Appendix B: Defiance Report: Bending & Torsion and BIW Modal Test

Mass Reduction for Light-Duty Vehicles for Model Years 2017-2025

ExovaDefiance
1628NorthwoodDrive
Troy
Michigan

USA
48084

T: +1 (248)458-5900
F: +1 (248)458-5901
E: sales@exova.oom

W:www.exova.com

Testing, calibrating, advising

EDAG Incorporation

Chevy Silverado BIW Static Bending and Torsion Tests

Exova Defiance Report No. 107429 (Chevy Silverado BIW Static Tests)

Prepared for:

EDAG Incorporation

Attn: JimDavis
248-514-7529
James.davies@edag-us.com

Prepared by:

Hong Yin

Hong Yin
Application Engineer
248-458-5900 x 73219
hong.yin@exova.com

March 10, 2014

1154 Maplelawn, Troy, MI 48084 Phone248-458-5900 Fax 248-458-5901
Website www.defiancetest.com

TABLE OF CONTENTS

EDAG Incorporation

Chevy Silverado BIW Static Bending and Torsion Tests

Exova Defiance Report No. 107429 (Chevy Silverado BIW Static Tests)

1.1 OBJECTIVE

The objective of the static torsion and bending tests was to identify the static torsion stiffness and the static bending stiffness values on a 2014MY Chevy Silverado BIW with the following four (4) configurations:

- Frame with cab and pickupbox
- Frame with cabonly
- Frame with pickup boxonly
- Frameonly

2.0 SUMMARY

Static bending and torsion testes testing were performed at Exova Defiance's Troy facility at 1154 Maplelawn from February 1024 to March 7, 2014. The static torsion and bending stiffness results are shown in Table 1. Static torsion and bending deflection plots are shown in **Appendix A**. Test setup photographs and equipment used on this project is shown in **Appendix B and C**,respectively.

Table 1: Static Torsion and Bending Stiffness Summary

Static Stiffness Tests	BIW Configurations			
	Frame+Cab+Box	Frame+Cab	Frame +Box	Frame
Torsion Stiffness (Nm/Deg)	5,509	5,261	3,428	3,270
Frame Loaded Driver Side Bending Stiffness (N/mm)	3,185	3,216	2,870	2,860
Frame Loaded Passenger Side Bending Stiffness (N/mm)	3,257	3,294	2,965	2,953
Sill Loaded Driver Side Bending Stiffness (N/mm)	1,947	1,947	na	na
Sill Loaded Passenger Side Bending Stiffness (N/mm)	1,947	1,947	na	na

3.0 STATICTESTS

3.1 TestSetup

The BIW was constrained using a minimum constraint support system with Heim joints. One torsion test and one bending test were conducted. For torsion test, the front supports (the loading points) for the BIW were at the front strut mounts and the rear supports were at the rear spring seats. For bending test, the front and rear supports were same as the torsion test. Frame loading point was at the halfway between the front and rear constraints. Cab rocker loading was also performed. Refer to the test setup photographs in**AppendixB**.

Linear Voltage Potentiometers (LVPs) were placed along the longitudinal direction of the structure to measure vertical displacements. Measurement locations included constraint points and body points. There were four measurement locations on constraints and thirty-two measurement locations on the body portion of the vehicle. Table 2 contains the coordinates of the measurement points. The original of X is at the very front of the front bumper with positive toward the rear of the vehicle. The Y is the distance between two LVPs at both the driver side and the passenger side for the same x position.

Table 2: Torsion/Bending (Frame Loading) Test LVP Locations

	Transducer Pair			
Location Name	Driver	Passenger	X (mm)	Y width (mm)
Front of framerail	1	14	0	810
Rail @ #2xmbr	2	15	300	840
Torsionloadpoint/frontconstraint	3	16	585	1170
Rail @ # 3 xmbr	4	17	870	760
Frame @A-Pillar	5	18	1250	970
# 4 xmbr	6	19	1685	1035
# 5 xmbr (Bending load)	7	20	2300	1065
Frame	8	21	2780	1045
C-pillar	9	22	3350	1050
Shock mnt. Xmbr	10	23	3860	1050
Rear Constraint	11	24	4160	1180
Rear Shock mnt. Xmbr	12	25	4670	1000
Rear of Frame	13	26	5130	990

3.2 TorsionTest

A hydraulic actuator was attached to the twist beam to apply the necessary torque to the structure. Following three warm-up cycles, torsion loads were applied at the front constraints. Torsion moment arm was 1.405 m (55.3 inches) and torsion moment force was 2,000 lbs (8,896 N). Counterclockwise motion (CCW, left twist) was defined as having the left side of the loading structure moving down and the right side moving up, as viewed from the front of the body (loading at front and fixed at rear of the body).Similarly, a clockwise motion (CW, right twist) was defined as the left side moving up andtherightsidemovingdown,asviewedfromthefrontofthebody. Theloading

sequence was as follows:

0, $^{1}/_{3}$ CW, $^{2}/_{3}$ CW, CW, $^{2}/_{3}$ CW, $^{1}/_{3}$ CW, 0, $^{1}/_{3}$ CCW, $^{2}/_{3}$ CCW, CCW, $^{2}/_{3}$ CCW, $^{1}/_{3}$ CCW, 0

Three runs were performed at each test.

3.3 Bending Test

For frame bending test, steel brackets were welded to the underside of the body. Refer to the photographs in **Appendix B**. These brackets were attached halfway between the front and rear constrains. A steel beam was then placed into the brackets to act as the loading bar for the input of the force to the body. A cable attached to the center of the beam applied a vertical pull through the pulley system that attached to an actuator. A load cell was used to measure a maximum load of 2,000 lbs (8,896 N) applied to the BIW in nine increments as one full cycle. The loading sequence was as follows:
0, $^{1}/_{4}$ MAX, $^{1}/_{2}$ MAX, $^{3}/_{4}$ MAX, MAX, $^{3}/_{4}$ MAX, $^{1}/_{2}$ MAX, $^{1}/_{4}$ MAX, 0
Three run were performed for frame bending test.

For cab rocker loading bending test, dead weight up to 500 lbswas applied to the left and right sides of rockers (total 1,000 lbs) in five increments as one full cycle.

3.4 Torsion TestResult

The calculated twist angles versus distance along the body (in the X-direction) were plotted. The twist angles at the front constraints (loading points) were used to calculate the torsion stiffness values. A linear regression analysis was performed for the twist angle results over all thirteen acquired load increments. The slope of the linear regression line was used to calculate the stiffness values shown in Table1.

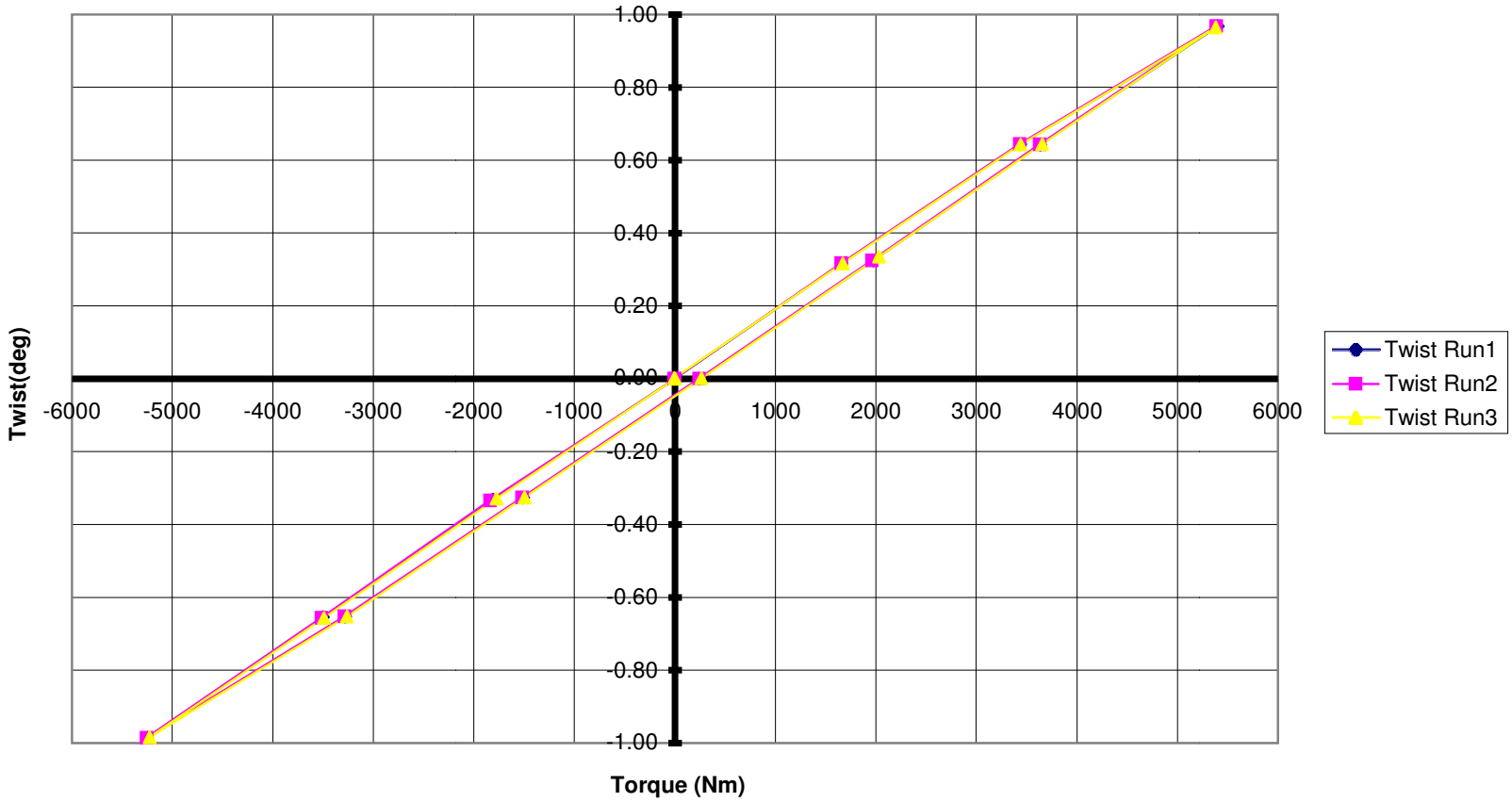
3.5 Bending TestResult

The deflections versus distance along the body (in the X-direction) were plotted. The deflections at the loading points were used to calculate the bending stiffness values. A linear regression analysis was performed for the deflection results over the nine load increments. The slope of the linear regression line was used to calculate the stiffness values shown in Table 1.

Appendix A

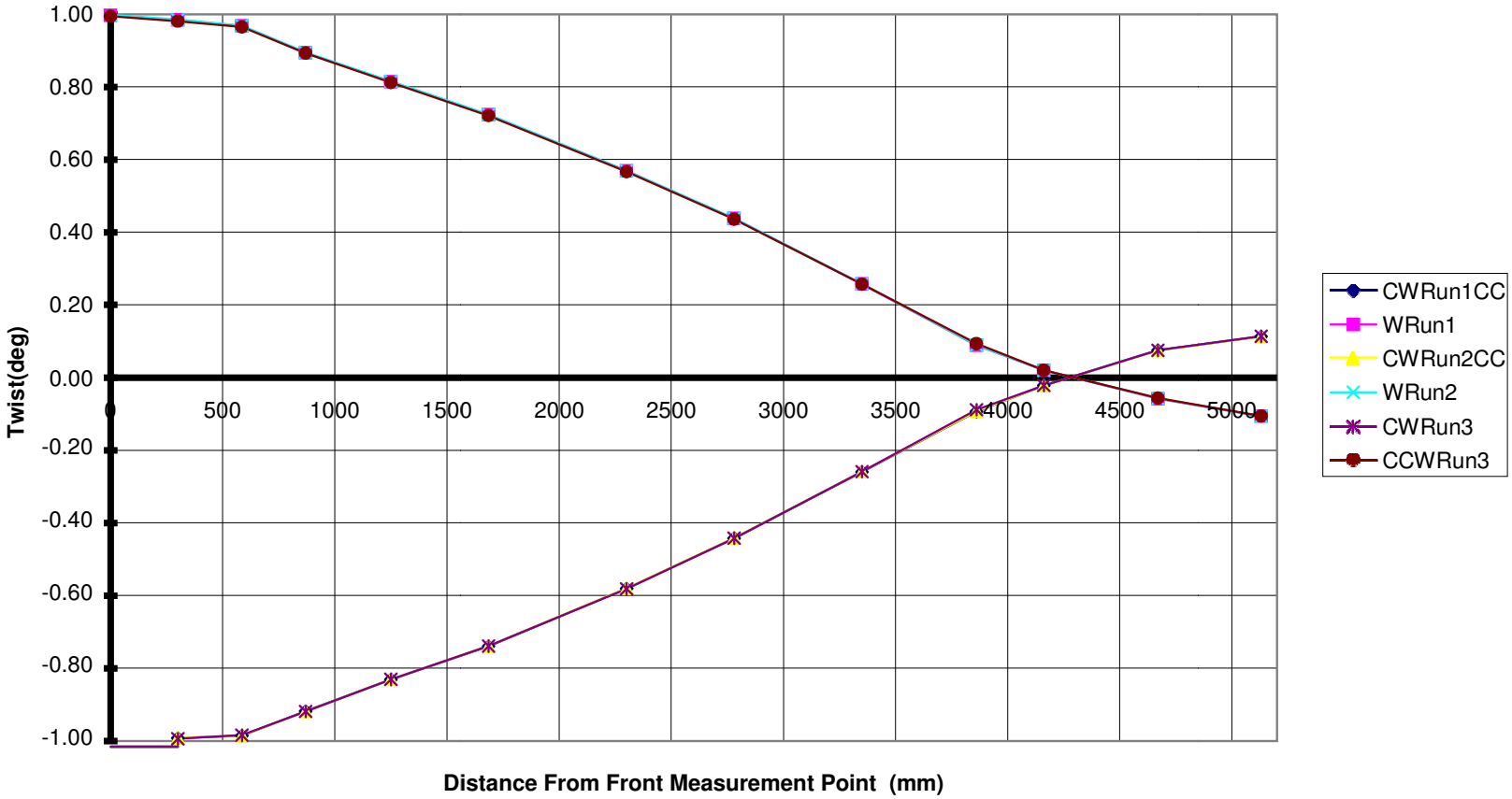
BIW Static Torsion and Bending Test Deflection Plots

EDAGSiverado
Static Torsion Test - Body on Frame
Twist vs. Torque



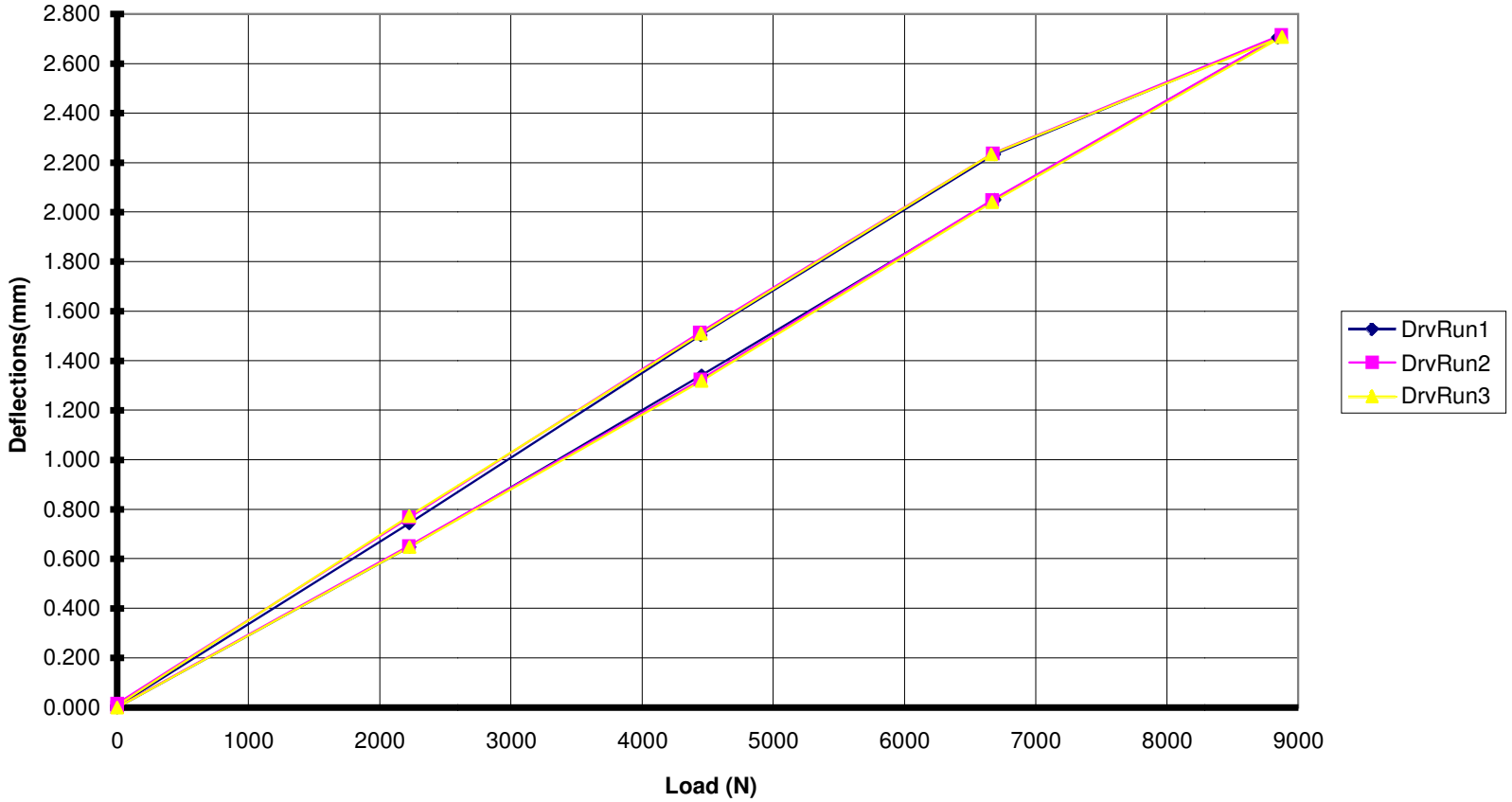
Uncorrected Stiffness = 5,391 Nm/deg
Corrected Stiffness = 5,509 Nm/deg

EDAG Silverado
Static Torsion Test - Body on Frame
Deflection vs. Position
Maximum Load (Raw Data)



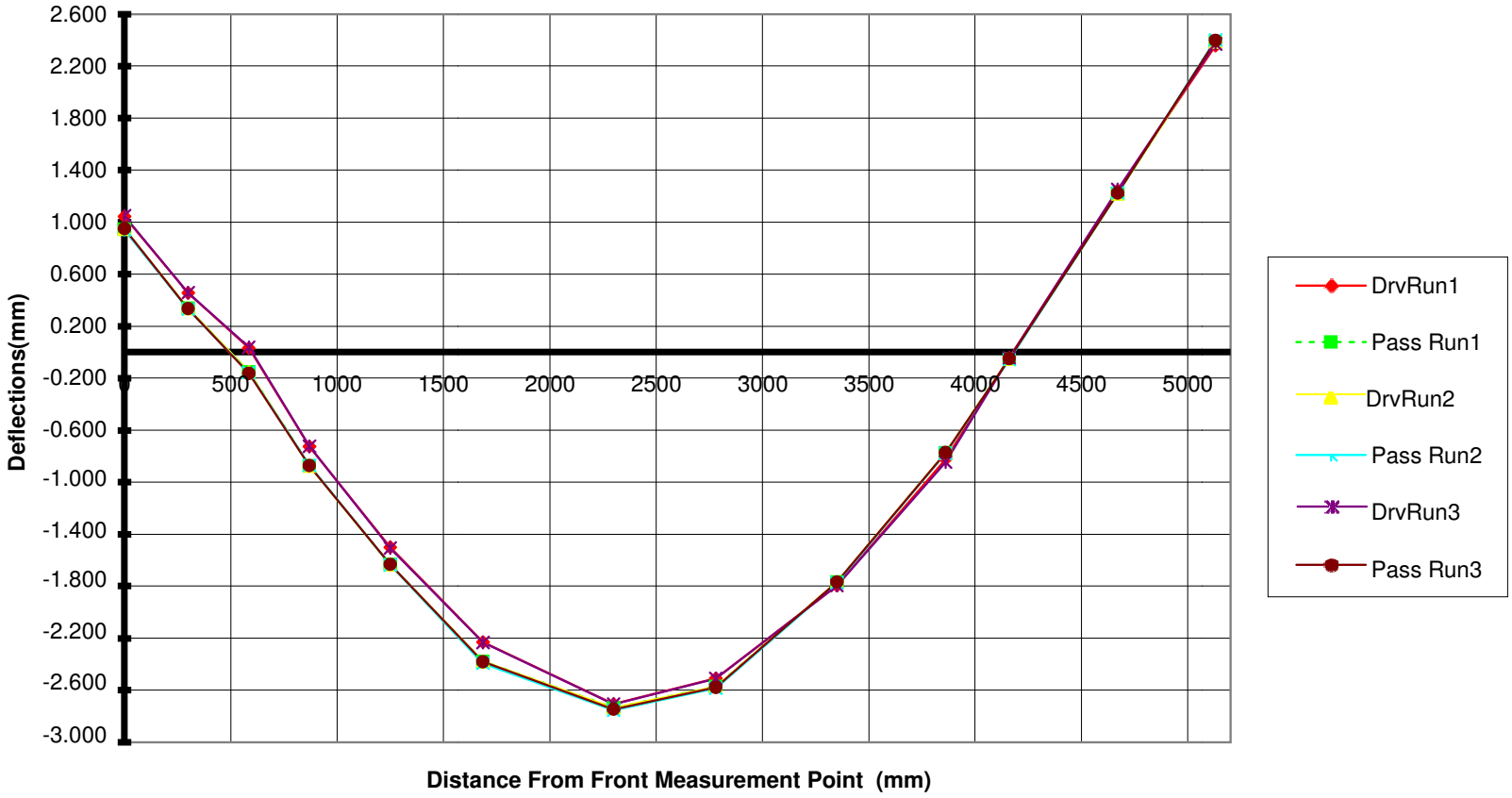
Uncorrected Stiffness = 5,391 Nm/deg
Corrected Stiffness = 5,509 Nm/deg

Silverado Body on Frame
Static Bending Test
Deflection vs. Load



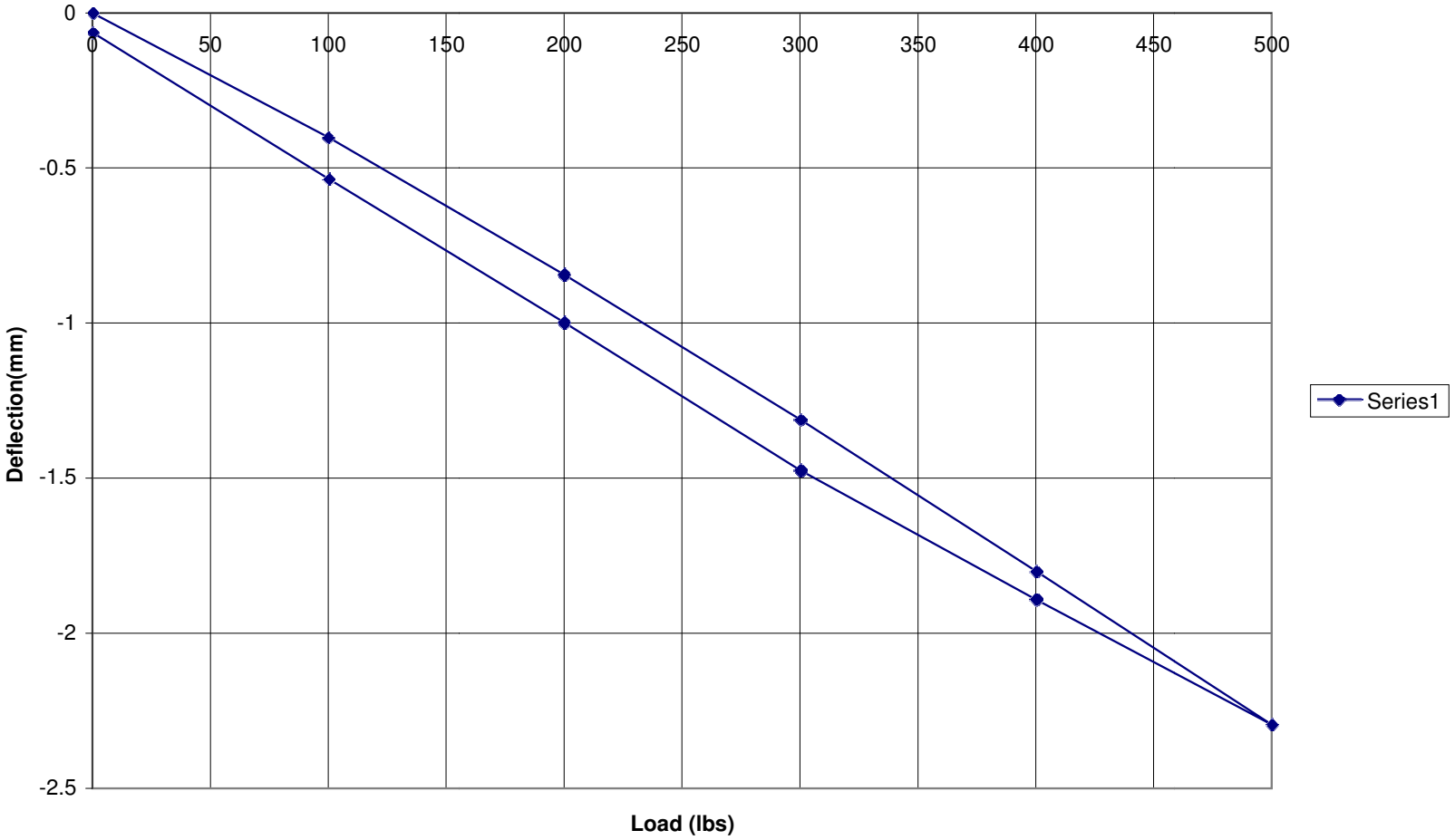
Corrected Driver Stiffness = 3185 N/mm
Corrected Passenger Stiffness = 3257 N/mm

Silverado Body on Frame
Static Bending Test
Deflection vs. Position
Maximum Load (Raw Data)

