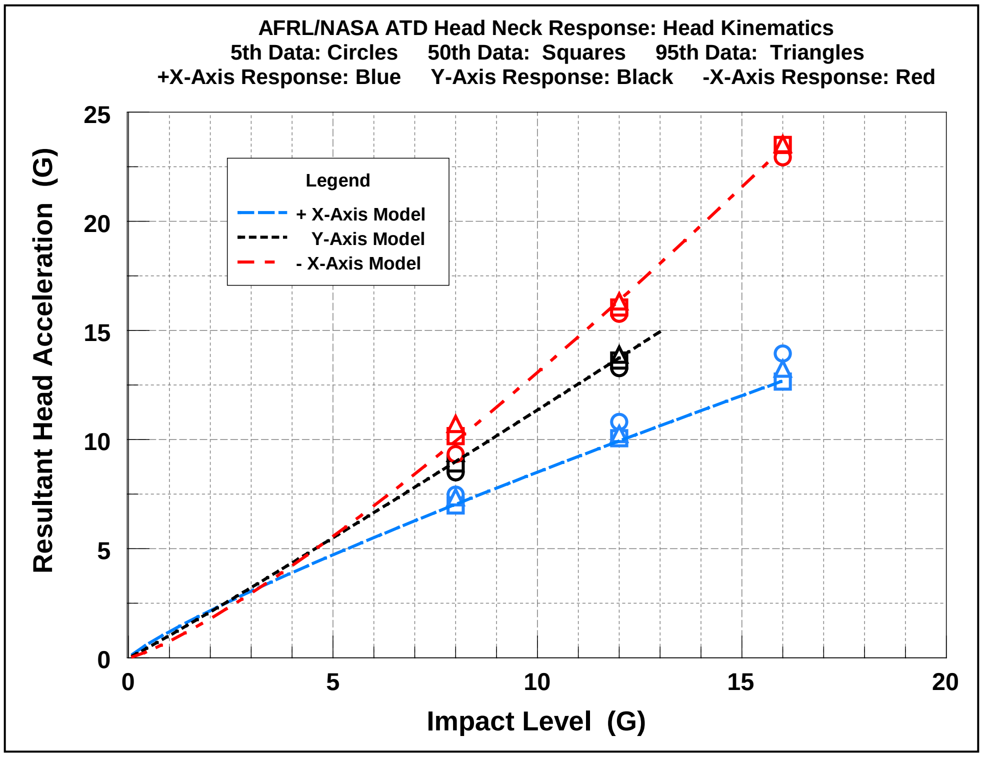

Figure 14. Resultant Head Acceleration as Function of Impact Level: 50 ms Pulse

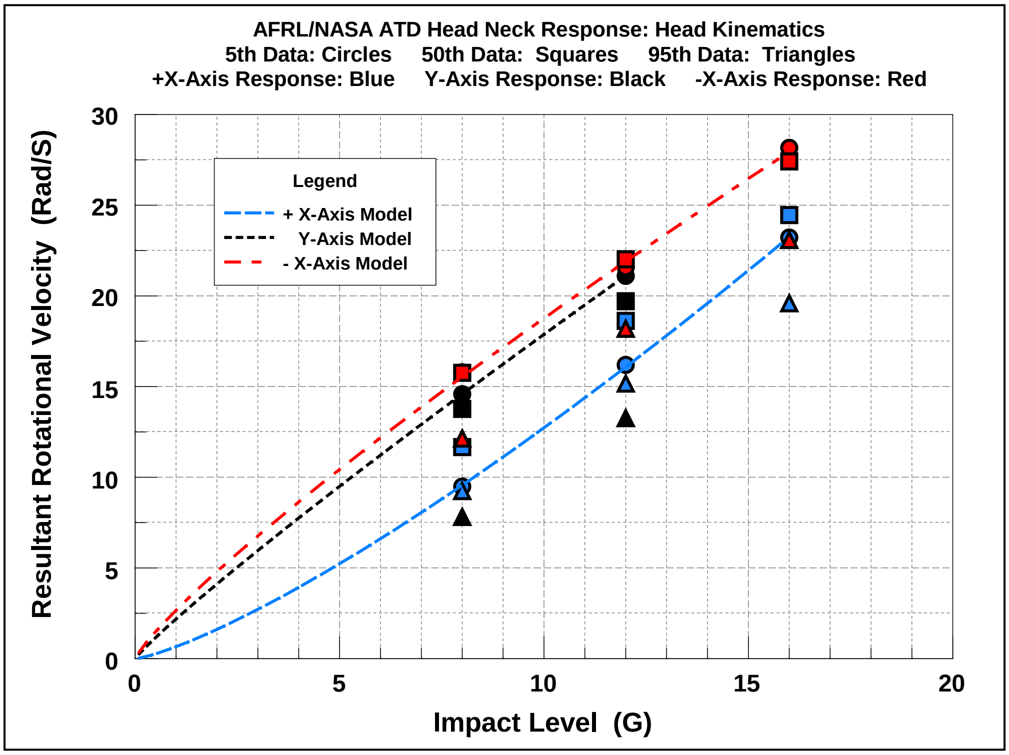

Figure 15. Resultant Head Rotationl Velocity as Function of Impact Level: 50 ms Pulse

7.4.2 Kinematic Response (50 ms): Head Impact Plates

The ATD head and neck responses with the 50 ms input pulse that involved impact plates and helmets were also analyzed with respect to the head kinimatic response based on calculated resultant head acceleration and the rotational velocity. The data is shown for primarily the +X-axis impact orientation at the assessed impact levels to compare the response with and without a helmet containing Confor foam inserts. The impact of the head plates required the analysis of the rotational velocities to focus on the primary rotation in the axis of impact and not the resultant rotational velocity; therefore, the Ry rotational velocity was assessed for the +X-axis impacts. No data was collected in the –X-axis impact orientation, and no comparative data was collected in the Y-axis impact orientation. The data with the impact plate and helmet configurations are shown in Tables 7 and 8 using the same calculated response parameters as previously shown for the head kinematic responses.

Table 7. ATD Head Acceleration Response: 50 ms Pulse with Plate/Helmet

Peak Input (G)	Test Set-Up (+X-Axis Impact Orientation)	5th ATD Resultant Head Acceleration (G)	50th ATD Resultant Head Acceleration (G)
8	Plate	32.47	35.34
	Plate with Confor	12.88	14.66
	Plate and Helmet	13.92	16.56
10	Plate	73.55	56.8
12	Plate	102.86	72.59
	Plate and Helmet	21.26	31.19
16	Plate and Helmet	26.43	38.68

The ATD resultant head accelerations all show a trend to increase as a function of the impact level as expected, and the peaks indicate plate contact. Figure 16 compares the resultant head acceleration of the 50th ATD in free motion with no impact plate (from previous data set analysis), versus the resultant head acceleration of the 50th ATD in the test set-up with the impact plate. The majority of the data indicates little difference between the response of the ATD head sizes as a function of the impact levels. The data also indicates the effectiveness of using a helmet with a Confor foam insert to reduce the peak impact acceleration. The peak impact acceleration was reduced by over 50% for both ATD heads at the impact levels which allowed a comparison. The condition with just the Confor foam on the impact plate generated similar results. Figure 17 compares the the resultant head impact acceleration of the 50th ATD for impact conditions with and with-out the helmet with a 1.0 inch thick Confor foam insert.

Table 8. ATD Head Velocity Response: 50 ms Pulse with Plate/Helmet

Peak Input (G)	Test Set-Up (+X-Axis Impact Orientation)	5th ATD Resultant Head Rotational Velocity (Rad/S)	50th ATD Resultant Head Rotational Velocity (Rad/S)
8	Plate	8.26	7.37
	Plate with Confor	6.02	4.95
	Plate and Helmet	4.96	8.08
10	Plate	9.52	7.74
12	Plate	8.90	6.99
	Plate and Helmet	5.92	8.83
16	Plate and Helmet	6.59	9.34

The ATD resultant head rotational velocities all showed a slight trend to increase as a function of the impact level for the both the plate only and the plate plus helmet impact configuration. The majority of the data indicates little difference between the response of the 5th and 50th ATD head and necks as a function of the three impact levels. The peak values in these configurations are due to the rapid transition of the each head from a negative Ry rotation to a positive Ry rotation following contact with the plate (ie, a rebound affect) as indicated by the head acceleration, and an example of this can be shown in Figure 18 with the impact transition occuring at approximately 60 ms. The Rx rotational velocity, which was priamry during the lateral Y-axis impact orientation, also displayed this same rebound event.

It is interesting to note that the test conditions with the helmet and foam inserts did not have a significant effect on the resultant head rotational velocity, but there was a more noticable reduction in peak values for the 5th ATD head rotation. This may have been due to the fact that the Confor foam in the helmet used by the 5th ATD used 2.0 inch thick foam compared to the 1.0 inch thick foam used for the 50th ATD. It must also be noted that some of the test conditions had different head or head plus helmet initial off-set distances from the impact plate, but they tended to stay consistent for each manikin, and therefore were not specifically addressed in the data summaries as a test variable.

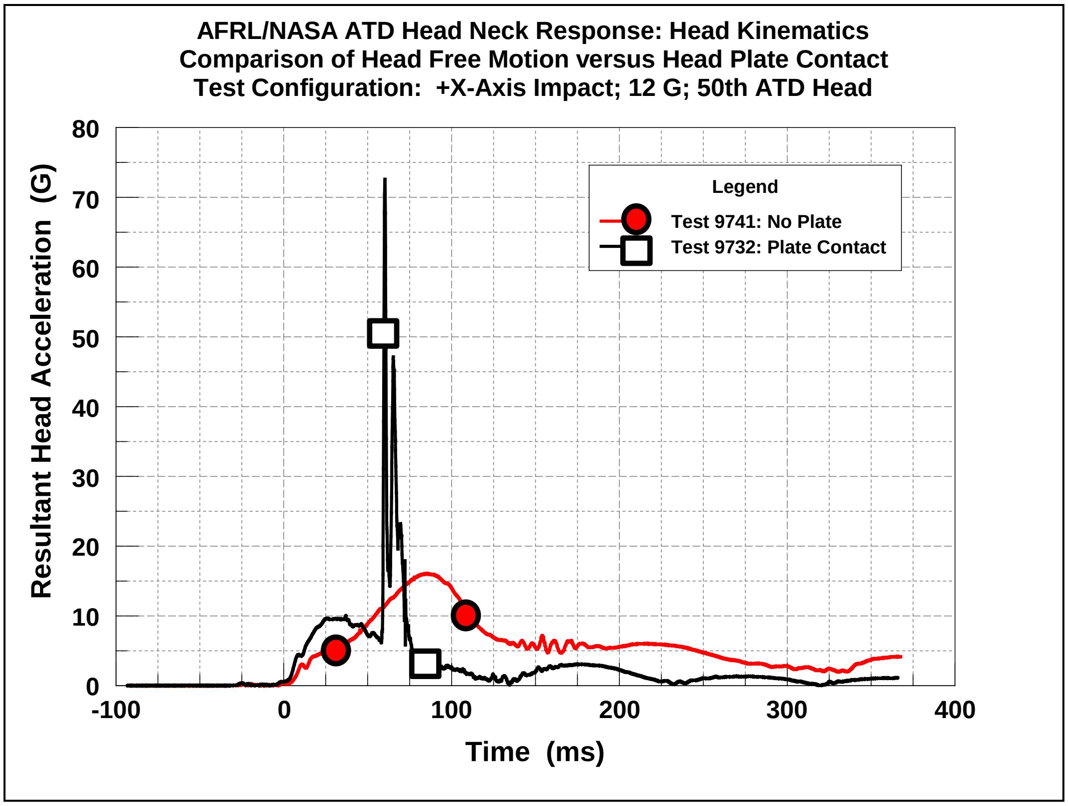

Figure 16. Resultant Head Acceleration with Impact Plate Contact: 50 ms Pulse

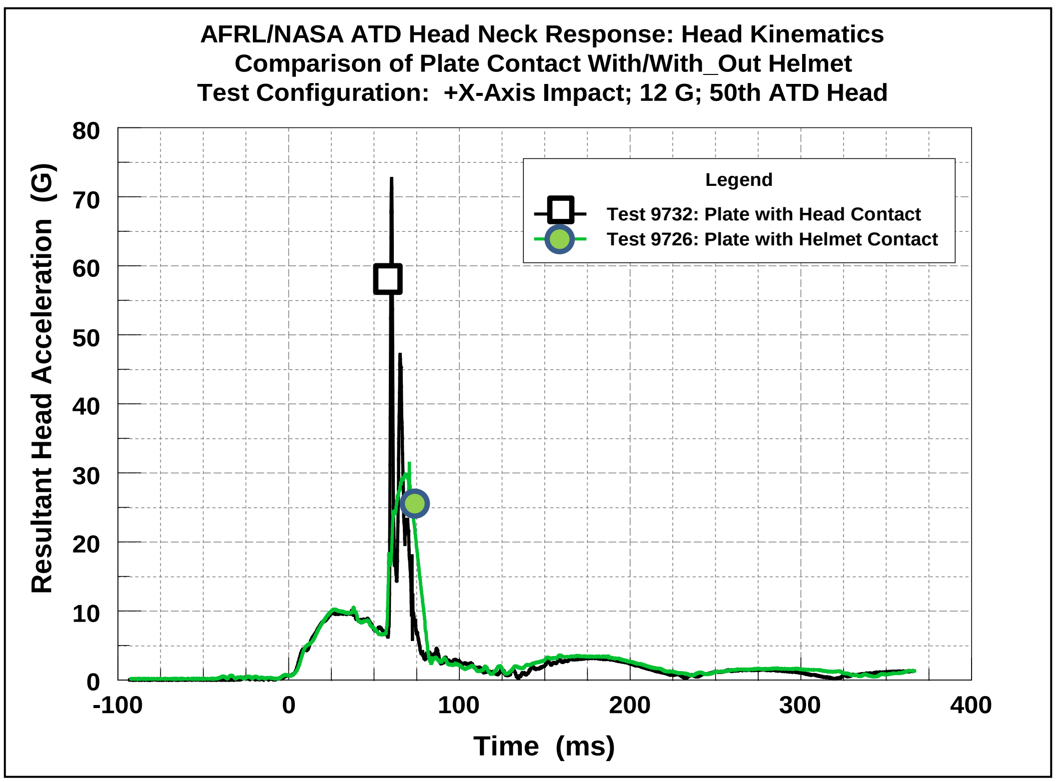

Figure 17. Resultant Head Acceleration with Impact Plate Contact: 50 ms Pulse

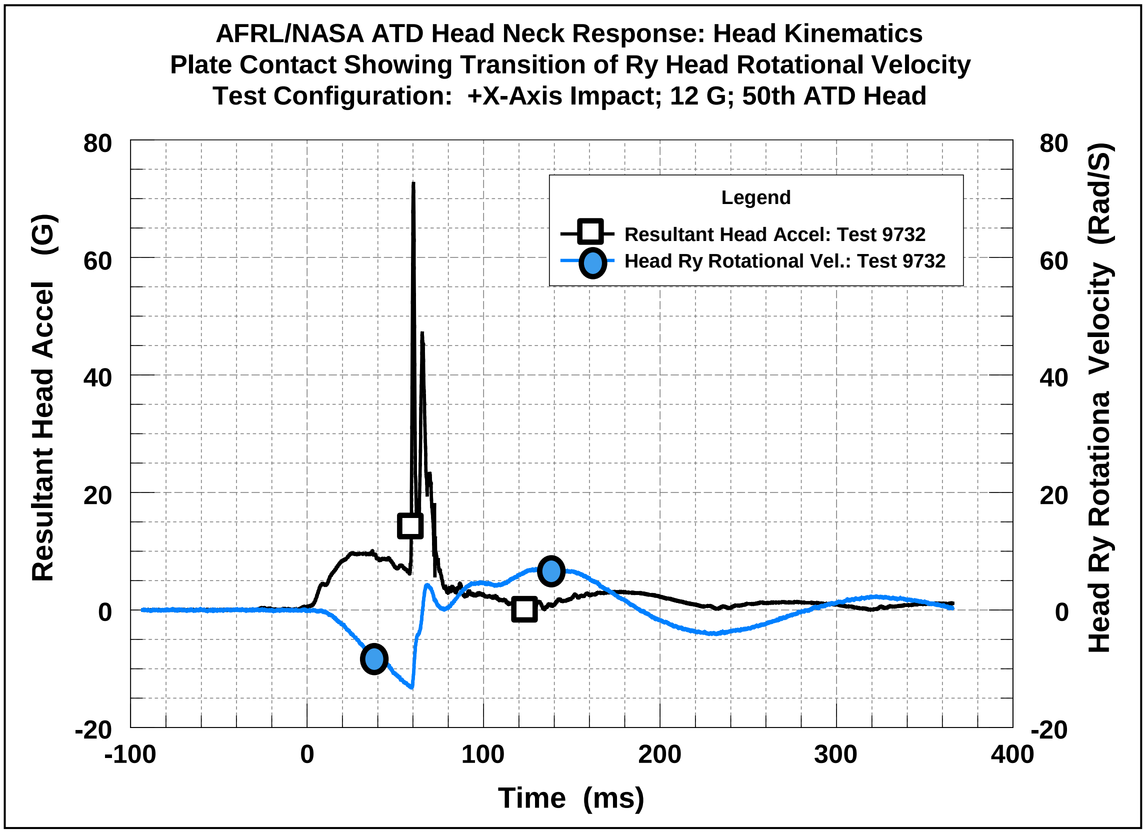

Figure 18. Head Acceleration/Head Ry Velocity with Impact Plate Contact: 50 ms Pulse

7.4.3 Neck Load Response (50 ms): No Head Impact Plates

The ATD neck load responses with the 50 ms input pulse were analyzed with respect to the occipital condyle based on measured shear, tension, and compression loads and torque. Select data in Tables 9 and 10 are shown for each impact orientation at the assessed impact levels for all the analyzed response parameters for the test conditions with the head impact plate positioned on the test fixtures to not allow a head strike during the impact.

Table 9. ATD Neck Shear Load Response: 50 ms Pulse with No Plate/Helmet

Peak Input (G)	Test Set-Up (Impact Orientation)	5th ATD Shear Load (lb)	50th ATD Shear Load (lb)	95th ATD Shear Load (lb)
8	+X-Axis	38.33	51.34	51.52
	+X-Axis (45° Yaw)	22.8	29.71	40.02
	Y-Axis	57.85	66.37	81.55
	-X-Axis	69.94	87.17	99.62
	-X-Axis (45° Yaw)	56.35	67.72	25.48
12	+X-Axis	47.54	62.74	74.17
	+X-Axis (45° Yaw)	35.47	38.82	53.65
	Y-Axis	88.45	95.93	121.45
	-X-Axis	107.32	132	148.53
	-X-Axis (45° Yaw)	91.64	106.94	117.83
16	+X-Axis	57.63	78.71	97.18
	+X-Axis (45° Yaw)	48.86	50.49	69.33
	-X-Axis	156.55	193.91	209.31
	-X-Axis (45° Yaw)	130.46	156.48	165.54

The shear loads from impacts in the +X-axis and the –X-axis orientations were analyzed using the measured shear-x loads in the upper neck load cell, and the shear loads from impacts in the Y-axis orientation was analyzed using the measured shear-y load in the upper neck load cell. The ATD neck shear loads all showed a trend to increase as a function of the impact level and as a function of the impact orientation. The majority of the data indicates some difference between the response of the ATD head sizes as a function of impact orientation at each of the three impact levels. The neck shear loads increased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis, with the -X-axis response being the greatest at each impact level. The neck shear loads also increased as the ATD changed from the 5th ATD to the 50th ATD, and then to the 95th ATD, with the 95th ATD having the greatest values at each impact level. The repeat tests at the indicated impact orientations had the head at a yaw angle of 45°, and as expected, the measured shear loads (in the respective impact orientation) were reduced due to the shear force being distributed between both the measured shear-x and the shear-y load in the upper neck load cell.

The data plot in Figure 19 demonstrates the relationship between the data sets across the three different impact orientations, and the noticable variation in the response across the three different

ATD head and necks. The data sets were fit with a Power Function ($y=a*x^b$) regression model versus a Liner Function because it provided a higher COD or R^2 value, and this indicates a better prediction of the portion of the neck shear load (dependent variable) based on the input acceleration (independent variable). A single Power Function regression model is shown for each impact orientation for clarity on the plot. The r and R^2 for the regression models in each group was a minimum 0.999 and 0.997 respectively, highlighting a strong model fit.

Table 10. ATD Neck Torque Response: 50 ms Pulse with No Plate/Helmet

Peak Input (G)	Test Set-Up (Impact Orientation)	5th ATD Neck Torque (in-lb)	50th ATD Neck Torque (in-lb)	95th ATD Neck Torque (in-lb)
8	+X-Axis	78.71	114.6	118.3
	+X-Axis (45° Yaw)	54.36	81.87	84.91
	Y-Axis	108.16	155.93	164.45
	-X-Axis	160.48	212.38	229.89
	-X-Axis (45° Yaw)	126.03	158.08	171.78
12	+X-Axis	126.59	205.03	217.89
	+X-Axis (45° Yaw)	82.14	127.54	147.15
	Y-Axis	188.98	250.15	259.87
	-X-Axis	274.94	346.91	351.56
	-X-Axis (45° Yaw)	214.88	259.93	274.61
16	+X-Axis	171.64	283	310.92
	+X-Axis (45° Yaw)	126.27	195.76	211.82
	-X-Axis	401.54	512.02	514.99
	-X-Axis (45° Yaw)	333.14	389.84	402.73

The neck torques from impacts in the +X-axis and the –X-axis orientations were analyzed using the measured My torque in the upper neck load cell, and the neck torques from impacts in the Y-axis orientation were analyzed using the measured Mx torque in the upper neck load cell. The ATD neck torque showed a trend to increase as a function of the impact level and as a function of the impact orientation. The 95^{th} ATD had the greatest response of the the three ATD head and necks, and the majority of the data indicates a minor difference between the response of the 50^{th} and 95^{th} ATD head and necks as a function of impact orientation at each of the three impact levels. The 5^{th} ATD neck torque had smaller peak values compared to the other two ATD head and necks at each impact orientation and impact level. The 5^{th} ATD neck torque was smaller by approximately 50 in-lb at each impact level compared to the 50^{th} ATD, and by approximately

100 in-lb to 150 in-lb at each impact level compared to the 95th ATD. The neck torques increased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis, with the -X-axis response being the greatest at each impact level. The repeat tests at the indicated impact orientations had the head at a yaw angle of 45°, and as expected, the measured neck torques (in the respective impact orientation) were reduced due to the neck torque being distributed between both the measured My torque and Mx torque in the upper neck load cell.

The data plot in Figure 20 demonstrates the relationship between the data sets across the three different impact orientations, and the noticable variation in the response across the three different ATD head and necks. The data sets were fit with a Power Function ($y=a*x^b$) regression model versus a Liner Function because it provided a higher COD or R^2 value, and this indicates a better prediction of the portion of the neck torque (dependent variable) based on the input acceleration (independent variable). A single Power Function regression model is shown for each impact orientation for clarity on the plot. The r and R^2 for the regression models in each group was a minimum 0.998 and 0.996 respectively, highlighting a strong model fit.

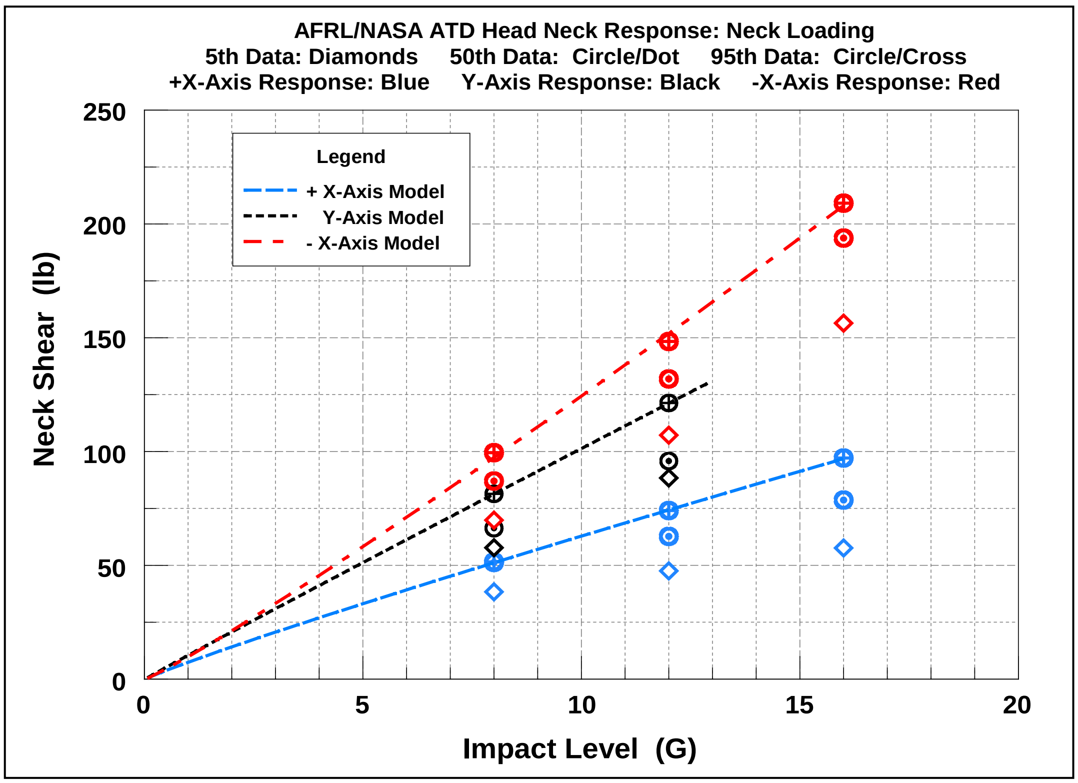

Figure 19. Neck Shear Loads as Function of Impact Level: 50 ms Pulse

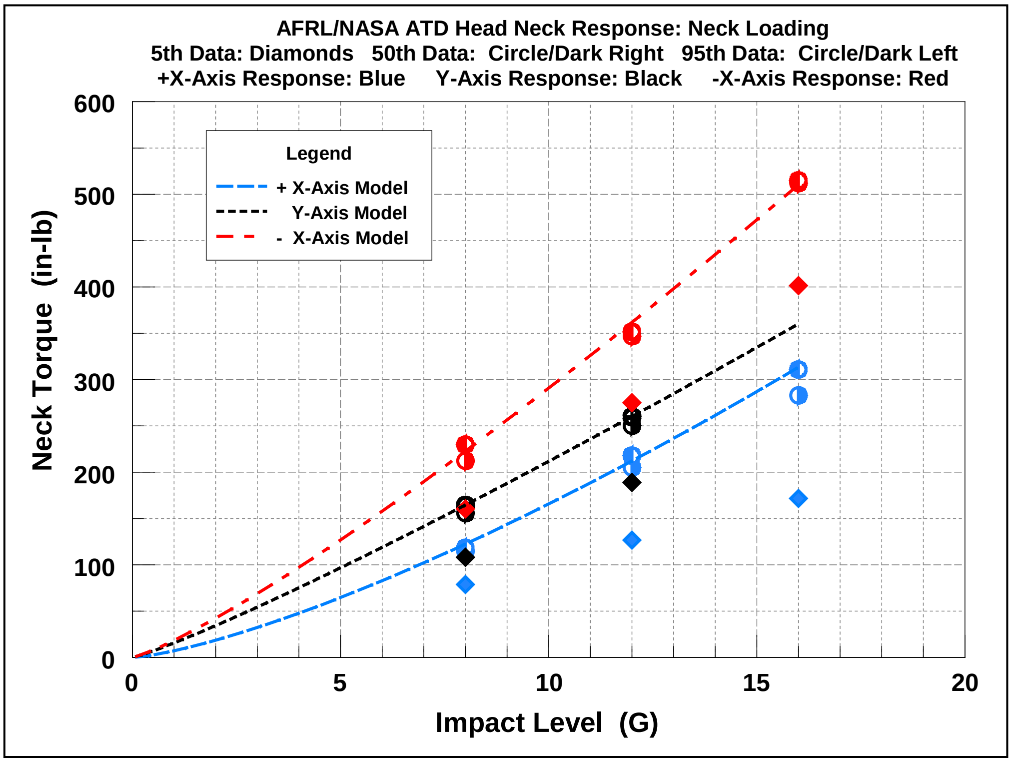

Figure 20. Neck Torque as Function of Impact Level: 50 ms Pulse

7.4.4 Neck Load Response (50 ms): Head Impact Plates

The ATD neck load with the 50 ms input pulse that involved impact plates and helmets were analyzed with respect to the load response based on following impact of the head and or head and helmet with the impact plate. The data is shown for primarily the +X-axis impact orientation to compare the loads response with and without a helmet which contained Confor foam inserts. An overview of the data from this data set indicated that the analysis would focus on neck torque because the neck shear loads, and neck compression loads showed very little variability; therefore, the tension load and My torque was assessed for the +X-axis impacts.

No data was collected in the –X-axis impact orientation, and no comparative data was collected in the Y-axis impact orientation. Data was collected with the 95th ATD, but not for a comparative analysis; therefore, only data for the 5th and 50th ATDs will be shown, and are presented in Tables 11 and 12.

Table 11. ATD Neck Tension Load Response: 50 ms Pulse with Plate/Helmet

Peak Input (G)	Test Set-Up (+X-Axis Impact Orientation)	5th ATD Neck Tension (lb)	50th ATD Neck Tension (lb)
8	Plate	30.26	93.41
	Plate with Confor	8.02	3.59
	Plate and Helmet	8.35	13.01
10	Plate	44.38	134.94
12	Plate	39.63	156.19
	Plate and Helmet	16.64	21.27
16	Plate and Helmet	14.02	21.56

The ATD neck tension loads all show a trend to increase as a function of the impact level as expected, and the peak loads all indicate plate contact. The neck tension load of the 50th ATD in free motion with no impact plate are much smaller than the neck tension load of the 50th ATD in the test set-up with the impact plate, and show a similar result to what was demonstrated by the head accleration in Figure 16. The majority of the data with the impact plate indicates the 50th ATD neck tension loads following impact with the plate to be 3-4 times greater than the neck tension loads measured in the 5th ATD. The data also indicates the effectiveness of using a helmet with a Confor foam insert to reduce the peak impact acceleration, and these accelerations were reduced from between 50 to 85% for both ATD heads at the impact levels allowing a comparison of the data. The condition with just the Confor foam on the impact plate generated similar results to the results shown with the combined helmet and Confor foam insert .

Table 12. ATD Neck Torque Response: 50 ms Pulse with Plate/Helmet

Peak Input (G)	Test Set-Up (+X-Axis Impact Orientation)	5th ATD Neck Torque (in-lb)	50th ATD Neck Torque (in-lb)
8	Plate	64.07	82.31
	Plate with Confor	27.60	43.51
	Plate and Helmet	58.72	88.93
10	Plate	61.63	95.16
12	Plate	73.24	90.86
	Plate and Helmet	67.96	110.09
16	Plate and Helmet	73.43	114.7

The ATD neck torques showed a slight trend to increase as a function of the impact level for the both the plate only and the plate plus helmet impact configuration. The majority of the data indicates a noticable difference between the response of the 5th and 50th ATD head and necks as a function of the three impact levels with the 50th ATD response having a 50% or more greater value. The peak values in these configurations are due to the rapid transition of each head from a negative Ry rotation to a positive Ry rotation following contact with the plate (ie, a rebound affect) as indicated by the spike in neck tension; an example of this can be shown in Figure 21 with the impact transition occuring at approximately 60 ms.

It is interesting to note that the test conditions with the helmet and foam inserts did not have a significant effect on the neck torque, but the results with the helmet and foam were slightly higher. This was most likely due to the rebound initiating rapid rotation of the head and helmet combination relative to the neck. It must also be noted that some of the test conditions had different head or head plus helmet initial off-set distances from the impact plate, but they tended to stay consistent for each manikin, and therefore were not specifically addressed in the data summaries as a test variable.

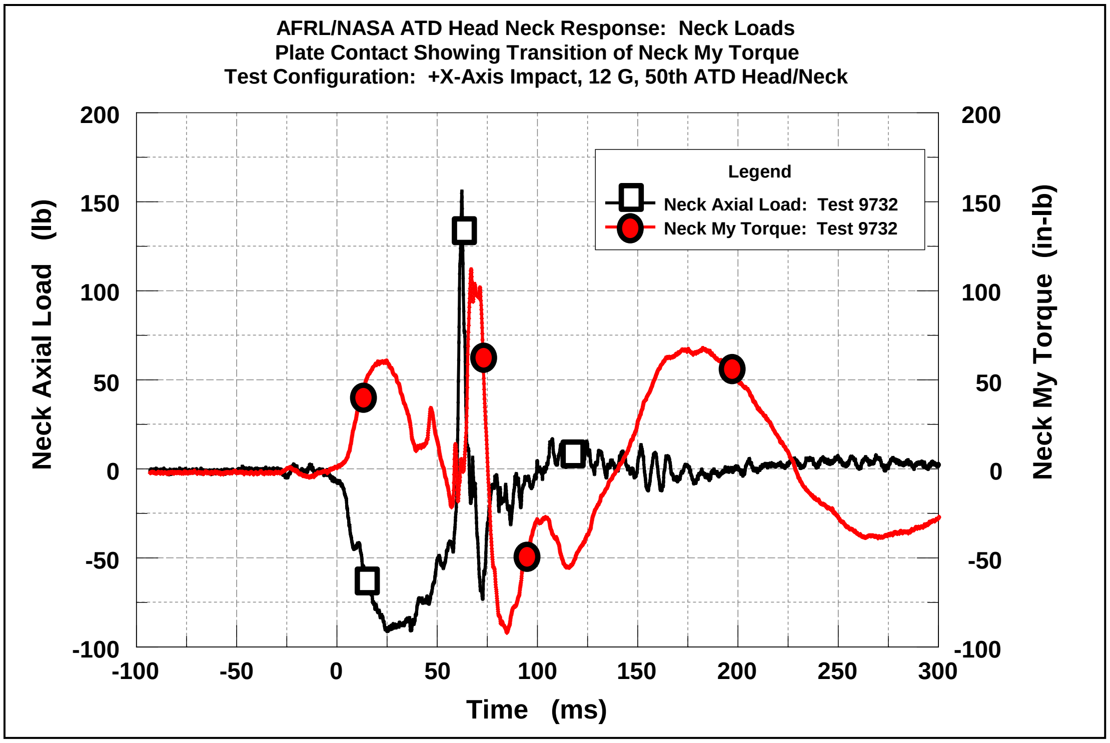

Figure 21. Neck Axial Load/Neck My Torque with Impact Plate Contact: 50 ms Pulse

7.5 ATD Head/Neck Response: 100 ms Pulse

The ATD head and neck responses for the tests completed with the impact acceleration consisting of the 100 ms pulse were also addressed by analyzing both the kinematic and inertial reactions. The kinematic reactions consisted of the assessment of the measured head acceleration and rotational velocity including any calculated resultant values. The inertial reactions consisted of the assessment upper neck loads and torques including any calculated resultant values.

The head and neck kinematic reactions are addressed first, and are followed by the upper neck loads and torques in following sections using the same data presentation method as shown for the kinematic response.

7.5.1 Kinematic Response (100 ms): No Head Impact Plates

The ATD head and neck responses with the 100 ms input pulse were analyzed with respect to the head kinimatic response based on calculated resultant head acceleration and calculated resultant rotational velocity from all the test cells that were set-up with the impact plate positioned away from the ATD heads and also that were set-up without using a helmet. The data are shown in Tables 13 and 14 for each impact orientation at the assessed impact levels for both calculated response parameters.

Table 13. ATD Head Acceleration Response: 100 ms Pulse with No Plate/Helmet

Peak Input (G)	Test Set-Up (Impact Orientation)	5th ATD Resultant Head Acceleration (G)	50th ATD Resultant Head Acceleration (G)	95th ATD Resultant Head Acceleration (G)
6	+X-Axis	6.07	5.98	6.19
	Y-Axis	7.32	7.35	7.08
	-X-Axis	8.34	8.36	7.55
8	+X-Axis	7.20	7.73	8.13
10	+X-Axis	10.31	10.51	11.05
	Y-Axis	13.82	13.57	12.10
	-X-Axis	16.01	15.49	13.94
12	+X-Axis	16.54	15.26	16.12
	Y-Axis	17.93	17.7	15.19
	-X-Axis	19.87	19.37	17.34

The ATD resultant head accelerations, resulting from the approximate 100 ms time-to-peak input pulse, all show a trend to increase as a function of the impact level and as a function of the impact orientation (impact direction). The majority of the data indicates only slight differences between the response of the ATD head sizes as a function of impact orientation at a given impact level. It is interesting to note that the resultant head acceleration increased as the impact orientation changed from +X-axis to Y-axis to -X-axis, with the -X-axis response being the greatest at each impact level. This head acceleration increase as a function of impact orientation was also demonstrated with the approximate 50 ms time-to-peak input pulse test condition.

The data plot in Figure 22 demonstrates the relationship between the data sets across the three different impact orientations, and the relatively small variation in the response across the three different ATD head and necks. The data sets were fit with a Power Function ($y=a*x^b$) regression model versus a Liner Function because it provided a higher COD or R^2 value, and this indicates a better prediction of the portion of the head acceleration variance (dependent variable) based on the input acceleration (independent variable). A single Power Function regression model is shown for each impact orientation for clarity on the plot using data from the 50th ATD. The r and R^2 for the regression models in each group was a minimum 0.987 and 0.973 respectively, highlighting a strong model fit.

Table 14. ATD Head Velocity Response: 100 ms Pulse with No Plate/Helmet

Peak Input (G)	Test Set-Up (Impact Orientation)	5th ATD Resultant Head Rotational Velocity (Rad/S)	50th ATD Resultant Head Rotational Velocity (Rad/S)	95th ATD Resultant Head Rotational Velocity (Rad/S)
6	+X-Axis	9.96	11.96	6.73
	Y-Axis	9.96	8.5	2.65
	-X-Axis	11.20	9.33	4.19
8	+X-Axis	17.98	18.95	12.7
10	+X-Axis	21.20	23	16.31
	Y-Axis	18.90	17.8	9.01
	-X-Axis	18.13	18.12	12.4
12	+X-Axis	25.29	26.75	20.36
	Y-Axis	22.18	20.93	12.22
	-X-Axis	20.26	21	15.2

The ATD resultant head rotational velocity, resulting from the approximate 100 ms time-to-peak input pulse, all show a trend to increase as a function of the impact level and as a function of the impact orientation (impact direction). The data indicates a larger spread of the data between the response of the three ATD head and necks as a function of impact orientation at each of the three impact levels. The 95th ATD head and neck rotational velocity had smaller peak values compared to the other two ATD head and necks at each impact orientation and impact level, which was also the case with the cooresponding 50 ms time-to-peak data. It is very interesting to note that the resultant head rotational velocity decreased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis, with the +X-axis data being the greatest. This was the oppposite of what was demonstrated by the head rotational velocity data for the 50 ms time-to-peak input pulse.

The data plot in Figure 23 demonstrates the relationship between the data sets across the three different impact directions, and the variation in the response across the three different ATD head and necks. The data sets were fit with a Power Function (y=a*xb) regression model versus a Liner Function because it provided a higher R^2 value, and this indicates a better prediction of the portion of the head rotationa velocity variance (dependent variable) based on the input acceleration (independent variable). A single Power Function regression model is shown for each impact orientation for clarity on the plot. The r and R^2 for the regression models in each group was a minimum 0.998 and 0.996 respectively, indicating the regression model's strong fit.

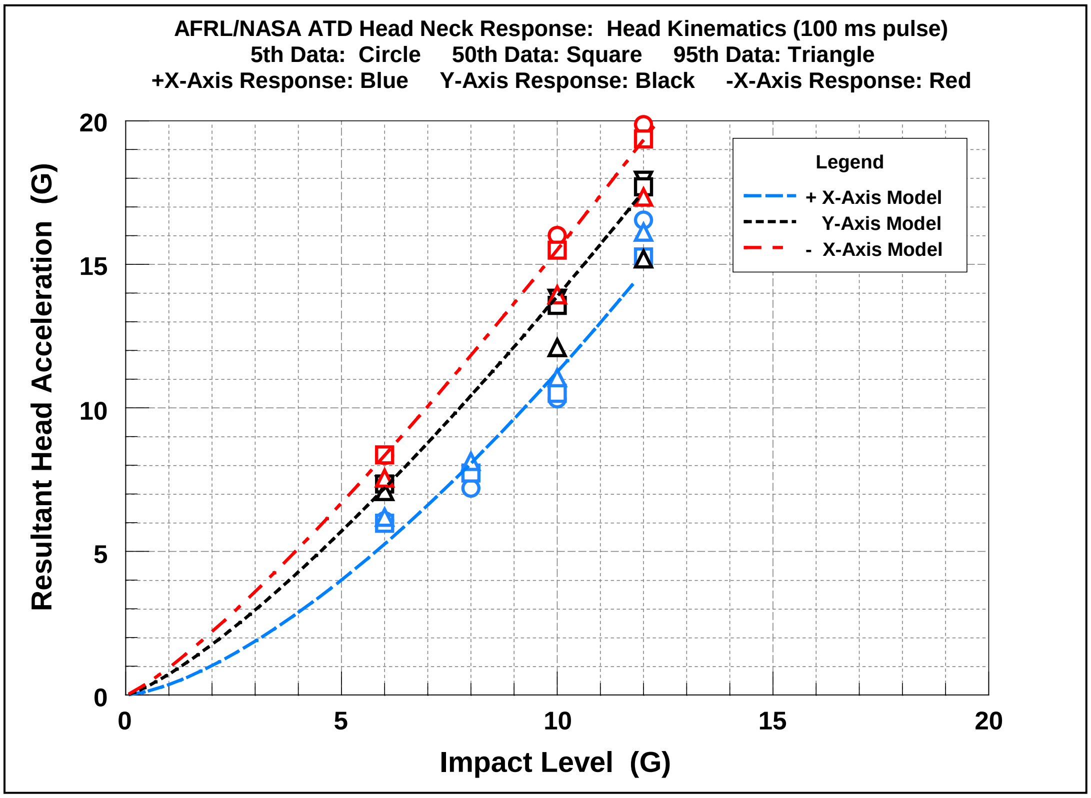

Figure 22. Resultant Head Acceleration as Function of Impact Level: 100 ms Pulse

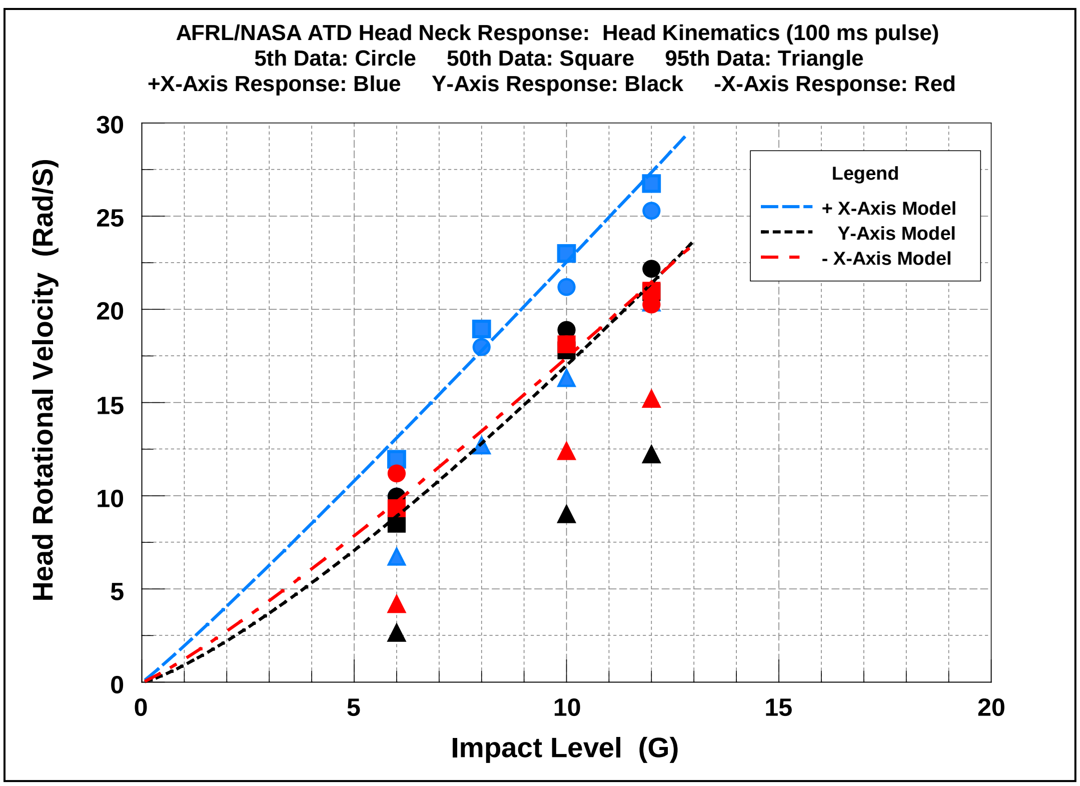

Figure 23. Resultant Rotationl Velocity as Function of Impact Level: 100 ms Pulse

7.5.2 Kinematic Response (100 ms): Head Impact Plates

The ATD head and neck responses with the 100 ms input pulse that involved impact plates and helmets were also analyzed with respect to the head kinimatic response based on calculated resultant head acceleration and the rotational velocity. The data is shown for the +X-axis impact orientation at the assessed impact levels to compare the response with and without a helmet. No tests were conducted with Confor foam inserts similar to what was conducted with the 50 ms input pulse. The impact of the head plates required the analysis of the rotational velocities to focus on the primary rotation in the axis of impact and not the resultant rotational velocity; therefore, the Ry rotational velocity was assessed for the +X-axis impacts. No data was collected in the –X-axis impact orientation, and no comparative data was collected in the Y-axis impact orientation. Data was collected with the 95th ATD, but not for a comparative analysis; therefore, only data for the 5th and 50th ATDs will be presented. The data with the impact plate and helmet configurations are shown in Tables 15 and 16 using the same calculated response parameters as previously shown for the head kinematic responses.

Table 15. ATD Head Acceleration Response: 100 ms Pulse with Plate/Helmet

Peak Input (G)	Test Set-Up (+X-Axis Impact Orientation)	5th ATD Resultant Head Acceleration (G)	50th ATD Resultant Head Acceleration (G)
6	Plate	22.93	23.19
	Plate and Helmet	11.33	16.05
10	Plate	77.85	45.36
	Plate and Helmet	18.6	27.66
12	Plate	99.8	60.09
	Plate and Helmet	20.75	32.33
15	Plate and Helmet	26.51	37.76

The ATD resultant head accelerations all show a trend to increase as a function of the impact level as expected, and the peaks indicate plate contact. The majority of the data indicates a slight difference between the response of the ATD head sizes as a function of the impact levels with the 5th ATD having a higher impact response at the higher impact levels. The data also indicates the effectiveness of using a helmet to reduce the sharp spikes resulting from the impact. The peak impact acceleration was reduced by approximately 50% or more for both ATD heads at the impact levels which allowed a comparison. Figure 24 compares the the resultant head impact acceleration of the 5th ATD for impact conditions with and with-out the helmet.

Table16. ATD Head Velocity Response: 100 ms Pulse with Plate/Helmet

Peak Input (G)	Test Set-Up (+X-Axis Impact Orientation)	5^{th} ATD Resultant Head Rotational Velocity (Rad/S)	50^{th} ATD Resultant Head Rotational Velocity (Rad/S)
6	Plate	5.29	6.16
	Plate and Helmet	5.85	8.01
10	Plate	10.93	10.04
	Plate and Helmet	9.01	12.40
12	Plate	13.09	12.11
	Plate and Helmet	10.61	14.09
15	Plate and Helmet	12.51	16.04

The ATD resultant head rotational velocities all showed a slight trend to increase as a function of the impact level for the both the plate only and the plate plus helmet impact configuration. The majority of the data indicates little difference between the response of the 5^{th} and 50^{th} ATD head and necks as a function of the three impact levels. The peak values in these configurations are due to the rapid transition of the each head from a negative Ry rotation to a positive Ry rotation following contact with the plate (i.e., a rebound affect) as indicated by the head acceleration, and an example of this can be shown in Figure 18 with the impact transition occuring at approximately 60 ms. The Rx rotational velocity, which was primary during the lateral Y-axis impact orientation, also displayed this same rebound event.

It is interesting to note that the test conditions with the helmet and foam inserts did not have a significant effect on the resultant head rotational velocity, but there was a more noticable reduction in peak values for the 5^{th} ATD head rotation. This may have been due to the fact that the Confor foam in the helmet used by the 5^{th} ATD used 2.0 inch thick foam compared to the 1.0 inch thick foam used for the 50^{th} ATD. It must also be noted that some of the test conditions had different head or head plus helmet initial off-set distances from the impact plate, but they tended to stay consistent for each manikin, and therefore were not specifically addressed in the data summaries as a test variable.

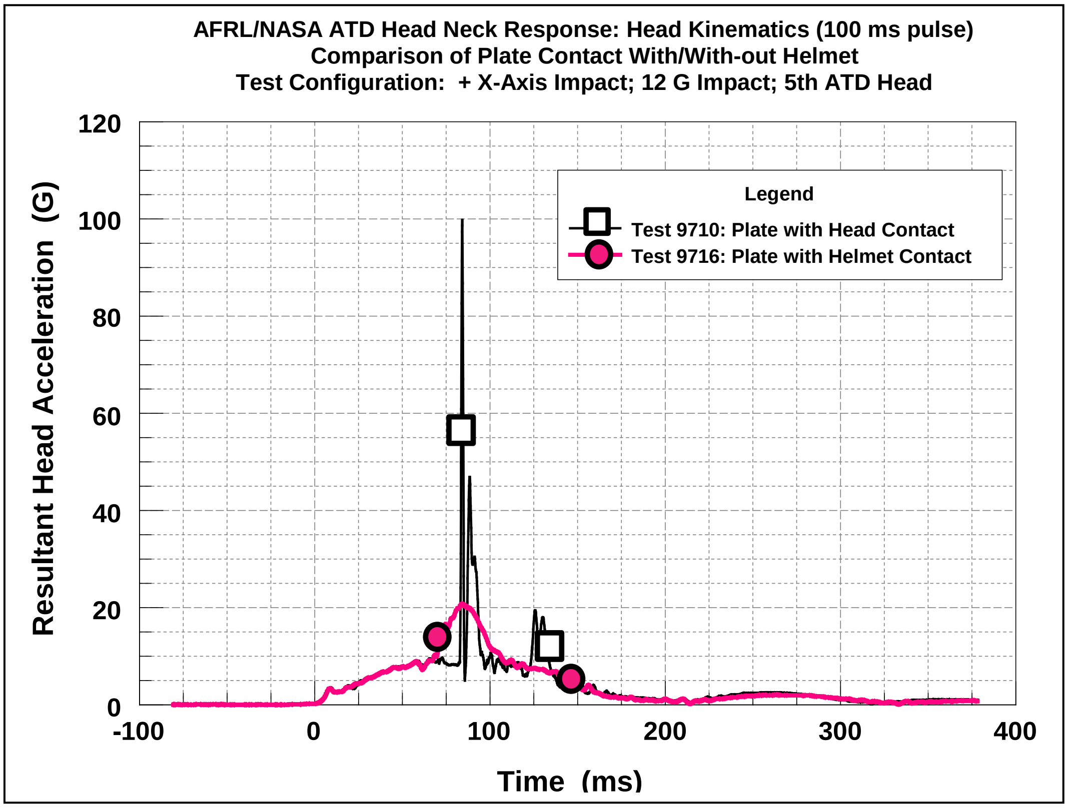

Figure 24. Resultant Head Acceleration with Impact Plate Contact: 100 ms Pulse

7.5.3 Neck Load Response (100 ms): No Head Impact Plates

The ATD neck load responses with the 100 ms input pulse were analyzed with respect to the occipital condyle based on measured shear, tension, and compression loads and rotational torque. Select data in Tables 17 and 18 are shown for each impact orientation at the assessed impact levels for all the analyzed response parameters for the test conditions with the head impact plate positioned on the test fixtures to not allow a head strike during the impact.

Table 17. ATD Neck Shear Load Response: 100 ms Pulse with No Plate/Helmet

Peak Input (G)	Test Set-Up (Impact Orientation)	5th ATD Shear Load (lb)	50th ATD Shear Load (lb)	95th ATD Shear Load (lb)
6	+X-Axis	34.24	47.86	49.3
	Y-Axis	51.85	57.54	62.21
	-X-Axis	57.48	69.58	73.7
8	+X-Axis	48.89	63.04	71.12
10	+X-Axis	62.77	83.27	88.16
	Y-Axis	96.61	99.65	109.4
	-X-Axis	108.37	130.37	132.03
12	+X-Axis	92.39	107.81	111.94
	Y-Axis	117.3	127.53	134.5
	-X-Axis	133.04	161.94	162.14

The shear loads from impacts in the +X-axis and the –X-axis orientations were analyzed using the measured shear-x loads in the upper neck load cell, and the shear loads from impacts in the Y-axis orientation was analyzed using the measured shear-y load in the upper neck load cell. The ATD neck shear loads all showed a trend to increase as a function of the impact level and as a function of the impact orientation. The majority of the data indicates some minor differences between the response of the ATD head sizes as a function of impact orientation at each of the three impact levels. The neck shear loads increased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis, with the -X-axis response being the greatest at each impact level. The neck shear loads also increased as the ATD changed from the 5th ATD to the 50th ATD, and then to the 95th ATD, with the 95th ATD having the greatest values at each impact level. The repeat tests at the indicated impact orientations had the head at a yaw angle of 45°, and as expected, the measured shear loads (in the respective impact orientation) were reduced due to the shear force being distributed between both the measured shear-x and the shear-y load in the upper neck load cell.

The data plot in Figure 25 demonstrates the relationship between the data sets across the three different impact orientations, and the noticable variation in the response across the three different ATD head and necks. The data sets were fit with a Power Function ($y=a*x^b$) regression model versus a Liner Function because it provided a higher COD or R^2 value, and this indicates a better prediction of the portion of the neck shear load (dependent variable) based on the input acceleration (independent variable). A single Power Function regression model is shown for each impact orientation for clarity on the plot. The r and R^2 for the regression models in each group was a minimum 0.999 and 0.997 respectively, highlighting a strong model fit.

Table 18. ATD Neck Torque Response: 100 ms Pulse with No Plate/Helmet

Peak Input (G)	Test Set-Up (Impact Orientation)	5th ATD Neck Torque (in-lb)	50th ATD Neck Torque (in-lb)	95th ATD Neck Torque (in-lb)
6	+X-Axis	63.27	106.78	84.57
	Y-Axis	77.57	110.35	109.98
	-X-Axis	109.36	146.68	141.84
8	+X-Axis	122.16	179.17	148.96
10	+X-Axis	167.18	252	212.92
	Y-Axis	156.59	221.05	204.68
	-X-Axis	212.92	279.14	263.67
12	+X-Axis	212.92	279.14	263.67
	Y-Axis	220.19	292.29	270.58
	-X-Axis	264.66	350.29	324.19

The neck torques from impacts in the +X-axis and the –X-axis orientations were analyzed using the measured My torque in the upper neck load cell, and the neck torques from impacts in the Y-axis orientation were analyzed using the measured Mx torque in the upper neck load cell. The ATD neck torque showed a trend to increase as a function of the impact level and as a function of the impact orientation. The majority of the data indicates minor difference between the response of the 50th and 95th ATD head and necks as a function of impact orientation at each of the three impact levels; however, the 50th ATD neck torque was larger for most of the comparisons. The 5th ATD neck torque had smaller peak values compared to the other two ATDs at each impact orientation and impact level, and was smaller by approximately 100 to 150 in-lb at each impact level. The neck torques increased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis, with the -X-axis response being the greatest at each impact level. The difference between the responses in the +X-axis and the Y-axis were mininal, and the –X-axis reponses were much greater than both by approximately 100 to 300 in-lb. The repeat tests at the indicated impact orientations had the head at a yaw angle of 45°, and as expected, the measured neck torques (in the respective impact orientation) were reduced due to the neck torque being distributed between both the measured My torque and Mx torque in the upper neck load cell.

The data plot in Figure 26 demonstrates the relationship between the data sets across the three different impact orientations, and the noticable variation in the response across the three different ATD head and necks. The data sets were fit with a Power Function ($y=a*x^b$) regression model versus a Liner Function because it provided a higher COD or R^2 value, and this indicates a better prediction of the portion of the neck torque (dependent variable) based on the input acceleration (independent variable). A single Power Function regression model is shown for each impact orientation for clarity on the plot. The r and R^2 for the regression models in each group was a minimum 0.999 and 0.996 respectively, highlighting a strong model fit.

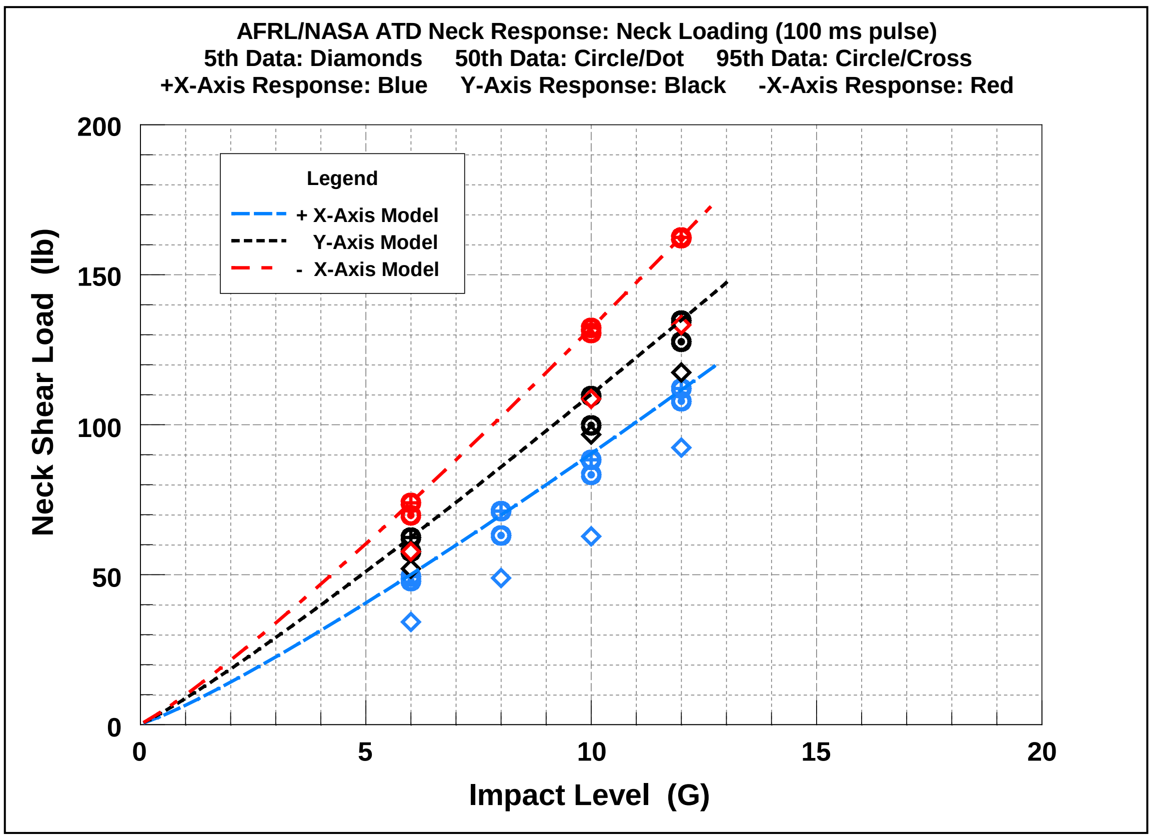

Figure 25. Neck Shear Loads as Function of Impact Level: 100 ms Pulse

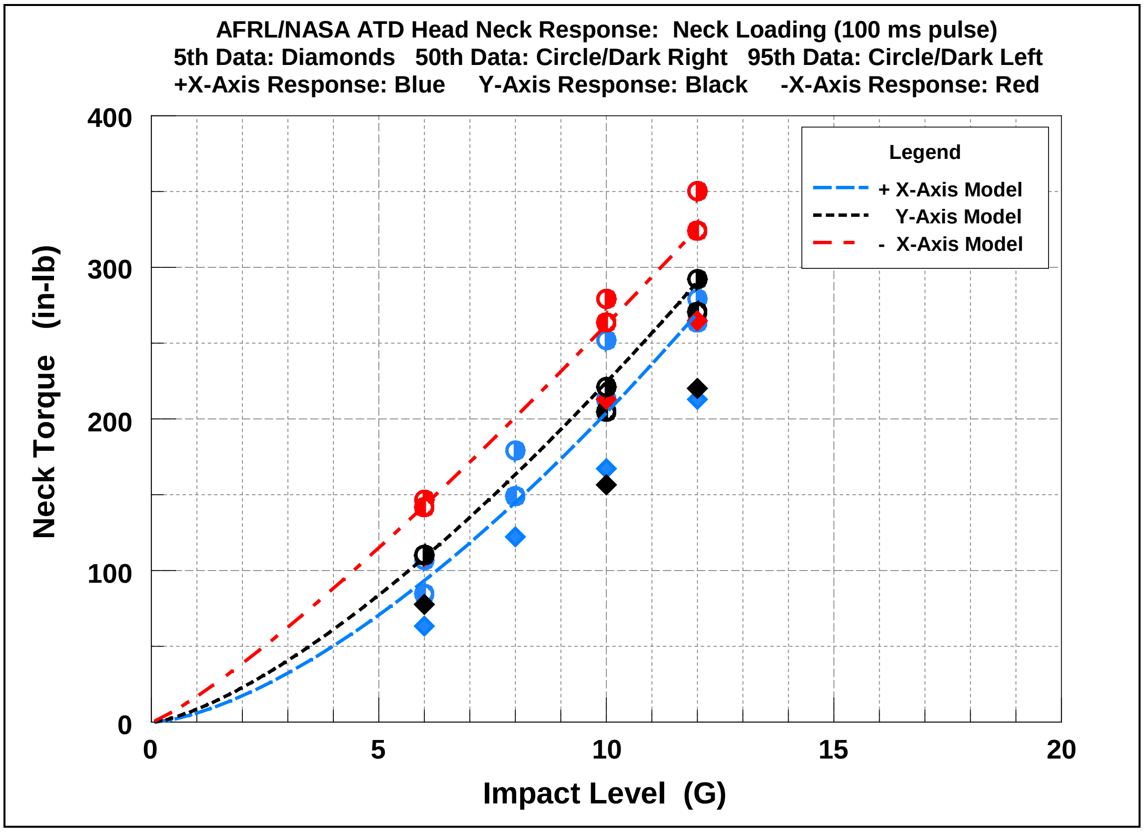

Figure 26. Neck Torque as Function of Impact Level: 100 ms Pulse

7.5.4 Neck Load Response (100 ms): Head Impact Plates

The ATD neck load with the 100 ms input pulse that involved impact plates and helmets were analyzed with respect to the load response based on following impact of the head and or head and helmet with the impact plate. The data is shown for primarily the +X-axis impact orientation to compare the loads response with and without a helmet which contained Confor foam inserts. An overview of the data from this data set indicated that the analysis would focus on neck torque because the neck shear loads, and neck compression loads showed very little variability; therefore, the tension load and My torque was assessed for the +X-axis impacts.

No data was collected in the –X-axis impact orientation, and no comparative data was collected in the Y-axis impact orientation. Data was collected with the 95th ATD, but not for a comparative analysis; therefore, only data for the 5th and 50th ATDs will be shown, and are presented in Tables19 and 20.

Table 19. ATD Neck Tension Load Response: 100 ms Pulse with Plate/Helmet

Peak Input (G)	Test Set-Up (+X-Axis Impact Orientation)	5th ATD Neck Tension (lb)	50th ATD Neck Tension (lb)
6	Plate	17.21	66.59
	Plate and Helmet	10.85	11.12
10	Plate	38.49	116.42
	Plate and Helmet	7.31	7.21
12	Plate	65.3	139.64
	Plate and Helmet	10.38	8.83
15	Plate and Helmet	10.45	7.82

The ATD neck tension loads all show a trend to increase as a function of the impact level as expected, and the peak loads all indicate plate contact. The neck tension loads of the 50th ATD in free motion with no impact plate are much smaller than the neck tension loads of the 50th ATD in the test set-up with the impact plate, and show a similar result to what was demonstrated by the head accleration. The majority of the data with the impact plate indicates the 50th ATD neck tension loads following impact with the plate to be 2-3 times greater than the neck tension loads measured in the 5th ATD. The data also indicates the effectiveness of using a helmet to reduce the peak impact acceleration, and these accelerations were reduced from between 60 to 90% for both ATD heads at the impact levels allowing a comparison of the data

Table 20. ATD Neck Torque Response: 100 ms Pulse with Plate/Helmet

Peak Input (G)	Test Set-Up (+X-Axis Impact Orientation)	5^{th} ATD Neck Torque (in-lb)	50^{th} ATD Neck Torque (in-lb)
6	Plate	45.82	67.58
	Plate and Helmet	38.42	71.74
10	Plate	41.93	61.65
	Plate and Helmet	38.73	76.44
12	Plate	48.25	73.81
	Plate and Helmet	54.31	78.64
15	Plate and Helmet	52.51	92.28

The ATD neck torques showed a slight trend to increase as a function of the impact level for the both the plate only and the plate plus helmet impact configuration. The majority of the data indicates a small difference between the response of the 5^{th} and 50^{th} ATD head and necks as a function of the three impact levels with the 50^{th} ATD response being greater. The peak values in these configurations are due to the rapid transition of each head from a negative Ry rotation to a positive Ry rotation following contact with the plate (ie, a rebound affect) as indicated by the spike in neck tension; an example of this can be shown in Figure 27 with the impact transition occuring at approximately 75 - 80 ms.

It is interesting to note that the test conditions with the helmet did not have a significant effect on the neck torque, but the results with the helmet were slightly higher in most cases. This was most likely due to the rebound initiating rapid rotation of the head and helmet combination relative to the neck. It must also be noted that some of the test conditions had different head or head plus helmet initial off-set distances from the impact plate, but they tended to stay consistent for each manikin, and therefore were not specifically addressed in the data summaries as a test variable.

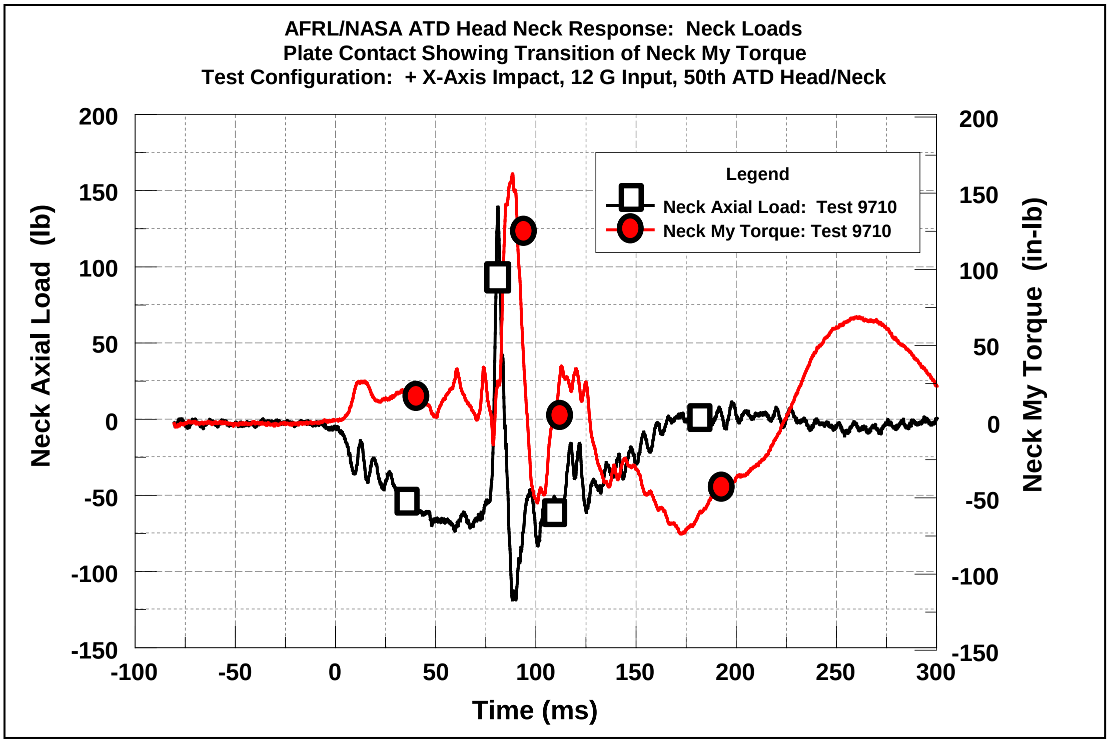

Figure 27. Neck Axial Load/Neck My Torque with Impact Plate Contact: 100 ms Pulse

8.0 SUMMARY AND CONCLUSIONS

Research was conducted involving a series of impacts on the HIA in multiple impact orientations as part of a collaboration research effort between NASA and AFRL. The purpose of the effort was to evaluate and conduct a comparison of the biodynamic response of different sized ATD head and neck configurations to support the development of computational models used to evaluate crew injury risk and aid in the design of seat and restraint systems for NASA's space vehicles and USAF air vehicles. Testing was completed using a head and neck combination from a 5th Hybrid III female aerospace ATD, a 50th Hybrid III male aerospace ATD, and a 95th Hybrid III male aerospace ATD.

A specially designed test matrix was developed to assess each ATD head and neck response as a function of both impact orientation, magnitude of the impact acceleration input pulse, and rise-time or time-to-peak of the impact acceleration input pulse. Secondary independent test variables included tests with or with-out a helmet mounted on the head, and tests with or with-out the inclusion of a contact plate that provided impact for the head or head plus helmet. The impact orientations consisted of +X-axis, -X-axis, and Y-axis with the directions relative to the manikin axis reference frame on the inclined test fixture. The head and neck test fixtures positioned each ATD head/neck combination at a 40° angle from the horizontal (rotated up from the HIA sled deck), which caused some of the input energy from the acceleration pulse to be directed into the Z-axis of each neck. This configuration (as directed by NASA) was used to simulate the typical orientation of the crew module relative to the landing surface following module re-entry post mission. The experimental impact magnitudes provided by the HIA ranged from 6 to 15 G in the +X-axis impact orientation, and from 8 to 16 G in both the –X-axis and Y-axis impact orientations. The time-to-peak input pulses consisted of approximately 50 ms and 100 ms which were generated by HIA impact pins 10 and 23 respectively.

Comparative assessment of the data from the tests conducted with the 50 ms pulse were seperated by whether or not the contact plate was included in the tests, and were analyzed with respect to both kinematic and inertial reactions (head accelerations and velocities, and neck loads and torques respectively).

- Free motion of the ATD heads without the contact plate indicated that the head kinematics showed a trend to increase as a function of the impact level, and a majority of the data indicated minor differences between the response of the ATD head and necks. The exception was the 95th ATD head and neck rotational velocity which had smaller peak values compared to the other two ATD head and necks at each impact orientation and impact level. The head kinematic peak values increased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis based on the data that were analyzed.

- Free motion of the ATD heads without the contact plate also indicated that the head and neck forces demonstrated similar observations as the head kinematics. The exception was the 5th ATD shear load and neck torque which were less than the other two ATD head and necks.

- All the kinematic and inertial response data sets that were analyzed were fit with a Power Function with r and R^2 values that exceeded 0.99 highlighting a strong model fit based on the limited data.

- ATD head and neck data sets with the contact plates consisted of only the 5th and the 50th ATD head and necks, and all the data sets indicated the effectiveness of using either a helmet or a helmet with the Confor foam insert. The kinematic and inertial responses were both reduced by an average of 50% to 80% at all the impact levels allowing comparisons when using a helmet or a helmet with the Confor foam.

Comparative assessment of the data from the tests conducted with the 100 ms pulse were also seperated by whether or not the contact plate was included in the tests, and were also analyzed with respect to both kinematic and inertial reactions (head accelerations and velocities, and neck loads and torques respectively).

- Free motion of the ATD heads without the contact plate indicated that the head kinematics showed a trend to increase as a function of the impact level, and a majority of the data indicated minor difference between the response of the ATD head and necks. The exception was the 95th ATD head and neck rotational velocity which had smaller peak values compared to the other two ATD head and necks at each impact orientation and impact level which was also the case with the cooresponding 50 ms time-to-peak data. The head kinematics increased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis based on the data that were analyzed; however, it is very interesting to note that the resultant head rotational velocity decreased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis, with the +X-axis data being the greatest. This was not observed with the data set with the 50 ms pulse.

- Free motion of the ATD heads without the contact plate also indicated that the head and neck forces demonstrated similar observations as the head kinematics with the exception of a greater spread of the data across the three ATD head and necks. As shown with the 50 ms pulse data, the 5th ATD shear loads and neck torques were less than the other two ATD head and necks. The neck loading peak values as a function of impact orientation increased as the impact orientation changed from the +X-axis to the Y-axis and then to the -X-axis based on the data that were analyzed.

- All the kinematic and inertial response data sets were also fit with a Power Function with r and R^2 values that exceeded 0.99 highlighting a strong model fit based on the limited data.

- ATD head and neck data sets with the contact plates consisted of only the 5th and the 50th ATD head and necks, and all the data sets indicated the effectiveness of using either a helmet or a helmet with the Confor foam insert. The kinematic and inertial responses were both reduced by an average of 50% to 90% at all the impact levels allowing comparisons when using a helmet.

The purpose of the tests was addressed, and current test data provides some indication of the relative similarities and differences between the three ATD head and neck sizes under controlled impact conditions. The data also indicated that the addition of a helmet or a helmet with additional foam padding successfully reduced kinematic response and inertial neck loads in the three different impact configurations compared to a no-helmet configuration.   It should also be mentioned that the limited number of tests with each of the three ATD head and neck configurations did not allow for any statistical significance of the results, but did provide general response trends.

It is recommended that further research be conducted to investigate the effects of different impact pulse time-to-peaks as the current data sets allude to potential changes in both kinematic and inertial responses.

