REPORT NUMBER 201UI-MGA-21-5

SAFETY COMPLIANCE TESTING FOR FMVSS 201
Occupant Protection In Interior Impact
Upper Interior Head Impact Protection

FORD MOTOR CO.
2021 Ford F-150 Crew Cab
NHTSA No. C20210204

MGA RESEARCH CORPORATION
446 Executive Drive
Troy, Michigan 48083

Test Dates: July 22-23, 2021
Report Date: September 16, 2021

FINAL REPORT

PREPARED FOR:

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
ENFORCEMENT
OFFICE OF VEHICLE SAFETY COMPLIANCE
1200 New Jersey Avenue, SE
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WASHINGTON, D.C. 20590

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Approval Date: _____

FINAL REPORT ACCEPTANCE BY OVSC:

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15. Supplementary Notes			
16. Abstract A compliance test series was conducted on the subject 2021 Ford F-150 Crew Cab, NHTSA No. C20210204, in accordance with the specifications of the Office of Vehicle Safety Compliance Test Procedure No. TP-201U. The testing was conducted at MGA Research Corporation in Troy, Michigan on July 22-23, 2021. Test failures identified were as follows: None			
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1.0 PURPOSE OF COMPLIANCE TEST

The FMVSS 201 upper interior compliance test sponsored by the National Highway Traffic Safety Administration (NHTSA) was conducted under Contract DTNH-22-16-D00028. The purpose of this test was to evaluate upper interior head impact protection performance of a 2021 Ford F-150 Crew Cab.

Tests were conducted on July 22-23, 2021 on a 2021 Ford F-150 Crew Cab, manufactured by Ford Motor Company.

All tests were conducted in accordance with the U. S. Department of Transportation, National Highway Traffic Safety Administration's Laboratory Test Procedure TP-201U-02 dated January 2016 along with section 12.1, Vehicle Test Weight and Attitude, of TP-201U-01, and the corresponding MGA Research Corporation's FMVSS 201U procedure number MGATP_201U_FRAME#2 dated 03/31/2020.

All tests were conducted at MGA Research Corporation in Troy, Michigan and were performed by MGA engineers and technicians. The FMVSS 201U impactor test machine was used to conduct the testing. Target locations were determined by using a Coordinate Measurement Machine in conjunction with the MGA EZ-Target™ program and MGA procedure MGATP_201U_Test Series dated 03/31/2020.

2.0 COMPLIANCE TEST DATA SUMMARY

The 2021 Ford F-150 Crew Cab was equipped with A, B, and rear pillars, an adjustable seat belt anchorage on the B-pillars, a fixed seat belt anchorage on the rear pillars, and assist handles located on the front driver A-pillar, front passenger A-pillar, rear driver B-pillar, and rear passenger B-pillar, and a front overhead console.

Upon completion of targeting the test vehicle, twelve (12) targets were chosen to be impacted based upon engineering judgment and certification test data provided by the manufacturer. The twelve (12) targets chosen were:

AP1	BP3	RH	UR2@SR2
BP1	FH1	SR1	UR3@BP
BP2	RP2	SR2B	UR7@SR1

The HIC(d) measured using the Part 572L (Free Motion Headform) was below 1000 for each tested component.

TABLE 2-1

SUMMARY TABLE OF TEST RESULTS

VEH. MOD YR/MAKE/MODEL/BODY: 2021 Ford F-150 Crew Cab

VEH. NHTSA NO.: C20210204 VIN: 1FTEW1CP6MKD17763

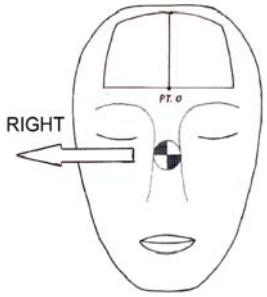
COLOR: Carbonized Gray VEH. BUILD DATE: December 2020

TEST DATES: July 22-23, 2021 TEST LABORATORY: MGA Research Corp.