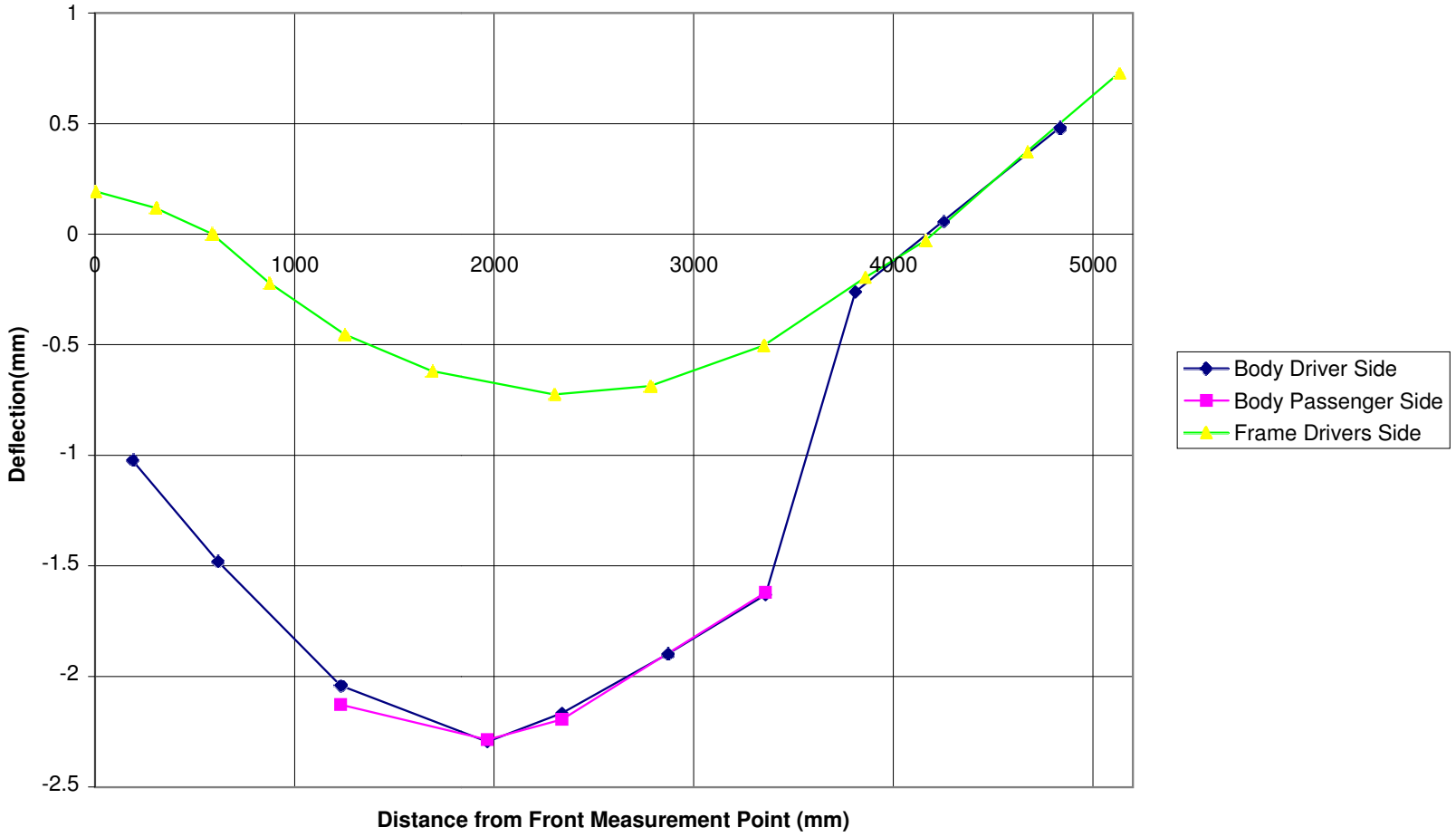


Corrected Driver Stiffness = 3185 N/mm
Corrected Passenger Stiffness = 3257 N/mm

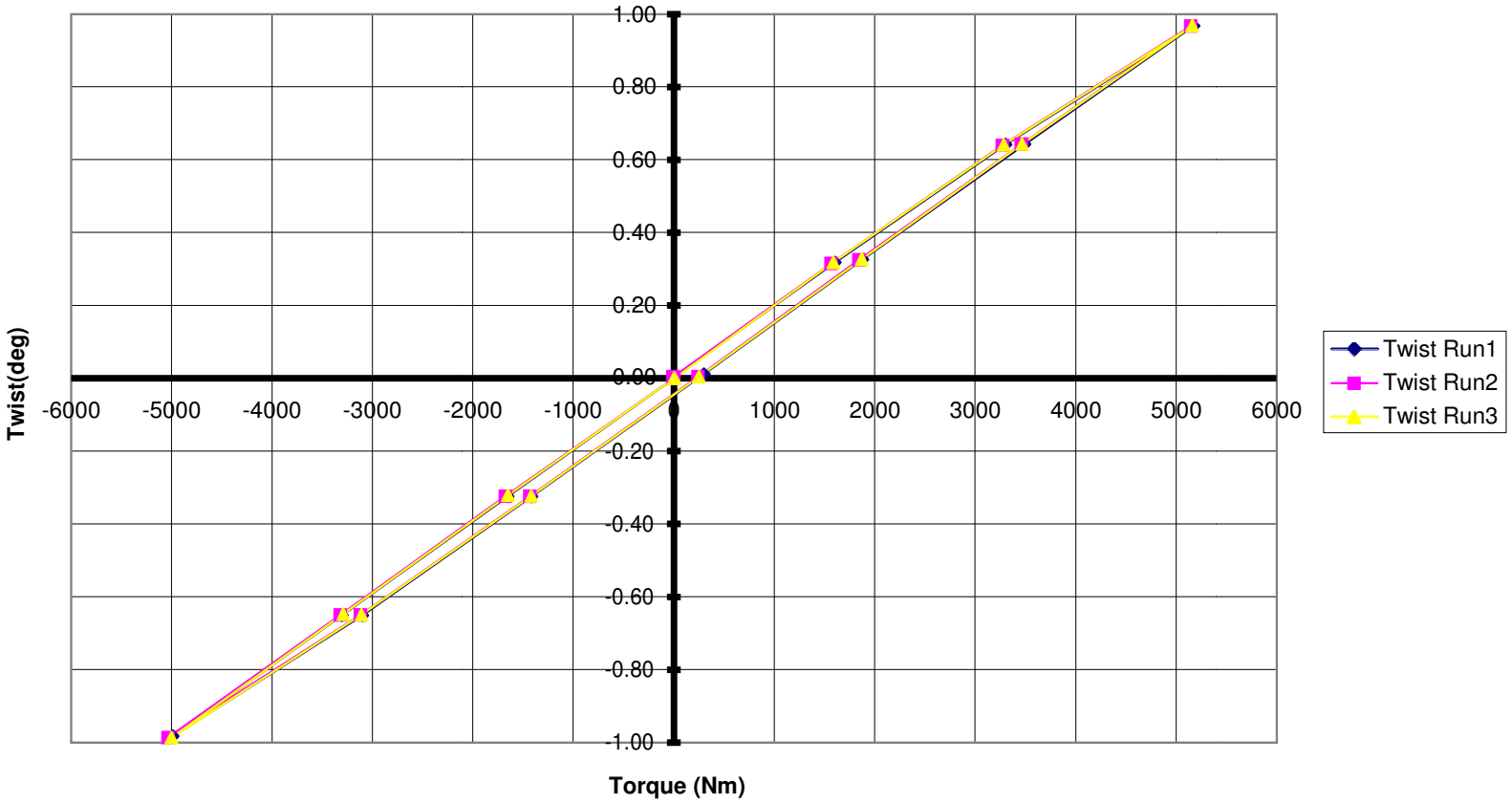
Sill Loaded Bending
Body on Frame



Sill Loaded Bending
Body on the Frame

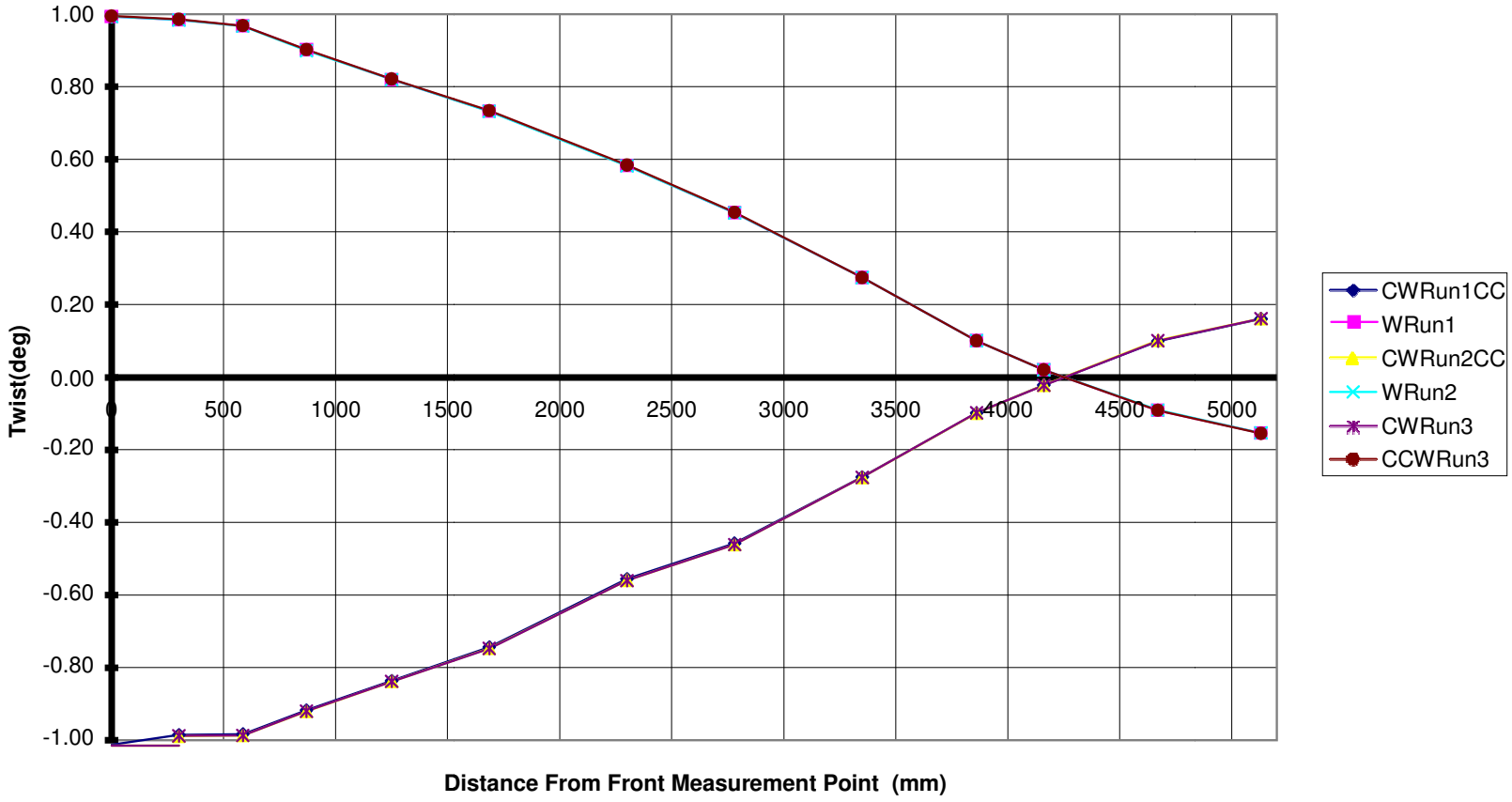


EDAGSiverado
Static Torsion Test - Cab on Frame
Twist vs. Torque



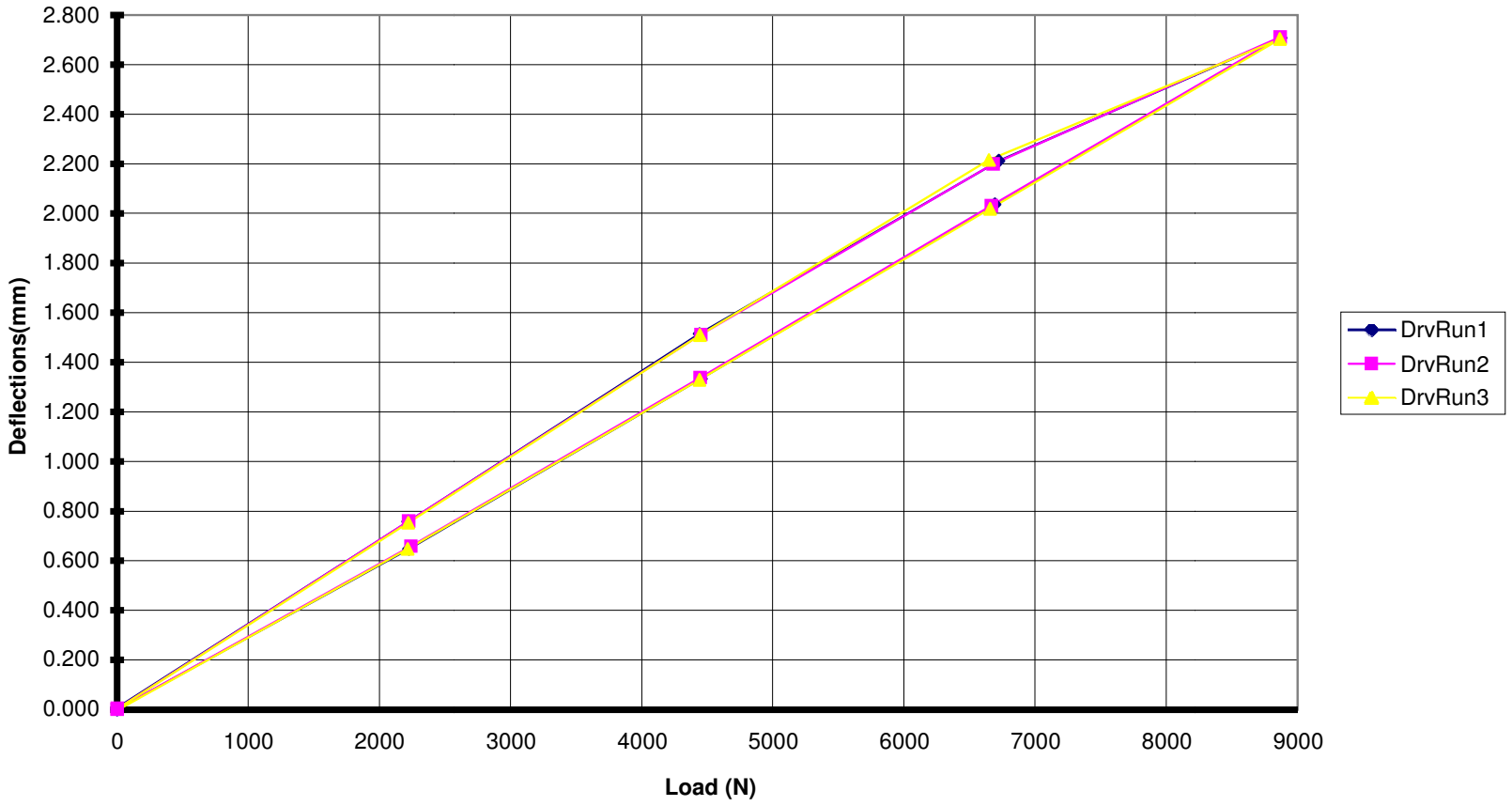
Uncorrected Stiffness = 5,148 Nm/deg
Corrected Stiffness = 5,261 Nm/deg

EDAG Silverado
Static Torsion Test - Cab on Frame
Deflection vs. Position
Maximum Load (Raw Data)



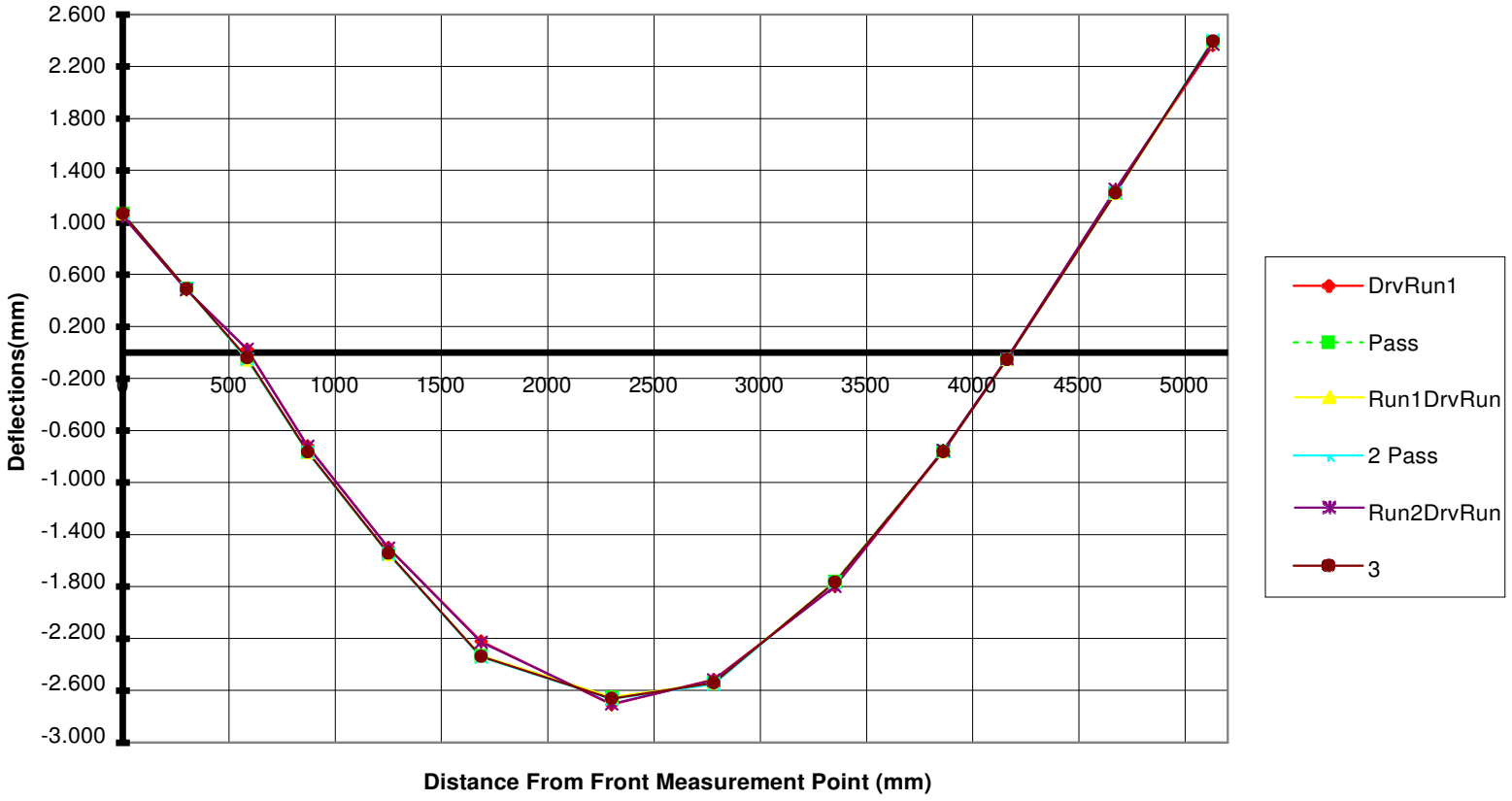
Uncorrected Stiffness = 5,148 Nm/deg
Corrected Stiffness = 5,261 Nm/deg

Silverado Cab on Frame
Static Bending Test (w/o cargobox)
Deflection vs. Load



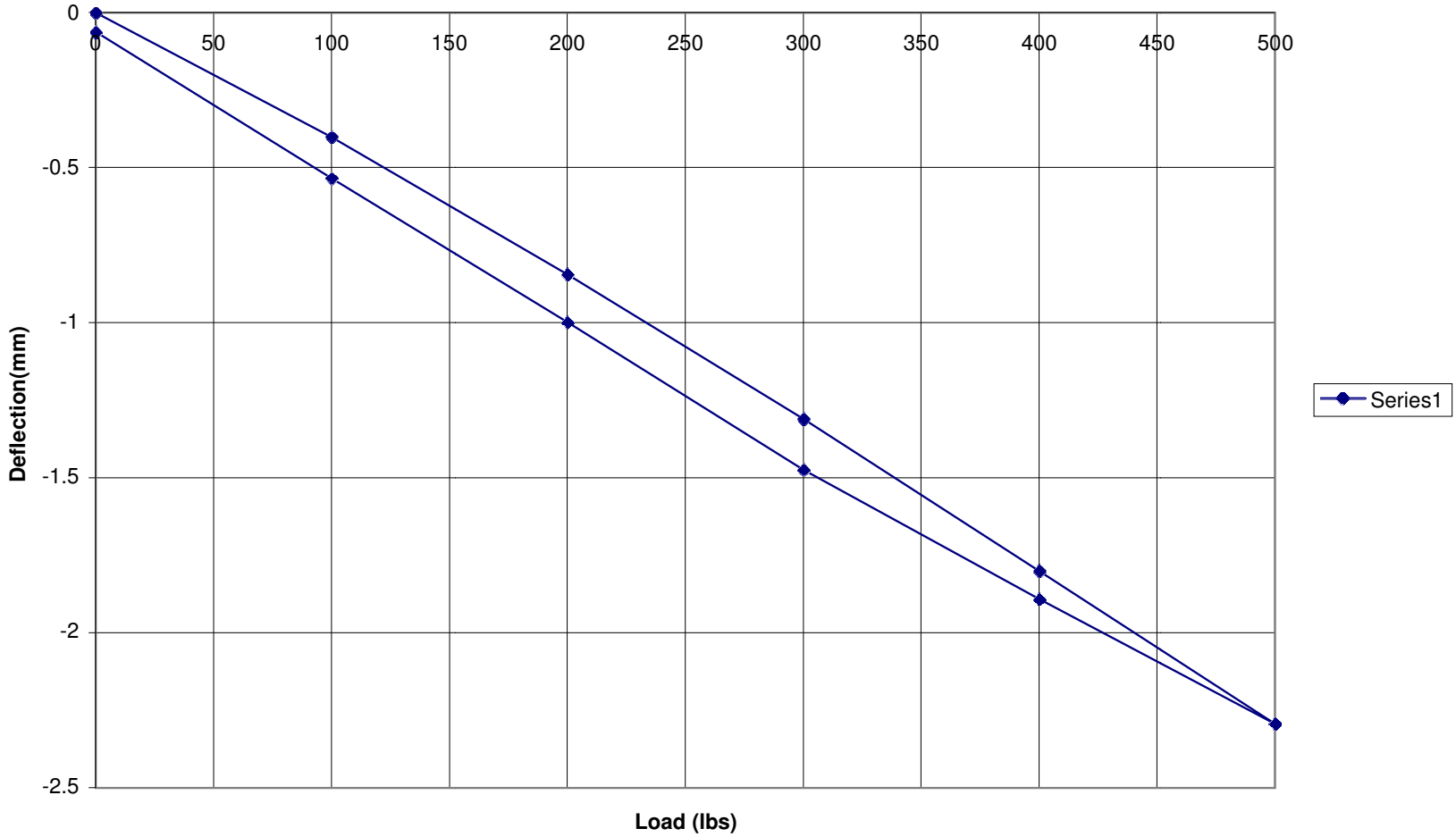
Corrected Driver Stiffness = 3216 N/mm
Corrected Passenger Stiffness = 3294 N/mm

Silverado Cab on Frame
Static Bending Test (w/o cargobox)
Deflection vs. Position
Maximum Load (Raw Data)

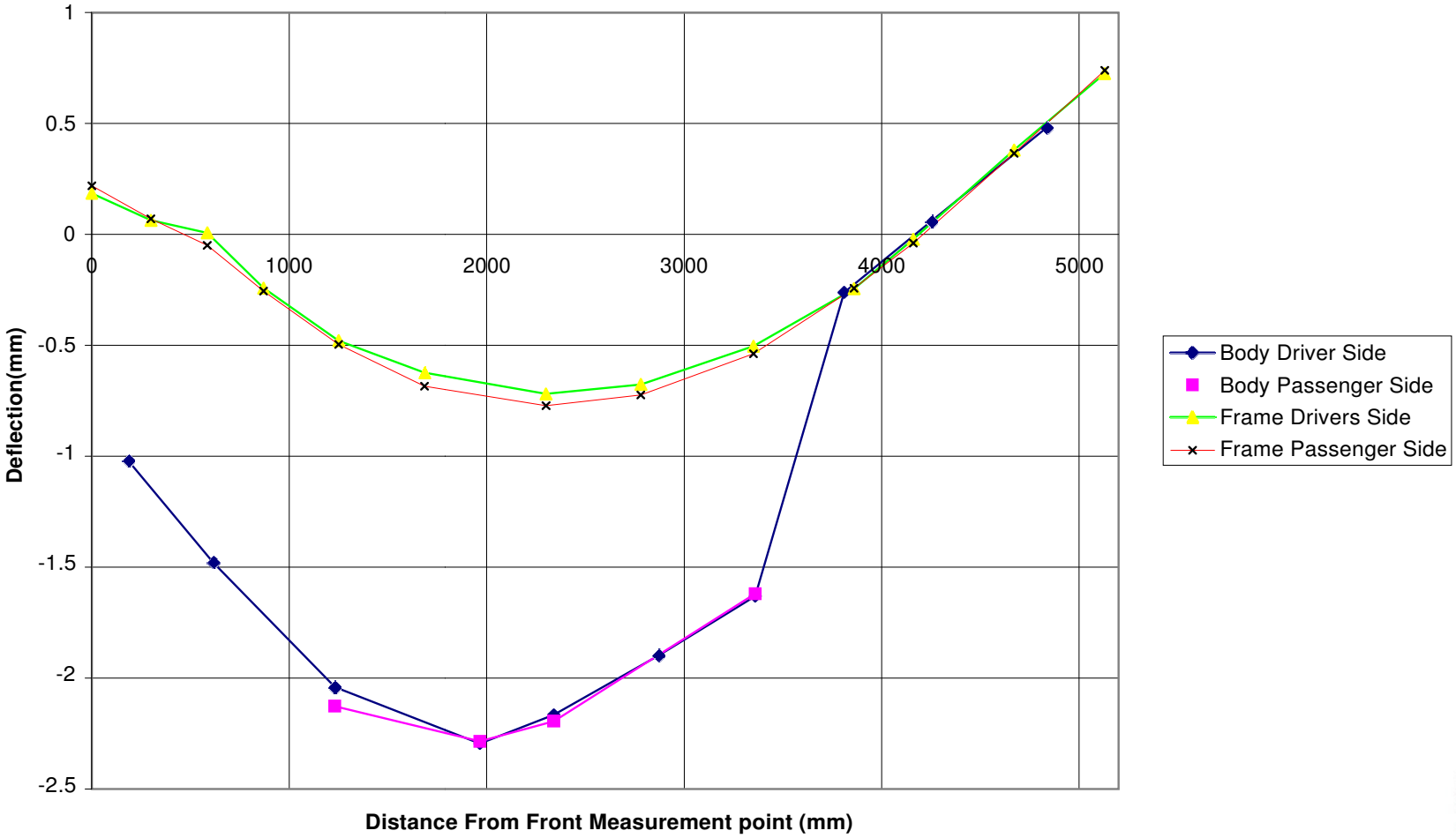


Corrected Driver Stiffness = 3216 N/mm
Corrected Passenger Stiffness = 3294 N/mm

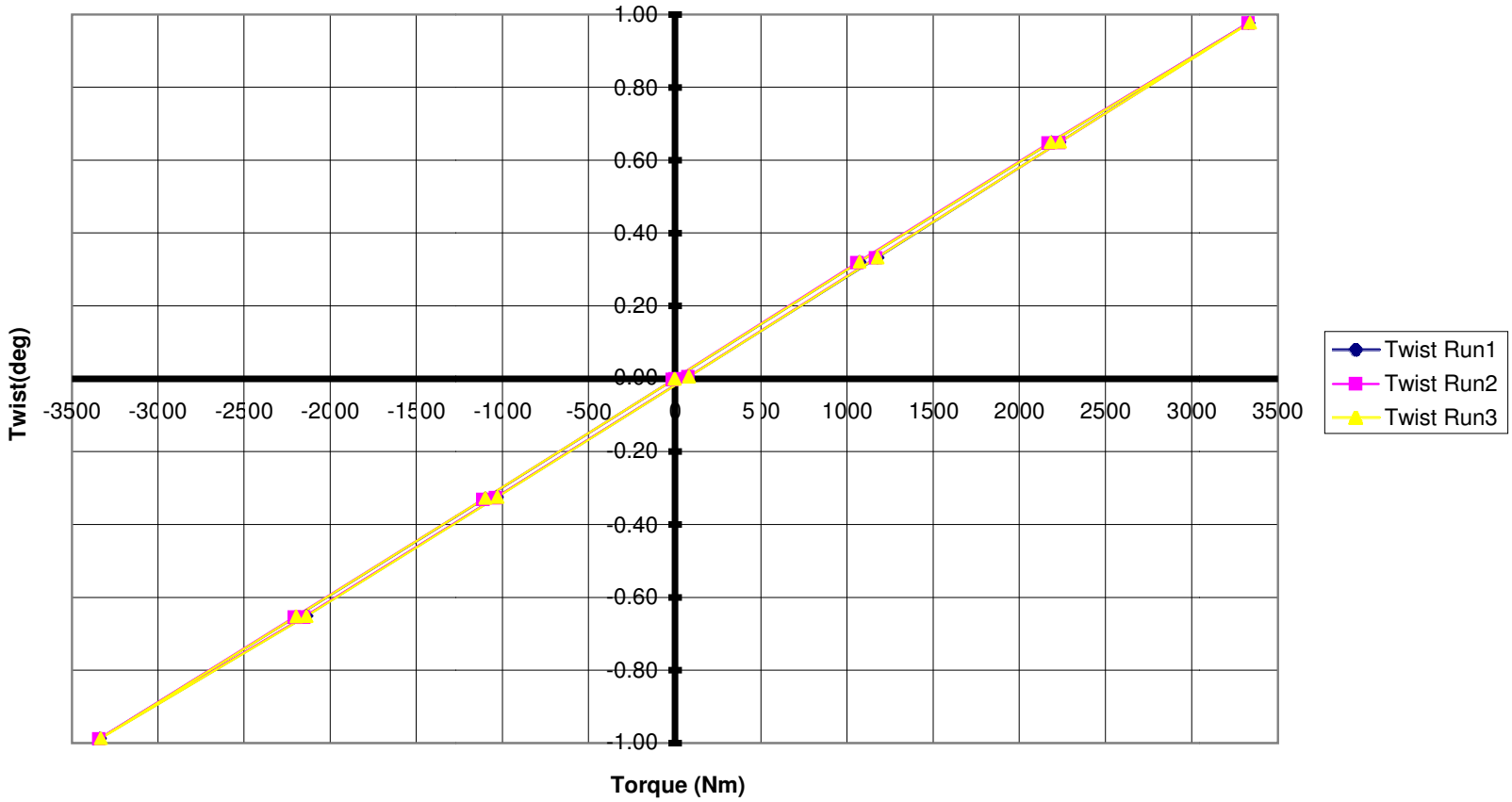
Sill Loaded Bending
Silverado Cab on the Frame



Sill Loaded Bending
Silverado Cab on the Frame

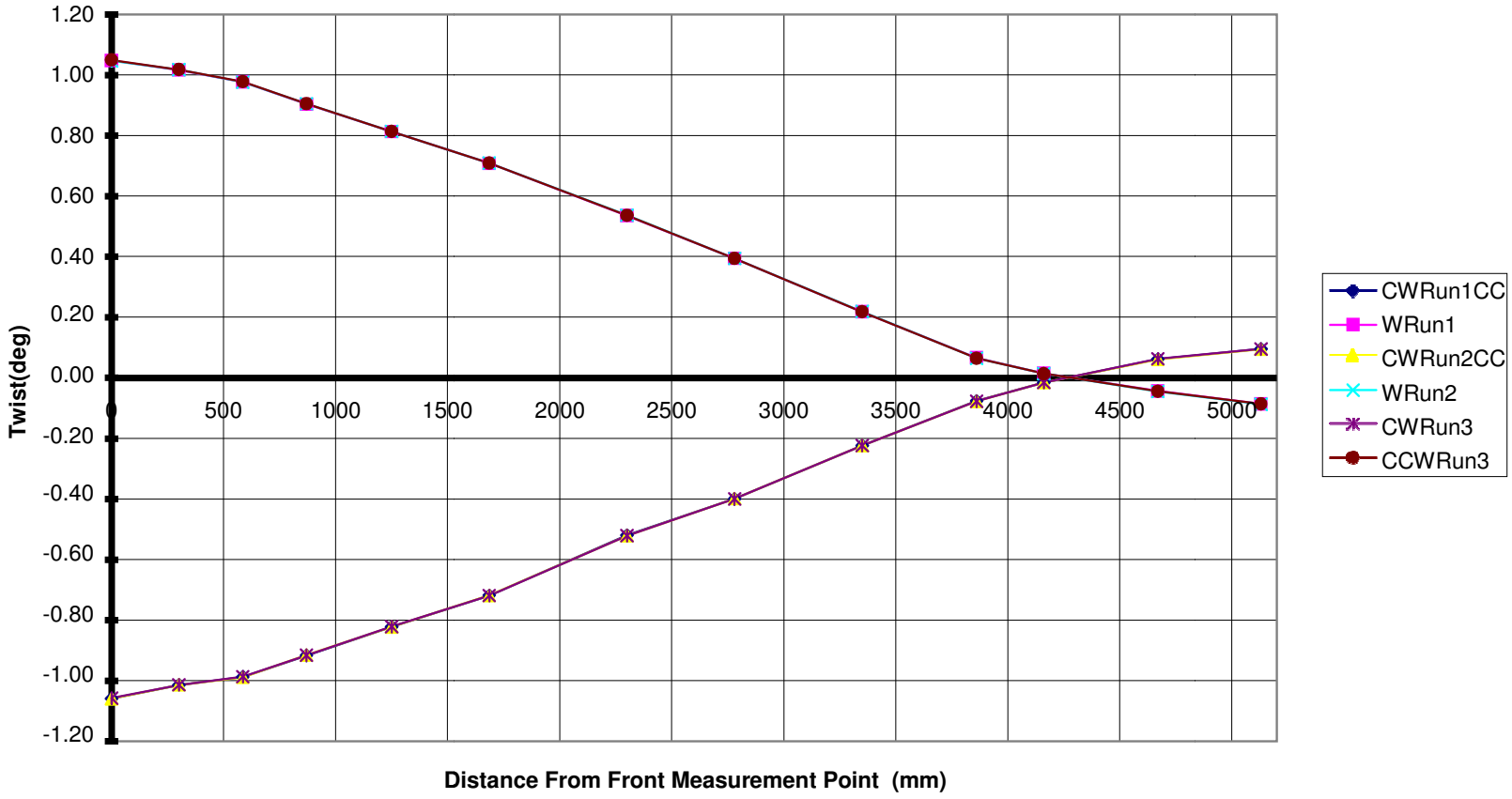


EDAGSiverado
Static Torsion Test - Box on Frame
Twist vs. Torque



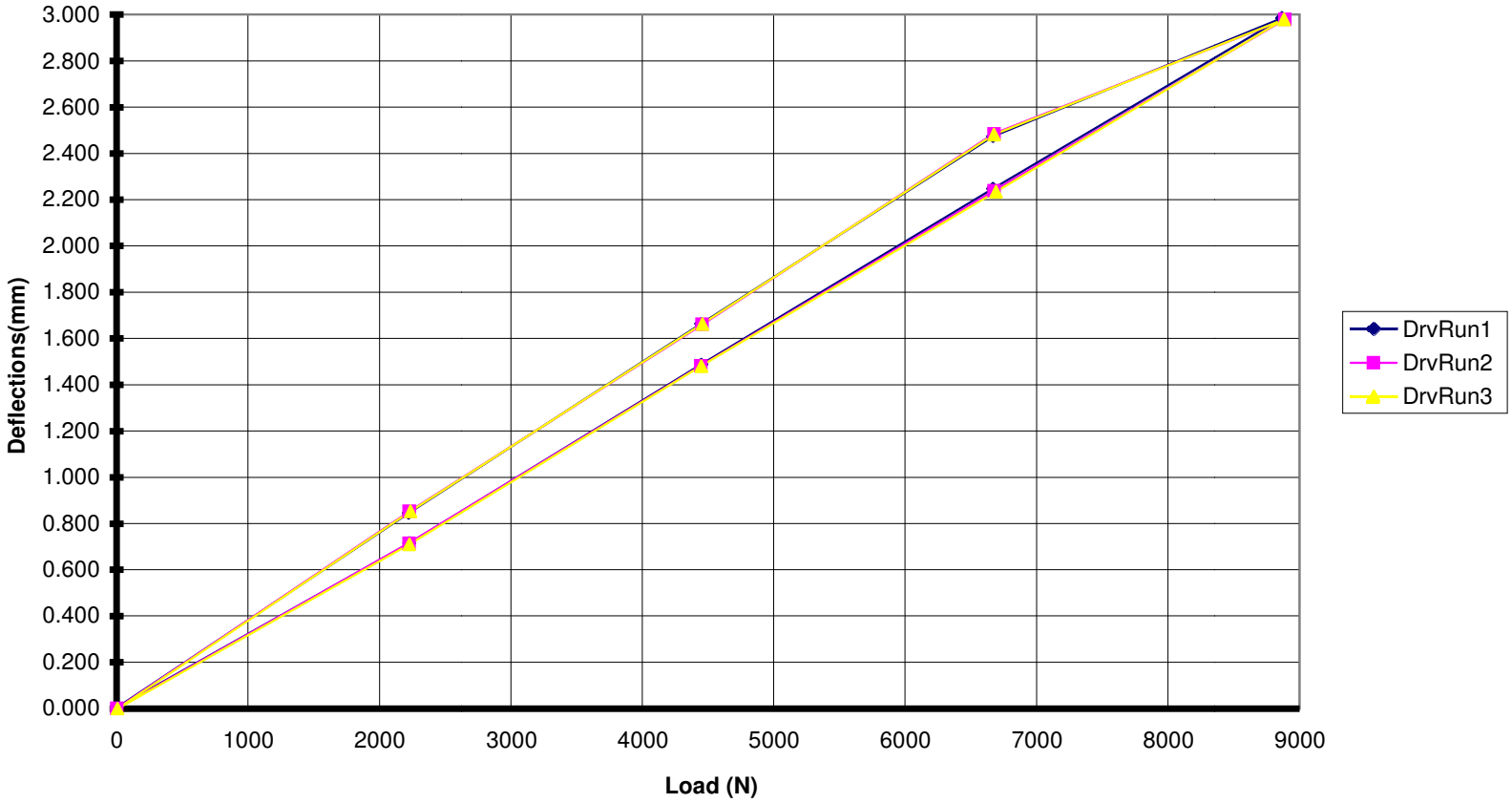
Uncorrected Stiffness = 3,376 Nm/deg
Corrected Stiffness = 3,428 Nm/deg