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LIST OF SYMBOLS, ABBREVIATIONS AND ACRONYMS

711 HPW	711 Human Performance Wing
ABP	Aircrew Biodynamics and Protection
ACES	Advanced Crew Escape Suit
AFRL	Air Force Research Laboratory
ANCHOR	ACES Non-Conformal Helmet Occupant Restraint
ATD	Anthropomorphic Test Device
CBDN	Collaborative Biomechanics Data Network
CCP	Crew Commercial Program
CEV	Crew Exploration Vehicle
CMOS	Complementary Metal–Oxide–Semiconductor
DTS	Diversified Technical Systems
EuroSID	European Side Impact Dummy
FE	Finite Element
fps	frames-per-second
G	for this report, free-fall acceleration on earth
GB	Giga-Byte
HIA	Horizontal Impulse Accelerator
HSIR	Human Systems Integration Requirements
HYGE	Hydraulically Controlled, Gas Energized
in-lb	symbol for inch-pounds: unit of torque
lb	symbol for pound; unit of weight
IST	Infoscitex
LSTC	Livermore Software Technology Corporation
ms	symbol for milliseconds; unit of time
MANIC	Multi-Axial Neck Injury Criteria
My	Moment about Y-axis
NASA	National Aeronautics and Space Administration
NESC	NASA Engineering and Safety Center
PC	Personal Computer
SAE	Society of Automotive Engineers
TDAS	Test Data Analysis System
THOR	Test device for Human Occupant Restraint
USAF	United States Air Force
VDT	Vertical Deceleration Tower
WPAFB	Wright-Patterson Air Force Base

APPENDIX A. ELECTRONIC DATA CHANNEL DESCRIPTIONS: STUDY 201809

PROGRAM: Biodynamic Assessment for the NASA COMMERCIAL CREW Program using the Horizontal Impulse Accelerator (HIA)	TEST DATES: 27 Sept 2018; 1 Oct - 4 Oct 2018
STUDY NUMBER: 2011809	TEST NUMBERS: 9695 - 9700; 9701 - 9749
FACILITY: HORIZONTAL IMPULSE ACCELERATOR	SAMPLE RATE: 10K
DATA COLLECTION SYSTEM: TDAS PRO	FILTER FREQUENCY: SAE J-211
	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	SLED X ACCEL (G)	ENTRAN EGE-72-200	93C93C19-R12	18-Sep-18	2.354 mv/g at 10V exc	19-Nov-18	2.3162 mv/g at 10V exc	1.60	.23540 mv/v/g	FULL	50 G	
2	SLED Y ACCEL (G)	ENTRAN EGA-125F-100D	93C93C19-R11	18-Sep-18	2.2608 mv/g at 10V exc	19-Nov-18	2.2284 mv/g at 10v exc	1.40	.22608 mv/v/g	FULL	50 G	
3	SLED Z ACCEL (G)	ENTRAN EGA-125F-100D	93C93C19-R10	18-Sep-18	2.2346 mv/g at 10V exc	19-Nov-18	2.2058 mv/g at 10v exc	1.30	.22346 mv/v/g	FULL	50 G	
4	HEAD FIXTURE X ACCEL (G)	ENTRAN EGV3-F-250	Q1008N (X)	20-Sep-18	1.0002 mv/g at 10V exc	11-Oct-18	.9986 mv/g at 10V exc	0.34	.10002 mv/v/g	FULL	50 G	
5	HEAD FIXTURE Y ACCEL (G)	ENTRAN EGV3-F-250	Q1008N (Y)	20-Sep-18	.8062 mv/g at 10V exc	11-Oct-18	.8028 mv/g at 10V exc	0.42	.08062 mv/v/g	FULL	50 G	
6	HEAD FIXTURE Z ACCEL (G)	ENTRAN EGV3-F-250	Q1008N (Z)	20-Sep-18	1.0048 mv/g at 10V exc	11-Oct-18	1.0046 mv/g at 10V exc	0.02	.10048 mv/v/g	FULL	50 G	
7	INT HEAD X ACCEL (G)	MEAS SPEC EGCS-S425-250	R13081	20-Sep-18	.6010 mv/g at 10V exc	08-Oct-18	.5996 mv/g at 10V exc	0.23	.05595 mv/v/g	FULL	250 G	
8	INT HEAD Y ACCEL (G)	MEAS SPEC EGCS-S425-250	R13082	20-Sep-18	.5684 mv/g at 10V exc	08-Oct-18	.5688 mv/g at 10V exc	-0.07	.06100 mv/v/g	FULL	250 G	
9	INT HEAD Z ACCEL (G)	MEAS SPEC EGCS-S425-250	R13085	20-Sep-18	.6188 mv/g at 10V exc	08-Oct-18	.6208 mv/g at 10V exc	-0.32	.05775 mv/v/g	FULL	250 G	
10	INT HEAD Rx ANG RATE (RAD/SEC)	DTS ARS-1500	2401	15-Jun-18	69.450444 mv/rad/sec at 5V exc	9-Oct-18	69.478214 mv/rad/sec at 5V exc	-0.04	13.8900888 mv/v/rad/sec	FULL	30 RAD/SEC	
11	INT HEAD Ry ANG RATE (RAD/SEC)	DTS ARS-8K	14769	20-Sep-18	10.857467 mv/rad/sec at 5V exc	9-Oct-18	10.850955 mv/rad/sec at 5V exc	0.06	2.1714934 mv/v/rad/sec	FULL	139 RAD/SEC	
12	INT HEAD Rz ANG RATE (RAD/SEC)	DTS ARS-1500	335	19-Jul-18	73.838099 mv/rad/sec at 5V exc	9-Oct-18	73.507791 mv/rad/sec at 5V exc	0.45	14.7676198 mv/v/rad/sec	FULL	30 RAD/SEC	
13	INT NECK X FORCE (LB)	DENTON 1716A	779	19-Oct-18	8.292 uv/lb at 10V exc	17-Nov-18	8.261 uv/lb at 10V exc	0.37	.0008292 mv/v/lb	FULL	2000 LB	
14	INT NECK Y FORCE (LB)	DENTON 1716A	779	19-Oct-18	8.428 uv/lb at 10V exc	17-Nov-18	8.334 uv/lb at 10V exc	1.11	.0008428 mv/v/lb	FULL	2000 LB	
15	INT NECK Z FORCE (LB)	DENTON 1716A	779	19-Oct-18	4.465 uv/lb at 10V exc	17-Nov-18	4.488 uv/lb at 10V exc	-0.52	.0004465 mv/v/lb	FULL	3000 LB	
16	INT NECK Mx TORQUE (IN-LB)	DENTON 1716A	779	19-Oct-18	6.749 uv/in-lb at 10V exc	17-Nov-18	6.644 uv/in-lb at 10V exc	1.56	.0006749 mv/v/in-lb	FULL	2500 IN-LB	
17	INT NECK My TORQUE (IN-LB)	DENTON 1716A	779	19-Oct-18	6.859 uv/in-lb at 10V exc	17-Nov-18	6.724 uv/in-lb at 10V exc	1.97	.0006859 mv/v/in-lb	FULL	2500 IN-LB	
18	INT NECK Mz TORQUE (IN-LB)	DENTON 1716A	779	19-Oct-18	9.051 uv/in-lb at 10V exc	17-Nov-18	9.060 uv/in-lb at 10V exc	-0.10	.0009051 mv/v/in-lb	FULL	2500 IN-LB	
19	INT LOWER NECK X FORCE (LB)	HUMANETICS 5045	EG8815	27-Apr-18	7.9093 uv/lb at 10V exc				.00079093 mv/v/lb	FULL	3000 LB	

20	INT LOWER NECK Y FORCE (LB)	HUMANETICS 5045	EG8815	27-Apr-18	7.9746 uv/lb at 10V exc				.00079746 mv/v/lb	FULL	3000 LB	
21	INT LOWER NECK Z FORCE (LB)	HUMANETICS 5045	EG8815	27-Apr-18	4.3511 uv/lb at 10V exc				.00043511 mv/v/lb	FULL	3000 LB	
22	INT LOWER NECK Mx TORQUE (LB)	HUMANETICS 5045	EG8815	27-Apr-18	4.8631 uv/in-lb at 10V exc				.00048631 mv/v/in-lb	FULL	4000 IN-LB	
23	INT LOWER NECK My TORQUE (LB)	HUMANETICS 5045	EG8815	27-Apr-18	5.0946 uv/in-lb at 10V exc				.00050946 mv/v/in-lb	FULL	4000 IN-LB	
24	INT LOWER NECK Mz TORQUE (LB)	HUMANETICS 5045	EG8815	27-Apr-18	6.7728 uv/in-lb at 10V exc				.00067728 mv/v/in-lb	FULL	3000 IN-LB	
25	INT HEAD2 X ACCEL (G)	MEAS SPEC EGCS-S425-250	N182LC	20-Sep-18	.5214 mv/g at 10V exc	08-Oct-18	.5232 mv/g at 10V exc	-0.35	.05214 mv/v/g	FULL	250 G	
26	INT HEAD2 Y ACCEL (G)	MEAS SPEC EGCS-S425-250	N182LD	20-Sep-18	.5456 mv/g at 10V exc	08-Oct-18	.5436 mv/g at 10V exc	0.37	.05456 mv/v/g	FULL	250 G	
27	INT HEAD2 Z ACCEL (G)	MEAS SPEC EGCS-S425-250	N182LE	20-Sep-18	.5576 mv/g at 10V exc	08-Oct-18	.5576 mv/g at 10V exc	0.00	.05576 mv/v/g	FULL	250 G	
28	INT HEAD2 Rx ANG RATE (RAD/SEC)	DTS ARS-1500	1588	23-Jul-18	71.209621 mv/rad/sec at 5V exc	09-Oct-18	71.115570 mv/rad/sec at 5V exc	1.32	14.2419242 mv/v/rad/sec	FULL	30 RAD/SEC	
29	INT HEAD2 Ry ANG RATE (RAD/SEC)	DTS ARS-8K	11762	20-Sep-18	10.940686 mv/rad/sec at 5V exc	09-Oct-18	10.975009 mv/rad/sec at 5V exc	-0.32	2.1881372 mv/v/rad/sec	FULL	139 RAD/SEC	
30	INT HEAD2 Rz ANG RATE (RAD/SEC)	DTS ARS-1500	2719	19-Jul-18	70.635753 mv/rad/sec at 5V exc	09-Oct-18	69.447648 mv/rad/sec	1.68	14.1271506 mv/v/rad/sec	FULL	30 RAD/SEC	
31	INT NECK2 X FORCE (LB)	DENTON 1716A	624	20-Oct-18	8.243 uv/lb at 10V exc	17-Nov-18	8.248 uv/lb at 10V exc	-0.06	.0008243 mv/v/lb	FULL	2000 LB	
32	INT NECK2 Y FORCE (LB)	DENTON 1716A	624	20-Oct-18	8.641 uv/lb at 10V exc	17-Nov-18	8.443 uv/lb at 10V exc	2.29	.0008641 mv/v/lb	FULL	2000 LB	
33	INT NECK2 Z FORCE (LB)	DENTON 1716A	624	20-Oct-18	4.571 uv/lb at 10V exc	17-Nov-18	4.530 uv/lb at 10V exc	0.90	.0004571 mv/v/lb	FULL	3000 LB	
34	INT NECK2 Mx TORQUE (IN-LB)	DENTON 1716A	624	20-Oct-18	6.756 uv/in-lb at 10V exc	17-Nov-18	6.711 uv/in-lb at 10V exc	0.67	.0006756 mv/v/in-lb	FULL	2500 IN-LB	
35	INT NECK2 My TORQUE (IN-LB)	DENTON 1716A	624	20-Oct-18	6.854 uv/in-lb at 10V exc	17-Nov-18	6.750 uv/in-lb at 10v exc	1.52	.0006854 mv/v/lb	FULL	2500 IN-LB	
36	INT NECK2 Mz TORQUE (IN-LB)	DENTON 1716A	624	20-Oct-18	9.070 uv/in-lb at 10V exc	17-Nov-18	9.111 uv/in-lb at 10V exc	-0.45	.0009070 mv/v/in-lb	FULL	2500 IN-LB	
37	INT LOWER NECK2 X FORCE (LB)	HUMANETICS 5832	EH0986	27-Jul-18	6.508 mv/lb at 10V exc				.0006508 mv/v/lb	FULL	3000 LB	
38	INT LOWER NECK2 Y FORCE (LB)	HUMANETICS 5832	EH0986	27-Jul-18	6.627 uv/lb at 10V exc				.0006627 mv/v/lb	FULL	3000 LB	
39	INT LOWER NECK2 Z FORCE (LB)	HUMANETICS 5832	EH0986	27-Jul-18	3.323 uv/lb at 10V exc				.0003323 mv/v/lb	FULL	3000 LB	
40	INT LOWER NECK2 Mx TORQUE (LB)	HUMANETICS 5832	EH0986	27-Jul-18	2.221 uv/in-lb at 10V exc				.0002221 mv/v/in-lb	FULL	6000 IN-LB	
41	INT LOWER NECK2 My TORQUE (LB)	HUMANETICS 5832	EH0986	27-Jul-18	2.441 uv/in-lb at 10V exc				.0002441 mv/v/in-lb	FULL	6000 IN-LB	
42	INT LOWER NECK2 Mz TORQUE (LB)	HUMANETICS 5832	EH0986	27-Jul-18	3.538 uv/in-lb at 10V exc				.0003538 m/v/in-lb	FULL	4000 IN-LB	
43	INT HEAD3 X ACCEL (G)	MEAS SPEC EGCS-S425-250	Q1812R	20-Sep-18	.5546 mv/g at 10V exc	08-Oct-18	.5568 mv/g at 10V exc	-0.40	.05546 mv/v/g	FULL	250 G	
44	INT HEAD3 Y ACCEL (G)	MEAS SPEC EGCS-S425-250	N182LF	20-Sep-18	.5164 mv/g at 10V exc	08-Oct-18	.5164 mv/g at 10V exc	0.00	.05164 mv/v/g	FULL	250 G	

45	INT HEAD3 Z ACCEL (G)	MEAS SPEC EGCS-S425-250	Q1812T	20-Sep-18	.5390 mv/g at 10V exc	08-Oct-18	.5404 mv/g at 10V exc	-0.26	.05390 mv/v/g	FULL	250 G
46	INT HEAD3 Ry Ang ACCEL (RAD/SEC2)	ENDEVCO 7302BM4	10020	20-Sep-18	4.831 uv/rad/sec2 at 10V exc	08-Oct-18	4.850 mv/rad/sec2 at 10V exc	-0.39	.0004831 mv/v/rad/sec2	FULL	5000 RAD/SEC2
47	INT HEAD3 Rx ANG RATE (RAD/SEC)	DTS ARS-8K	14116	20-Sep-18	11.354318 mv/rad/sec at 5V exc	09-Oct-18	11.262956 mv/rad/sec at 5V exc	0.80	2.2708636 mv/v/rad/sec	FULL	139 RAD/SEC
48	INT HEAD3 Ry ANG RATE (RAD/SEC)	DTS ARS-8K	13457	20-Sep-18	10.764533 mv/rad/sec at 5V exc	09-Oct-18	10.681423 mv/rad/sec at 5V exc	0.77	2.1529066 mv/v/rad/sec	FULL	139 RAD/SEC
49	INT HEAD3 Rz ANG RATE (RAD/SEC)	DTS ARS-8K	14882	20-Sep-18	10.934612 mv/rad/sec at 5V exc	09-Oct-18	10.973734 mv/rad/sec at 5V exc	-0.36	2.1869224 mv/v/rad/sec	FULL	139 RAD/SEC
50	INT NECK3 X FORCE (LB)	DENTON 1716A	127	25-Sep-18	8.156 uv/lb at 10V exc	17-Nov-18	8.183 uv/lb at 10V exc	-0.33	.0008156 mv/v/lb	FULL	2000 LB
51	INT NECK3 Y FORCE (LB)	DENTON 1716A	127	25-Sep-18	8.295 uv/lb at 10V exc	17-Nov-18	8.193 uv/lb at 10V exc	1.23	.0008295 mv/v/lb	FULL	2000 LB
52	INT NECK3 Z FORCE (LB)	DENTON 1716A	127	25-Sep-18	4.611 uv/lb at 10V exc	17-Nov-18	4.546 uv/lb at 10v exc	1.41	.0004611 mv/v/lb	FULL	3000 LB
53	INT NECK3 Mx TORQUE (IN-LB)	DENTON 1716A	127	25-Sep-18	6.679 uv/in-lb at 10V exc	17-Nov-18	6.637 uv/in-lb at 10V exc	0.63	.0006679 mv/v/in-lb	FULL	2500 IN-LB
54	INT NECK3 My TORQUE (IN-LB)	DENTON 1716A	127	25-Sep-18	6.697 uv/in-lb at 10V exc	17-Nov-18	6.621 uv/in-lb at 10V exc	1.13	.0006697 mv/v/in-lb	FULL	2500 IN-LB
55	INT NECK3 Mz TORQUE (IN-LB)	DENTON 1716A	127	25-Sep-18	8.945 uv/in-lb at 10V exc	17-Nov-18	8.918 uv/in-lb at 10V exc	0.30	.0008945 mv/v/in-lb	FULL	2500 IN-LB
56	INT LOWER NECK3 X FORCE (LB)	HUMANETICS 5832	EH6753	15-Jun-18	6.5158 uv/lb at 10V exc				.00065158 mv/v/lb	FULL	3000 LB
57	INT LOWER NECK Y FORCE (LB)	HUMANETICS 5832	EH6753	15-Jun-18	6.6311 uv/lb at 10V exc				.00066311 mv/v/lb	FULL	3000 LB
58	INT LOWER NECK Z FORCE (LB)	HUMANETICS 5832	EH6753	15-Jun-18	3.30676 uv/lb at 10V exc				.000330676 mv/v/lb	FULL	4000 LB
59	INT LOWER NECK Mx TORQUE (LB)	HUMANETICS 5832	EH6753	15-Jun-18	2.27519 uv/in-lb at 10V exc				.000227519 mv/v/in-lb	FULL	6000 IN-LB
60	INT LOWER NECK My TORQUE (LB)	HUMANETICS 5832	EH6753	15-Jun-18	2.44939 uv/in-lb at 10V exc				.000244939 mv/v/in-lb	FULL	6000 IN-LB
61	INT LOWER NECK Mz TORQUE (LB)	HUMANETICS 5832	EH6753	15-Jun-18	3.48411 uv/in-lb at 10V exc				.000348411 mv/v/in-lb	FULL	4000 IN-LB
62	HEAD2 FIXTURE X ACCEL (G)	MEAS SPEC EGCS-S425-250	V170ZE	18-Jul-18	.5260 mv/g at 10V exc	08-Oct-18	.5260 mv/g at 10V exc	0.00	.05620 mv/v/g	FULL	250 G
63	HEAD2 FIXTURE Y ACCEL (G)	MEAS SPEC EGCS-S425-250	R1307Y	20-Sep-18	.5506 mv/g at 10V exc	08-Oct-18	.5492 mv/g at 10V exc	0.25	.05506 mv/v/g	FULL	250 G
64	HEAD2 FIXTURE Z ACCEL (G)	MEAS SPEC EGCS-S425-250	R150VK	20-Sep-18	.5232 mv/g at 10V exc	08-Oct-18	.5210 mv/g at 10V exc	0.41	.05232 mv/v/g	FULL	250 G
65	HEAD3 FIXTURE X ACCEL (G)	MEAS SPEC EGCS-S425-250	R130NQ	20-Sep-18	.5726 mv/g at 10V exc	08-Oct-18	.5718 mv/g at 10V exc	0.14	.05726 mv/v/g	FULL	250 G
66	HEAD3 FIXTURE Y ACCEL (G)	MEAS SPEC EGCS-S425-250	R130NP	20-Sep-18	.6088 mv/g at 10V exc	08-Oct-18	.6100 mv/g at 10V exc	-0.20	.06088 mv/v/g	FULL	250 G
67	HEAD3 FIXTURE Z ACCEL (G)	MEAS SPEC EGCS-S425-250	R130NU	20-Sep-18	.5688 mv/g at 10V exc	08-Oct-18	.5664 mv/g at 10V exc	0.42	.05688 mv/v/g	FULL	250 G

APPENDIX B. HIA TEST-BY-TEST DESCRIPTION SUMMARY: STUDY 201809

HIA Test Program: Biodynamic Response of ATD Necks During Horizontal Impact

HIA Study Number: 201809

HIA Test-by-Test Summary for Tests 9695 through 9749 (Phase I: Manikin Heads)

HIA Test Dates: Oct 2018

The following is a review of the test configuration for each test conducted on the HIA (Horizontal Impulse Accelerator) during Phase I impacts with the isolated anthropomorphic test device (ATD) heads. All tests conducted incorporated the use of the 5% Hybrid III Female Aerospace head, the 50% Hybrid III Aerospace head, and the 95% Hybrid III Aerospace head simultaneously. All manikins were provided by the AFRL. All tests were conducted with HIA Pin 23 (Rise Time ≈ 100ms) and HIA PIN 10 (Rise Time ≈ 50 ms). Pitch angle of head/neck fixture provided a +Z-axis impact component for all tests.

- **Tests 9695 - 9700:** PROF Tests for 8, 12, 16 G Impact Levels: Rise Time (Rt): approximately 100 ms Rt; HIA Pin – 23.
  Successful Tests – PROOF Tests

- **Test 9701:** CELL S; Impact Level (G): 6; Metering Pin: 23; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 5.63 G
  No Test – G level to low.

- **Test 9702:** CELL S; Impact Level (G): 6; Metering Pin: 23; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 6.11 G
  Successful Test – Desired test condition achieved.

- **Test 9703:** CELL V; Impact Level (G): 6; Metering Pin: 23; Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 6.07 G
  Successful Test – Desired test condition achieved.

- **Test 9704:** CELL Y; Impact Level (G): 6; Metering Pin: 23; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 6.05 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9705</u>:** CELL BB; Impact Level (G): 6; Metering Pin: 23; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head; Impact level = 6.03 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9706</u>:** CELL T; Impact Level (G): 10; Metering Pin: 23; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 9.78 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9707</u>:** CELL W; Impact Level (G): 10; Metering Pin: 23; Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 9.99 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9708</u>:** CELL Z; Impact Level (G): 10; Metering Pin: 23; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 10.01 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9709</u>:** CELL CC; Impact Level (G): 10; Metering Pin: 23; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head; Impact level = 9.87 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9710</u>:** CELL DD; Impact Level (G): 12; Metering Pin: 23; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head; Impact level = 11.77 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9711</u>:** CELL U; Impact Level (G): 12; Metering Pin: 23; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 11.90 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9712</u>:** CELL S2; Impact Level (G): 8; Metering Pin: 23; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 8.09 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9713</u>:** CELL AA; Impact Level (G): 12; Metering Pin: 23; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 11.85 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9714</u>:** CELL X; Impact Level (G): 12; Metering Pin: 23; Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 11.77 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9715</u>:** CELL GG; Impact Level (G): 12; Metering Pin: 23;
  5th and 50th Heads: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head//Boeing-type helmet on each;
  95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
  Impact level = 11.93 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9716</u>:** CELL GG; Impact Level (G): 12; Metering Pin: 23;
  5th and 50th Heads: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head/Boeing-type helmet on 5th, 1" offset from head/Boeing-type helmet on 50th;
  95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
  Impact level = 11.90 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9717</u>:** CELL EE; Impact Level (G): 6; Metering Pin: 23;
  5th and 50th Heads: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head/Boeing-type helmet on 5th, 1" offset from head/Boeing-type helmet on 50th;
  95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
  Impact level = 6.07 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9718</u>:** CELL FF; Impact Level (G): 10; Metering Pin: 23;
  5th and 50th Heads: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head/Boeing-type helmet on 5th, 1" offset from head/Boeing-type helmet on 50th;
  95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
  Impact level = 9.87 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9719</u>:** CELL GG2; Impact Level (G): 16; Metering Pin: 23;

5th and 50th Heads: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head/Boeing-type helmet on 5th, 1" offset from head/Boeing-type helmet on 50th;
95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
Impact level = 14.91 G
Successful Test – Customer accepted input; desired test condition achieved

- **<u>Test 9720</u>:** CELL II; Impact Level (G): 10; Metering Pin: 23;
  5th and 50th Heads: Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1" offset from head/Boeing-type helmet;
  95th Head: Impact Orientation: +Y; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head;
  Impact level = 9.97 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9721</u>:** CELL HH; Impact Level (G): 6; Metering Pin: 23;
  5th and 50th Heads: Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1" offset from head/Boeing-type helmet;
  95th Head: Impact Orientation: +Y; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2" offset from head
  Impact level = 6.10 G
  Successful Test – Desired test condition achieved.

- **<u>Test 9722</u>:** Proof Test for CELL M; Impact Level (G): 8; Metering Pin: 10; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, all three heads restrained against plate for proof test
  Impact level = 7.78 G, Rise Time = 40.9 ms
  No Test – Desired conditions not achieved (G level to low).

- **<u>Test 9723</u>:** CELL M; Impact Level (G): 8; Metering Pin: 10;
  5th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 3" offset from head/Boeing-type helmet; 2" of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  50th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 3" offset from head/Boeing-type helmet; 1" of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
  Impact level = 8.56 G, Rise Time = 40.2 ms
  No Test – Desired conditions not achieved (G level to high).

- **<u>Test 9724</u>:** CELL M; Impact Level (G): 8; Metering Pin: 10;

5th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1” offset from head/Boeing-type helmet; 2” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
50th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset from head/Boeing-type helmet; 1” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
Impact level = 8.27 G, Rise Time = 41.8 ms (230 lb ballast added to increase rise time)
Successful Test – Desired conditions achieved (G level accepted by NASA, little change to Rise Time).

- **<u>Test 9725</u>:** CELL N; Impact Level (G): 12; Metering Pin: 10;
  5th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1” offset from head/Boeing-type helmet; 2” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  50th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset from head/Boeing-type helmet; 1” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
  Impact level = 9.79 G
  No Test – Desired conditions not achieved (G level to low).
- **<u>Test 9726</u>:** CELL N; Impact Level (G): 12; Metering Pin: 10;
  5th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1” offset from head/Boeing-type helmet; 2” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  50th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset from head/Boeing-type helmet; 1” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
  Impact level = 12.53 G
  Successful Test – Desired conditions achieved (G level accepted by NASA).

- **<u>Test 9727</u>:** CELL O; Impact Level (G): 16; Metering Pin: 10;

5th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1” offset from head/Boeing-type helmet; 2” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
50th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset from head/Boeing-type helmet; 1” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
95th Head: Impact Orientation: -X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No;
Impact level = 15.62 G
Successful Test – Desired conditions achieved (G level accepted by NASA).

- **<u>Test 9728</u>:** CELL Q; Impact Level (G): 12; Metering Pin: 10;
  5th Head: Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset from head/earcup of Boeing-type helmet; 2” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  50th Head: Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset from head/earcup of Boeing-type helmet; 1” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  95th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1” of Confor CF42AC foam (pink) added to plate;
  Impact level = 12.69 G
  Successful Test – Desired conditions achieved (G level accepted by NASA).

- **<u>Test 9729</u>:** CELL R; Impact Level (G): 16; Metering Pin: 10;
  5th Head: Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset from head/earcup of Boeing-type helmet; 2” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  50th Head: Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset from head/earcup of Boeing-type helmet; 1” of Confor CF42AC foam (pink) added to back of helmet beneath helmet shell
  95th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1” of Confor CF42AC foam (pink) added to plate;
  Impact level = 15.53G
  Successful Test – Desired conditions achieved (G level accepted by NASA).

- **<u>Test 9730</u>:** CELL P; Impact Level (G): 8; Metering Pin: 10;

5th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1” offset, 1” of Confor CF42AC foam (pink) added to plate, No helmet
50th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1” offset, 1” of Confor CF42AC foam (pink) added to plate, No Helmet
95th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 20°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 1” of Confor CF42AC foam (pink) added to plate;
Impact level = 8.30 G
Successful Test – Desired conditions achieved (G level accepted by NASA).

- **Test 9731:** CELL J; Impact Level (G): 8; Metering Pin: 10;
  5th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset, No helmet
  50th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset, No Helmet
  95th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset, No Helmet;
  Impact level = 7.89 G
  Successful Test – Desired conditions achieved (G level accepted by NASA).

- **Test 9732:** CELL K; Impact Level (G): 12; Metering Pin: 10;
  5th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset, No helmet
  50th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset, No Helmet
  95th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset, No Helmet;
  Impact level = 12.19 G
  Successful Test – Desired conditions achieved (G level accepted by NASA).

- **Test 9733:** CELL L; Impact Level (G): 10; Metering Pin: 10;
  5th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset, No helmet
  50th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset, No Helmet
  95th Head: Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: Yes, 2” offset, No Helmet;
  Impact level = 10.13 G
  Successful Test – Desired conditions achieved.

- **Test 9734:** CELL A; Impact Level (G): 8; Metering Pin: 10;   Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 8.06 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9735</u>:** CELL B; Impact Level (G): 12; Metering Pin: 10; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 12.14 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9736</u>:** CELL C; Impact Level (G): 16; Metering Pin: 10; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 15.97 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9737</u>:** CELL D; Impact Level (G): 8; Metering Pin: 10; Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 8.17 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9738</u>:** CELL E; Impact Level (G): 12; Metering Pin: 10; Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 12.08 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9739</u>:** CELL F; Impact Level (G): 10; Metering Pin: 10; Impact Orientation: +Y; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 10.47 G
  Successful Test – Desired conditions achieved (G level accepted by NASA).

- **<u>Test 9740</u>:** CELL G; Impact Level (G): 8; Metering Pin: 10; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 8.16 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9741</u>:** CELL H; Impact Level (G): 12; Metering Pin: 10; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 12.00 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9742</u>:** CELL I; Impact Level (G): 16; Metering Pin: 10; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 16.05 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9743</u>:** CELL G1; Impact Level (G): 8; Metering Pin: 10; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 45°; Head Strike Plate: No; Impact level = 8.18 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9744</u>:** CELL H1; Impact Level (G): 12; Metering Pin: 10; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 45°; Head Strike Plate: No; Impact level = 12.04 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9745</u>:** CELL I1; Impact Level (G): 16; Metering Pin: 10; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 45°; Head Strike Plate: No; Impact level = 16.07 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9746</u>:** CELL A1; Impact Level (G): 8; Metering Pin: 10; Impact Orientation: +X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 45°; Head Strike Plate: No; Impact level = 8.05 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9747</u>:** CELL B1; Impact Level (G): 12; Metering Pin: 10; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 45°; Head Strike Plate: No; Impact level = 11.89 G
  Successful Test – Desired conditions achieved.

- **<u>Test 9748</u>:** CELL C1; Impact Level (G): 16; Metering Pin: 10; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 45°; Head Strike Plate: No; Impact level = 16.07 G
  Successful Test – Desired conditions achieved.

- ***<u>Test 9749</u>:*** *Extra Test; Impact Level (G): 12; Metering Pin: 10; Impact Orientation: -X; Head Fixture Pitch Angle: 40°; Head Fixture Yaw Angle: 0°; Head Strike Plate: No; Impact level = 12.13 G*
  *Successful Test – Data will not be used in analysis***.**

APPENDIX C. SAMPLE DATA SHEETS: TEST PROGRAM PROCESSED DATA QUICK-LOOKS

The following are examples of the post-test processed data for selected test configurations. Data will be seperated based on the input pulse time-to-peak. Examples will be shown with the ATD head and necks in the no-plate ("free motion") and contact plate configuration.

50 ms Time-to-Peak Input Acceleration

Free-Motion:

Test # 9735   Cell B   Impact Level/Orientation: 12 G/+X-axis   Plate/Helmet: No/No

Contact Plate:

Test # 9732   Cell K   Impact Level/Orientation: 12 G/+X-axis   Plate/Helmet: Yes/No

Test # 9726   Cell N   Impact Level/Orientation: 12 G/+X-axis   Plate/Helmet: Yes/Yes

100 ms Time-to-Peak Input Acceleration

Free-Motion:

Test # 9711   Cell U   Impact Level/Orientation: 12 G/+X-axis   Plate/Helmet: No/No

Contact Plate:

Test # 9710 Cell DD   Impact Level/Orientation: 12 G/+X-axis   Plate/Helmet: Yes/No

Test # 9715 Cell GG Impact Level/Orientation: 12 G/+X-axis   Plate/Helmet: Yes/Yes

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				8.3	
Impact Rise Time (Ms)				41.5	
Impact Duration (Ms)				110.7	
Velocity Change (Ft/Sec)		25.45			
SLED X ACCEL (G)	0.04	12.14	-0.41	41.5	114.9
SLED Y ACCEL (G)	0.00	0.51	-0.83	28.4	50.4
SLED Z ACCEL (G)	0.00	0.17	-1.09	155.6	33.9
SLED RESULTANT	0.07	12.18	0.20	41.5	0.0
INTEGRATED ACCEL (FT/SEC)	0.02	25.45	0.05	110.6	0.0
HEAD FIXTURE X ACCEL (G)	0.03	8.96	-0.83	39.8	152.2
HEAD FIXTURE Y ACCEL (G)	0.01	4.36	-0.95	51.6	93.5
HEAD FIXTURE Z ACCEL (G)	0.03	8.77	-0.41	39.0	116.7
HEAD FIXTURE RESULTANT (G)	0.08	12.66	0.17	39.5	172.1
HEAD FIXTURE2 X ACCEL (G)	0.04	9.25	-0.57	42.7	151.3
HEAD FIXTURE2 Y ACCEL (G)	0.01	1.80	-1.18	59.6	52.1
HEAD FIXTURE2 Z ACCEL (G)	0.04	8.04	-0.43	41.0	116.3
HEAD FIXTURE2 RESULTANT (G)	0.08	12.27	0.18	41.2	322.7
HEAD FIXTURE3 X ACCEL (G)	0.03	9.46	-0.50	41.5	150.1
HEAD FIXTURE3 Y ACCEL (G)	0.00	1.40	-1.28	51.6	60.2
HEAD FIXTURE3 Z ACCEL (G)	0.03	8.09	-0.70	40.6	115.1
HEAD FIXTURE3 RESULTANT (G)	0.09	12.44	0.18	41.1	162.6
INT HEAD X ACCEL (G)	0.02	6.89	-5.35	107.7	260.2
INT HEAD Y ACCEL (G)	0.00	0.68	-0.77	73.5	107.7
INT HEAD Z ACCEL (G)	0.05	9.79	-3.70	34.7	221.3
INT HEAD RESULTANT (G)	0.10	10.81	0.54	35.2	2.0
INT HEAD HIC		8.94		20.0	50.0
INT HEAD Ry ANG VELOCITY (RAD/SEC)	-0.01	1.06	-1.73	202.2	38.1
INT HEAD Ry ANG VELOCITY (RAD/SEC)	-0.01	16.18	-15.37	216.2	81.8
INT HEAD Rz ANG VELOCITY (RAD/SEC)	-0.01	0.65	-1.02	35.3	35.0
INT HEAD ANG VELOCITY RESULTANT	0.12	16.20	0.02	216.2	0.3
INT NECK X FORCE (LB)	0.58	47.54	-37.21	74.4	259.0
INT NECK Y FORCE (LB)	-0.44	5.00	-2.39	107.6	224.7
INT NECK Z FORCE (LB)	-1.69	27.81	-79.73	210.3	35.0
INT NECK RESULTANT (LB)	2.00	86.11	4.20	34.9	0.4

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT NECK Mx TORQUE (IN-LB)	0.81	19.36	-14.63	51.5	59.4
INT NECK My TORQUE (IN-LB)	0.05	98.91	-126.59	264.9	121.8
INT NECK Mz TORQUE (IN-LB)	-0.45	6.96	-7.78	223.4	68.7
INT NECK TORQUE RES (IN-LB)	1.46	126.65	0.82	121.8	323.3
INT LOWER NECK X FORCE (LB)	-0.47	82.09	-41.33	63.1	236.0
INT LOWER NECK Y FORCE (LB)	-0.03	4.55	-10.32	237.7	46.6
INT LOWER NECK Z FORCE (LB)	1.07	36.57	-88.90	197.0	35.1
INT LOWER NECK RESULTANT (LB)	1.69	113.42	2.85	35.1	1.9
INT LOWER NECK Mx TORQUE (IN-LB)	0.13	22.55	-12.57	41.1	220.9
INT LOWER NECK My TORQUE (IN-LB)	-1.47	420.96	-436.61	263.1	101.4
INT LOWER NECK Mz TORQUE (IN-LB)	-1.14	34.43	-8.86	108.8	47.0
INT LOWER NECK TORQUE RES (IN-LB)	2.38	437.93	2.03	101.4	1.5
INT HEAD2 X ACCEL (G)	0.02	7.30	-7.05	85.7	241.8
INT HEAD2 Y ACCEL (G)	0.00	0.65	-0.46	84.5	84.8
INT HEAD2 Z ACCEL (G)	0.04	9.10	-4.63	26.7	199.5
INT HEAD2 RESULTANT (G)	0.10	10.06	0.41	37.8	0.0
INT HEAD2 HIC		7.47		20.4	50.4
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	0.00	0.78	-0.83	59.7	206.3
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	-0.01	18.62	-16.42	208.3	81.7
INT HEAD2 Rz ANG VELOCITY (RAD/SEC)	0.00	0.98	-1.48	88.5	39.9
INT HEAD2 ANG VELOCITY RESULTANT	0.06	18.63	0.02	208.3	3.8
INT NECK2 X FORCE (LB)	1.14	62.74	-57.57	89.9	239.7
INT NECK2 Y FORCE (LB)	-0.78	5.88	-6.48	202.0	131.1
INT NECK2 Z FORCE (LB)	-2.34	47.28	-93.22	202.6	26.9
INT NECK2 RESULTANT (LB)	2.83	99.99	5.09	37.9	0.8
INT NECK2 Mx TORQUE (IN-LB)	3.04	12.31	-11.98	265.6	72.4
INT NECK2 My TORQUE (IN-LB)	-0.57	169.30	-205.03	248.3	114.1
INT NECK2 Mz TORQUE (IN-LB)	0.14	6.54	-9.56	202.6	201.2
INT NECK2 TORQUE RES (IN-LB)	3.37	205.04	2.75	114.1	62.4
INT LOWER NECK2 X FORCE (LB)	-0.33	99.00	-64.39	36.8	230.4
INT LOWER NECK2 Y FORCE (LB)	-0.10	9.30	-8.27	69.5	49.8
INT LOWER NECK2 Z FORCE (LB)	-1.96	40.18	-133.29	199.8	37.3
INT LOWER NECK2 RESULTANT (LB)	2.54	162.17	6.48	37.2	0.8

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT LOWER NECK2 Mx TORQUE (IN-LB)	-2.88	25.68	-16.61	258.6	345.2
INT LOWER NECK2 My TORQUE (IN-LB)	-4.09	817.89	-740.87	247.5	86.7
INT LOWER NECK2 Mz TORQUE (IN-LB)	-1.04	23.06	-10.71	71.0	49.8
INT LOWER NECK2 TORQUE RES (IN-LB)	6.02	818.25	0.67	247.5	3.6
INT HEAD3 X ACCEL (G)	0.04	8.75	-8.15	100.4	217.1
INT HEAD3 Y ACCEL (G)	0.00	0.94	-0.84	208.6	48.6
INT HEAD3 Z ACCEL (G)	0.06	9.26	-3.72	31.8	193.2
INT HEAD3 RESULTANT (G)	0.14	10.25	0.53	37.2	0.0
INT HEAD3 HIC		7.94		22.5	52.5
INT HEAD3 Rx ANG VELOCITY (RAD/SEC)	-0.02	1.02	-0.59	56.6	92.4
INT HEAD3 Ry ANG VELOCITY (RAD/SEC)	-0.04	15.17	-13.23	179.8	73.9
INT HEAD3 Rz ANG VELOCITY (RAD/SEC)	0.01	0.43	-0.49	112.0	248.5
INT HEAD3 ANG VELOCITY RESULTANT	0.15	15.17	0.02	179.8	0.4
INT HEAD3 Ry ANG ACCEL (RAD/SEC2)	-0.05	593.28	-757.06	116.0	211.5
INT NECK3 X FORCE (LB)	0.08	74.17	-66.98	101.4	220.2
INT NECK3 Y FORCE (LB)	-0.19	7.65	-3.80	104.3	69.3
INT NECK3 Z FORCE (LB)	3.07	34.13	-92.39	152.8	31.7
INT NECK3 RESULTANT (LB)	3.16	102.26	1.11	31.1	0.0
INT NECK3 Mx TORQUE (IN-LB)	-0.58	19.97	-16.98	49.9	60.6
INT NECK3 My TORQUE (IN-LB)	-0.52	185.71	-217.89	214.1	112.7
INT NECK3 Mz TORQUE (IN-LB)	0.04	5.77	-4.72	30.6	233.4
INT NECK3 TORQUE RES (IN-LB)	1.87	217.91	0.55	112.7	0.5
INT LOWER NECK3 X FORCE (LB)	1.06	111.71	-66.85	41.2	223.0
INT LOWER NECK3 Y FORCE (LB)	0.46	5.38	-9.86	58.5	48.3
INT LOWER NECK3 Z FORCE (LB)	0.81	38.93	-135.72	168.9	31.9
INT LOWER NECK3 RESULTANT (LB)	2.60	174.18	7.03	31.9	189.2
INT LOWER NECK3 Mx TORQUE (IN-LB)	2.35	34.05	-35.22	27.9	51.8
INT LOWER NECK3 My TORQUE (IN-LB)	0.46	876.30	-888.39	218.6	97.4
INT LOWER NECK3 Mz TORQUE (IN-LB)	2.62	29.02	-20.15	203.9	51.8
INT LOWER NECK3 TORQUE RES (IN-LB)	5.35	888.59	2.96	97.4	5.6

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
5th NIJ SHEAR (LB)		47.54	-37.21	74.4	259.0
5th NIJ TENSION (LB)		27.81		210.3	
5th NIJ COMPRESSION (LB)		-79.73		35.0	
5th NIJ FLEXION (IN-LB)		124.27		265.7	
5th NIJ EXTENSION (IN-LB)		151.73		121.0	
5th NIJ NTF	0.0000	0.0905	0.0000	269.8	0.0
5th NIJ NTE	0.0001	0.2619	0.0000	115.5	0.0
5th NIJ NCF	0.0011	0.1099	0.0000	25.5	42.8
5th NIJ NCE	0.0020	0.1679	0.0000	150.5	0.0
5th NIJ NTF AIS >= 2		0.13			
5th NIJ NTF AIS >= 3		0.05			
5th NIJ NTF AIS >= 4		0.07			
5th NIJ NTF AIS >= 5		0.02			
5th NIJ NTE AIS >= 2		0.15			
5th NIJ NTE AIS >= 3		0.06			
5th NIJ NTE AIS >= 4		0.08			
5th NIJ NTE AIS >= 5		0.03			
5th NIJ NCF AIS >= 2		0.13			
5th NIJ NCF AIS >= 3		0.05			
5th NIJ NCF AIS >= 4		0.07			
5th NIJ NCF AIS >= 5		0.02			
5th NIJ NCE AIS >= 2		0.14			
5th NIJ NCE AIS >= 3		0.05			
5th NIJ NCE AIS >= 4		0.08			
5th NIJ NCE AIS >= 5		0.03			
50th NIJ SHEAR (LB)		62.74	-57.57	89.9	239.7
50th NIJ TENSION (LB)		47.28		202.6	
50th NIJ COMPRESSION (LB)		-93.22		26.9	
50th NIJ FLEXION (IN-LB)		209.24		246.2	
50th NIJ EXTENSION (IN-LB)		243.01		114.1	
50th NIJ NTF	0.0000	0.0746	0.0000	244.3	0.0
50th NIJ NTE	0.0000	0.2187	0.0000	114.1	0.0
50th NIJ NCF	0.0003	0.0808	0.0000	26.9	0.2
50th NIJ NCE	0.0026	0.0947	0.0000	74.5	0.0
50th NIJ NTF AIS >= 2		0.12			
50th NIJ NTF AIS >= 3		0.04			
50th NIJ NTF AIS >= 4		0.07			
50th NIJ NTF AIS >= 5		0.02			
50th NIJ NTE AIS >= 2		0.14			
50th NIJ NTE AIS >= 3		0.06			
50th NIJ NTE AIS >= 4		0.08			
50th NIJ NTE AIS >= 5		0.03			

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
50th NIJ NCF AIS >= 2		0.12			
50th NIJ NCF AIS >= 3		0.04			
50th NIJ NCF AIS >= 4		0.07			
50th NIJ NCF AIS >= 5		0.02			
50th NIJ NCE AIS >= 2		0.13			
50th NIJ NCE AIS >= 3		0.05			
50th NIJ NCE AIS >= 4		0.07			
50th NIJ NCE AIS >= 5		0.02			
95th NIJ SHEAR (LB)		74.17	-66.98	101.4	220.2
95th NIJ TENSION (LB)		34.13		152.8	
95th NIJ COMPRESSION (LB)		-92.39		31.7	
95th NIJ FLEXION (IN-LB)		230.17		214.1	
95th NIJ EXTENSION (IN-LB)		262.63		112.7	
95th NIJ NTF	0.0005	0.0652	0.0000	209.6	0.0
95th NIJ NTE	0.0019	0.1834	0.0000	112.8	0.0
95th NIJ NCF	0.0000	0.0620	0.0000	217.9	0.0
95th NIJ NCE	0.0000	0.1171	0.0000	79.9	0.1
95th NIJ NTF AIS >= 2		0.12			
95th NIJ NTF AIS >= 3		0.04			
95th NIJ NTF AIS >= 4		0.07			
95th NIJ NTF AIS >= 5		0.02			
95th NIJ NTE AIS >= 2		0.14			
95th NIJ NTE AIS >= 3		0.05			
95th NIJ NTE AIS >= 4		0.08			
95th NIJ NTE AIS >= 5		0.03			
95th NIJ NCF AIS >= 2		0.12			
95th NIJ NCF AIS >= 3		0.04			
95th NIJ NCF AIS >= 4		0.07			
95th NIJ NCF AIS >= 5		0.02			
95th NIJ NCE AIS >= 2		0.13			
95th NIJ NCE AIS >= 3		0.05			
95th NIJ NCE AIS >= 4		0.07			

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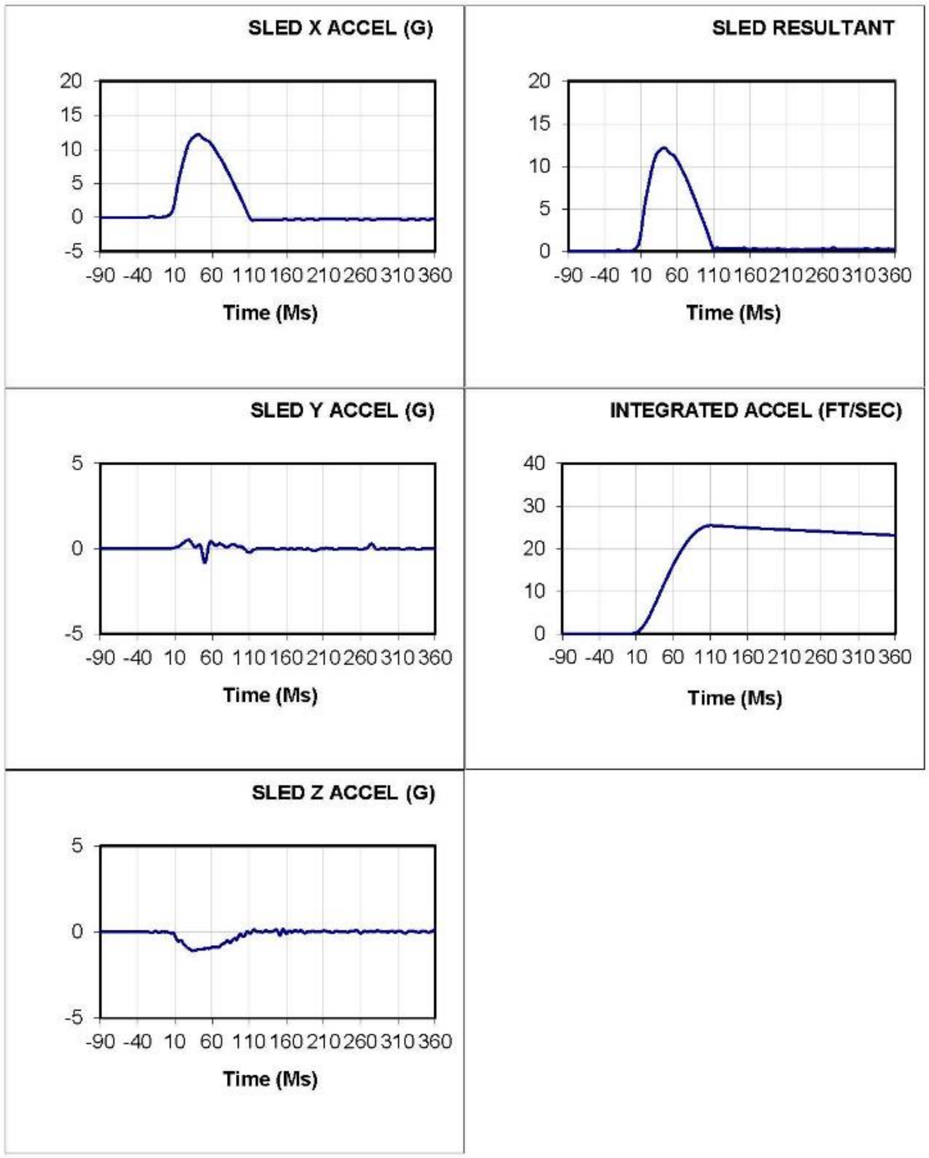

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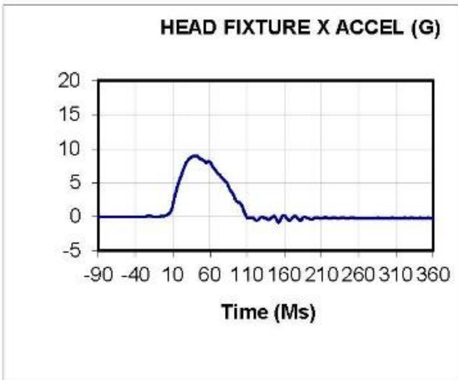

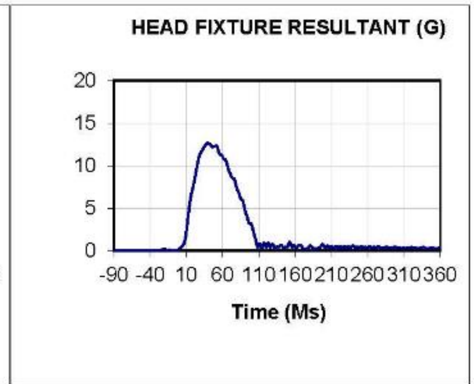

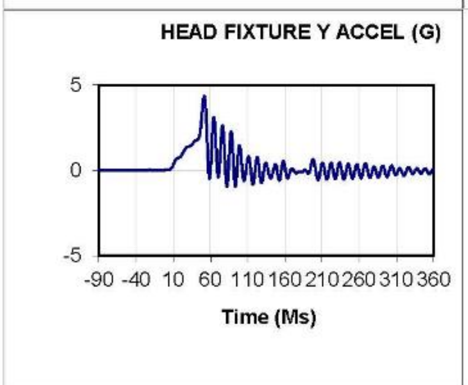

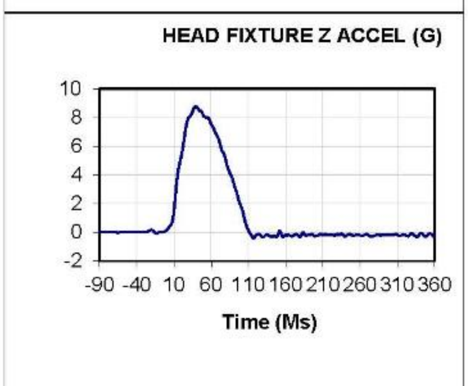

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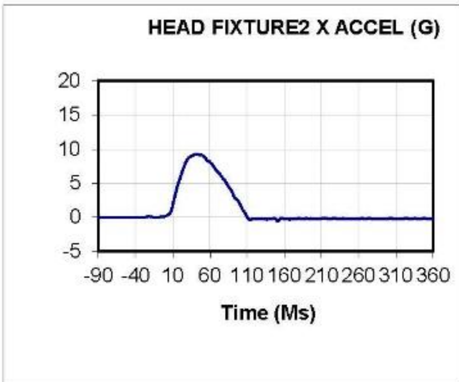

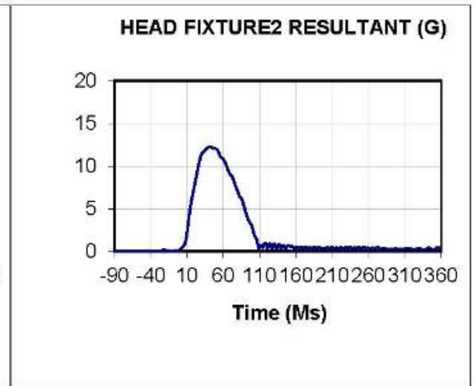

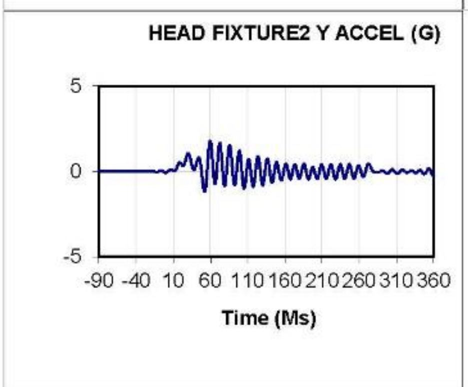

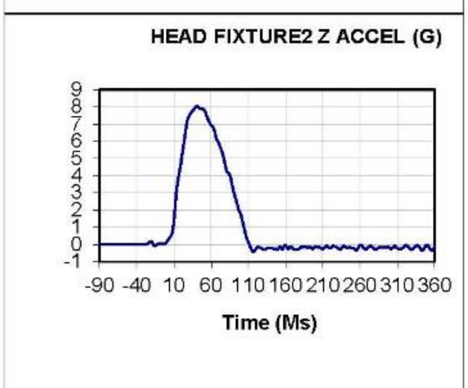

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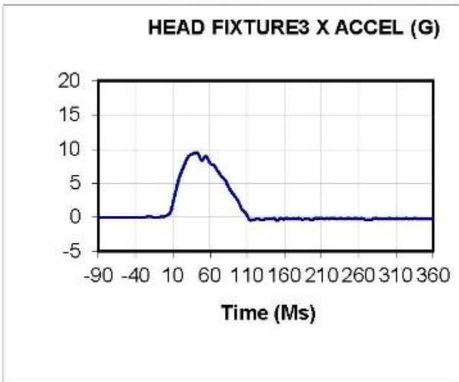

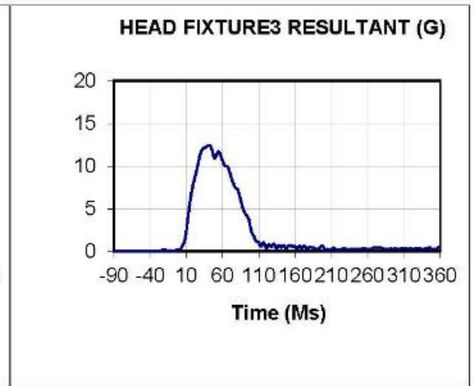

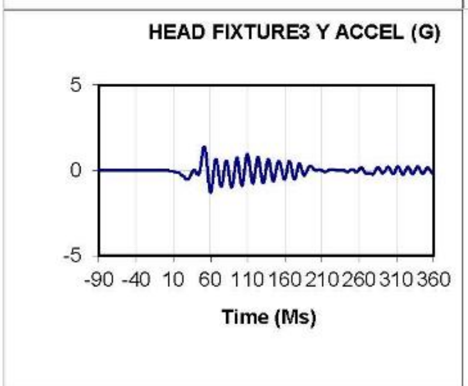

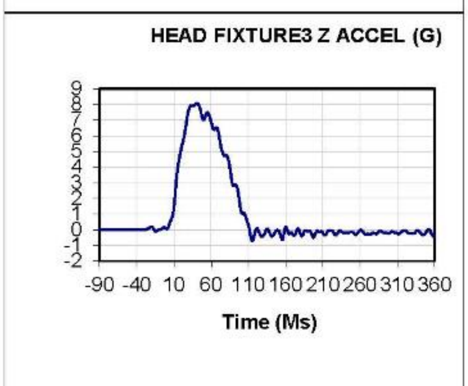

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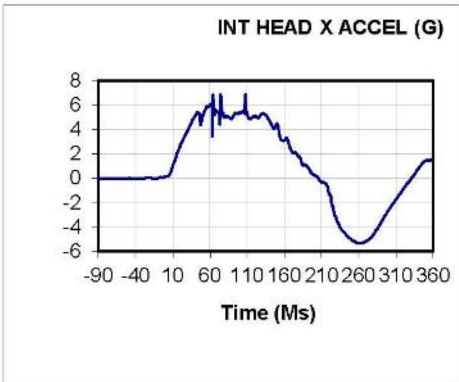

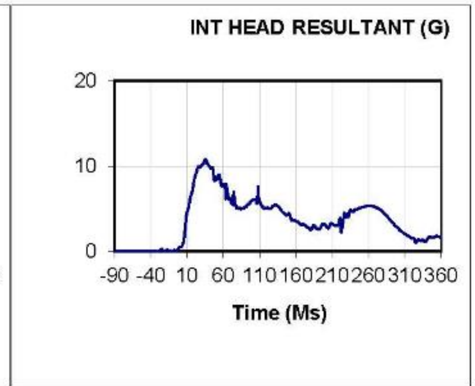

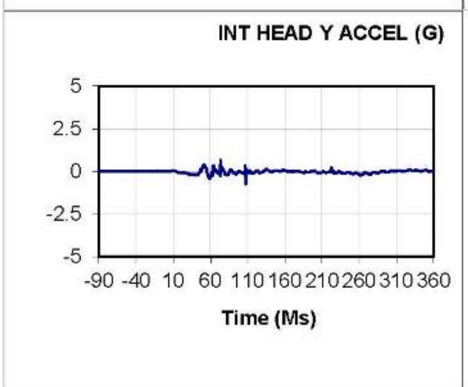

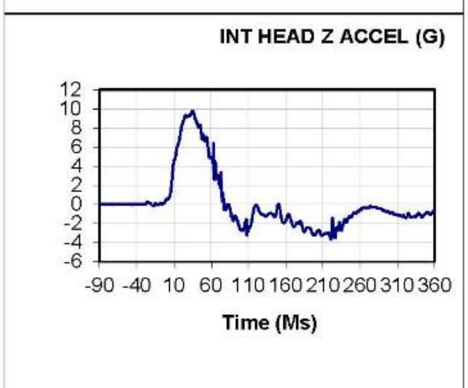

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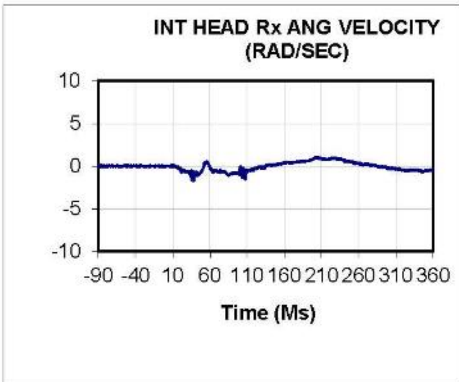

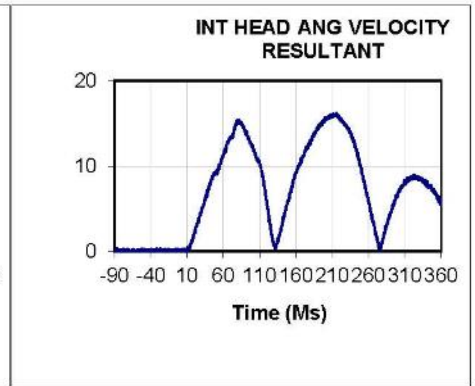

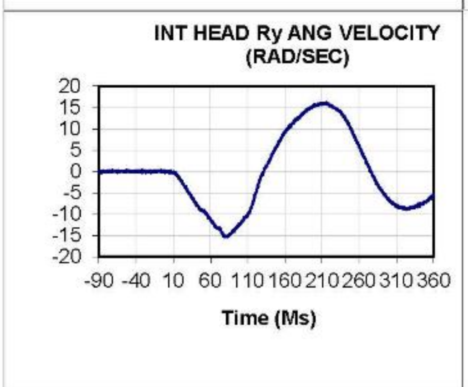

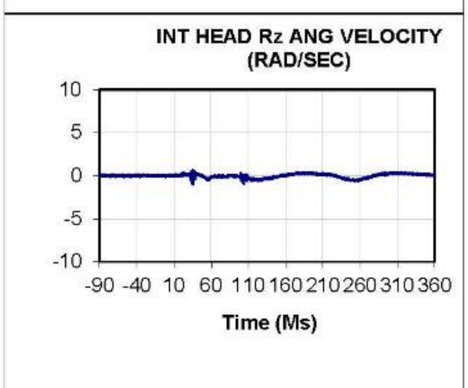

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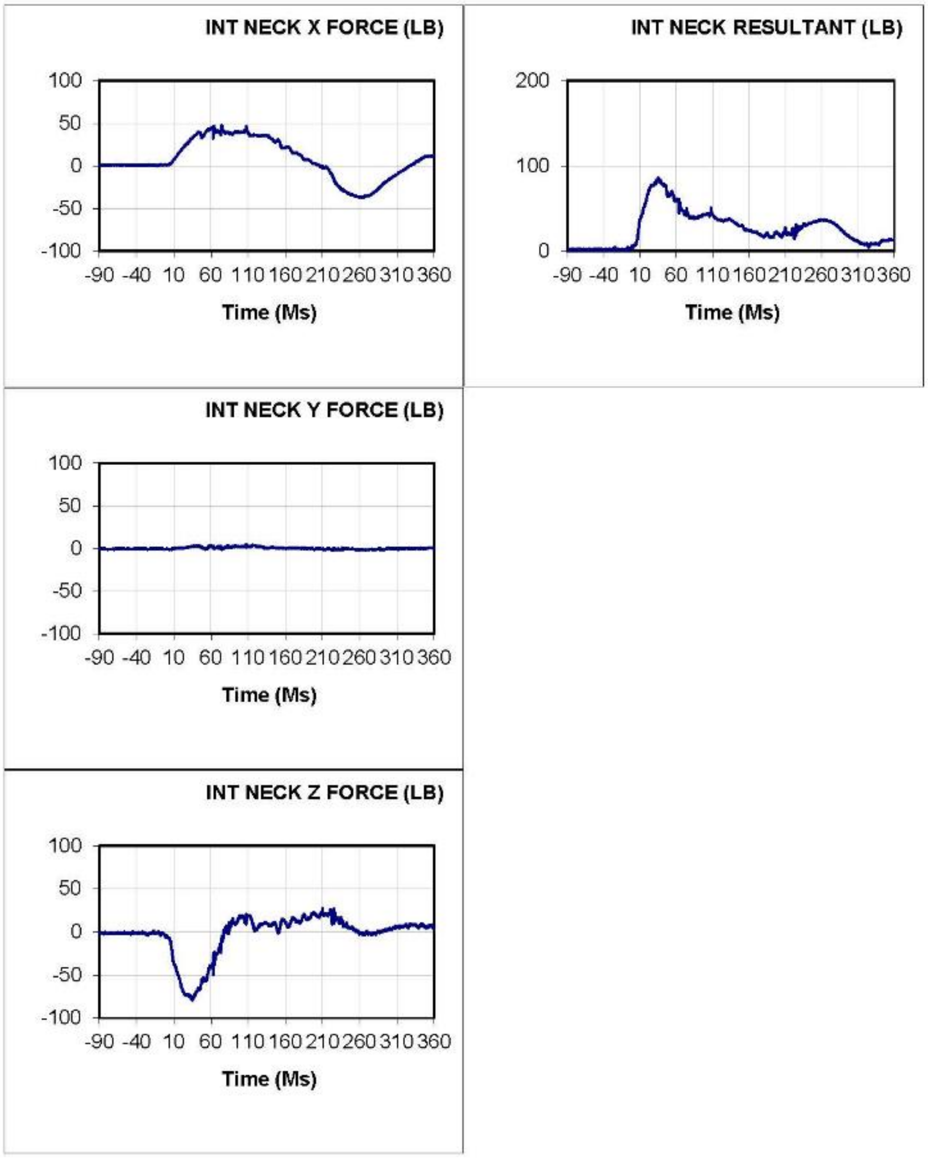

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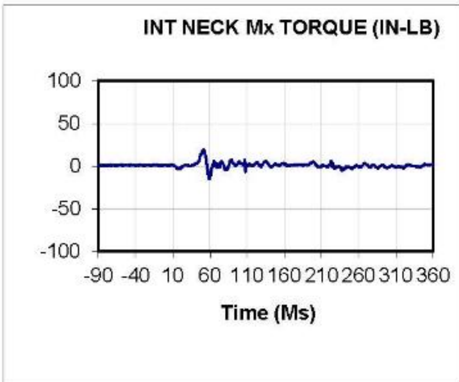

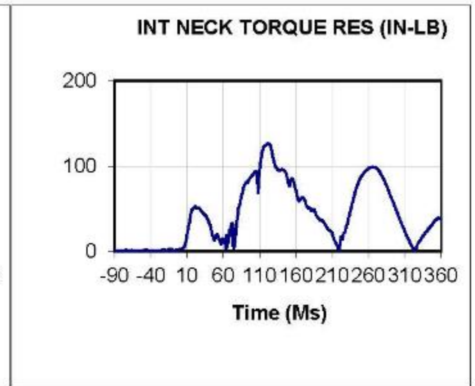

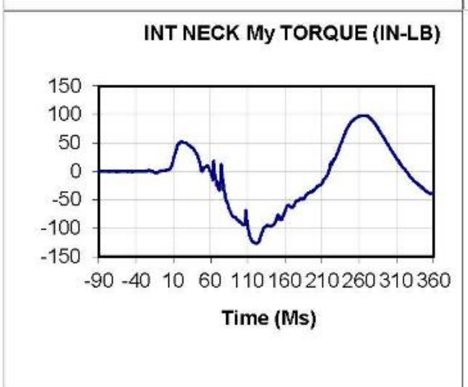

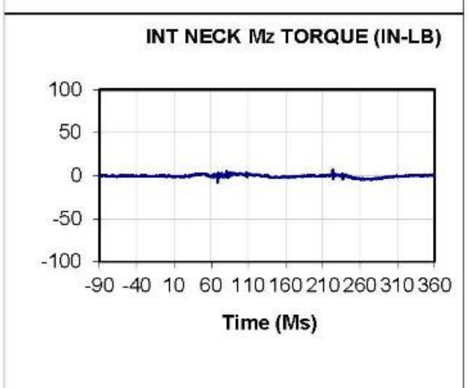

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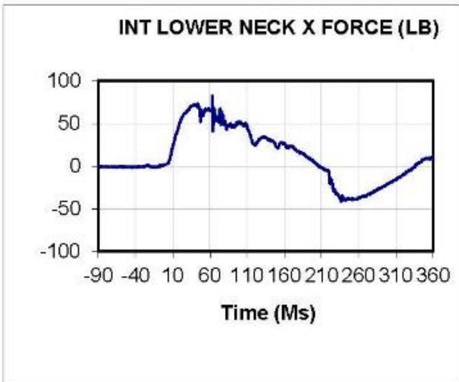
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-50
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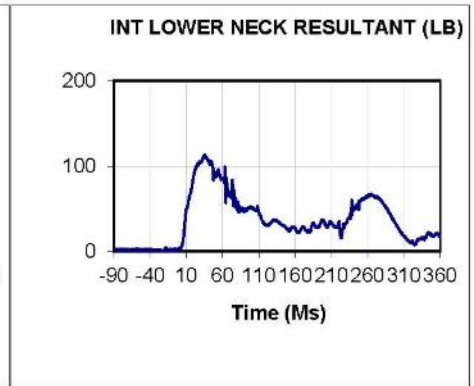
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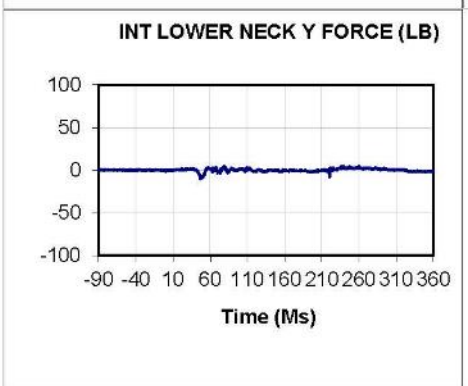
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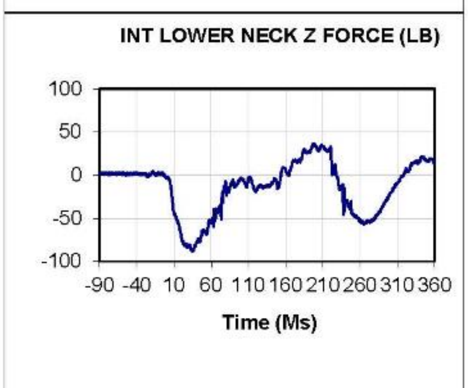
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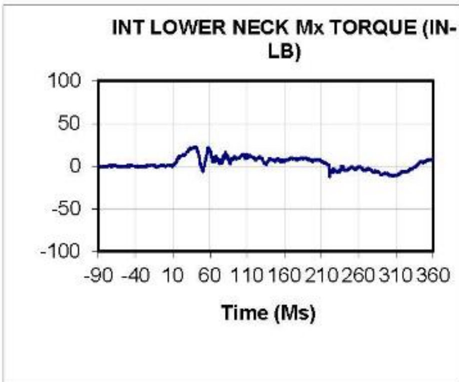

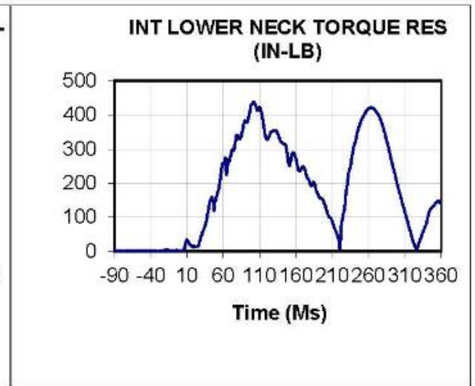

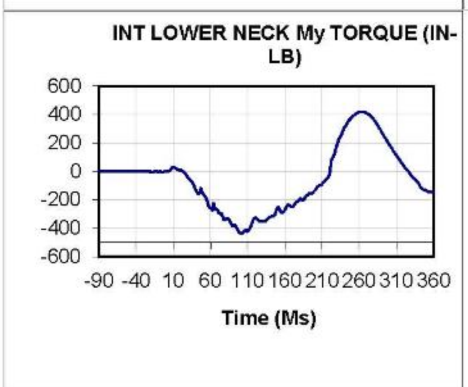

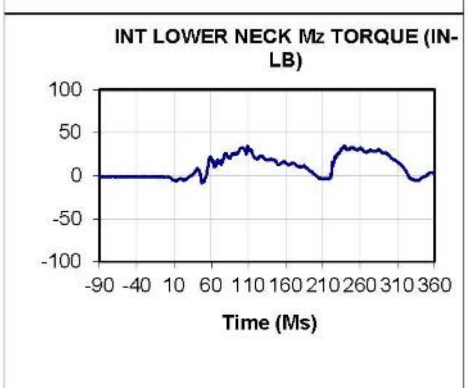

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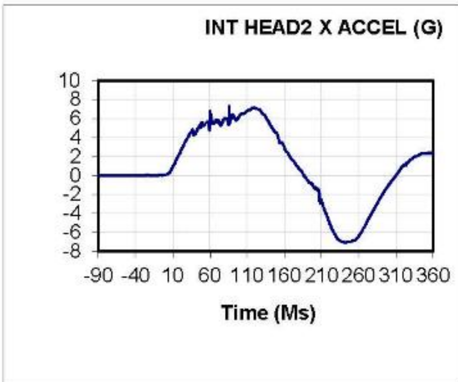

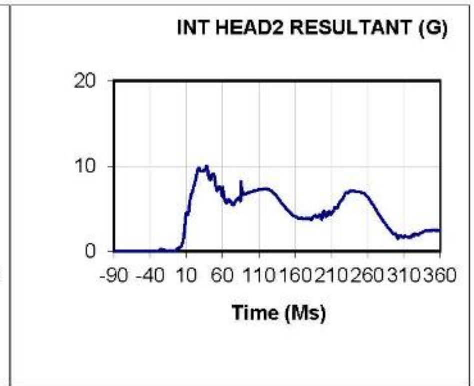

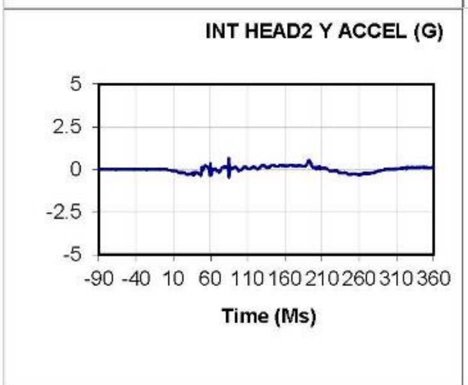

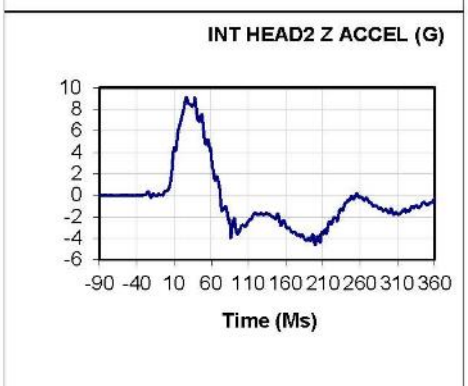

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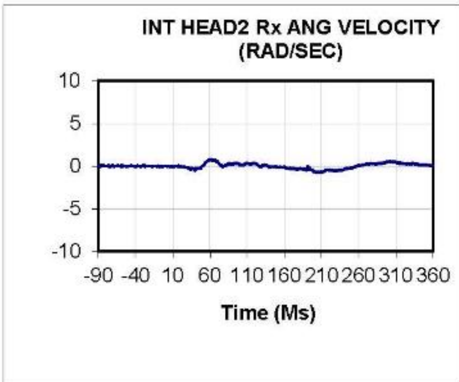

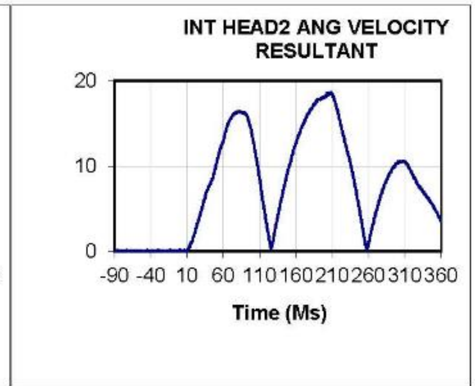

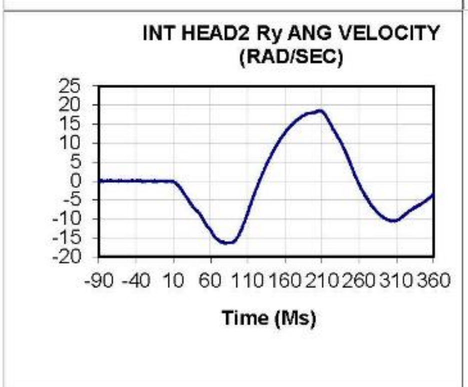

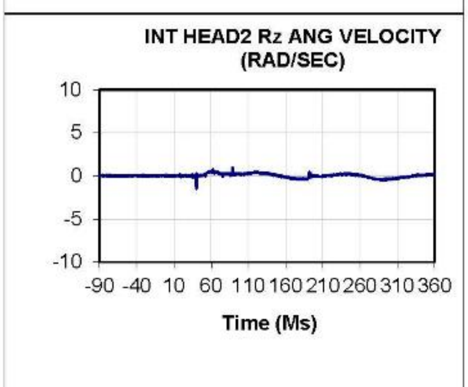

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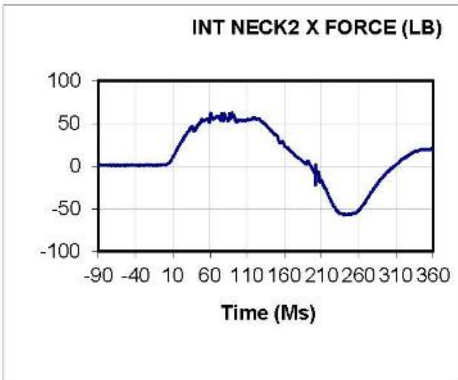