EDAG Silverado
Static Torsion Test - Box on Frame
Deflection vs. Position
Maximum Load (Raw Data)

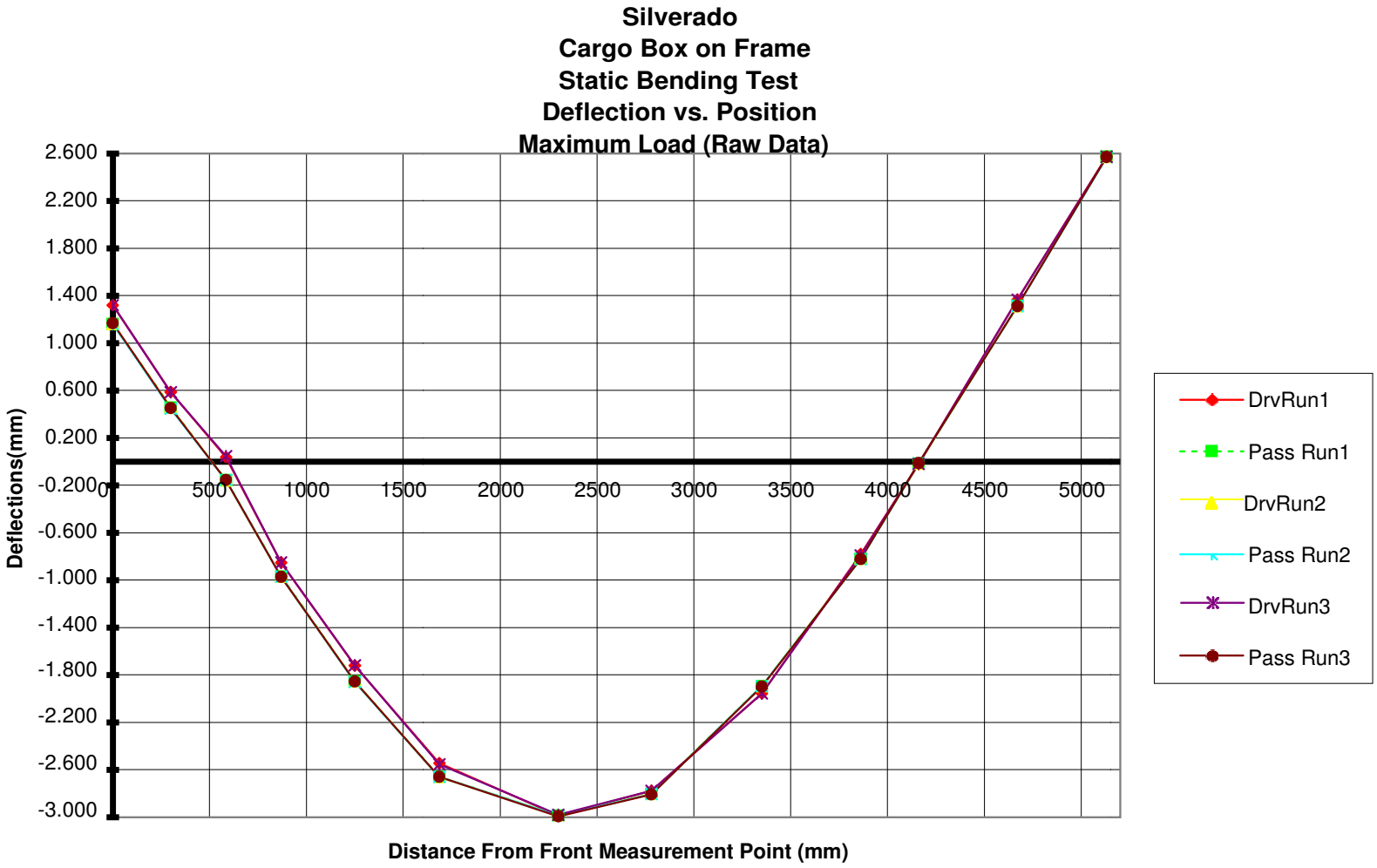


Uncorrected Stiffness = 3,376 Nm/deg
Corrected Stiffness = 3,428 Nm/deg

Silverado
Cargo Box on Frame
Static Bending Test
Deflection vs. Load

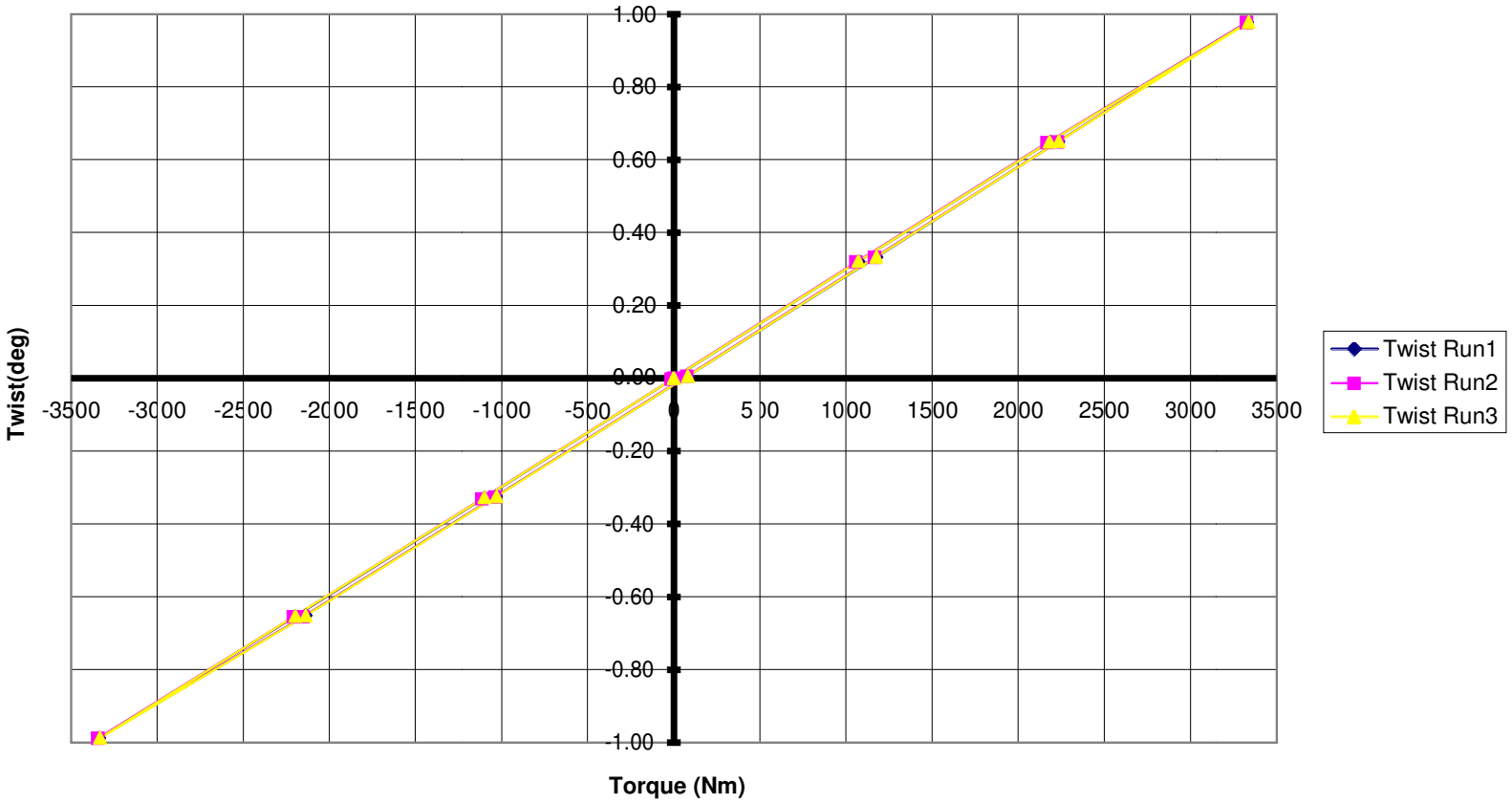


Corrected Driver Stiffness = 2870 N/mm
Corrected Passenger Stiffness = 2965 N/mm



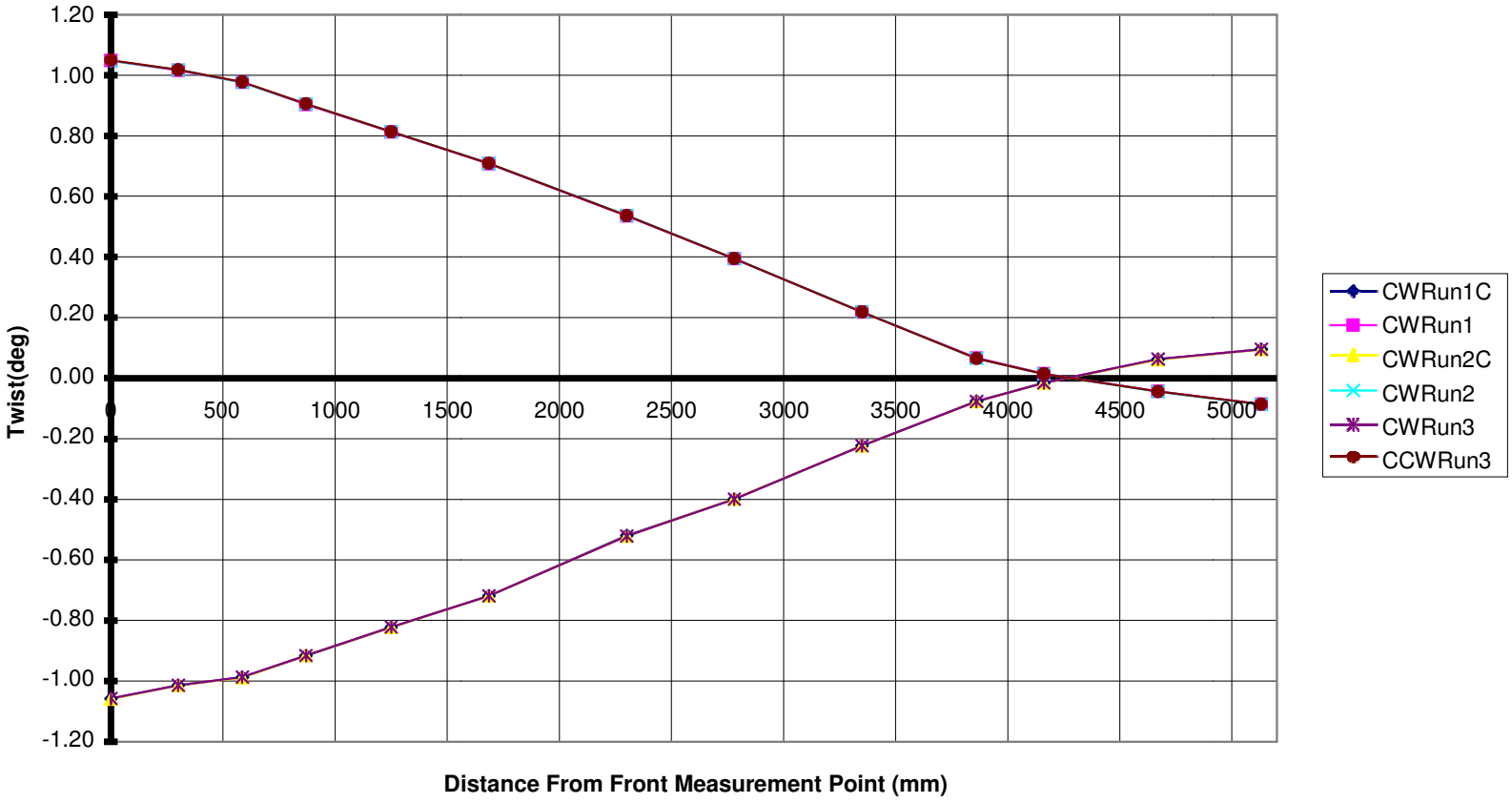
Corrected Driver Stiffness = 2870 N/mm
Corrected Passenger Stiffness = 2965 N/mm

EDAGSiverado
Static Torsion Test - Box on Frame
Twist vs. Torque



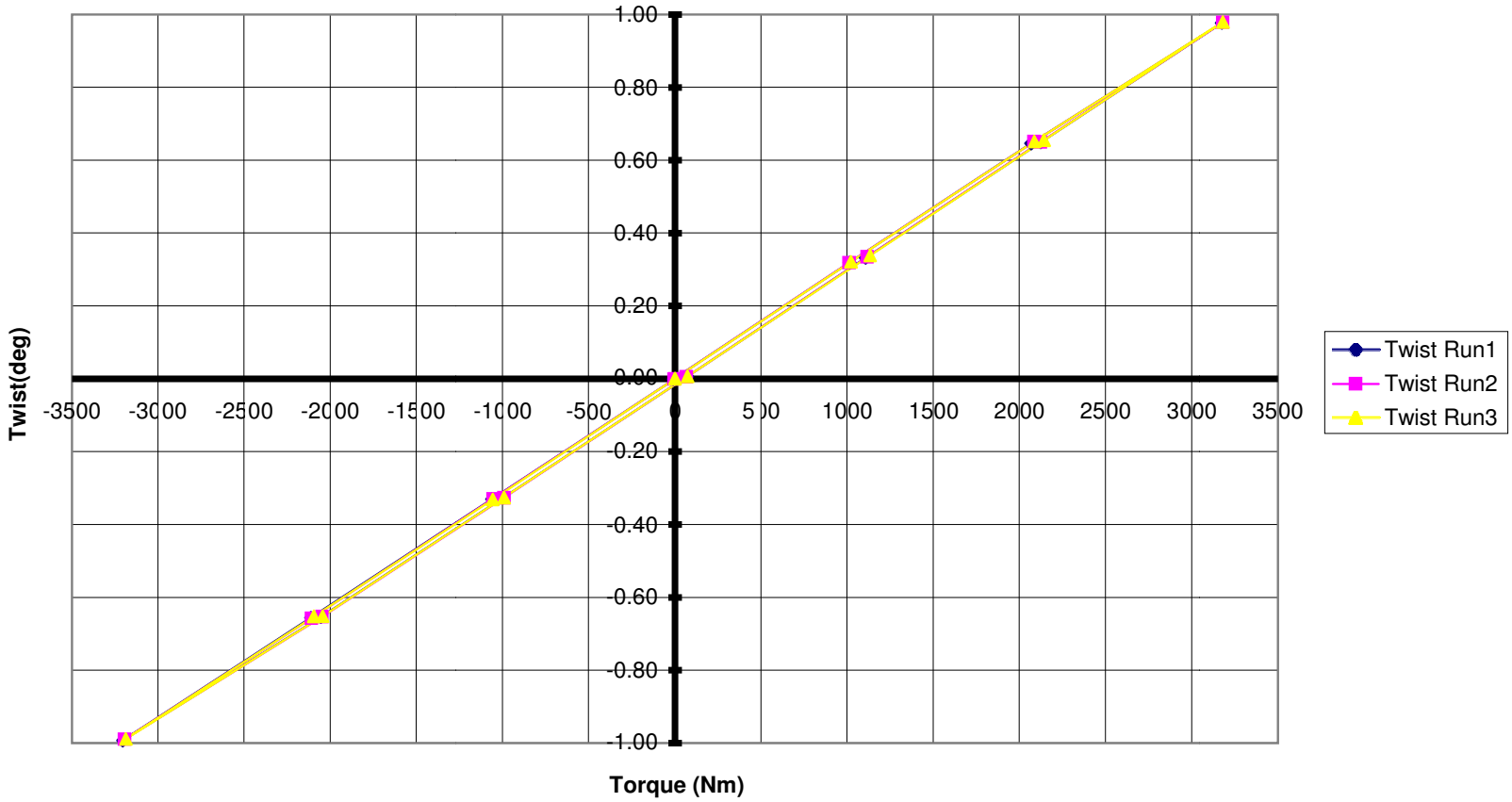
Uncorrected Stiffness = 3,376 Nm/deg
Corrected Stiffness = 3,428 Nm/deg

EDAG Silverado
Static Torsion Test - Box on Frame
Deflection vs. Position
Maximum Load (Raw Data)



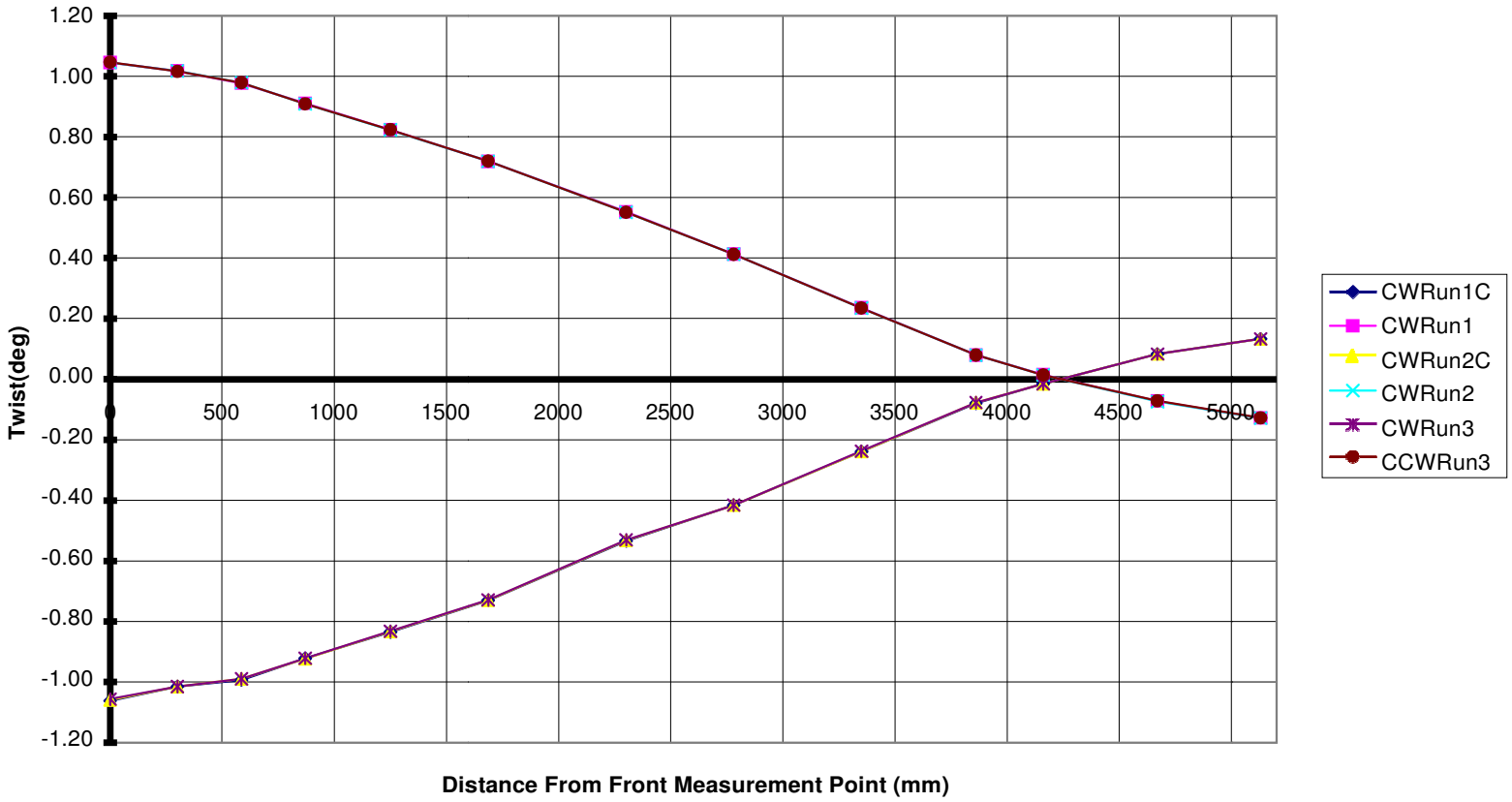
Uncorrected Stiffness = 3,376 Nm/deg
Corrected Stiffness = 3,428 Nm/deg

EDAGSiverado
Static Torsion Test - Bare Frame
Twist vs. Torque



Uncorrected Stiffness = 3,220 Nm/deg
Corrected Stiffness = 3,270 Nm/deg

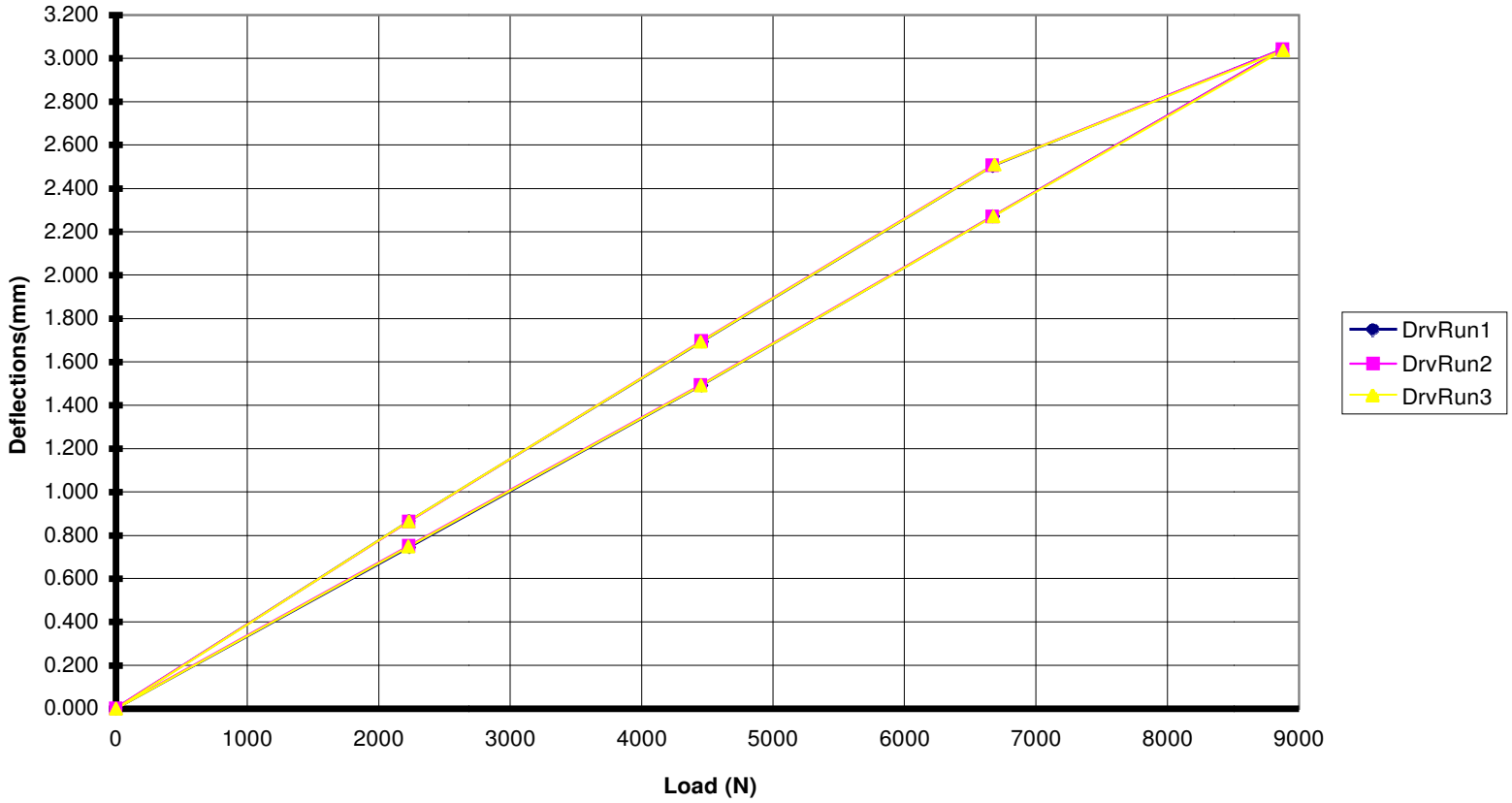
EDAG Silverado
Static Torsion Test - Bare Frame
Deflection vs. Position
Maximum Load (RawData)



Uncorrected Stiffness = 3,220 Nm/deg

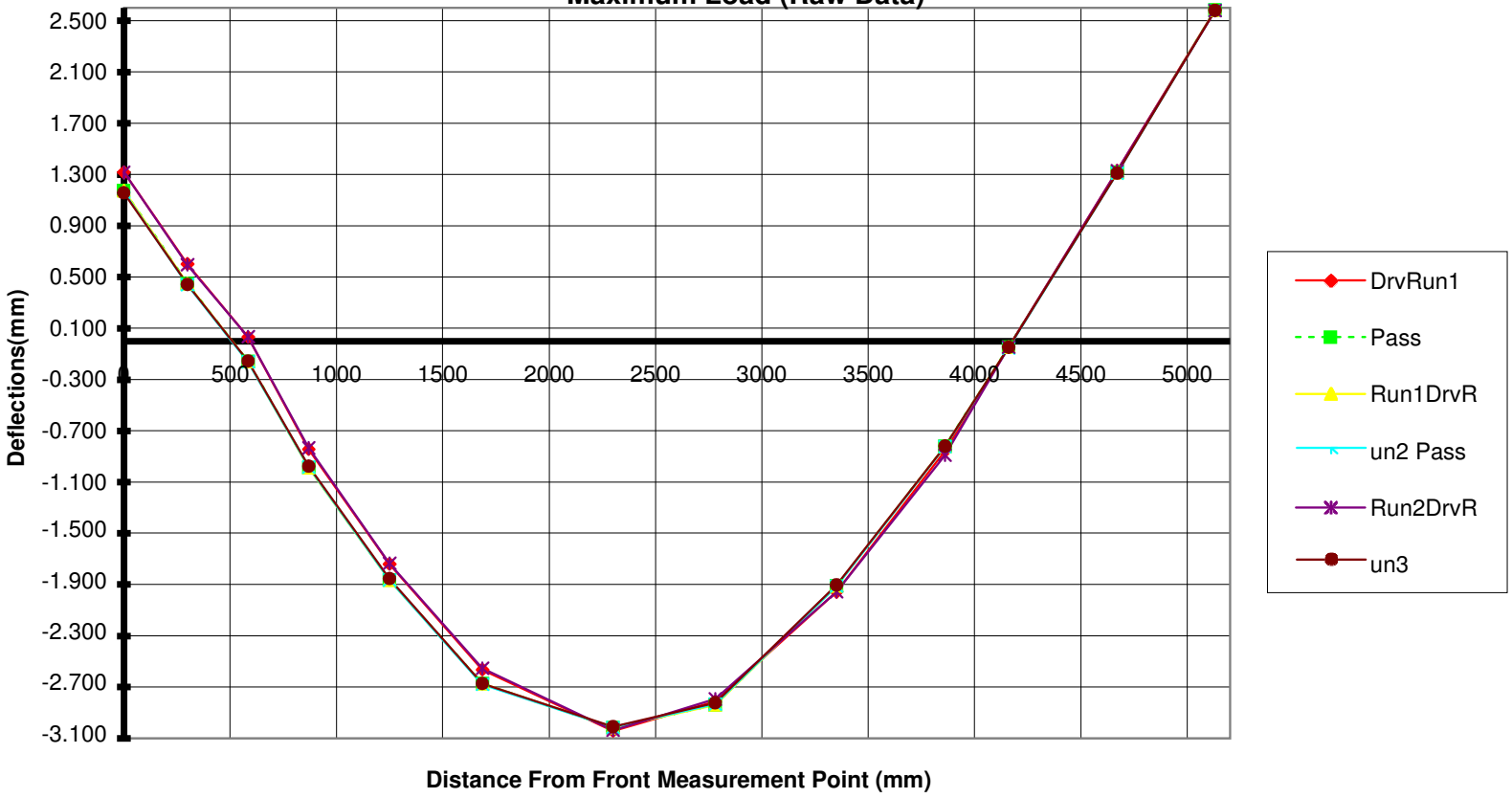
Corrected Stiffness = 3,270 Nm/deg

Silverado
Bare Frame
Static Bending Test
Deflection vs. Load



Corrected Driver Stiffness = 2860 N/mm
Corrected Passenger Stiffness = 2953 N/mm

Silverado
BareFrame
Static Bending Test
Deflection vs. Position
Maximum Load (Raw Data)

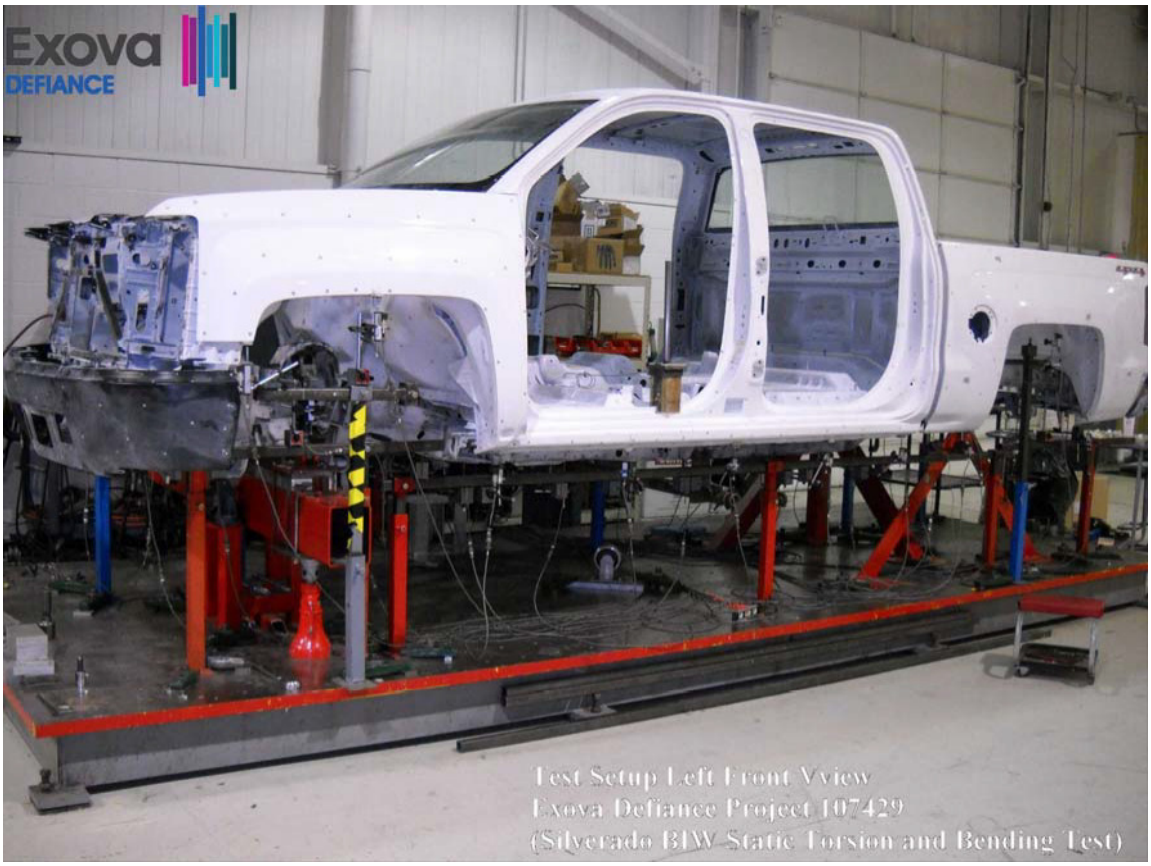


Corrected Driver Stiffness = 2860 N/mm
Corrected Passenger Stiffness = 2953 N/mm

Appendix B

BIW Static Torsion and Bending Test Setup Photographs


Exova
DEFIANCE
Test Setup Overview
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

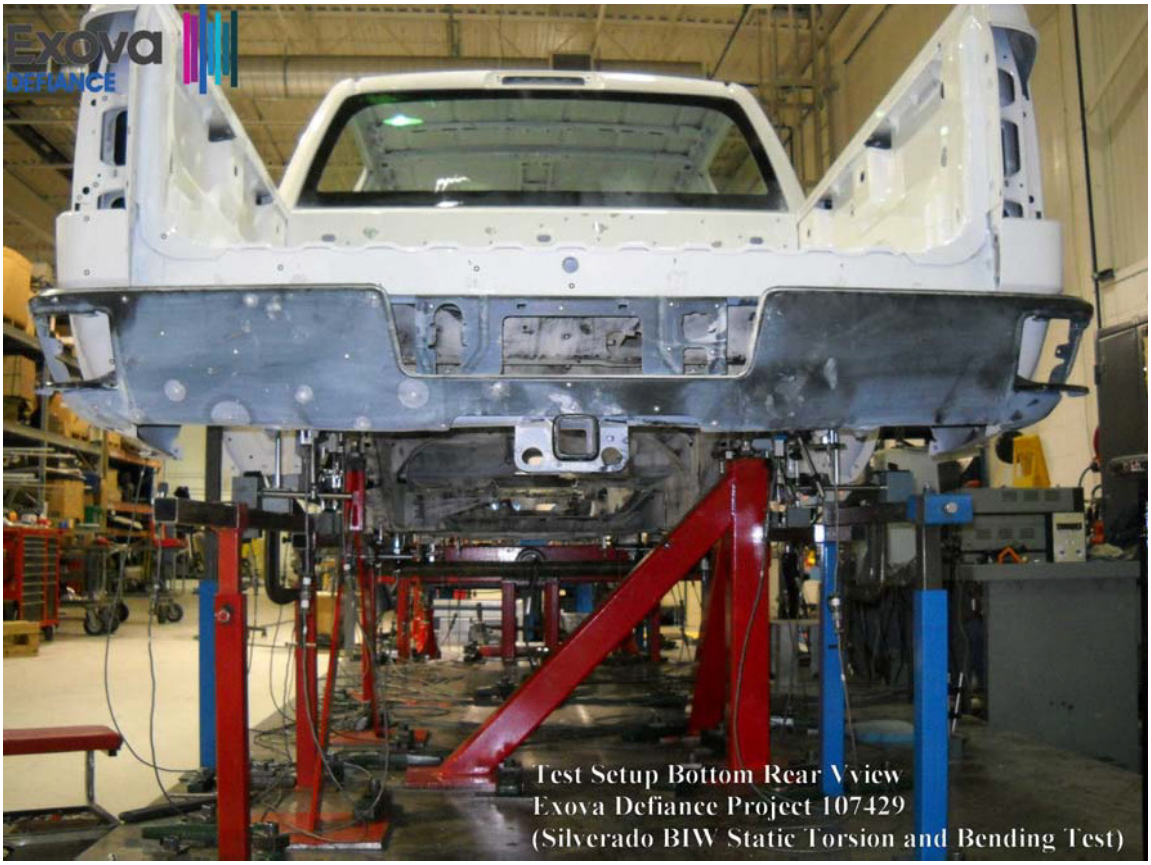

Exova
DEFIANCE
Test Setup Left Front Vview
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Test Setup Front Vview
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Test Setup Front Vview
Exova Defiance Project 107429


Test Setup Left Rear Vview
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Test Setup Rear Vview
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

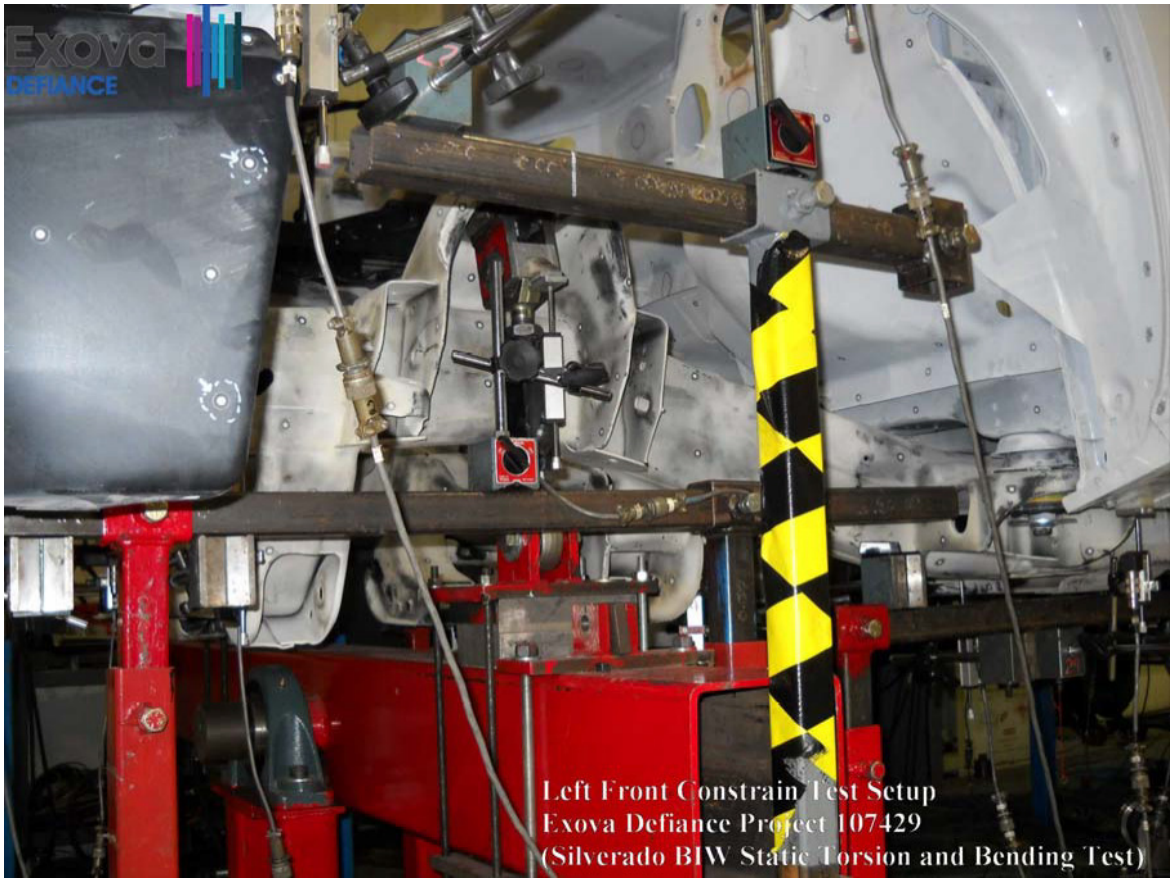

Exova
DEFIANCE
Test Setup Bottom Rear Vview
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

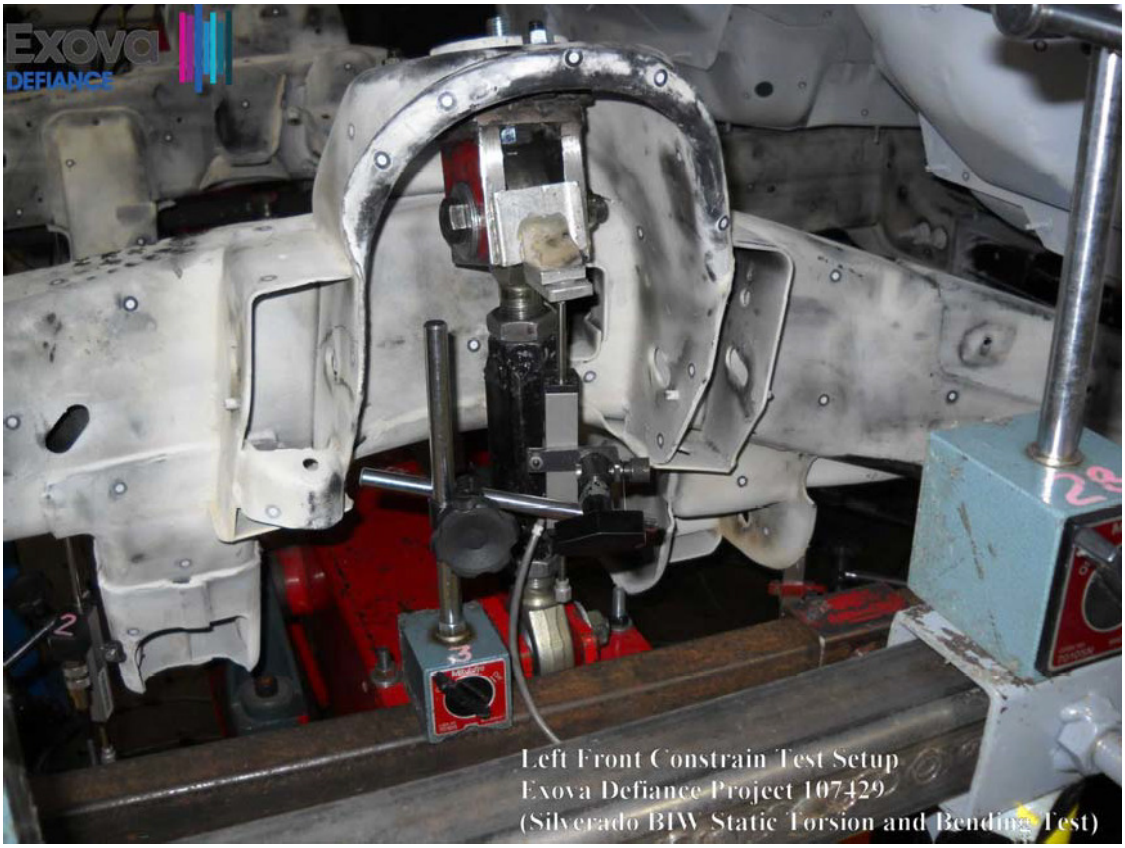

Exova
DEFIANCE
4x4
Test Setup Right Rear Vview
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

ACCREDITED


Exova
DEFIANCE
Test Setup Right Front Vview
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Torsion Loading Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Left Front Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

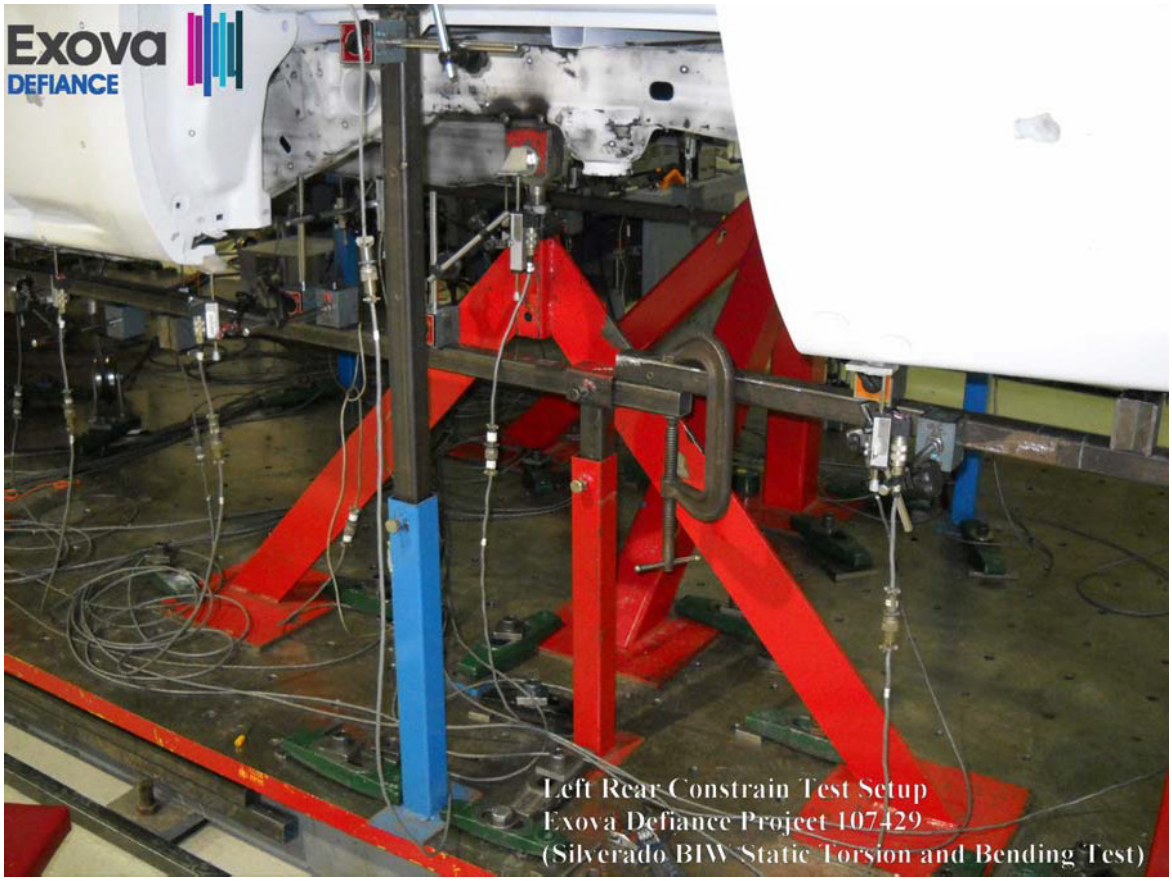

Exova
DEFIANCE
Left Front Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Left Front Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

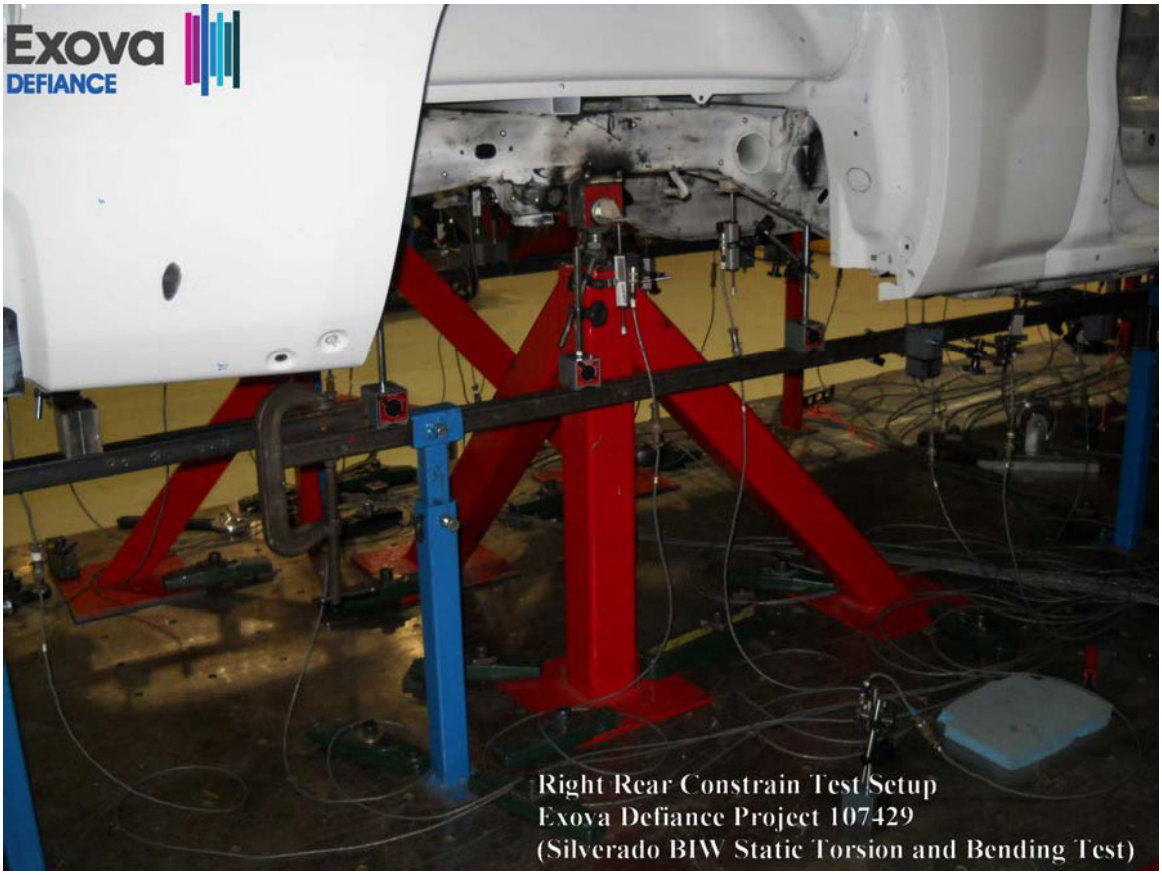

Exova
DEFIANCE
Left Rear Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

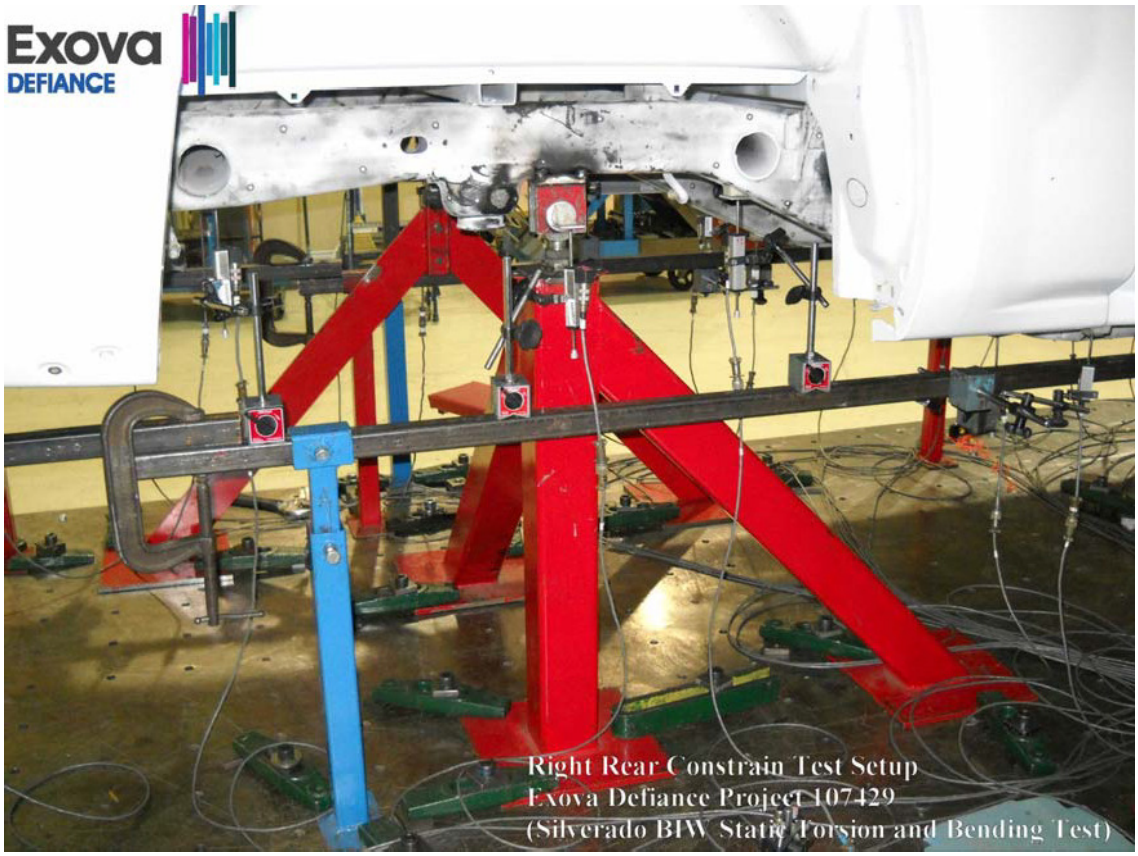
ACCREDITED


Exova
DEFIANCE
Left Rear Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

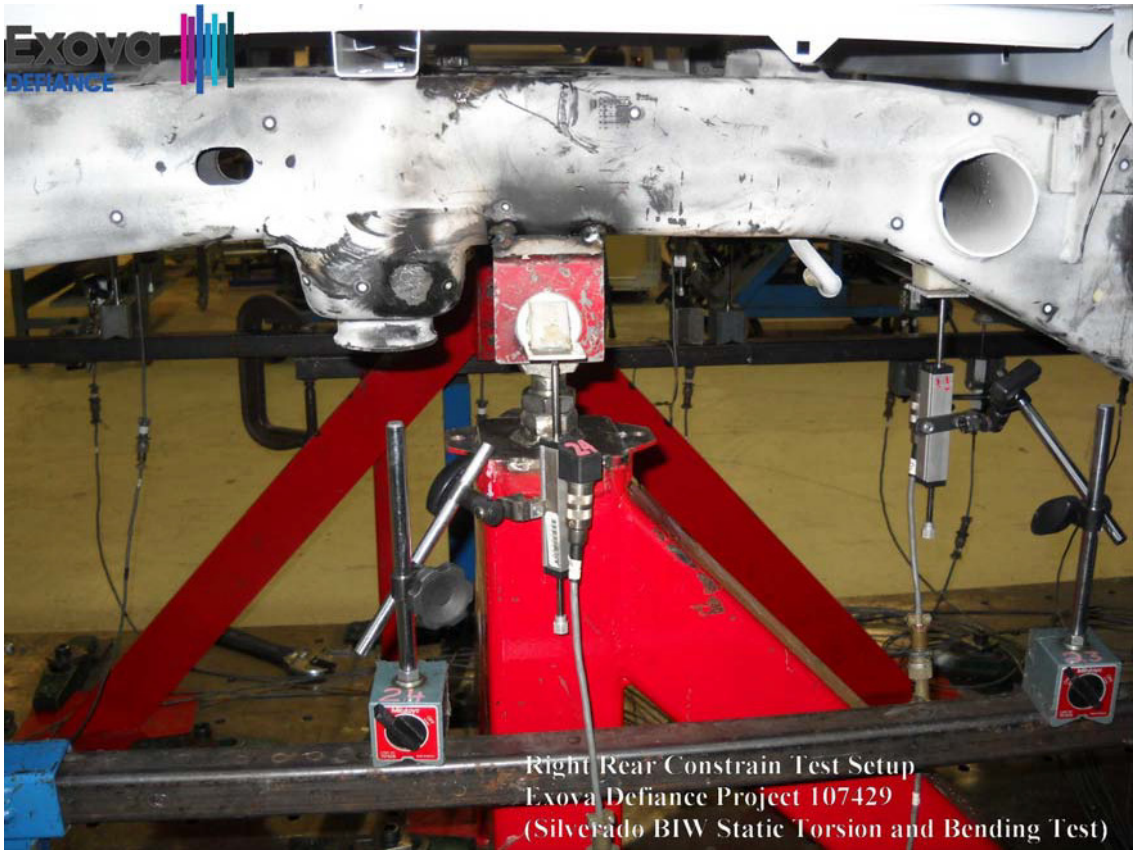

Exova
DEFIANCE
Left Rear Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Left Rear Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

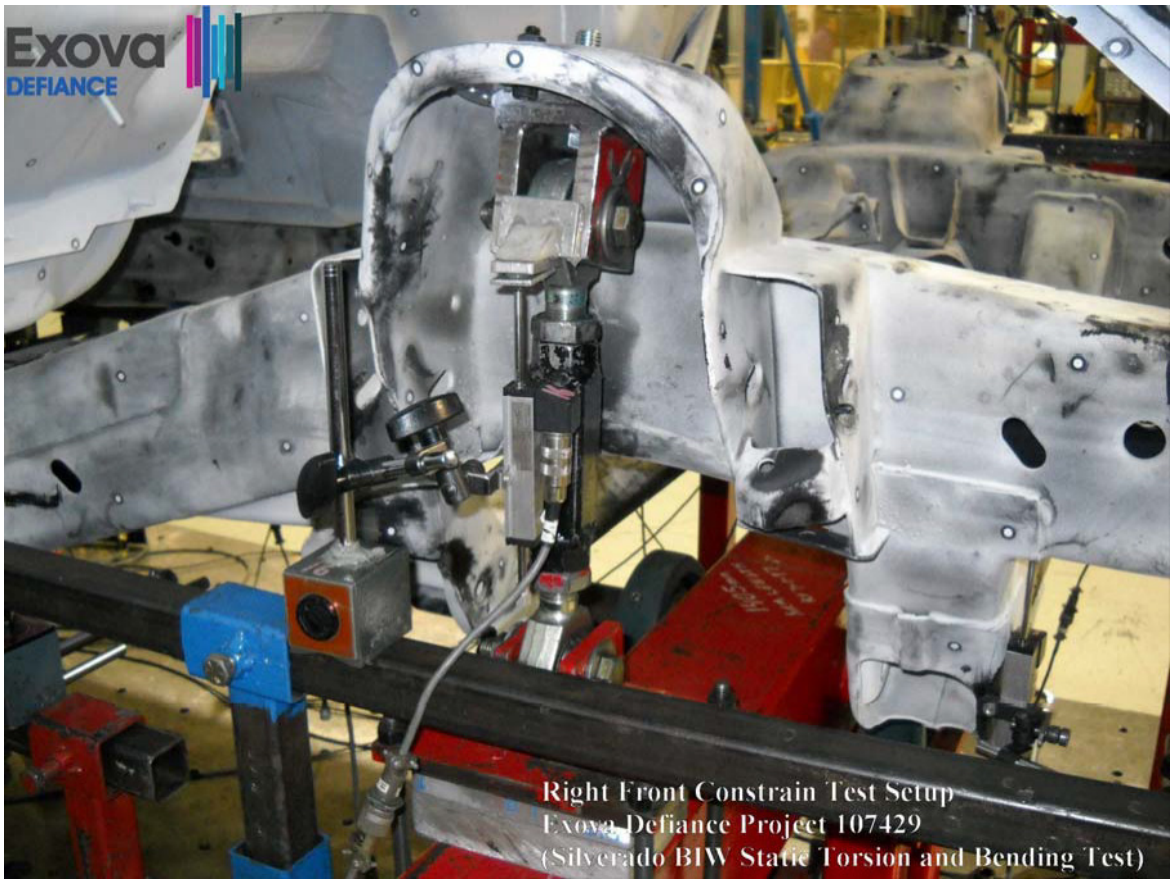

Exova
DEFIANCE
Right Rear Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

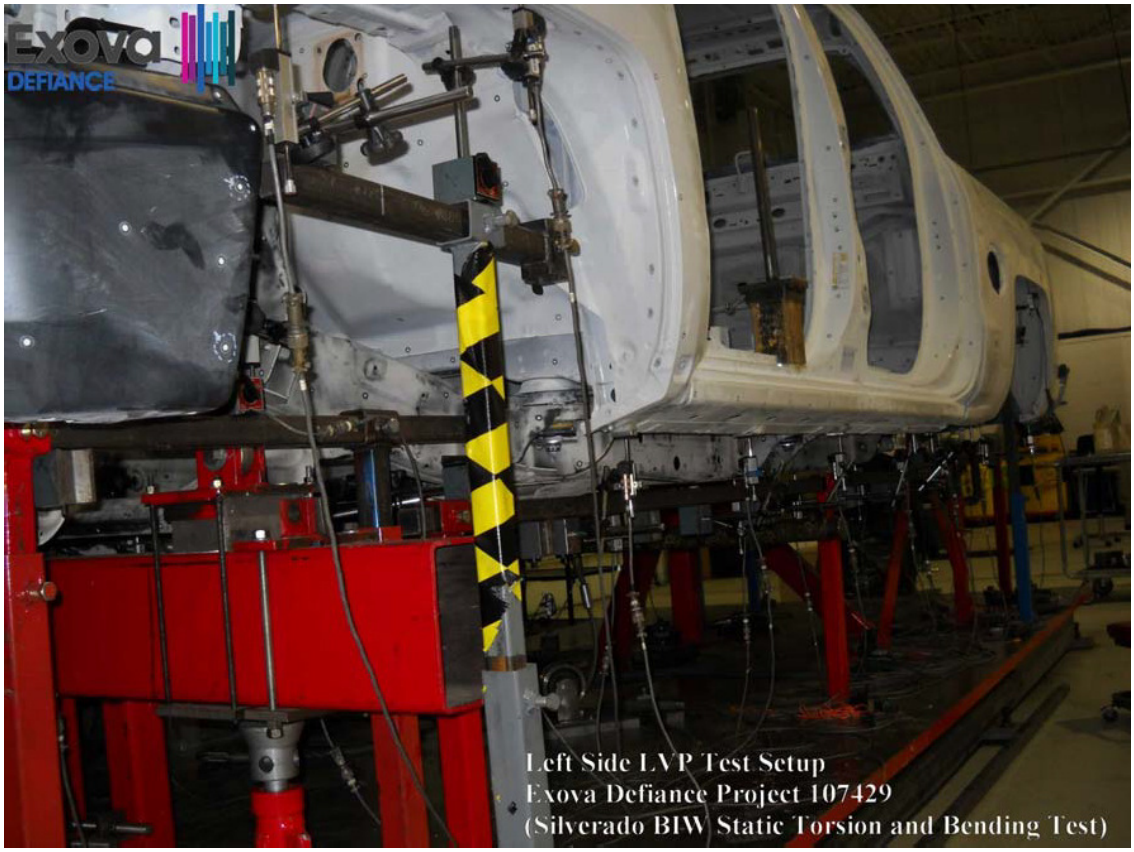

Exova
DEFIANCE
Right Rear Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Right Rear Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Right Rear Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Right Front Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Right Front Constrain Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Left Side LVP Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