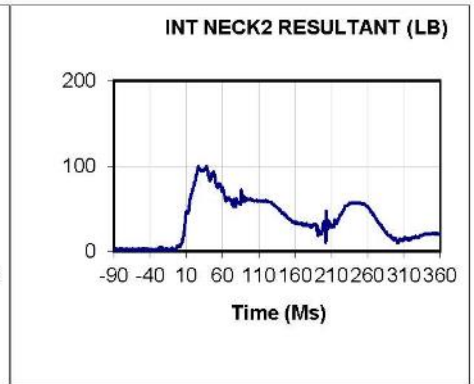

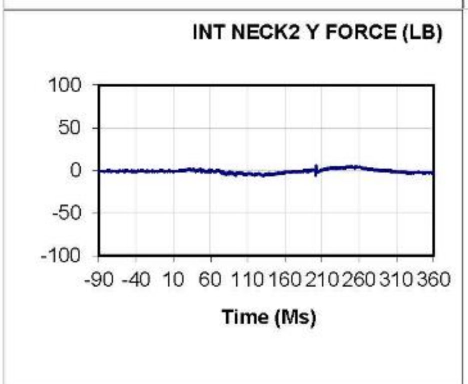

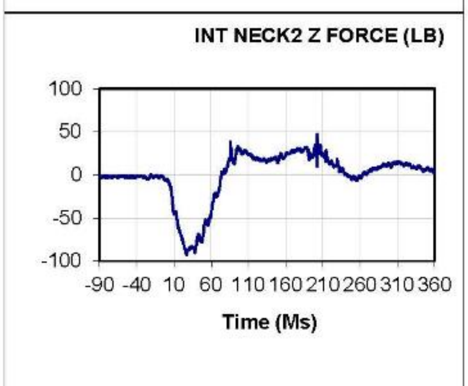

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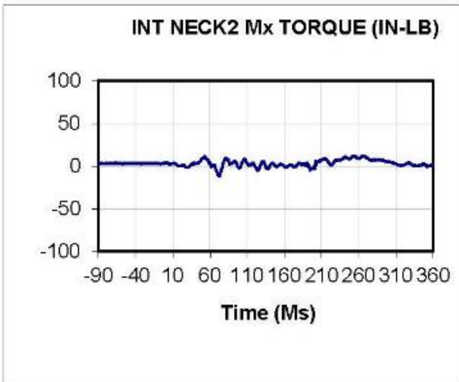

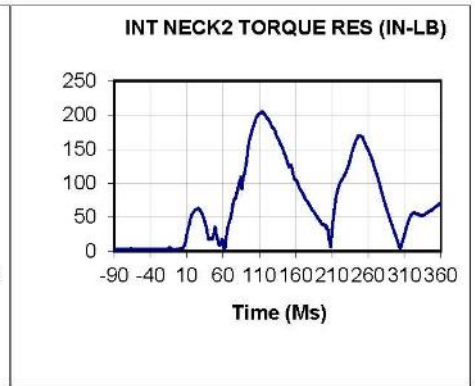

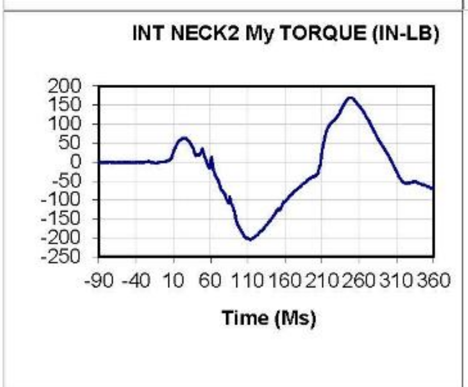

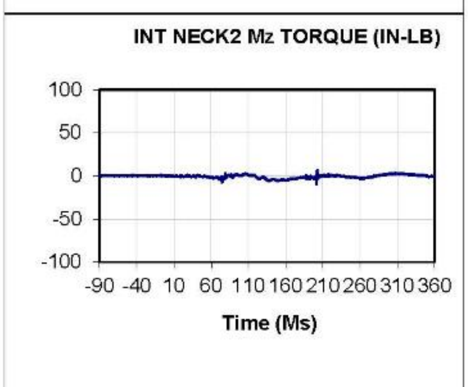

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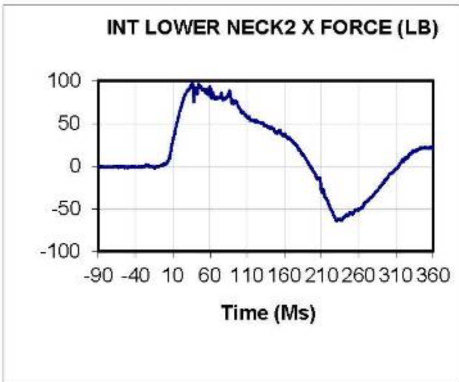

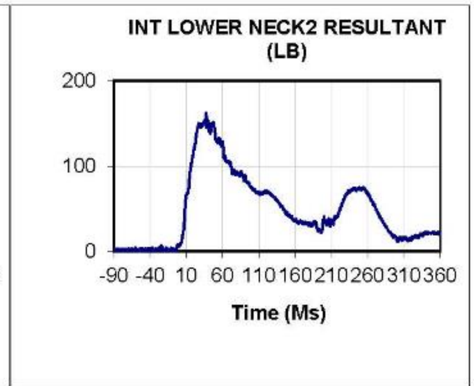

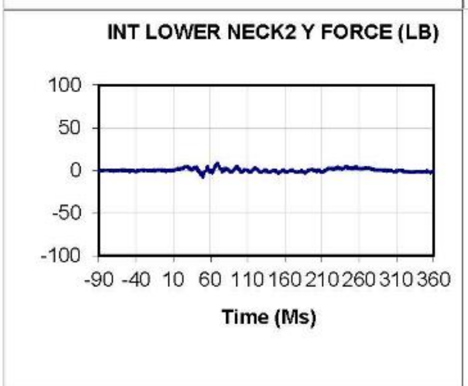

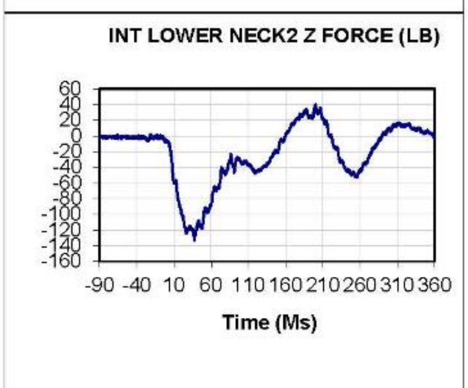

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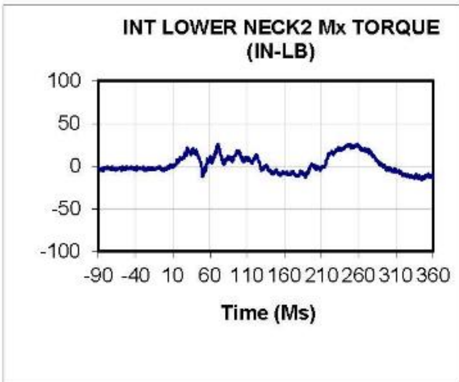

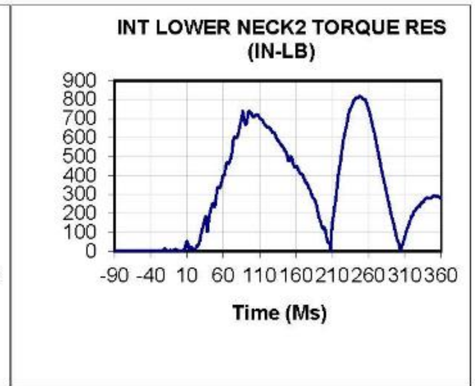

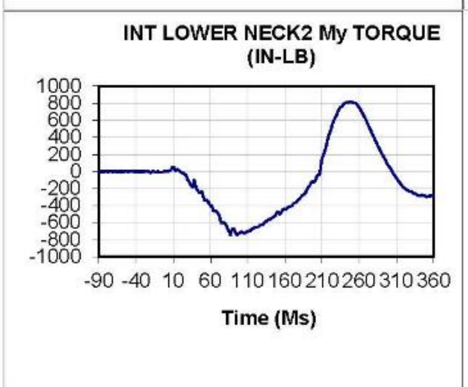

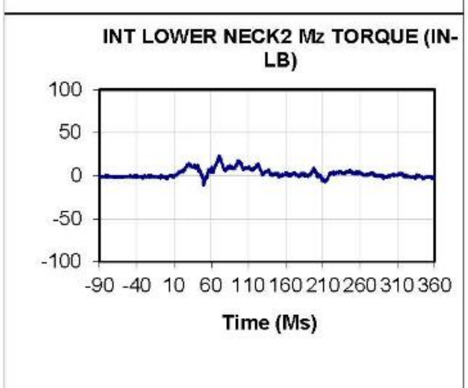

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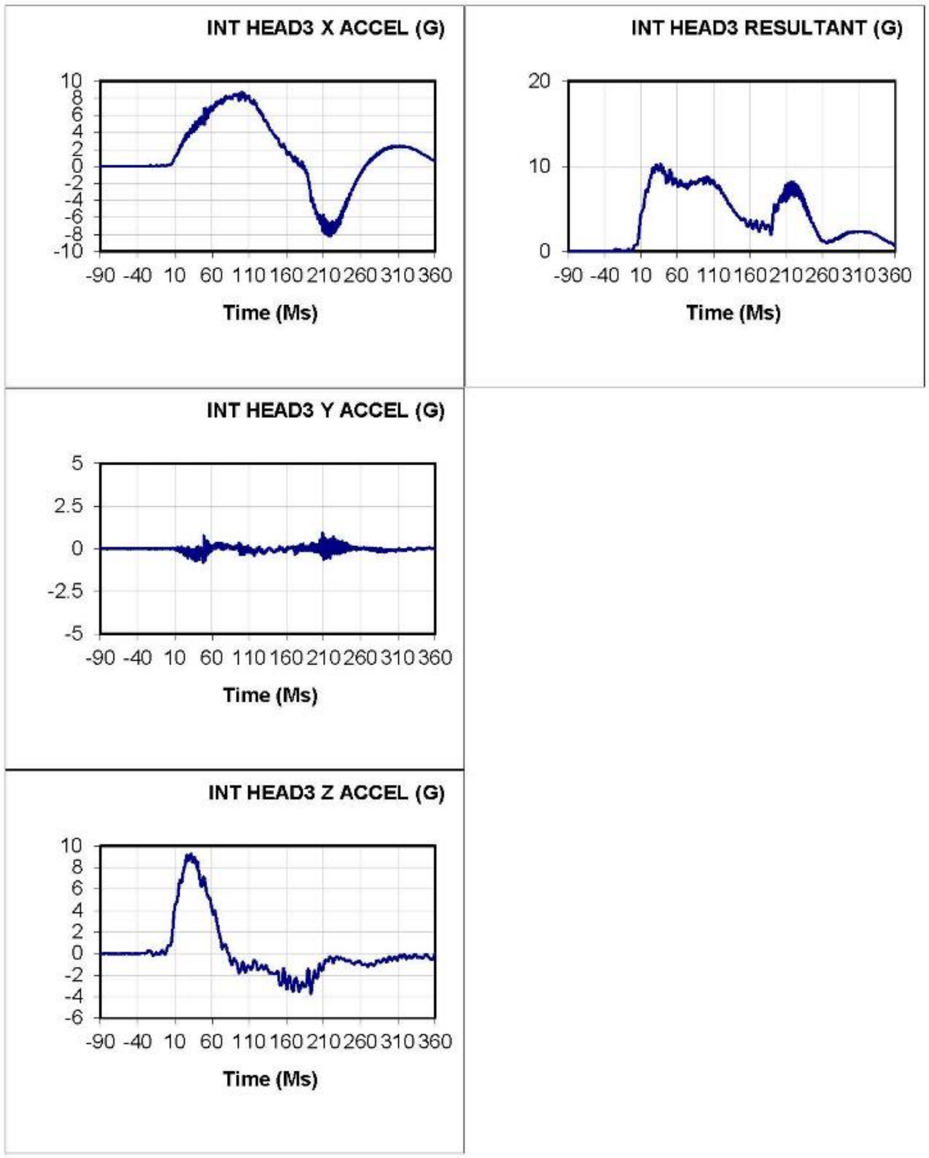

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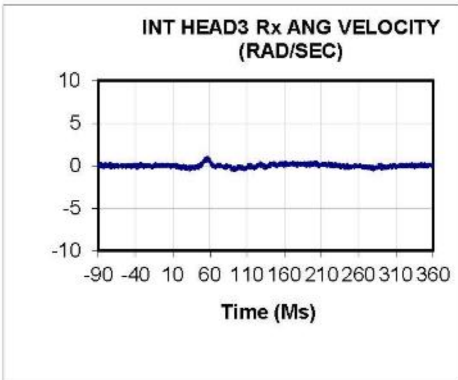

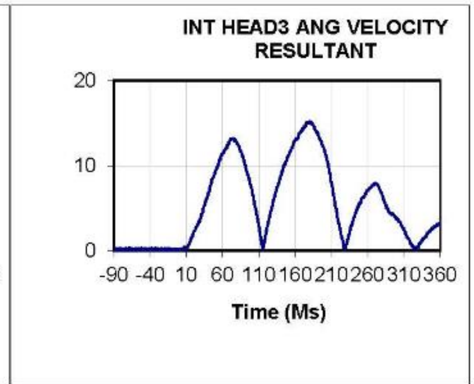

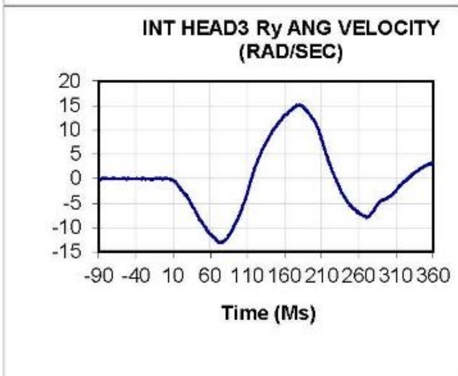

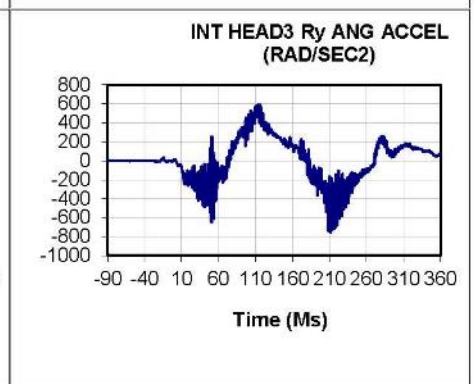

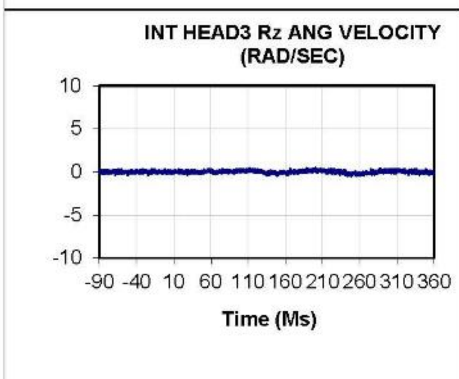

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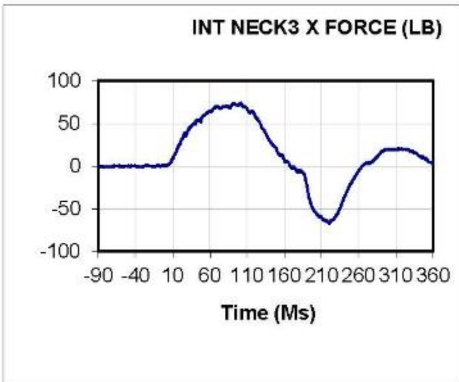

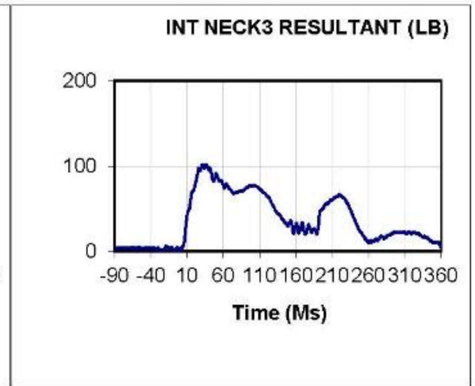

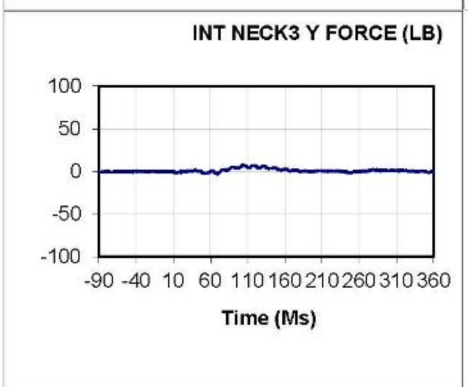

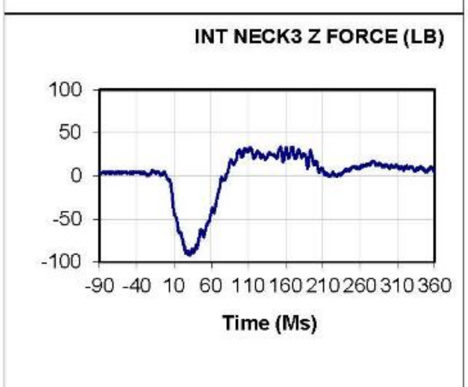

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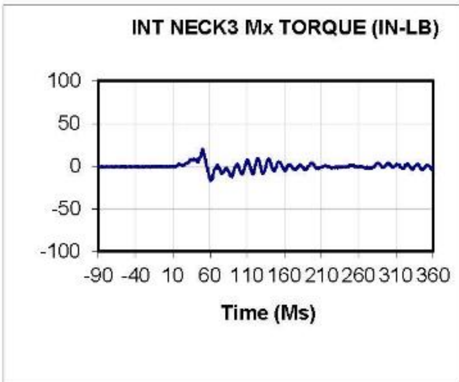
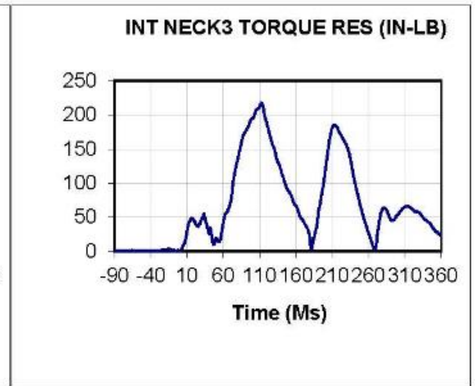
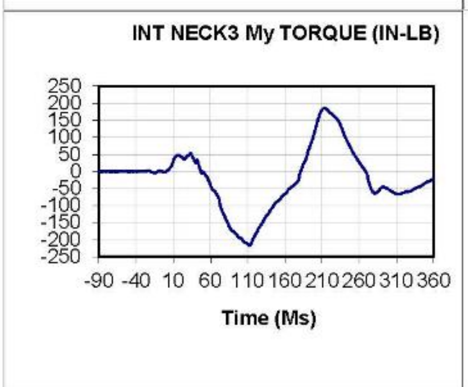
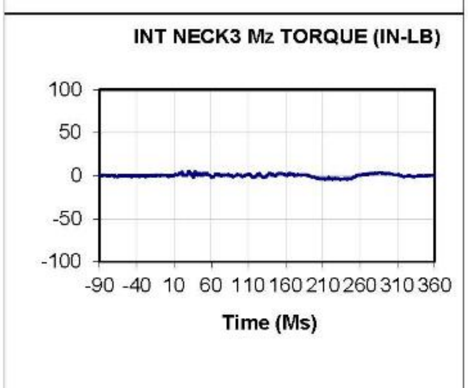
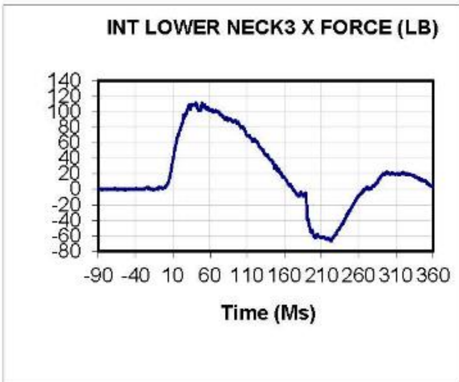


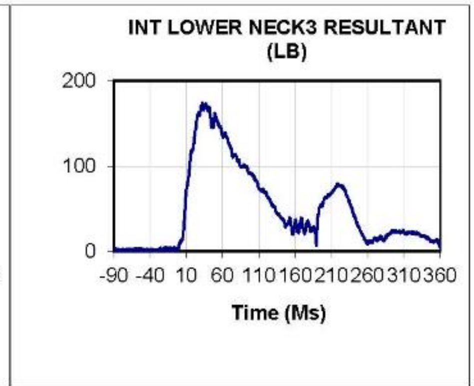


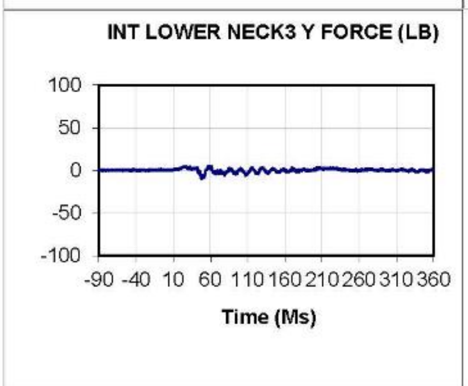


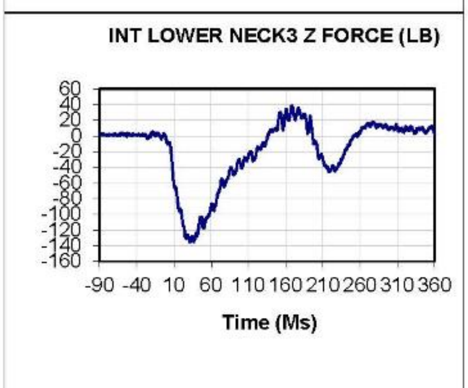


201809 Test: 9735 Test Date: 181004 Subj: H3HEADS Cell: B









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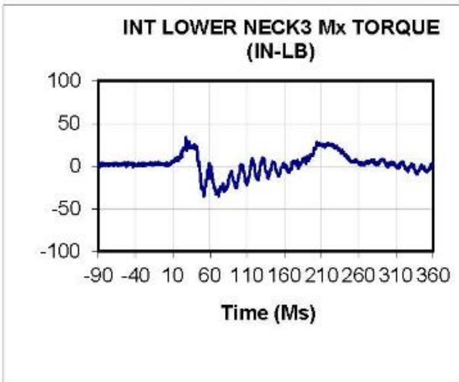

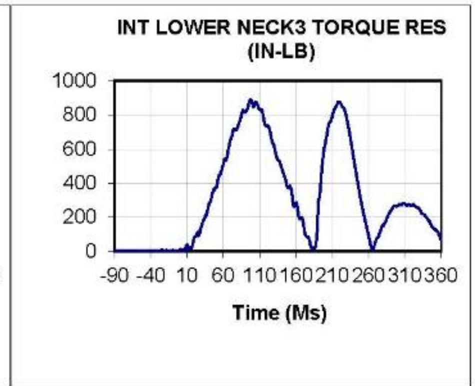

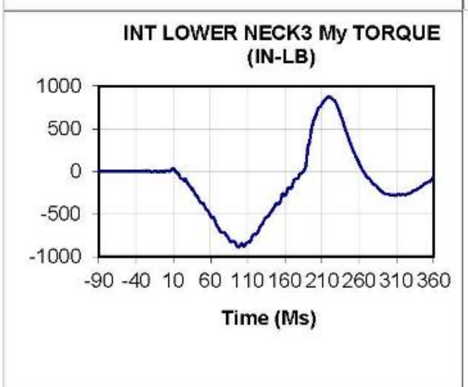

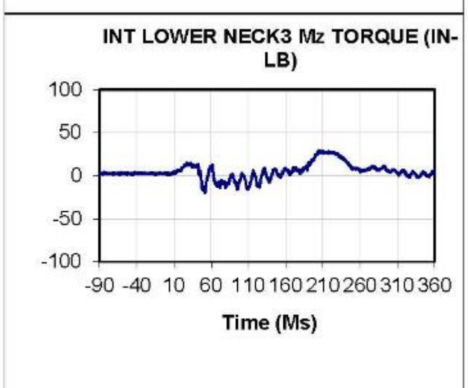

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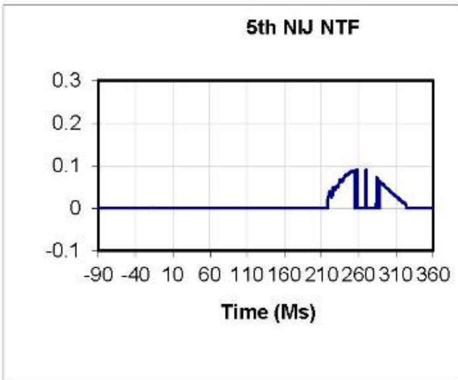

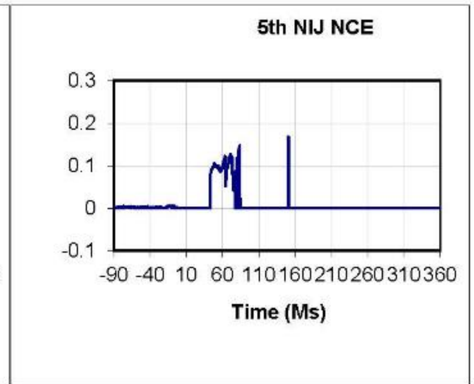

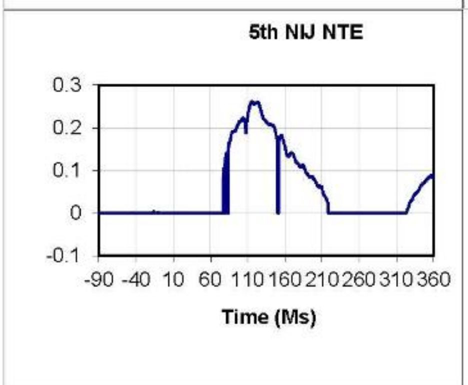

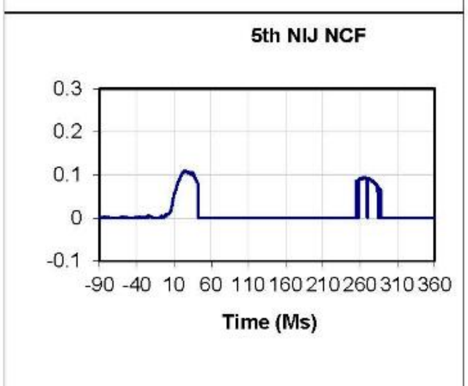

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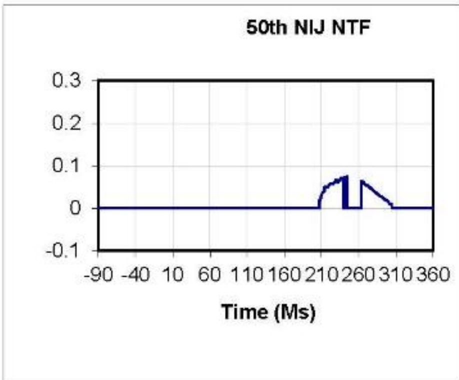

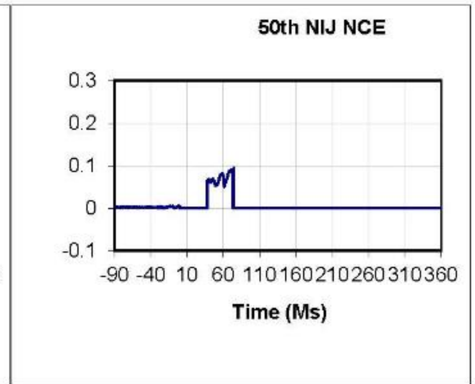

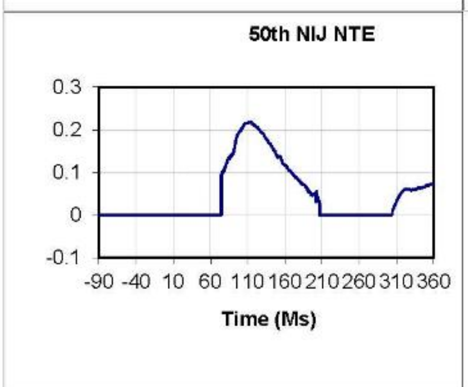

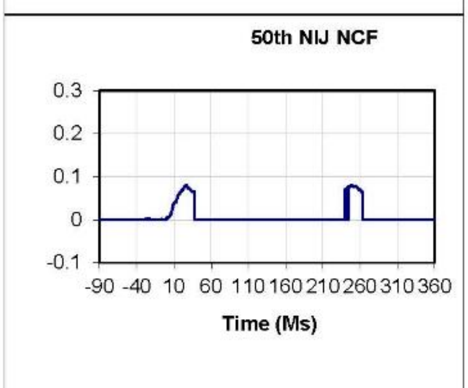

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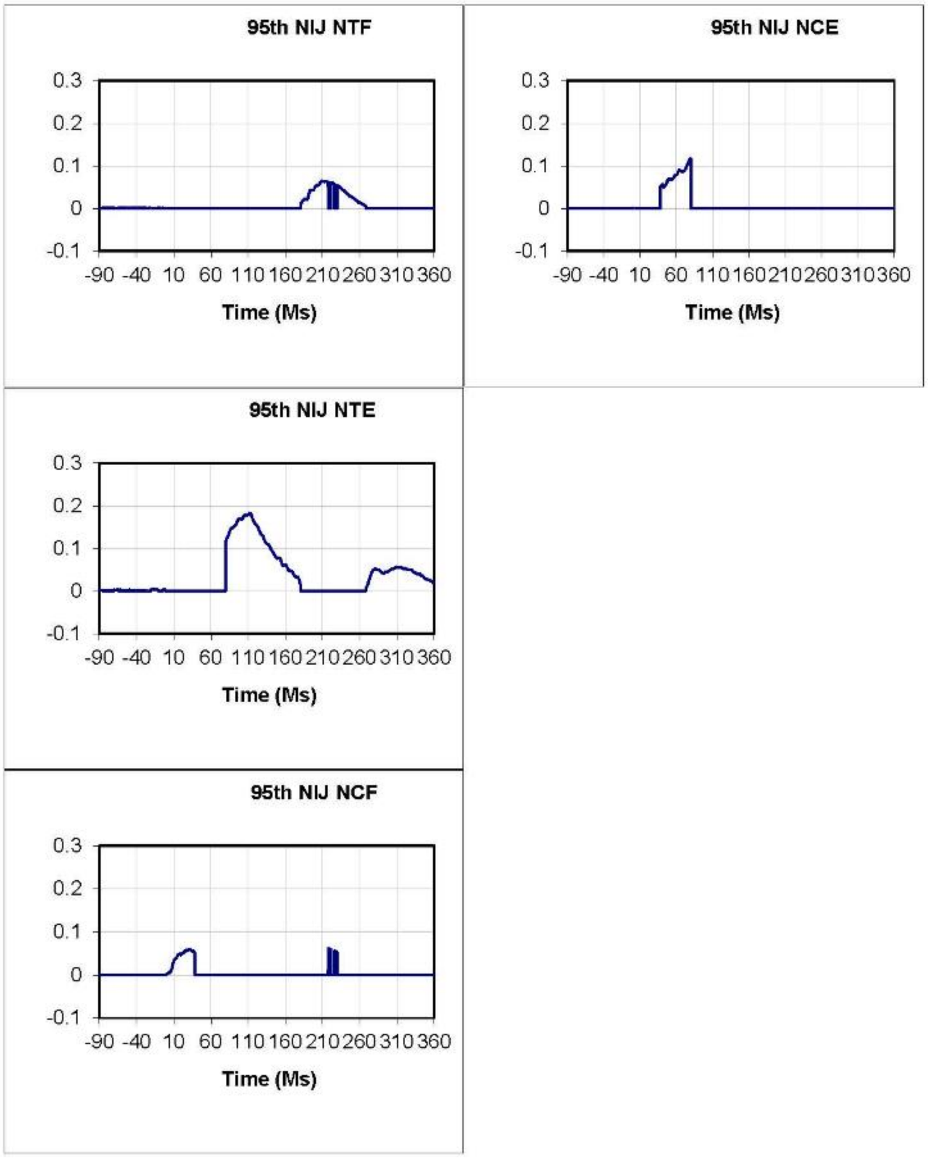

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201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: K

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				6.8	
Impact Rise Time (Ms)				39.7	
Impact Duration (Ms)				107.4	
Velocity Change (Ft/Sec)		24.91			
SLED X ACCEL (G)	0.05	12.19	-0.40	39.7	111.1
SLED Y ACCEL (G)	0.00	0.52	-0.88	27.1	48.2
SLED Z ACCEL (G)	-0.01	0.25	-1.11	130.7	42.5
SLED RESULTANT	0.08	12.24	0.17	39.7	116.6
INTEGRATED ACCEL (FT/SEC)	0.03	24.91	0.06	107.3	0.0
HEAD FIXTURE X ACCEL (G)	0.04	9.02	-0.88	38.1	151.2
HEAD FIXTURE Y ACCEL (G)	0.01	4.52	-1.42	49.3	110.1
HEAD FIXTURE Z ACCEL (G)	0.03	8.76	-0.62	40.0	110.7
HEAD FIXTURE RESULTANT (G)	0.10	12.68	0.08	39.1	113.0
HEAD FIXTURE2 X ACCEL (G)	0.03	9.31	-0.61	39.0	114.2
HEAD FIXTURE2 Y ACCEL (G)	0.01	1.83	-1.16	57.0	49.9
HEAD FIXTURE2 Z ACCEL (G)	0.03	8.07	-0.66	40.6	114.0
HEAD FIXTURE2 RESULTANT (G)	0.10	12.31	0.03	39.8	121.2
HEAD FIXTURE3 X ACCEL (G)	0.04	9.51	-0.61	38.6	113.2
HEAD FIXTURE3 Y ACCEL (G)	0.00	1.58	-1.24	49.3	85.3
HEAD FIXTURE3 Z ACCEL (G)	0.03	8.16	-0.87	38.3	113.0
HEAD FIXTURE3 RESULTANT (G)	0.12	12.53	0.15	38.4	193.8
INT HEAD X ACCEL (G)	0.03	102.49	-3.03	67.7	193.4
INT HEAD Y ACCEL (G)	0.00	2.27	-0.53	67.7	56.3
INT HEAD Z ACCEL (G)	0.06	9.66	-8.60	23.8	67.6
INT HEAD RESULTANT (G)	0.16	102.86	0.22	67.7	355.9
INT HEAD HIC		76.71		67.1	68.4
INT HEAD Ry ANG VELOCITY (RAD/SEC)	0.00	9.59	-5.91	75.6	74.2
INT HEAD Ry ANG VELOCITY (RAD/SEC)	-0.02	8.90	-13.40	154.3	65.2
INT HEAD Rz ANG VELOCITY (RAD/SEC)	0.00	6.85	-8.39	75.9	74.8
INT HEAD ANG VELOCITY RESULTANT	0.12	13.43	0.03	65.2	1.1
INT NECK X FORCE (LB)	0.33	52.18	-25.51	73.1	67.6
INT NECK Y FORCE (LB)	-0.53	3.97	-6.30	53.9	72.4
INT NECK Z FORCE (LB)	-1.19	39.63	-77.55	69.1	33.2
INT NECK RESULTANT (LB)	1.80	84.49	0.35	34.6	356.4

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Nom G: 12.0 Cell: K

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT NECK Mx TORQUE (IN-LB)	0.83	21.42	-12.26	49.9	55.7
INT NECK My TORQUE (IN-LB)	0.26	59.65	-73.24	200.5	68.0
INT NECK Mz TORQUE (IN-LB)	-0.36	12.98	-15.35	51.6	52.7
INT NECK TORQUE RES (IN-LB)	1.61	73.43	0.68	68.0	256.1
INT LOWER NECK X FORCE (LB)	-0.17	84.88	-25.77	59.1	190.2
INT LOWER NECK Y FORCE (LB)	0.32	9.80	-10.67	72.0	45.4
INT LOWER NECK Z FORCE (LB)	0.65	29.74	-89.11	126.5	51.8
INT LOWER NECK RESULTANT (LB)	1.81	112.70	2.29	31.9	154.6
INT LOWER NECK Mx TORQUE (IN-LB)	0.49	25.04	-21.32	98.3	216.9
INT LOWER NECK My TORQUE (IN-LB)	-0.62	245.14	-432.83	193.9	69.8
INT LOWER NECK Mz TORQUE (IN-LB)	-0.56	39.84	-6.99	69.9	11.4
INT LOWER NECK TORQUE RES (IN-LB)	2.21	434.78	3.73	69.8	0.0
INT HEAD2 X ACCEL (G)	0.03	72.56	-3.07	60.3	176.9
INT HEAD2 Y ACCEL (G)	0.00	2.60	-1.43	60.9	72.5
INT HEAD2 Z ACCEL (G)	0.05	8.93	-13.51	36.9	62.3
INT HEAD2 RESULTANT (G)	0.14	72.59	0.05	60.3	319.2
INT HEAD2 HIC		60.19		59.2	70.5
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	0.00	1.64	-1.07	71.9	72.1
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	-0.03	6.99	-13.20	134.5	59.3
INT HEAD2 Rz ANG VELOCITY (RAD/SEC)	0.00	3.71	-7.18	60.4	72.1
INT HEAD2 ANG VELOCITY RESULTANT	0.08	13.23	0.03	59.2	4.4
INT NECK2 X FORCE (LB)	1.00	72.56	-25.47	66.7	176.8
INT NECK2 Y FORCE (LB)	-0.45	4.06	-4.02	73.8	65.1
INT NECK2 Z FORCE (LB)	-0.87	156.19	-90.87	62.3	25.0
INT NECK2 RESULTANT (LB)	2.02	161.08	0.30	62.3	318.5
INT NECK2 Mx TORQUE (IN-LB)	0.31	15.08	-9.95	62.3	76.9
INT NECK2 My TORQUE (IN-LB)	-1.12	113.11	-90.86	66.9	84.8
INT NECK2 Mz TORQUE (IN-LB)	-0.80	2.71	-8.38	63.2	74.9
INT NECK2 TORQUE RES (IN-LB)	1.91	113.20	0.56	66.9	228.9
INT LOWER NECK2 X FORCE (LB)	0.46	172.43	-31.48	63.1	174.5
INT LOWER NECK2 Y FORCE (LB)	-0.38	50.04	-22.72	64.1	62.9
INT LOWER NECK2 Z FORCE (LB)	-1.49	144.58	-149.53	61.9	36.4
INT LOWER NECK2 RESULTANT (LB)	2.58	197.83	1.14	63.0	318.2

201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: K

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT LOWER NECK2 Mx TORQUE (IN-LB)	-1.59	64.61	-21.79	64.3	63.1
INT LOWER NECK2 My TORQUE (IN-LB)	-1.32	362.19	-1017.34	178.7	62.6
INT LOWER NECK2 Mz TORQUE (IN-LB)	0.26	92.12	-35.34	64.5	64.9
INT LOWER NECK2 TORQUE RES (IN-LB)	4.50	1017.44	1.87	62.6	1.5
INT HEAD3 X ACCEL (G)	0.05	76.45	-5.39	67.5	163.5
INT HEAD3 Y ACCEL (G)	0.00	16.12	-12.47	74.8	76.0
INT HEAD3 Z ACCEL (G)	0.06	9.48	-5.68	29.3	69.3
INT HEAD3 RESULTANT (G)	0.16	76.81	0.11	67.5	286.2
INT HEAD3 HIC		68.66		66.1	76.7
INT HEAD3 Rx ANG VELOCITY (RAD/SEC)	0.01	1.74	-1.46	68.5	72.7
INT HEAD3 Ry ANG VELOCITY (RAD/SEC)	-0.02	8.87	-13.84	130.2	66.7
INT HEAD3 Rz ANG VELOCITY (RAD/SEC)	0.01	1.15	-1.25	76.9	67.0
INT HEAD3 ANG VELOCITY RESULTANT	0.15	13.90	0.05	66.7	0.2
INT HEAD3 Ry ANG ACCEL (RAD/SEC2)	-0.44	7038.35	-5599.46	70.4	77.6
INT NECK3 X FORCE (LB)	0.15	67.96	-44.92	64.6	164.5
INT NECK3 Y FORCE (LB)	-0.32	4.57	-6.28	71.7	73.1
INT NECK3 Z FORCE (LB)	2.71	113.74	-97.93	69.5	29.4
INT NECK3 RESULTANT (LB)	2.89	119.51	2.77	69.5	0.0
INT NECK3 Mx TORQUE (IN-LB)	0.15	20.85	-21.07	47.7	71.9
INT NECK3 My TORQUE (IN-LB)	-0.73	122.83	-105.41	157.7	70.3
INT NECK3 Mz TORQUE (IN-LB)	-0.68	4.21	-11.11	68.3	83.3
INT NECK3 TORQUE RES (IN-LB)	2.38	122.85	1.34	157.7	128.9
INT LOWER NECK3 X FORCE (LB)	0.67	146.45	-47.92	71.1	160.8
INT LOWER NECK3 Y FORCE (LB)	0.35	37.56	-26.29	70.4	70.8
INT LOWER NECK3 Z FORCE (LB)	1.75	78.78	-140.87	69.2	29.8
INT LOWER NECK3 RESULTANT (LB)	3.05	176.71	1.93	29.7	285.5
INT LOWER NECK3 Mx TORQUE (IN-LB)	2.00	41.27	-56.75	158.9	76.5
INT LOWER NECK3 My TORQUE (IN-LB)	0.48	572.57	-1038.57	164.8	69.8
INT LOWER NECK3 Mz TORQUE (IN-LB)	2.70	61.37	-59.80	70.8	71.2
INT LOWER NECK3 TORQUE RES (IN-LB)	6.23	1038.69	2.89	69.8	353.8

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
5th NIJ SHEAR (LB)		52.18	-25.51	73.1	67.6
5th NIJ TENSION (LB)		39.63		69.1	
5th NIJ COMPRESSION (LB)		-77.55		33.2	
5th NIJ FLEXION (IN-LB)		75.75		200.6	
5th NIJ EXTENSION (IN-LB)		74.02		68.4	
5th NIJ NTF	0.0001	0.0569	0.0000	198.8	0.0
5th NIJ NTE	0.0005	0.1377	0.0000	69.0	0.0
5th NIJ NCF	0.0016	0.1139	0.0000	23.7	41.0
5th NIJ NCE	0.0007	0.1220	0.0000	91.6	0.0
5th NIJ NTF AIS >= 2		0.12			
5th NIJ NTF AIS >= 3		0.04			
5th NIJ NTF AIS >= 4		0.07			
5th NIJ NTF AIS >= 5		0.02			
5th NIJ NTE AIS >= 2		0.13			
5th NIJ NTE AIS >= 3		0.05			
5th NIJ NTE AIS >= 4		0.07			
5th NIJ NTE AIS >= 5		0.03			
5th NIJ NCF AIS >= 2		0.13			
5th NIJ NCF AIS >= 3		0.05			
5th NIJ NCF AIS >= 4		0.07			
5th NIJ NCF AIS >= 5		0.02			
5th NIJ NCE AIS >= 2		0.13			
5th NIJ NCE AIS >= 3		0.05			
5th NIJ NCE AIS >= 4		0.07			
5th NIJ NCE AIS >= 5		0.02			
50th NIJ SHEAR (LB)		72.56	-25.47	66.7	176.8
50th NIJ TENSION (LB)		156.19		62.3	
50th NIJ COMPRESSION (LB)		-90.87		25.0	
50th NIJ FLEXION (IN-LB)		85.48		182.5	
50th NIJ EXTENSION (IN-LB)		103.74		84.9	
50th NIJ NTF	0.0000	0.0337	0.0000	165.4	0.0
50th NIJ NTE	0.0006	0.1215	0.0000	62.3	0.0
50th NIJ NCF	0.0002	0.0789	0.0000	25.0	35.2
50th NIJ NCE	0.0019	0.1041	0.0000	86.6	0.0
50th NIJ NTF AIS >= 2		0.12			
50th NIJ NTF AIS >= 3		0.04			
50th NIJ NTF AIS >= 4		0.07			
50th NIJ NTF AIS >= 5		0.02			
50th NIJ NTE AIS >= 2		0.13			
50th NIJ NTE AIS >= 3		0.05			
50th NIJ NTE AIS >= 4		0.07			
50th NIJ NTE AIS >= 5		0.02			

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Nom G: 12.0 Cell: K

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
50th NIJ NCF AIS >= 2		0.12			
50th NIJ NCF AIS >= 3		0.04			
50th NIJ NCF AIS >= 4		0.07			
50th NIJ NCF AIS >= 5		0.02			
50th NIJ NCE AIS >= 2		0.13			
50th NIJ NCE AIS >= 3		0.05			
50th NIJ NCE AIS >= 4		0.07			
50th NIJ NCE AIS >= 5		0.02			
95th NIJ SHEAR (LB)		67.96	-44.92	64.6	164.5
95th NIJ TENSION (LB)		113.74		69.5	
95th NIJ COMPRESSION (LB)		-97.93		29.4	
95th NIJ FLEXION (IN-LB)		152.42		157.6	
95th NIJ EXTENSION (IN-LB)		131.10		70.4	
95th NIJ NTF	0.0006	0.0468	0.0000	159.9	0.0
95th NIJ NTE	0.0019	0.1391	0.0000	69.6	0.0
95th NIJ NCF	0.0000	0.0644	0.0000	30.5	36.4
95th NIJ NCE	0.0000	0.0858	0.0000	88.6	0.0
95th NIJ NTF AIS >= 2		0.12			
95th NIJ NTF AIS >= 3		0.04			
95th NIJ NTF AIS >= 4		0.07			
95th NIJ NTF AIS >= 5		0.02			
95th NIJ NTE AIS >= 2		0.13			
95th NIJ NTE AIS >= 3		0.05			
95th NIJ NTE AIS >= 4		0.07			
95th NIJ NTE AIS >= 5		0.03			
95th NIJ NCF AIS >= 2		0.12			
95th NIJ NCF AIS >= 3		0.04			
95th NIJ NCF AIS >= 4		0.07			
95th NIJ NCF AIS >= 5		0.02			
95th NIJ NCE AIS >= 2		0.12			
95th NIJ NCE AIS >= 3		0.04			
95th NIJ NCE AIS >= 4		0.07			

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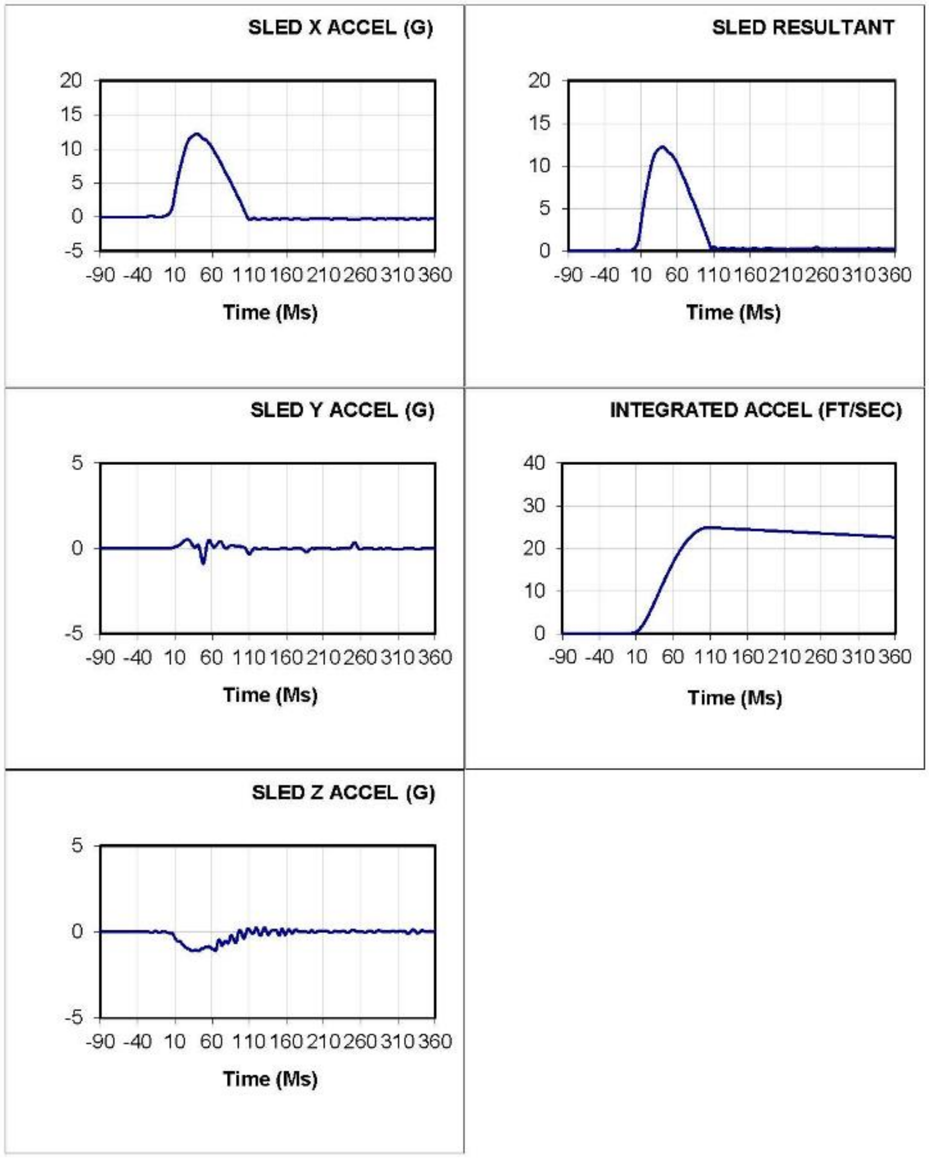

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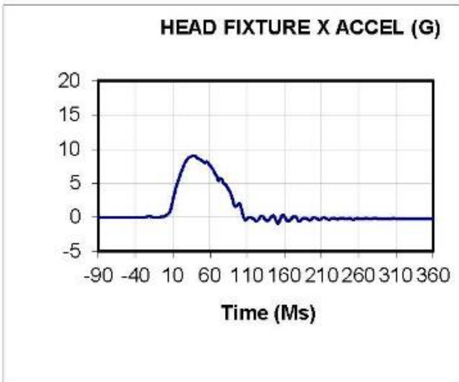
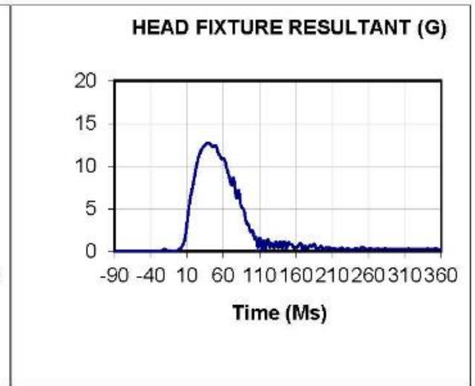
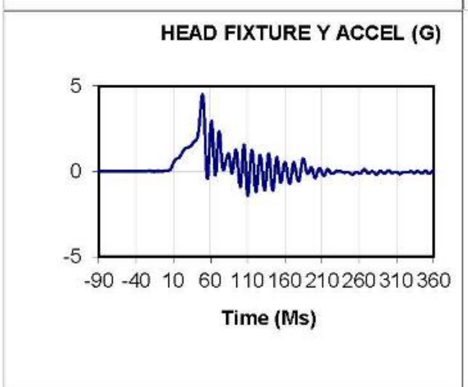
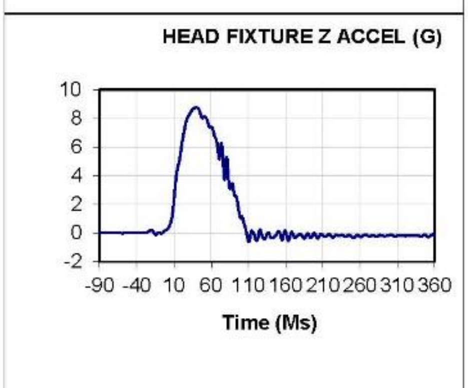
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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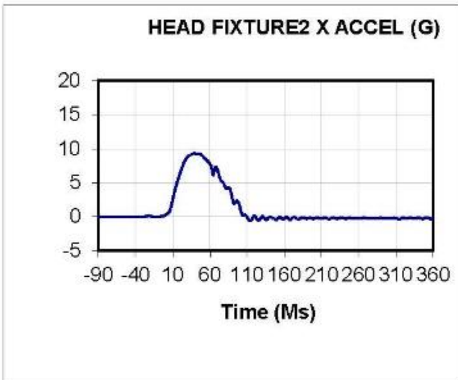
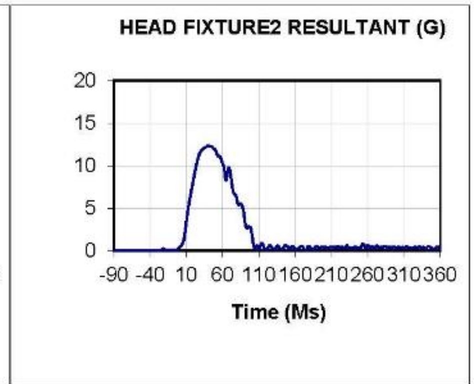
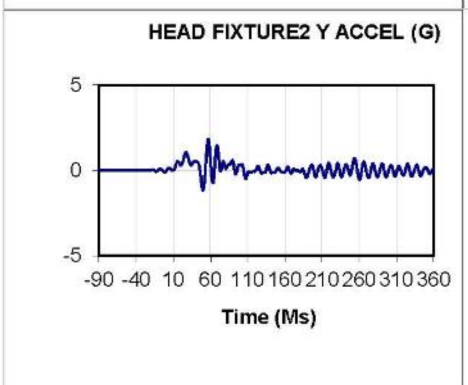
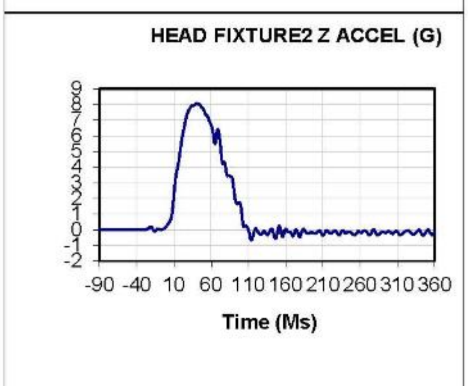
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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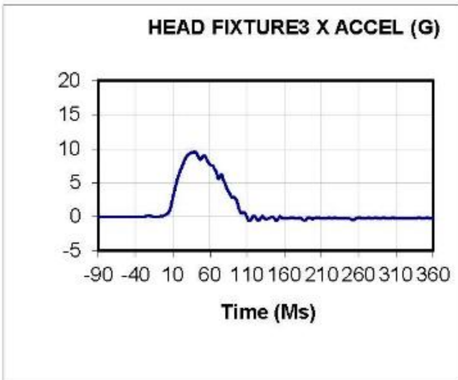
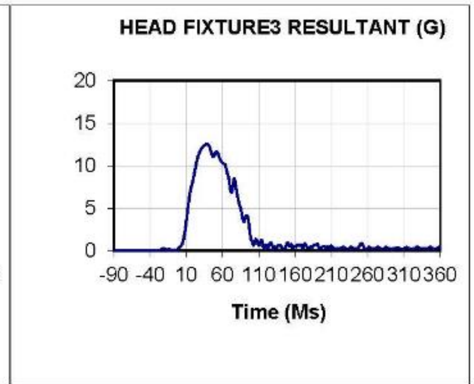
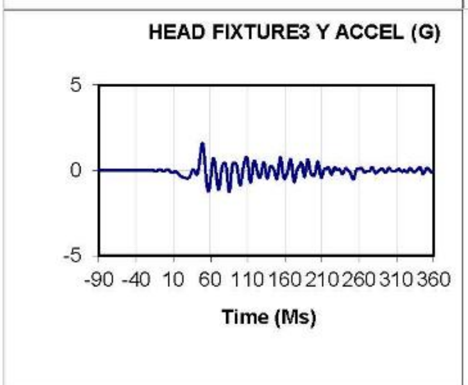
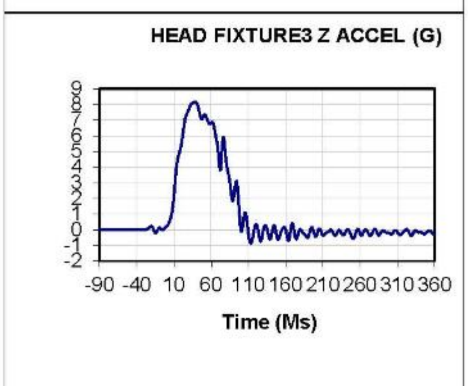
Distribution A: Approved for public release. 88ABW-2019-5126, cleared on 23 October 2019

201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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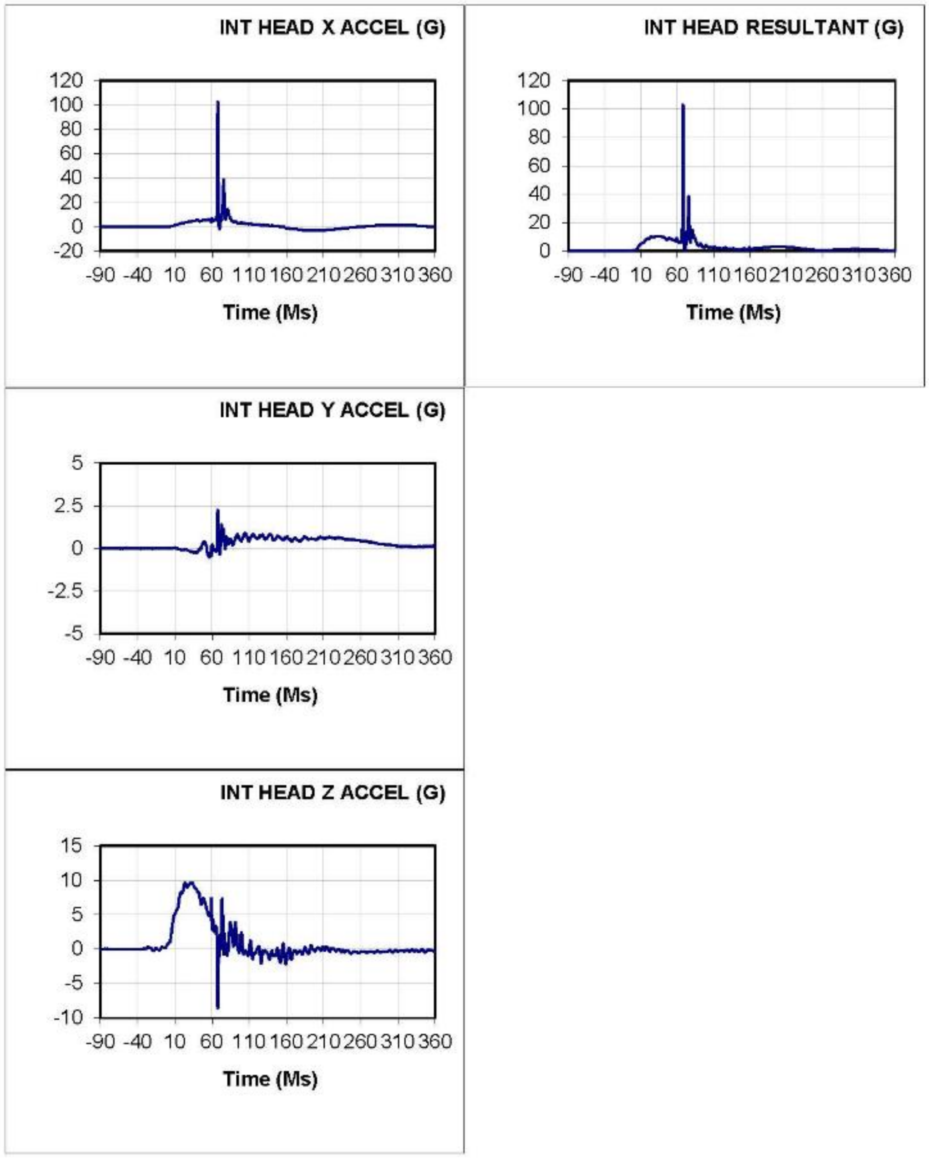
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K



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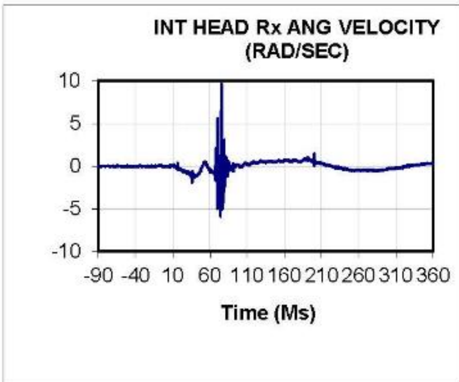
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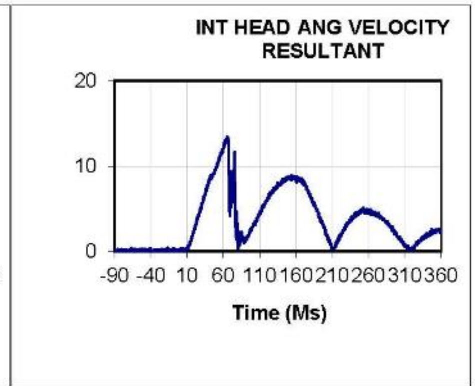
(RAD/SEC)
10
5
0
-5
-10
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)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RESULTANT
20
10
0
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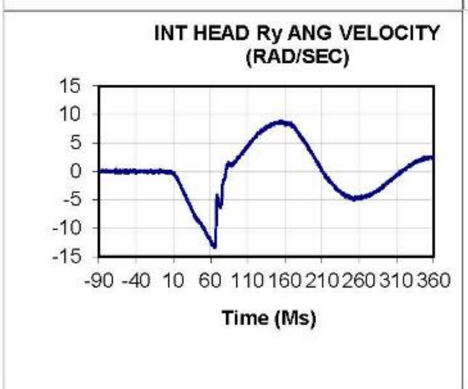
Time (Ms)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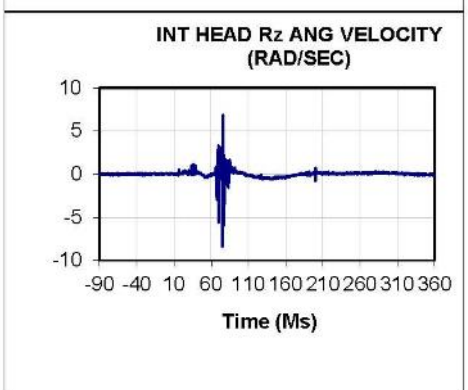
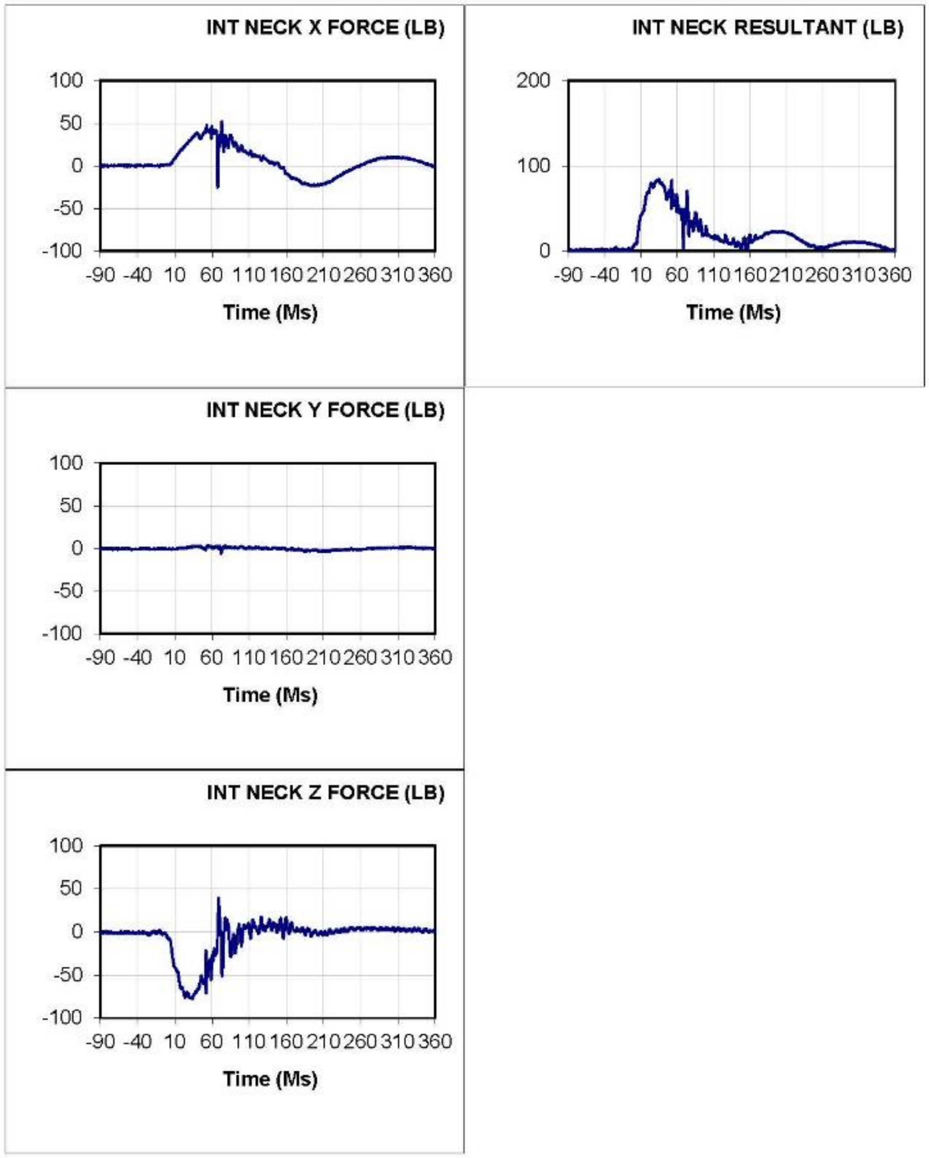
(RAD/SEC)
15
10
5
0
-5
-10
-15
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)


INT HEAD Rz ANG VELOCITY
(RAD/SEC)
10
5
0
-5
-10
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)

201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K



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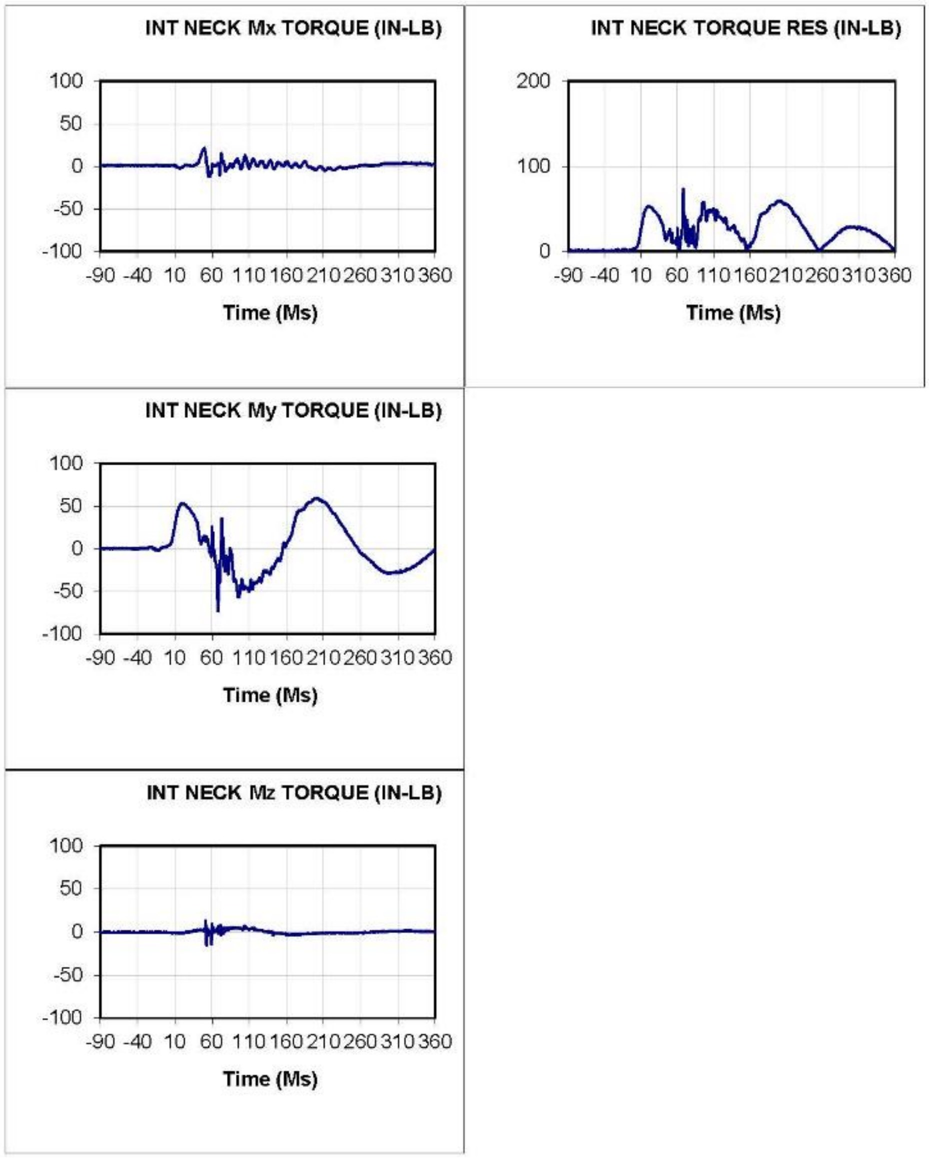
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K



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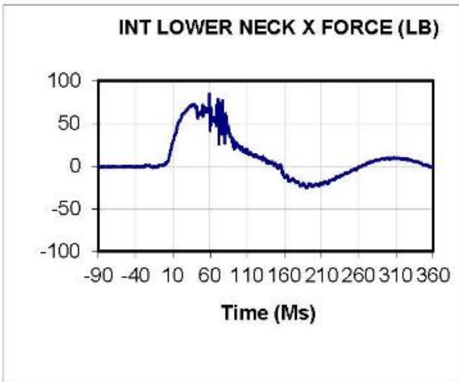
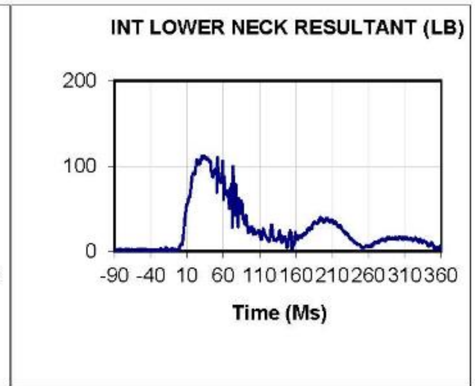
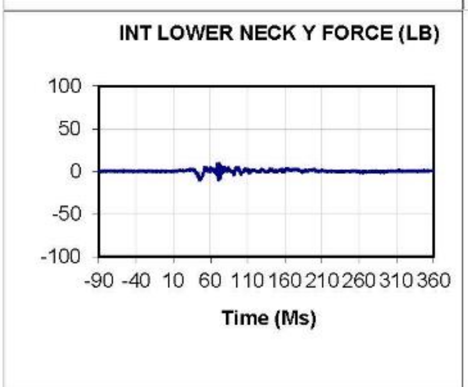
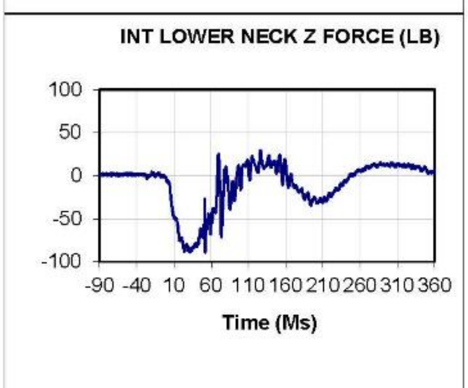
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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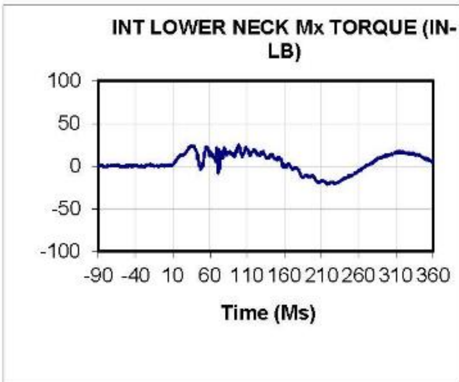
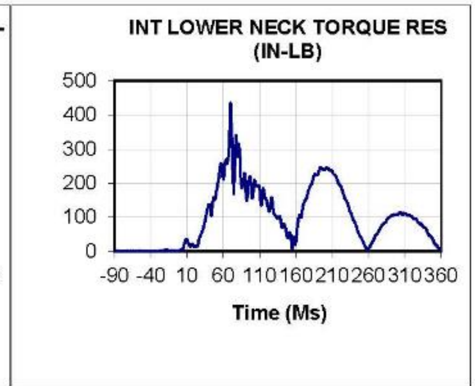
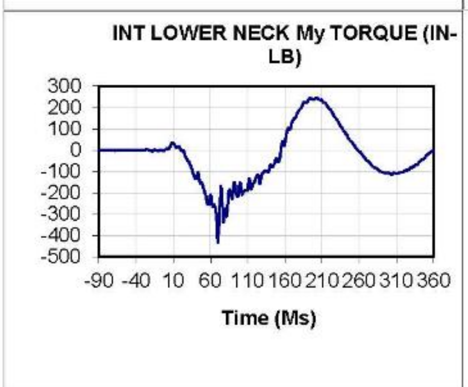
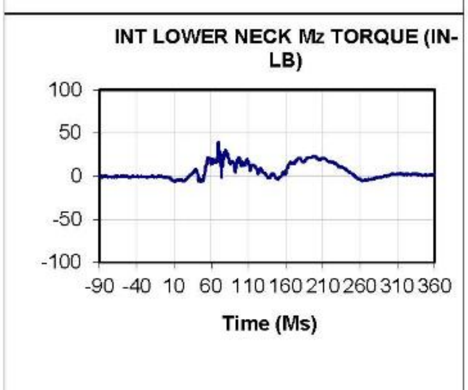
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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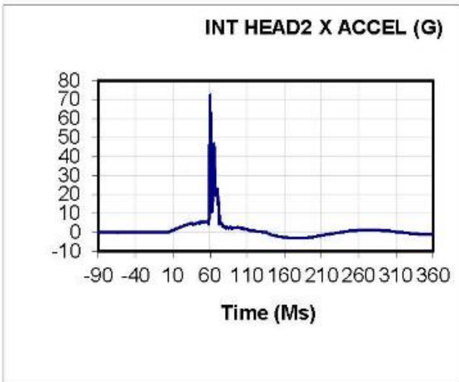
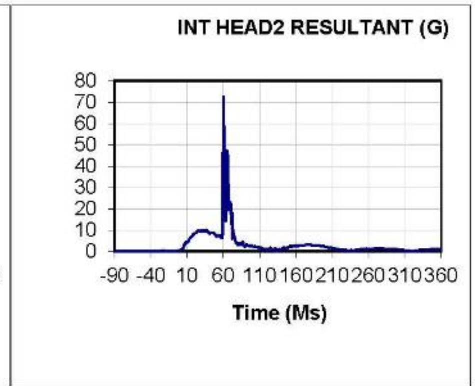
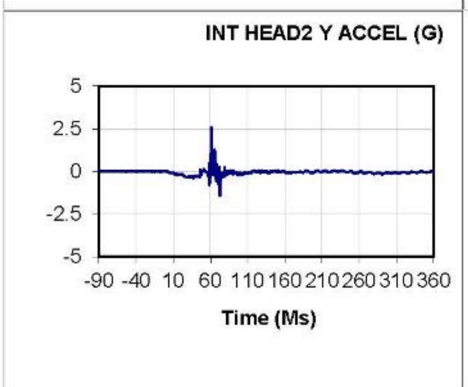
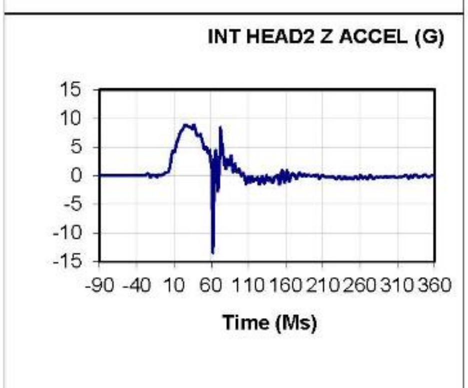
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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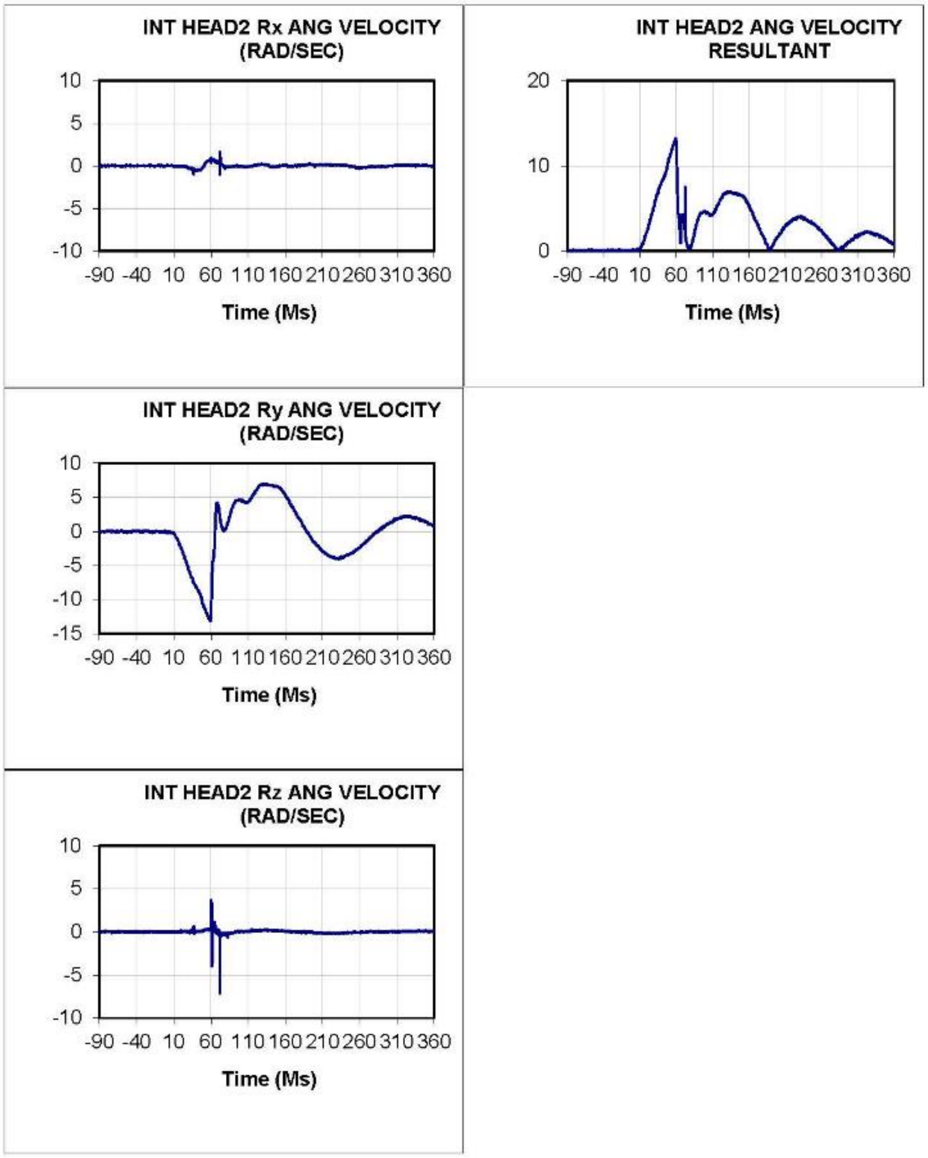
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K



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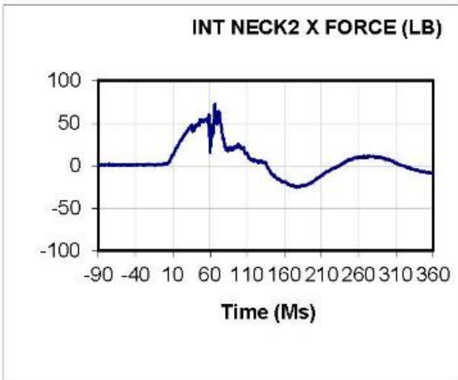
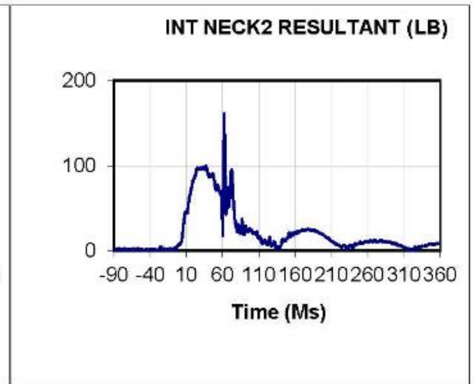
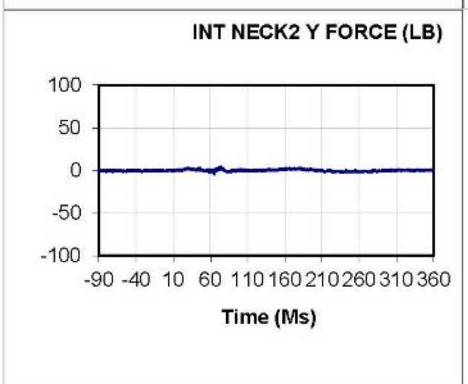
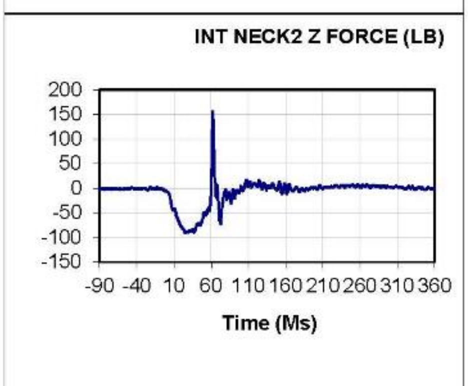
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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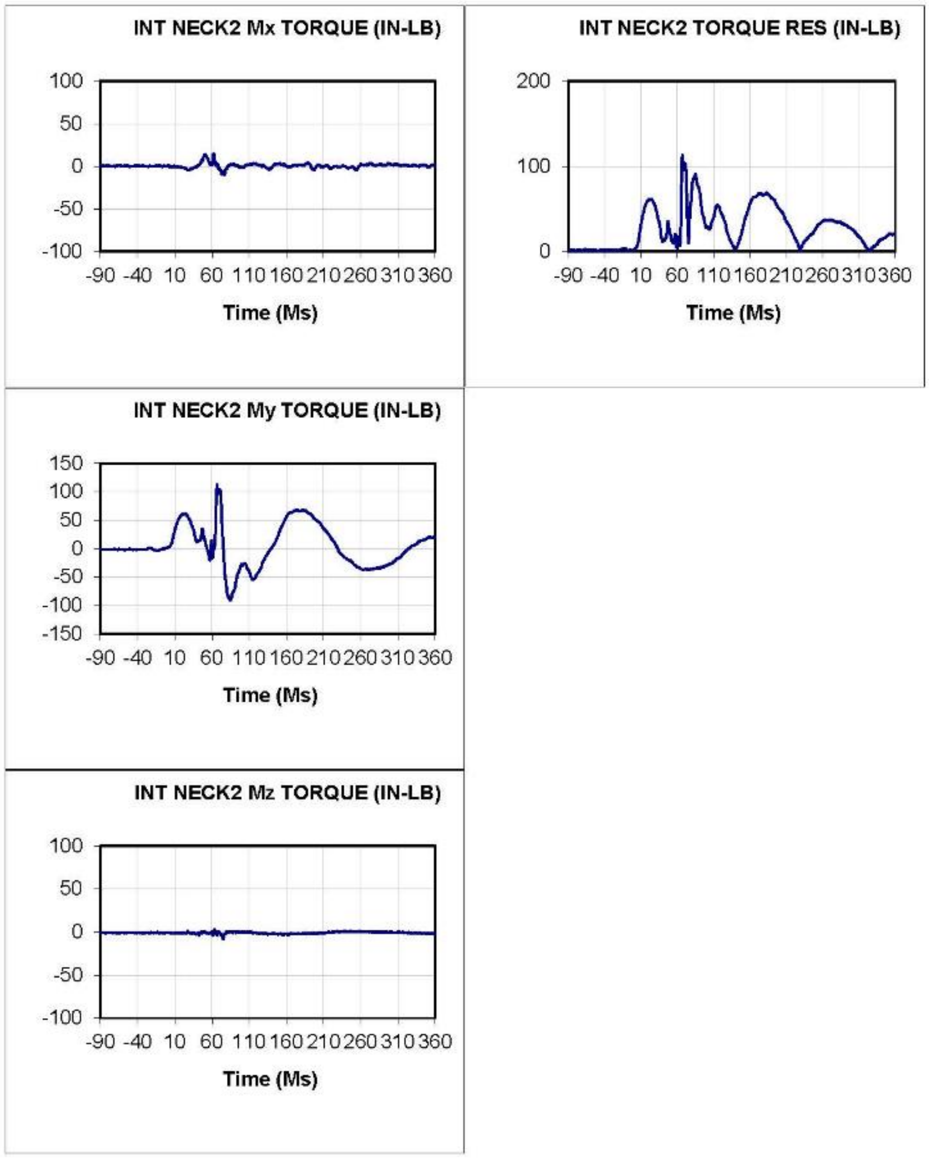

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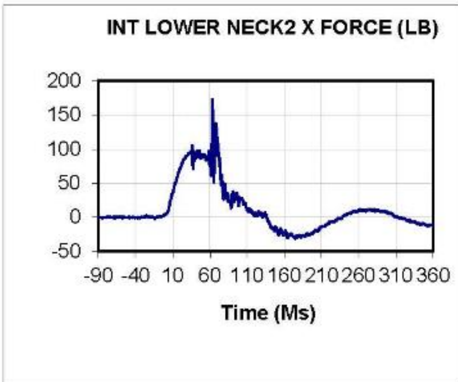

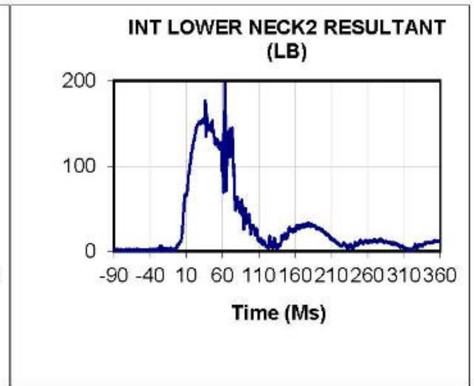

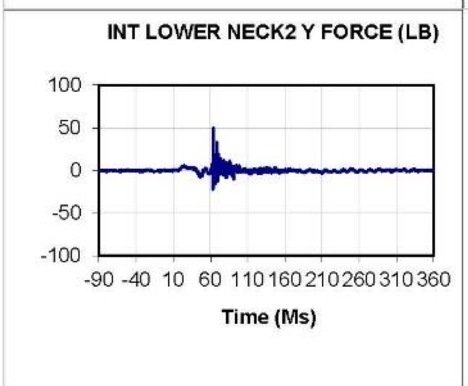

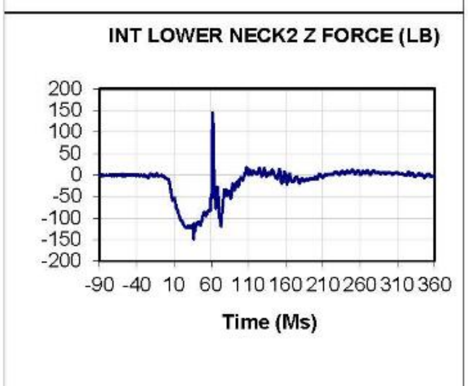

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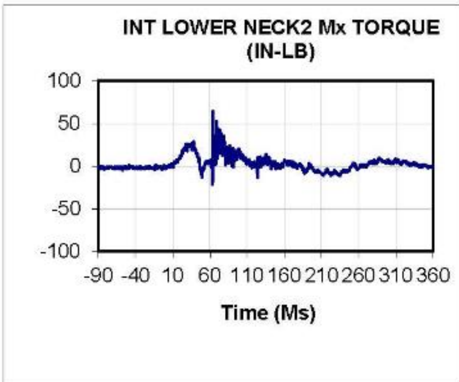
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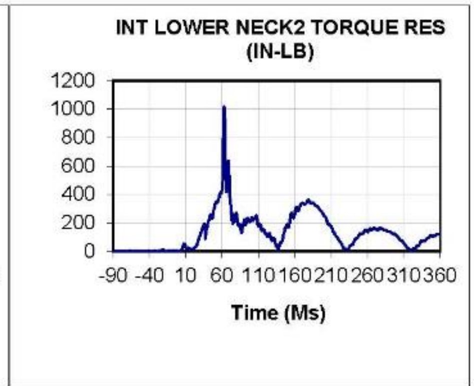
100
50
0
-50
-100
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)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1000
800
600
400
200
0
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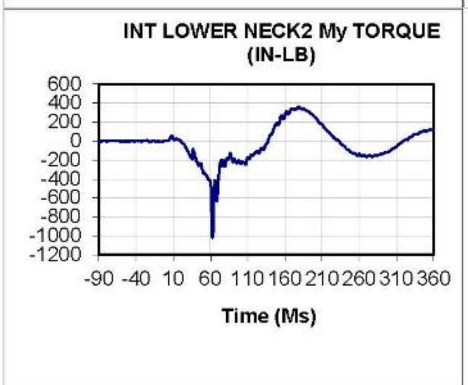
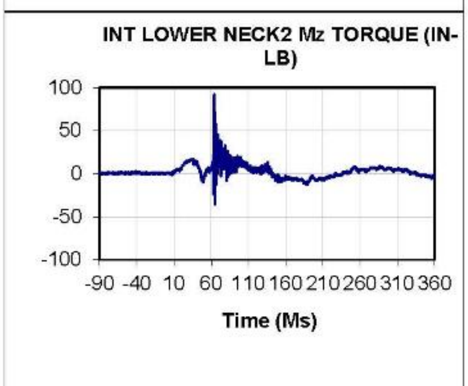
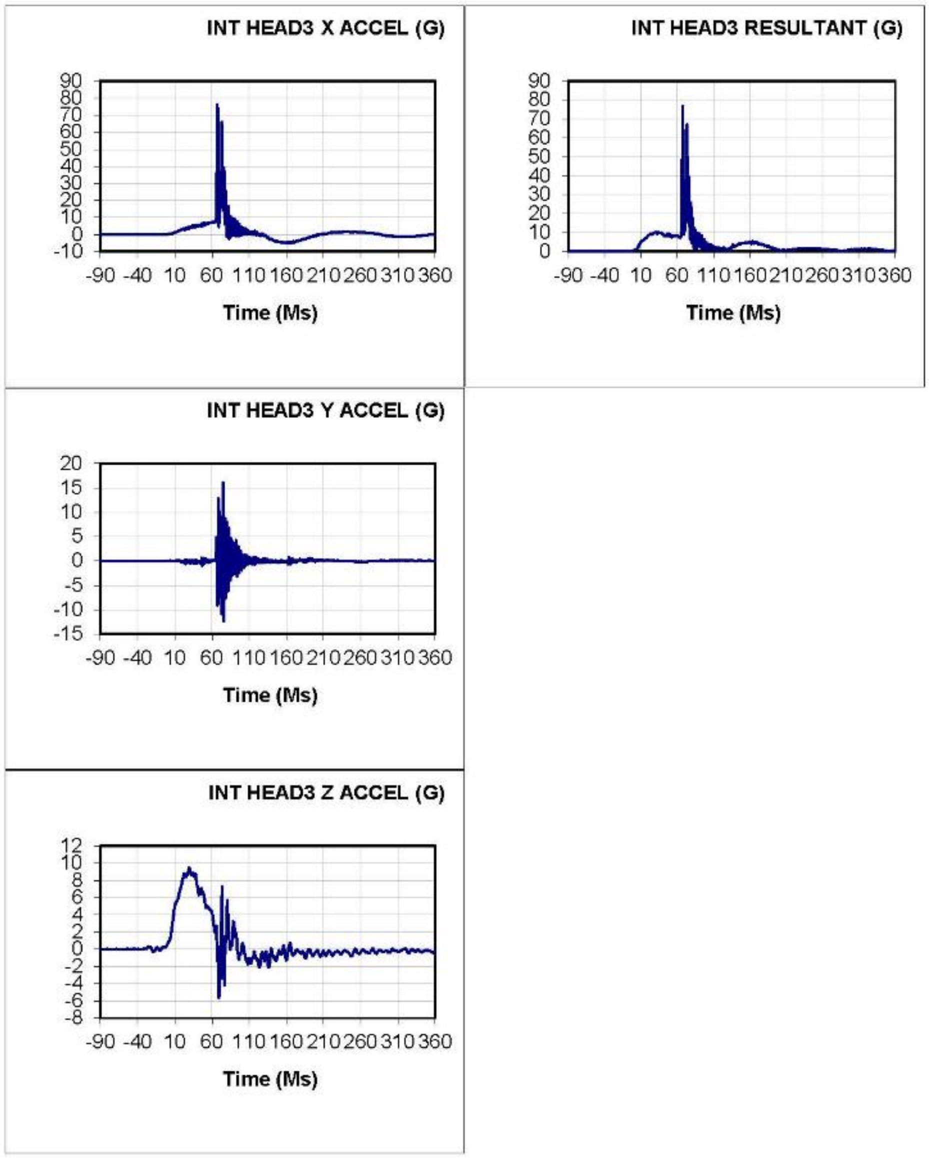
Time (Ms)


INT LOWER NECK2 My TORQUE (IN-LB)
600
400
200
0
-200
-400
-600
-800
-1000
-1200
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)


INT LOWER NECK2 Mz TORQUE (IN-LB)
100
50
0
-50
-100
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)

201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K



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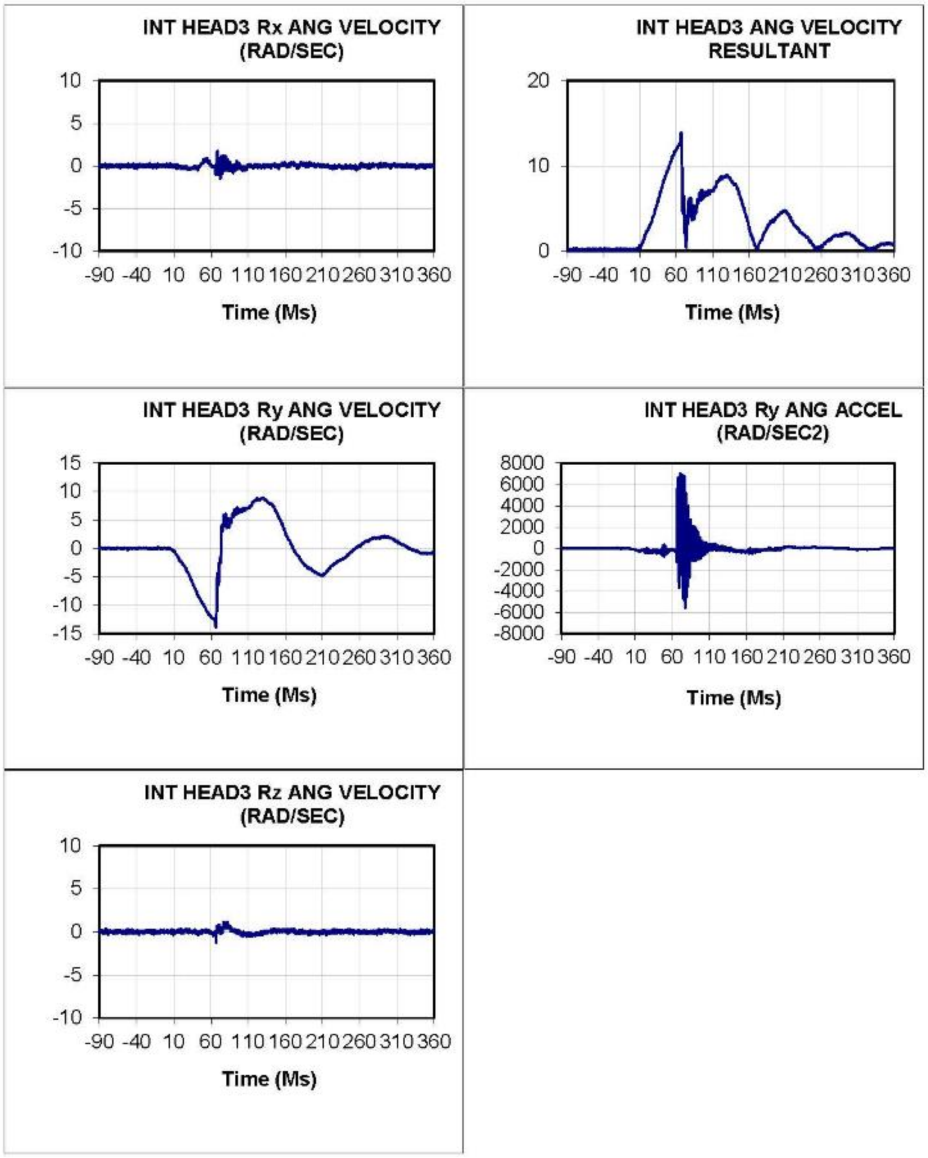
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K



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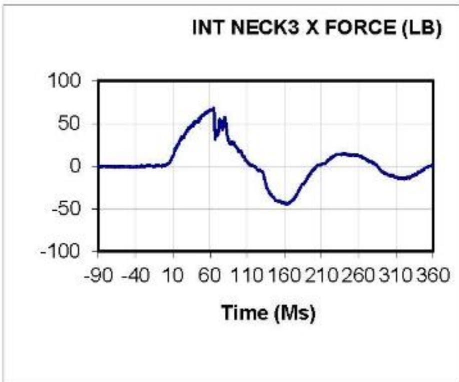
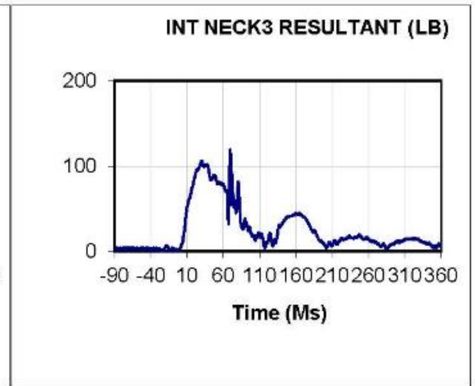
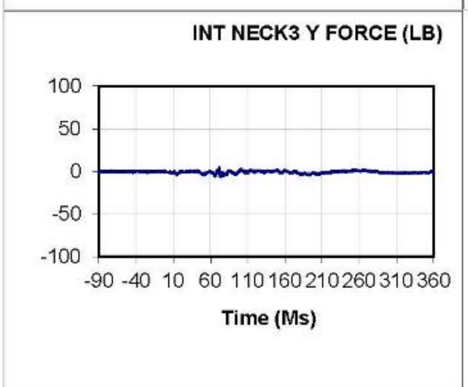
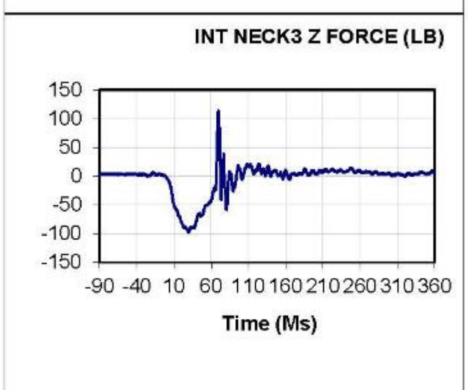
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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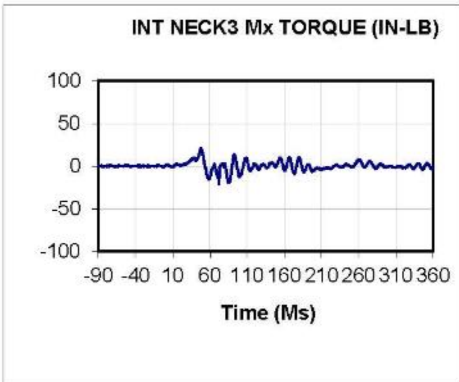
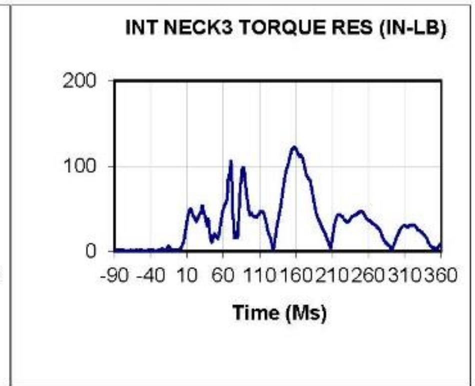
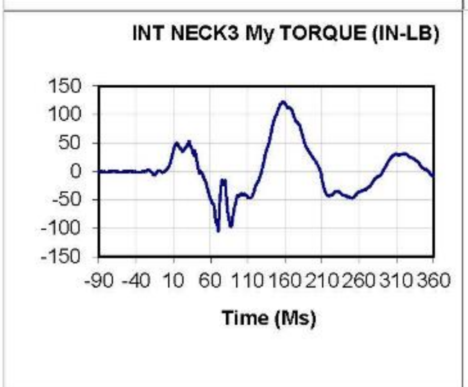
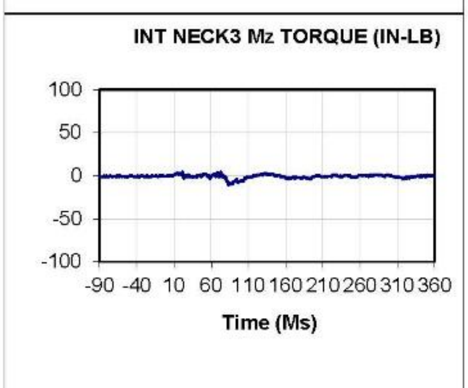
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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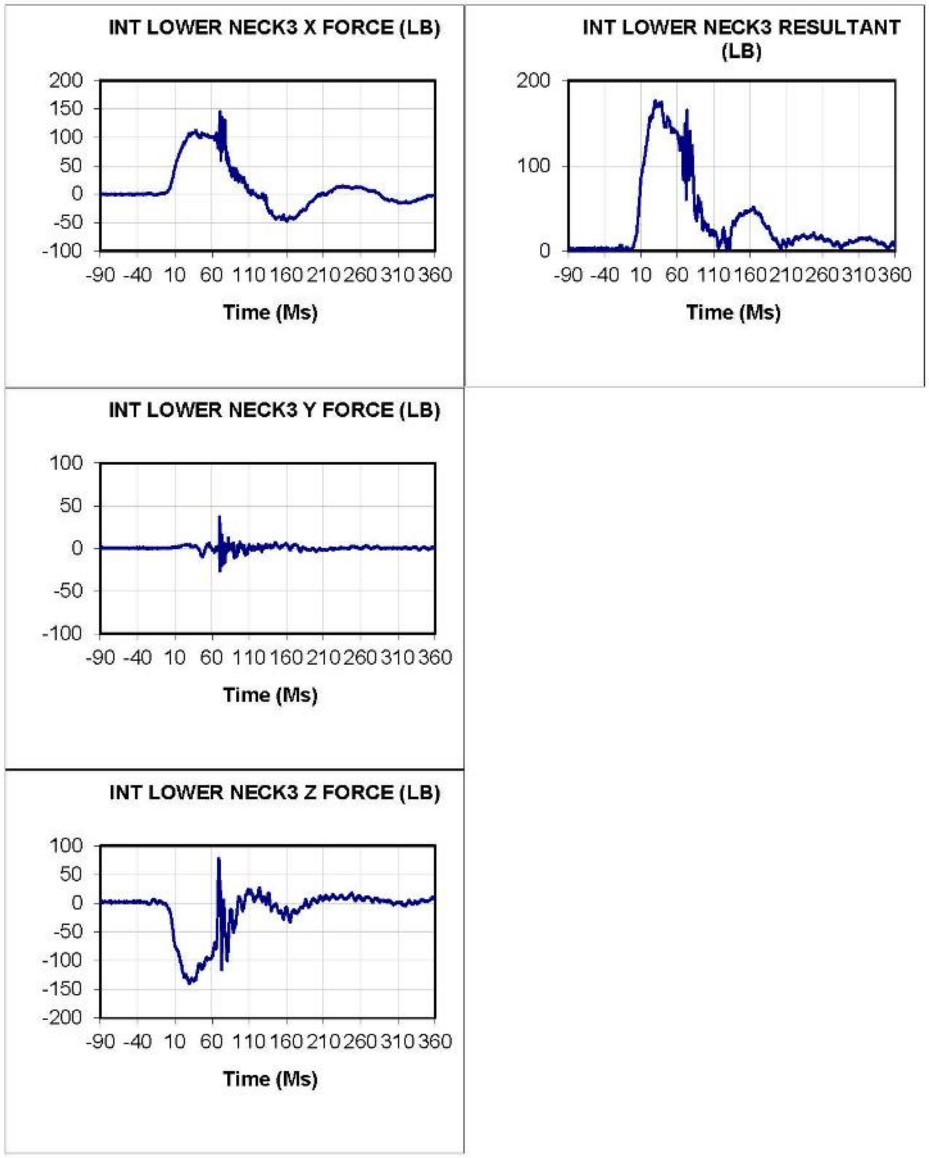
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K



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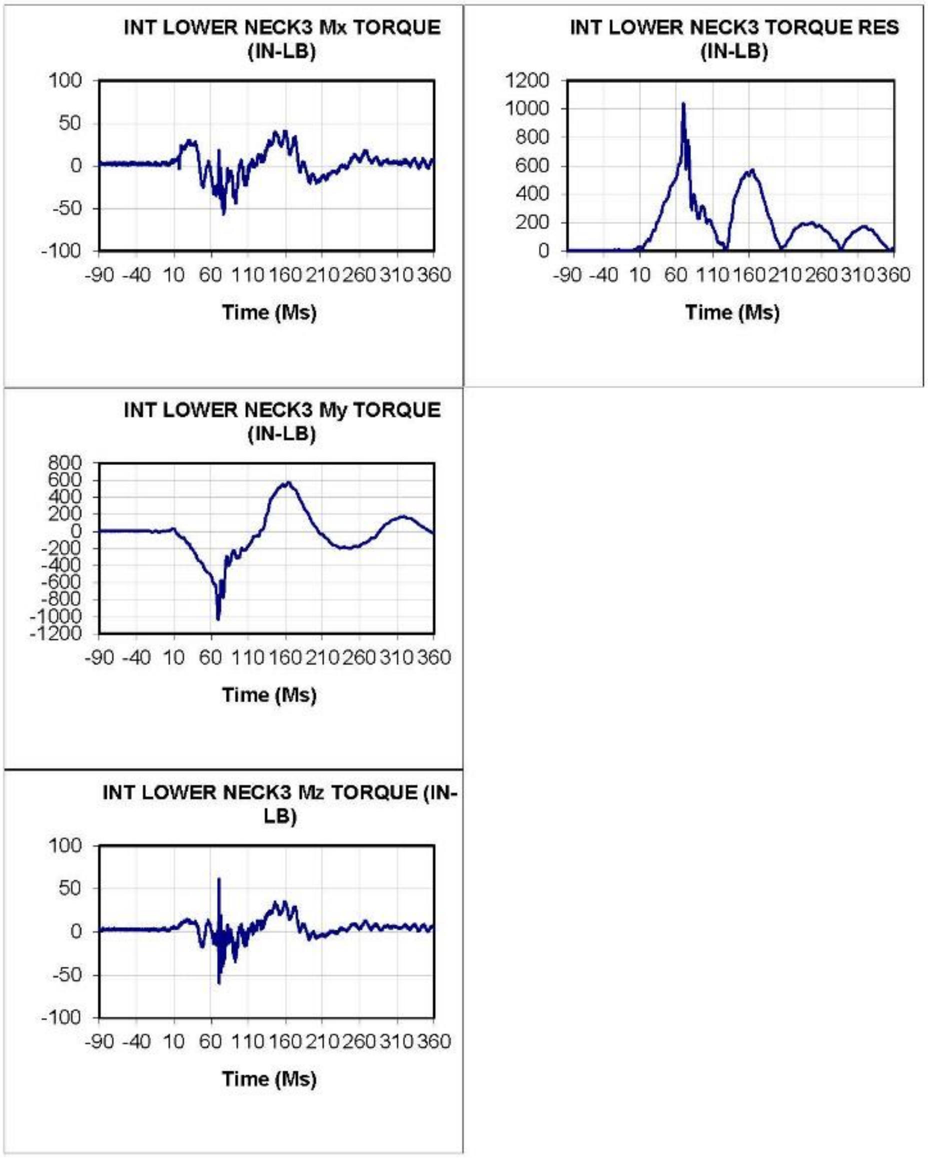
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K



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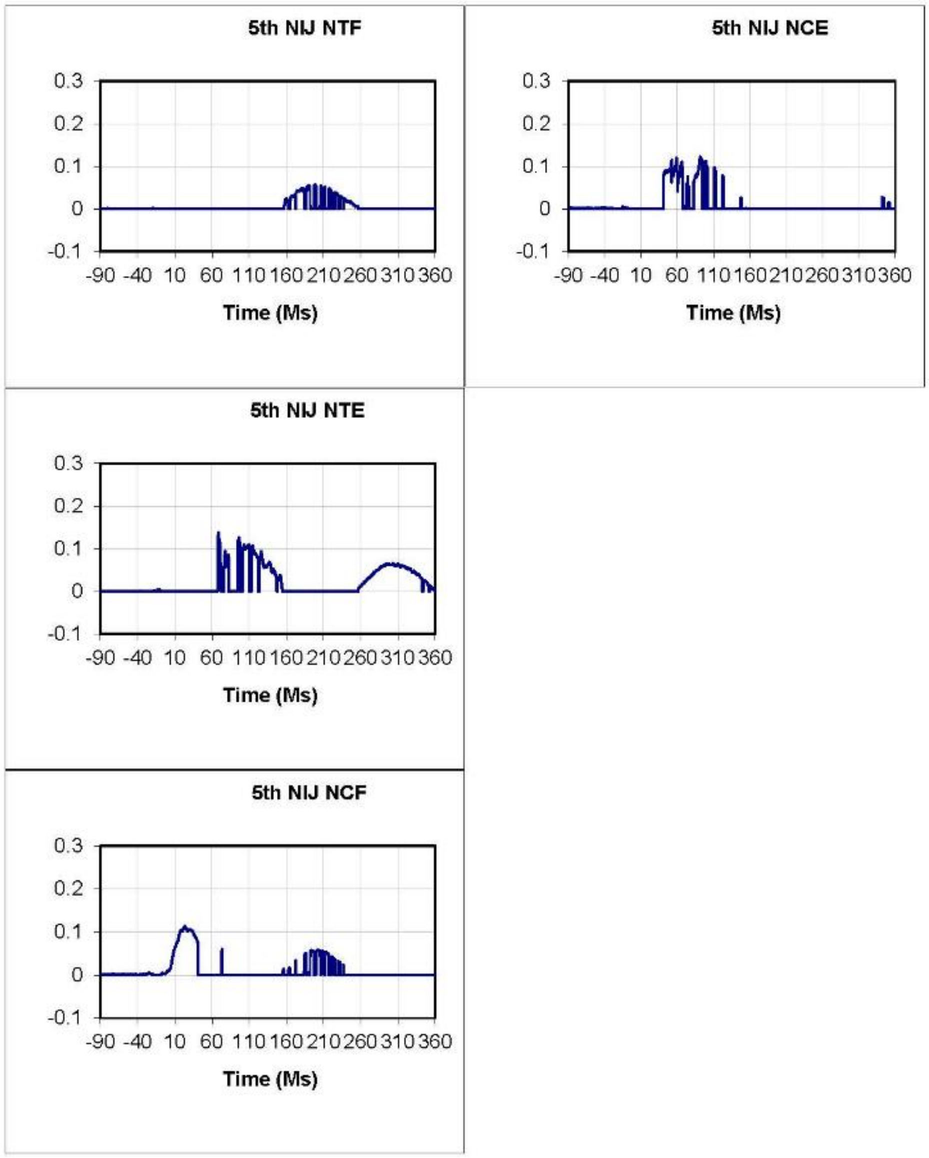
201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K



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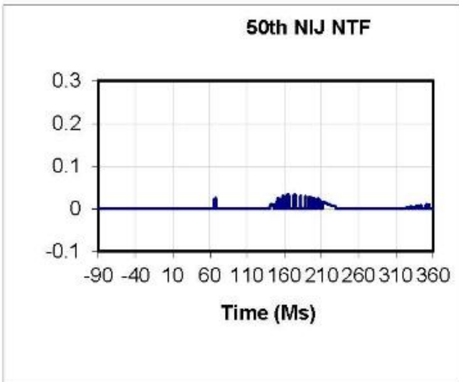
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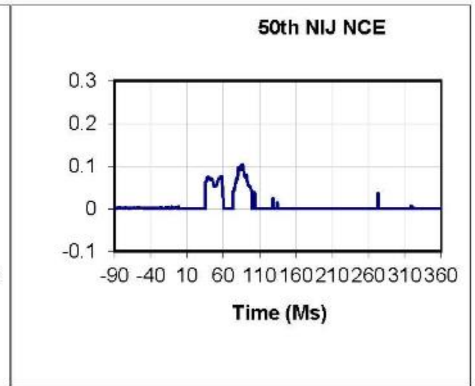
0.1
0
-0.1
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)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0.1
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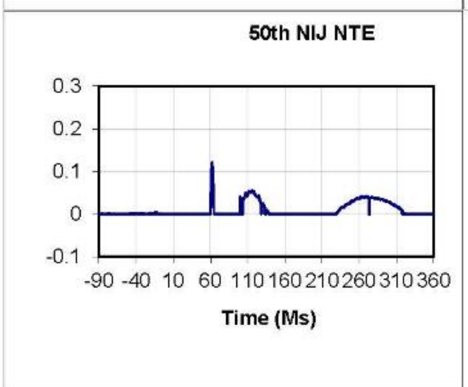
Time (Ms)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0.2
0.1
0
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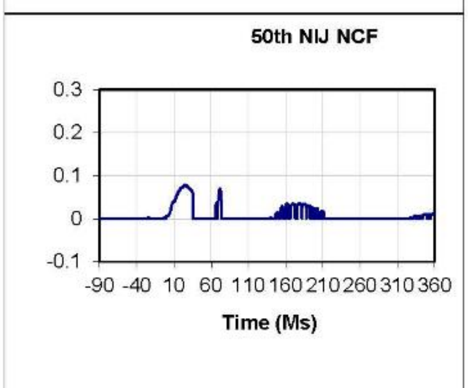
Time (Ms)


50th NIJ NCF
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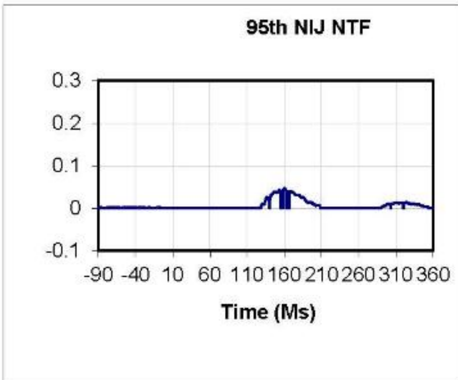
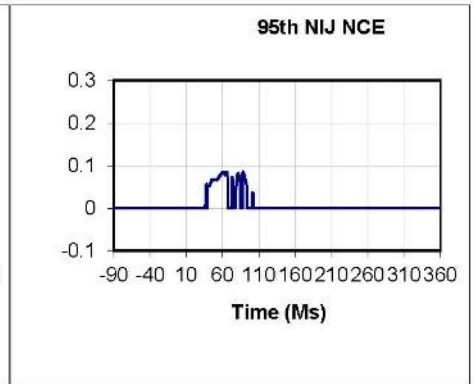
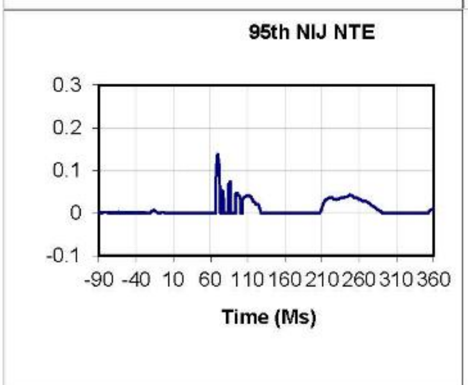
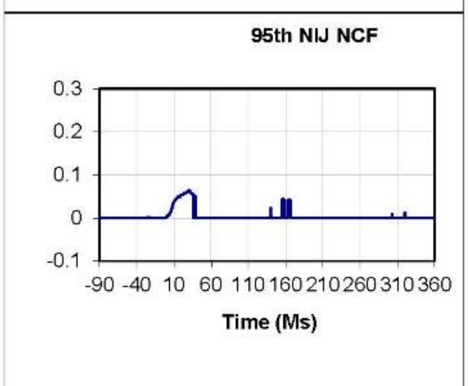
0.1
0
-0.1
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)

201809 Test: 9732 Test Date: 181003 Subj: H3HEADS Cell: K









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201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: N

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				7.5	
Impact Rise Time (Ms)				39.7	
Impact Duration (Ms)				107.4	
Velocity Change (Ft/Sec)		25.42			
SLED X ACCEL (G)	0.00	12.53	-0.45	39.7	111.3
SLED Y ACCEL (G)	0.00	0.61	-0.91	56.4	48.5
SLED Z ACCEL (G)	0.00	0.24	-1.15	109.2	43.2
SLED RESULTANT	0.07	12.58	0.16	39.7	107.0
INTEGRATED ACCEL (FT/SEC)	0.02	25.42	0.06	107.3	0.0
HEAD FIXTURE X ACCEL (G)	0.00	9.38	-0.81	38.6	151.0
HEAD FIXTURE Y ACCEL (G)	0.00	4.46	-1.14	49.3	111.6
HEAD FIXTURE Z ACCEL (G)	-0.01	9.07	-0.66	39.4	110.0
HEAD FIXTURE RESULTANT (G)	0.09	13.15	0.08	39.1	114.3
HEAD FIXTURE2 X ACCEL (G)	0.01	9.59	-0.63	40.0	150.0
HEAD FIXTURE2 Y ACCEL (G)	0.00	2.45	-1.69	71.6	50.9
HEAD FIXTURE2 Z ACCEL (G)	0.00	8.36	-0.55	40.8	112.3
HEAD FIXTURE2 RESULTANT (G)	0.13	12.72	0.13	40.3	122.4
HEAD FIXTURE3 X ACCEL (G)	0.00	12.54	-0.60	33.0	115.3
HEAD FIXTURE3 Y ACCEL (G)	-0.01	1.75	-2.25	49.8	36.2
HEAD FIXTURE3 Z ACCEL (G)	-0.02	4.81	-0.67	49.3	121.4
HEAD FIXTURE3 RESULTANT (G)	0.10	12.96	0.16	34.0	135.2
INT HEAD X ACCEL (G)	0.01	20.64	-1.98	60.0	178.8
INT HEAD Y ACCEL (G)	0.00	0.50	-0.66	51.5	64.9
INT HEAD Z ACCEL (G)	0.05	10.05	-2.08	30.0	151.2
INT HEAD RESULTANT (G)	0.14	21.26	0.10	60.0	337.6
INT HEAD HIC		29.49		48.9	73.9
INT HEAD Ry ANG VELOCITY (RAD/SEC)	0.01	2.02	-3.46	118.8	70.7
INT HEAD Ry ANG VELOCITY (RAD/SEC)	-0.02	5.92	-11.08	131.2	49.5
INT HEAD Rz ANG VELOCITY (RAD/SEC)	0.00	3.88	-3.29	70.8	71.1
INT HEAD ANG VELOCITY RESULTANT	0.12	11.12	0.03	48.4	0.9
INT NECK X FORCE (LB)	0.11	44.29	-17.64	41.7	182.0
INT NECK Y FORCE (LB)	-0.47	5.06	-4.30	38.0	209.1
INT NECK Z FORCE (LB)	0.02	16.64	-91.12	151.4	29.0
INT NECK RESULTANT (LB)	1.29	97.25	0.10	36.2	337.7

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Nom G: 12.0 Cell: N

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT NECK Mx TORQUE (IN-LB)	0.52	22.84	-9.87	50.3	213.8
INT NECK My TORQUE (IN-LB)	-0.57	57.99	-67.96	26.7	70.4
INT NECK Mz TORQUE (IN-LB)	-0.15	8.47	-5.54	36.2	167.3
INT NECK TORQUE RES (IN-LB)	1.46	68.12	0.26	70.4	346.5
INT LOWER NECK X FORCE (LB)	-0.46	85.04	-21.22	39.9	181.7
INT LOWER NECK Y FORCE (LB)	-0.22	7.11	-10.70	65.0	47.2
INT LOWER NECK Z FORCE (LB)	1.00	21.69	-110.13	107.1	34.4
INT LOWER NECK RESULTANT (LB)	1.94	136.63	1.83	34.3	324.5
INT LOWER NECK Mx TORQUE (IN-LB)	0.70	34.86	-27.77	98.7	206.5
INT LOWER NECK My TORQUE (IN-LB)	-0.23	178.68	-339.82	185.4	55.7
INT LOWER NECK Mz TORQUE (IN-LB)	-0.89	33.01	-9.24	57.5	44.1
INT LOWER NECK TORQUE RES (IN-LB)	2.52	341.65	3.08	55.7	0.0
INT HEAD2 X ACCEL (G)	0.02	31.14	-3.18	70.6	166.9
INT HEAD2 Y ACCEL (G)	0.00	0.82	-1.42	58.2	61.0
INT HEAD2 Z ACCEL (G)	0.03	9.50	-2.86	38.0	63.5
INT HEAD2 RESULTANT (G)	0.15	31.19	0.19	70.6	342.6
INT HEAD2 HIC		53.05		58.3	76.9
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	0.01	1.53	-2.05	70.5	70.8
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	0.01	8.83	-14.33	131.3	58.3
INT HEAD2 Rz ANG VELOCITY (RAD/SEC)	-0.01	3.33	-2.71	70.8	62.8
INT HEAD2 ANG VELOCITY RESULTANT	0.08	14.34	0.02	58.3	0.7
INT NECK2 X FORCE (LB)	0.96	60.17	-30.52	56.5	173.5
INT NECK2 Y FORCE (LB)	-0.66	3.70	-5.11	181.0	58.1
INT NECK2 Z FORCE (LB)	-0.87	21.27	-108.48	63.5	37.9
INT NECK2 RESULTANT (LB)	2.18	117.68	0.84	37.9	342.1
INT NECK2 Mx TORQUE (IN-LB)	2.50	26.29	-5.43	52.9	85.7
INT NECK2 My TORQUE (IN-LB)	-0.98	95.60	-110.09	176.9	82.8
INT NECK2 Mz TORQUE (IN-LB)	-0.74	2.00	-4.89	63.8	196.4
INT NECK2 TORQUE RES (IN-LB)	2.96	110.16	1.15	82.8	234.6
INT LOWER NECK2 X FORCE (LB)	0.07	111.19	-38.04	37.1	158.6
INT LOWER NECK2 Y FORCE (LB)	-0.58	8.26	-10.12	66.7	61.4
INT LOWER NECK2 Z FORCE (LB)	-2.51	19.30	-167.65	123.1	37.4
INT LOWER NECK2 RESULTANT (LB)	3.42	194.94	0.97	37.3	118.8

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT LOWER NECK2 Mx TORQUE (IN-LB)	-2.17	32.40	-19.02	30.9	105.7
INT LOWER NECK2 My TORQUE (IN-LB)	-1.38	438.14	-654.00	173.3	64.0
INT LOWER NECK2 Mz TORQUE (IN-LB)	-0.68	20.25	-16.00	30.9	49.4
INT LOWER NECK2 TORQUE RES (IN-LB)	5.07	654.07	1.28	64.0	341.3
INT HEAD3 X ACCEL (G)	-0.02	5.65	-16.82	193.7	74.0
INT HEAD3 Y ACCEL (G)	0.00	0.99	-0.64	73.8	138.6
INT HEAD3 Z ACCEL (G)	0.03	2.23	-6.29	14.3	61.6
INT HEAD3 RESULTANT (G)	0.12	17.39	0.07	74.0	1.8
INT HEAD3 HIC		33.10		59.0	89.0
INT HEAD3 Rx ANG VELOCITY (RAD/SEC)	0.00	1.55	-1.10	38.8	128.1
INT HEAD3 Ry ANG VELOCITY (RAD/SEC)	-0.01	15.84	-17.81	47.9	137.4
INT HEAD3 Rz ANG VELOCITY (RAD/SEC)	0.01	0.57	-0.49	188.4	58.7
INT HEAD3 ANG VELOCITY RESULTANT	0.15	17.82	0.02	137.4	1.2
INT HEAD3 Ry ANG ACCEL (RAD/SEC2)	1.18	590.87	-701.20	31.7	82.3
INT NECK3 X FORCE (LB)	-0.67	49.05	-154.10	197.8	73.7
INT NECK3 Y FORCE (LB)	0.51	8.47	-8.56	173.9	77.8
INT NECK3 Z FORCE (LB)	3.05	53.57	-17.25	62.2	18.7
INT NECK3 RESULTANT (LB)	3.23	159.43	2.15	69.3	1.3
INT NECK3 Mx TORQUE (IN-LB)	-0.45	17.50	-24.39	34.1	48.5
INT NECK3 My TORQUE (IN-LB)	0.01	347.56	-145.60	82.5	182.7
INT NECK3 Mz TORQUE (IN-LB)	0.17	4.67	-6.07	172.3	46.0
INT NECK3 TORQUE RES (IN-LB)	1.85	347.99	1.53	82.5	273.2
INT LOWER NECK3 X FORCE (LB)	0.22	55.37	-203.93	191.4	62.3
INT LOWER NECK3 Y FORCE (LB)	0.30	8.65	-17.08	44.5	32.2
INT LOWER NECK3 Z FORCE (LB)	0.20	43.63	-147.77	141.5	80.6
INT LOWER NECK3 RESULTANT (LB)	1.82	231.05	3.42	67.1	0.5
INT LOWER NECK3 Mx TORQUE (IN-LB)	1.00	29.78	-30.60	176.5	35.9
INT LOWER NECK3 My TORQUE (IN-LB)	7.84	2082.31	-636.86	75.9	190.7
INT LOWER NECK3 Mz TORQUE (IN-LB)	2.85	51.98	-8.54	48.7	229.8
INT LOWER NECK3 TORQUE RES (IN-LB)	8.81	2082.63	4.38	75.9	130.2

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Nom G: 12.0 Cell: N

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
5th NIJ SHEAR (LB)		44.29	-17.64	41.7	182.0
5th NIJ TENSION (LB)		16.64		151.4	
5th NIJ COMPRESSION (LB)		-91.12		29.0	
5th NIJ FLEXION (IN-LB)		55.03		175.0	
5th NIJ EXTENSION (IN-LB)		78.73		68.7	
5th NIJ NTF	0.0003	0.0466	0.0000	182.0	0.0
5th NIJ NTE	0.0010	0.1228	0.0000	64.6	0.0
5th NIJ NCF	0.0002	0.1315	0.0000	26.5	0.0
5th NIJ NCE	0.0012	0.1574	0.0000	68.7	0.6
5th NIJ NTF AIS >= 2		0.12			
5th NIJ NTF AIS >= 3		0.04			
5th NIJ NTF AIS >= 4		0.07			
5th NIJ NTF AIS >= 5		0.02			
5th NIJ NTE AIS >= 2		0.13			
5th NIJ NTE AIS >= 3		0.05			
5th NIJ NTE AIS >= 4		0.07			
5th NIJ NTE AIS >= 5		0.02			
5th NIJ NCF AIS >= 2		0.13			
5th NIJ NCF AIS >= 3		0.05			
5th NIJ NCF AIS >= 4		0.07			
5th NIJ NCF AIS >= 5		0.03			
5th NIJ NCE AIS >= 2		0.13			
5th NIJ NCE AIS >= 3		0.05			
5th NIJ NCE AIS >= 4		0.08			
5th NIJ NCE AIS >= 5		0.03			
50th NIJ SHEAR (LB)		60.17	-30.52	56.5	173.5
50th NIJ TENSION (LB)		21.27		63.5	
50th NIJ COMPRESSION (LB)		-108.48		37.9	
50th NIJ FLEXION (IN-LB)		115.89		177.0	
50th NIJ EXTENSION (IN-LB)		123.02		83.2	
50th NIJ NTF	0.0000	0.0472	0.0000	169.8	0.0
50th NIJ NTE	0.0007	0.0636	0.0000	64.5	0.0
50th NIJ NCF	0.0000	0.0922	0.0000	26.1	36.1
50th NIJ NCE	0.0018	0.1297	0.0000	77.6	0.0
50th NIJ NTF AIS >= 2		0.12			
50th NIJ NTF AIS >= 3		0.04			
50th NIJ NTF AIS >= 4		0.07			
50th NIJ NTF AIS >= 5		0.02			
50th NIJ NTE AIS >= 2		0.12			
50th NIJ NTE AIS >= 3		0.04			
50th NIJ NTE AIS >= 4		0.07			
50th NIJ NTE AIS >= 5		0.02			

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
50th NIJ NCF AIS >= 2		0.13			
50th NIJ NCF AIS >= 3		0.05			
50th NIJ NCF AIS >= 4		0.07			
50th NIJ NCF AIS >= 5		0.02			
50th NIJ NCE AIS >= 2		0.13			
50th NIJ NCE AIS >= 3		0.05			
50th NIJ NCE AIS >= 4		0.07			
50th NIJ NCE AIS >= 5		0.03			
95th NIJ SHEAR (LB)		49.05	-154.10	197.8	73.7
95th NIJ TENSION (LB)		53.57		62.2	
95th NIJ COMPRESSION (LB)		-17.25		18.7	
95th NIJ FLEXION (IN-LB)		450.52		82.3	
95th NIJ EXTENSION (IN-LB)		176.08		183.8	
95th NIJ NTF	0.0013	0.1376	0.0000	76.6	0.0
95th NIJ NTE	0.0008	0.1282	0.0000	182.2	5.3
95th NIJ NCF	0.0000	0.0342	0.0000	323.8	0.0
95th NIJ NCE	0.0000	0.0249	0.0000	18.1	0.0
95th NIJ NTF AIS >= 2		0.13			
95th NIJ NTF AIS >= 3		0.05			
95th NIJ NTF AIS >= 4		0.07			
95th NIJ NTF AIS >= 5		0.03			
95th NIJ NTE AIS >= 2		0.13			
95th NIJ NTE AIS >= 3		0.05			
95th NIJ NTE AIS >= 4		0.07			
95th NIJ NTE AIS >= 5		0.02			
95th NIJ NCF AIS >= 2		0.12			
95th NIJ NCF AIS >= 3		0.04			
95th NIJ NCF AIS >= 4		0.07			
95th NIJ NCF AIS >= 5		0.02			
95th NIJ NCE AIS >= 2		0.12			
95th NIJ NCE AIS >= 3		0.04			
95th NIJ NCE AIS >= 4		0.07			

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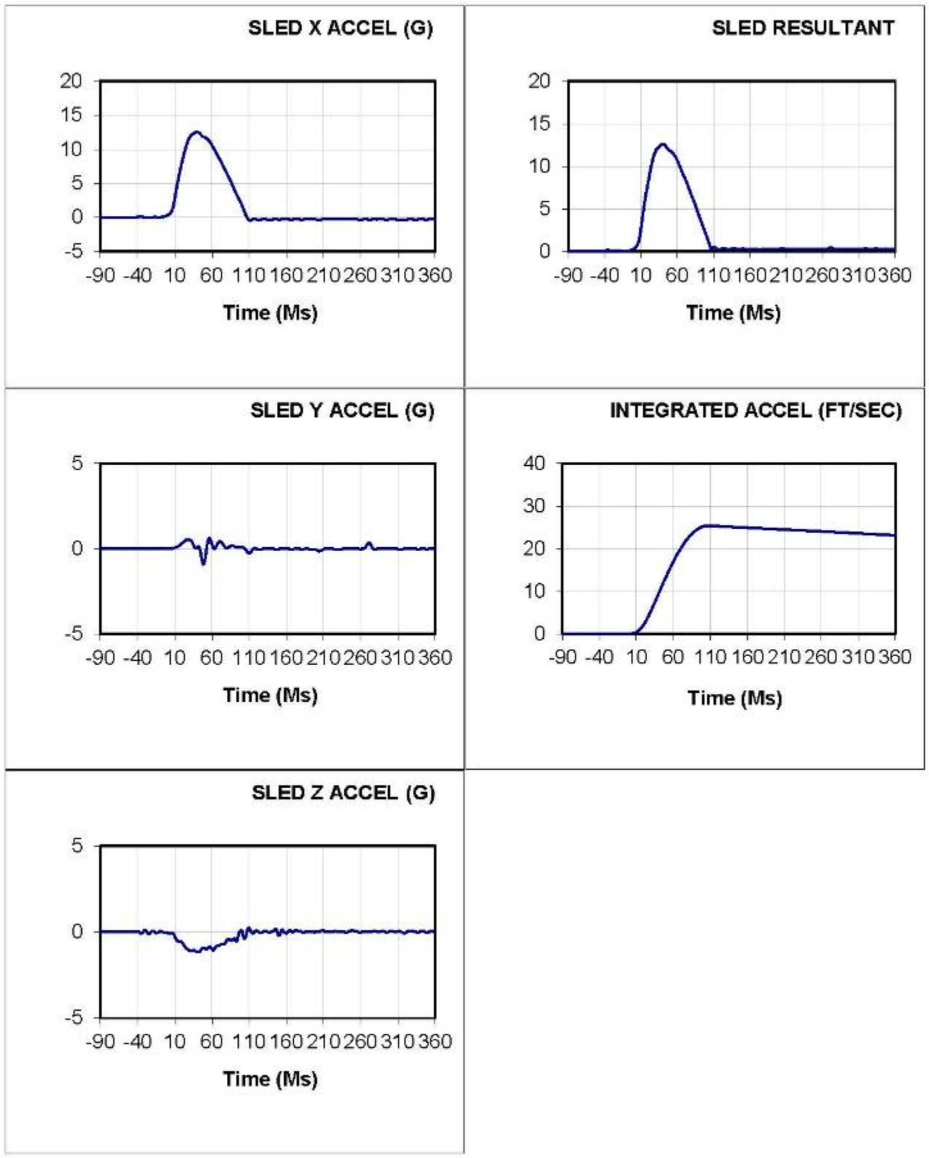

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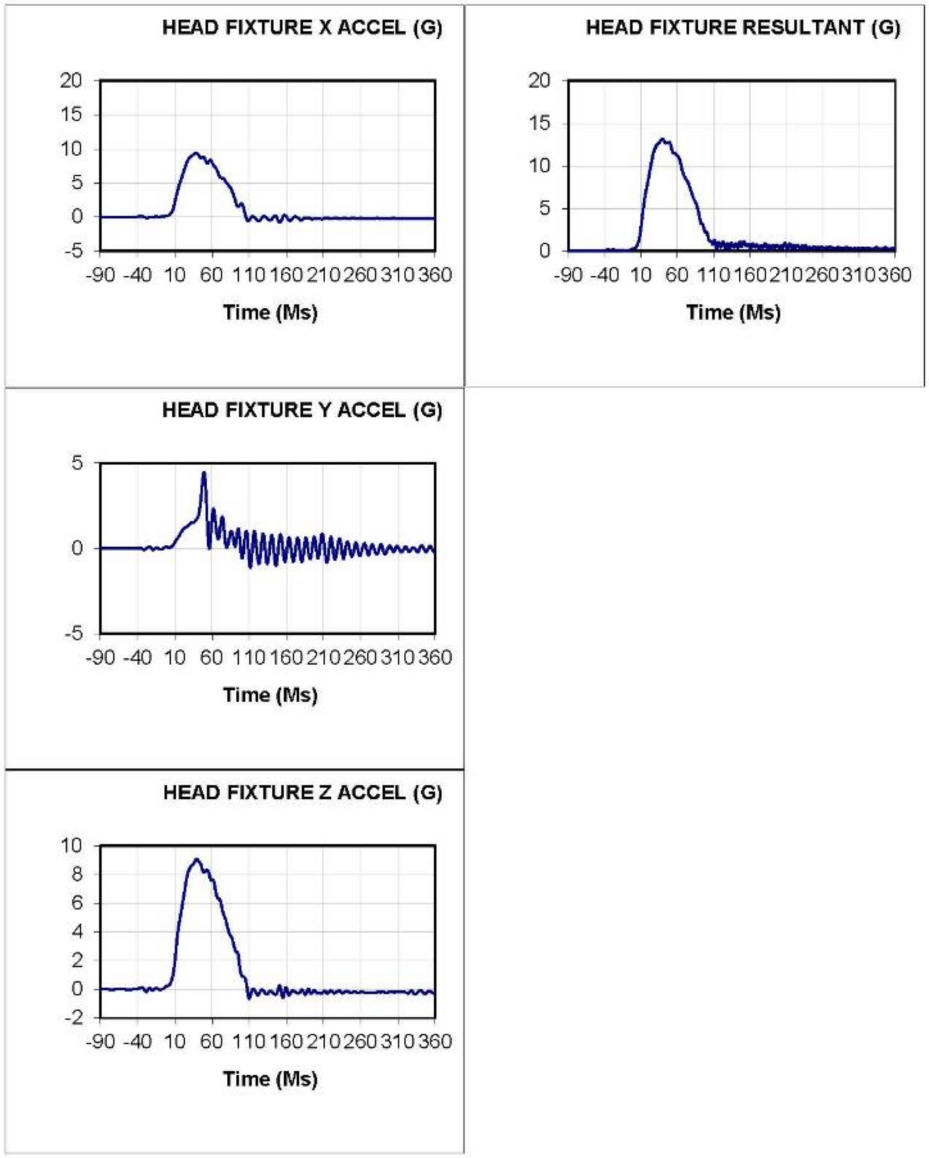

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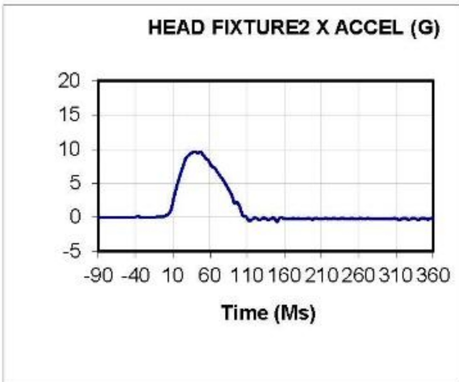
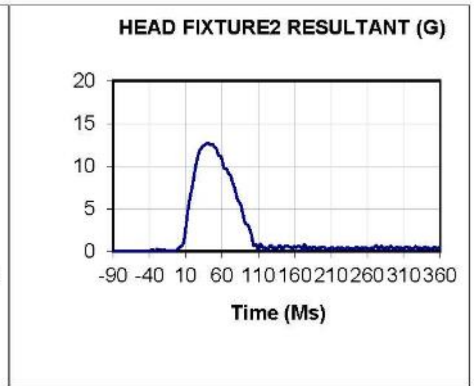
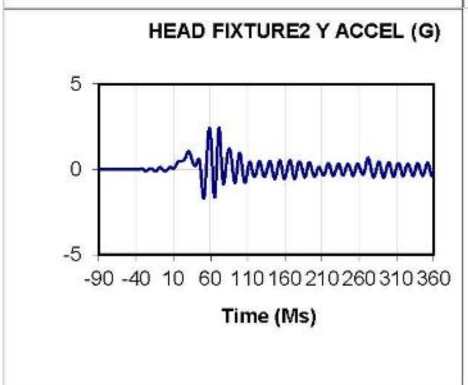
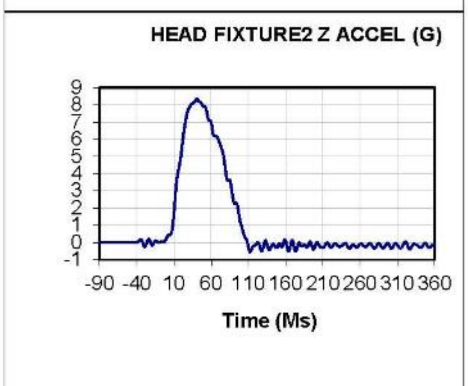
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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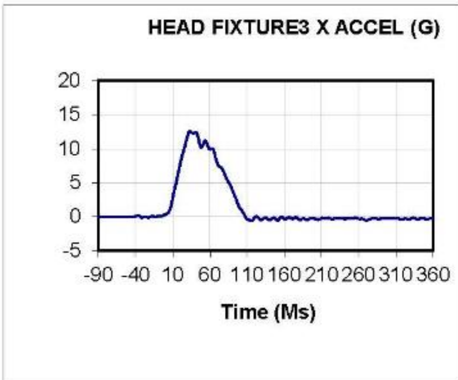

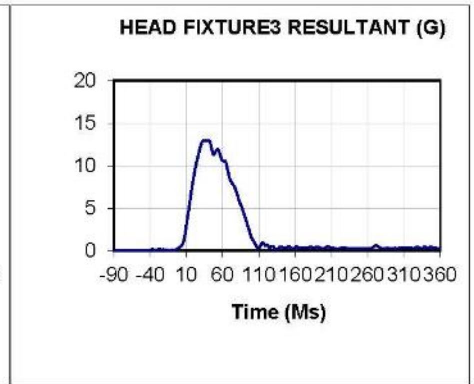

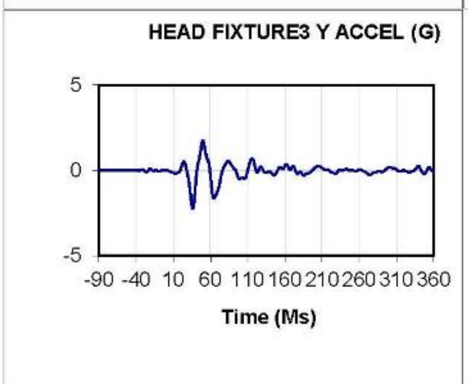

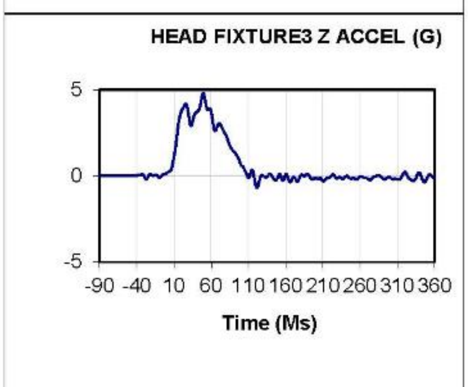

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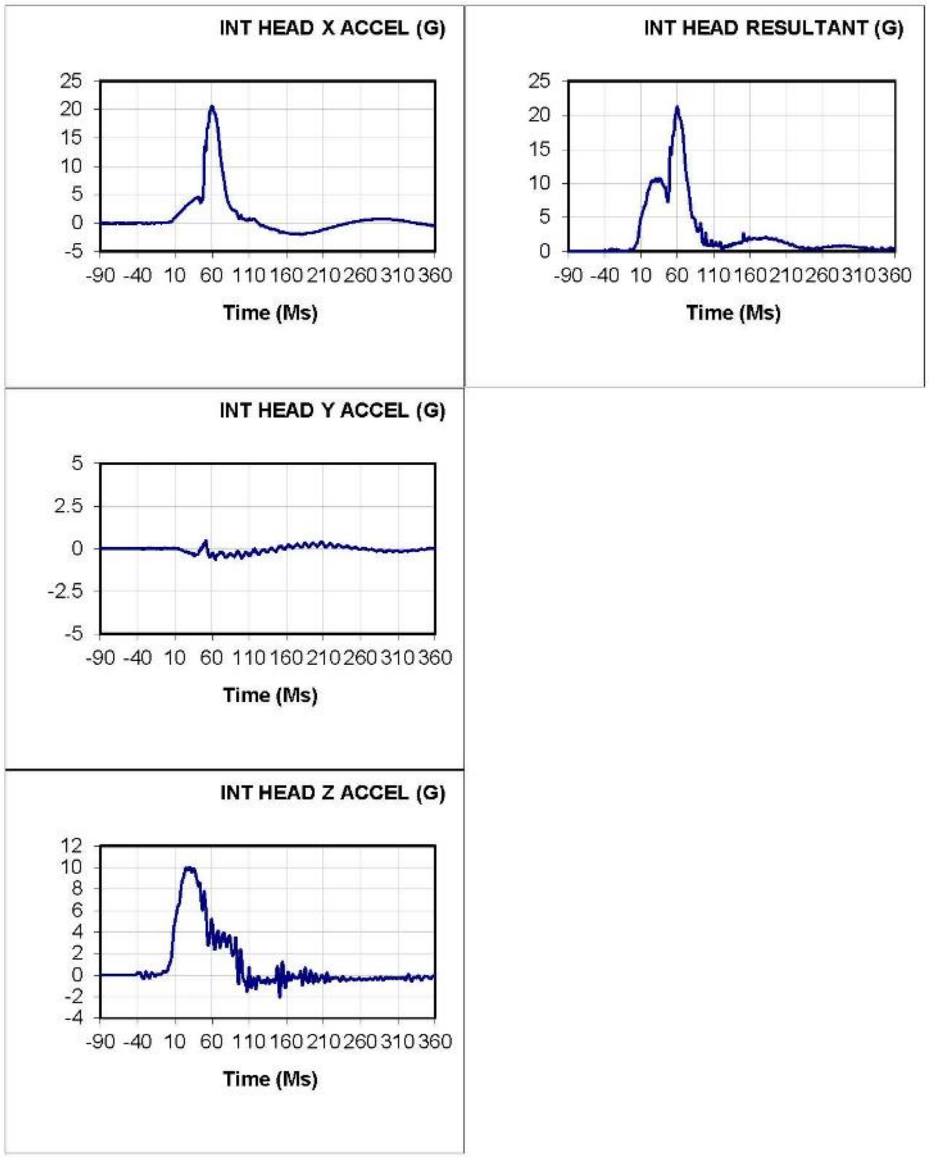

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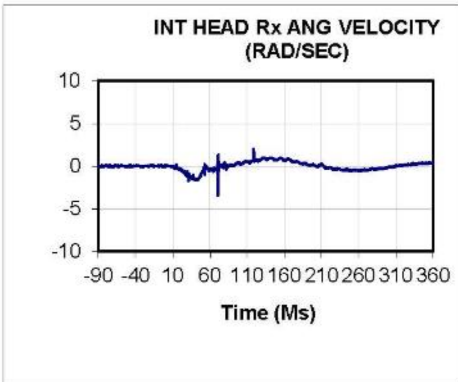

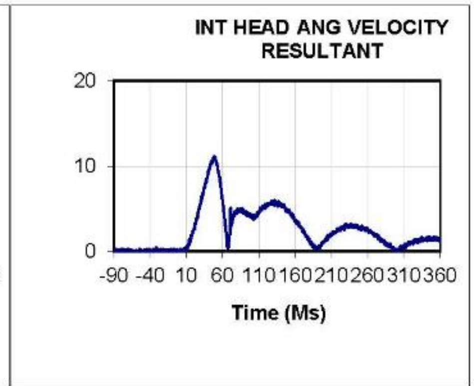

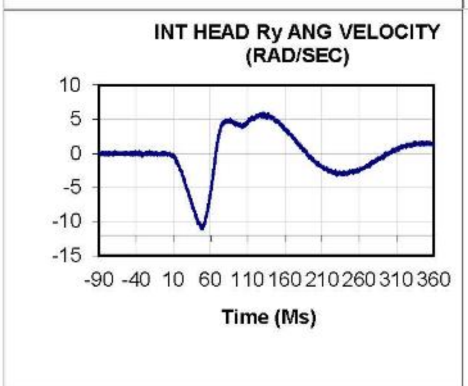

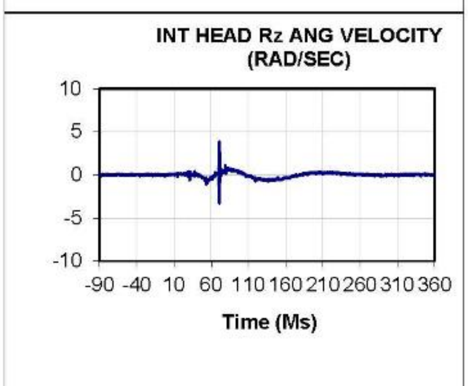

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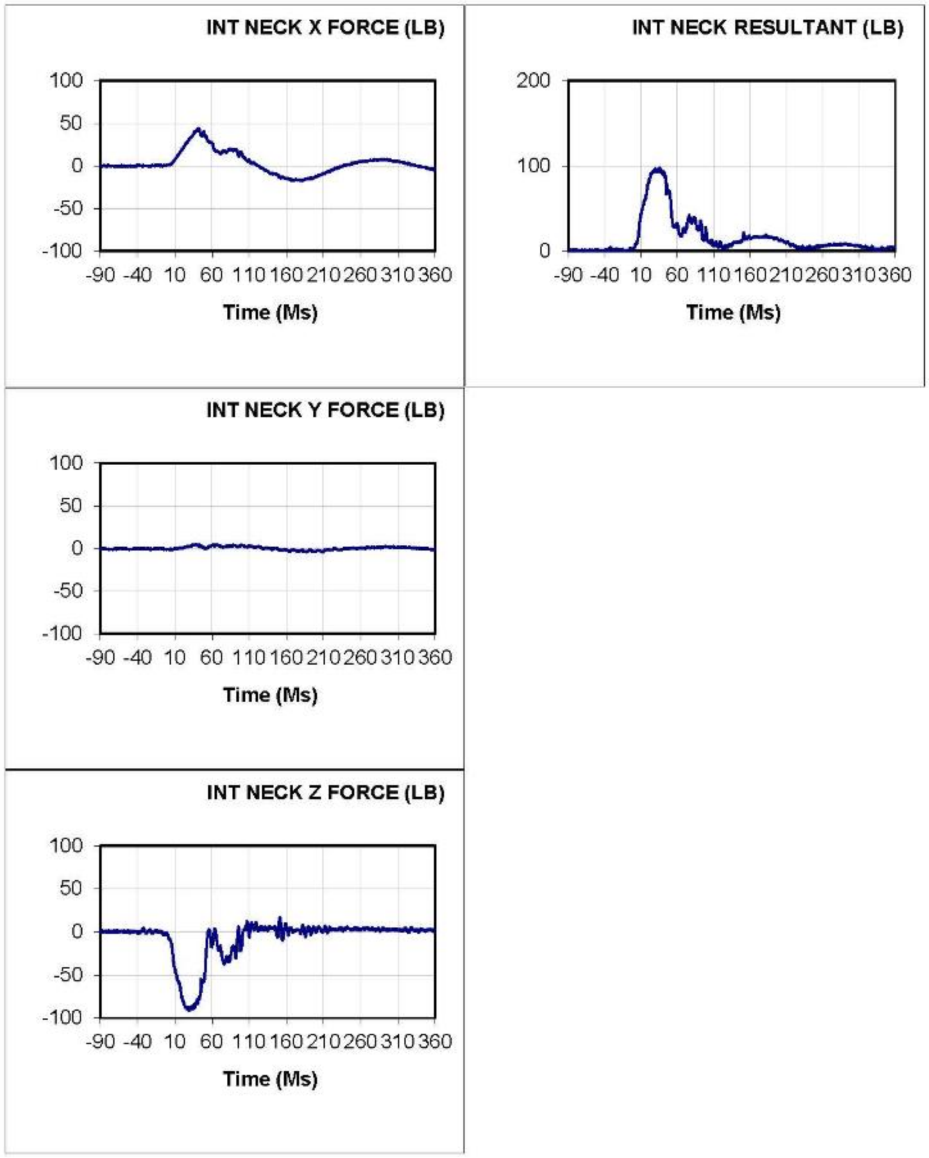