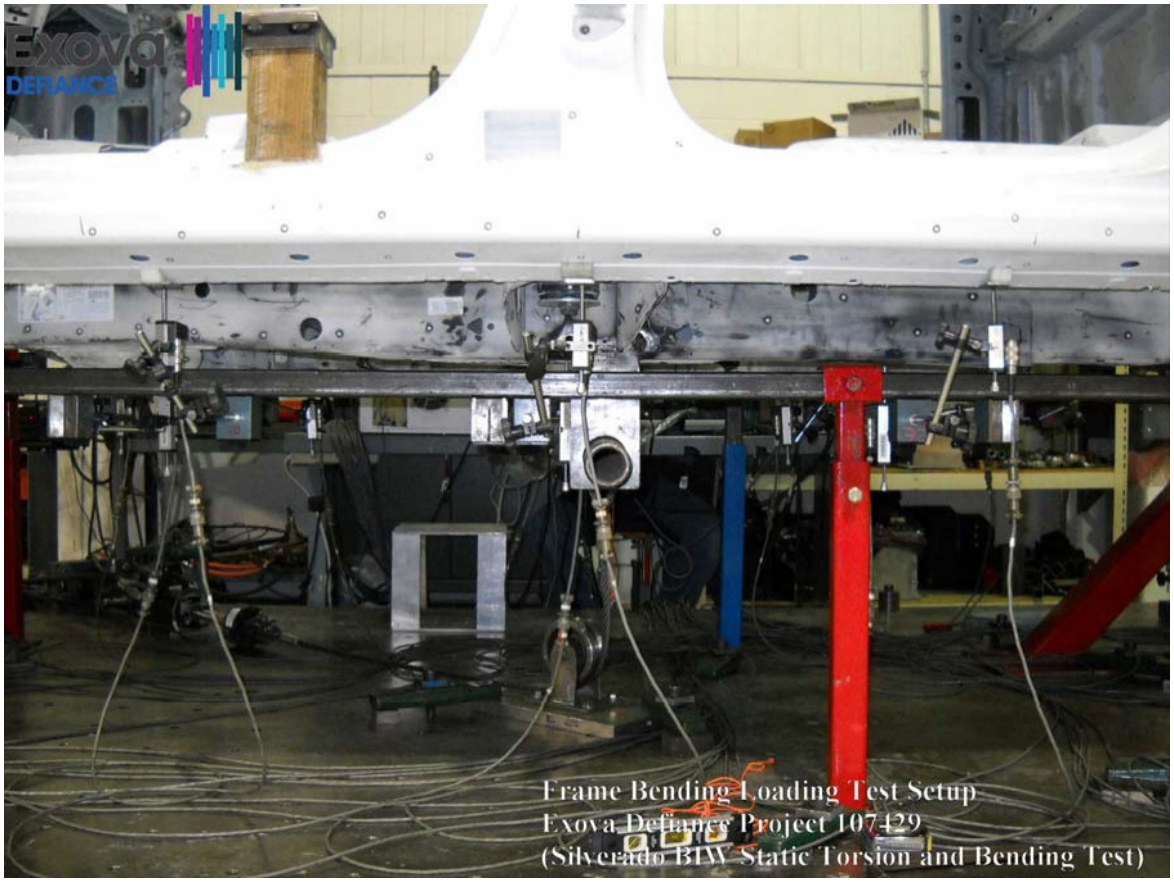
ACCREDITED


Left Side LVP Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

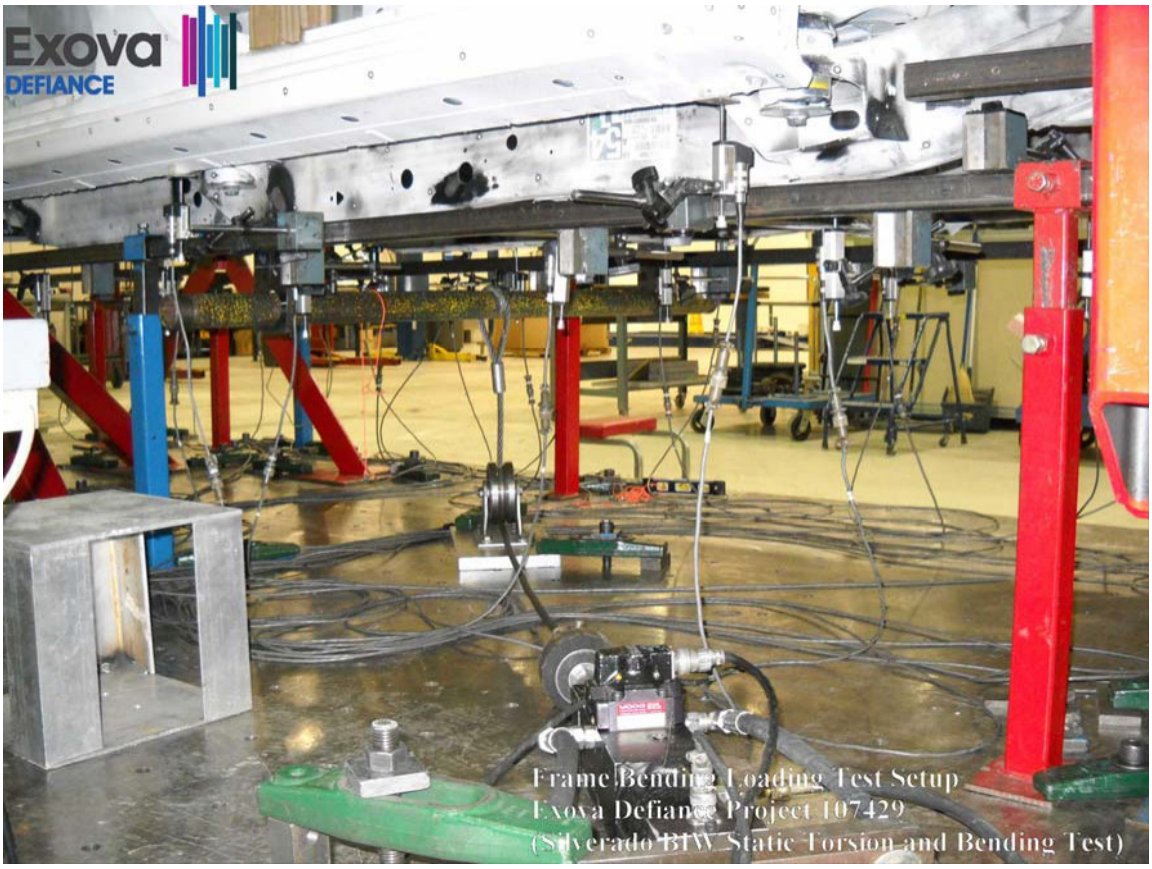

Right Side LVP Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

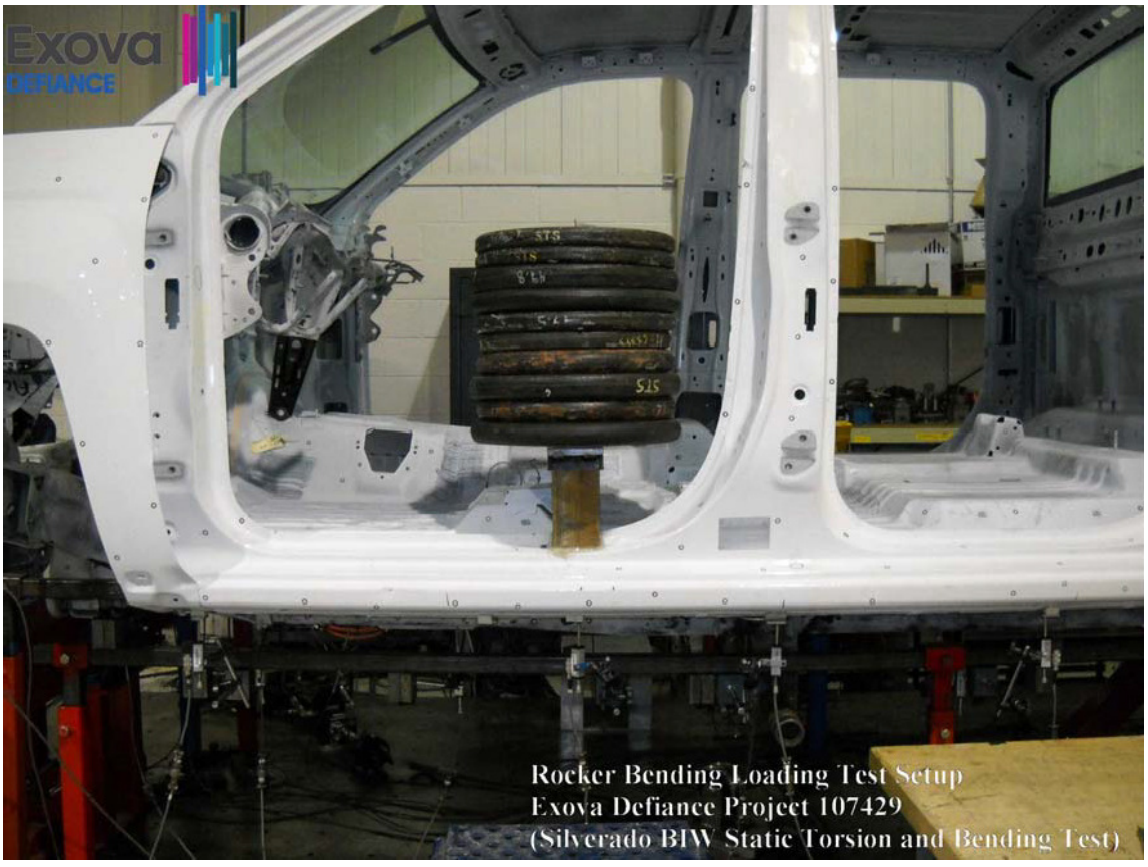

Exova
DEFIANCE
Right Side LVP Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Frame Bending Loading Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Frame Bending Loading Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

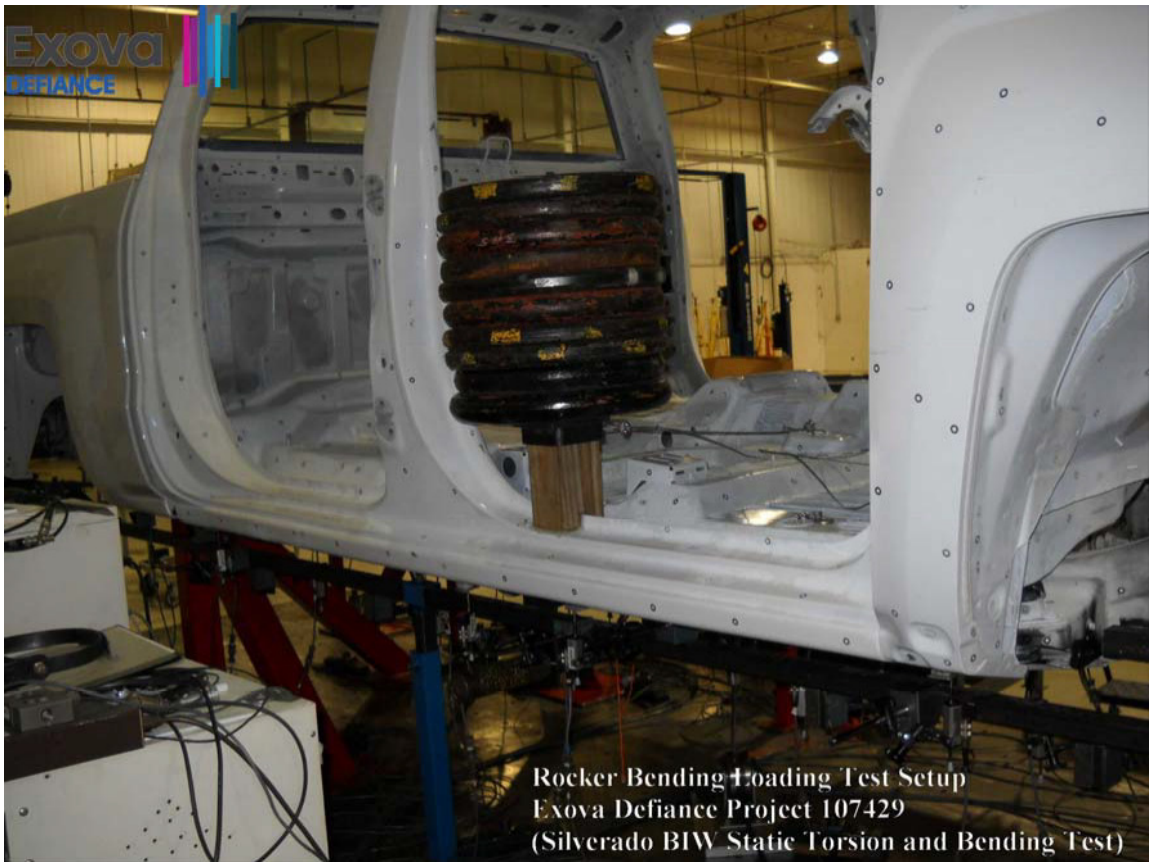

Frame Bending Loading Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Frame Bending Loading Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Rocker Bending Loading Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

ACCREDITED


Exova
DEFIANCE
Rocker Bending Loading Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Rocker Bending Loading Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
2TON
Cab on the Frame Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

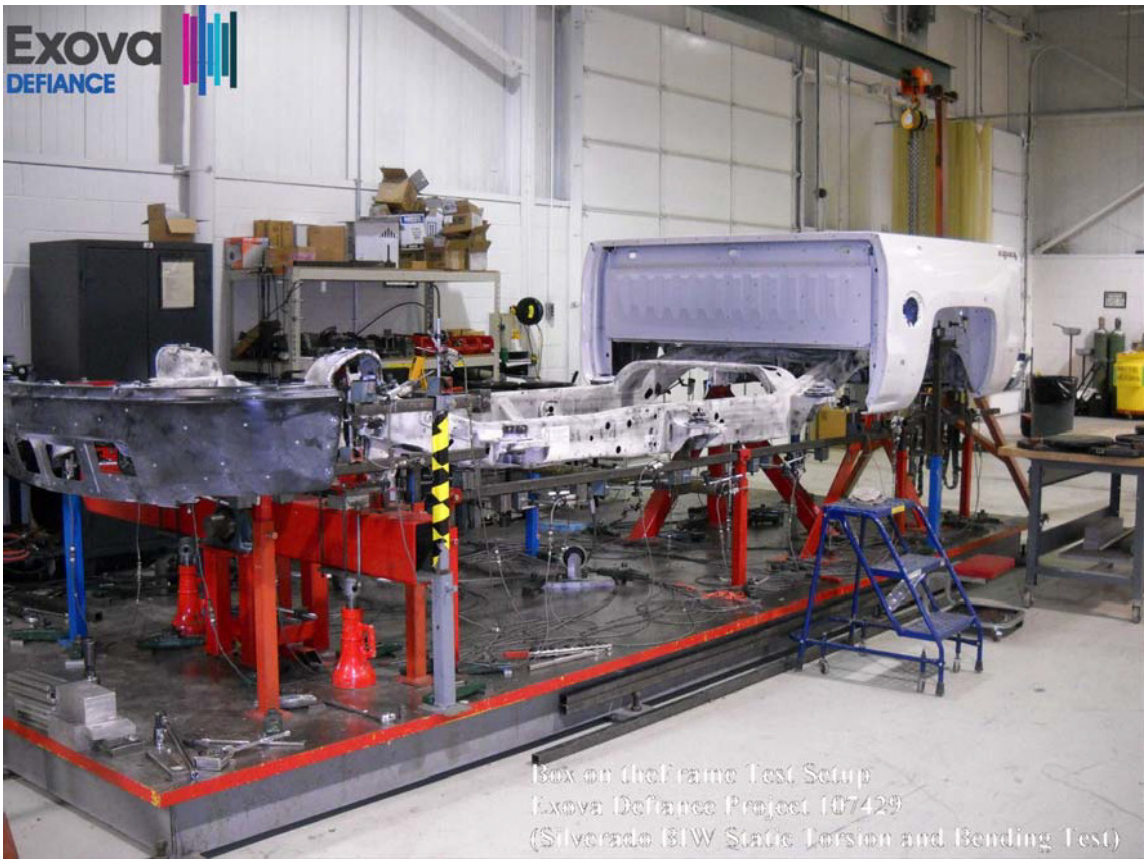

Exova
DEFIANCE
4x4
Cab on the Frame Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

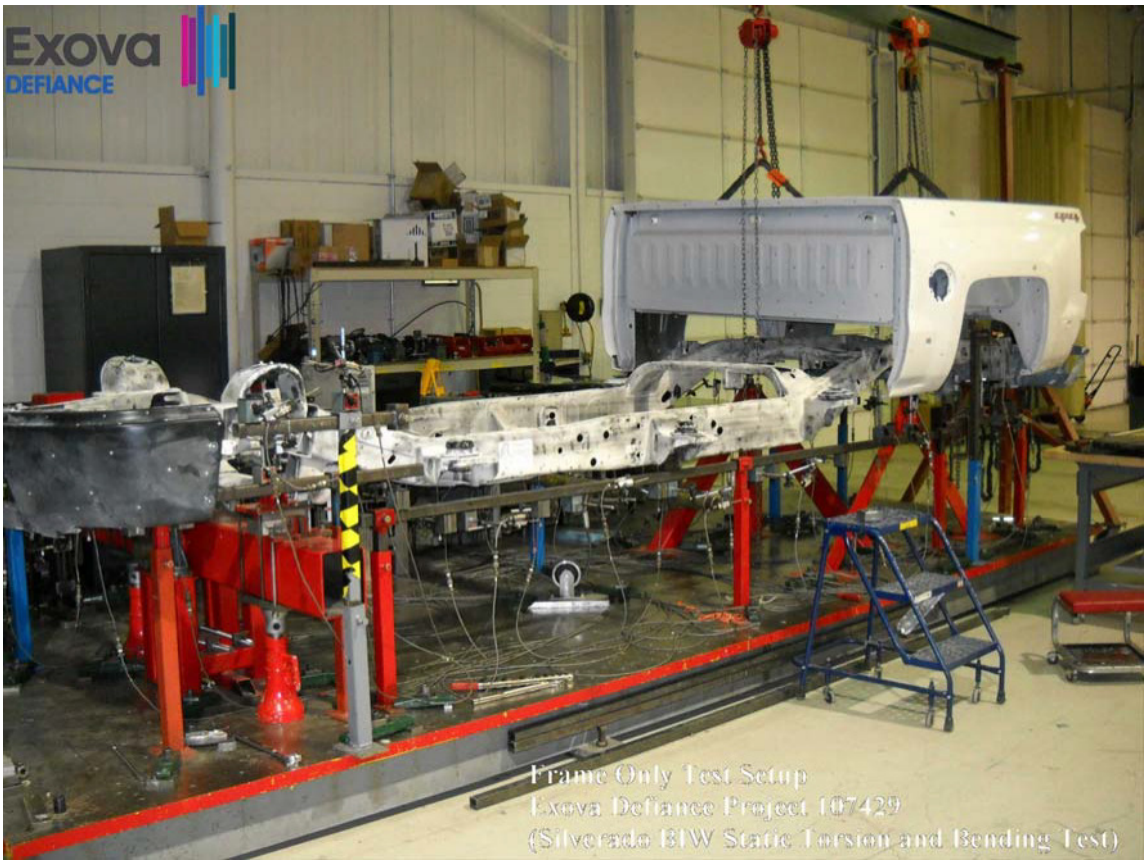
Cab on the Frame Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

Cab on the Frame Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
2TON
Box on the Frame Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
2TON
Box on the Frame Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Box on the Frame Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


Exova
DEFIANCE
Frame Only Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


EXOVA
DEFIANCE
4x4
Frame Only Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)


EXOVA
DEFIANCE
Frame Only Test Setup
Exova Defiance Project 107429
(Silverado BIW Static Torsion and Bending Test)

Appendix C

Equipment List

Equipment

Description	ModelNumber	SerialNumber	Asset	Capacity1	Capacity2	Ch.	Ch. Description	Type ofCalSchedule	Next Cal Date
Project Number: 107429	**Project Name:** Silverado BIW Bending &Torsion								
ActivityNumber:30	**Activity Name:Static Stiffness**			**Sample:** 1					
ACController	406.11(AC)	4671	0031179	AC					
ControlUnit	436.11(FG)	959	0031261						
ESeriesMultifunctionDAQBoard	PCI-6031E	0xB627AD	0039200	64 In/2 Out	100k/ 16 Bit			Scheduled Calibration	4/6/2014
	Load Cell	3173-3K	1879	0032096	3,000 Lbs			Scheduled Calibration	3/30/2014
LVP	TRS50	000608	0019911	2 In				Scheduled Calibration	10/7/2014
	TRS50	000621	0019927	2 In				Scheduled Calibration	10/7/2014
	TRS50	000632	0019918	2 In				Scheduled Calibration	10/7/2014
	TRS50	000637	0036316	2 In				Scheduled Calibration	10/7/2014
	TRS50	003083	0019928	2 In				Scheduled Calibration	10/7/2014
	TRS50	003103	0019914	2 In				Scheduled Calibration	10/7/2014
	TRS50	003171	0019913	2 In				Scheduled Calibration	10/7/2014
	TRS50	003194	0019915	2 In				Scheduled Calibration	10/7/2014
	TRS50	003219	0035971	2 In				Scheduled Calibration	10/7/2014
	TRS50	046436	0041361	2 in.				Scheduled Calibration	10/7/2014
	TRS50	0609	0019932	2 In				Scheduled Calibration	10/7/2014
	TRS50	0622	0019934	2 In				Scheduled Calibration	10/7/2014
	TRS50	0634	0019935	2 In				Scheduled Calibration	10/7/2014
	TRS50	0639	0019936	2 In				Scheduled Calibration	10/7/2014
	TRS50	0660	0019930	2 In				Scheduled Calibration	10/7/2014
	TRS50	16566G	0019912	2 In				Scheduled Calibration	10/7/2014
	TRS50	3093	0019931	2 In				Scheduled Calibration	10/7/2014
	TRS50	3173	0019937	2 In				Scheduled Calibration	10/7/2014
	TRS50	3174	0019938	2 In				Scheduled Calibration	10/7/2014
	TRS50	3192	0019929	2 In				Scheduled Calibration	10/7/2014
	TRS50	607	0035608	2 In				Scheduled Calibration	10/7/2014
	TRS50	655	0035609	2 In				Scheduled Calibration	10/7/2014
	TRS50	86032G	0040585	2 In				Scheduled Calibration	10/7/2014
	TRS50	86034G	0039143	2 In				Scheduled Calibration	10/7/2014

Description	Model Number	Serial Number	Asset	Capacity 1	Capacity 2	Ch.	Ch. Description	Type of Cal S
LVP	TRS50	Red # 18	0036304	2 In				Scheduled Cal
Panel Meter	DVM24/2000B	0035807	0035807	0-20 Volts				Scheduled Cal
Power Supply	XTS20-3	22296	0034420	20 Volts	3 Amp			
Servo valve	760-779A	101	0033161	2.5 GPM				
Temperature/RH Probe	RHDP	11318	0002693	2 Channel				

Defiance
1628 Northwood Drive
Troy
Michigan
USA
48084

T: +1 (248) 458-5900
F: +1 (248) 458-5901
E: sales@exova.com
W: www.exova.com

Testing, calibrating, advising

EDAG Incorporation

Chevy Silverado Cab BIW Modal Test

Exova Defiance Report No. 107429 (Chevy Silverado Cab BIW Modal Test)

Prepared for:

EDAG Inc.

Attn: Jim Davis
248-514-7529
James.davis@edag-us.com

Prepared by:

Hong Yin
Application Engineer
(248) 458 5900 Ext. 73219
hong.yin@exova.com

March 19, 2014

Table of Contents

EDAG Incorporation

Chevy Silverado Cab BIW Modal Test

Exova Defiance Report No. 107429 (Chevy Silverado Cab BIW Modal Test)

1.0 OBJECTIVE

The objective of this modal test was to find the modal properties of a Chevy Silverado Cab BIW (with front and rear glass) within 10 to 100 Hz frequency range.

2.0 SUMMARY

Modal test was performed at Exova Defiance's Troy facility from March 14 to 19, 2014. Mode description table on page 3 describes the modes that were identified. Geometry and verification plots are provided in **Appendix A**. Animated mode shapes in AVI file format are provided to the customers separately.

MODAL TESTS

Mechanical Setup

The BIW was supported with four rubber airbags at four locations to give an approximation of 'free-free' boundary condition. Air pressure in the airbags was reduced as much as possible to minimize the interference of these supports on the lowest flexible modes of the structure. Refer to **Appendix B** for test setup photographs.

Modal Test Setup and Data Acquisition

Tri-axial accelerometers were attached to each of the selected geometry points with hot-melt glue that was sufficiently rigid for the frequency range of interest. The accelerometer fore/aft and lateral axes were placed as close as possible to parallel with the floor resulting in an orthogonal orientation of the vertical axis with the floor. This orientation was achieved with the use of low-mass nylon tapered blocks. When necessary, these blocks were placed between the accelerometer and the body surface. The factory calibration of all the accelerometer axis sensitivities was checked prior to testing.

Excitation to the BIW was provided with two electro-dynamic shakers. These shakers

were set up with a rigid mounting of the bases to the floor. The positioning of the shakers is shown in the photographs in **Appendix B**. The front shaker was positioned 15 degrees

from vertical in the lateral direction. The rear shaker was positioned 15 degrees from vertical in the fore/aft direction. The combined orientation of these two shakers allowed for effectively exciting the significant modes.

The structure's linearity, test time-invariance, and reciprocity were checked and are shown in **Appendix A**. An excitation force of 3.6 N_{rms} was selected for these tests.

LMS Test.Lab software and SCADAS MOBILE recorder were used for acquiring the excitations and responses. To observe the quality of the measured excitation and responses, the time domain force input and selected accelerometer responses were monitored in real-time. Additionally, the drive point FRFs, ordinary coherence functions, and autopower spectrum of the force inputs were also monitored. Data acquisition parameters are listed in the following table:

BIW Modal Test Data Acquisition Parameters

Sampling Frequency	256 Hz
Useable Frequency Bandwidth	128 Hz
Transform Size	2048
Frequency Resolution	0.125 Hz
Windowing	Uniform/Uniform
Shaker Excitation Profile	Burst Random (40% burst length)
Number of Averages	25
FRF Estimation	H_1
Shaker Excitation Bandwidth	0-128 Hz
Shaker Armature Mass	< 0.4 lbs
Shaker Control Method	Current Control Mode

Modal Parameter Estimation

PolyMax and Automatic Modal Parameters Selection in Test.Lab were used to curve-fit the acquired experimental data (FRFs) and to select the modes from 10 to 100 Hz. From these results, mode frequencies were determined along with damping values. A graphical animation of the geometries for each of the modes was used to aid in describing the characteristics of the modes. Upper and lower residual mode correction was used for the FRF synthesis. The synthesized FRF summation and the measured one are shown in **Appendix A**.

Modal parameter estimation table is listed in the following page.

MODAL PARAMETER ESTIMATION DESCRIPTION TABLE

Department: NVH **Project No.:** 107429
Date: 03/19/14 **Engineer:** Hong Yin **Technician** Ken Knight

Project Title: Chevy Silverado Cab BIW Modal Test
Description: Experimental Modal Testing for a Silverado Cab BIW

VIN / ID	Manufacturer	Make	Body Style	Build	Weight	Driveline	Engine	Trans	Tires
	GM		BIW						

Boundary Condition: Air rides for simulated 'free-free' conditions **Exciter(s):** 2 modal shakers

Exciter Orientation: 1. Left front rail with exciter skewed vertical and 15 degrees lateral
2. Right rear lower corner with exciter skewed vertical and 15 degrees fore/aft

Curve Fitting: LMS PolyMAX

MODAL PARAMETERS

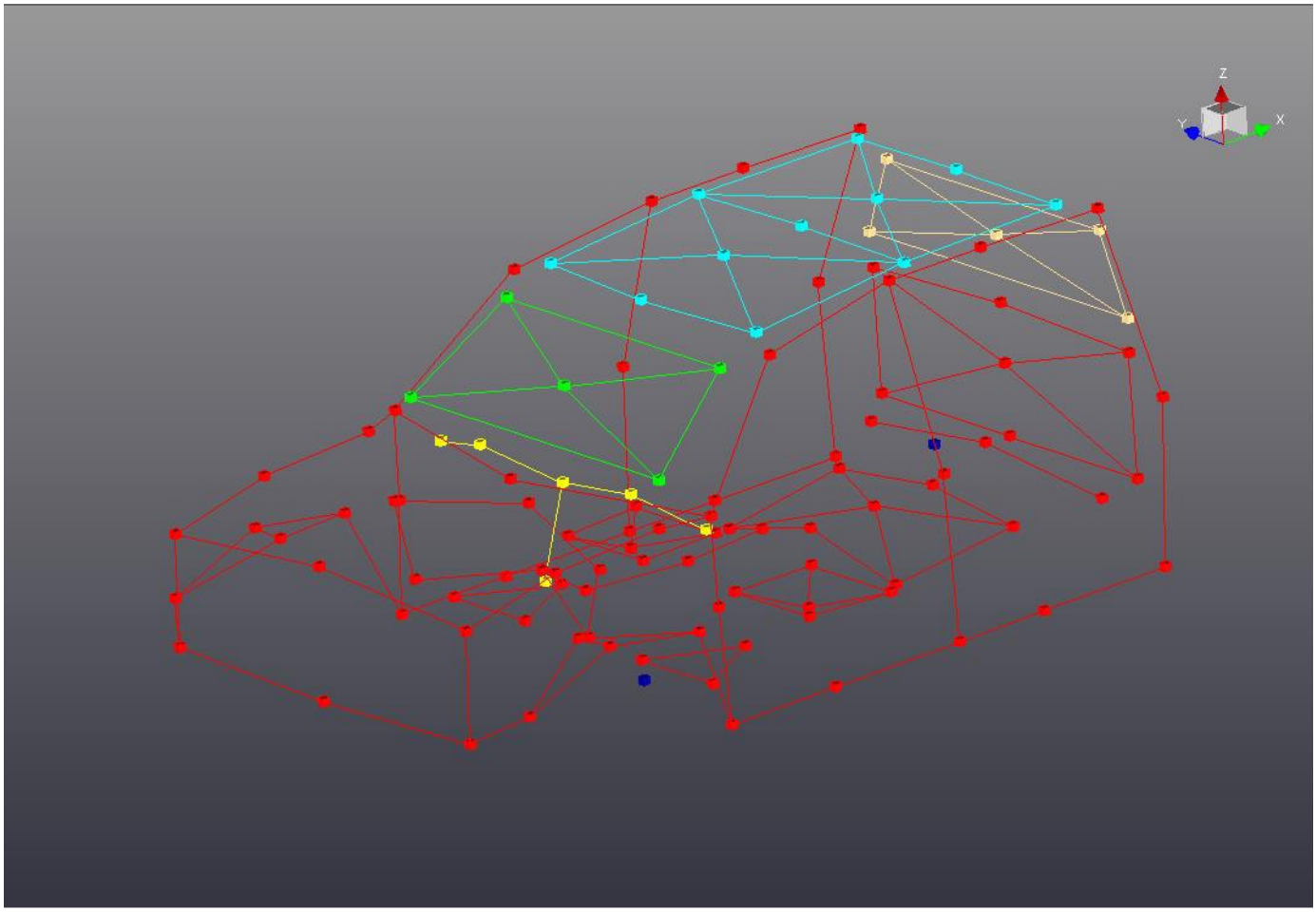
Mode Number	Frequency (Hz)	Damping	Modal Shape Description
Mode 1	22.508 Hz	0.72%	**First Global Vertical Bending (more front)**
Mode 2	30.341 Hz	0.35%	Rear End Panel and Glass Fore-Aft Bending. Floor Vertical Bending
Mode 3	36.097 Hz	0.57%	**First Global Lateral Bending (more front)**
Mode 4	39.935 Hz	0.54%	Floor and Rear Roof Vertical Bending
Mode 5	41.902 Hz	0.78%	Floor and Roof Vertical Bending
Mode 6	46.473 Hz	0.64%	**First Global Torsion**
Mode 7	55.470 Hz	0.64%	Roof and Floor Vertical Bending
Mode 8	68.271 Hz	0.91%	Rear End Panel and Glass Fore-Aft Bending. Floor Vertical Bending. IP Mode

Appendix A

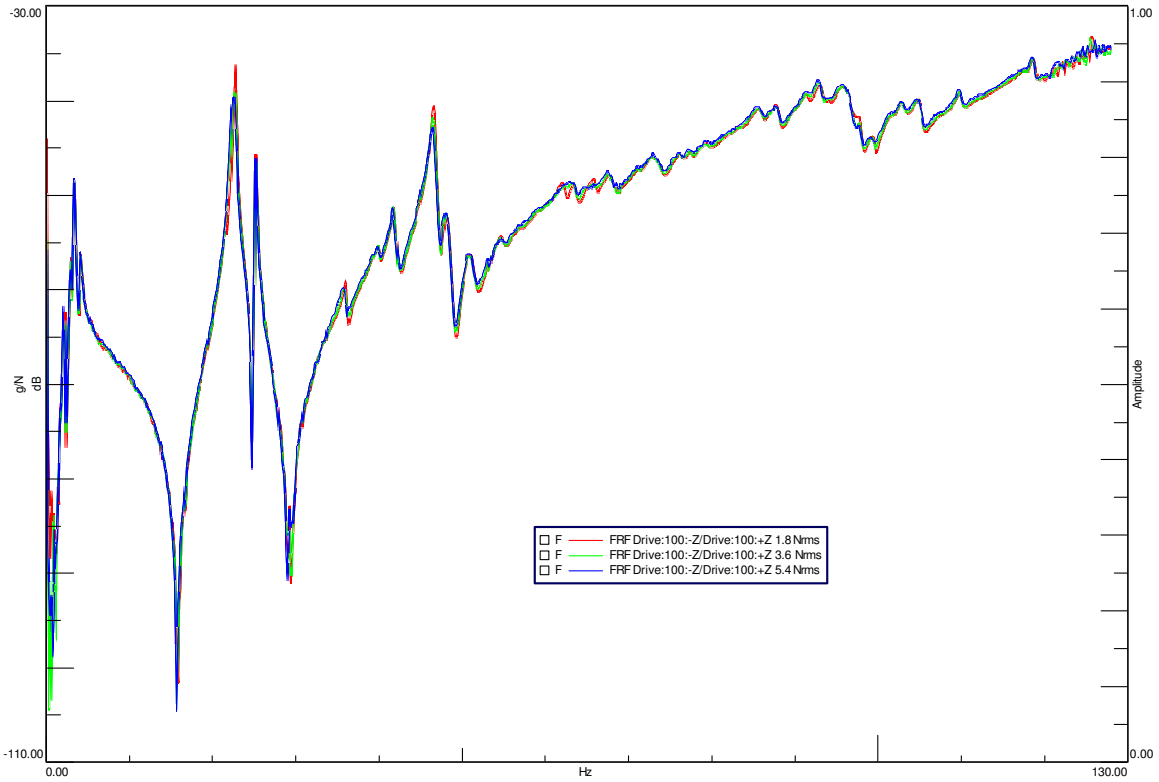
BIW Modal Test Plots

Geometry Plot

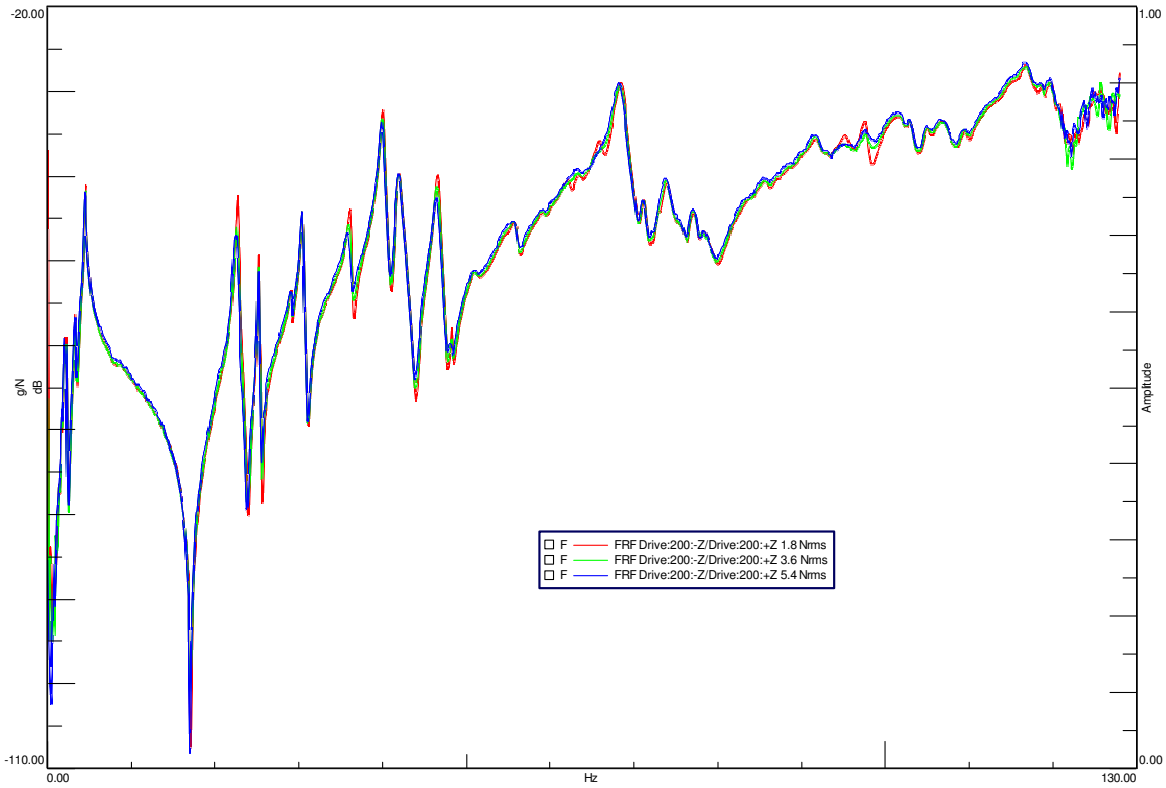
Modal Experiment Validation Plots
- Linearity Check
- Reciprocity Check
- Time-invariance Check
- Synthesized vs. Measured – Body Point No.9



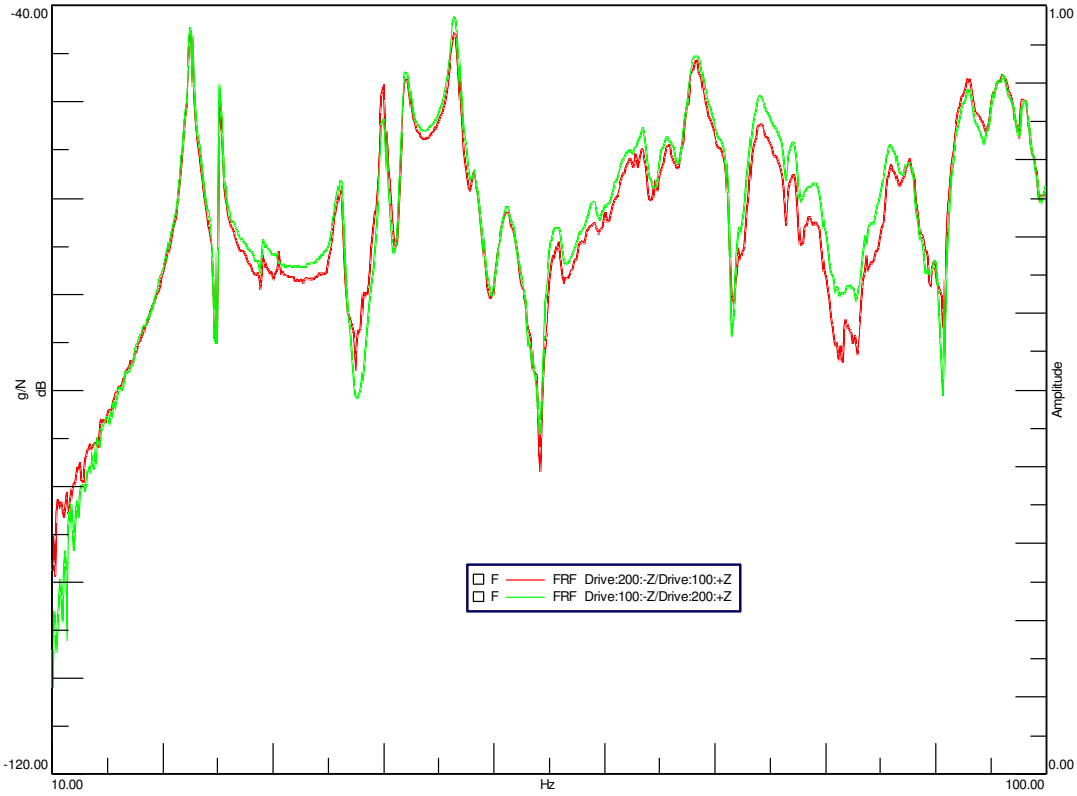
Geometry



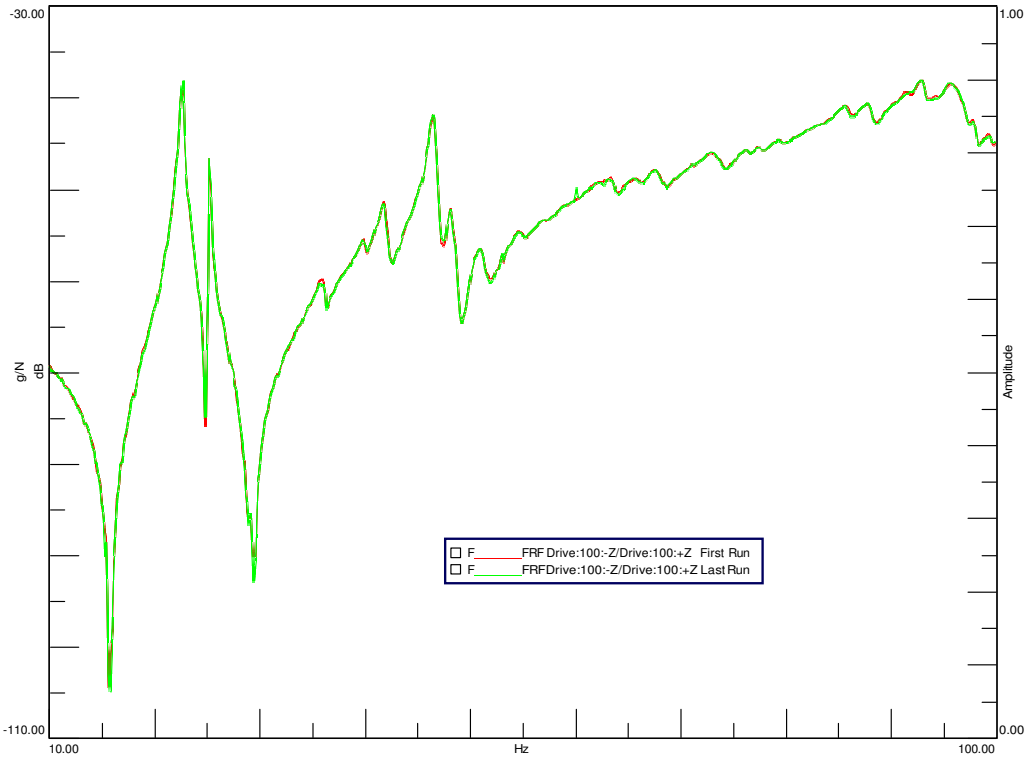
Linearity Check – Front Drive Point



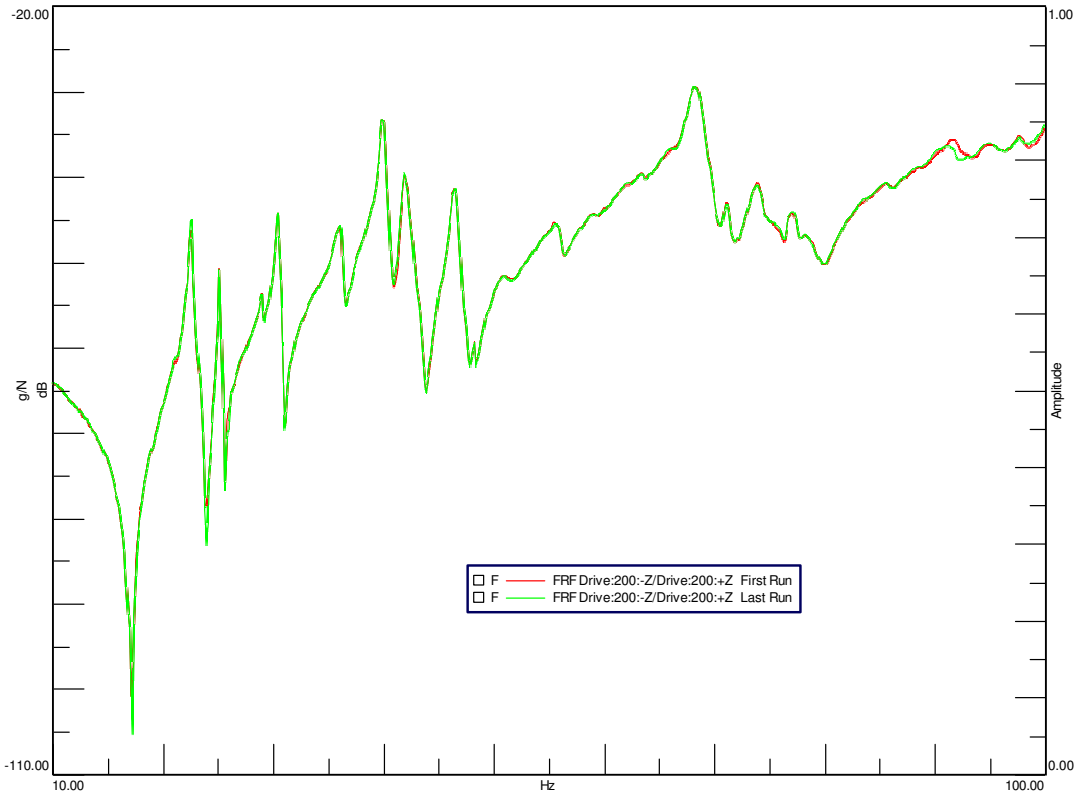
Linearity Check – Rear Drive Point



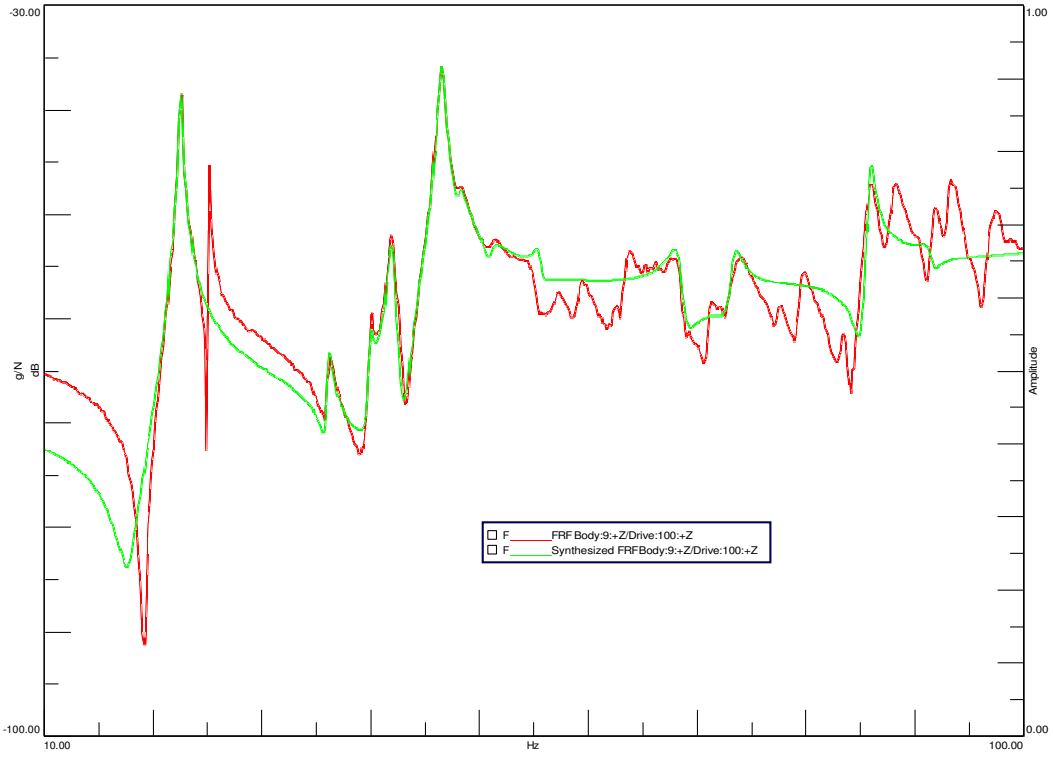
Reciprocity Check



Time-invariance Check – Front Drive Point



Time-invariance Check – Rear Drive Point



Synthesized vs. Measured – Body Point No.9

Appendix B

BIW Modal Test Photographs


Exova
DEFIANCE
FIRST AID
Test Setup Overview
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Test Setup Left Front View
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Test Setup Front View
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Test Setup Right Front View
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

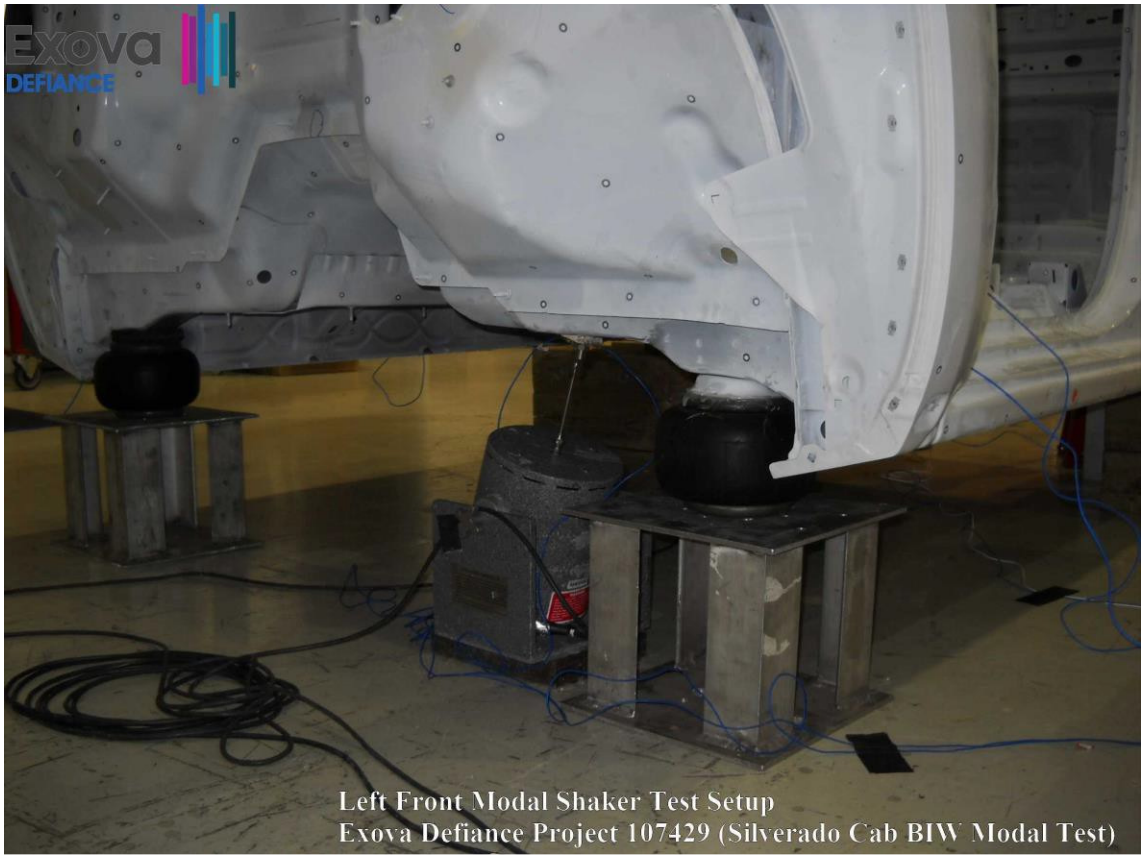

Exova
DEFIANCE
EXIT
Test Setup Left Rear View
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
EXIT
Test Setup Rear View
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Test Setup Left Rear View
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Air Bag Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

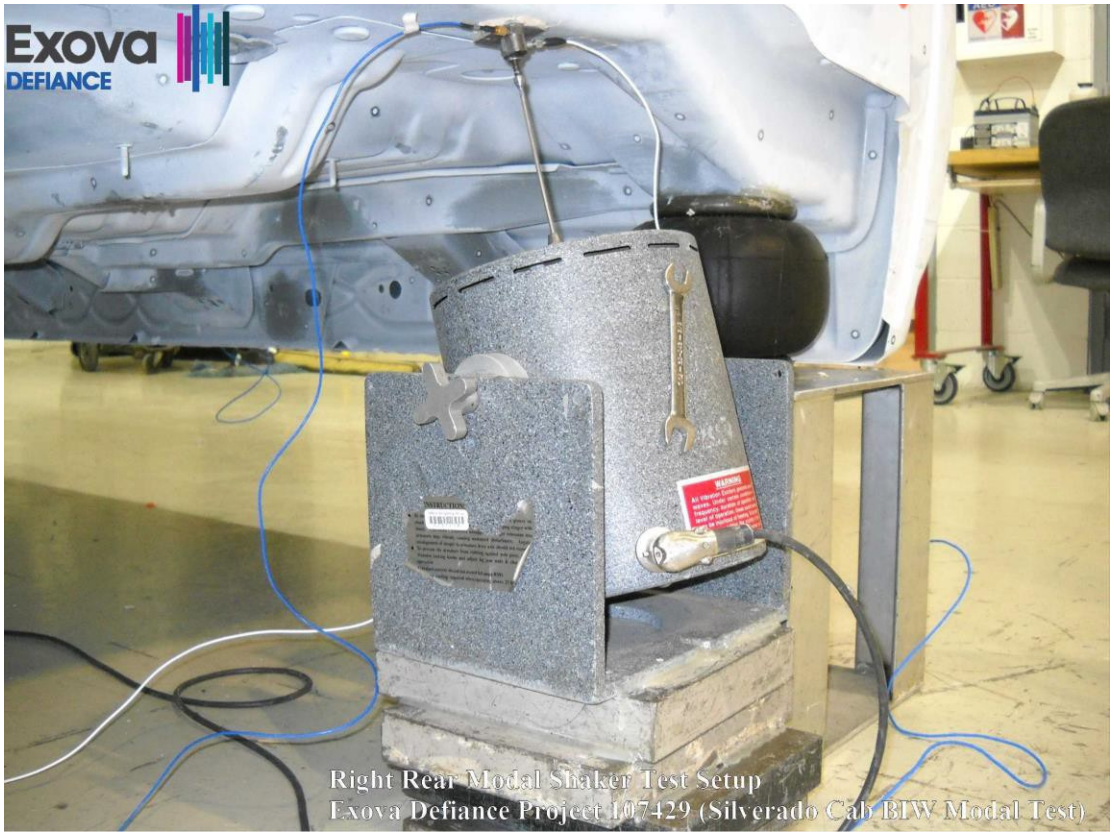

Exova
DEFIANCE
Air Bag Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

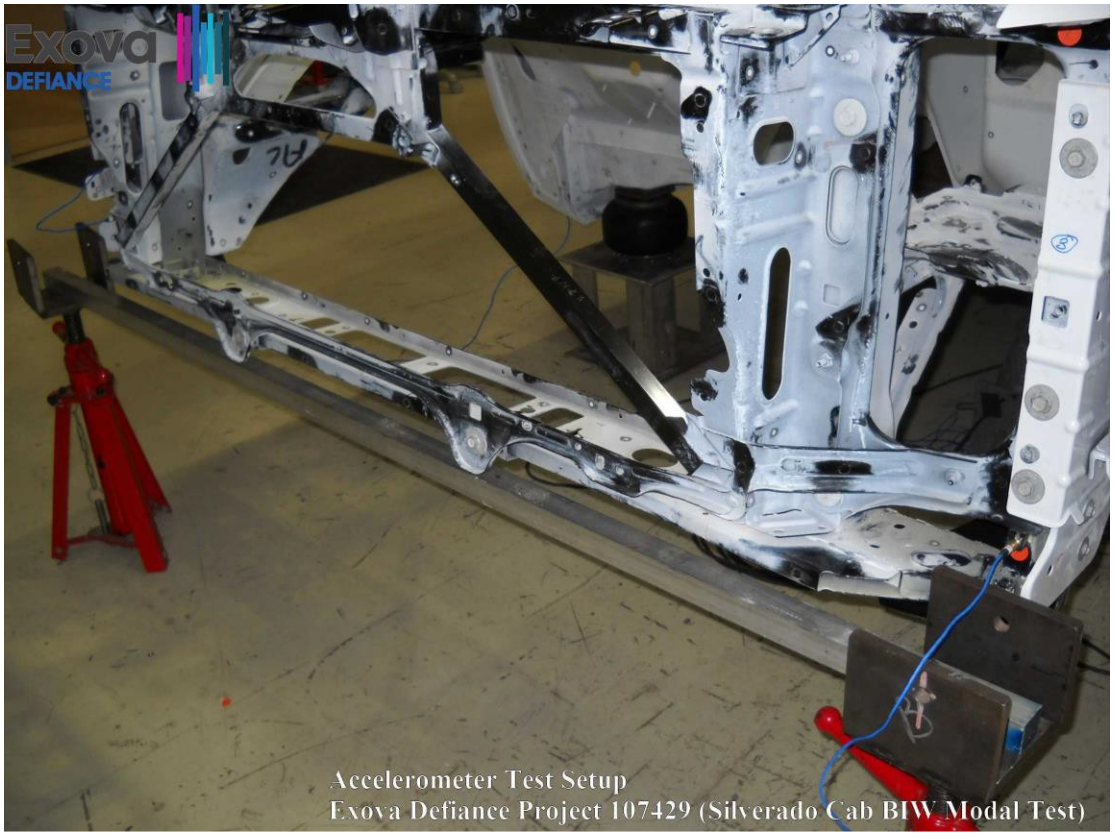

Exova
DEFIANCE
Left Front Modal Shaker Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

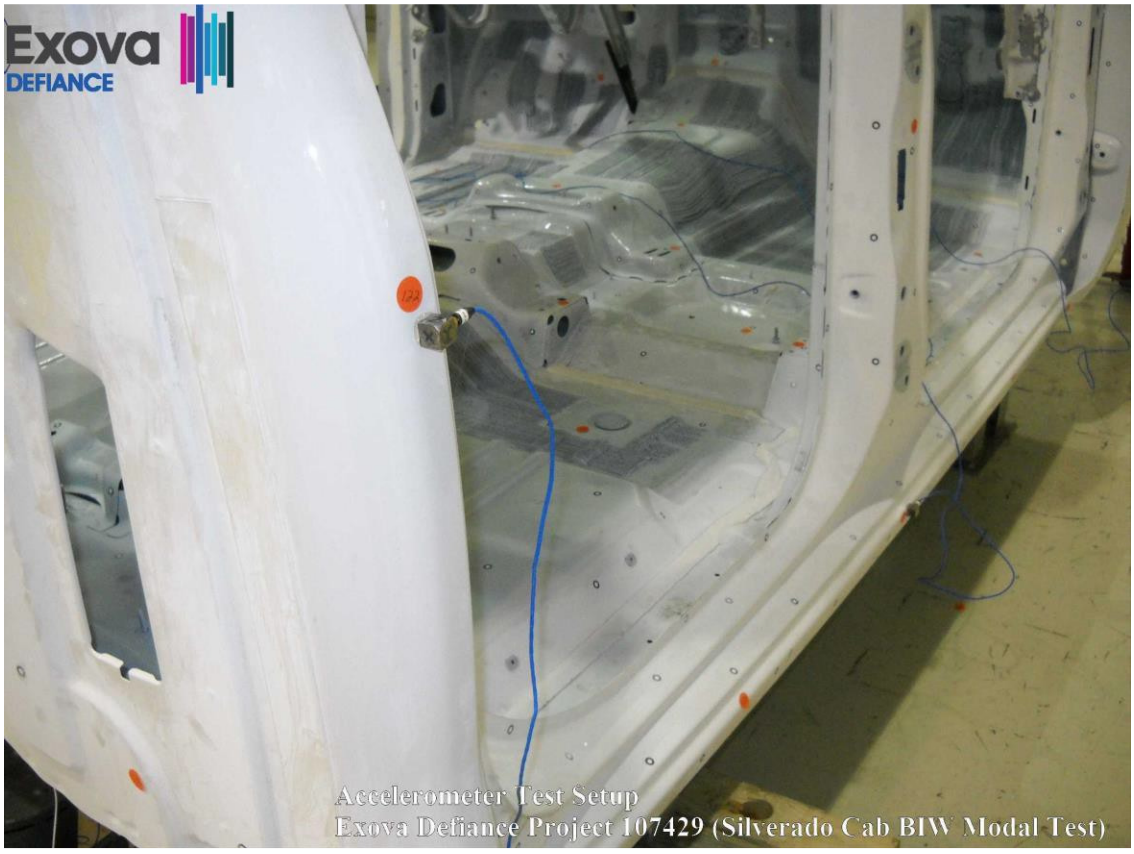

Exova
DEFIANCE
Left Front Modal Shaker Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

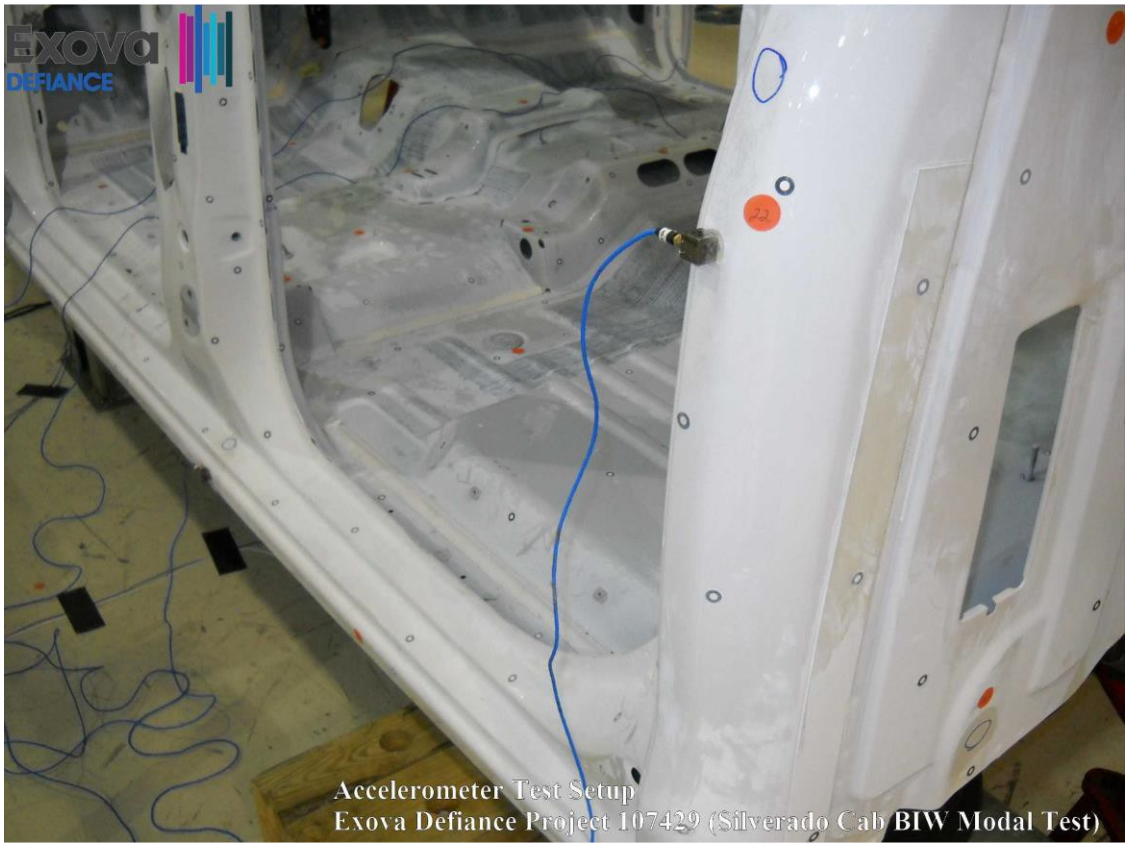

Exova
DEFIANCE
Left Front Modal Shaker Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Right Rear Modal Shaker Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

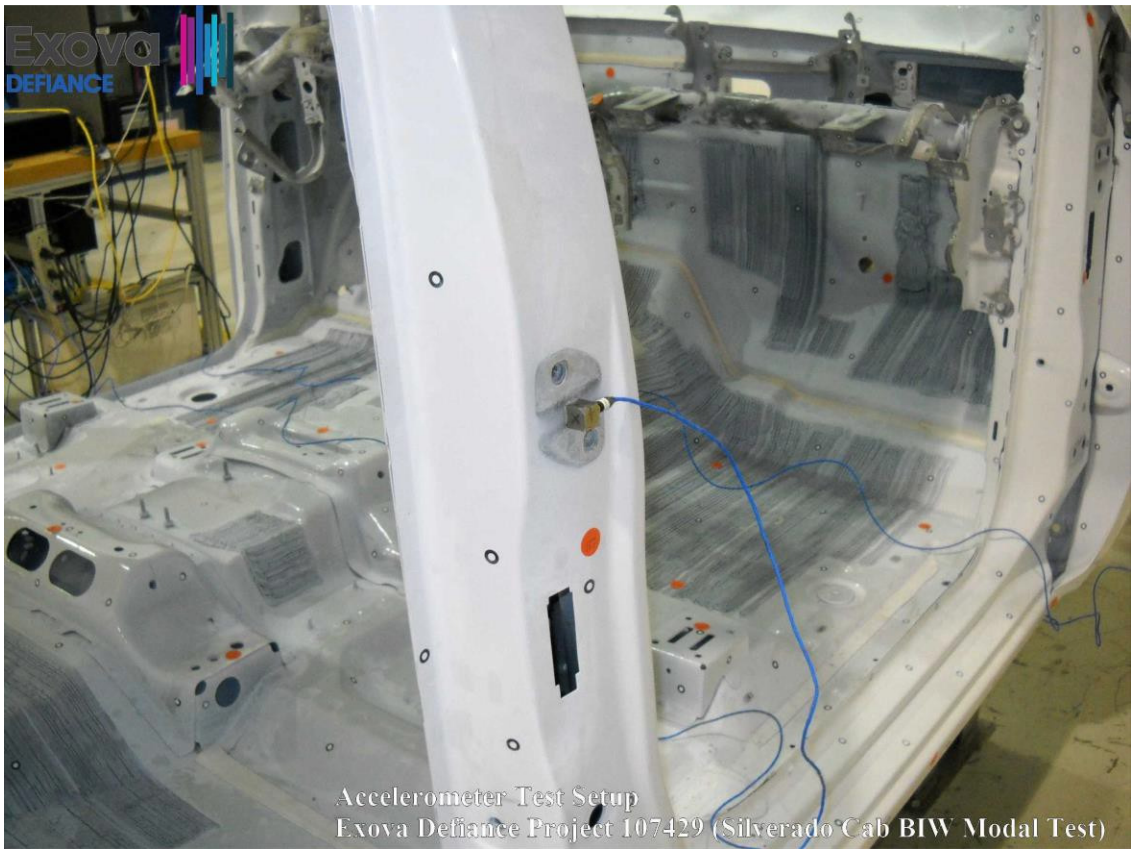

Exova
DEFIANCE
Right Rear Modal Shaker Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