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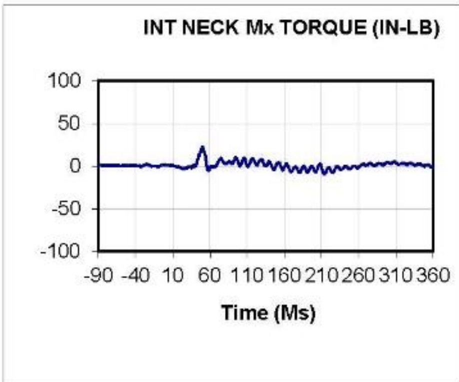

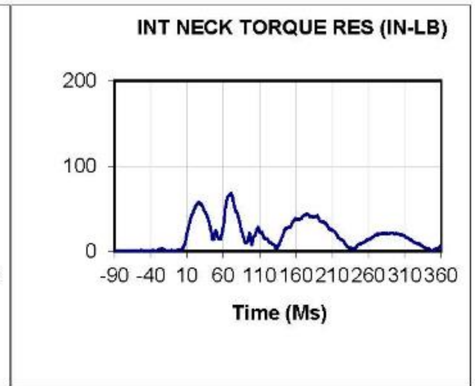

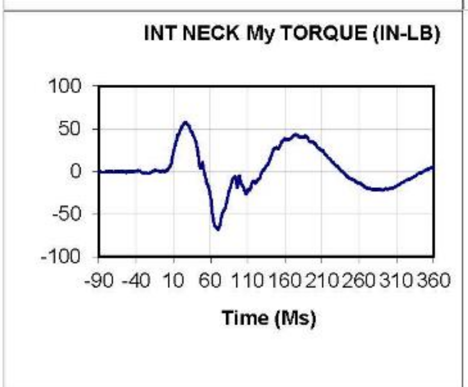

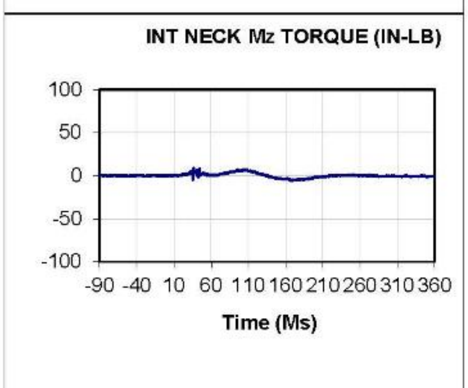

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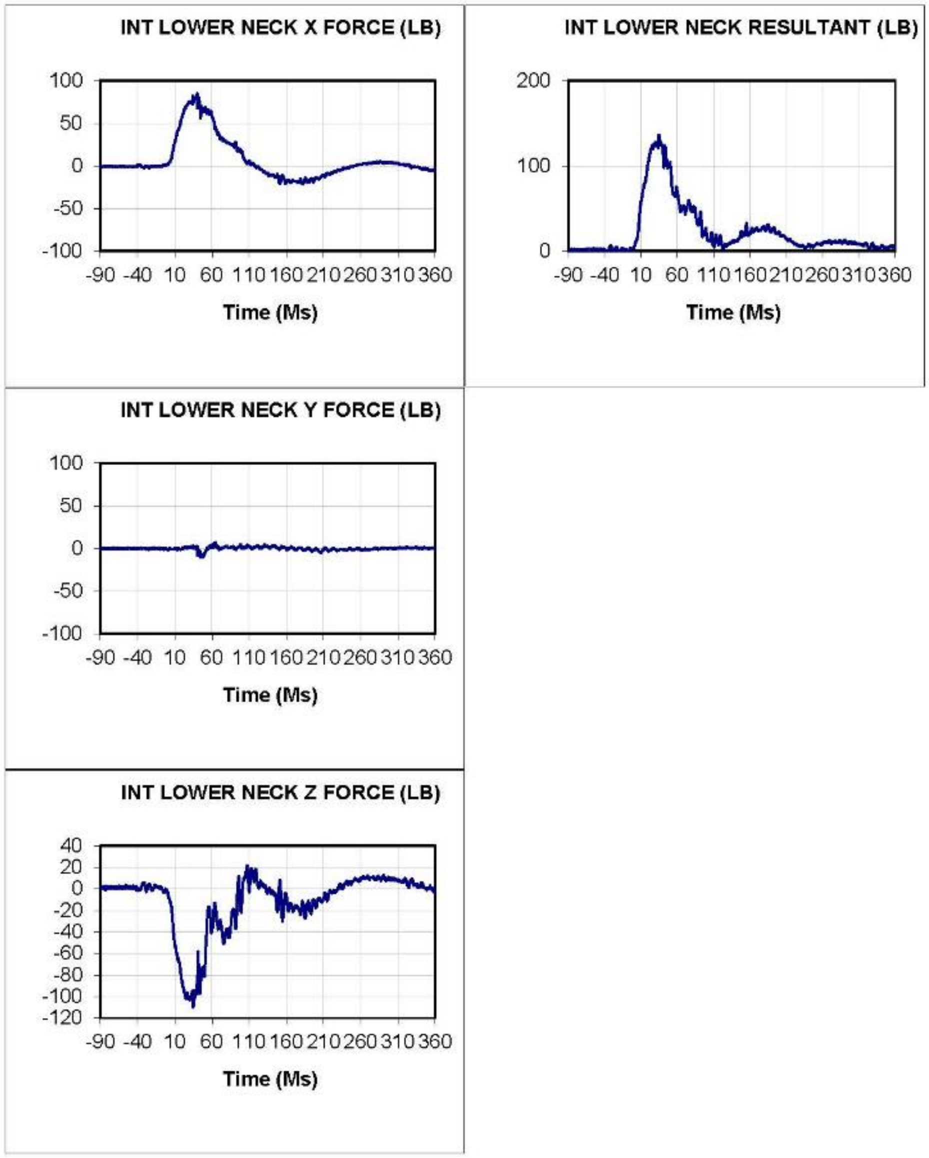

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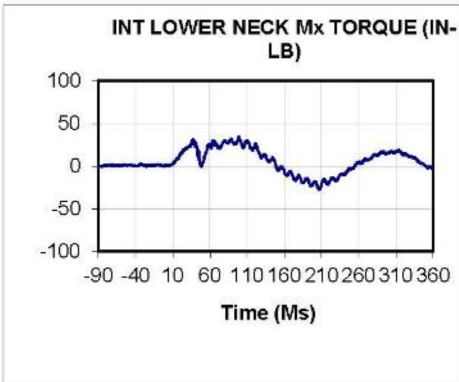

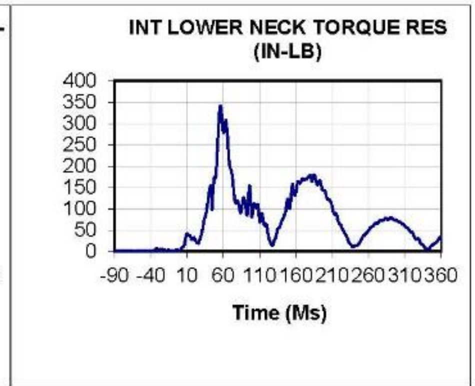

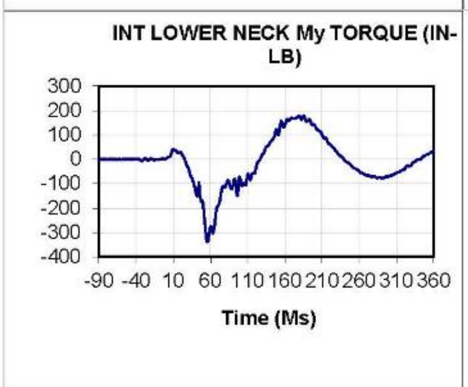

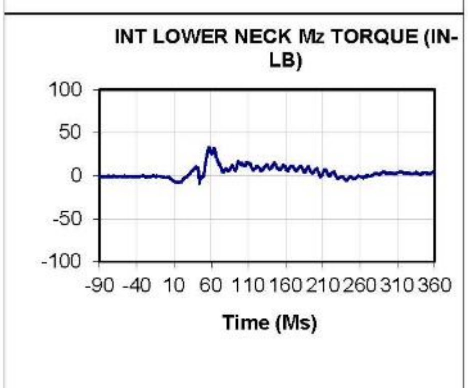

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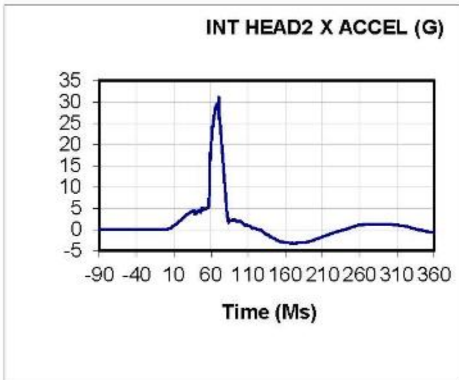

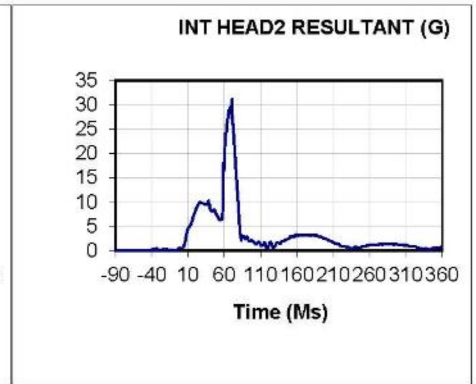

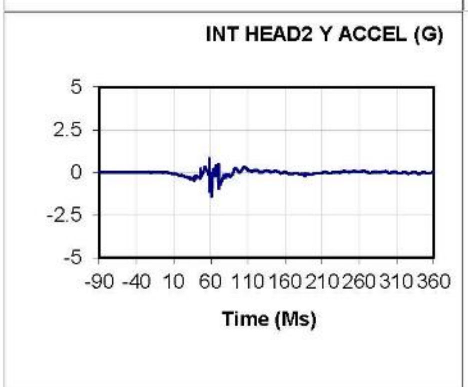

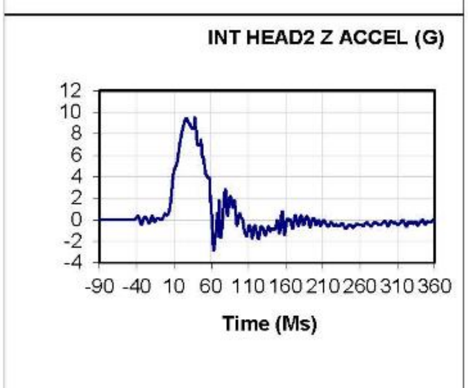

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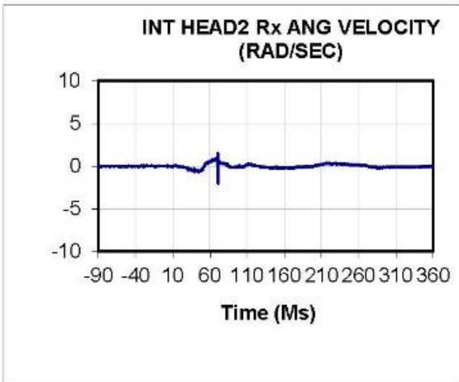
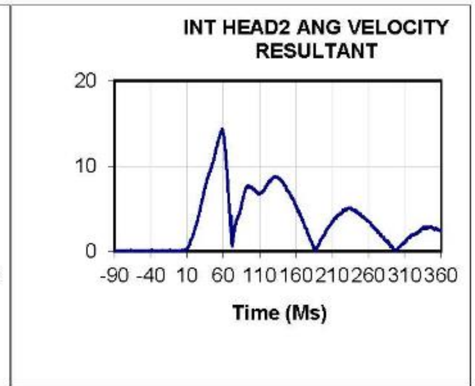
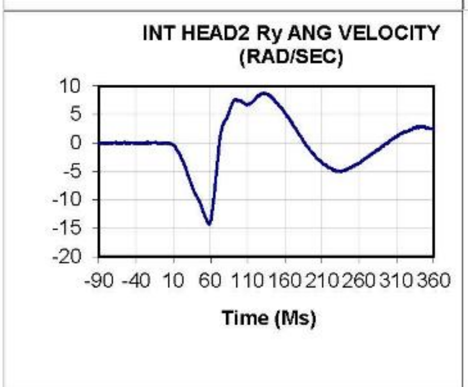
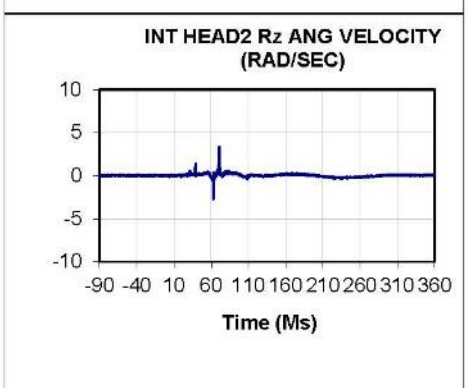
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N

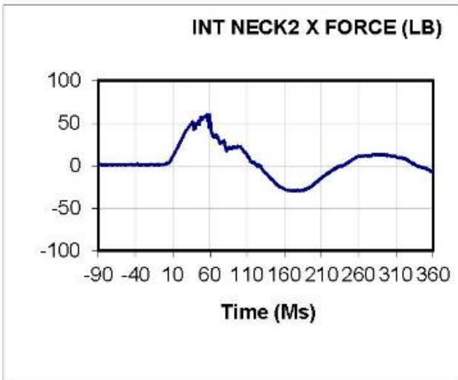


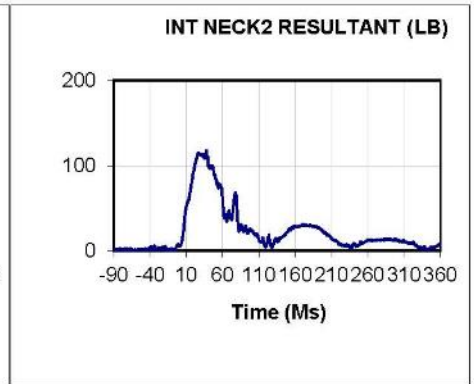


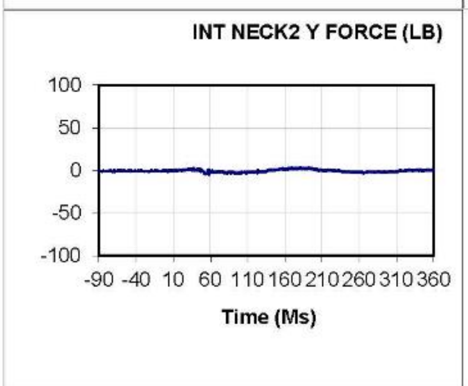


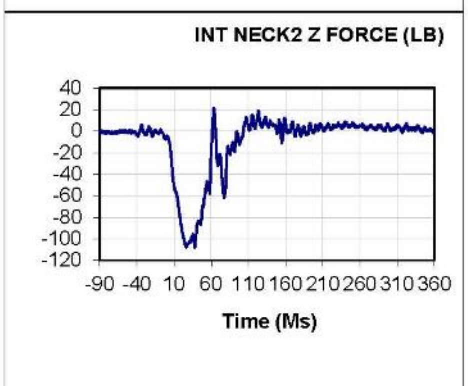


201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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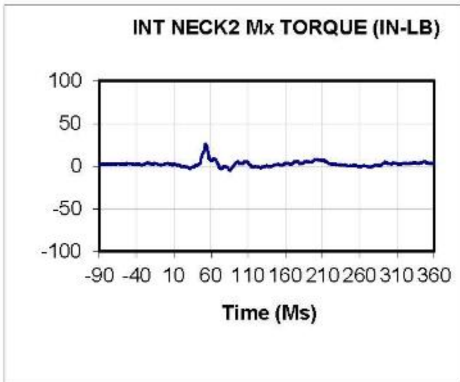
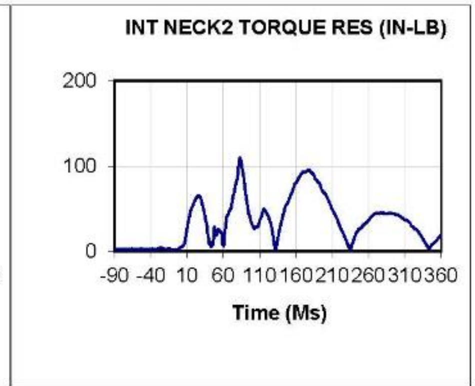
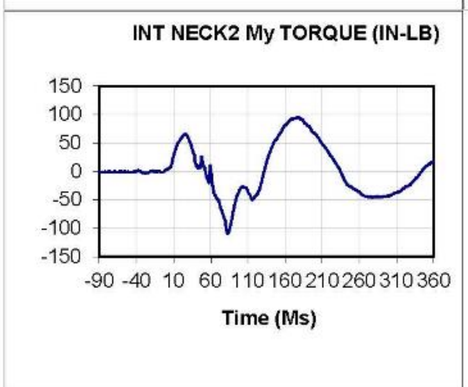
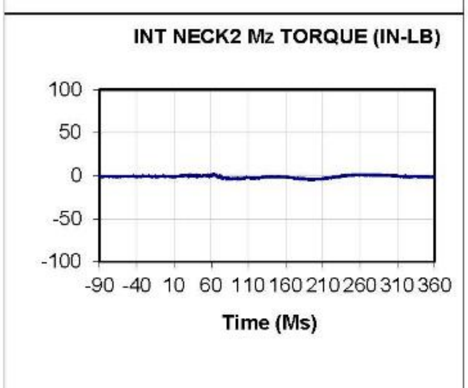
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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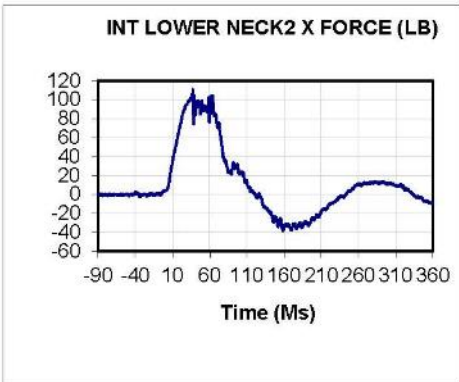
INT LOWER NECK2 X FORCE (LB)
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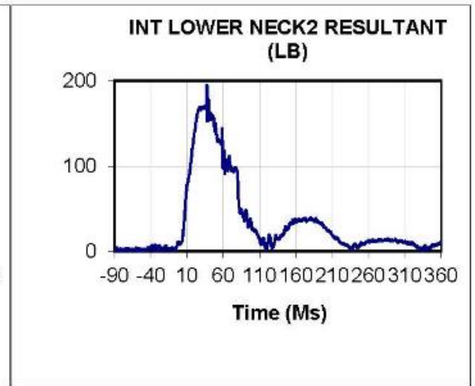
100
80
60
40
20
0
-20
-40
-60
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)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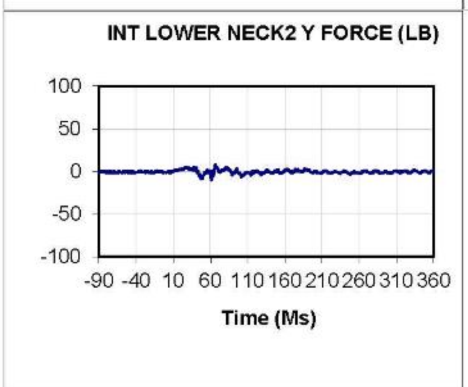
100
0
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)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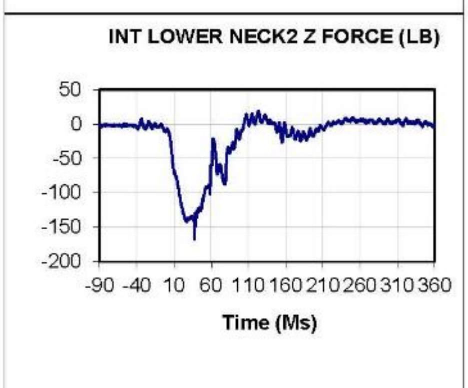
50
0
-50
-100
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)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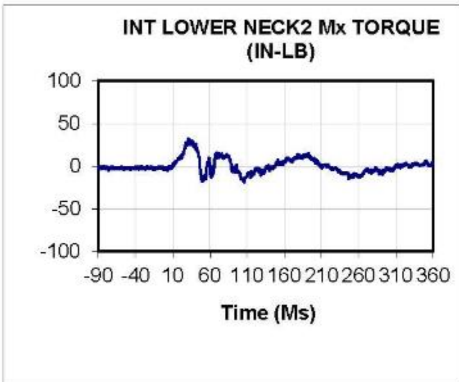
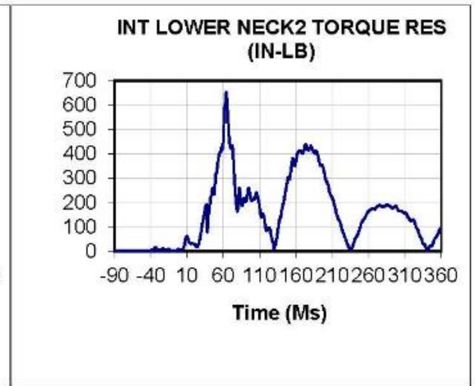
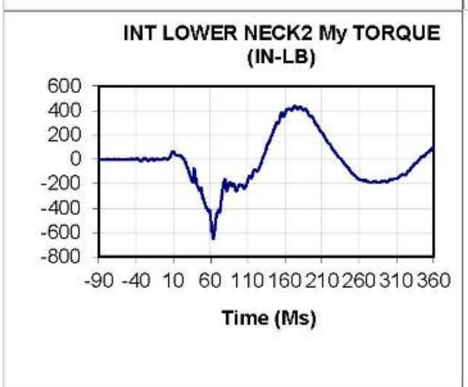
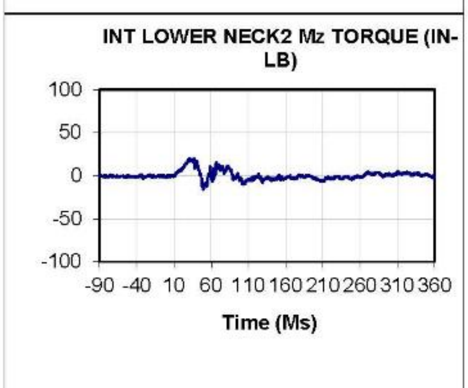
50
0
-50
-100
-150
-200
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)

201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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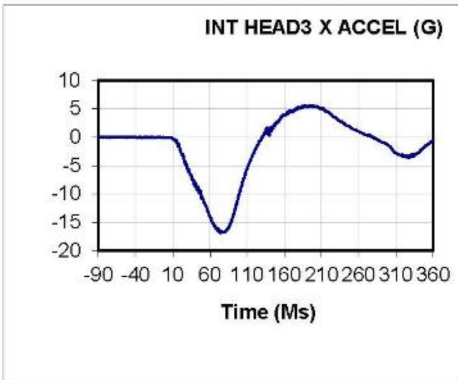
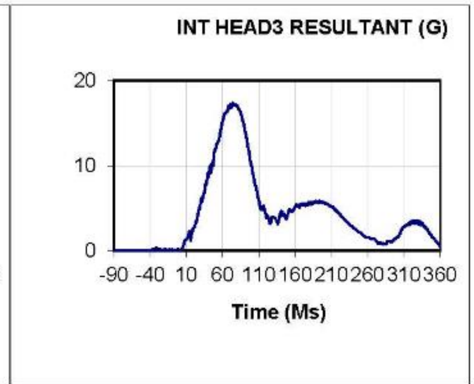
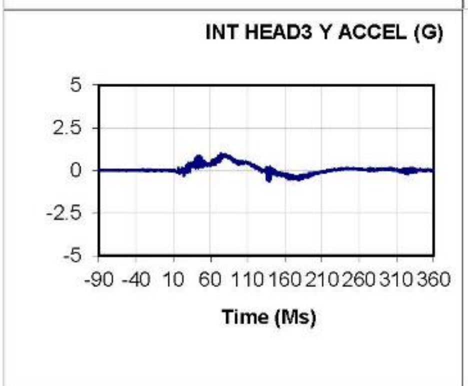
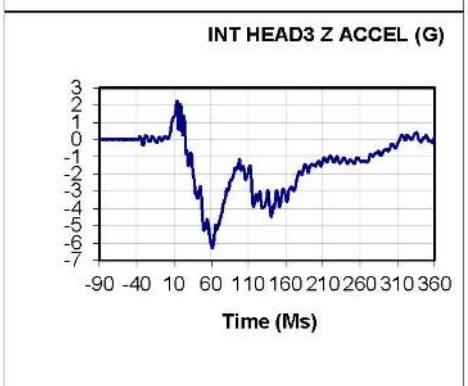
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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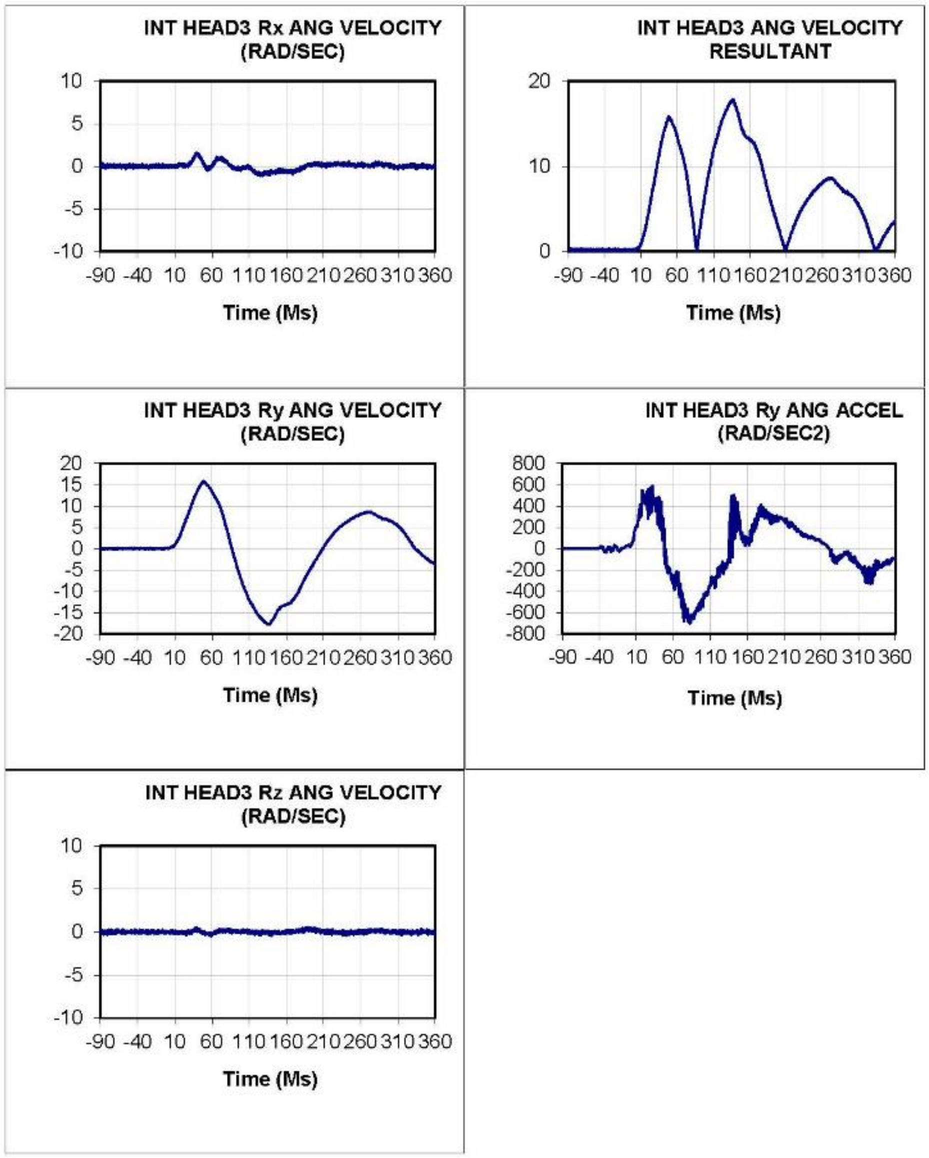
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N



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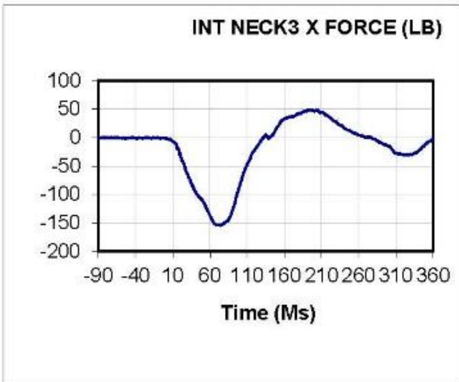
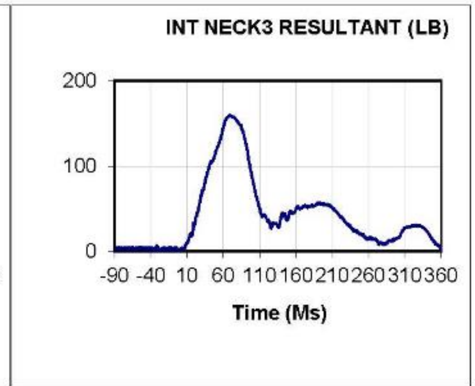
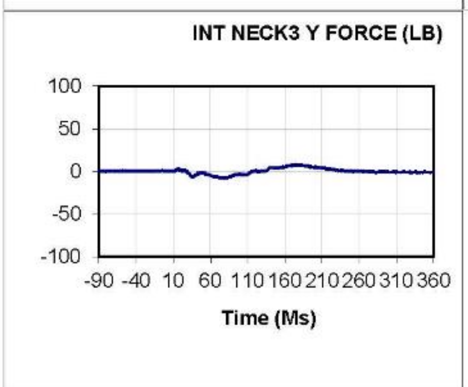
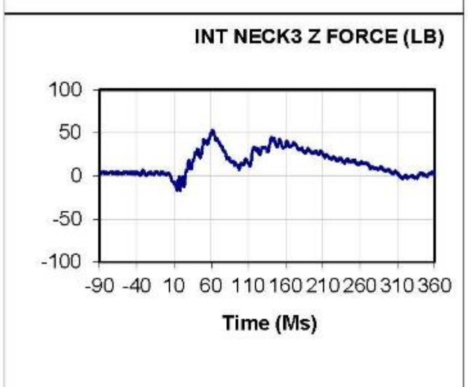
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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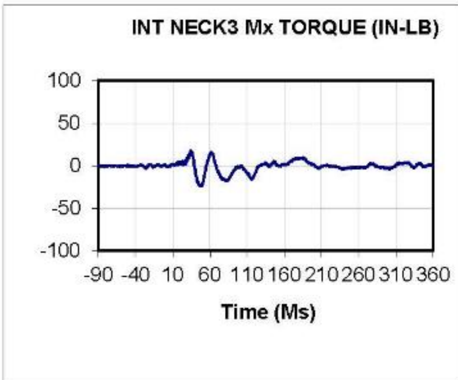
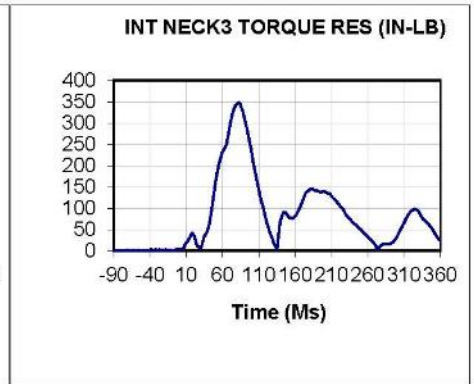
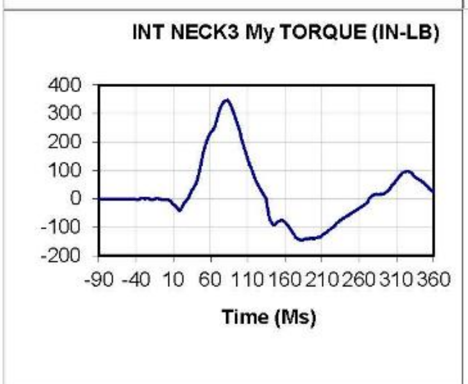
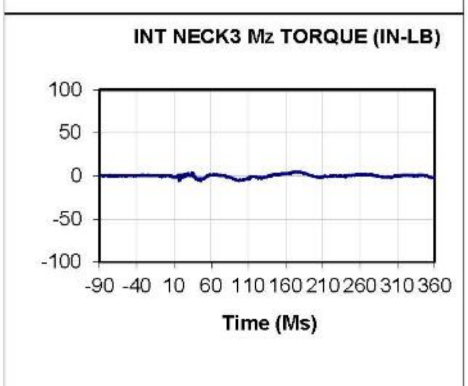
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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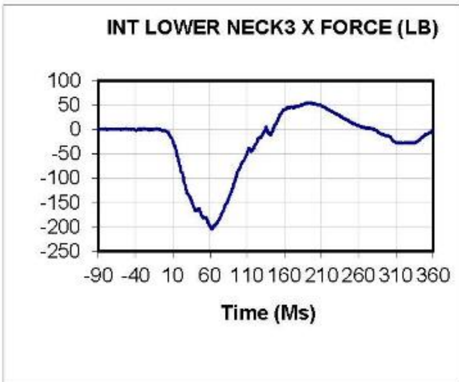
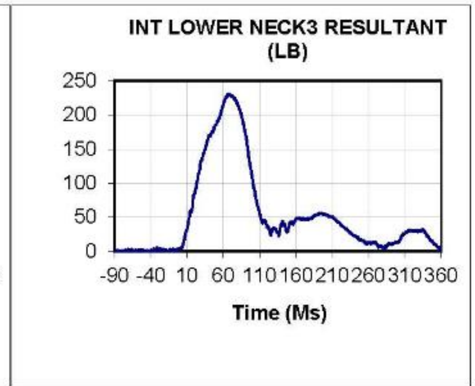
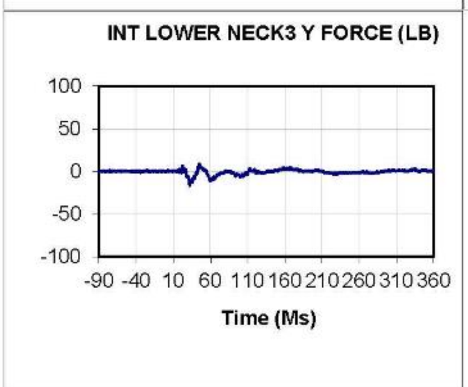
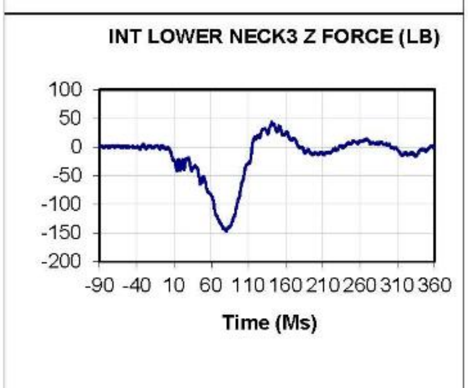
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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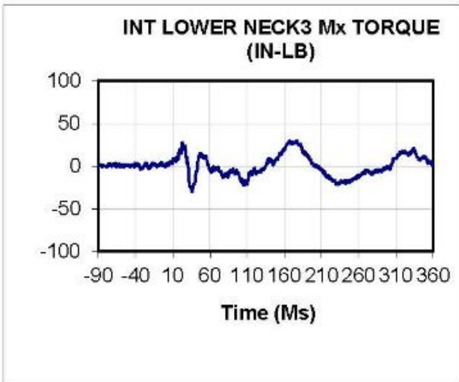
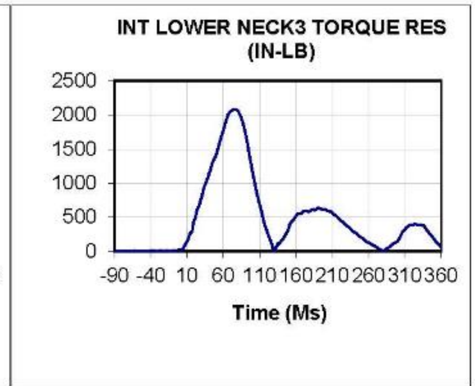
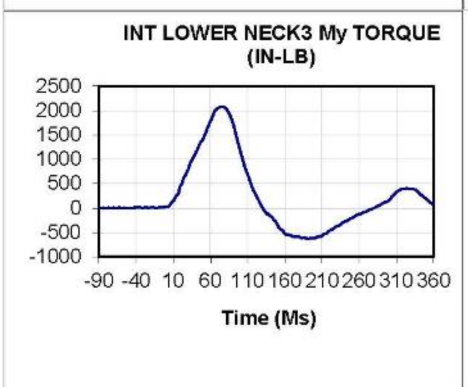
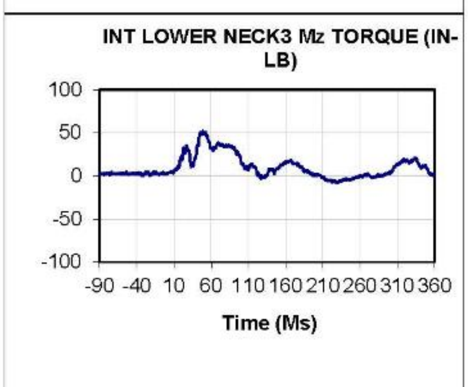
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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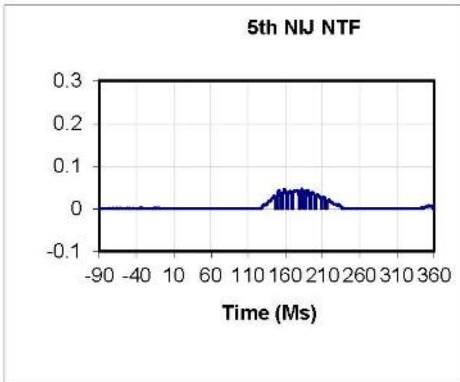
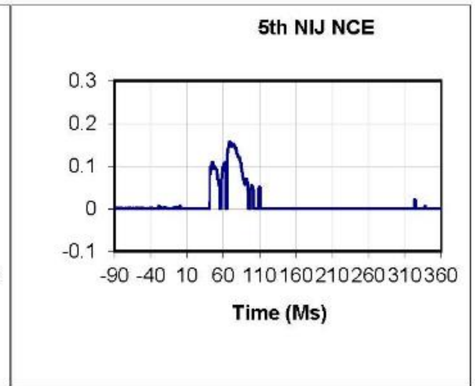
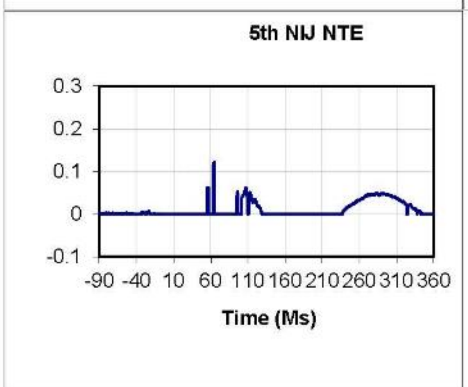
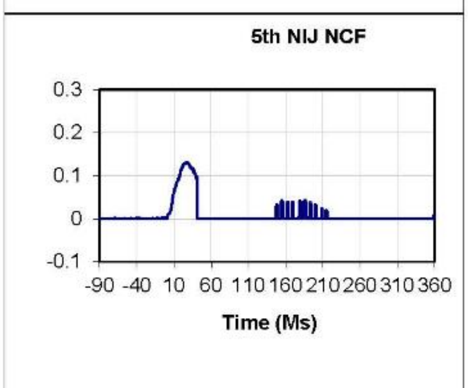
201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N









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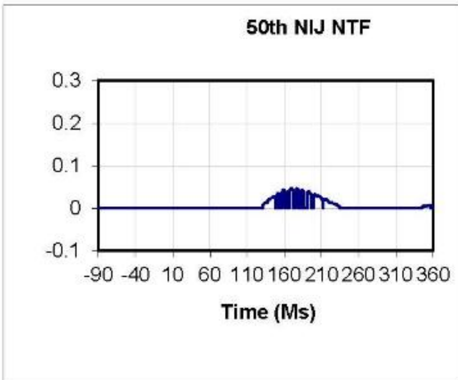
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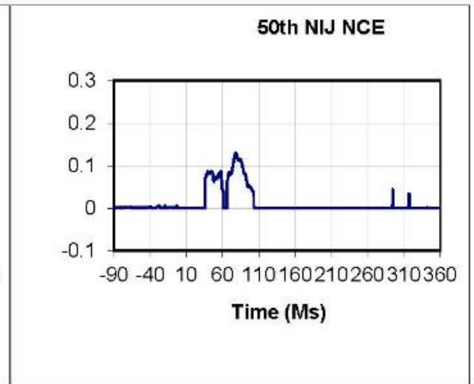
0.3
0.2
0.1
0
-0.1
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)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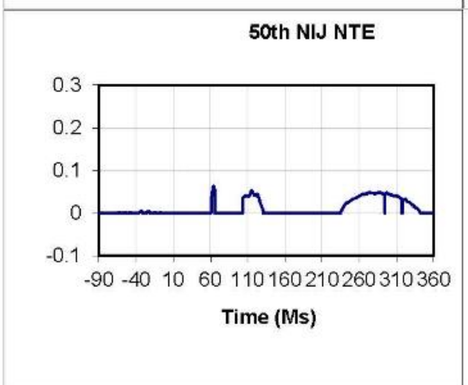
0.2
0.1
0
-0.1
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)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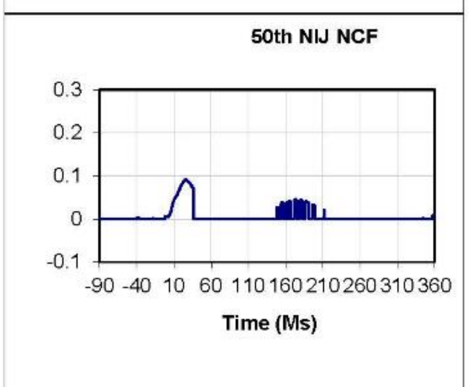
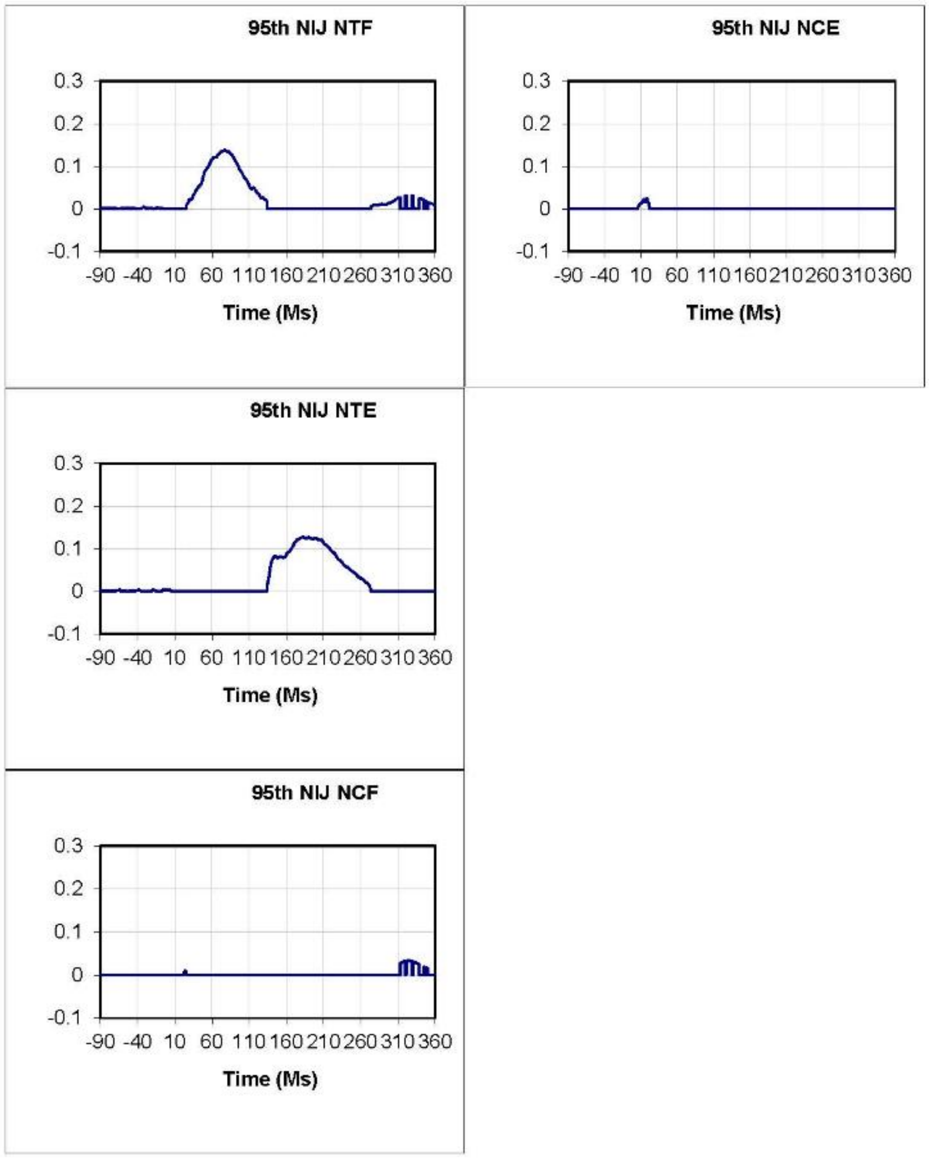
0.2
0.1
0
-0.1
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)


50th NIJ NCF
0.3
0.2
0.1
0
-0.1
-90 -40 10 60 110 160 210 260 310 360
Time (Ms)

201809 Test: 9726 Test Date: 181003 Subj: H3HEADS Cell: N



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201809 Test: 9711 Test Date: 181002 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: U

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				18.3	
Impact Rise Time (Ms)				84.5	
Impact Duration (Ms)				169.2	
Velocity Change (Ft/Sec)		39.26			
SLED X ACCEL (G)	0.03	11.90	-0.53	84.5	173.6
SLED Y ACCEL (G)	0.00	0.56	-0.65	80.8	54.4
SLED Z ACCEL (G)	0.00	0.20	-1.13	247.2	71.5
SLED RESULTANT	0.03	11.95	0.05	84.3	169.3
INTEGRATED ACCEL (FT/SEC)	-0.02	39.26	0.01	169.2	0.0
HEAD FIXTURE X ACCEL (G)	0.02	8.95	-0.61	84.6	172.1
HEAD FIXTURE Y ACCEL (G)	0.00	3.66	-1.03	55.9	178.6
HEAD FIXTURE Z ACCEL (G)	0.02	8.52	-0.50	83.7	177.3
HEAD FIXTURE RESULTANT (G)	0.04	12.65	0.17	92.1	364.8
HEAD FIXTURE2 X ACCEL (G)	0.02	9.13	-0.48	91.6	173.6
HEAD FIXTURE2 Y ACCEL (G)	0.00	1.47	-0.71	63.9	56.4
HEAD FIXTURE2 Z ACCEL (G)	0.02	7.97	-0.43	89.3	245.9
HEAD FIXTURE2 RESULTANT (G)	0.06	12.12	0.08	89.2	168.9
HEAD FIXTURE3 X ACCEL (G)	0.02	9.30	-0.52	88.3	173.5
HEAD FIXTURE3 Y ACCEL (G)	-0.01	1.06	-0.94	54.5	63.5
HEAD FIXTURE3 Z ACCEL (G)	0.01	8.12	-0.81	88.4	294.3
HEAD FIXTURE3 RESULTANT (G)	0.05	12.35	0.11	88.3	343.9
INT HEAD X ACCEL (G)	0.01	14.93	-8.69	157.6	290.1
INT HEAD Y ACCEL (G)	0.00	0.93	-0.41	170.9	282.9
INT HEAD Z ACCEL (G)	0.05	7.77	-10.63	58.0	133.4
INT HEAD RESULTANT (G)	0.06	16.54	0.29	160.5	0.0
INT HEAD HIC		25.69		134.8	164.8
INT HEAD Ry ANG VELOCITY (RAD/SEC)	0.01	1.31	-2.72	252.8	113.8
INT HEAD Ry ANG VELOCITY (RAD/SEC)	0.01	25.27	-23.69	243.6	118.8
INT HEAD Rz ANG VELOCITY (RAD/SEC)	0.00	1.25	-2.31	201.6	140.9
INT HEAD ANG VELOCITY RESULTANT	0.11	25.29	0.02	243.6	1.8
INT NECK X FORCE (LB)	0.73	92.39	-59.06	150.9	290.4
INT NECK Y FORCE (LB)	-0.37	25.33	-3.42	112.3	160.3
INT NECK Z FORCE (LB)	-1.10	97.46	-62.56	160.4	57.9
INT NECK RESULTANT (LB)	1.53	120.87	2.74	160.4	0.0

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201809 Test: 9711 Test Date: 181002 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: U

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT NECK Mx TORQUE (IN-LB)	0.73	16.94	-13.97	54.8	62.4
INT NECK My TORQUE (IN-LB)	-0.43	169.83	-314.14	296.8	156.5
INT NECK Mz TORQUE (IN-LB)	-0.62	10.73	-18.47	118.2	137.7
INT NECK TORQUE RES (IN-LB)	1.24	314.30	1.08	156.5	0.6
INT LOWER NECK X FORCE (LB)	-0.21	119.03	-67.52	133.5	272.5
INT LOWER NECK Y FORCE (LB)	-0.34	6.29	-9.35	153.6	52.1
INT LOWER NECK Z FORCE (LB)	1.39	76.40	-121.63	238.6	156.7
INT LOWER NECK RESULTANT (LB)	1.64	136.78	1.45	160.8	0.6
INT LOWER NECK Mx TORQUE (IN-LB)	0.76	21.08	-15.23	61.3	170.1
INT LOWER NECK My TORQUE (IN-LB)	-0.50	701.39	-860.26	292.2	160.0
INT LOWER NECK Mz TORQUE (IN-LB)	-1.67	64.68	-15.69	133.1	363.9
INT LOWER NECK TORQUE RES (IN-LB)	2.12	860.71	2.11	160.1	0.9
INT HEAD2 X ACCEL (G)	0.01	13.86	-10.80	149.3	280.3
INT HEAD2 Y ACCEL (G)	0.00	0.85	-0.55	163.6	72.8
INT HEAD2 Z ACCEL (G)	0.04	6.98	-9.60	58.9	134.8
INT HEAD2 RESULTANT (G)	0.06	15.26	0.24	149.2	0.0
INT HEAD2 HIC		24.86		130.2	160.2
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	0.00	1.80	-0.99	102.7	193.6
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	0.00	26.74	-22.45	239.2	111.9
INT HEAD2 Rz ANG VELOCITY (RAD/SEC)	-0.01	1.46	-1.49	152.8	209.2
INT HEAD2 ANG VELOCITY RESULTANT	0.09	26.75	0.01	239.2	4.1
INT NECK2 X FORCE (LB)	1.35	107.81	-86.88	148.8	280.3
INT NECK2 Y FORCE (LB)	-0.55	4.25	-14.13	281.7	158.8
INT NECK2 Z FORCE (LB)	-2.29	100.69	-71.81	136.8	58.4
INT NECK2 RESULTANT (LB)	2.77	135.77	3.19	136.8	0.2
INT NECK2 Mx TORQUE (IN-LB)	0.60	9.83	-14.95	291.7	150.8
INT NECK2 My TORQUE (IN-LB)	-0.76	263.98	-387.17	283.1	153.3
INT NECK2 Mz TORQUE (IN-LB)	-0.78	9.48	-19.76	249.5	171.9
INT NECK2 TORQUE RES (IN-LB)	1.41	387.41	1.18	153.3	0.3
INT LOWER NECK2 X FORCE (LB)	-0.49	143.44	-100.80	129.6	262.3
INT LOWER NECK2 Y FORCE (LB)	-1.16	6.21	-6.56	73.1	53.1
INT LOWER NECK2 Z FORCE (LB)	-2.48	81.67	-145.74	228.8	148.9
INT LOWER NECK2 RESULTANT (LB)	2.93	178.28	4.28	139.1	0.2

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201809 Test: 9711 Test Date: 181002 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: U

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT LOWER NECK2 Mx TORQUE (IN-LB)	-1.51	37.08	-37.31	281.3	167.2
INT LOWER NECK2 My TORQUE (IN-LB)	-0.24	1258.20	-1250.66	280.6	137.1
INT LOWER NECK2 Mz TORQUE (IN-LB)	-1.45	19.09	-12.59	256.5	311.4
INT LOWER NECK2 TORQUE RES (IN-LB)	2.64	1258.77	0.96	280.6	1.0
INT HEAD3 X ACCEL (G)	0.00	15.83	-10.24	119.4	268.2
INT HEAD3 Y ACCEL (G)	0.00	2.88	-4.83	118.0	119.0
INT HEAD3 Z ACCEL (G)	0.04	7.69	-5.72	62.3	228.8
INT HEAD3 RESULTANT (G)	0.07	16.12	0.28	119.4	0.0
INT HEAD3 HIC		17.11		124.6	154.6
INT HEAD3 Rx ANG VELOCITY (RAD/SEC)	0.02	0.76	-0.60	56.5	88.9
INT HEAD3 Ry ANG VELOCITY (RAD/SEC)	0.02	20.36	-15.29	227.6	105.7
INT HEAD3 Rz ANG VELOCITY (RAD/SEC)	0.03	0.66	-0.49	138.3	297.0
INT HEAD3 ANG VELOCITY RESULTANT	0.14	20.36	0.03	227.6	1.9
INT HEAD3 Ry ANG ACCEL (RAD/SEC2)	-0.63	2621.78	-1944.99	119.5	120.6
INT NECK3 X FORCE (LB)	-0.39	111.94	-89.22	148.2	265.8
INT NECK3 Y FORCE (LB)	-0.58	9.23	-3.56	138.2	59.6
INT NECK3 Z FORCE (LB)	2.32	53.31	-80.18	141.2	62.2
INT NECK3 RESULTANT (LB)	2.53	122.92	0.53	139.9	0.5
INT NECK3 Mx TORQUE (IN-LB)	-0.52	18.76	-12.15	53.3	63.9
INT NECK3 My TORQUE (IN-LB)	-0.55	234.17	-299.65	271.2	152.7
INT NECK3 Mz TORQUE (IN-LB)	-1.76	5.78	-6.09	120.3	263.6
INT NECK3 TORQUE RES (IN-LB)	2.38	299.65	0.28	152.7	68.7
INT LOWER NECK3 X FORCE (LB)	-0.37	135.81	-91.34	125.4	262.9
INT LOWER NECK3 Y FORCE (LB)	0.00	6.45	-8.39	271.9	51.5
INT LOWER NECK3 Z FORCE (LB)	0.58	54.40	-125.57	212.8	70.4
INT LOWER NECK3 RESULTANT (LB)	1.60	167.67	3.00	70.4	0.5
INT LOWER NECK3 Mx TORQUE (IN-LB)	2.32	57.36	-35.26	272.2	170.1
INT LOWER NECK3 My TORQUE (IN-LB)	4.87	1176.73	-1225.79	266.9	135.9
INT LOWER NECK3 Mz TORQUE (IN-LB)	3.28	37.93	-13.71	271.5	51.9
INT LOWER NECK3 TORQUE RES (IN-LB)	6.65	1225.88	3.81	135.9	1.9

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Nom G: 12.0 Cell: U

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
5th NIJ SHEAR (LB)		92.39	-59.06	150.9	290.4
5th NIJ TENSION (LB)		97.46		160.4	
5th NIJ COMPRESSION (LB)		-62.56		57.9	
5th NIJ FLEXION (IN-LB)		209.98		297.0	
5th NIJ EXTENSION (IN-LB)		369.59		155.6	
5th NIJ NTF	0.0000	0.1628	0.0000	296.3	0.0
5th NIJ NTE	0.0002	0.7059	0.0000	156.7	0.0
5th NIJ NCF	0.0001	0.1592	0.0000	297.2	0.0
5th NIJ NCE	0.0027	0.2196	0.0000	112.3	1.5
5th NIJ NTF AIS >= 2		0.13			
5th NIJ NTF AIS >= 3		0.05			
5th NIJ NTF AIS >= 4		0.08			
5th NIJ NTF AIS >= 5		0.03			
5th NIJ NTE AIS >= 2		0.23			
5th NIJ NTE AIS >= 3		0.14			
5th NIJ NTE AIS >= 4		0.14			
5th NIJ NTE AIS >= 5		0.05			
5th NIJ NCF AIS >= 2		0.13			
5th NIJ NCF AIS >= 3		0.05			
5th NIJ NCF AIS >= 4		0.08			
5th NIJ NCF AIS >= 5		0.03			
5th NIJ NCE AIS >= 2		0.14			
5th NIJ NCE AIS >= 3		0.06			
5th NIJ NCE AIS >= 4		0.08			
5th NIJ NCE AIS >= 5		0.03			
50th NIJ SHEAR (LB)		107.81	-86.88	148.8	280.3
50th NIJ TENSION (LB)		100.69		136.8	
50th NIJ COMPRESSION (LB)		-71.81		58.4	
50th NIJ FLEXION (IN-LB)		324.17		282.5	
50th NIJ EXTENSION (IN-LB)		457.40		153.2	
50th NIJ NTF	0.0000	0.1206	0.0000	282.0	0.0
50th NIJ NTE	0.0000	0.4248	0.0000	153.1	0.0
50th NIJ NCF	0.0000	0.1166	0.0000	280.0	0.0
50th NIJ NCE	0.0031	0.0785	0.0000	83.0	0.8
50th NIJ NTF AIS >= 2		0.13			
50th NIJ NTF AIS >= 3		0.05			
50th NIJ NTF AIS >= 4		0.07			
50th NIJ NTF AIS >= 5		0.02			
50th NIJ NTE AIS >= 2		0.18			
50th NIJ NTE AIS >= 3		0.08			
50th NIJ NTE AIS >= 4		0.10			
50th NIJ NTE AIS >= 5		0.04			

201809 Test: 9711 Test Date: 181002 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: U

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
50th NIJ NCF AIS >= 2		0.13			
50th NIJ NCF AIS >= 3		0.05			
50th NIJ NCF AIS >= 4		0.07			
50th NIJ NCF AIS >= 5		0.02			
50th NIJ NCE AIS >= 2		0.12			
50th NIJ NCE AIS >= 3		0.04			
50th NIJ NCE AIS >= 4		0.07			
50th NIJ NCE AIS >= 5		0.02			
95th NIJ SHEAR (LB)		111.94	-89.22	148.2	265.8
95th NIJ TENSION (LB)		53.31		141.2	
95th NIJ COMPRESSION (LB)		-80.18		62.2	
95th NIJ FLEXION (IN-LB)		294.54		270.9	
95th NIJ EXTENSION (IN-LB)		372.99		151.7	
95th NIJ NTF	0.0005	0.0865	0.0000	262.7	0.0
95th NIJ NTE	0.0011	0.2623	0.0000	152.7	0.0
95th NIJ NCF	0.0000	0.0817	0.0000	267.3	0.1
95th NIJ NCE	0.0000	0.1129	0.0000	101.7	0.0
95th NIJ NTF AIS >= 2		0.12			
95th NIJ NTF AIS >= 3		0.04			
95th NIJ NTF AIS >= 4		0.07			
95th NIJ NTF AIS >= 5		0.02			
95th NIJ NTE AIS >= 2		0.15			
95th NIJ NTE AIS >= 3		0.06			
95th NIJ NTE AIS >= 4		0.08			
95th NIJ NTE AIS >= 5		0.03			
95th NIJ NCF AIS >= 2		0.12			
95th NIJ NCF AIS >= 3		0.04			
95th NIJ NCF AIS >= 4		0.07			
95th NIJ NCF AIS >= 5		0.02			
95th NIJ NCE AIS >= 2		0.13			
95th NIJ NCE AIS >= 3		0.05			
95th NIJ NCE AIS >= 4		0.07			

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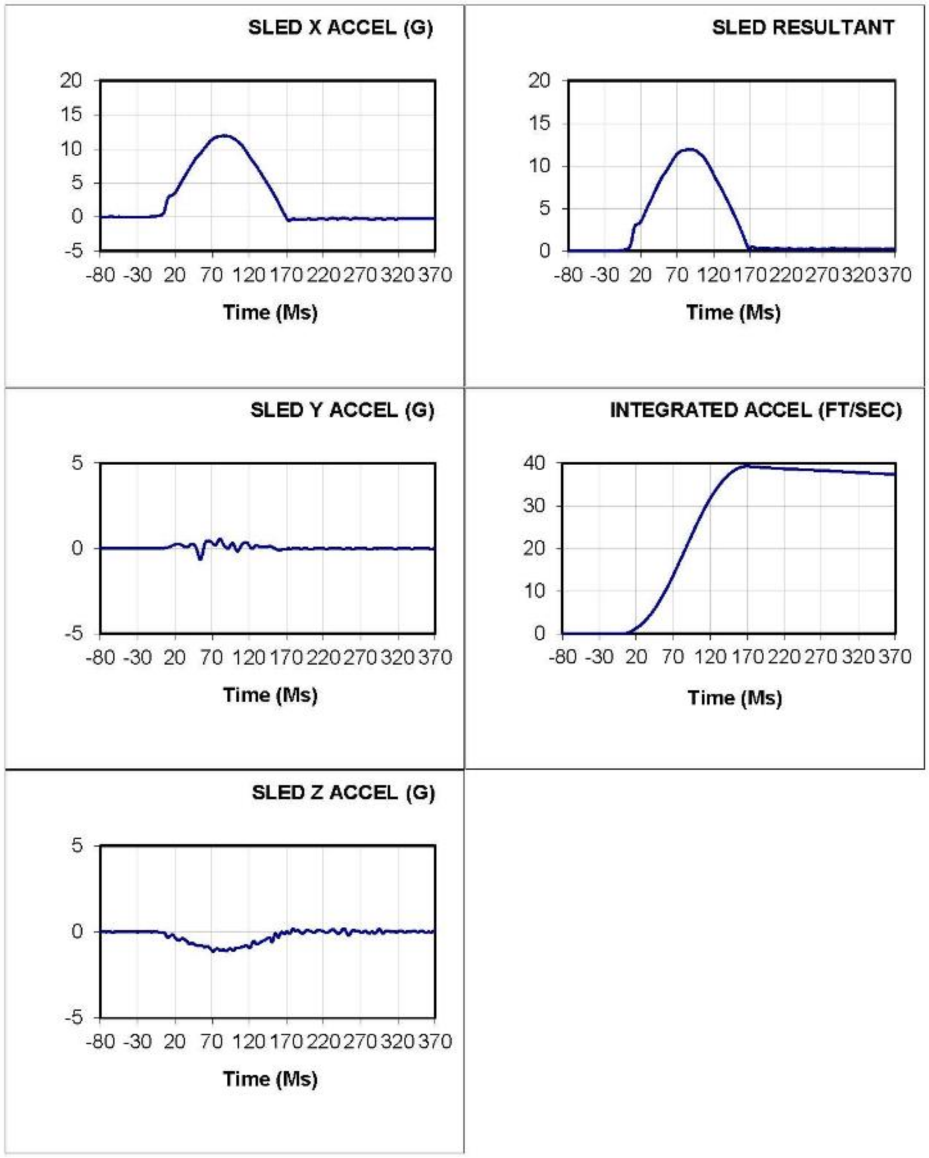

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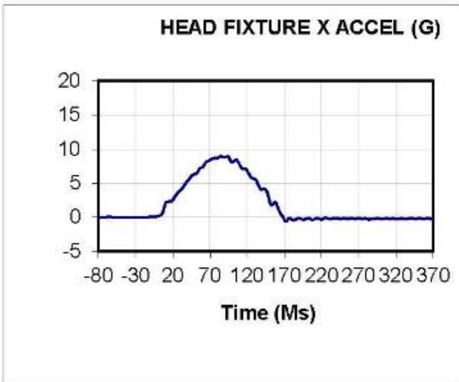

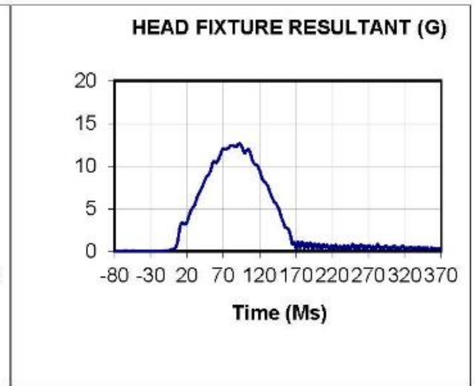

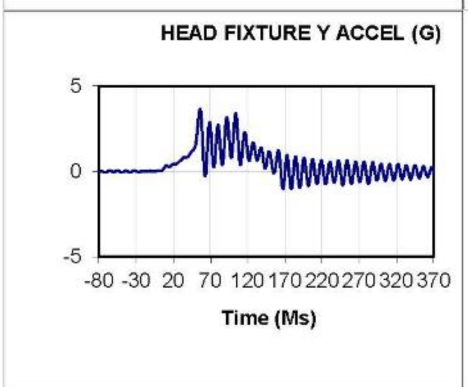

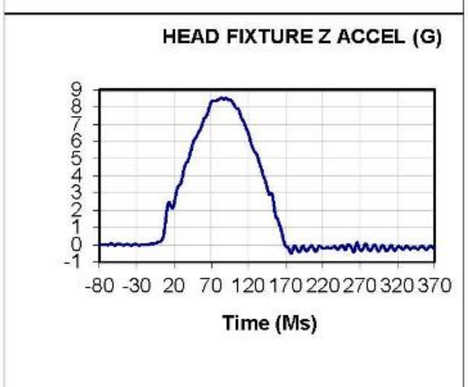

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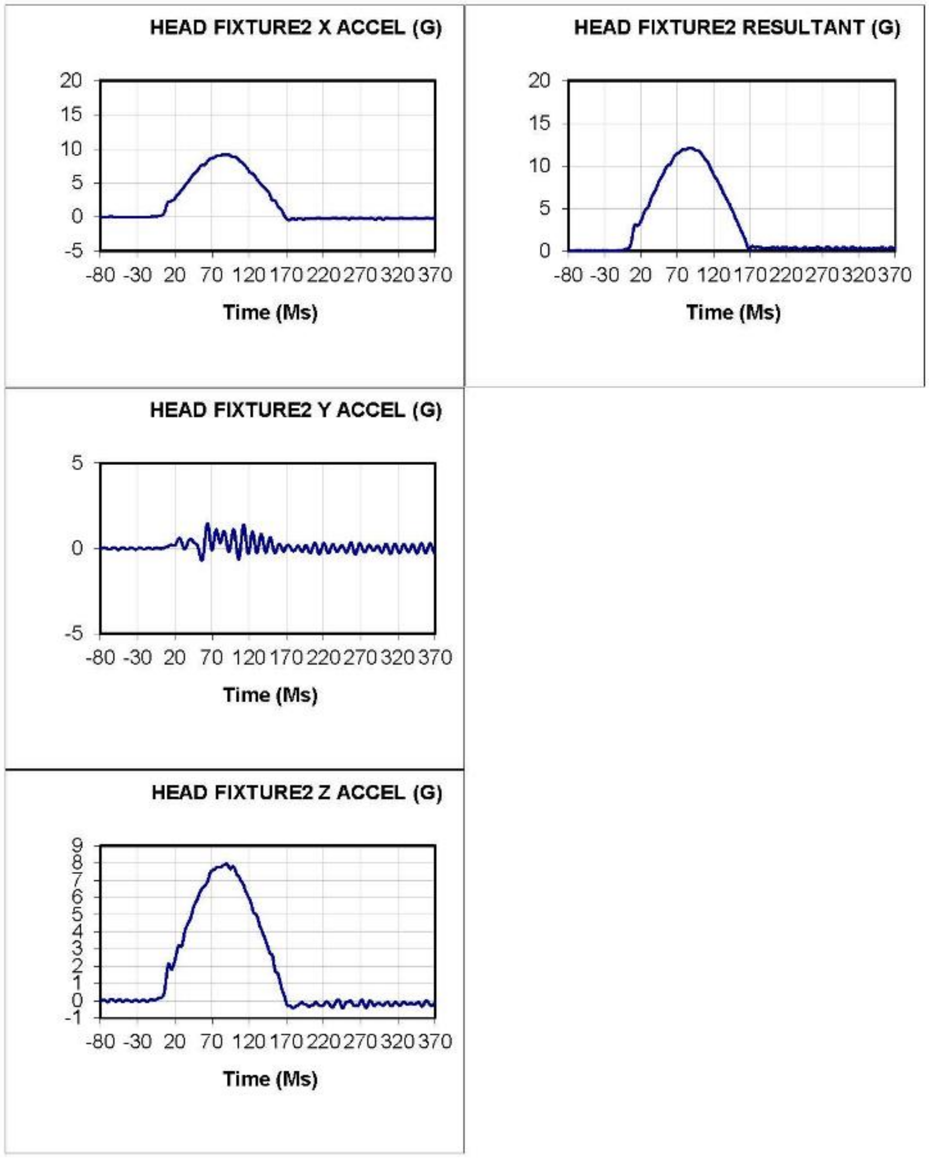

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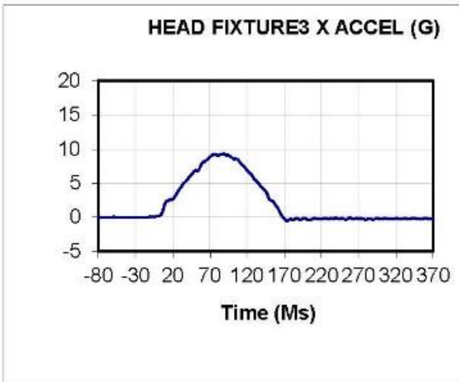

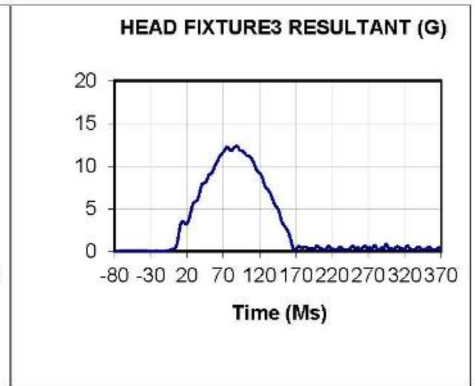

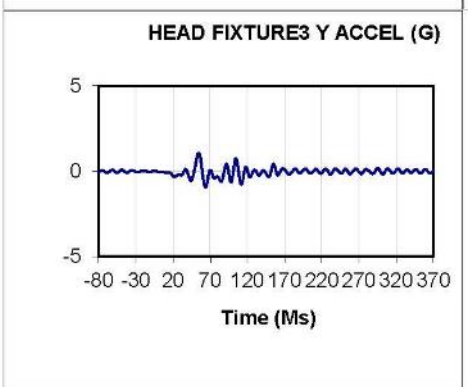

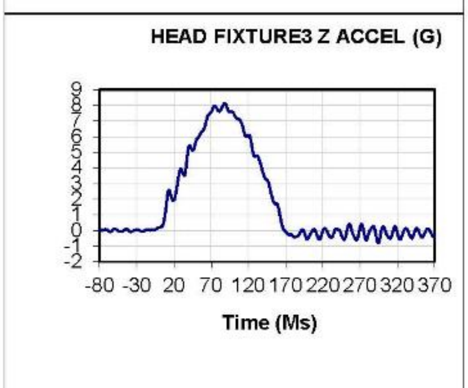

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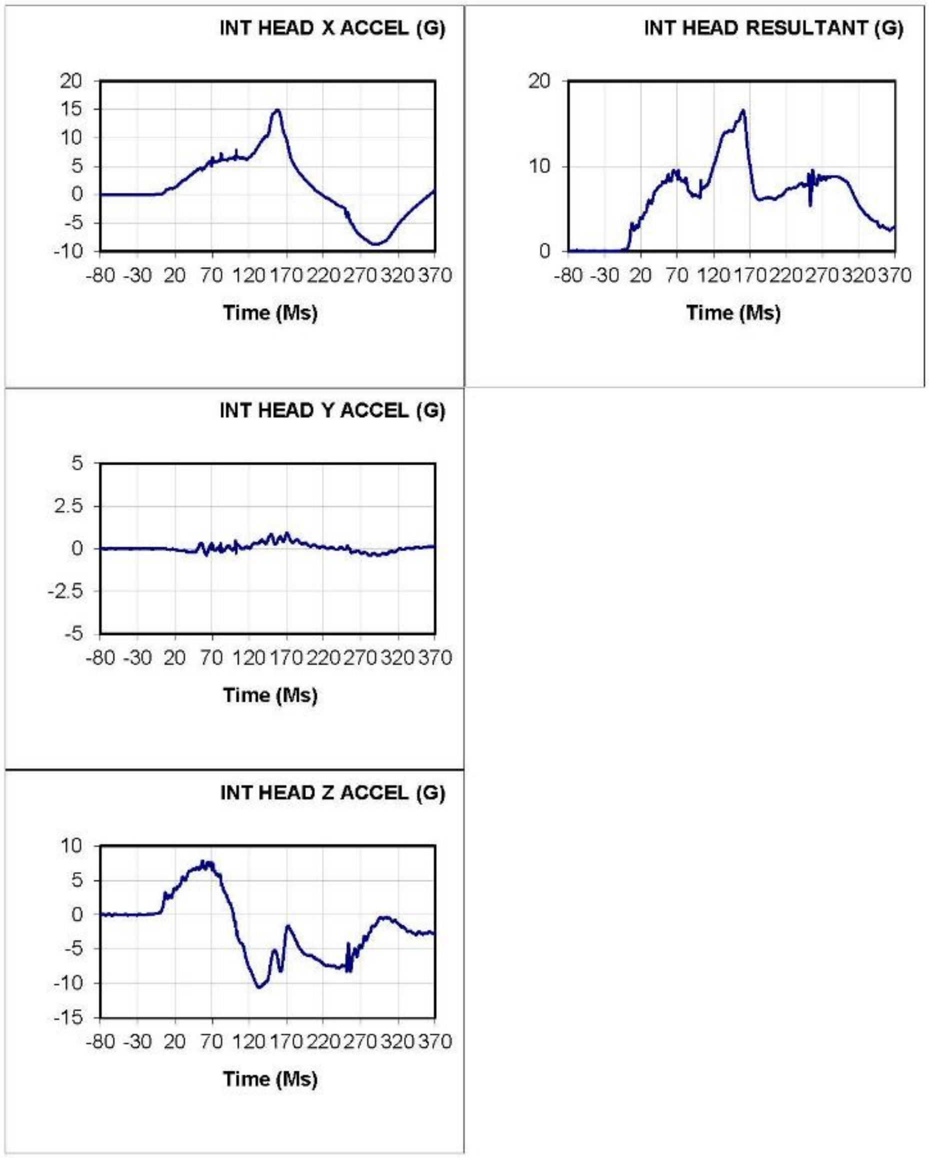

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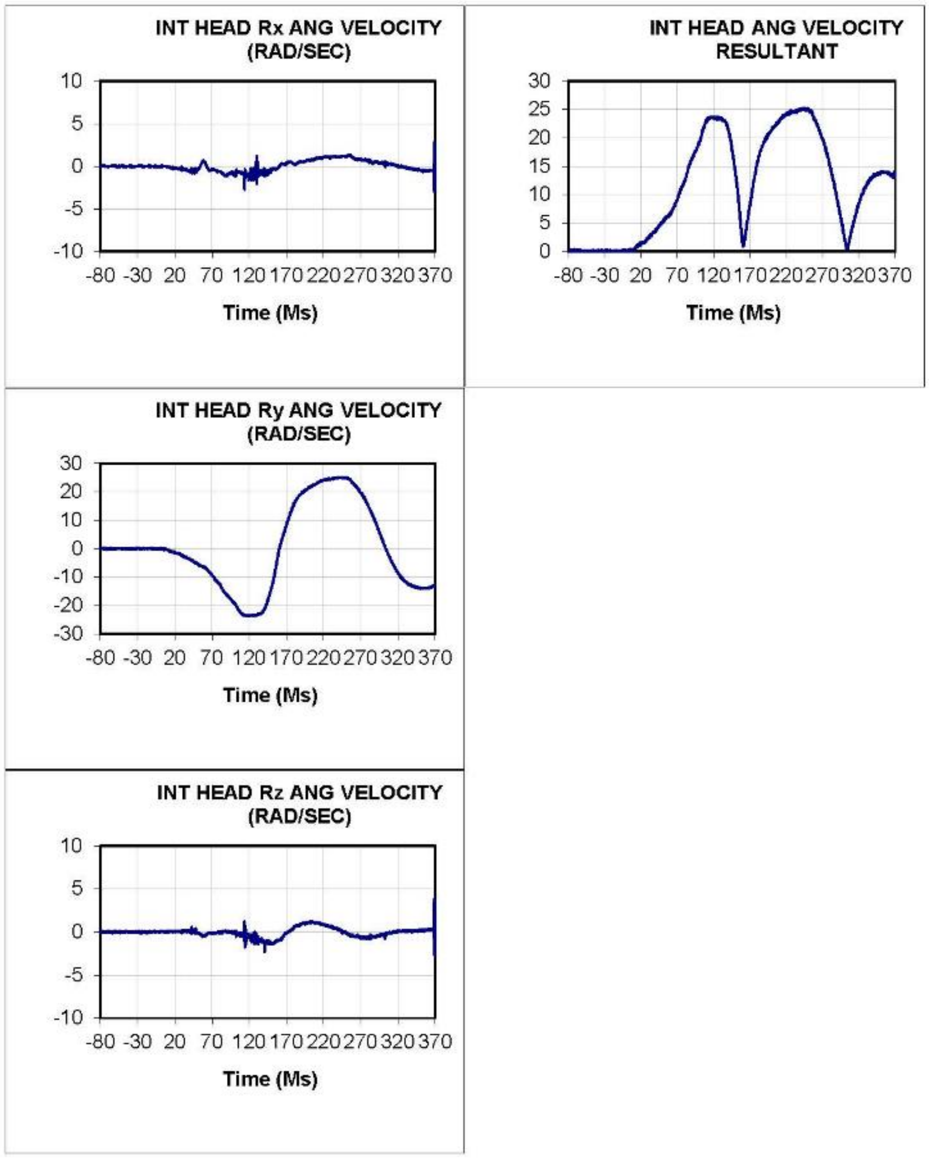

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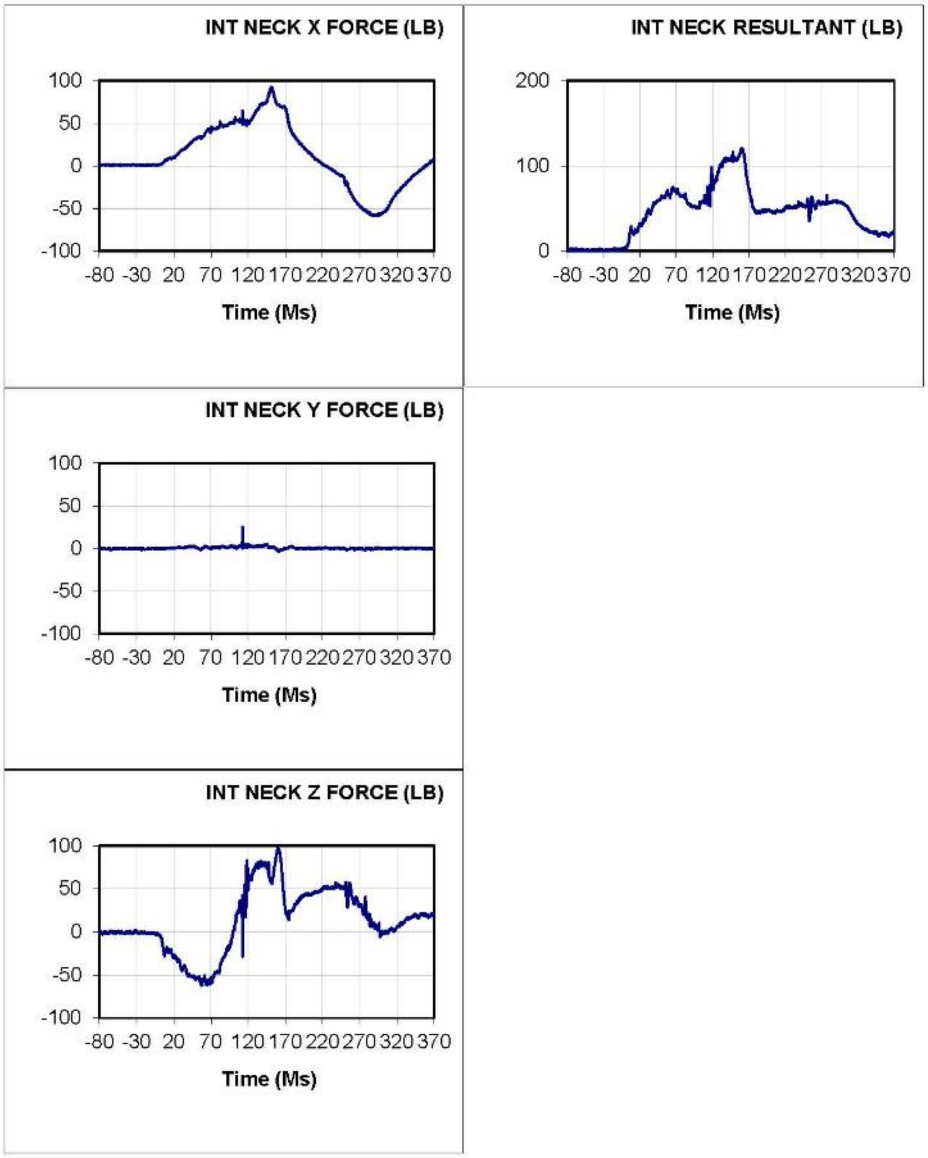

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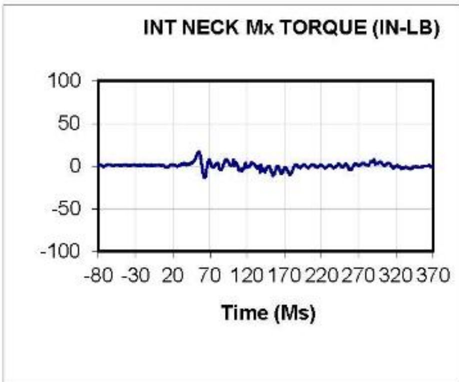

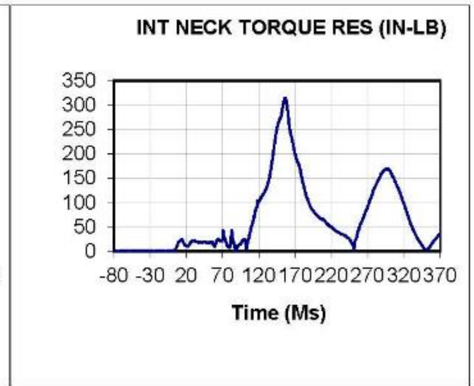

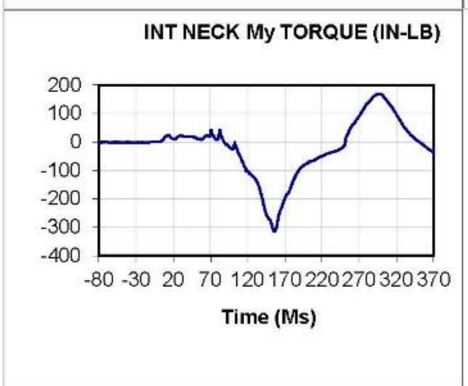

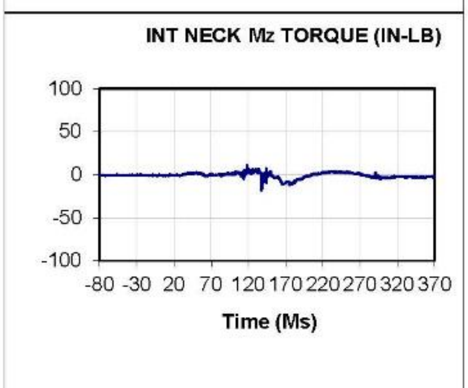

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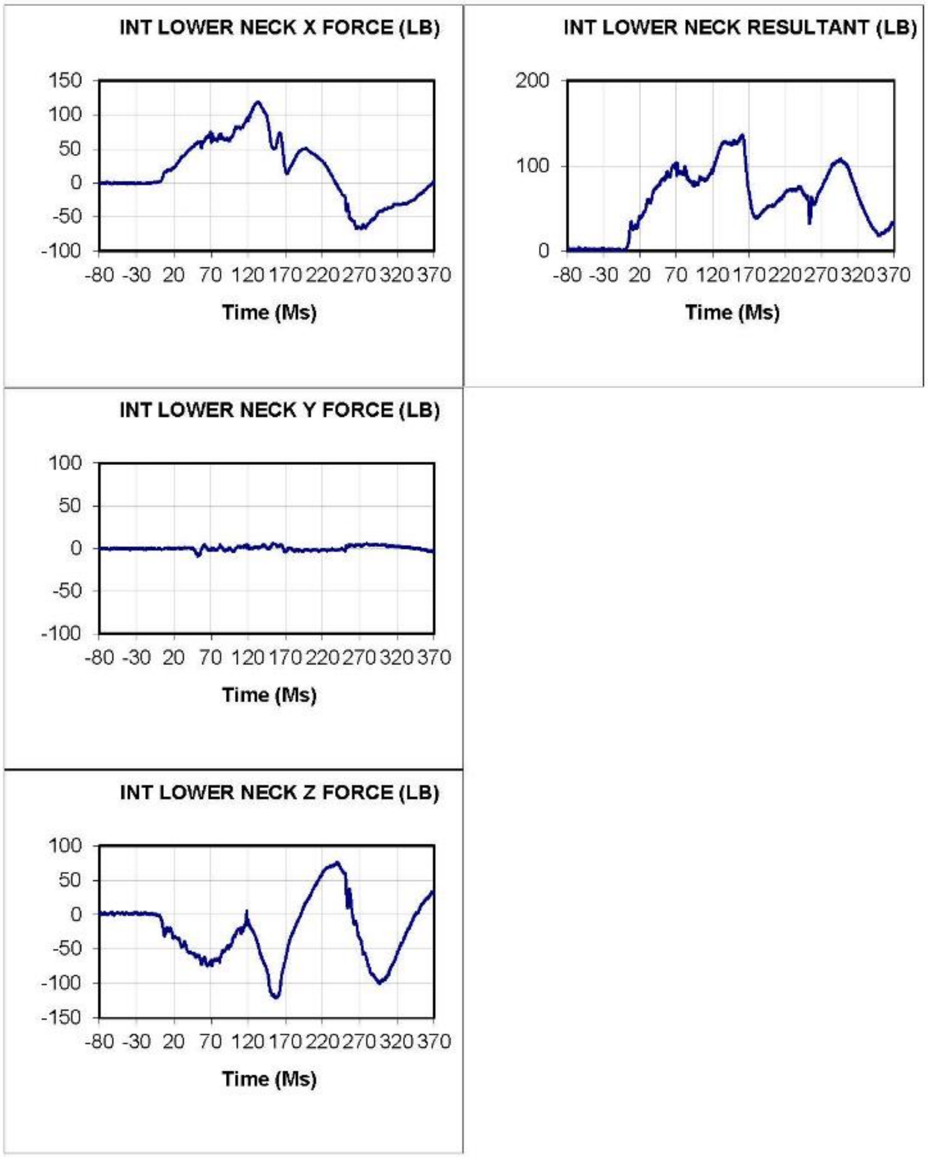

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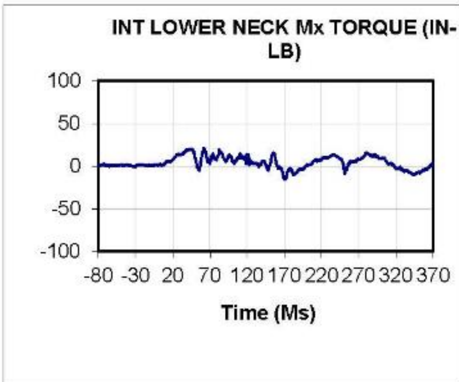

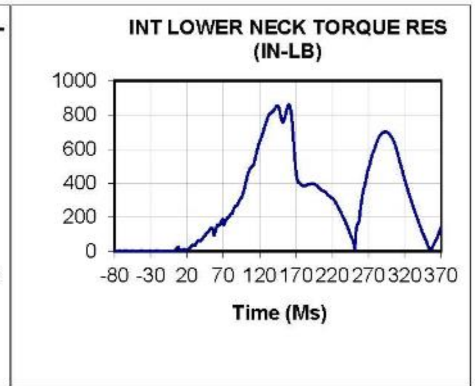

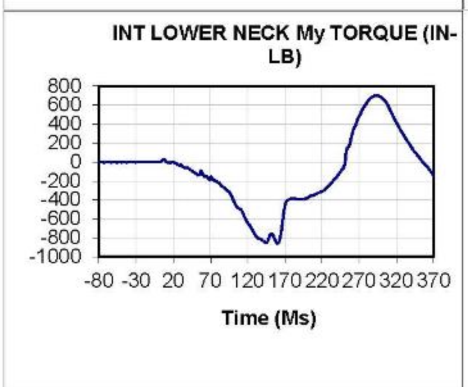

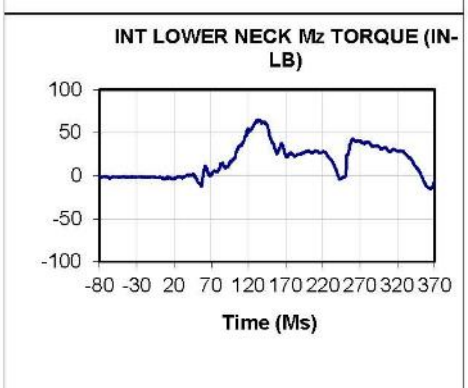

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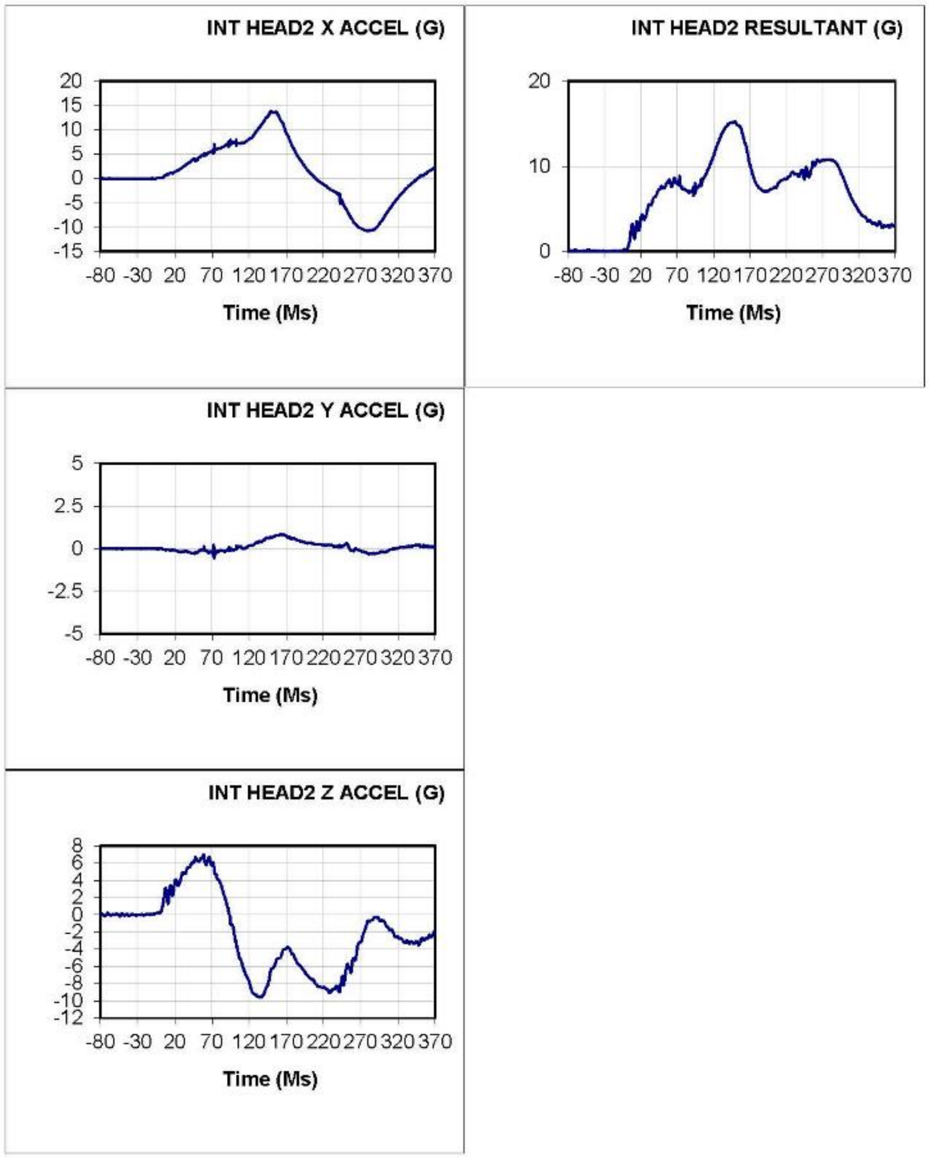

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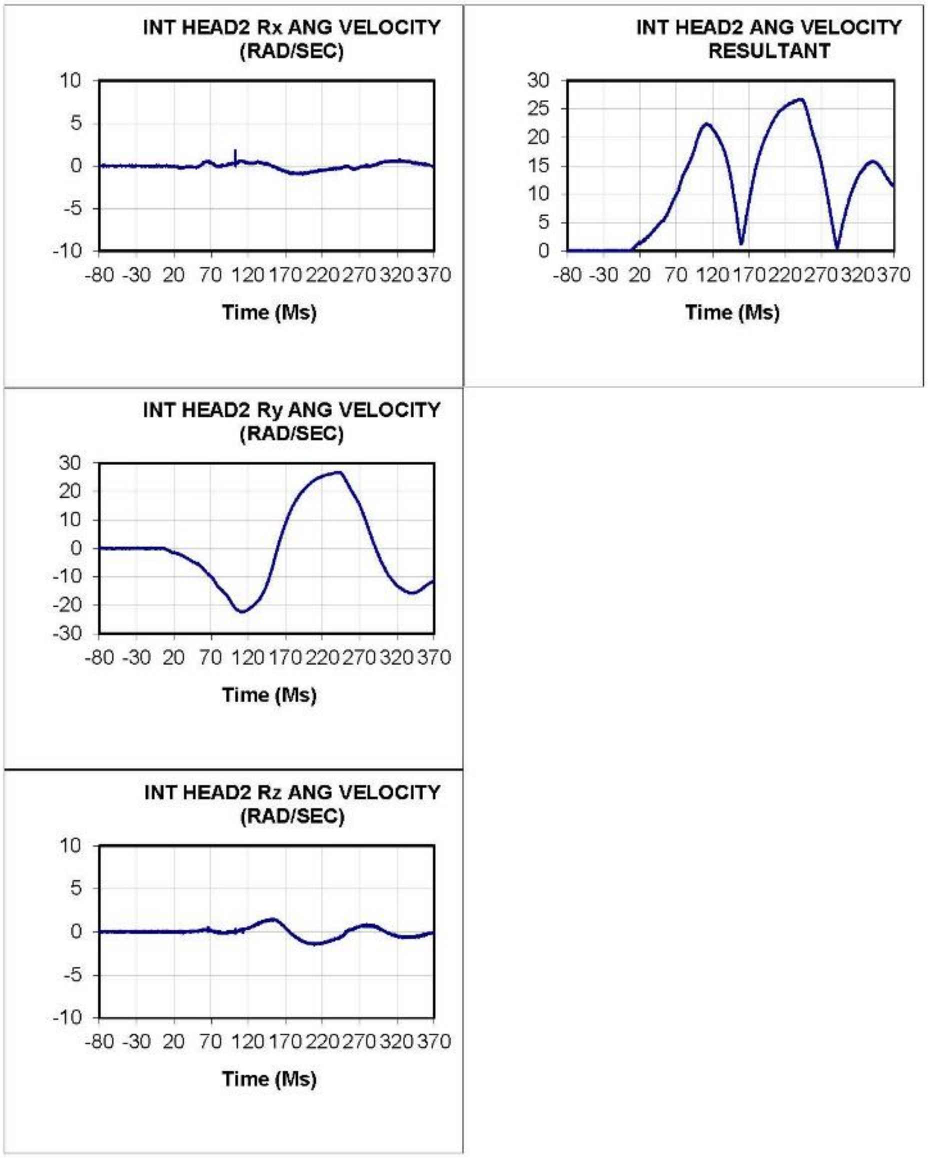

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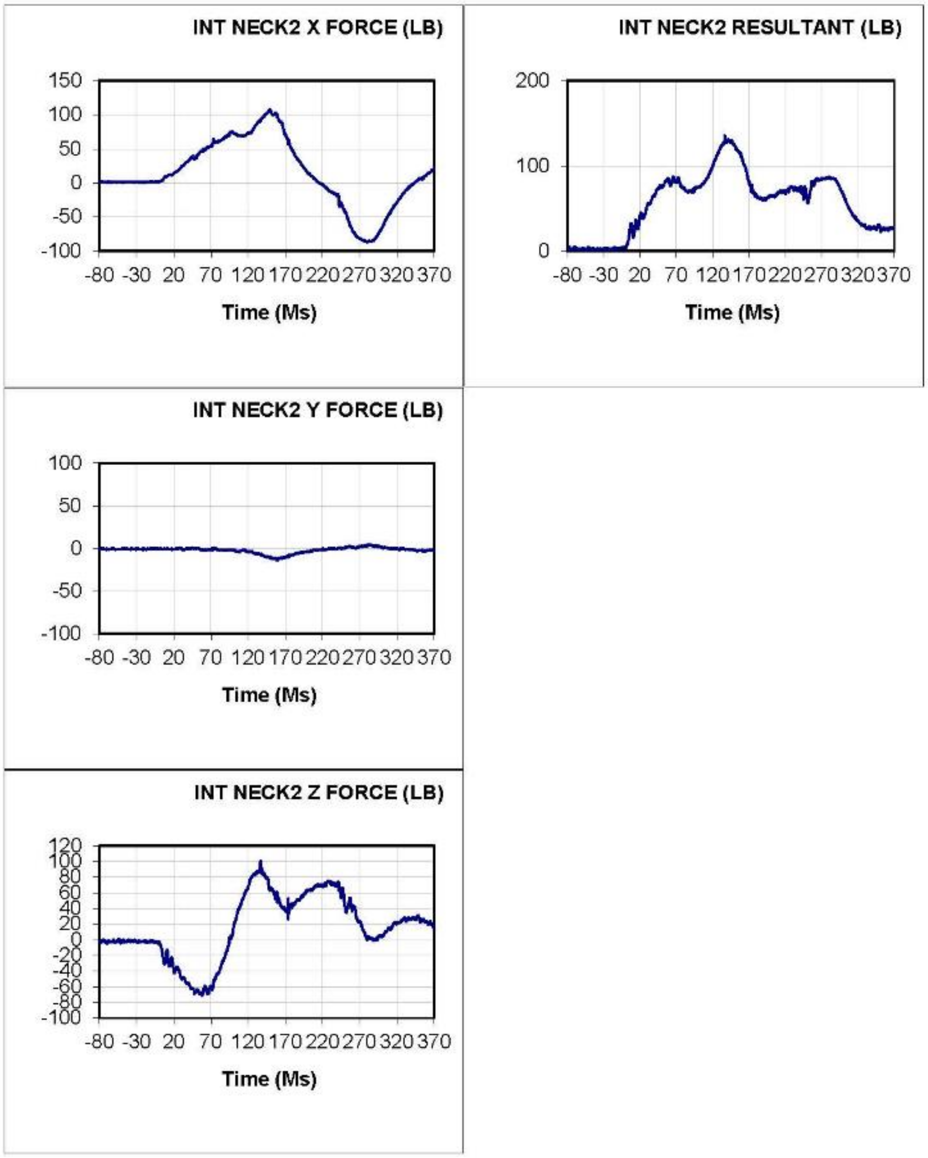

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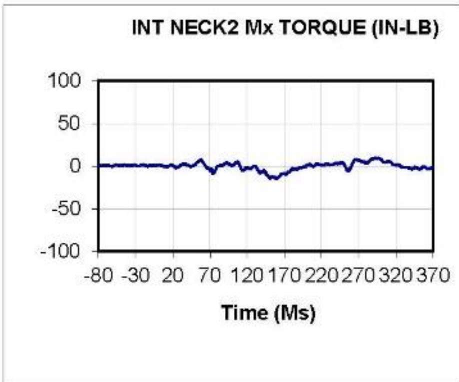

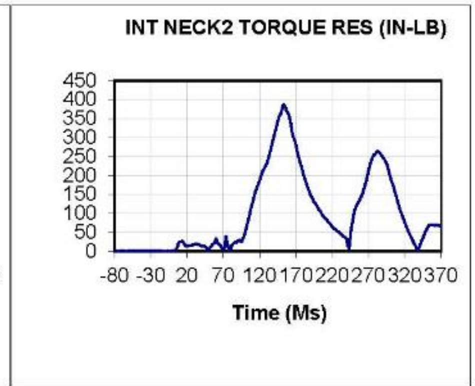

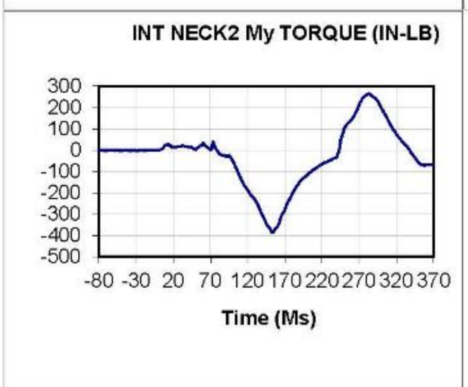

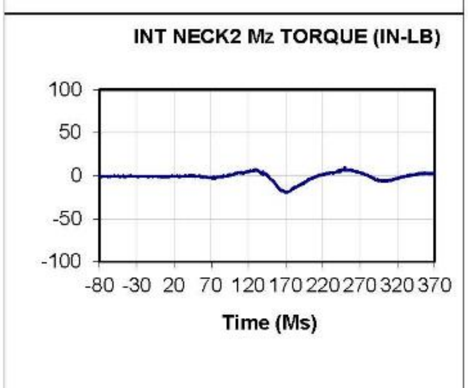

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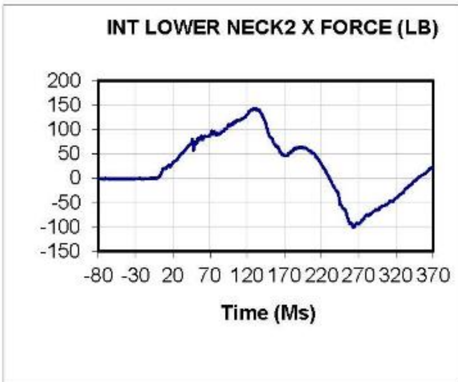

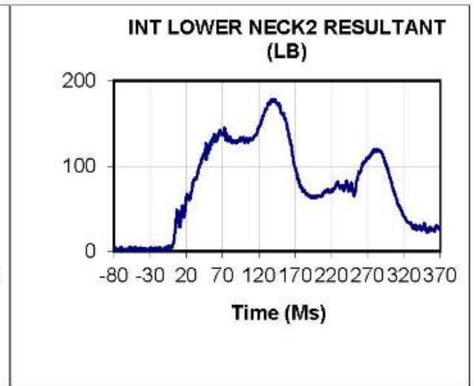

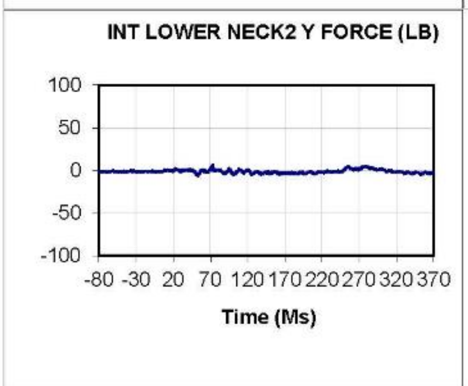

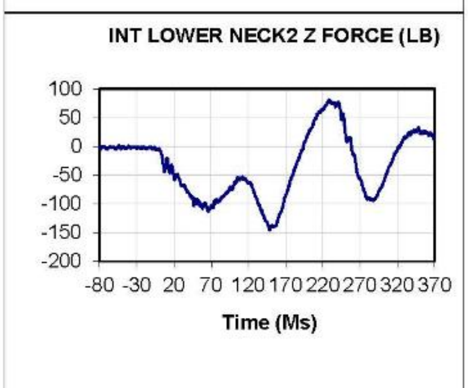

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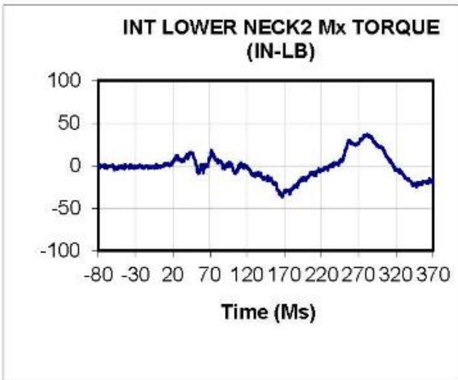
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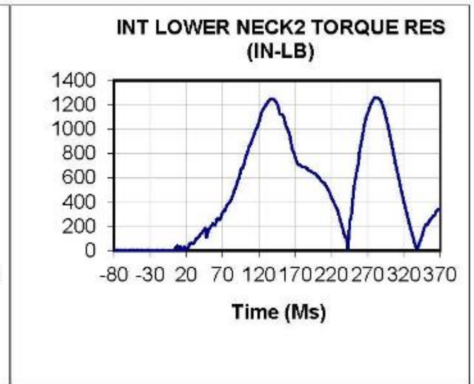
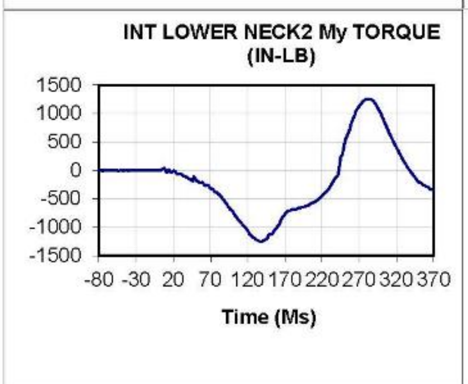
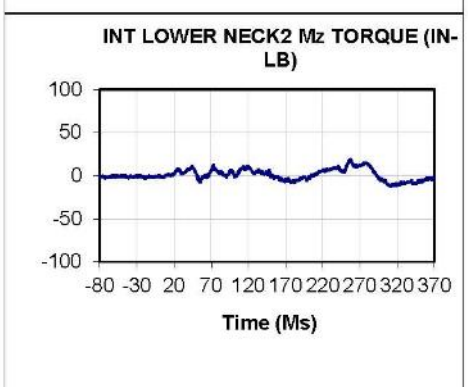
100
50
0
-50
-100
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)


INT LOWER NECK2 TORQUE RES (IN-LB)
1400
1200
1000
800
600
400
200
0
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)


INT LOWER NECK2 My TORQUE (IN-LB)
1500
1000
500
0
-500
-1000
-1500
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)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100
50
0
-50
-100
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)

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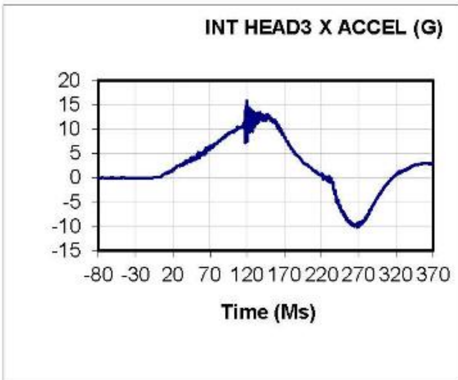

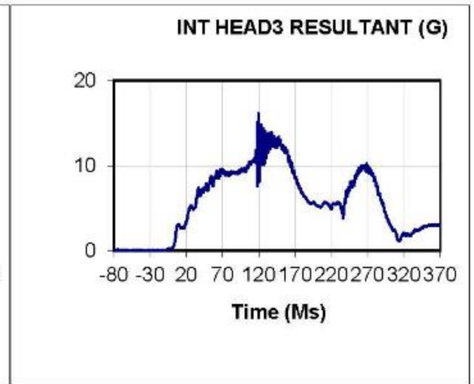

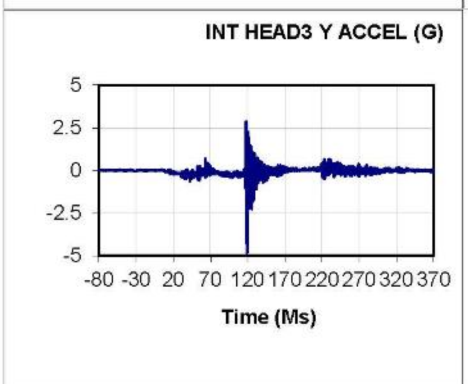

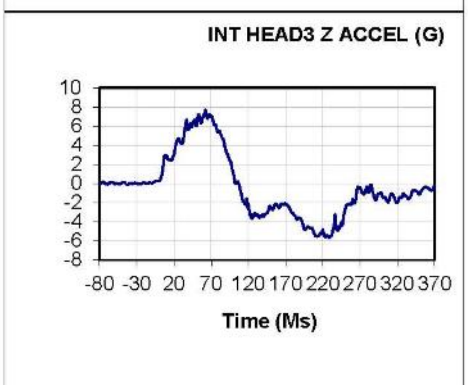

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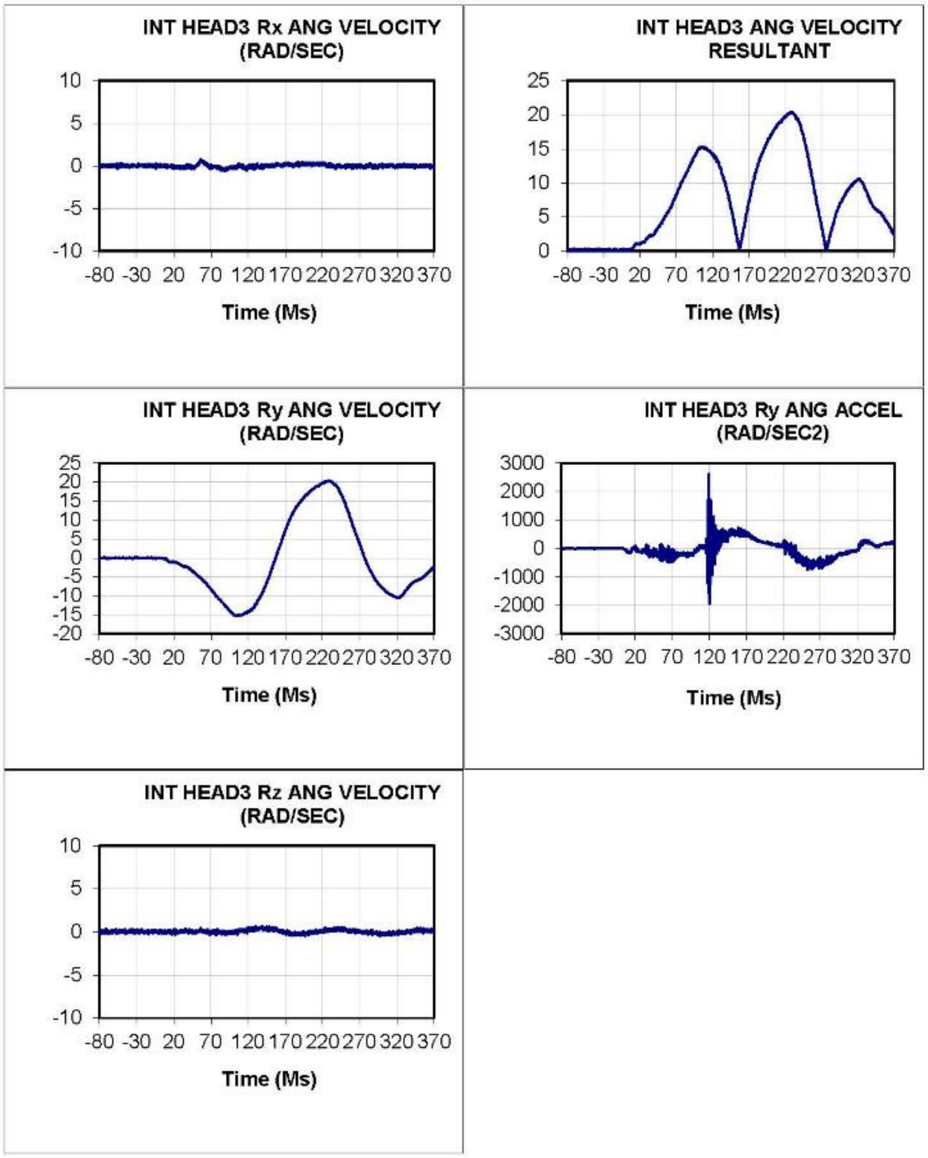
201809 Test: 9711 Test Date: 181002 Subj: H3HEADS Cell: U



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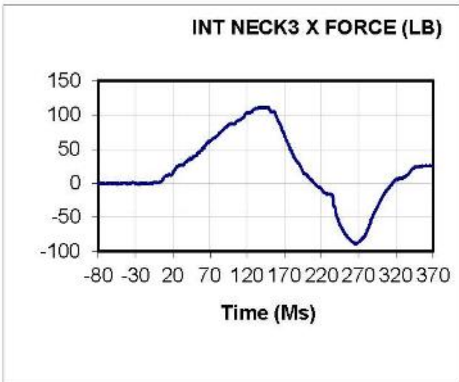
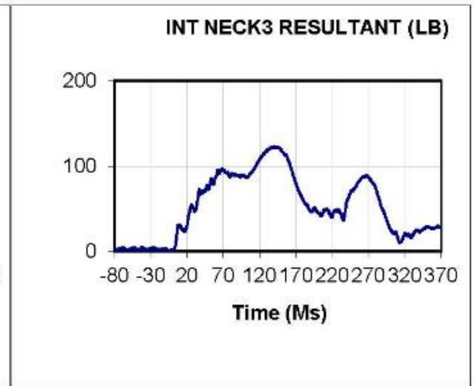
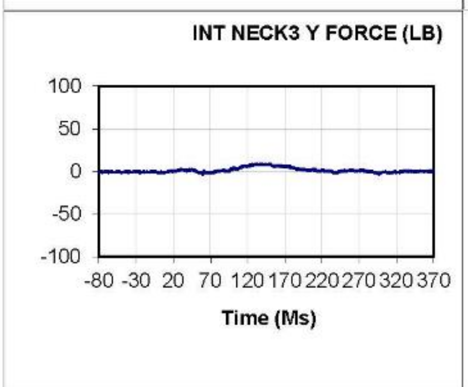
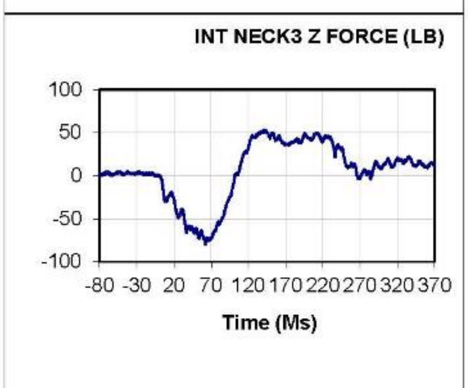
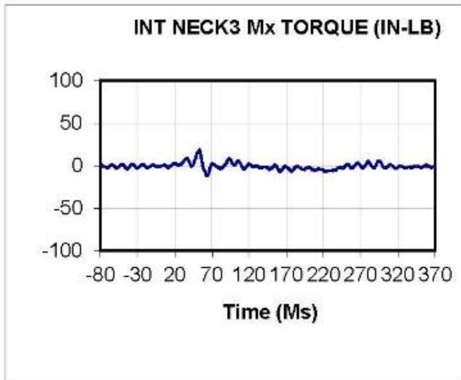


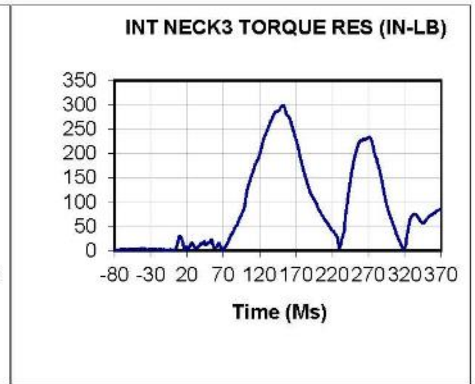


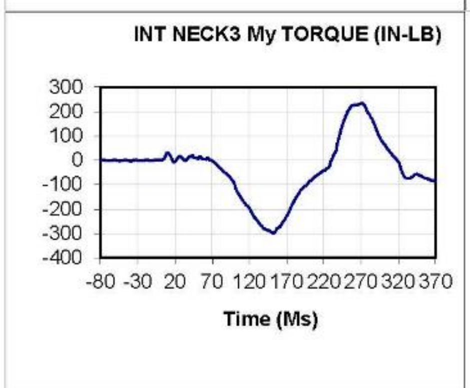


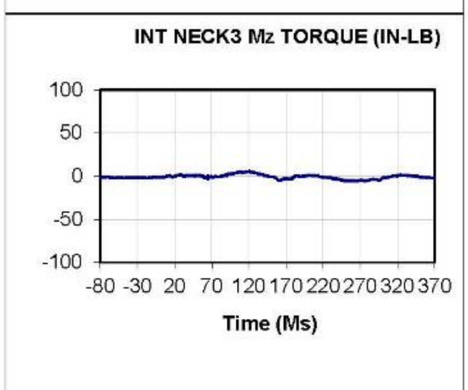


201809 Test: 9711 Test Date: 181002 Subj: H3HEADS Cell: U









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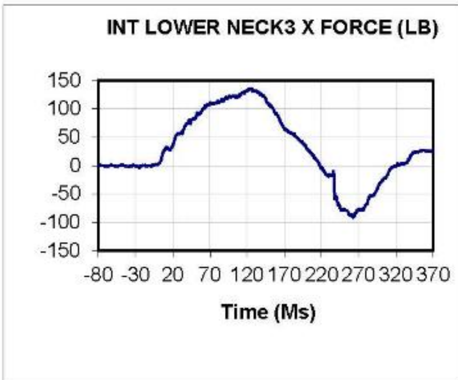
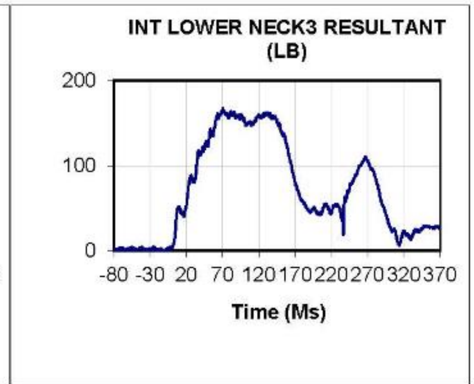
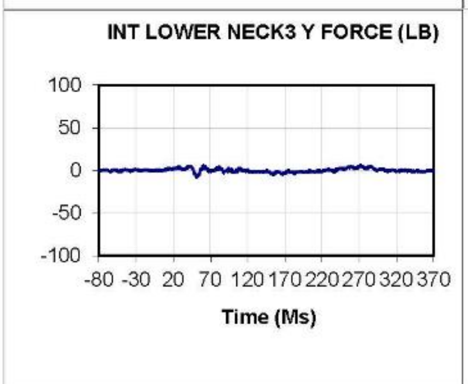


INT LOWER NECK3 X FORCE (LB)
150
100
50
0
-50
-100
-150
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)



INT LOWER NECK3 RESULTANT (LB)
200
100
0
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)



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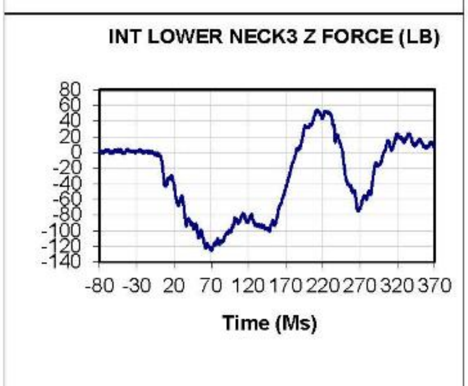
100
50
0
-50
-100
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)



INT LOWER NECK3 Z FORCE (LB)
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)

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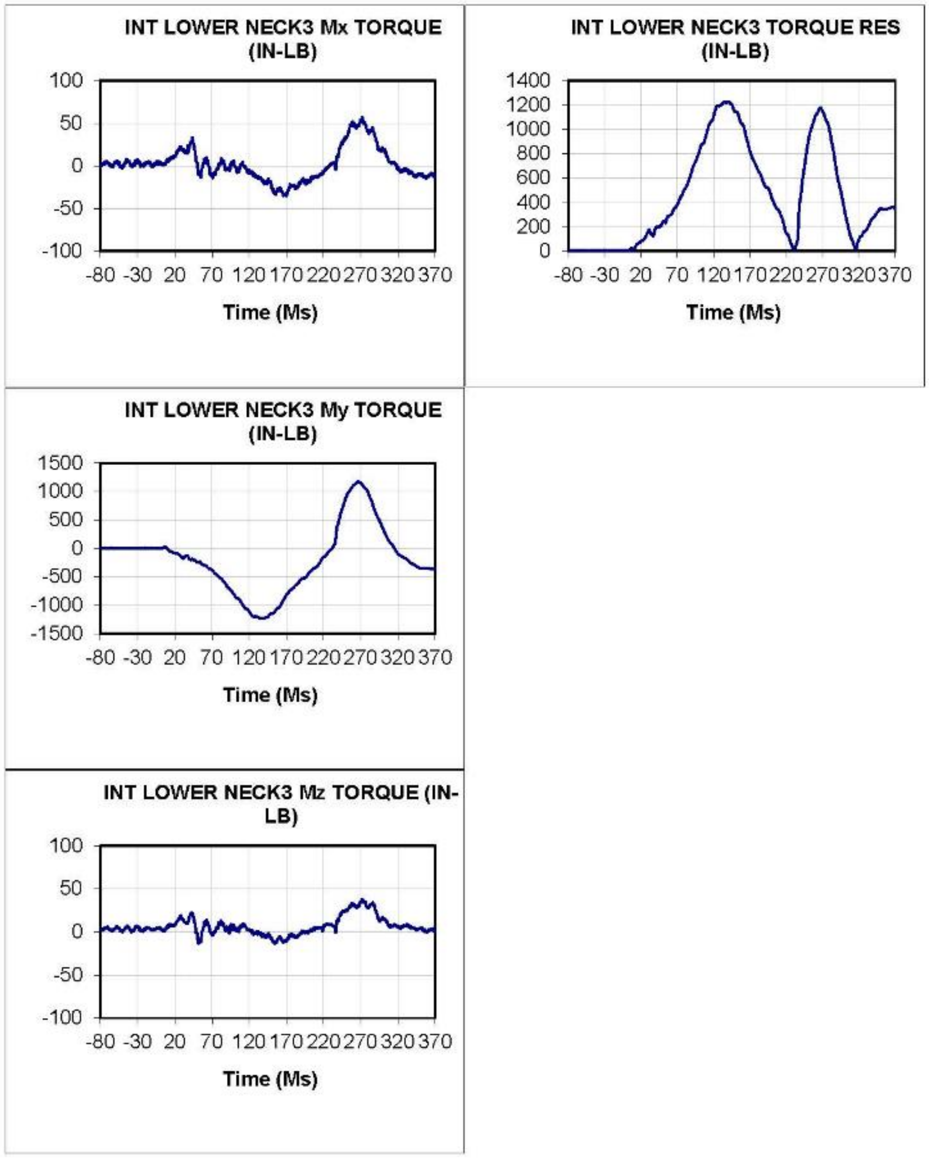

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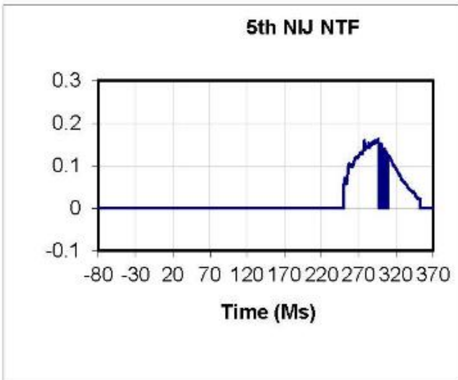

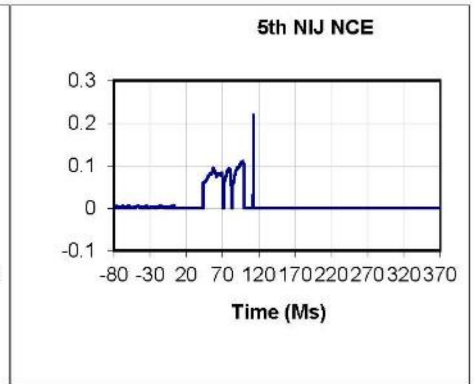

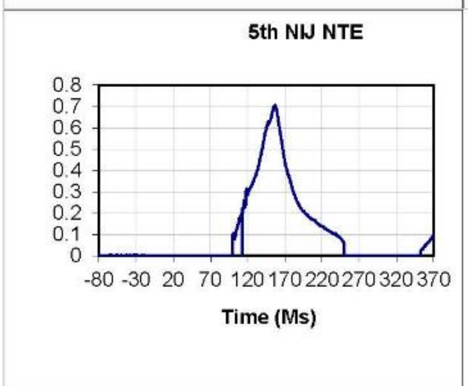

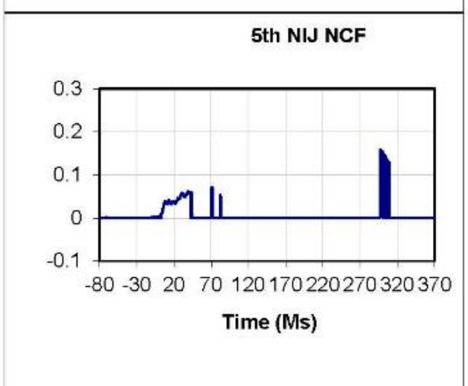

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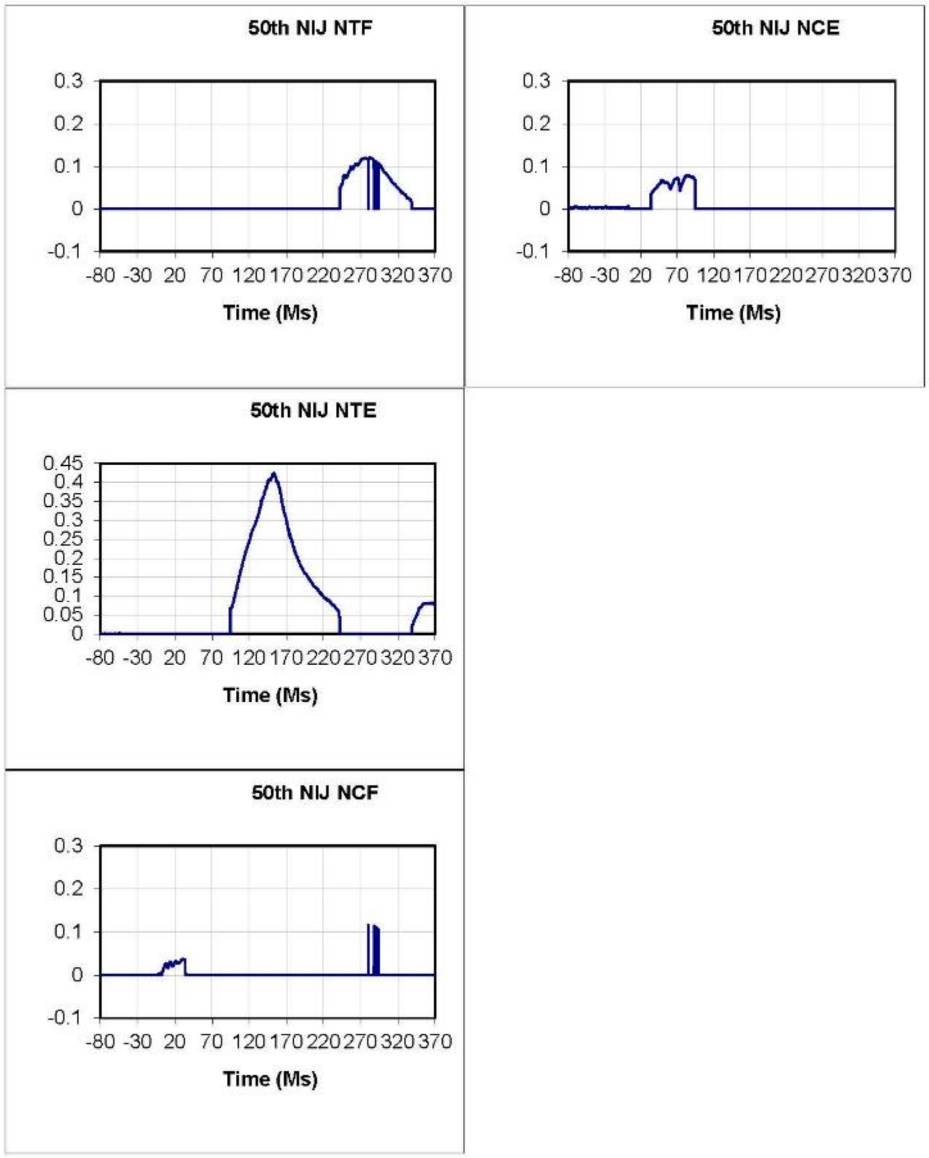

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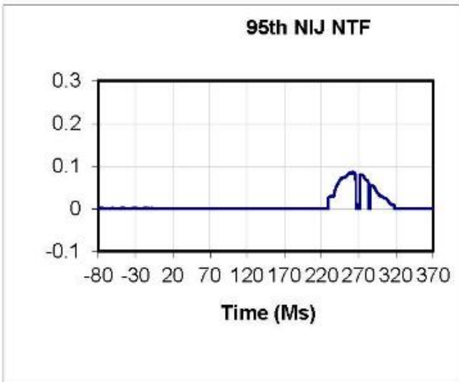

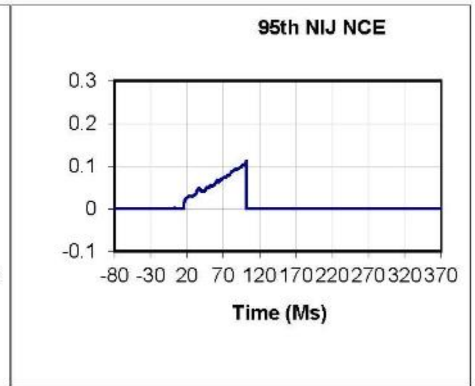

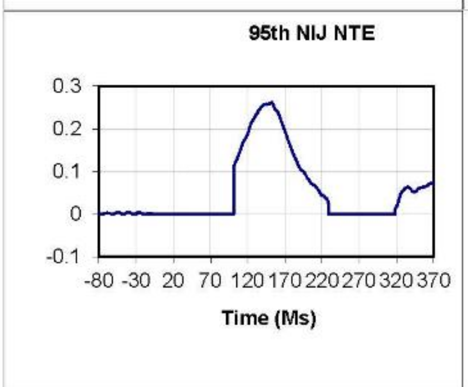

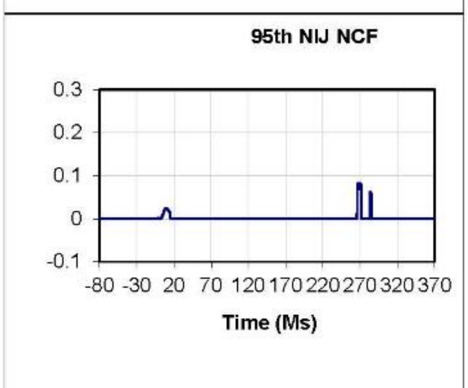

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201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Wt: 273.0
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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				19.5	
Impact Rise Time (Ms)				91.5	
Impact Duration (Ms)				171.2	
Velocity Change (Ft/Sec)		39.16			
SLED X ACCEL (G)	0.01	11.77	-0.42	91.5	175.2
SLED Y ACCEL (G)	0.00	0.53	-0.64	82.0	55.9
SLED Z ACCEL (G)	0.00	0.21	-1.41	248.7	93.1
SLED RESULTANT	0.03	11.84	0.03	91.9	171.2
INTEGRATED ACCEL (FT/SEC)	-0.01	39.16	0.02	171.2	0.0
HEAD FIXTURE X ACCEL (G)	0.01	9.48	-0.39	93.2	173.3
HEAD FIXTURE Y ACCEL (G)	0.00	3.69	-0.44	57.2	211.8
HEAD FIXTURE Z ACCEL (G)	0.01	9.40	-0.45	92.6	260.9
HEAD FIXTURE RESULTANT (G)	0.04	13.37	0.18	92.9	254.8
HEAD FIXTURE2 X ACCEL (G)	0.01	9.77	-0.47	87.7	174.4
HEAD FIXTURE2 Y ACCEL (G)	0.00	1.36	-0.59	65.2	57.6
HEAD FIXTURE2 Z ACCEL (G)	0.01	8.43	-0.51	86.4	233.0
HEAD FIXTURE2 RESULTANT (G)	0.03	12.92	0.13	87.2	238.3
HEAD FIXTURE3 X ACCEL (G)	0.01	10.14	-0.48	96.8	176.9
HEAD FIXTURE3 Y ACCEL (G)	0.00	0.99	-1.25	157.9	142.1
HEAD FIXTURE3 Z ACCEL (G)	0.01	8.92	-0.88	95.7	187.3
HEAD FIXTURE3 RESULTANT (G)	0.05	13.44	0.07	96.1	183.6
INT HEAD X ACCEL (G)	0.00	99.75	-2.55	84.1	259.1
INT HEAD Y ACCEL (G)	0.00	2.58	-0.53	84.0	127.5
INT HEAD Z ACCEL (G)	0.03	9.24	-4.66	100.4	86.2
INT HEAD RESULTANT (G)	0.07	99.80	0.16	84.1	317.9
INT HEAD HIC		72.97		83.5	84.8
INT HEAD Ry ANG VELOCITY (RAD/SEC)	0.00	4.55	-6.22	95.4	95.9
INT HEAD Ry ANG VELOCITY (RAD/SEC)	0.00	6.95	-13.06	209.5	83.1
INT HEAD Rz ANG VELOCITY (RAD/SEC)	-0.01	5.20	-5.50	92.8	93.1
INT HEAD ANG VELOCITY RESULTANT	0.10	13.09	0.02	83.1	6.0
INT NECK X FORCE (LB)	0.56	50.47	-18.32	95.1	84.0
INT NECK Y FORCE (LB)	-0.62	7.23	-4.71	84.7	89.2
INT NECK Z FORCE (LB)	-1.34	65.30	-76.50	85.9	100.4
INT NECK RESULTANT (LB)	1.75	85.78	0.81	100.4	316.9

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT NECK Mx TORQUE (IN-LB)	1.61	17.97	-14.12	55.9	112.4
INT NECK My TORQUE (IN-LB)	-0.57	76.67	-48.25	92.8	171.0
INT NECK Mz TORQUE (IN-LB)	-1.15	10.62	-4.48	89.1	317.6
INT NECK TORQUE RES (IN-LB)	2.15	76.69	2.00	92.8	2.2
INT LOWER NECK X FORCE (LB)	-1.39	99.84	-22.87	90.4	258.2
INT LOWER NECK Y FORCE (LB)	-0.52	9.89	-12.27	110.6	92.8
INT LOWER NECK Z FORCE (LB)	0.50	38.61	-98.81	86.1	100.7
INT LOWER NECK RESULTANT (LB)	1.87	121.95	0.53	93.5	0.0
INT LOWER NECK Mx TORQUE (IN-LB)	1.17	36.79	-9.96	110.8	237.0
INT LOWER NECK My TORQUE (IN-LB)	-0.28	203.41	-455.10	261.5	86.8
INT LOWER NECK Mz TORQUE (IN-LB)	-1.54	41.68	-13.93	86.0	104.5
INT LOWER NECK TORQUE RES (IN-LB)	2.33	457.16	1.86	86.8	318.4
INT HEAD2 X ACCEL (G)	0.01	59.84	-3.12	78.9	259.6
INT HEAD2 Y ACCEL (G)	0.00	0.96	-1.25	79.6	85.3
INT HEAD2 Z ACCEL (G)	0.02	8.55	-9.40	90.3	81.0
INT HEAD2 RESULTANT (G)	0.05	60.09	0.21	78.9	0.1
INT HEAD2 HIC		62.42		77.7	89.0
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	0.00	0.54	-3.18	64.6	85.4
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	0.03	7.13	-12.11	225.7	77.4
INT HEAD2 Rz ANG VELOCITY (RAD/SEC)	-0.01	2.66	-10.47	79.1	85.5
INT HEAD2 ANG VELOCITY RESULTANT	0.07	12.11	0.02	77.4	156.7
INT NECK2 X FORCE (LB)	1.54	78.17	-24.34	90.1	263.2
INT NECK2 Y FORCE (LB)	-0.75	2.63	-3.29	260.9	155.6
INT NECK2 Z FORCE (LB)	-2.47	139.64	-118.13	81.1	88.3
INT NECK2 RESULTANT (LB)	3.08	146.48	0.62	81.1	315.4
INT NECK2 Mx TORQUE (IN-LB)	4.60	11.93	-8.49	59.6	75.2
INT NECK2 My TORQUE (IN-LB)	-1.67	162.04	-73.81	88.5	172.6
INT NECK2 Mz TORQUE (IN-LB)	-0.84	2.28	-4.26	82.5	72.1
INT NECK2 TORQUE RES (IN-LB)	5.01	162.06	2.41	88.5	70.5
INT LOWER NECK2 X FORCE (LB)	-1.27	175.38	-32.11	81.7	257.5
INT LOWER NECK2 Y FORCE (LB)	-0.82	32.98	-39.22	83.4	84.2
INT LOWER NECK2 Z FORCE (LB)	-3.00	100.21	-182.48	80.8	89.2
INT LOWER NECK2 RESULTANT (LB)	3.49	215.04	0.51	89.0	321.3

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT LOWER NECK2 Mx TORQUE (IN-LB)	-4.61	46.18	-57.76	83.7	84.6
INT LOWER NECK2 My TORQUE (IN-LB)	-2.79	354.30	-1068.65	262.3	81.7
INT LOWER NECK2 Mz TORQUE (IN-LB)	-1.89	51.68	-48.16	83.8	84.4
INT LOWER NECK2 TORQUE RES (IN-LB)	6.04	1068.73	1.72	81.7	221.6
INT HEAD3 X ACCEL (G)	-0.01	63.31	-4.13	87.8	255.1
INT HEAD3 Y ACCEL (G)	0.00	22.97	-15.00	97.8	93.2
INT HEAD3 Z ACCEL (G)	0.04	8.87	-1.61	107.0	183.5
INT HEAD3 RESULTANT (G)	0.07	63.85	0.11	87.9	298.2
INT HEAD3 HIC		89.84		86.7	97.3
INT HEAD3 Rx ANG VELOCITY (RAD/SEC)	0.00	1.61	-1.26	97.6	87.3
INT HEAD3 Ry ANG VELOCITY (RAD/SEC)	0.01	6.91	-12.31	222.1	87.2
INT HEAD3 Rz ANG VELOCITY (RAD/SEC)	0.01	1.86	-0.88	96.9	93.1
INT HEAD3 ANG VELOCITY RESULTANT	0.14	12.38	0.02	87.2	5.3
INT HEAD3 Ry ANG ACCEL (RAD/SEC2)	-0.36	6704.58	-6473.72	93.0	99.8
INT NECK3 X FORCE (LB)	0.11	77.73	-35.94	98.8	258.1
INT NECK3 Y FORCE (LB)	-0.48	7.68	-5.11	88.1	99.2
INT NECK3 Z FORCE (LB)	3.66	104.23	-99.66	91.6	99.6
INT NECK3 RESULTANT (LB)	3.76	125.28	1.03	99.6	2.0
INT NECK3 Mx TORQUE (IN-LB)	-0.35	15.67	-12.03	51.3	141.8
INT NECK3 My TORQUE (IN-LB)	-0.96	99.73	-91.97	250.7	169.4
INT NECK3 Mz TORQUE (IN-LB)	-0.44	10.04	-8.99	92.7	110.1
INT NECK3 TORQUE RES (IN-LB)	1.78	99.76	0.61	250.7	1.3
INT LOWER NECK3 X FORCE (LB)	0.05	179.48	-39.67	91.1	254.2
INT LOWER NECK3 Y FORCE (LB)	0.54	22.76	-20.38	90.5	91.0
INT LOWER NECK3 Z FORCE (LB)	1.58	22.43	-169.09	91.2	99.3
INT LOWER NECK3 RESULTANT (LB)	2.27	205.15	1.61	99.0	297.2
INT LOWER NECK3 Mx TORQUE (IN-LB)	2.93	34.74	-38.20	42.9	97.9
INT LOWER NECK3 My TORQUE (IN-LB)	6.68	465.49	-1095.37	251.6	91.4
INT LOWER NECK3 Mz TORQUE (IN-LB)	4.53	54.54	-28.08	90.9	91.4
INT LOWER NECK3 TORQUE RES (IN-LB)	8.89	1095.76	2.33	91.4	295.5

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
5th NIJ SHEAR (LB)		50.47	-18.32	95.1	84.0
5th NIJ TENSION (LB)		65.30		85.9	
5th NIJ COMPRESSION (LB)		-76.50		100.4	
5th NIJ FLEXION (IN-LB)		58.59		262.0	
5th NIJ EXTENSION (IN-LB)		55.00		170.8	
5th NIJ NTF	0.0000	0.0460	0.0000	264.7	0.0
5th NIJ NTE	0.0002	0.1264	0.0000	87.1	0.0
5th NIJ NCF	0.0001	0.0999	0.0000	93.0	42.4
5th NIJ NCE	0.0029	0.1311	0.0000	104.0	0.0
5th NIJ NTF AIS >= 2		0.12			
5th NIJ NTF AIS >= 3		0.04			
5th NIJ NTF AIS >= 4		0.07			
5th NIJ NTF AIS >= 5		0.02			
5th NIJ NTE AIS >= 2		0.13			
5th NIJ NTE AIS >= 3		0.05			
5th NIJ NTE AIS >= 4		0.07			
5th NIJ NTE AIS >= 5		0.02			
5th NIJ NCF AIS >= 2		0.13			
5th NIJ NCF AIS >= 3		0.05			
5th NIJ NCF AIS >= 4		0.07			
5th NIJ NCF AIS >= 5		0.02			
5th NIJ NCE AIS >= 2		0.13			
5th NIJ NCE AIS >= 3		0.05			
5th NIJ NCE AIS >= 4		0.07			
5th NIJ NCE AIS >= 5		0.03			
50th NIJ SHEAR (LB)		78.17	-24.34	90.1	263.2
50th NIJ TENSION (LB)		139.64		81.1	
50th NIJ COMPRESSION (LB)		-118.13		88.3	
50th NIJ FLEXION (IN-LB)		109.02		88.1	
50th NIJ EXTENSION (IN-LB)		86.07		172.5	
50th NIJ NTF	0.0000	0.0629	0.0000	82.2	0.0
50th NIJ NTE	0.0000	0.0971	0.0000	80.9	0.0
50th NIJ NCF	0.0000	0.1246	0.0000	88.3	0.0
50th NIJ NCE	0.0041	0.1256	0.0000	101.0	4.9
50th NIJ NTF AIS >= 2		0.12			
50th NIJ NTF AIS >= 3		0.04			
50th NIJ NTF AIS >= 4		0.07			
50th NIJ NTF AIS >= 5		0.02			
50th NIJ NTE AIS >= 2		0.13			
50th NIJ NTE AIS >= 3		0.05			
50th NIJ NTE AIS >= 4		0.07			
50th NIJ NTE AIS >= 5		0.02			

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
50th NIJ NCF AIS >= 2		0.13			
50th NIJ NCF AIS >= 3		0.05			
50th NIJ NCF AIS >= 4		0.07			
50th NIJ NCF AIS >= 5		0.02			
50th NIJ NCE AIS >= 2		0.13			
50th NIJ NCE AIS >= 3		0.05			
50th NIJ NCE AIS >= 4		0.07			
50th NIJ NCE AIS >= 5		0.02			
95th NIJ SHEAR (LB)		77.73	-35.94	98.8	258.1
95th NIJ TENSION (LB)		104.23		91.6	
95th NIJ COMPRESSION (LB)		-99.66		99.6	
95th NIJ FLEXION (IN-LB)		124.02		250.7	
95th NIJ EXTENSION (IN-LB)		110.96		169.4	
95th NIJ NTF	0.0003	0.0372	0.0000	247.0	0.0
95th NIJ NTE	0.0024	0.0980	0.0000	90.0	1.6
95th NIJ NCF	0.0000	0.0648	0.0000	99.0	0.0
95th NIJ NCE	0.0000	0.1055	0.0000	107.0	0.0
95th NIJ NTF AIS >= 2		0.12			
95th NIJ NTF AIS >= 3		0.04			
95th NIJ NTF AIS >= 4		0.07			
95th NIJ NTF AIS >= 5		0.02			
95th NIJ NTE AIS >= 2		0.13			
95th NIJ NTE AIS >= 3		0.05			
95th NIJ NTE AIS >= 4		0.07			
95th NIJ NTE AIS >= 5		0.02			
95th NIJ NCF AIS >= 2		0.12			
95th NIJ NCF AIS >= 3		0.04			
95th NIJ NCF AIS >= 4		0.07			
95th NIJ NCF AIS >= 5		0.02			
95th NIJ NCE AIS >= 2		0.13			
95th NIJ NCE AIS >= 3		0.05			
95th NIJ NCE AIS >= 4		0.07			

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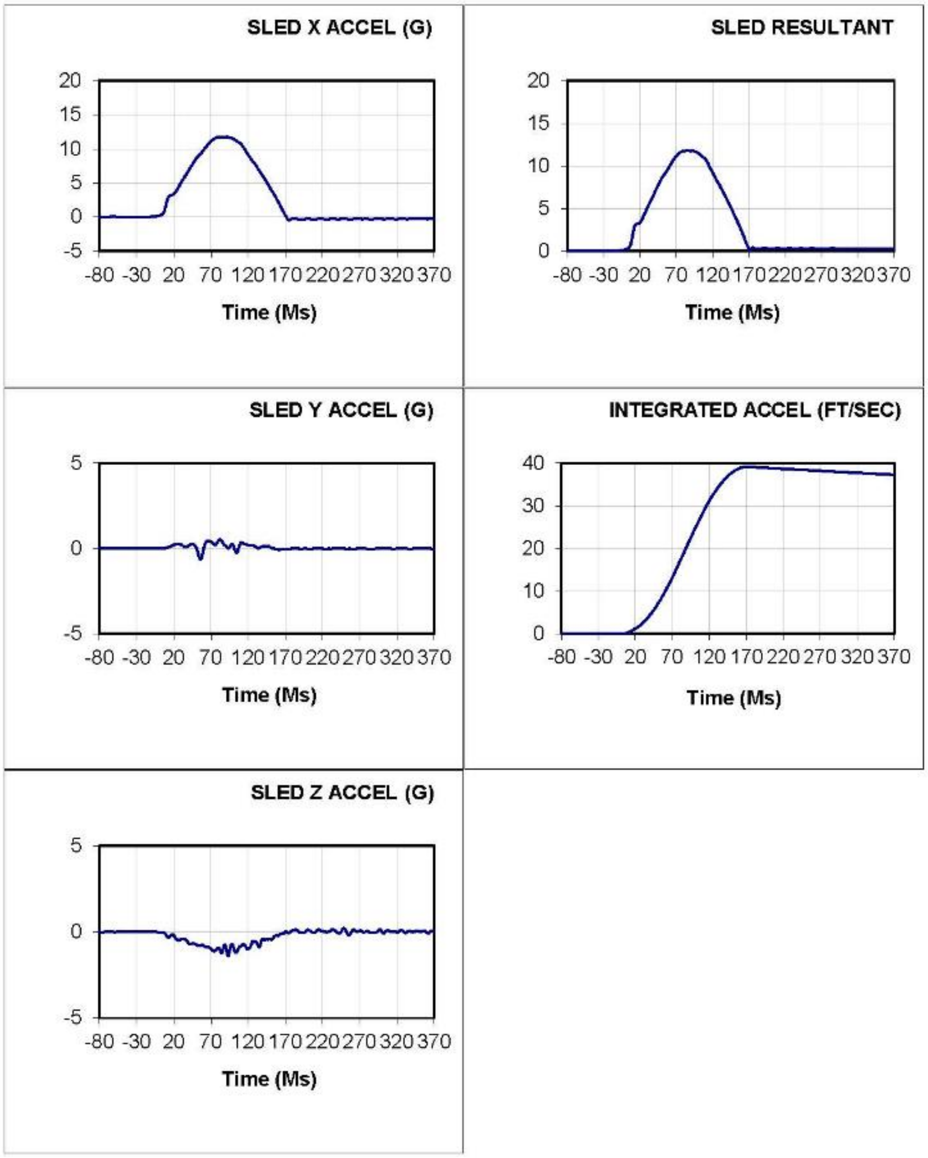