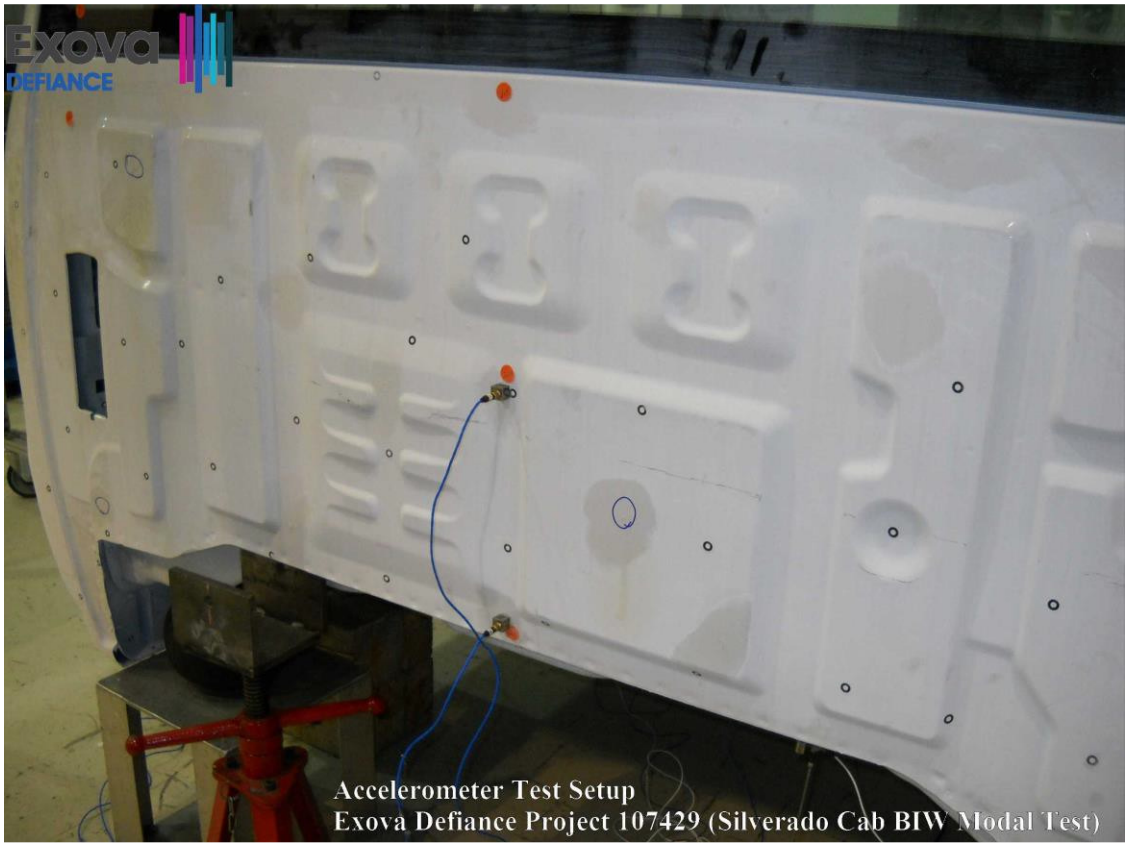

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

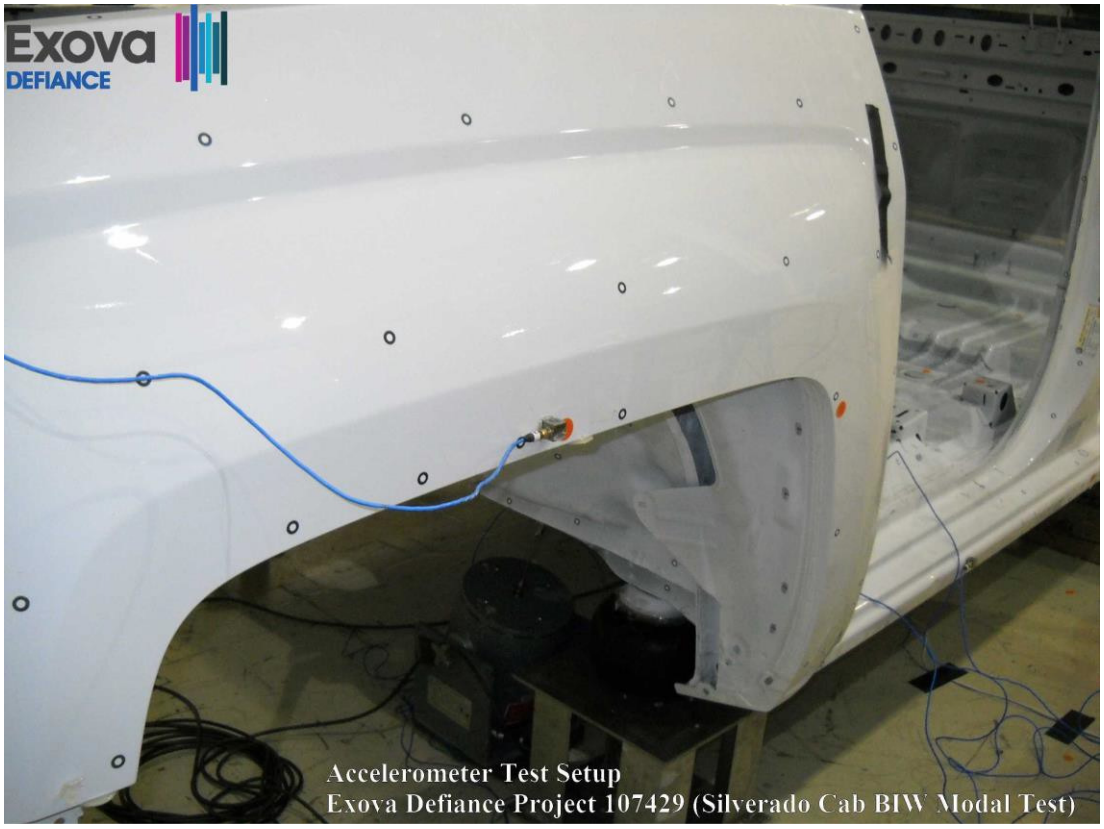

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
OFFICE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


OFFICE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

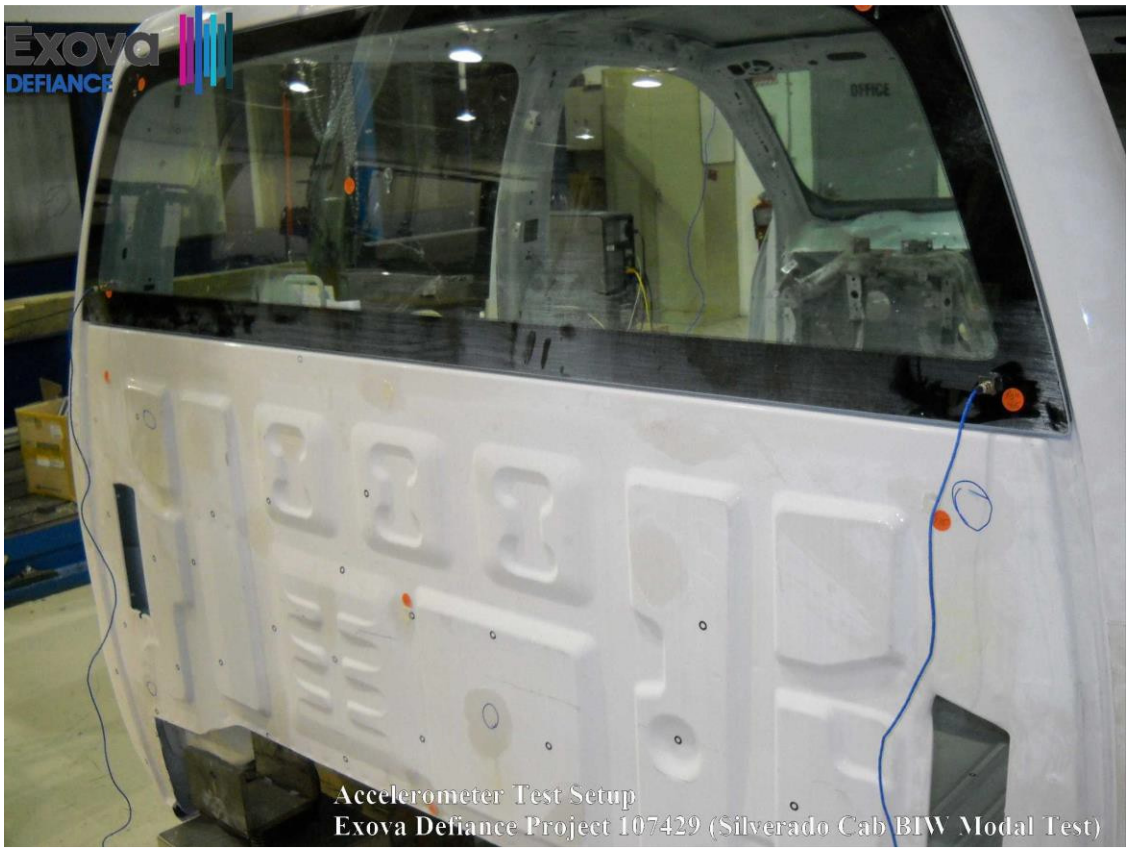

Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

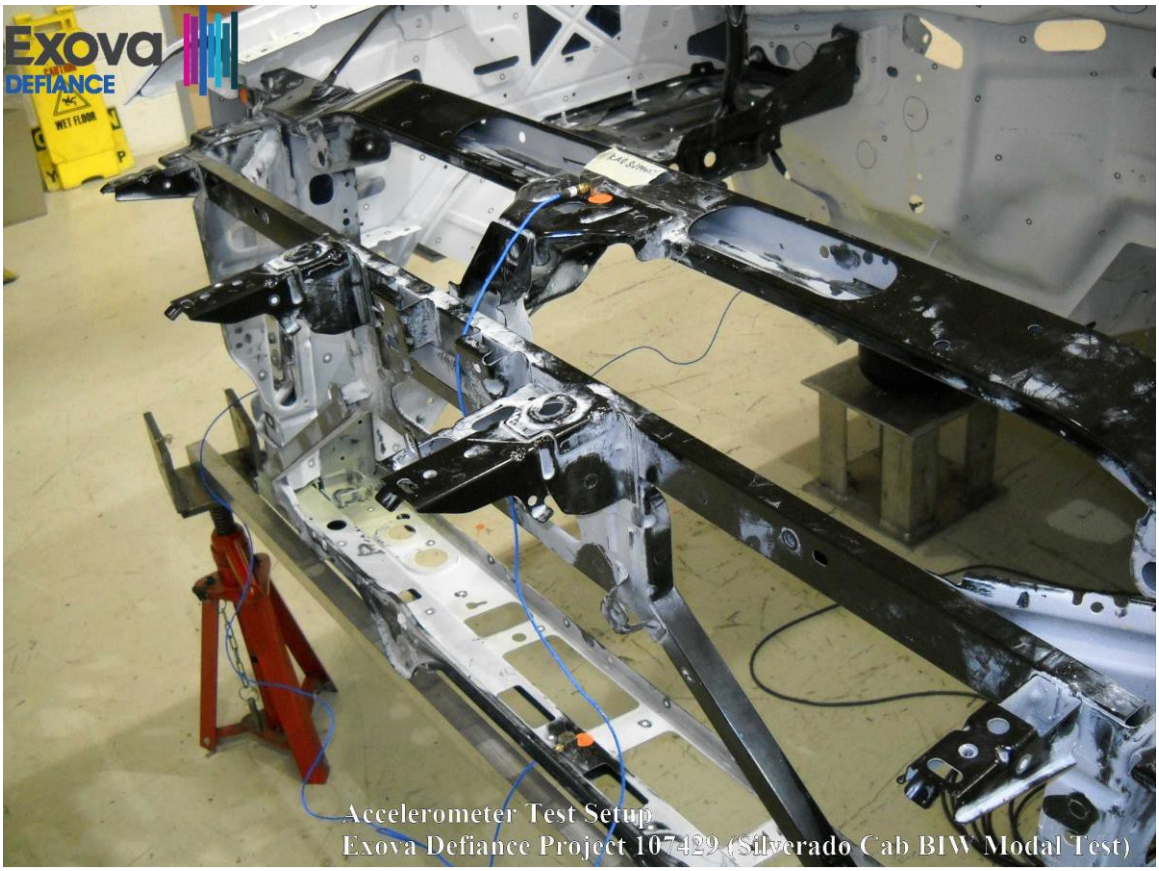

Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

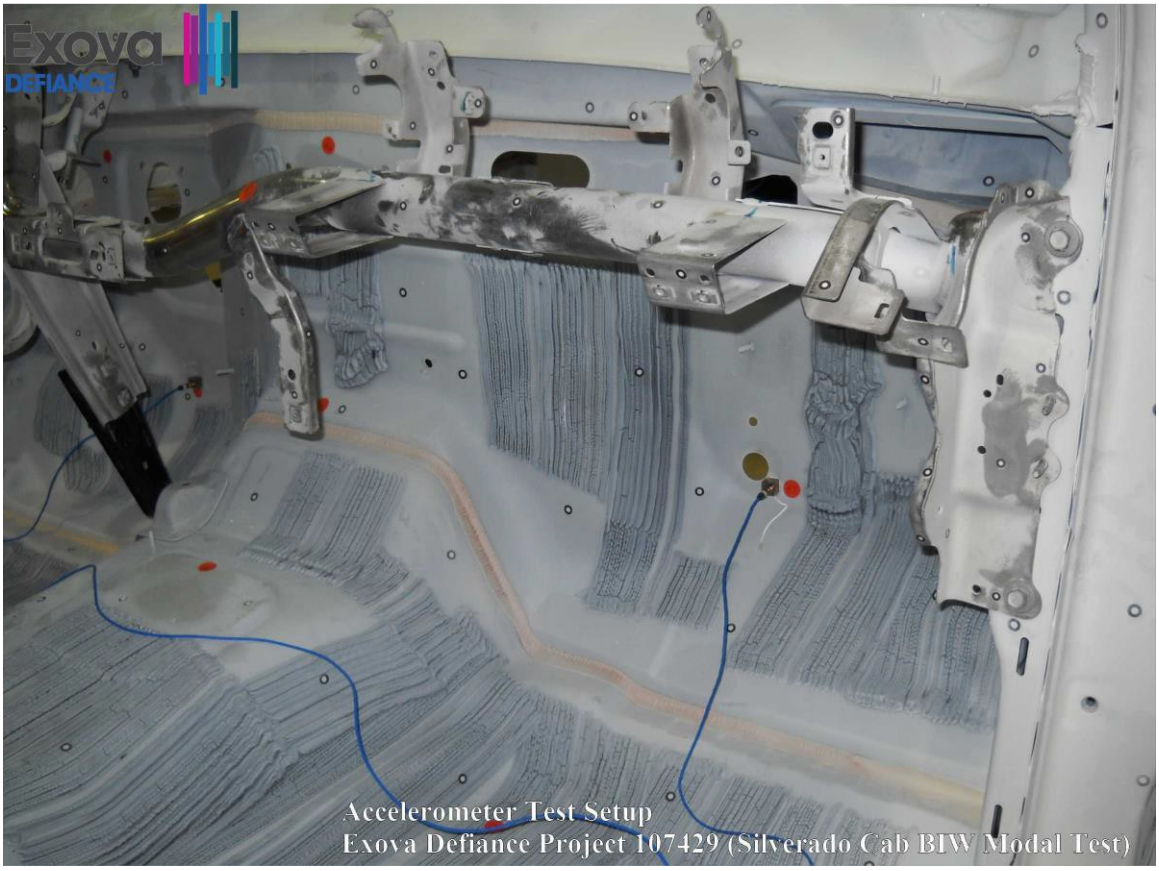

EXIT
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

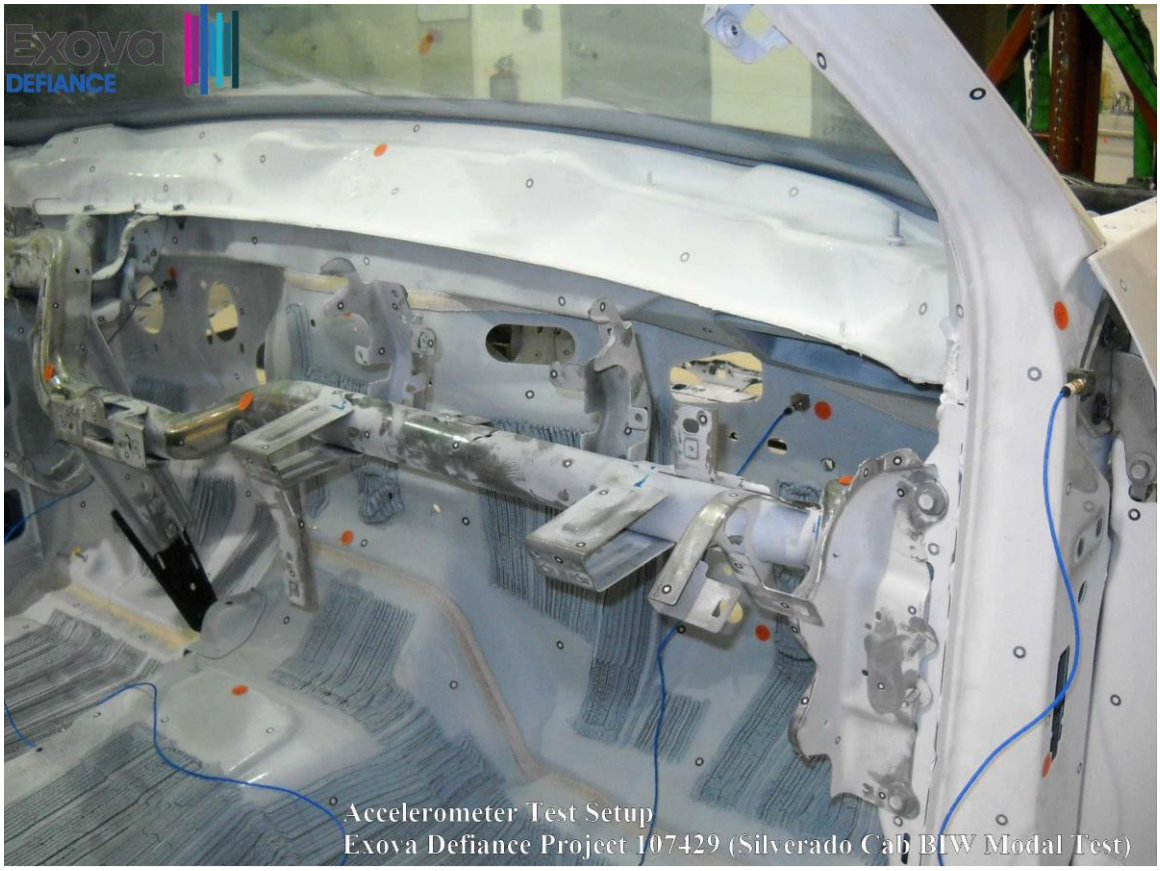

Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

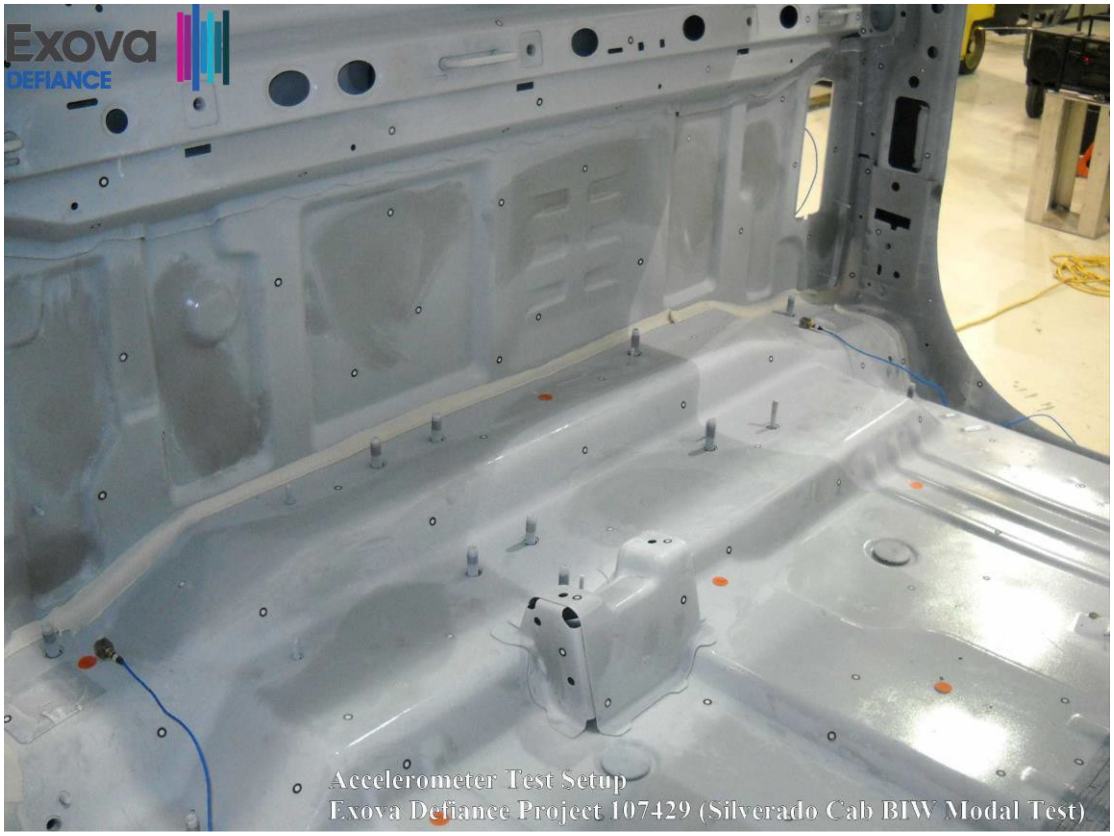

Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

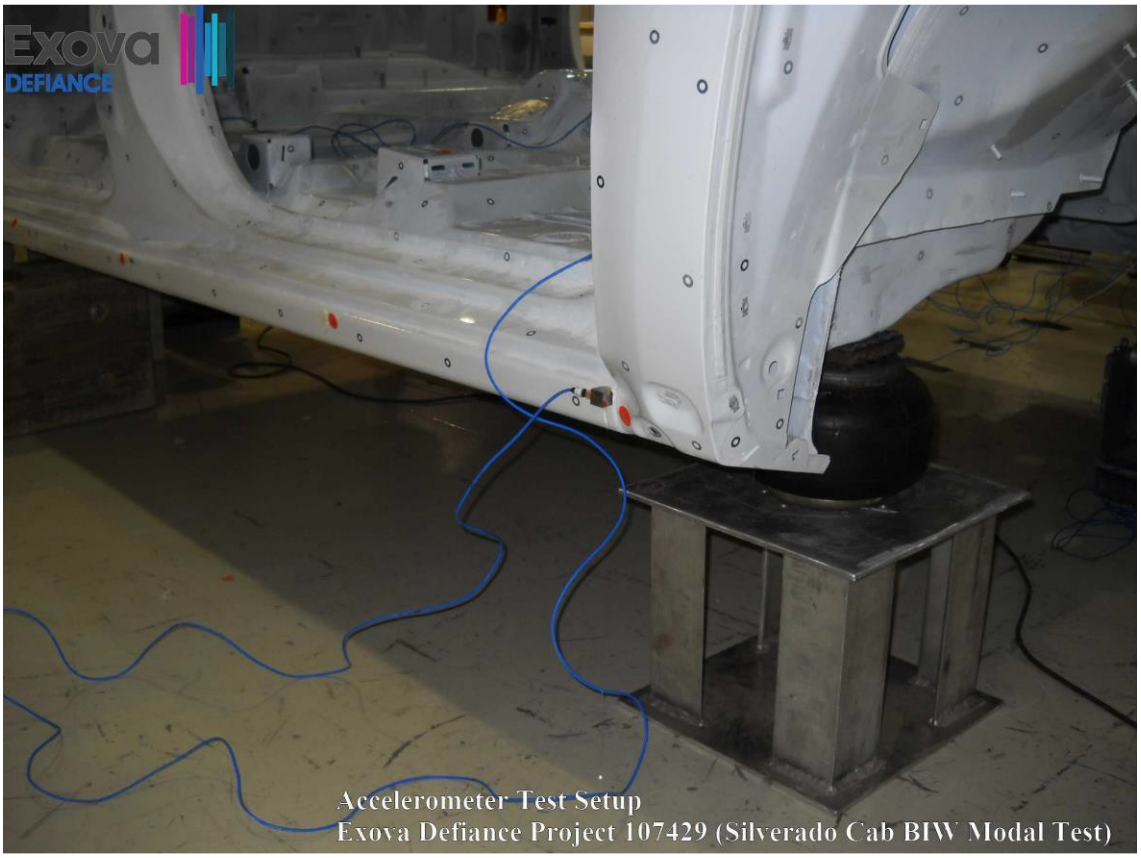

Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

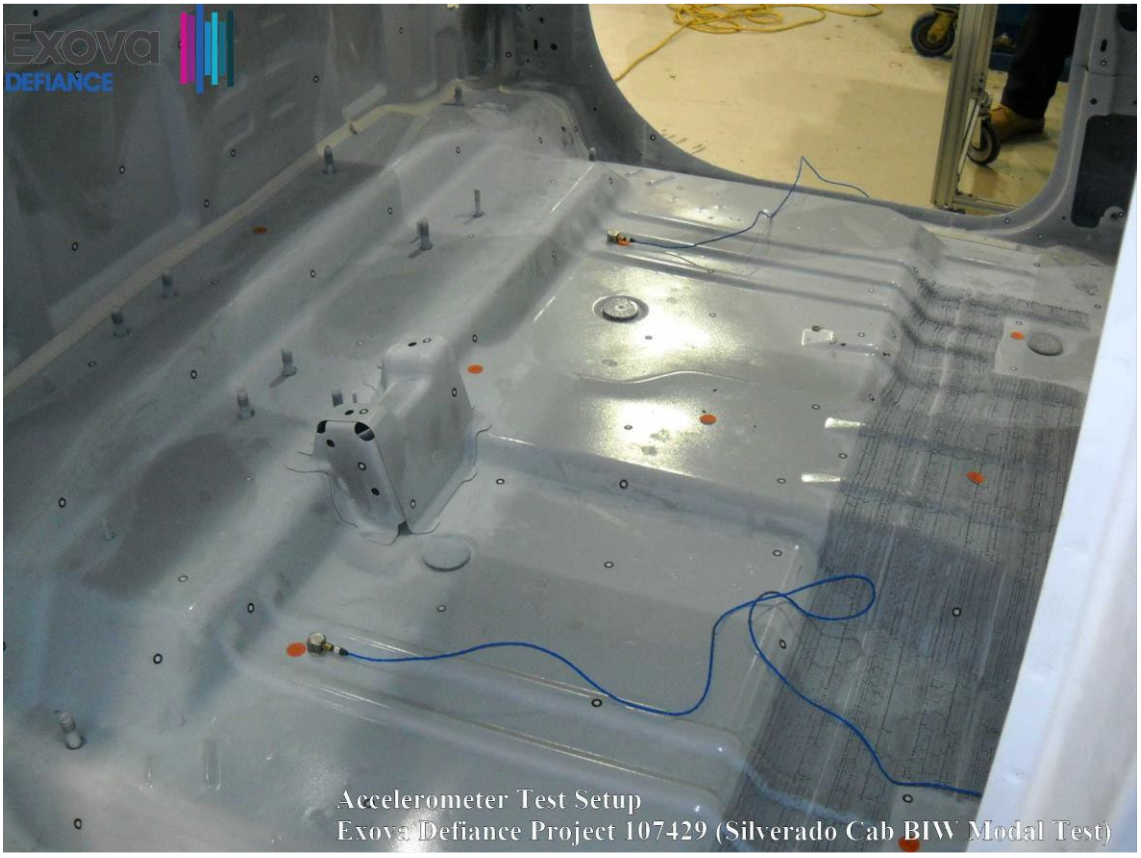

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
OFFICE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