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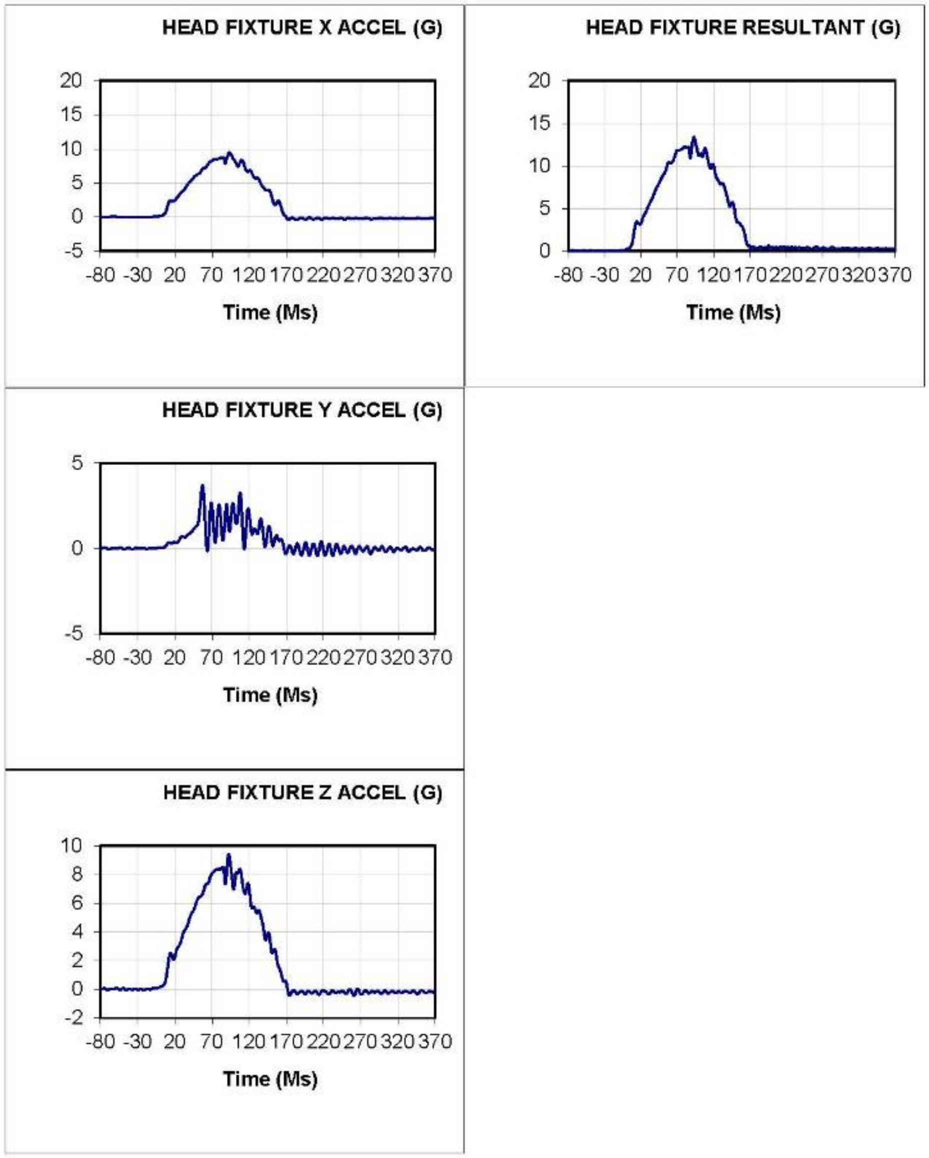
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD



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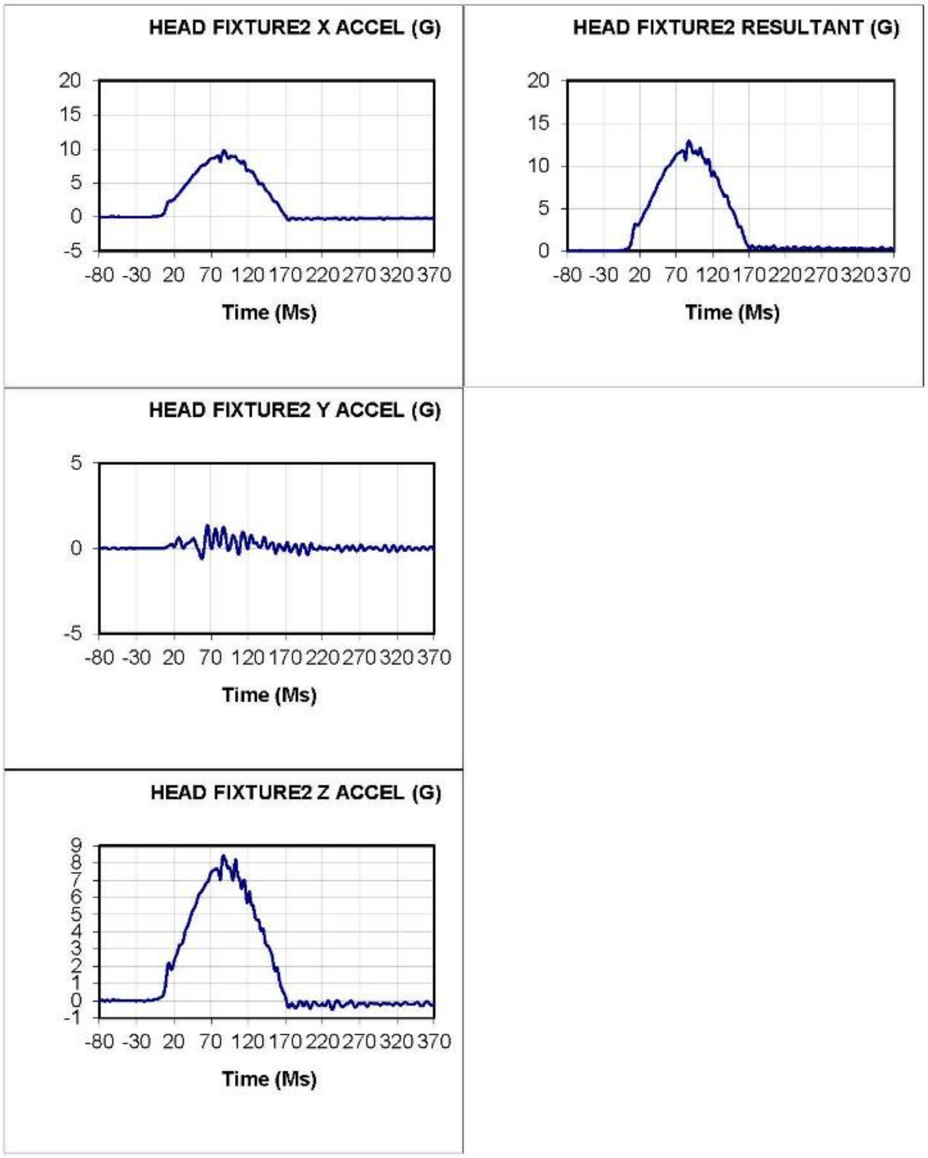
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD



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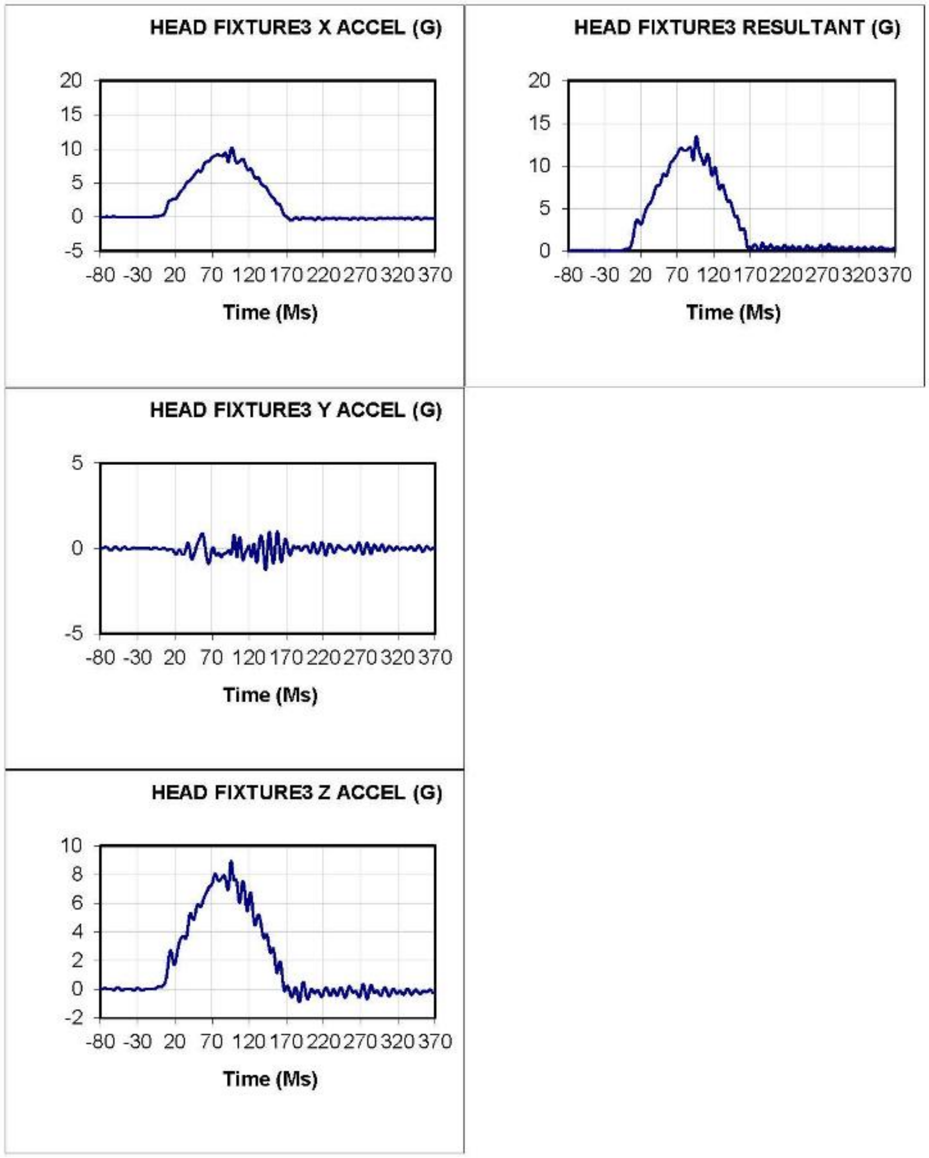
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD



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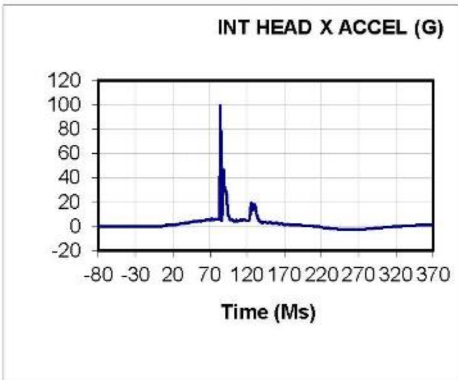
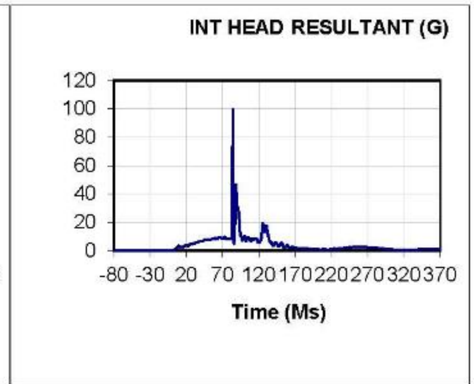
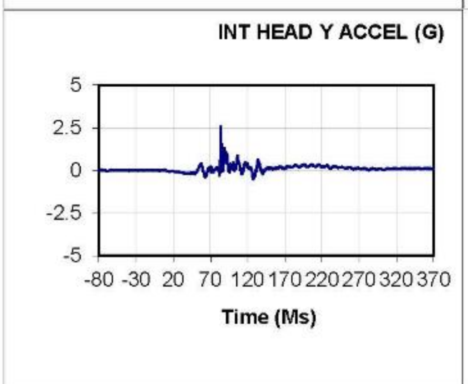
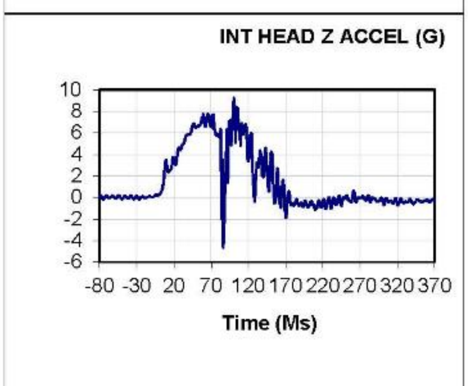
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD









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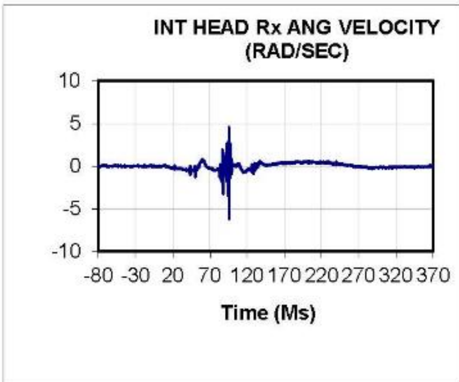

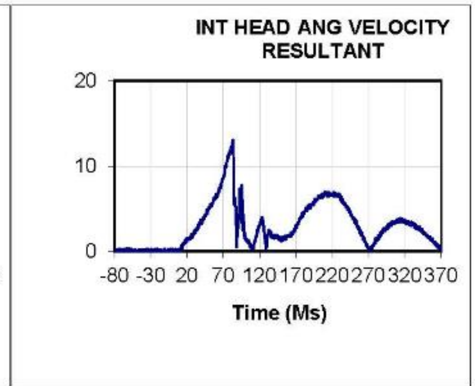

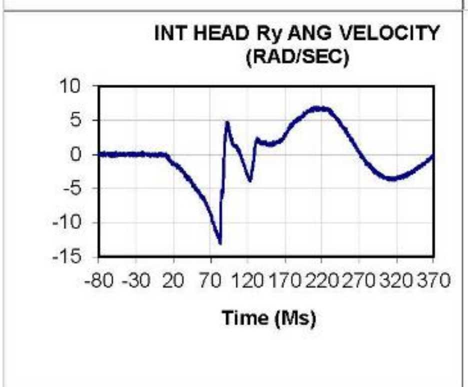

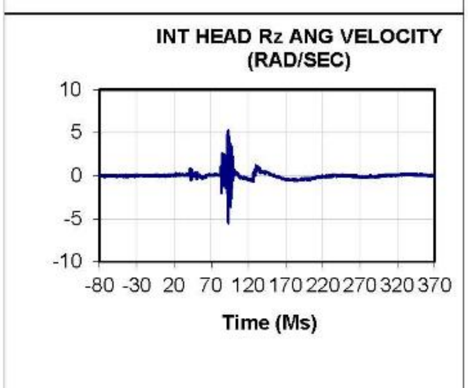

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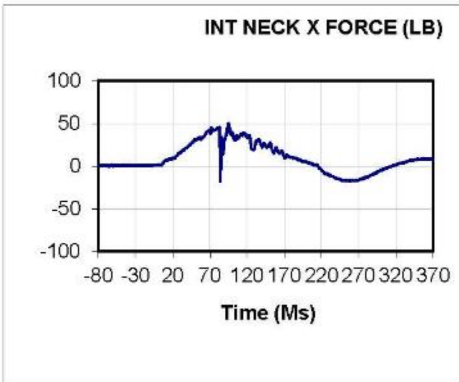

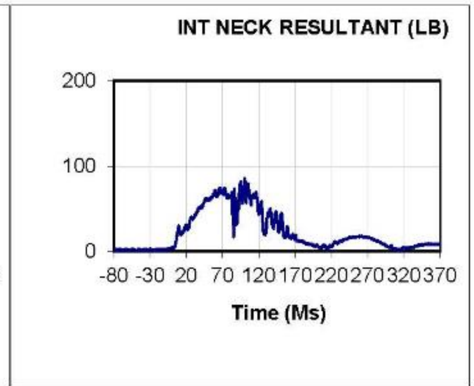

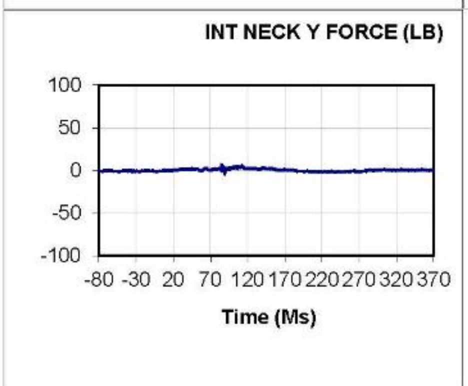

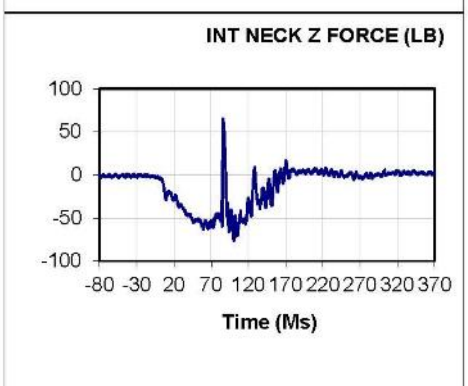

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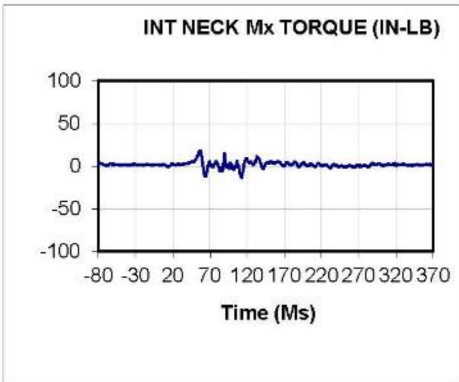
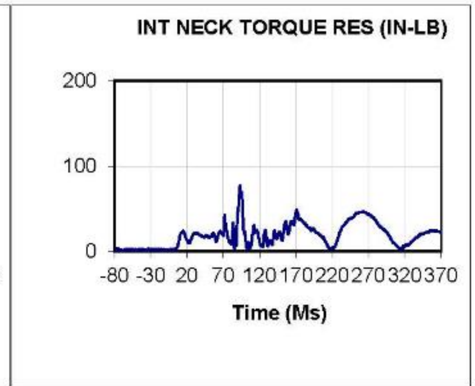
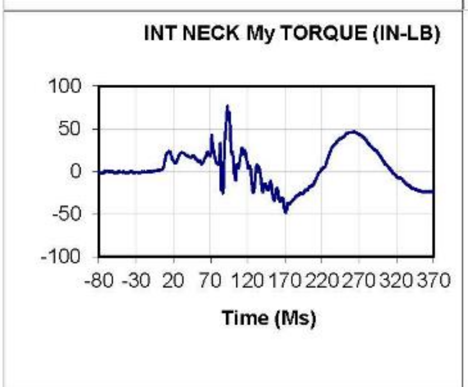
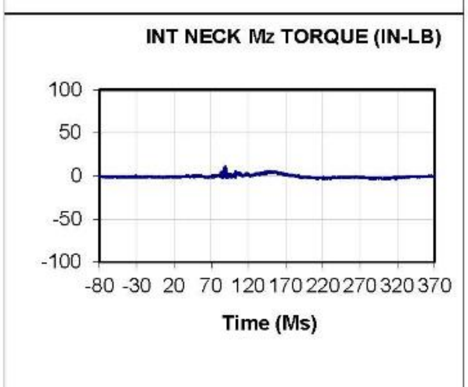
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD









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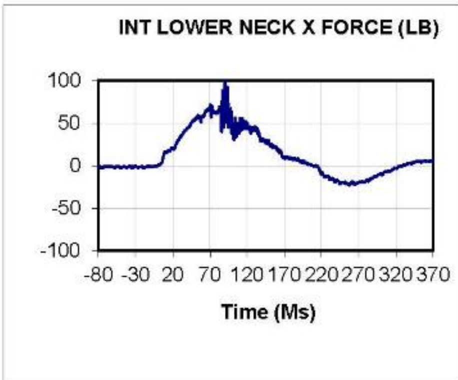
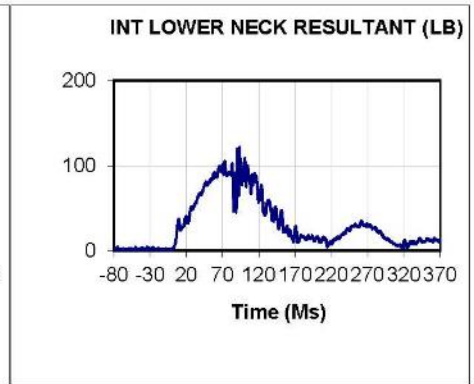
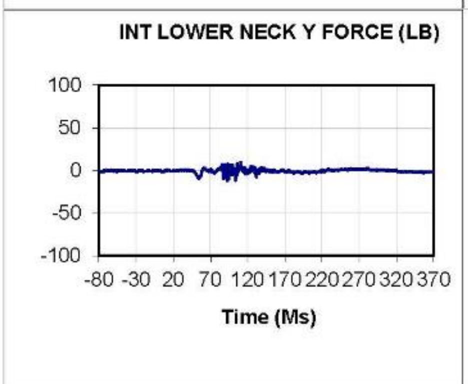
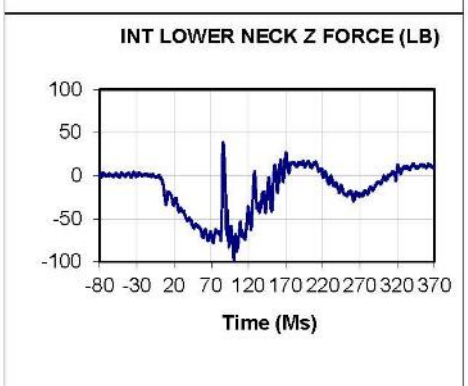
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD









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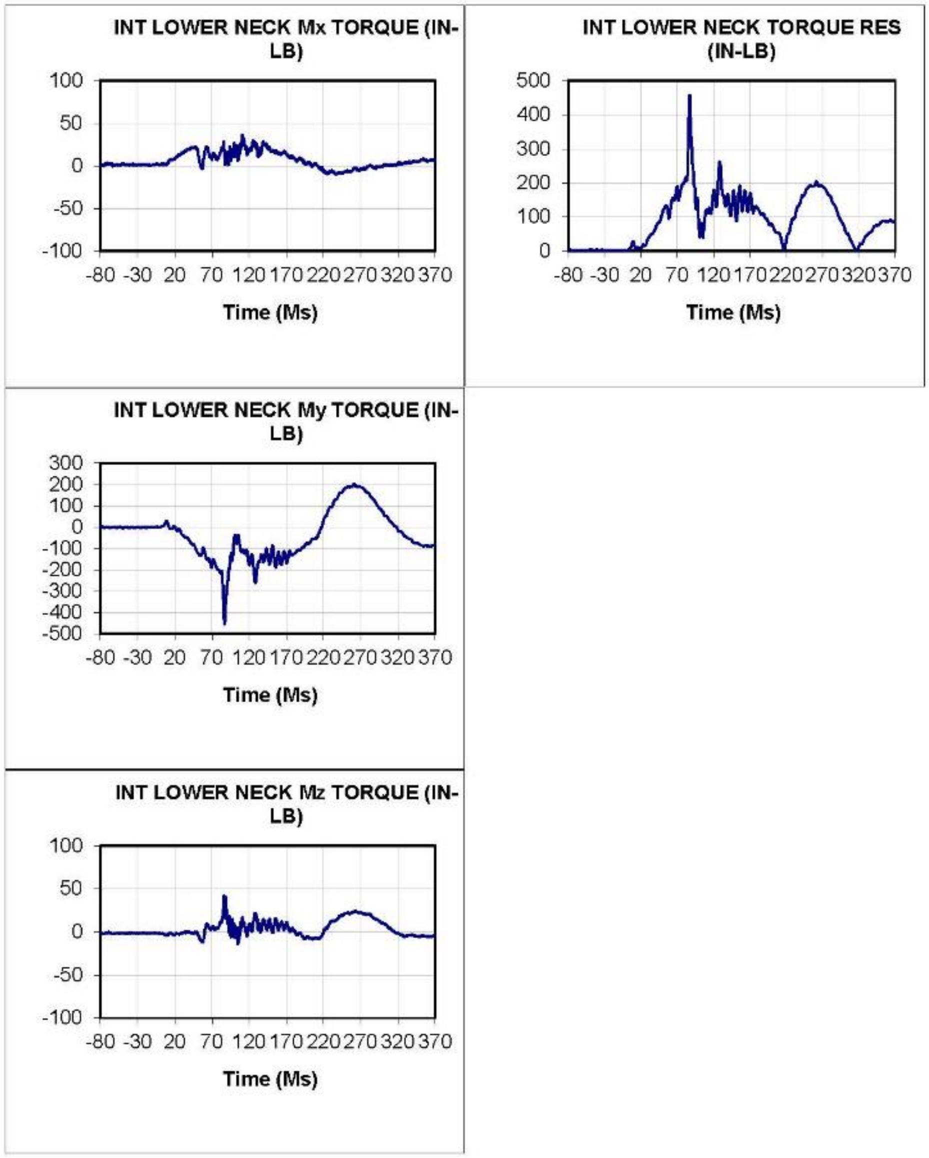
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD



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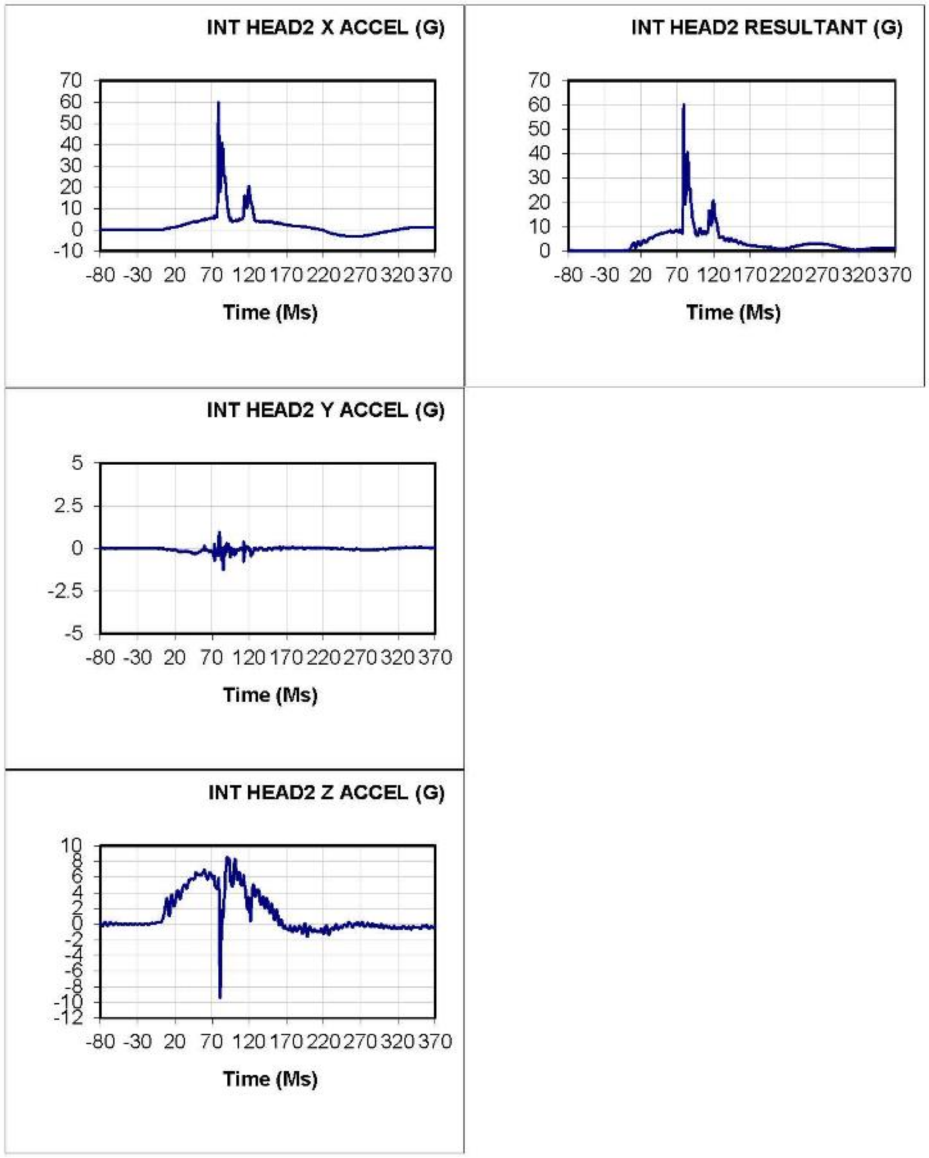
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD



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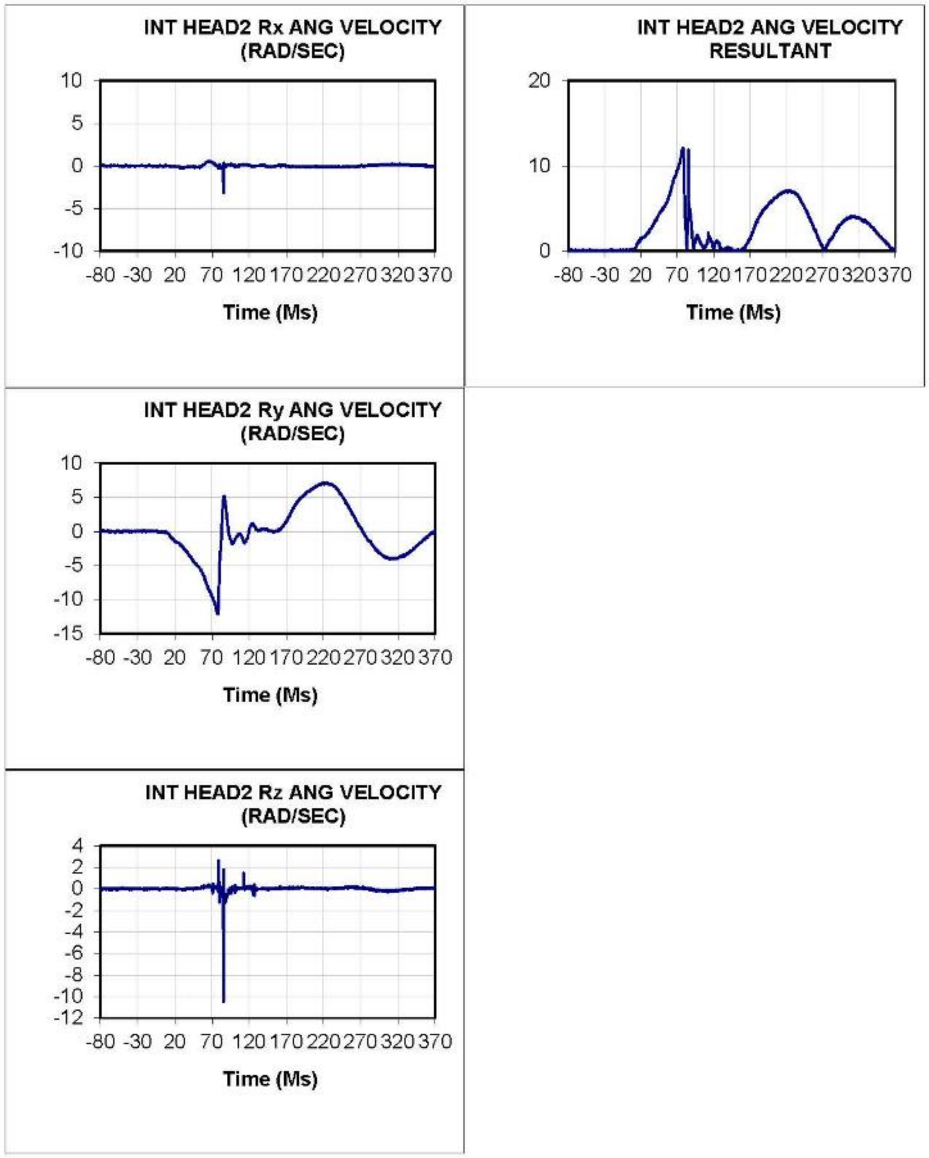
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD



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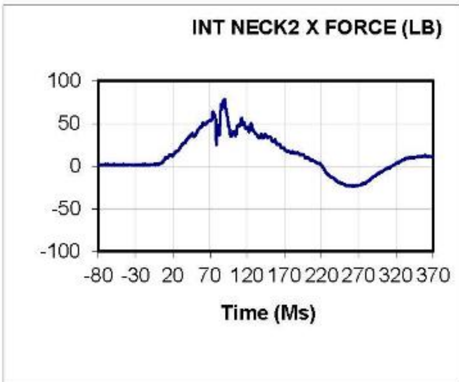
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-50
-100
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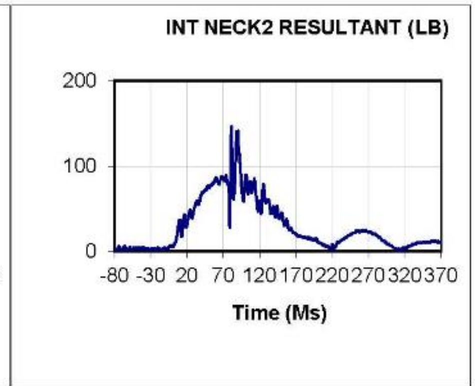
Time (Ms)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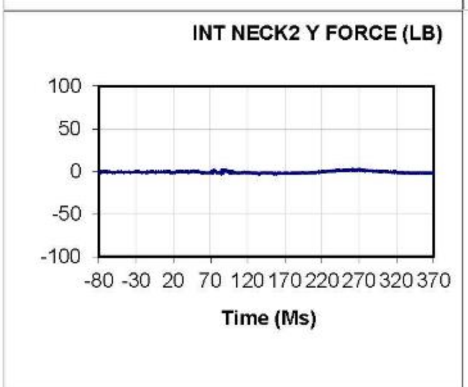
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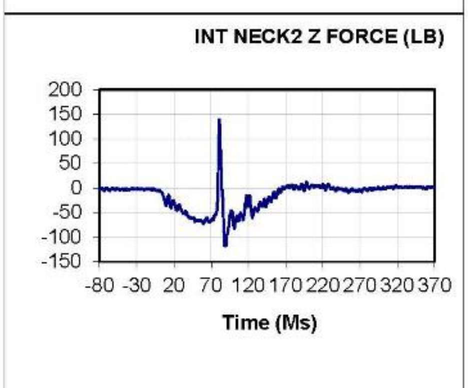
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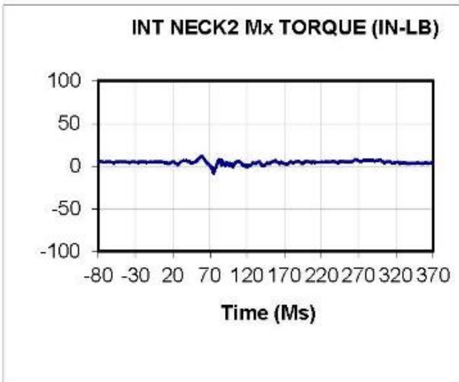
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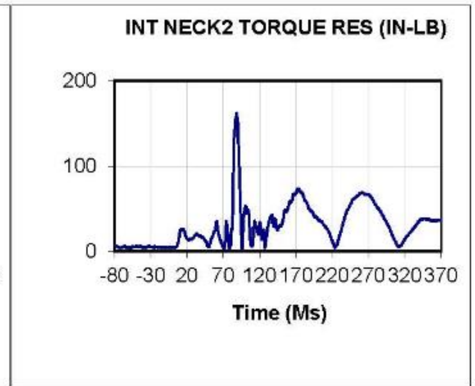
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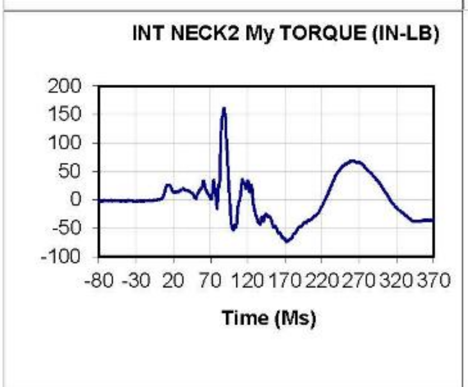
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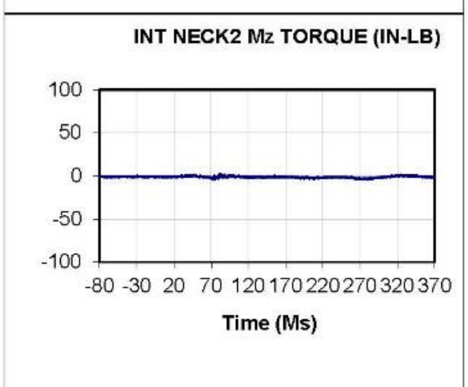
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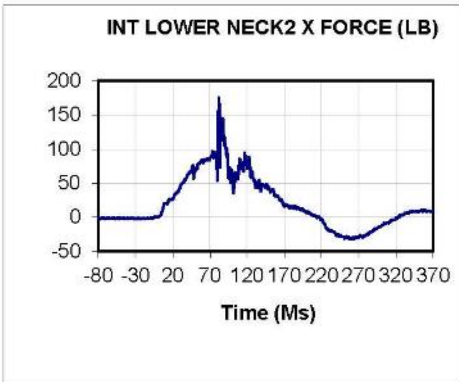
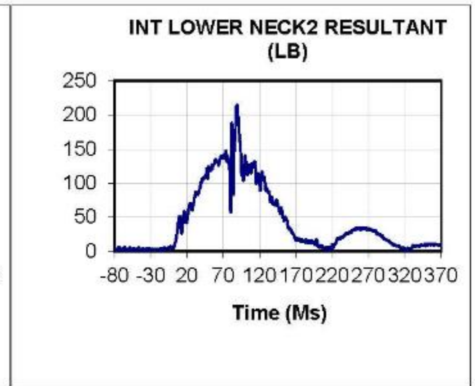
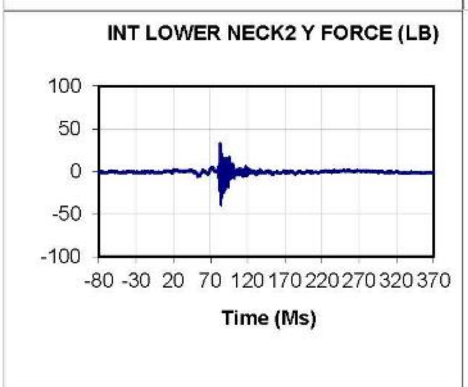
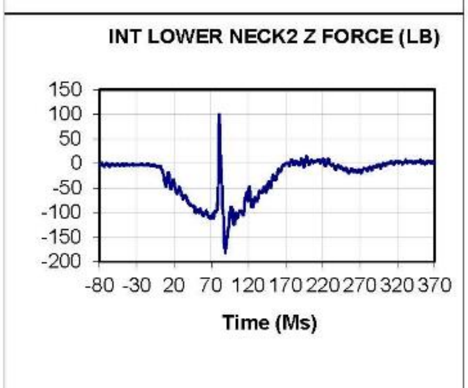
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD









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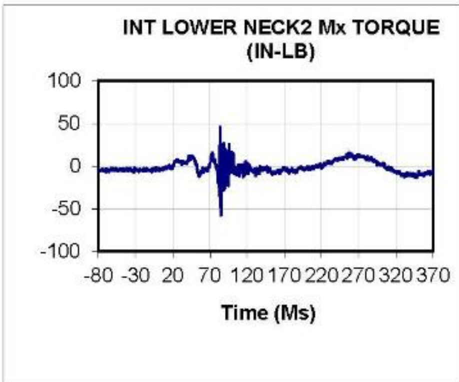

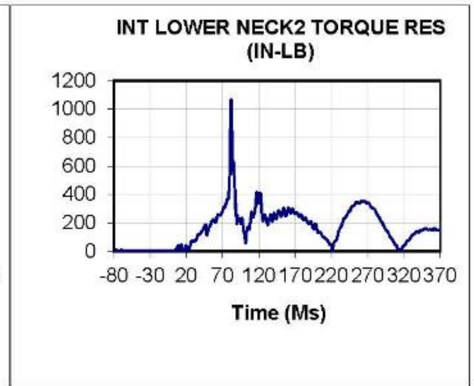

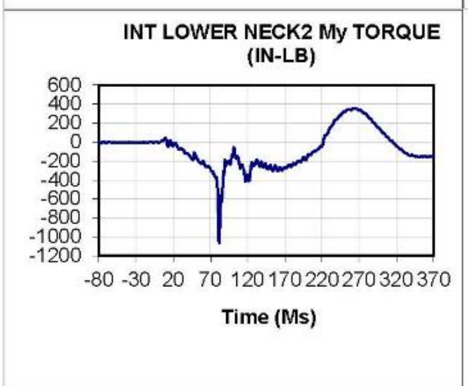

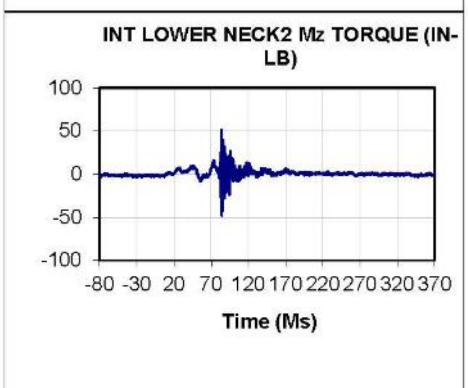

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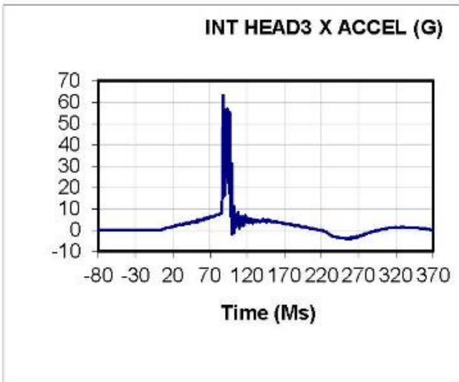

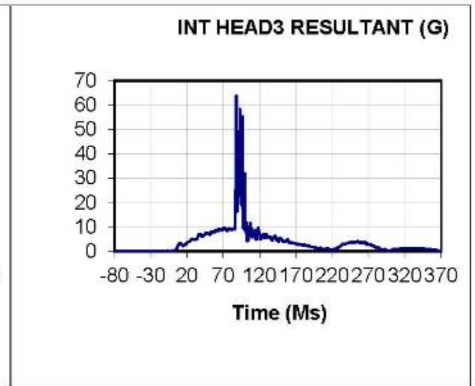

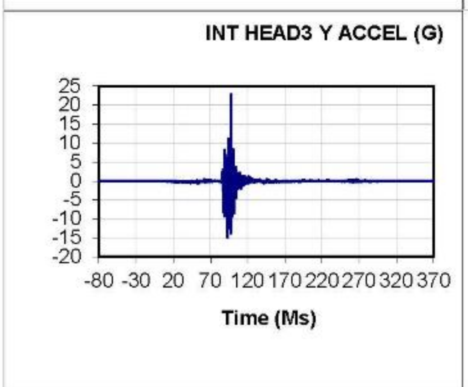

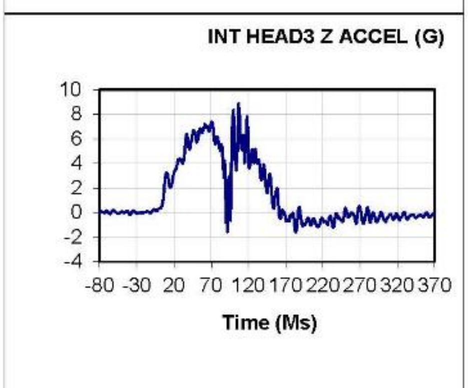

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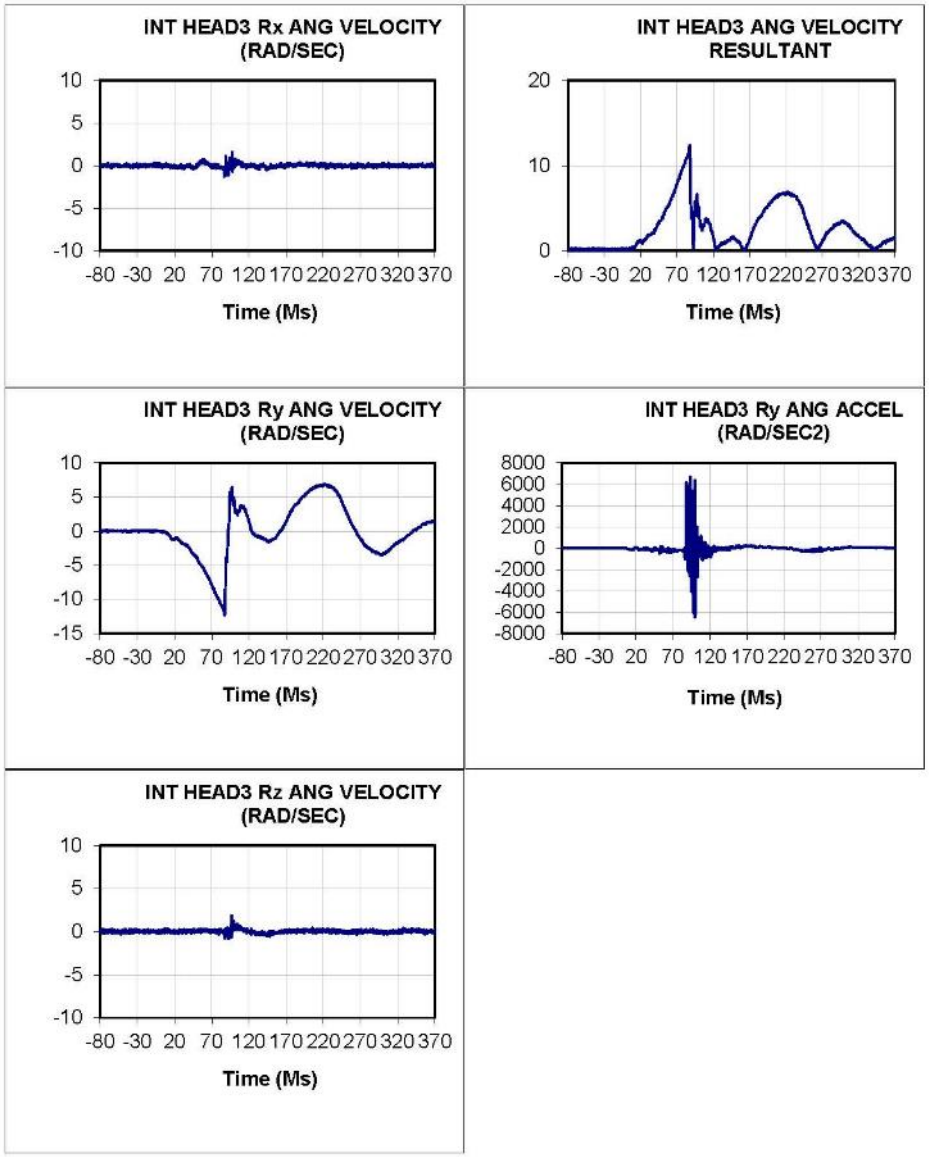

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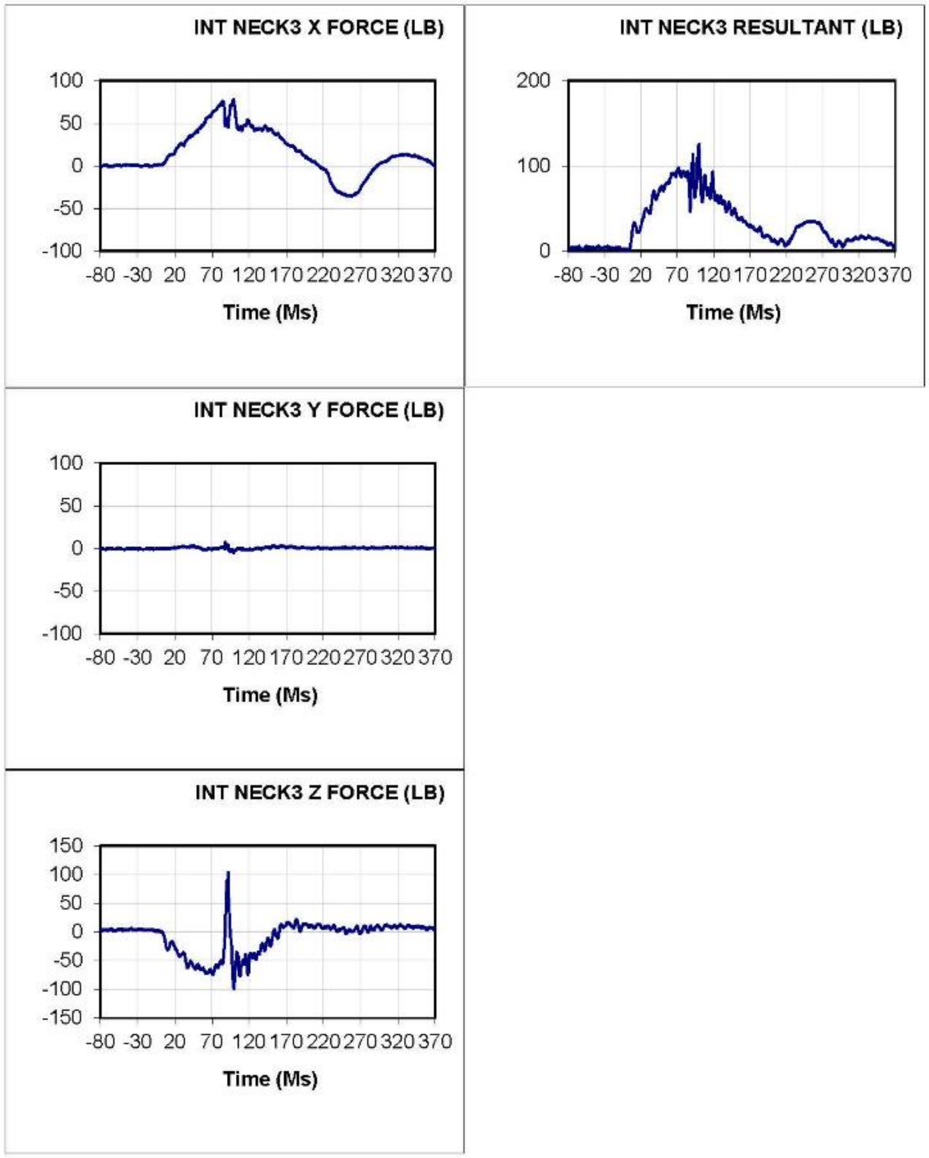
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD



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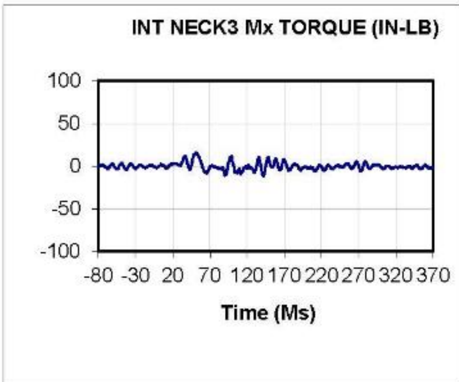

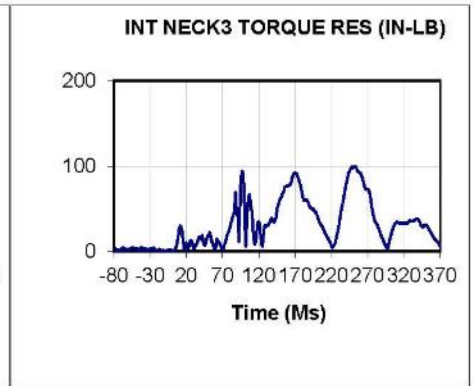

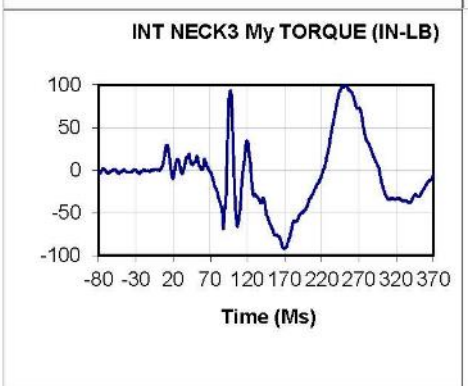

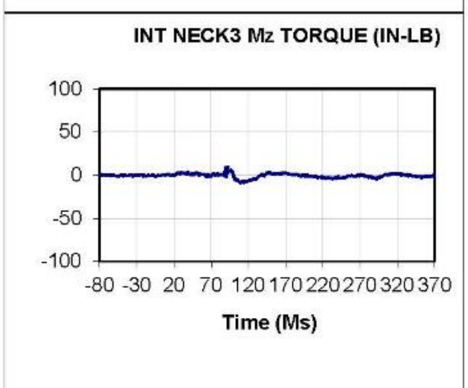

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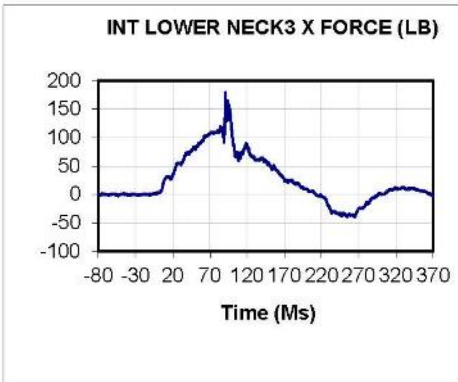
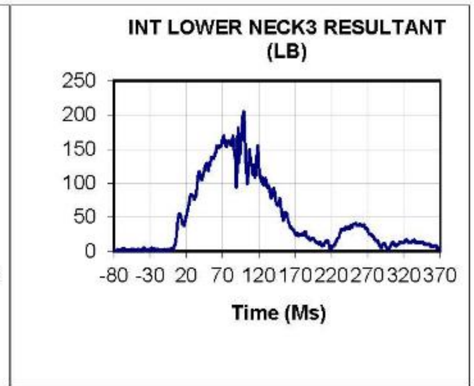
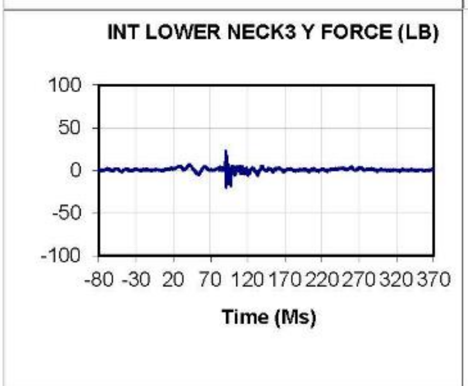
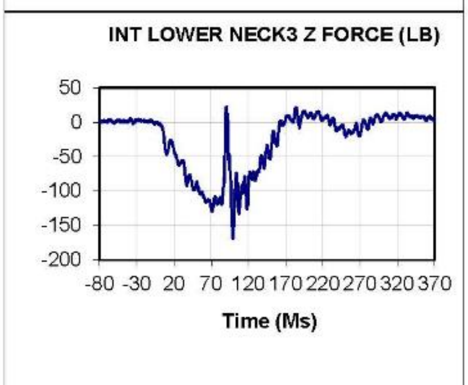
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD









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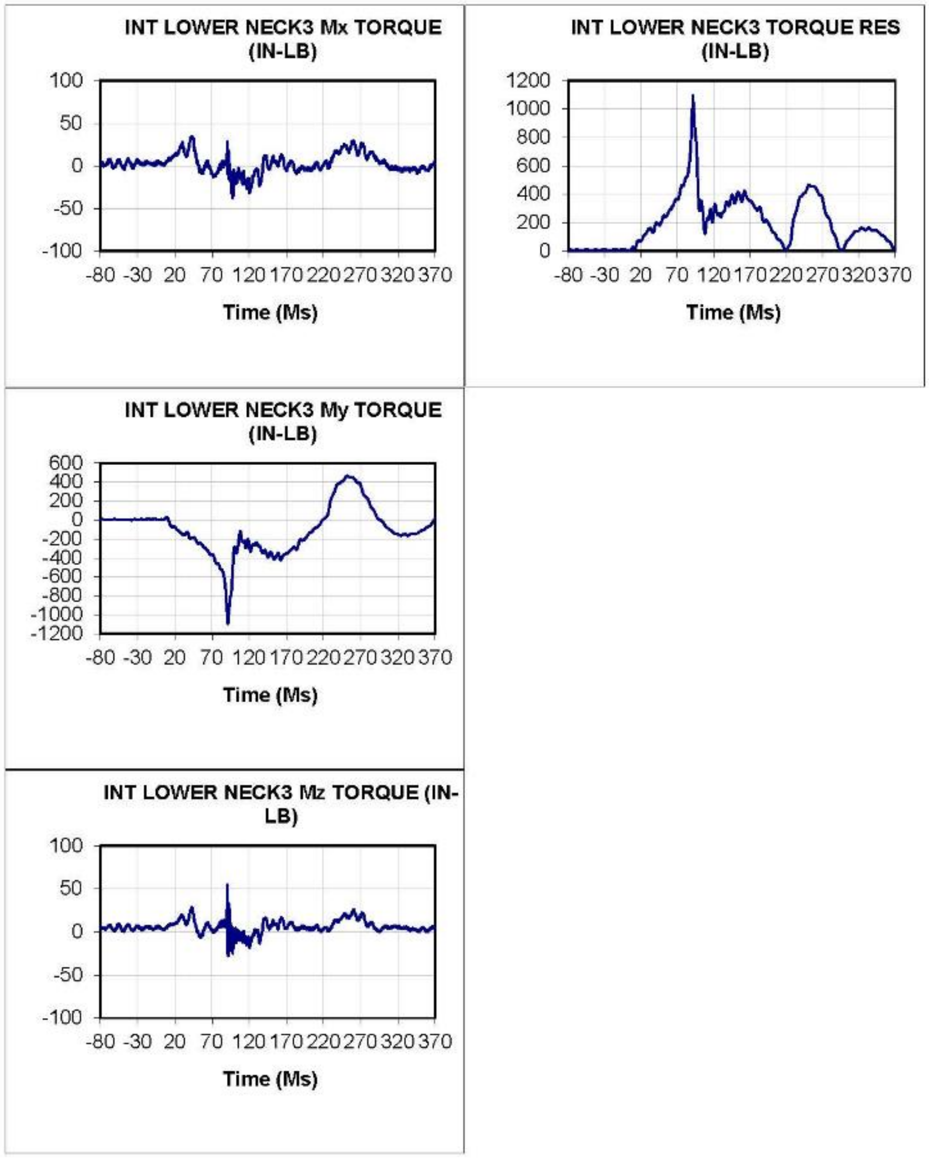
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD



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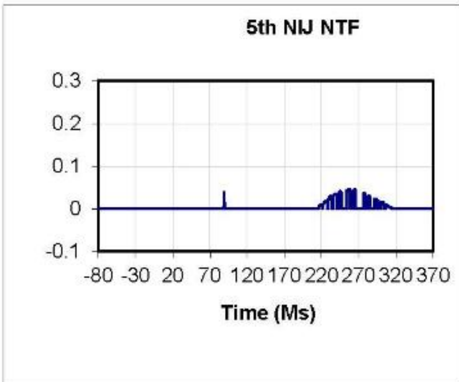

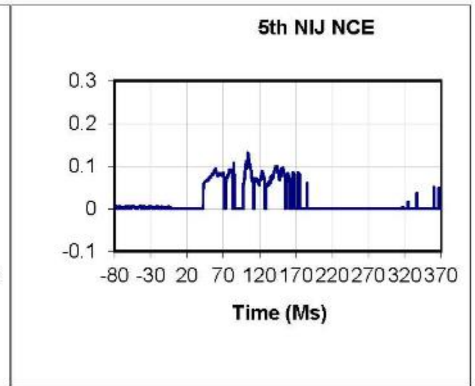

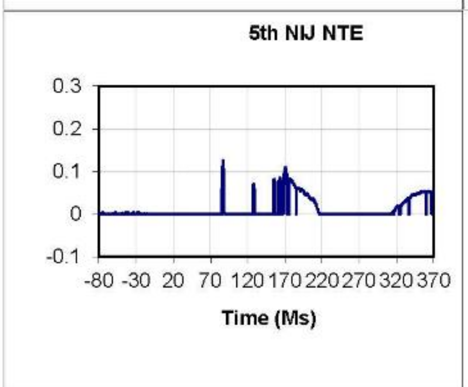

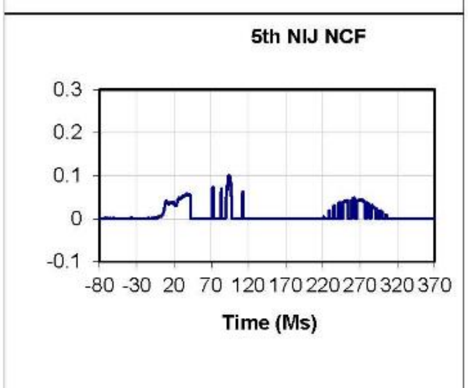

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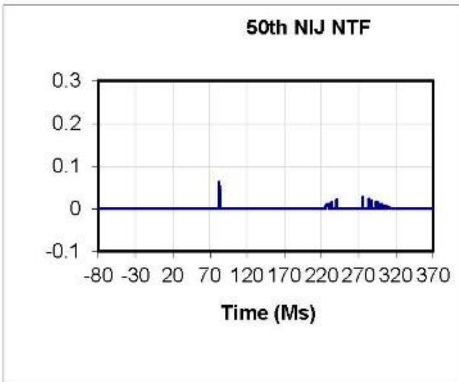
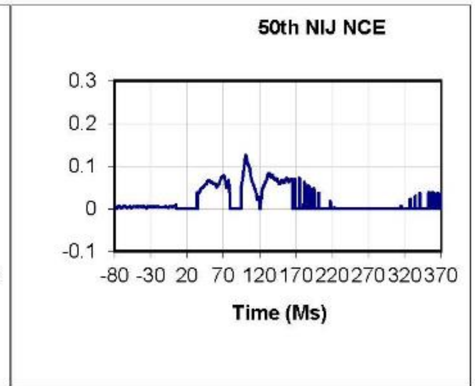
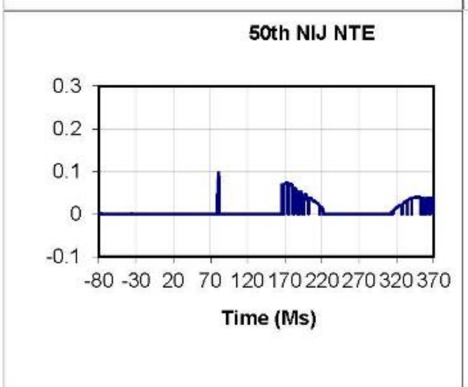
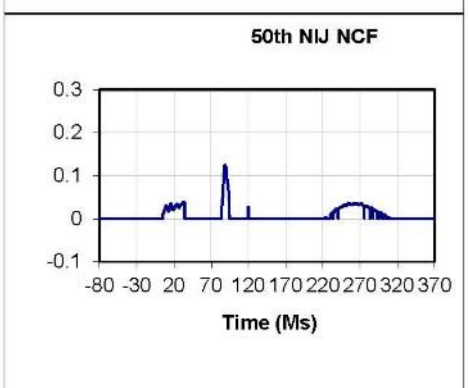
201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD

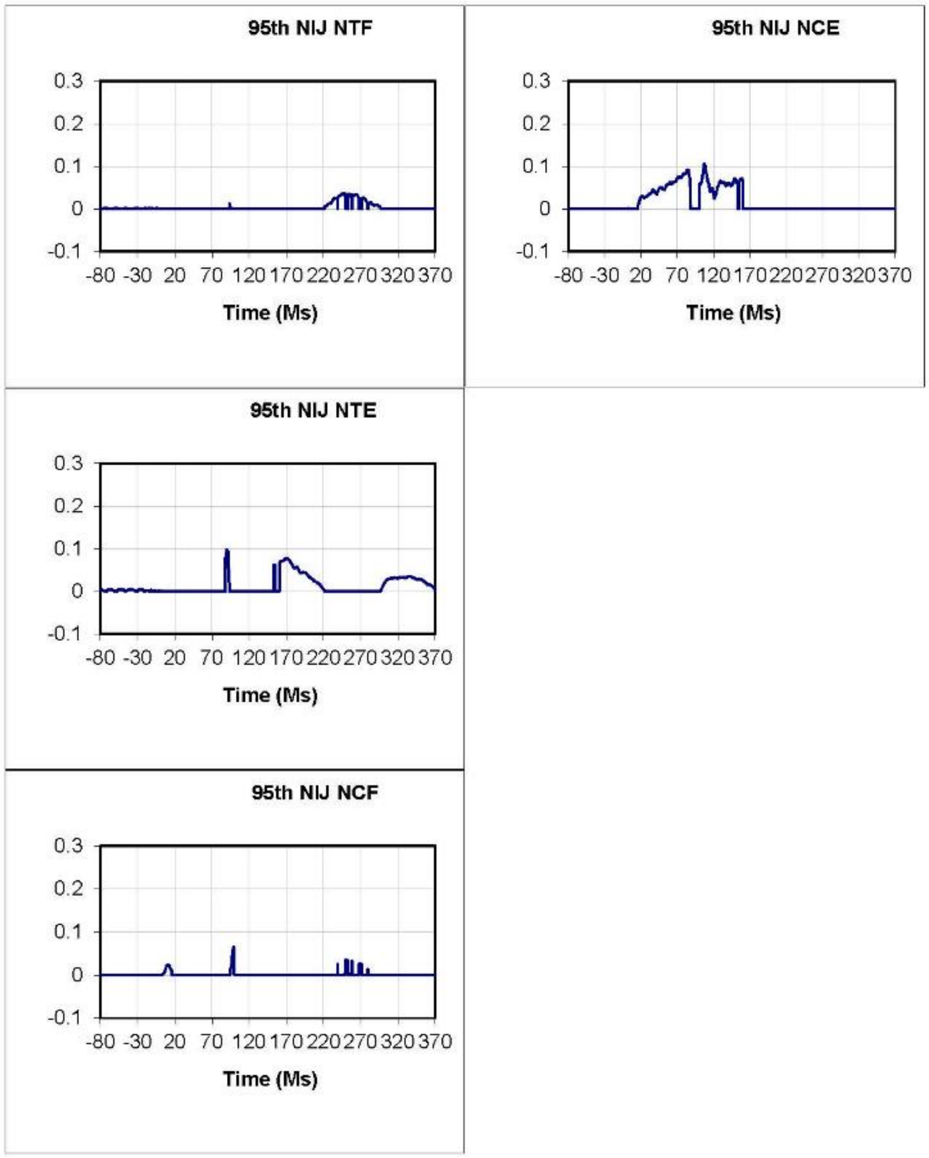








201809 Test: 9710 Test Date: 181002 Subj: H3HEADS Cell: DD



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201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: GG

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				19.3	
Impact Rise Time (Ms)				86.2	
Impact Duration (Ms)				170.3	
Velocity Change (Ft/Sec)		39.53			
SLED X ACCEL (G)	0.02	11.93	-0.40	86.2	174.4
SLED Y ACCEL (G)	0.00	0.54	-0.69	82.0	55.6
SLED Z ACCEL (G)	0.00	0.22	-1.13	246.7	84.3
SLED RESULTANT	0.02	11.98	0.02	85.9	170.3
INTEGRATED ACCEL (FT/SEC)	-0.01	39.53	0.02	170.3	0.0
HEAD FIXTURE X ACCEL (G)	0.02	9.00	-0.36	94.5	179.7
HEAD FIXTURE Y ACCEL (G)	0.00	3.64	-0.39	56.7	180.5
HEAD FIXTURE Z ACCEL (G)	0.01	8.66	-0.40	83.1	260.1
HEAD FIXTURE RESULTANT (G)	0.03	12.61	0.19	95.3	291.2
HEAD FIXTURE2 X ACCEL (G)	0.02	9.33	-0.34	91.6	177.8
HEAD FIXTURE2 Y ACCEL (G)	0.00	1.56	-0.92	79.8	57.5
HEAD FIXTURE2 Z ACCEL (G)	0.02	8.25	-0.55	91.2	246.9
HEAD FIXTURE2 RESULTANT (G)	0.03	12.48	0.16	91.2	356.4
HEAD FIXTURE3 X ACCEL (G)	0.02	11.55	-1.75	87.4	174.8
HEAD FIXTURE3 Y ACCEL (G)	0.01	1.06	-0.64	176.7	76.6
HEAD FIXTURE3 Z ACCEL (G)	0.01	4.37	-0.75	76.4	190.7
HEAD FIXTURE3 RESULTANT (G)	0.04	12.30	0.17	87.4	193.8
INT HEAD X ACCEL (G)	0.01	26.72	-2.49	98.5	263.9
INT HEAD Y ACCEL (G)	0.00	0.65	-0.49	73.7	116.2
INT HEAD Z ACCEL (G)	0.03	8.12	-1.38	58.7	220.4
INT HEAD RESULTANT (G)	0.04	26.72	0.33	98.5	0.2
INT HEAD HIC		50.68		82.8	112.3
INT HEAD Ry ANG VELOCITY (RAD/SEC)	0.00	6.20	-3.86	100.2	101.0
INT HEAD Ry ANG VELOCITY (RAD/SEC)	-0.02	8.26	-15.18	229.5	84.4
INT HEAD Rz ANG VELOCITY (RAD/SEC)	-0.01	7.45	-10.73	100.9	100.0
INT HEAD ANG VELOCITY RESULTANT	0.12	15.22	0.03	84.4	3.1
INT NECK X FORCE (LB)	0.49	58.17	-19.63	74.3	271.0
INT NECK Y FORCE (LB)	-0.19	9.10	-1.94	99.9	73.7
INT NECK Z FORCE (LB)	-0.32	10.38	-70.13	220.7	59.7
INT NECK RESULTANT (LB)	0.93	84.46	1.00	67.2	236.8

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201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: GG

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT NECK Mx TORQUE (IN-LB)	0.92	12.85	-14.21	72.1	64.4
INT NECK My TORQUE (IN-LB)	0.07	61.79	-54.31	291.3	170.9
INT NECK Mz TORQUE (IN-LB)	-0.52	11.62	-6.22	106.2	105.5
INT NECK TORQUE RES (IN-LB)	1.15	61.81	1.83	291.3	1.1
INT LOWER NECK X FORCE (LB)	-0.15	91.25	-24.96	73.4	282.1
INT LOWER NECK Y FORCE (LB)	0.28	6.36	-7.87	99.6	53.1
INT LOWER NECK Z FORCE (LB)	0.40	21.36	-87.96	190.5	75.7
INT LOWER NECK RESULTANT (LB)	1.00	122.35	1.92	73.5	347.8
INT LOWER NECK Mx TORQUE (IN-LB)	0.92	25.58	-8.19	142.5	240.4
INT LOWER NECK My TORQUE (IN-LB)	0.29	227.52	-347.09	285.7	87.2
INT LOWER NECK Mz TORQUE (IN-LB)	-0.70	29.88	-13.84	92.8	58.3
INT LOWER NECK TORQUE RES (IN-LB)	1.37	348.42	2.27	87.3	2.3
INT HEAD2 X ACCEL (G)	0.02	28.24	-2.71	90.0	261.8
INT HEAD2 Y ACCEL (G)	0.00	0.66	-1.27	75.4	78.7
INT HEAD2 Z ACCEL (G)	0.03	7.48	-1.22	52.1	227.9
INT HEAD2 RESULTANT (G)	0.05	28.31	0.27	90.0	0.2
INT HEAD2 HIC		56.75		77.4	99.2
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	0.00	0.57	-0.38	89.7	101.3
INT HEAD2 Ry ANG VELOCITY (RAD/SEC)	-0.01	7.51	-12.93	218.5	77.6
INT HEAD2 Rz ANG VELOCITY (RAD/SEC)	0.00	1.51	-0.63	90.2	89.8
INT HEAD2 ANG VELOCITY RESULTANT	0.07	12.93	0.02	77.6	3.2
INT NECK2 X FORCE (LB)	0.93	65.14	-25.21	76.4	264.3
INT NECK2 Y FORCE (LB)	-0.27	4.49	-3.19	262.4	165.8
INT NECK2 Z FORCE (LB)	-2.05	8.83	-88.49	168.9	97.0
INT NECK2 RESULTANT (LB)	2.34	99.21	0.19	97.0	328.7
INT NECK2 Mx TORQUE (IN-LB)	3.80	12.81	-5.50	59.7	144.7
INT NECK2 My TORQUE (IN-LB)	-0.72	81.80	-78.64	271.5	170.1
INT NECK2 Mz TORQUE (IN-LB)	-0.35	2.51	-6.33	65.4	121.4
INT NECK2 TORQUE RES (IN-LB)	3.91	82.19	1.52	271.5	94.5
INT LOWER NECK2 X FORCE (LB)	0.01	111.08	-31.53	83.4	259.8
INT LOWER NECK2 Y FORCE (LB)	-0.44	9.31	-7.54	85.8	54.2
INT LOWER NECK2 Z FORCE (LB)	-0.84	12.33	-136.79	348.0	97.1
INT LOWER NECK2 RESULTANT (LB)	1.46	156.50	1.88	96.6	223.0

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Nom G: 12.0 Cell: GG

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
INT LOWER NECK2 Mx TORQUE (IN-LB)	-2.67	31.47	-16.81	87.6	110.4
INT LOWER NECK2 My TORQUE (IN-LB)	-0.17	366.85	-519.81	271.5	83.8
INT LOWER NECK2 Mz TORQUE (IN-LB)	-0.05	29.38	-10.56	84.1	118.0
INT LOWER NECK2 TORQUE RES (IN-LB)	3.23	520.49	1.46	83.9	0.7
INT HEAD3 X ACCEL (G)	0.00	4.41	-17.03	240.9	108.5
INT HEAD3 Y ACCEL (G)	0.00	0.86	-0.62	104.2	187.8
INT HEAD3 Z ACCEL (G)	0.00	2.62	-5.89	171.5	95.1
INT HEAD3 RESULTANT (G)	0.03	17.87	0.07	108.5	0.2
INT HEAD3 HIC		36.21		90.6	120.6
INT HEAD3 Rx ANG VELOCITY (RAD/SEC)	0.02	1.06	-1.32	81.2	179.5
INT HEAD3 Ry ANG VELOCITY (RAD/SEC)	0.03	10.81	-14.25	76.2	187.5
INT HEAD3 Rz ANG VELOCITY (RAD/SEC)	-0.01	0.50	-0.44	242.5	141.0
INT HEAD3 ANG VELOCITY RESULTANT	0.16	14.25	0.09	187.5	119.0
INT HEAD3 Ry ANG ACCEL (RAD/SEC2)	2.05	569.50	-452.06	196.8	119.9
INT NECK3 X FORCE (LB)	-0.46	39.74	-157.98	241.5	104.3
INT NECK3 Y FORCE (LB)	0.24	8.36	-6.05	223.8	104.6
INT NECK3 Z FORCE (LB)	2.96	51.90	-22.71	95.2	171.6
INT NECK3 RESULTANT (LB)	3.05	165.52	2.12	104.9	3.0
INT NECK3 Mx TORQUE (IN-LB)	-0.10	15.35	-15.67	183.6	174.4
INT NECK3 My TORQUE (IN-LB)	-0.76	292.68	-111.51	109.5	234.7
INT NECK3 Mz TORQUE (IN-LB)	-0.47	4.68	-6.59	221.4	63.8
INT NECK3 TORQUE RES (IN-LB)	1.12	292.88	0.70	109.5	320.2
INT LOWER NECK3 X FORCE (LB)	-0.13	42.75	-212.56	247.4	95.8
INT LOWER NECK3 Y FORCE (LB)	0.62	10.09	-6.32	171.5	122.2
INT LOWER NECK3 Z FORCE (LB)	1.46	36.30	-142.11	186.5	112.0
INT LOWER NECK3 RESULTANT (LB)	1.83	247.84	2.27	103.7	0.4
INT LOWER NECK3 Mx TORQUE (IN-LB)	3.70	35.12	-36.00	221.3	272.9
INT LOWER NECK3 My TORQUE (IN-LB)	4.96	2145.69	-497.56	107.1	246.7
INT LOWER NECK3 Mz TORQUE (IN-LB)	3.16	34.87	-7.18	210.5	272.9
INT LOWER NECK3 TORQUE RES (IN-LB)	7.16	2145.91	11.20	107.1	326.0

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Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
5th NIJ SHEAR (LB)		58.17	-19.63	74.3	271.0
5th NIJ TENSION (LB)		10.38		220.7	
5th NIJ COMPRESSION (LB)		-70.13		59.7	
5th NIJ FLEXION (IN-LB)		74.67		286.7	
5th NIJ EXTENSION (IN-LB)		65.95		171.2	
5th NIJ NTF	0.0000	0.0605	0.0000	281.5	0.0
5th NIJ NTE	0.0003	0.1193	0.0000	171.3	0.0
5th NIJ NCF	0.0002	0.0733	0.0000	74.4	39.7
5th NIJ NCE	0.0008	0.1676	0.0000	99.9	0.0
5th NIJ NTF AIS >= 2		0.12			
5th NIJ NTF AIS >= 3		0.04			
5th NIJ NTF AIS >= 4		0.07			
5th NIJ NTF AIS >= 5		0.02			
5th NIJ NTE AIS >= 2		0.13			
5th NIJ NTE AIS >= 3		0.05			
5th NIJ NTE AIS >= 4		0.07			
5th NIJ NTE AIS >= 5		0.02			
5th NIJ NCF AIS >= 2		0.12			
5th NIJ NCF AIS >= 3		0.04			
5th NIJ NCF AIS >= 4		0.07			
5th NIJ NCF AIS >= 5		0.02			
5th NIJ NCE AIS >= 2		0.14			
5th NIJ NCE AIS >= 3		0.05			
5th NIJ NCE AIS >= 4		0.08			
5th NIJ NCE AIS >= 5		0.03			
50th NIJ SHEAR (LB)		65.14	-25.21	76.4	264.3
50th NIJ TENSION (LB)		8.83		168.9	
50th NIJ COMPRESSION (LB)		-88.49		97.0	
50th NIJ FLEXION (IN-LB)		99.03		271.2	
50th NIJ EXTENSION (IN-LB)		93.42		104.6	
50th NIJ NTF	0.0000	0.0370	0.0000	276.2	0.0
50th NIJ NTE	0.0000	0.0819	0.0000	168.9	0.0
50th NIJ NCF	0.0000	0.0391	0.0000	271.2	0.0
50th NIJ NCE	0.0026	0.1338	0.0000	105.1	0.2
50th NIJ NTF AIS >= 2		0.12			
50th NIJ NTF AIS >= 3		0.04			
50th NIJ NTF AIS >= 4		0.07			
50th NIJ NTF AIS >= 5		0.02			
50th NIJ NTE AIS >= 2		0.12			
50th NIJ NTE AIS >= 3		0.04			
50th NIJ NTE AIS >= 4		0.07			
50th NIJ NTE AIS >= 5		0.02			

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201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Wt: 273.0
Nom G: 12.0 Cell: GG

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
50th NIJ NCF AIS >= 2		0.12			
50th NIJ NCF AIS >= 3		0.04			
50th NIJ NCF AIS >= 4		0.07			
50th NIJ NCF AIS >= 5		0.02			
50th NIJ NCE AIS >= 2		0.13			
50th NIJ NCE AIS >= 3		0.05			
50th NIJ NCE AIS >= 4		0.07			
50th NIJ NCE AIS >= 5		0.03			
95th NIJ SHEAR (LB)		39.74	-157.98	241.5	104.3
95th NIJ TENSION (LB)		51.90		95.2	
95th NIJ COMPRESSION (LB)		-22.71		171.6	
95th NIJ FLEXION (IN-LB)		401.82		109.4	
95th NIJ EXTENSION (IN-LB)		137.37		236.8	
95th NIJ NTF	0.0004	0.1366	0.0000	109.4	0.4
95th NIJ NTE	0.0015	0.0990	0.0000	236.8	0.0
95th NIJ NCF	0.0000	0.0318	0.0000	171.6	0.0
95th NIJ NCE	0.0000	0.0105	0.0000	13.2	0.0
95th NIJ NTF AIS >= 2		0.13			
95th NIJ NTF AIS >= 3		0.05			
95th NIJ NTF AIS >= 4		0.07			
95th NIJ NTF AIS >= 5		0.03			
95th NIJ NTE AIS >= 2		0.13			
95th NIJ NTE AIS >= 3		0.05			
95th NIJ NTE AIS >= 4		0.07			
95th NIJ NTE AIS >= 5		0.02			
95th NIJ NCF AIS >= 2		0.12			
95th NIJ NCF AIS >= 3		0.04			
95th NIJ NCF AIS >= 4		0.07			
95th NIJ NCF AIS >= 5		0.02			
95th NIJ NCE AIS >= 2		0.11			
95th NIJ NCE AIS >= 3		0.04			
95th NIJ NCE AIS >= 4		0.06			

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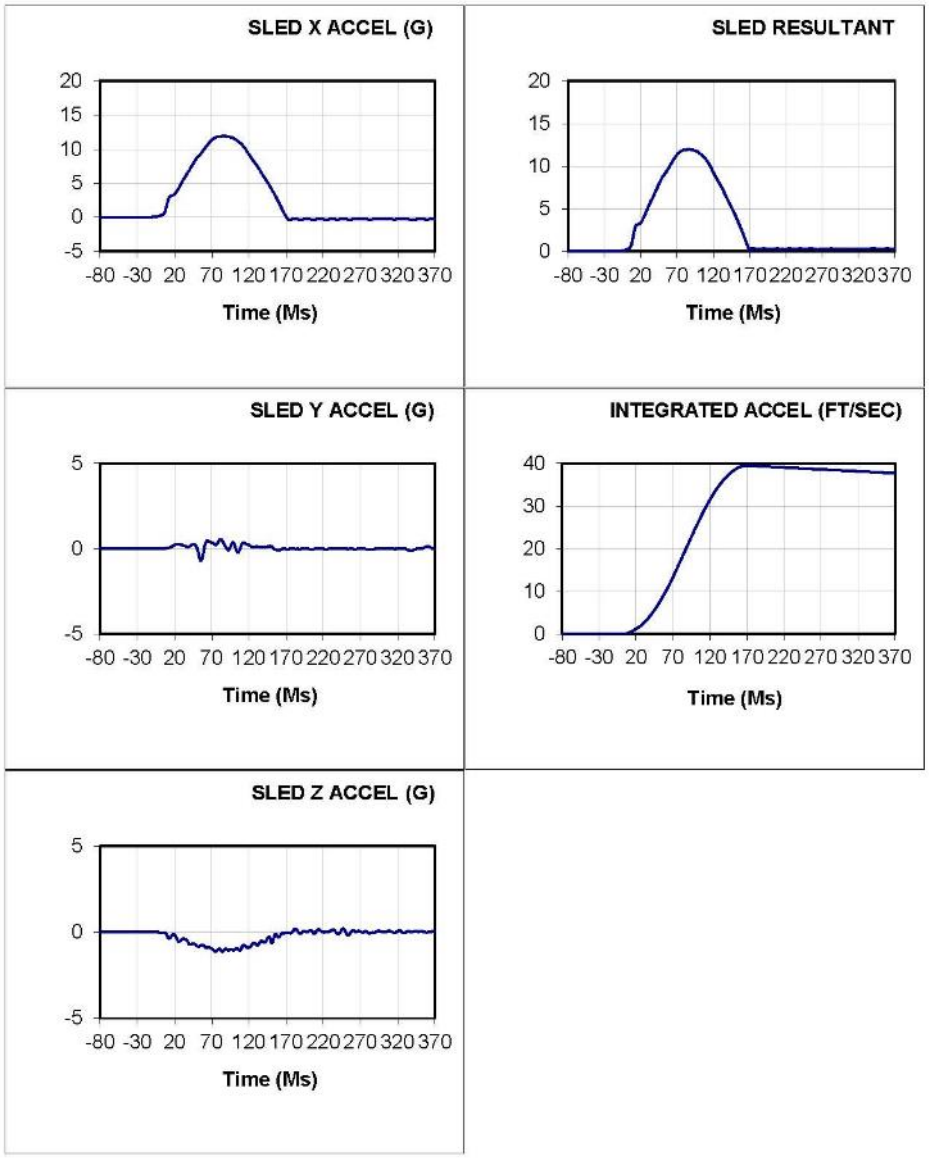

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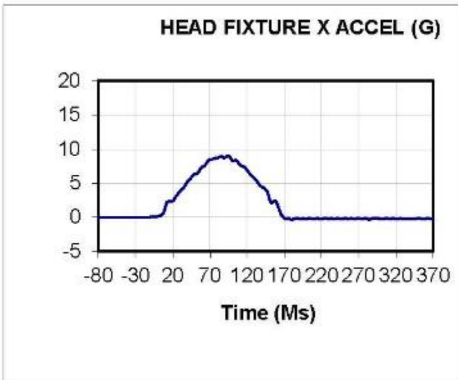
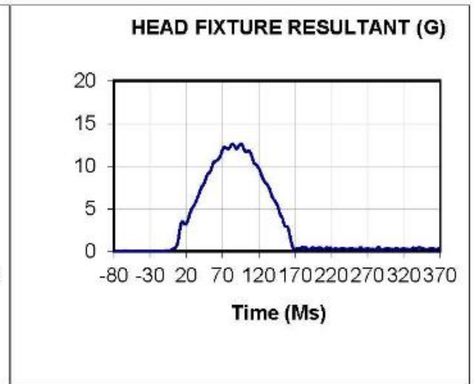
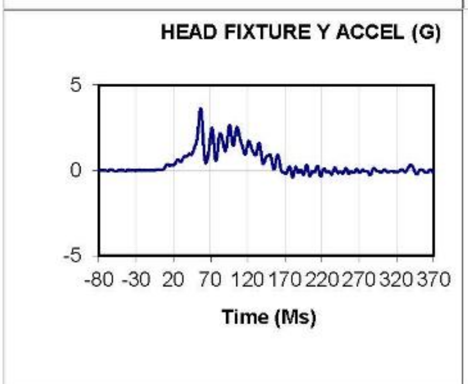
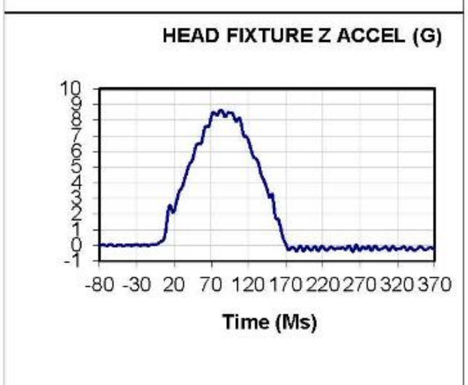
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG









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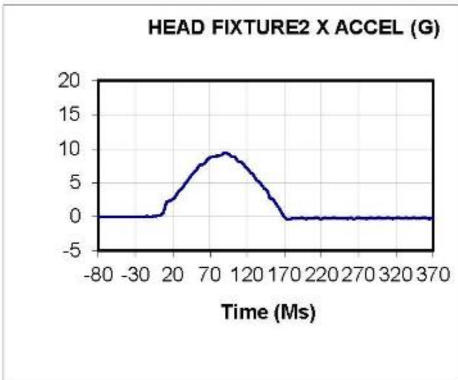
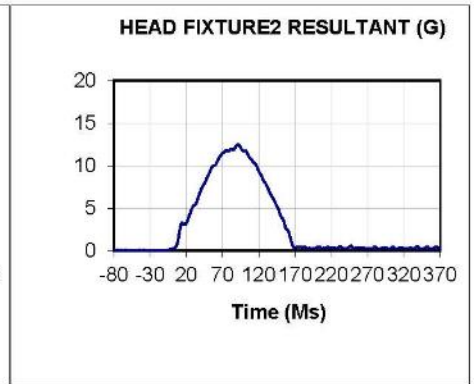
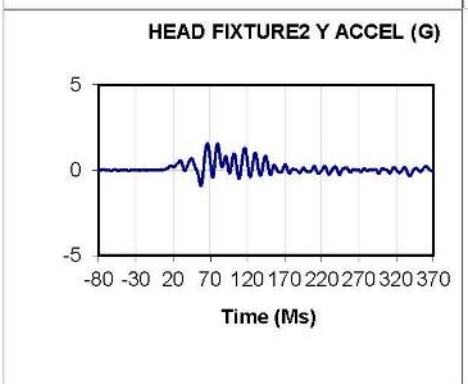
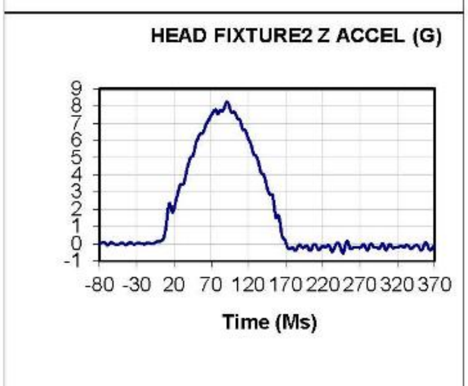
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG









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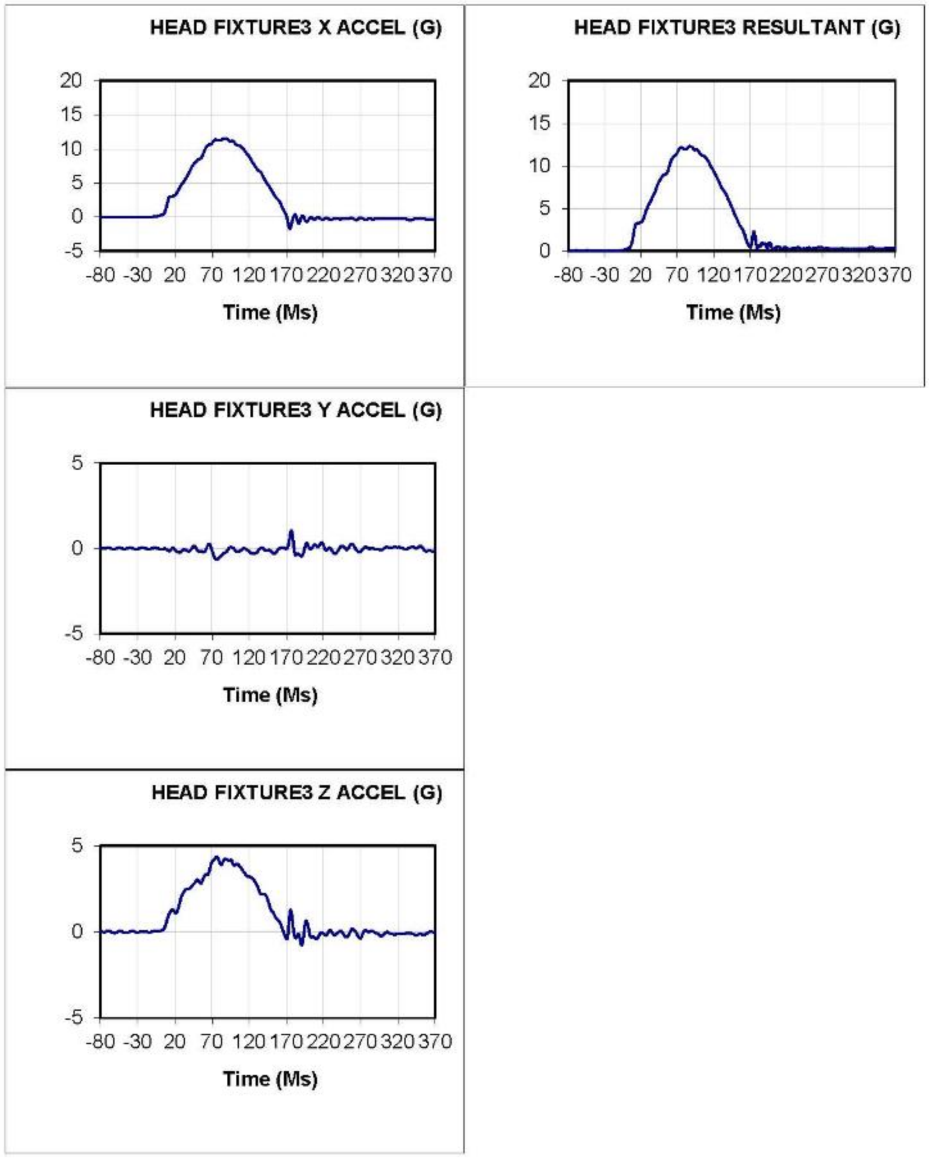

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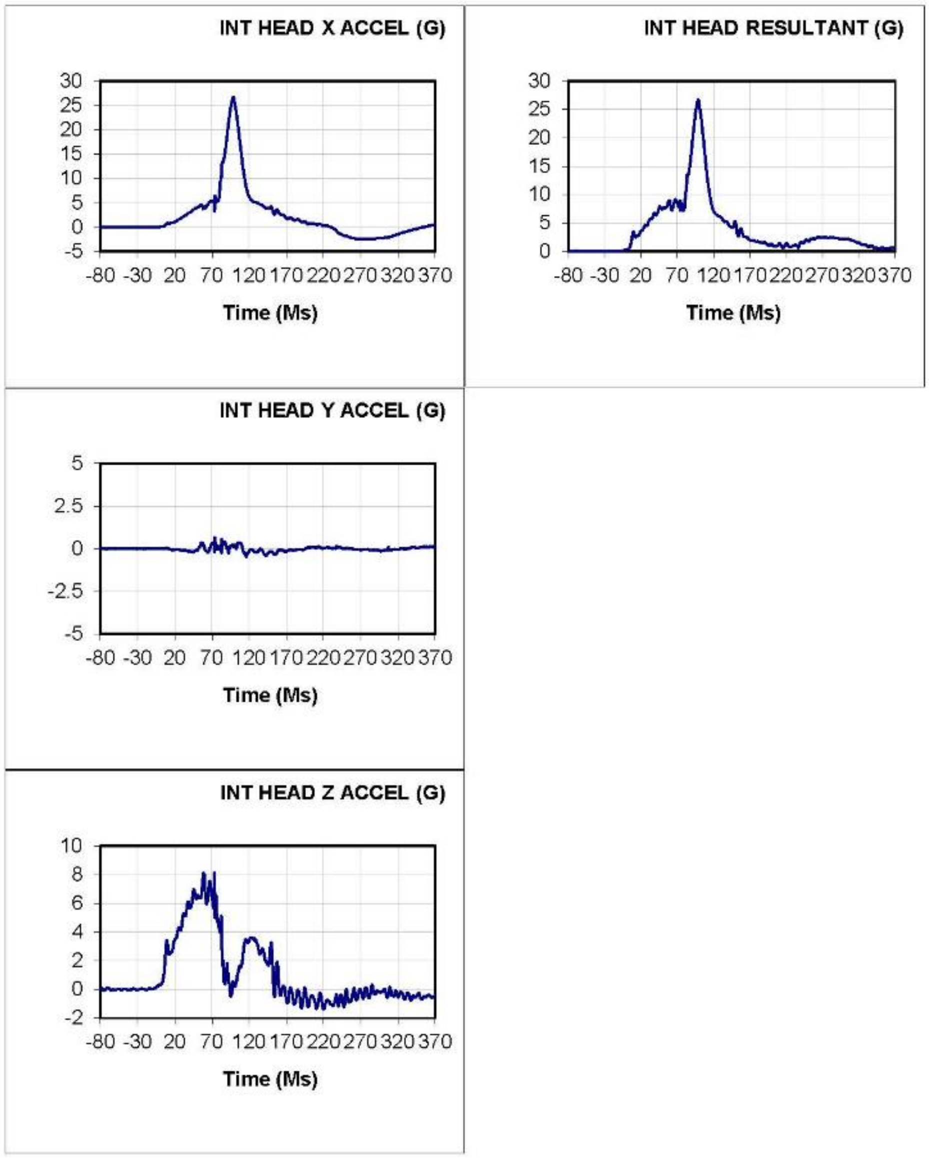
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG



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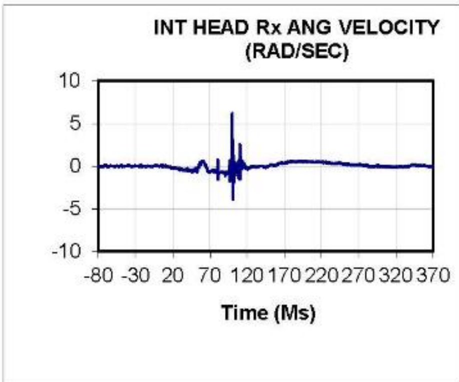
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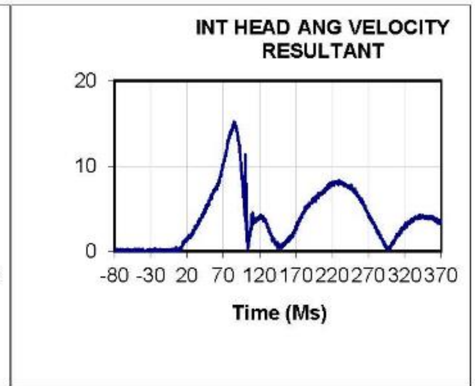
0
-5
-10
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)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RESULTANT
20
10
0
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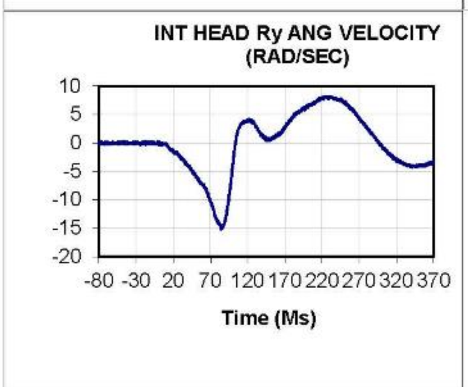
Time (Ms)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(RAD/SEC)
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5
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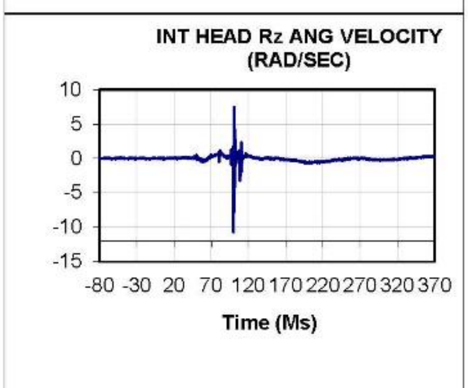
-5
-10
-15
-20
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)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(RAD/SEC)
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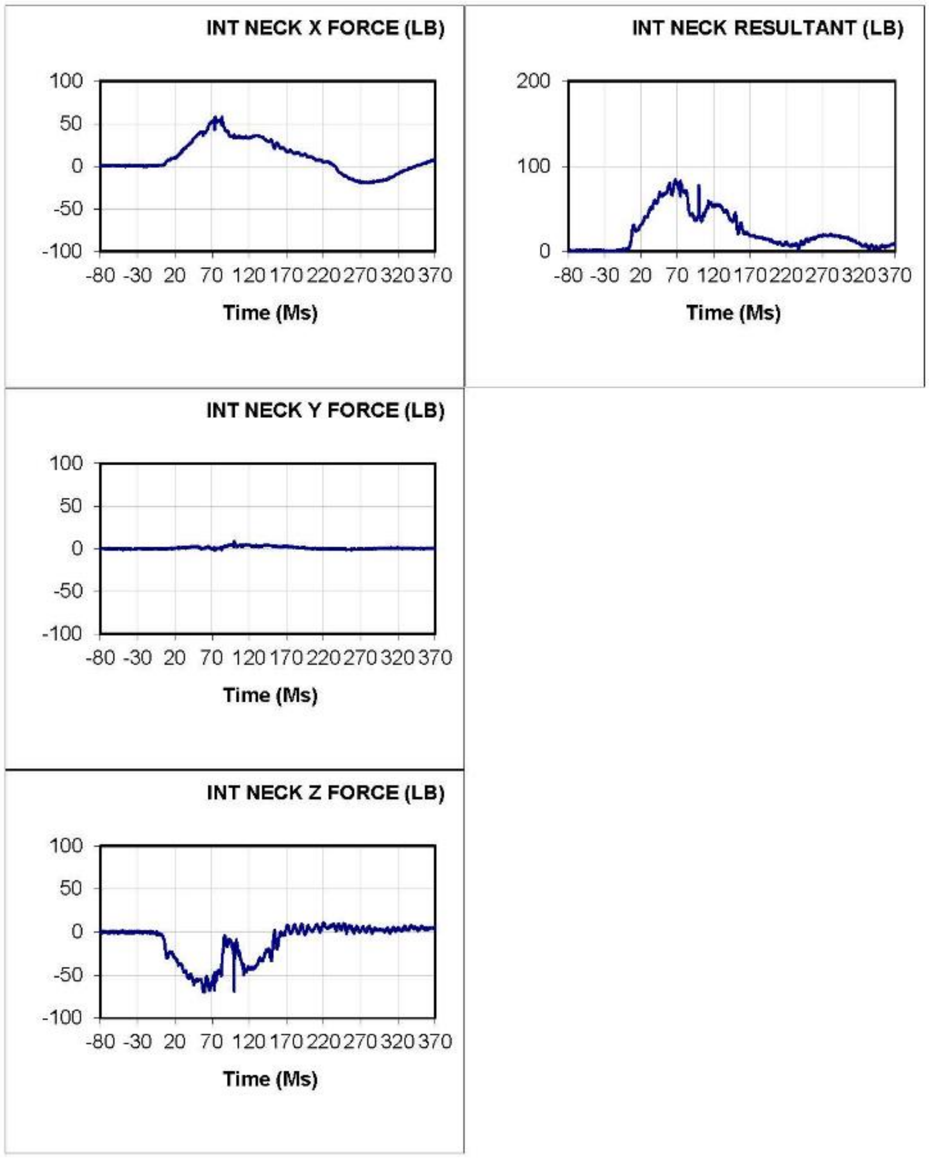
5
0
-5
-10
-15
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)

201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG



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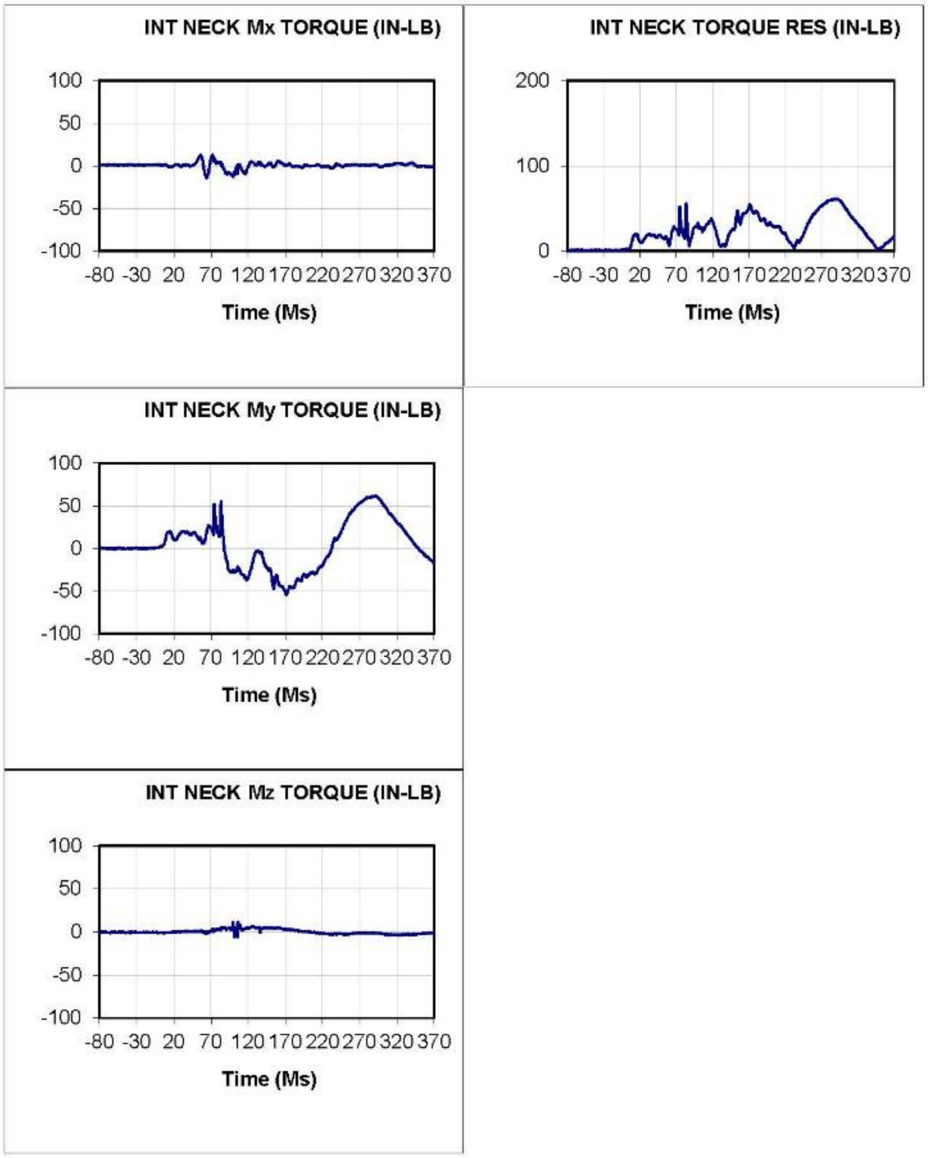
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG



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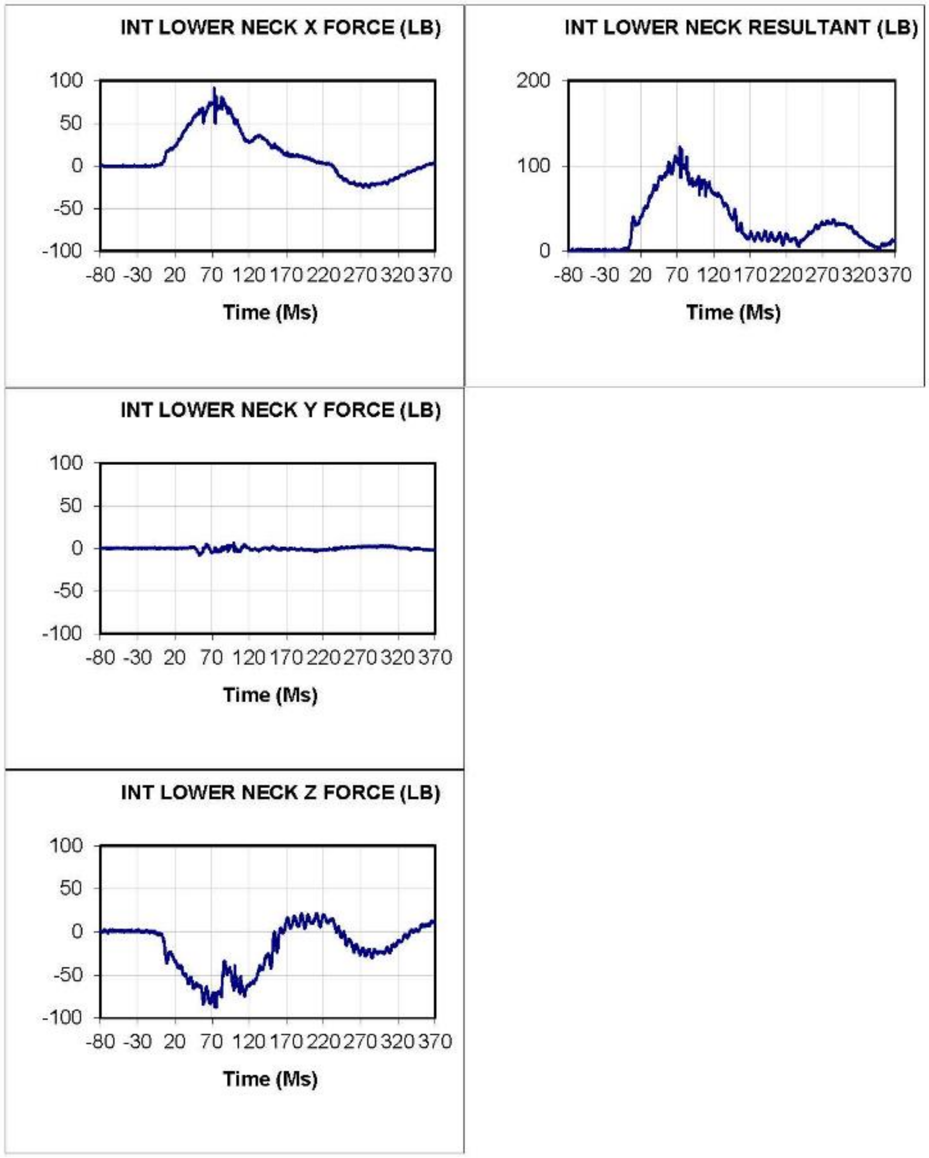
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG



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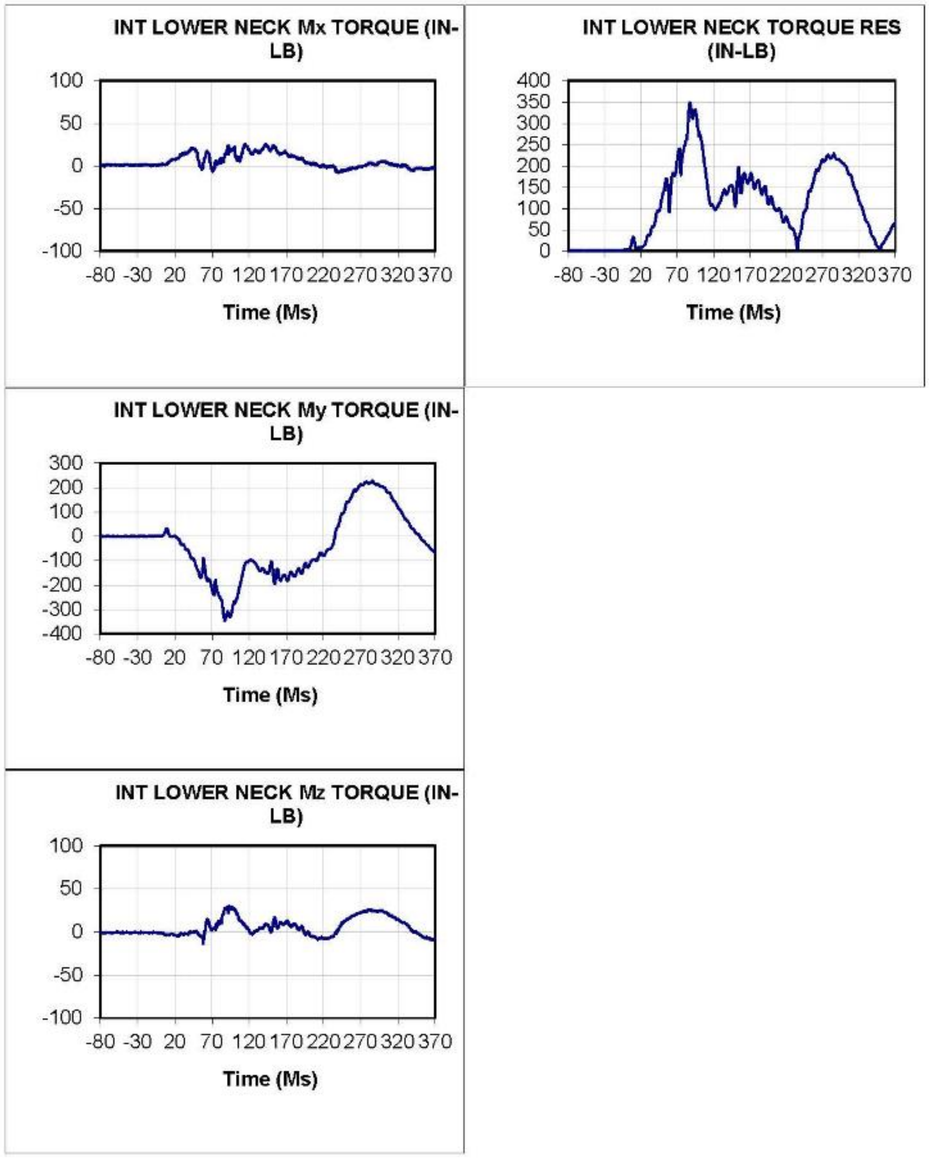
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG



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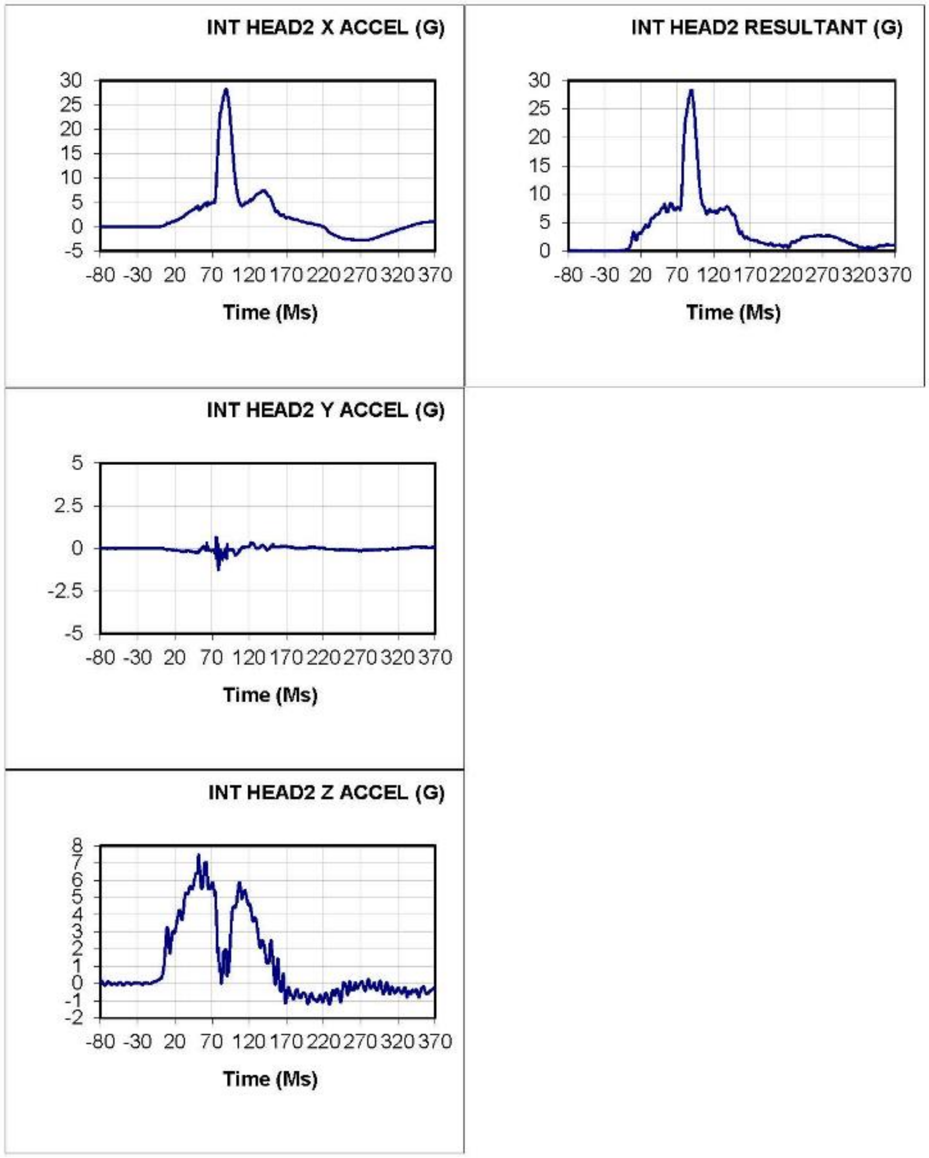
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG



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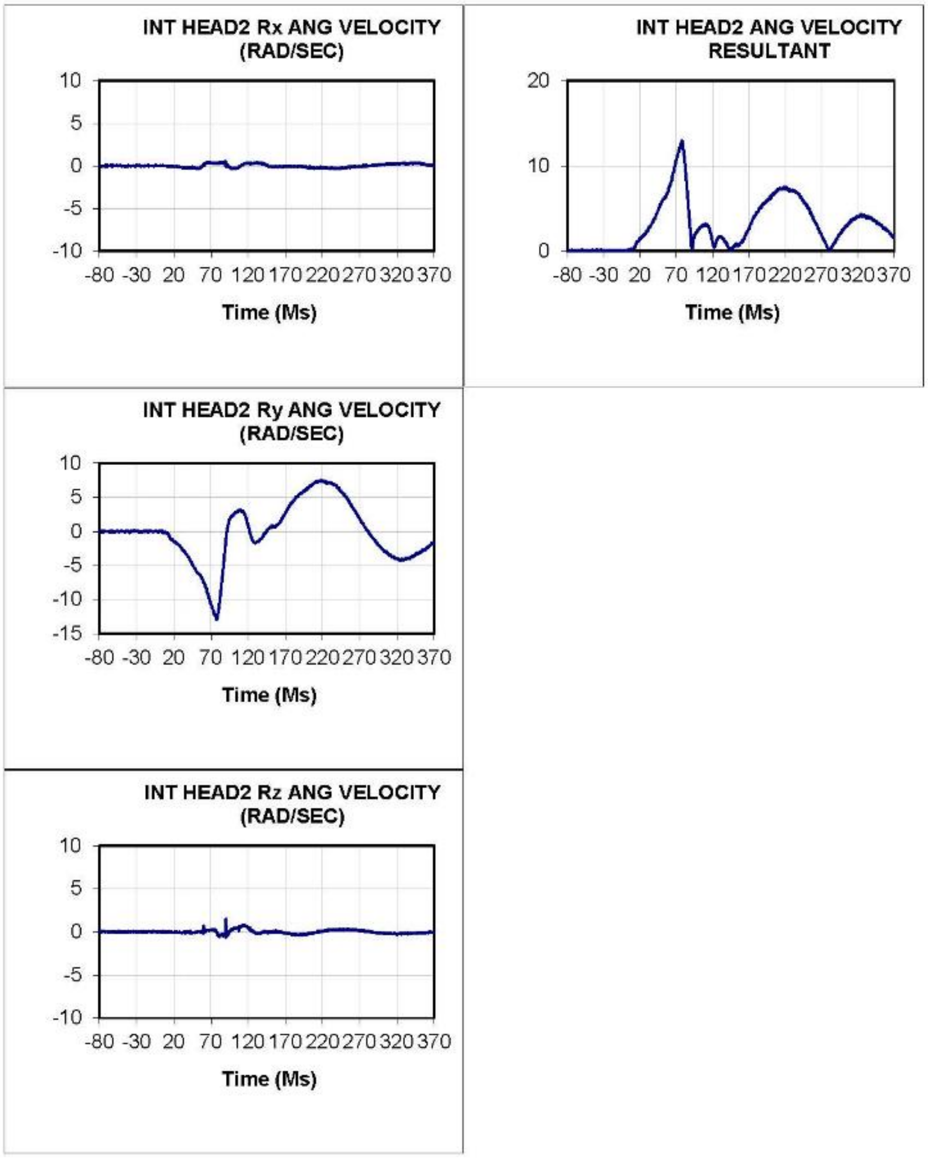

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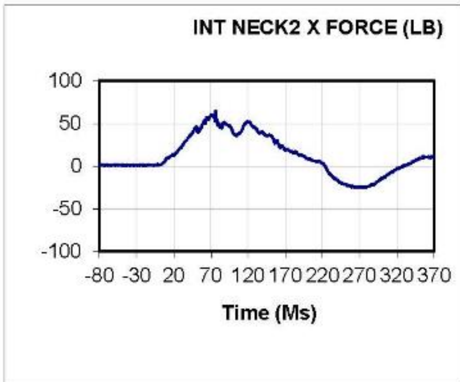
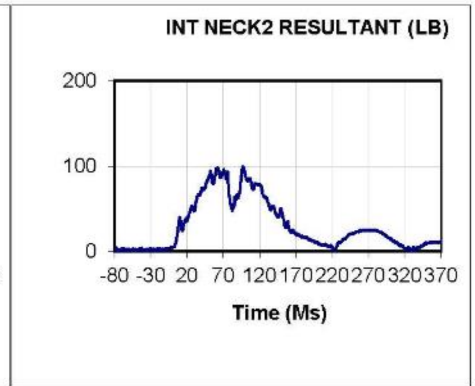
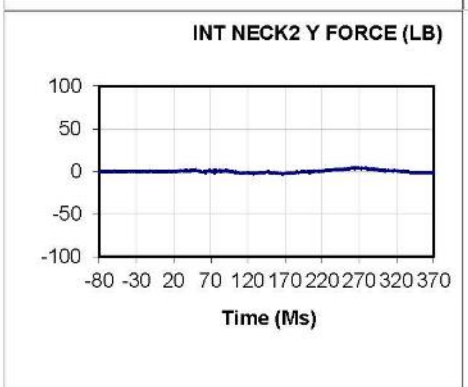
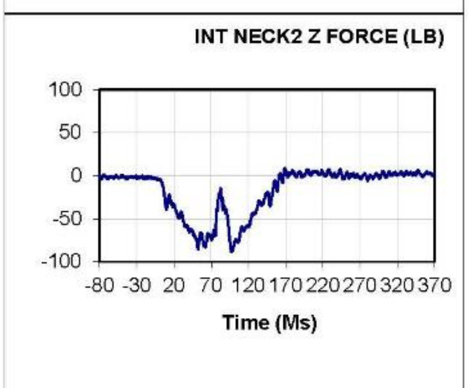
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG









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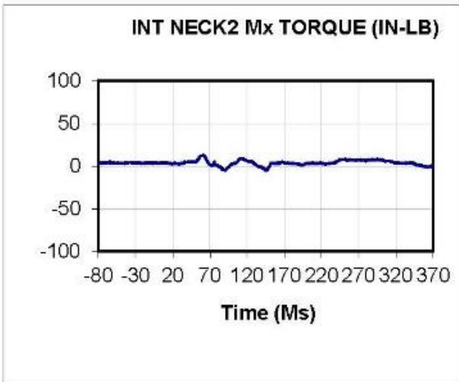
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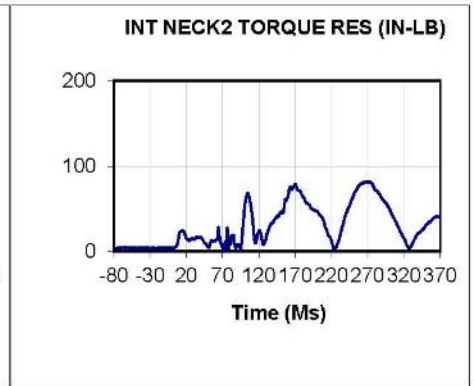
50
0
-50
-100
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)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100
0
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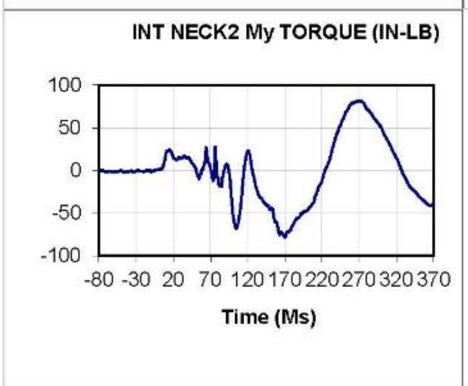
Time (Ms)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0
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-100
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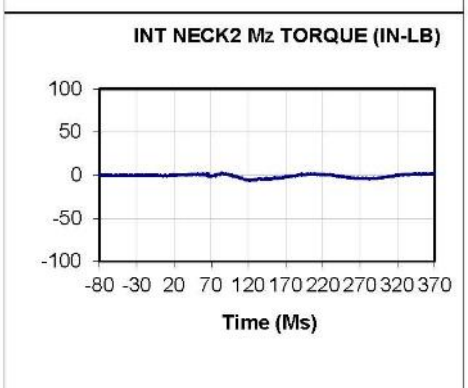
Time (Ms)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50
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-100
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)

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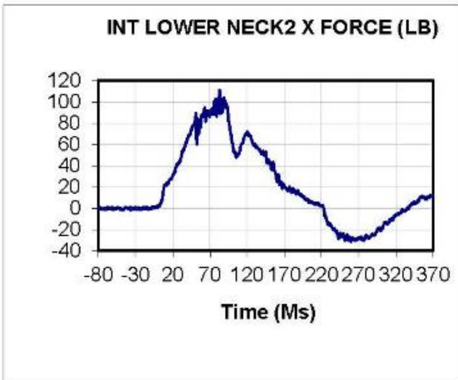

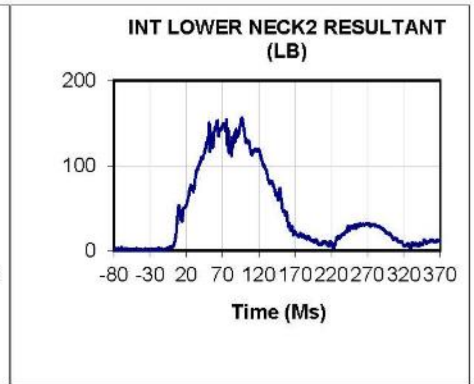

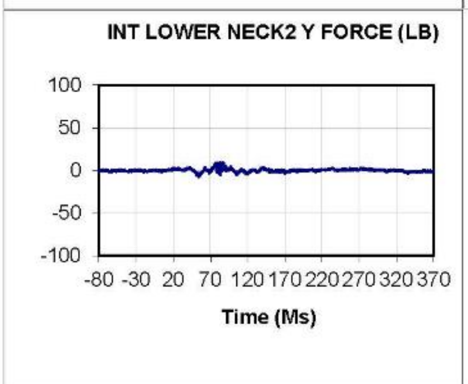

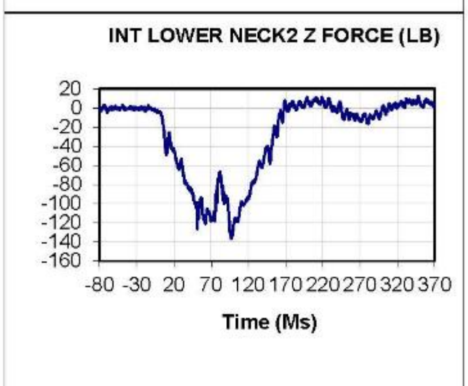

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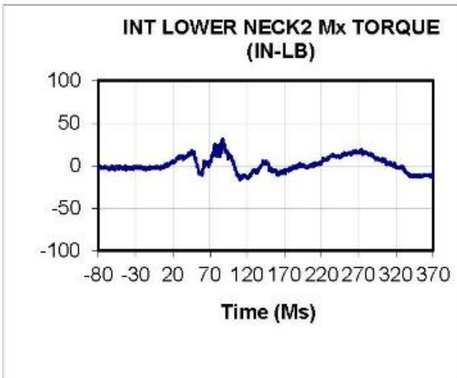
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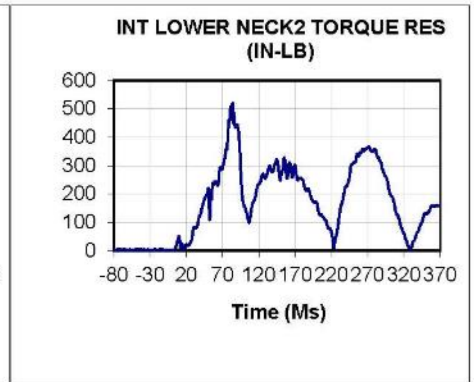
50
0
-50
-100
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)


INT LOWER NECK2 TORQUE RES (IN-LB)
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300
200
100
0
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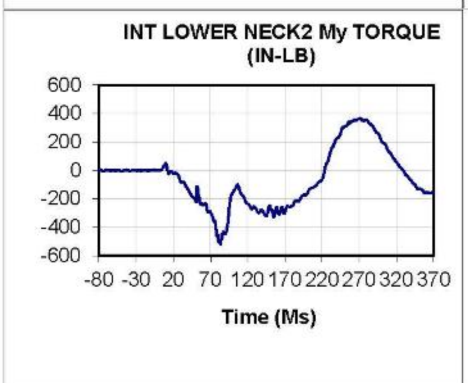
Time (Ms)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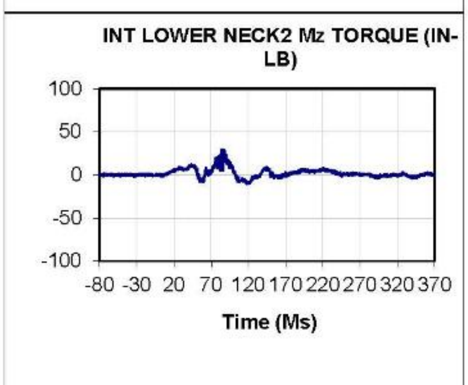
Time (Ms)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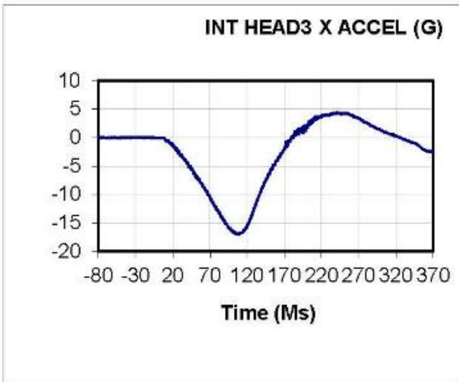
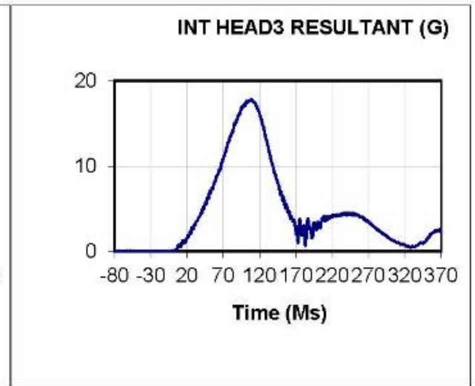
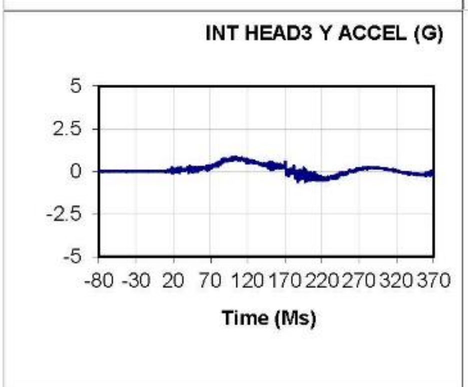
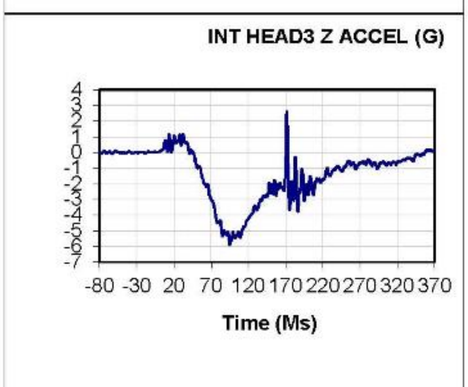
-80 -30 20 70 120 170 220 270 320 370
Time (Ms)

201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG









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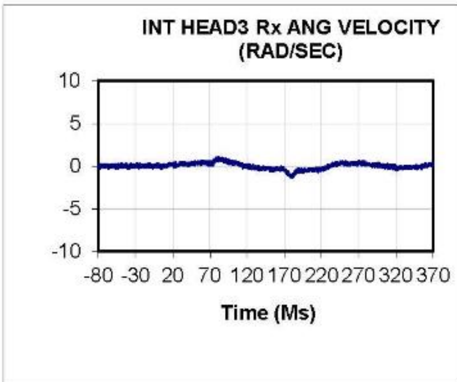

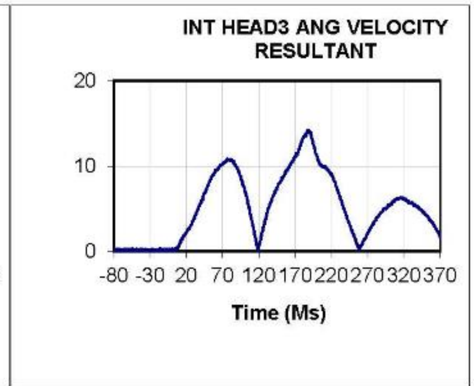

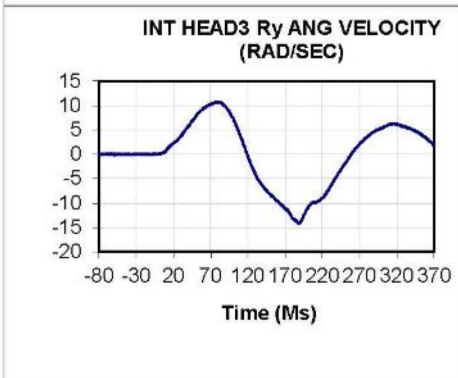

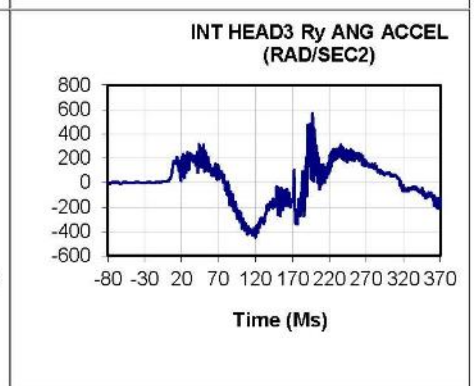

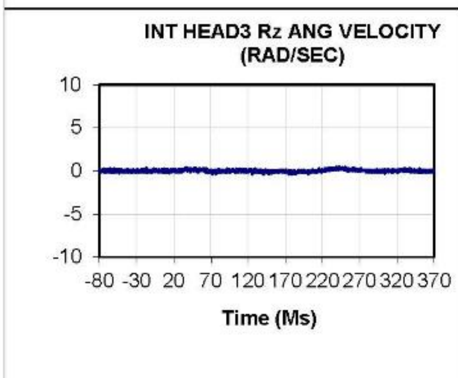

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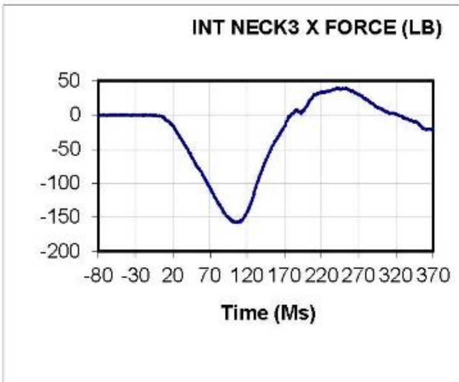

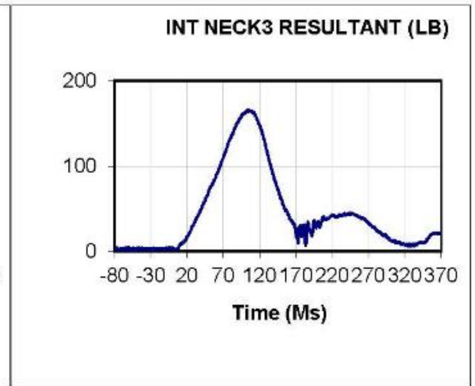

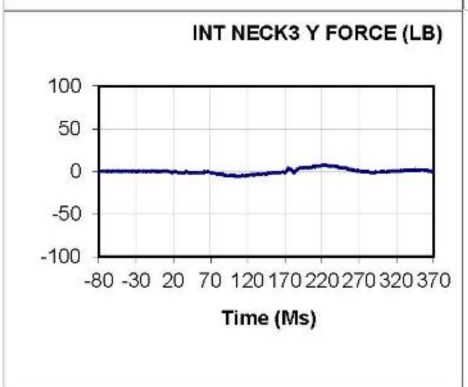

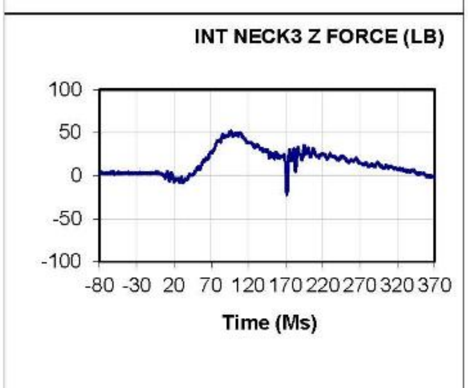

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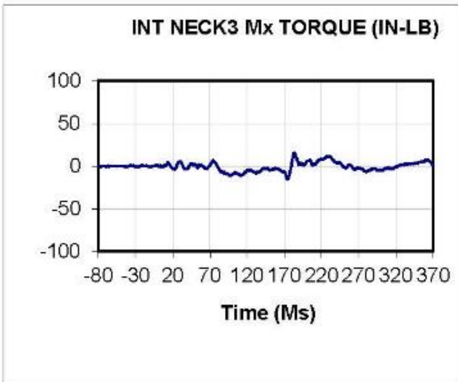
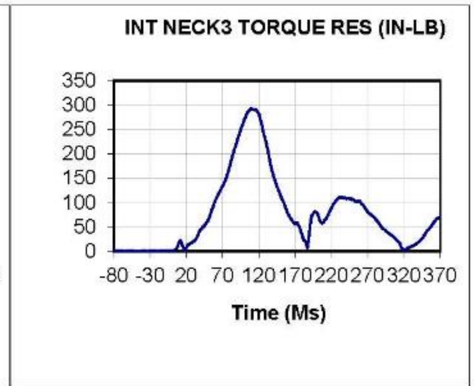
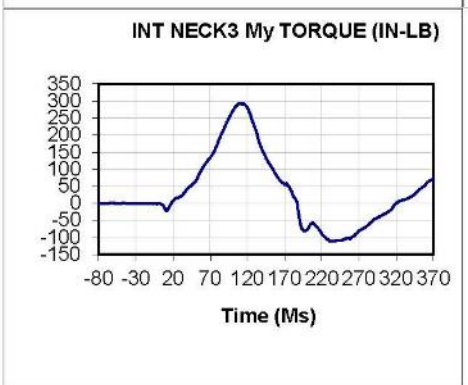
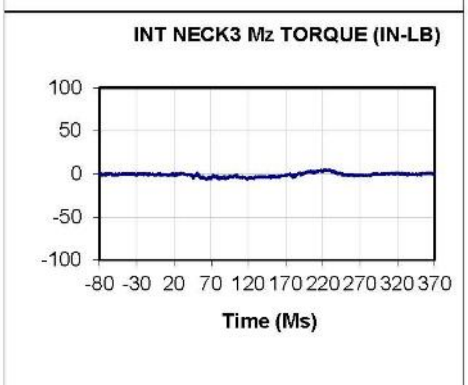
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG









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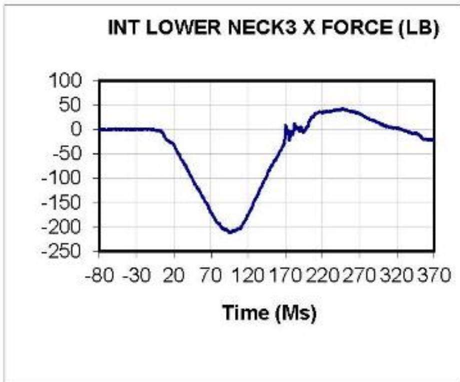
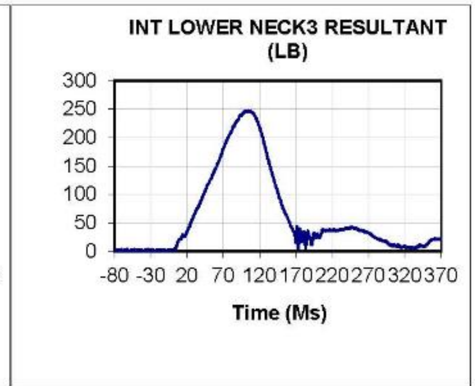
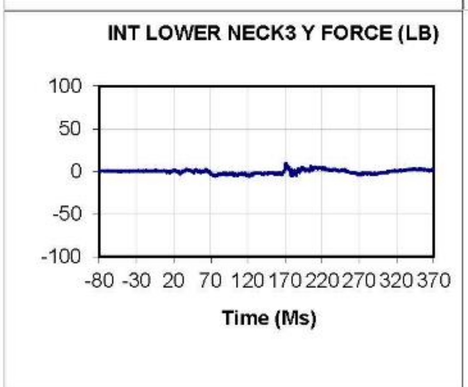
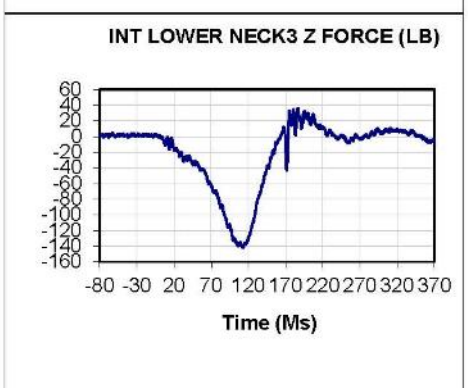
201809 Test: 9715 Test Date: 181002 Subj: H3HEADS Cell: GG









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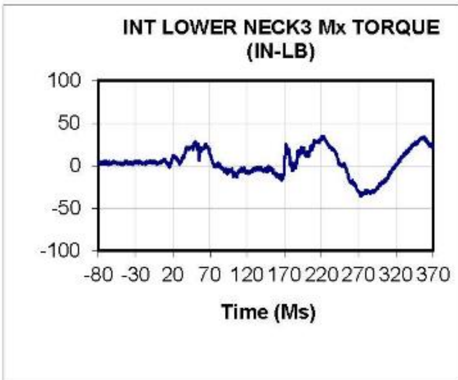

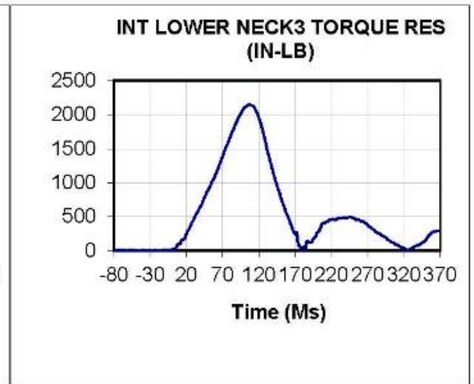

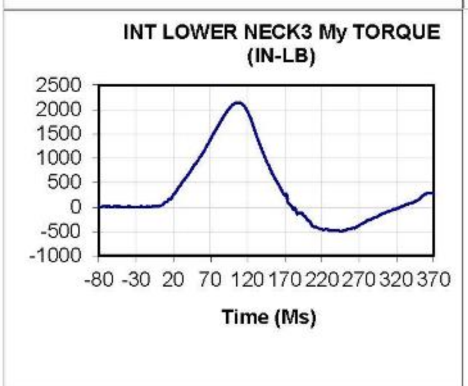

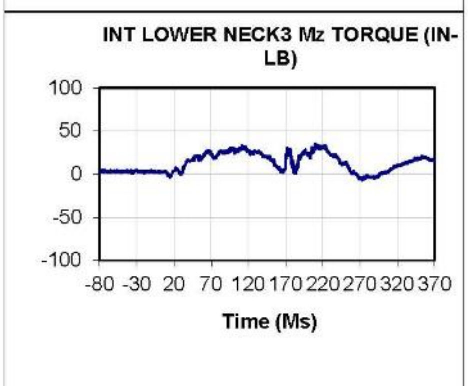

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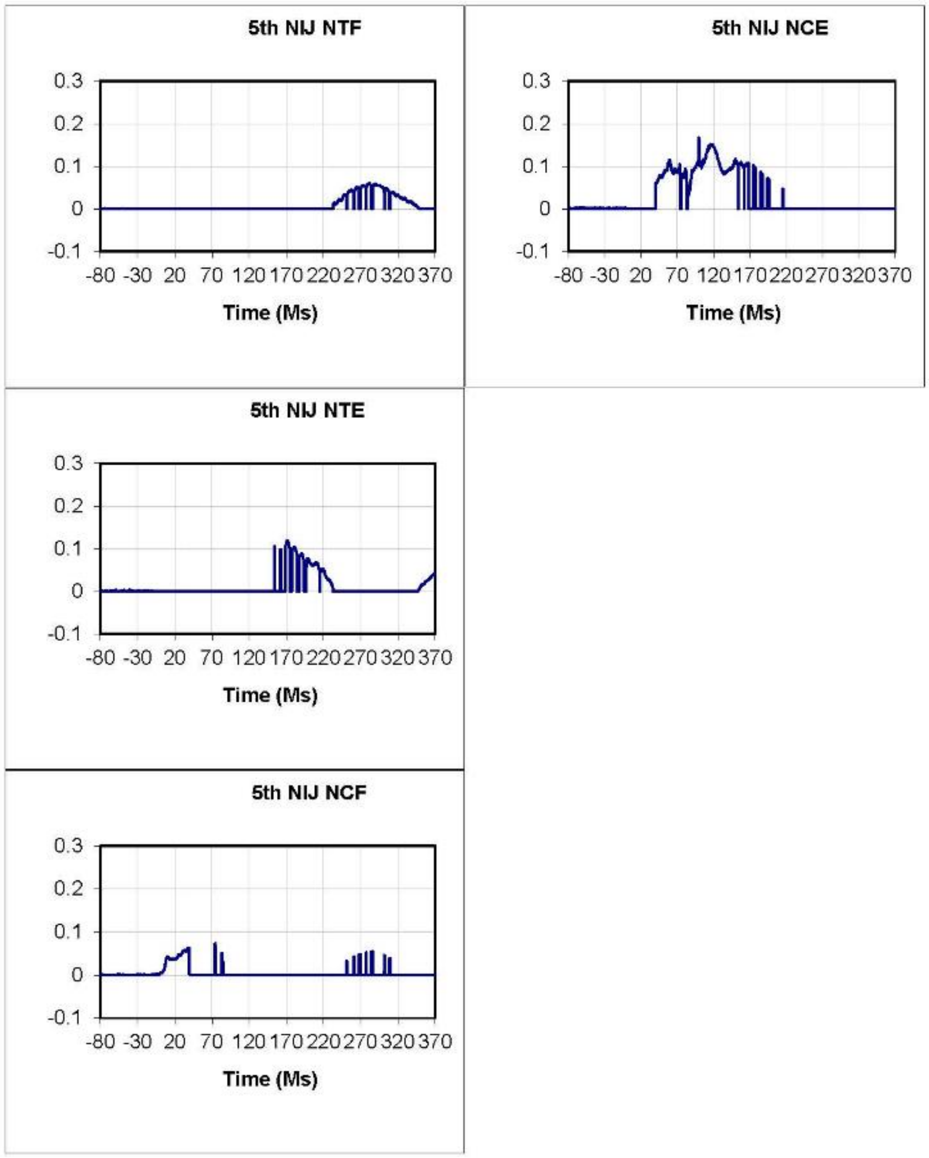

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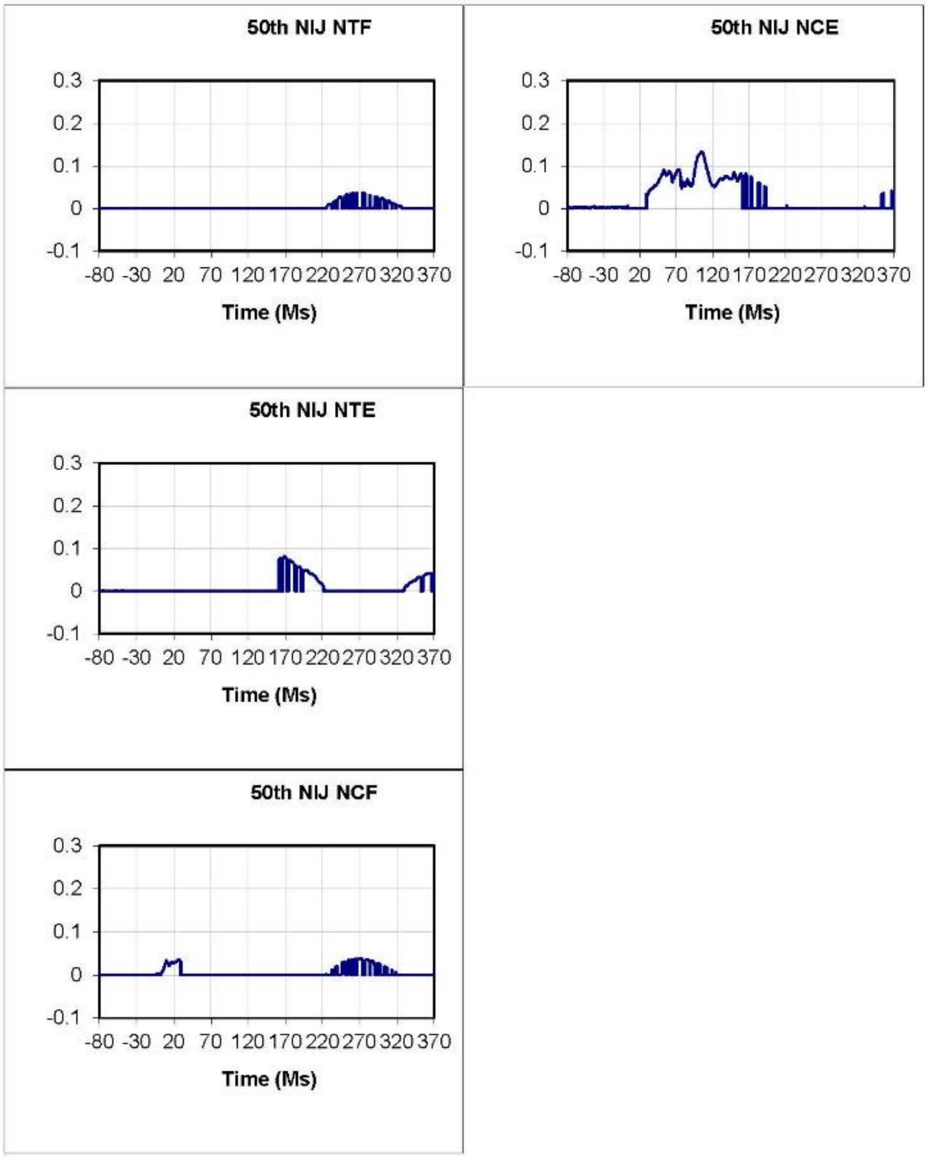

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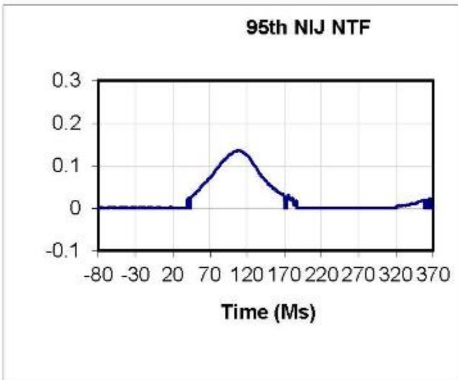

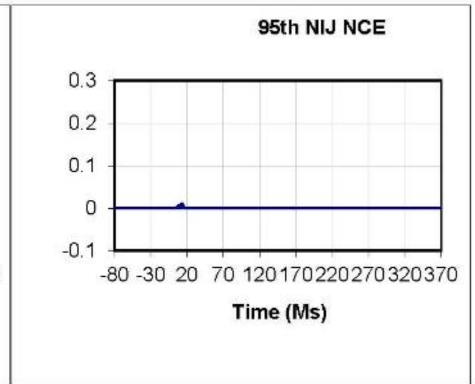

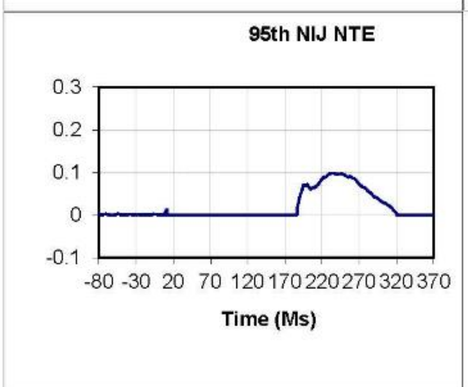

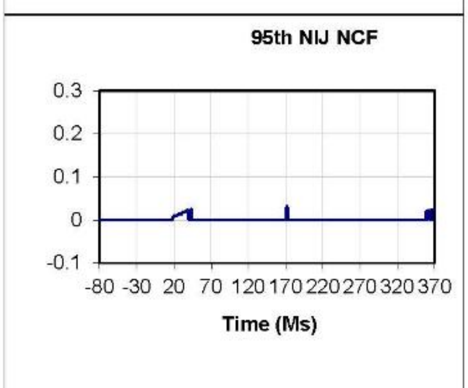

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