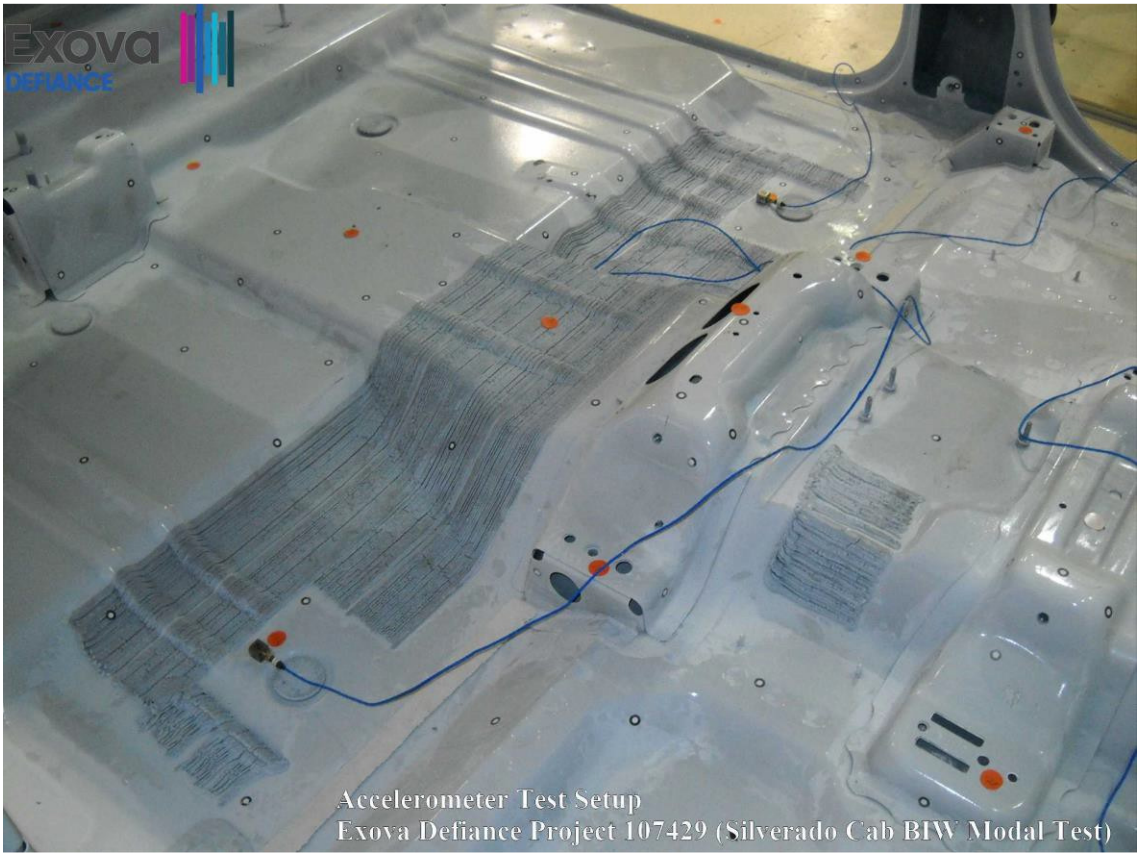

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

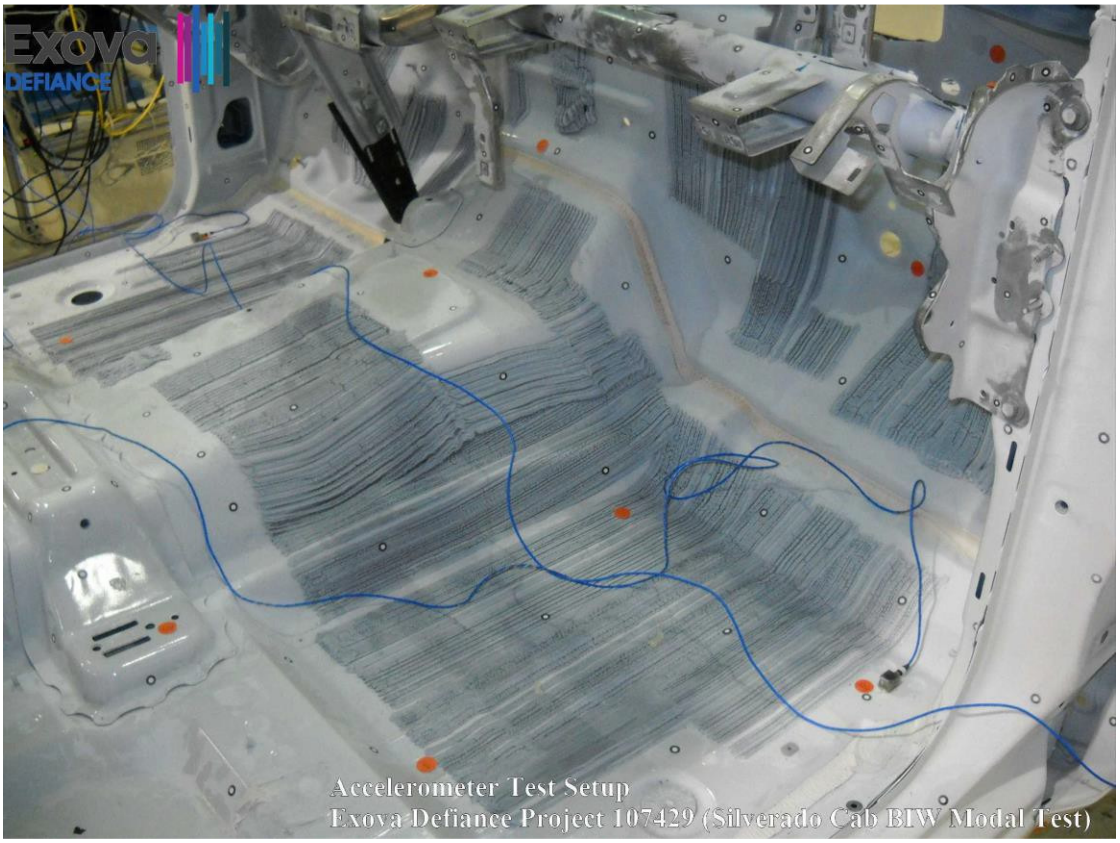

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

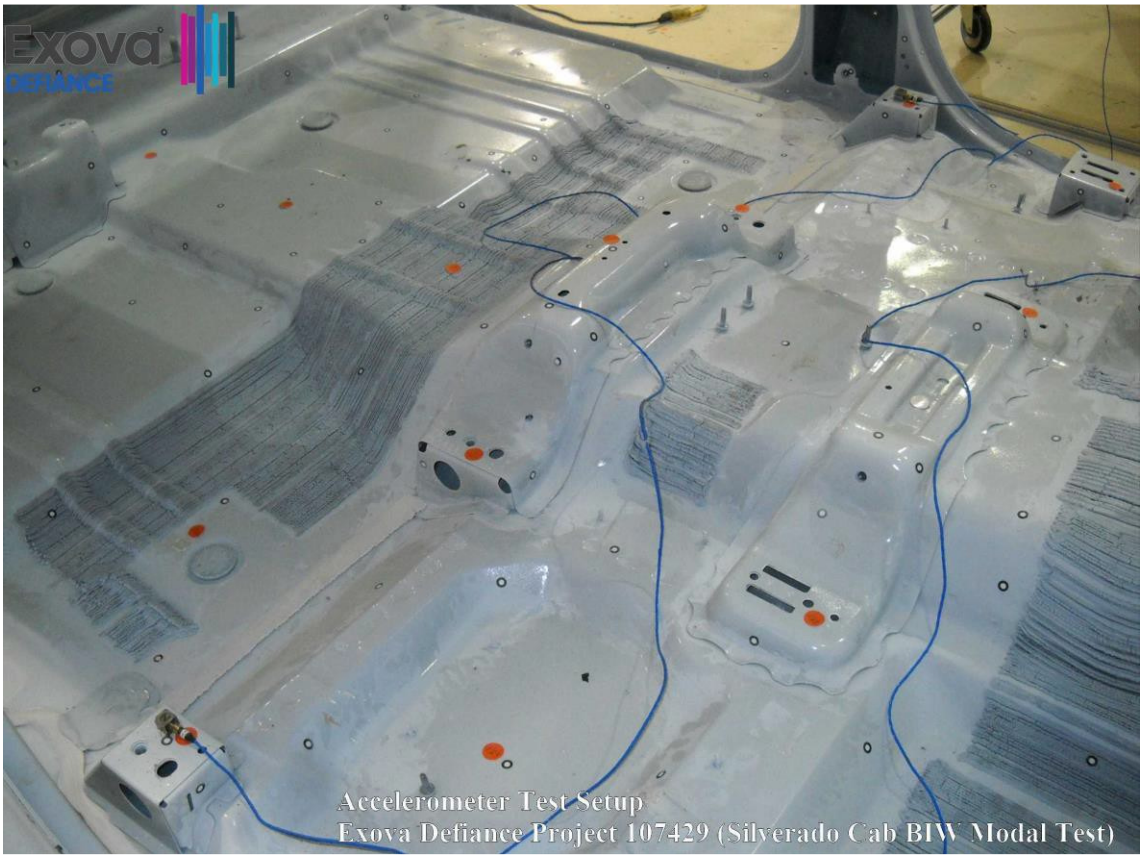

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

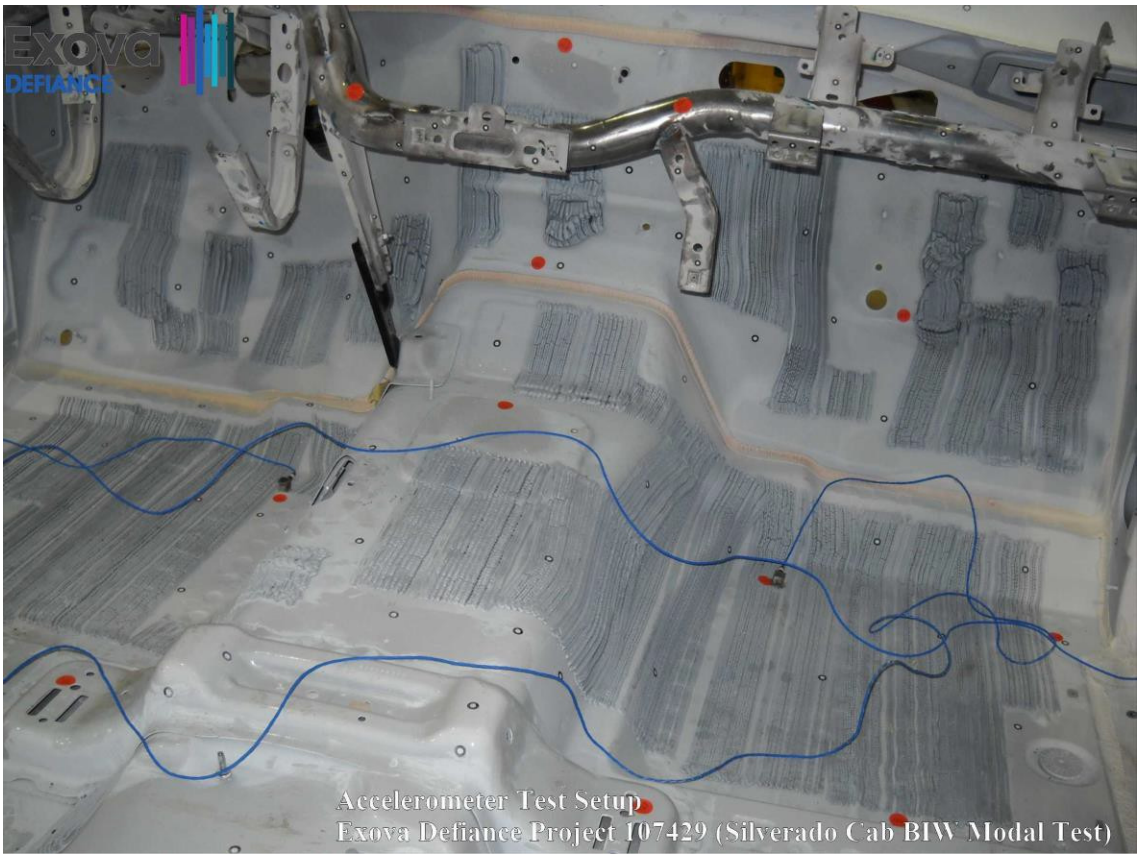

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

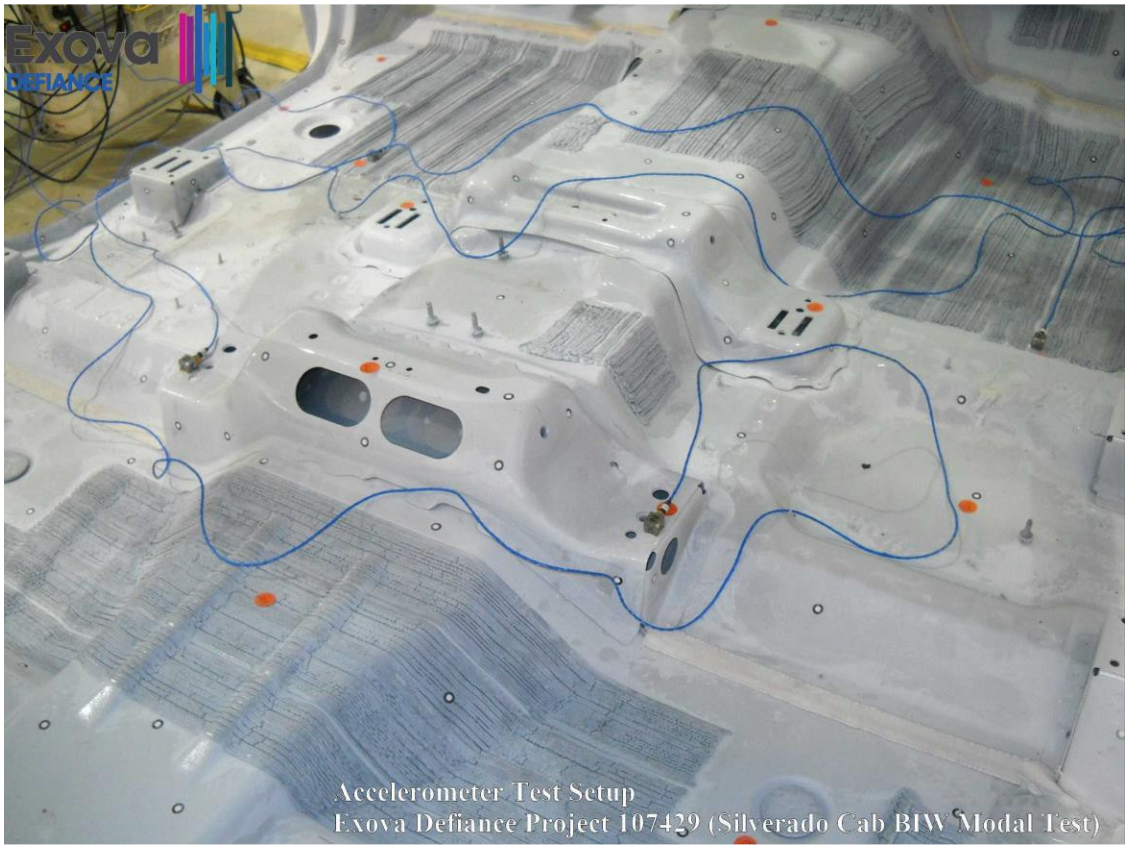

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

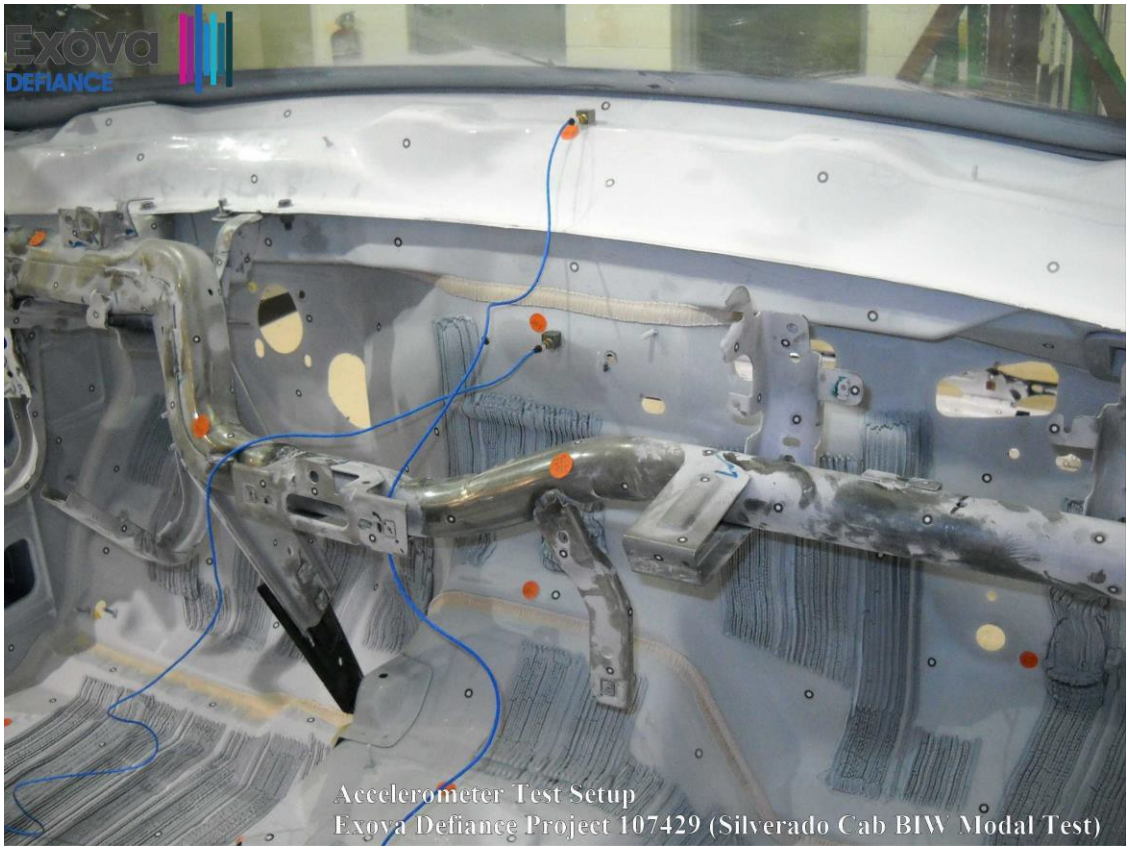

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

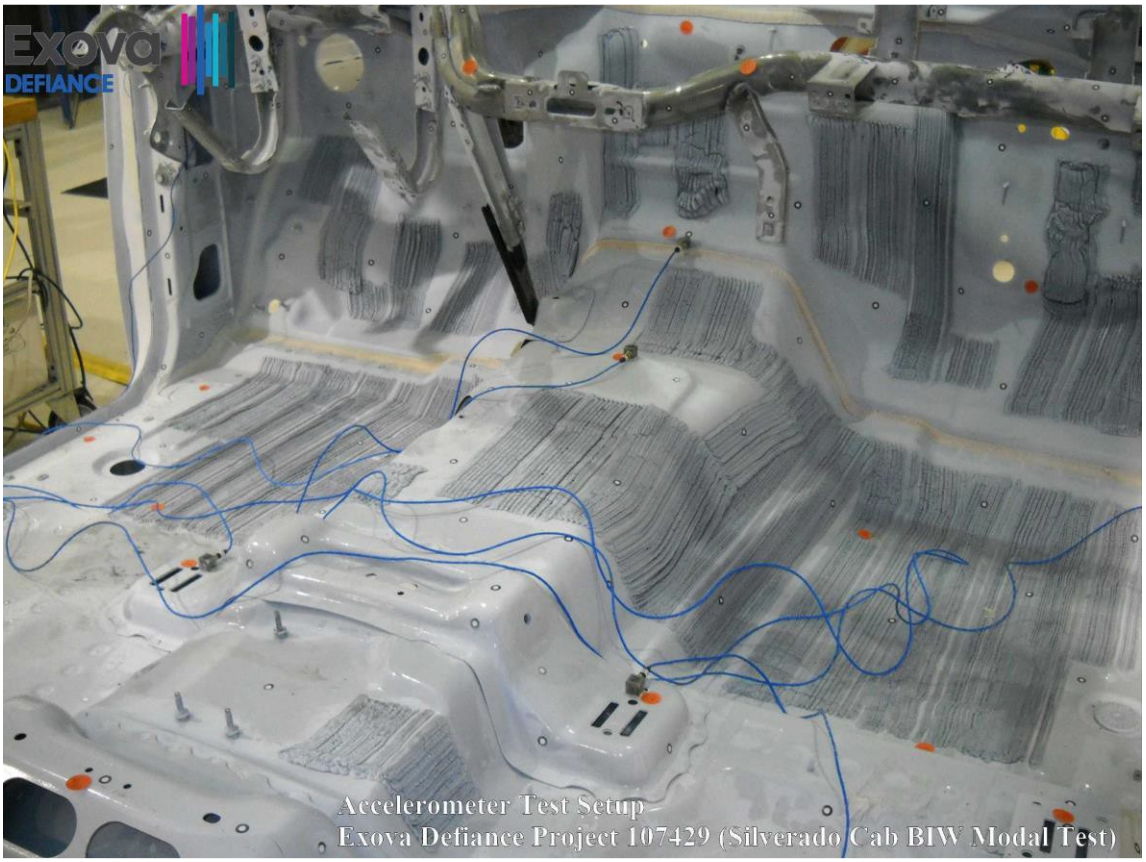

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

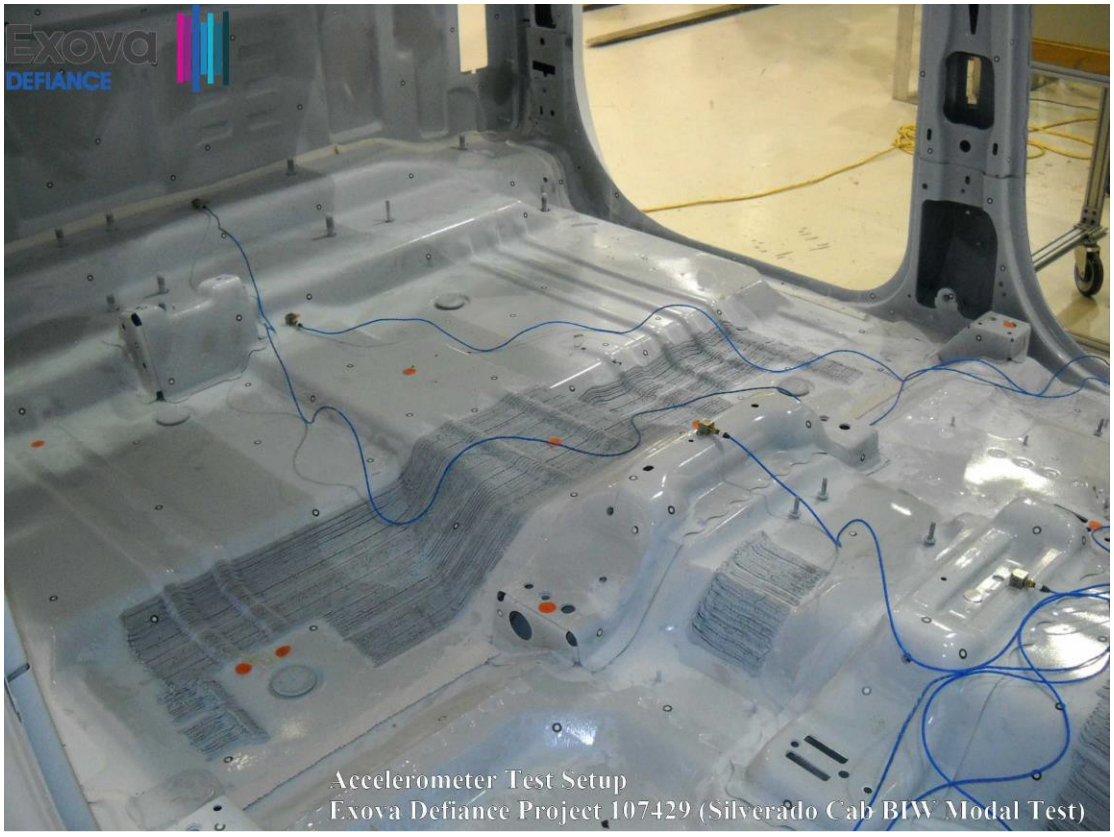

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

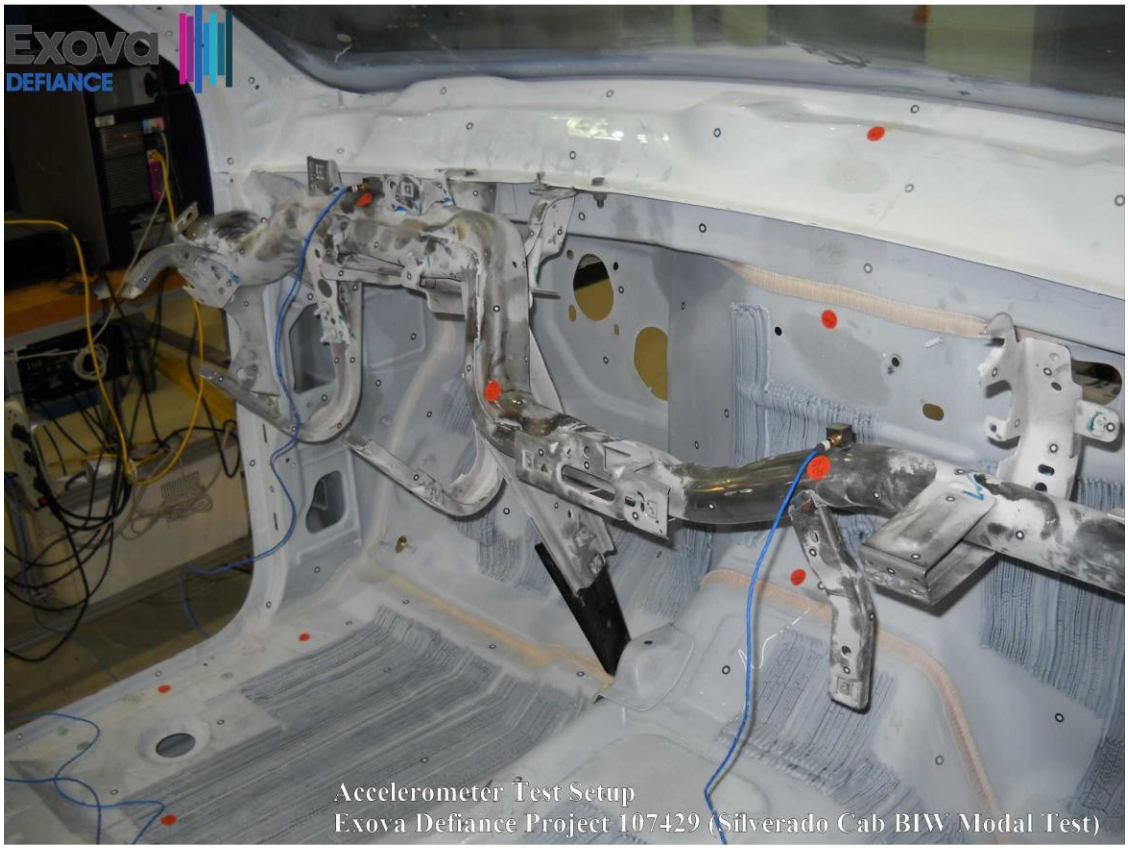

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

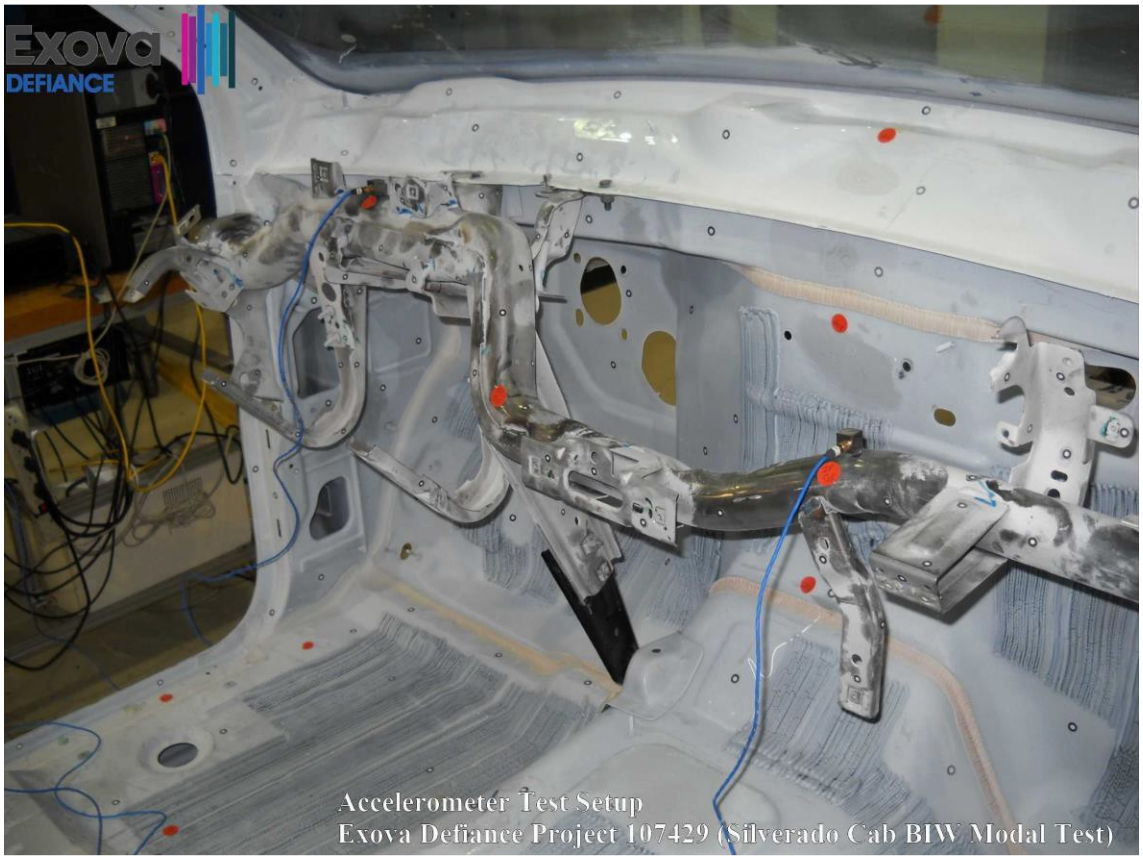

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

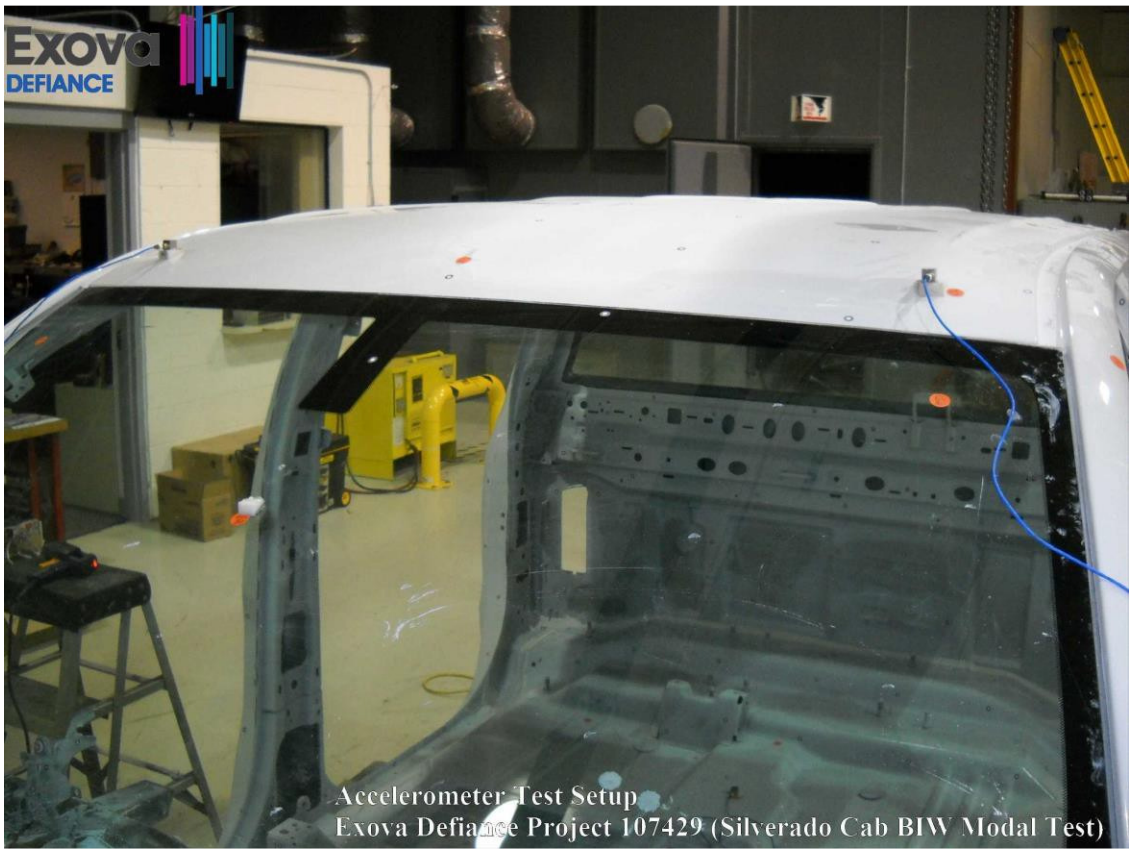

Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Exova
DEFIANCE
Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)


Accelerometer Test Setup
Exova Defiance Project 107429 (Silverado Cab BIW Modal Test)

Appendix C

Equipment

List

Equipment

Project Number: 107429
Project Name: Silverado Cab BIW Modal Test
Activity Number: 30 **Activity**
Name: 30-Run Sample: 1
Building: 10

Description	Model Number	Serial Number	Asset	Capacity 1	Capacity 2	Ch.	Ch. Description	Type of Cal Schedule	Next Cal Date
Accelerometer	356A15	17052	0039246	50 g	2-5000 Hz			Scheduled Calibration	7/17/2014
	356A15	17056	0039237	50 g	2-5000 Hz			Scheduled Calibration	7/16/2014
	356A15	32602	0041738	50 G's				Scheduled Calibration	7/16/2014
	356A15	32603	0041739	50 G's				Scheduled Calibration	7/16/2014
	4371	1187101	0030146	6,000 g	10-2,000 Hz			Scheduled Calibration	7/15/2014
	4371	1573268	0030161	6,000 g	10-2,000 Hz			Scheduled Calibration	7/15/2014
Charge Amplifier	2635	1029904	0031033					Scheduled Calibration	7/12/2014
	2635	1277897	0031077					Scheduled Calibration	7/17/2014
Electro Dynamic Shaker	MB50A	00176	0031618	50 Lbs					
	MB50A	00177	0031617	50 Lbs					
Electro Dynamic Shaker Amplifier	SS250VCF	218382	0031626						
	SS250VCF	218390	0031627						
Hand Held Shaker	394B06	634	0031798	1 g	.08 kHz			Scheduled Calibration	3/9/2015
Load Cell (Impulse Hammer)	208B	6847	0032162	10 Lbs				Scheduled Calibration.	7/21/2014
	208B01	15039	0032166	10 Lbs				Scheduled Calibration	7/21/2014
SCADAS Recorder	SCR 05-16	53092617	0042370	5-Slot					