OBSERVERS: Helen Kaleto, Ryan Jones, David Burkett, Kurt Reichert

TARGET	VEHICLE SIDE	HORIZONTAL ANGLE (deg)	VERTICAL ANGLE (deg)	VELOCITY (kph)	HIC(d)	FMH HIC	IMPACT ON FMH (mm)	
							Above	Left/Right
AP1	Right	109	20	18.97	394.6	302.4	19	0
BP1	Right	90	15	19.11	447.6	372.7	38	5 L
BP2	Left	270	10	24.00	583.2	552.4	17	1 L
BP3	Right	72	-4	24.32	782.1	816.1	19	2L
FH1	Left	180	50	23.71	909.3	984.7	28	17 L
RH	Right	0	24	23.39	638.0	625.1	19	1 R
RP2	Left	270	-3	23.94	696.2	702.2	22	9 L
SR1	Left	270	40	18.96	416.0	330.8	19	4 R
SR2B	Right	90	40	19.34	606.0	582.7	19	2L
UR2 SR2	Left	270	37	23.37	953.8	1043.6	46	0
UR3 BP	Left	270	38	23.80	968.6	1063.3	58	2 R
UR7 SR1	Right	90	50	24.03	771.2	801.7	47	0

Above and left/right refers to the position relative to reference pt. 0 where the target made contact with the Free Motion Headform. See the diagram below for details.



POST TEST COMMENTS:

The following description lists any post-test damage or other test observations for each target.

BP2 Left: Seat belt adjuster damaged.

FH1 Left: Windshield glass cracked.

UR7@SR1 Right: Headliner deformation.

REMARKS:

The targets listed were impacted in the following order:

Left: FH1, UR2@SR2, SR1, BP2, UR3@BP, RP2

Right: RH, AP1, UR7@SR1, SR2B, BP1, BP3

The 150 mm rule was observed for targets horizontal to each other and the 200 mm rule was observed for vertical components.

Recorded By: _____ Approved By: _____

Date: July 23, 2021

TABLE 2-2

GENERAL TEST AND VEHICLE PARAMETER DATA

VEH. MOD YR/MAKE/MODEL/BODY: 2021 Ford F-150 Crew Cab

VEH. NHTSA NO.: C20210204 VIN: 1FTEW1CP6MKD17763

COLOR: Carbonized Gray VEH. BUILD DATE: December 2020

TEST DATES: July 22-23, 2021 TEST LABORATORY: MGA Research Corp.

OBSERVERS: Helen Kaleto, Ryan Jones, David Burkett, Kurt Reichert

INTERIOR TRIM INFORMATION: A, B, and rear pillars, an adjustable seat belt anchorage on the B-pillars, a fixed seat belt anchorage on the rear pillars, and assist handles located on the front driver A-pillar, front passenger A-pillar, rear driver B-pillar, and rear passenger B-pillar, and a front overhead console.

SUNROOF INFORMATION:

Installed:	___Yes	_X_ No
Operation:	___Electric	____ Manual

SIDE RAIL CURTAIN AIRBAG INFORMATION:

Installed:	_X_Yes	____ No

ROLL-BAR INFORMATION:

Installed:	_____Yes	_X_ No
Padded:	_____Yes	_X_ No
Braces:	_____Yes	_X_ No

GENERAL INFORMATION:

Date Received: May 3, 2021; Odometer Reading: 913 miles

DATA FROM VEHICLE'S CERTIFICATION LABEL:

Vehicle Manufactured By: Ford Motor Company

Date of Manufacture: December 2020; VIN: 1FTEW1CP6MKD17763

GVWR: 2903 kg; GAWR FRONT: 1429 kg;

GAWR REAR: 1542 kg;

DATA FROM TIRE PLACARD:

Tire Pressure with Maximum Capacity Vehicle Load:

FRONT: 250 kPa REAR: 250 kPa

Recommended Tire Size: Front 265/60R18

Recommended Cold Tire Pressure:

FRONT: 250 kPa REAR: 250 kPa

Size of Tire on Test Vehicle: Front 265/65R18

Type of Spare Tire: 245/70R17; Space Saver: ___; Standard: X

VEHICLE CAPACITY DATA:

Type of Front Seats: Bench:___; Bucket: ___; Split Bench: X

Number of Occupants: Front 3; Rear; 3 TOTAL 6

VEHICLE CAPACITY WEIGHT:

Vehicle Capacity Weight (VCW) = 803 kg

No. of Occupants x 68 kg = 408 kg

Rated Cargo/Luggage Weight (RCLW) = 395 kg (difference)

Maximum Test Cargo/Luggage Weight = 136 kg

WEIGHT OF TEST VEHICLE AS DELIVERED AT LABORATORY: (with maximum fluids)

Right Front =	613.5 kg	Right Rear =	438.0 kg
Left Front =	604.0 kg	Left Rear =	434.0 kg
TOTAL FRONT =	1217.5 kg	TOTAL REAR =	872.0 kg
% Total Weight =	58.0 %	% Total Weight =	42.0 %

TOTAL DELIVERED WEIGHT = 2089.5 kg

CALCULATION OF VEHICLE'S TARGET TEST WEIGHT:

Total Delivered Weight = 2089.5 kg

Max. Test Cargo/Luggage Weight = 136.0 kg

Target Test Weight = 2225.5 kg

WEIGHT OF TEST VEHICLE FULLY LOADED:

Right Front =	611.5 kg	Right Rear =	508.0 kg
Left Front =	595.0 kg	Left Rear =	508.5 kg
TOTAL FRONT =	1206.5 kg	TOTAL REAR =	1016.5 kg
% Total Weight =	54.0 %	% Total Weight =	46.0 %

TOTAL TEST WEIGHT = 2223.0 kg

Weight of ballast secured in vehicle's cargo area = 133.5 kg

TEST VEHICLE ATTITUDE:

AS DELIVERED: Right Front 900 mm; Left Front 901 mm;
Right Rear 988 mm; Left Rear 986 mm;
Pitch Angle at Right Door Sill = 1.2 Rear is higher
Pitch Angle at Left Door Sill = 1.3 Rear is higher
Roll Angle at Front Bumper = 0.1 Right is higher
Roll Angle at Rear Bumper = 0.2 Right is higher

FULLY LOADED: Right Front 902 mm; Left Front 903 mm;
Right Rear 970 mm; Left Rear 968 mm;
Pitch Angle at Right Door Sill = 0.9 Rear is higher
Pitch Angle at Left Door Sill = 1.1 Rear is higher
Roll Angle at Front Bumper = 0.0
Roll Angle at Rear Bumper = 0.0

AS TARGETED: Right Front 1046 mm; Left Front 1042 mm;
Right Rear 1118 mm; Left Rear 1112 mm;
Pitch Angle at Right Door Sill = 1.1 Rear is higher
Pitch Angle at Left Door Sill = 1.3 Rear is higher
Roll Angle at Front Bumper = 0.1 Right is higher
Roll Angle at Rear Bumper = 0.2 Right is higher

AS TESTED ON RIGHT SIDE:

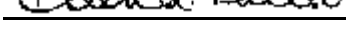
Pitch Angle at Right Door Sill =	1.1 Rear is higher
Pitch Angle at Left Door Sill =	1.3 Rear is higher
Roll Angle at Front Bumper =	0.0
Roll Angle at Rear Bumper =	0.2 Right is higher

AS TESTED ON LEFT SIDE:

Pitch Angle at Right Door Sill =	1.1 Rear is higher
Pitch Angle at Left Door Sill =	1.3 Rear is higher
Roll Angle at Front Bumper =	0.1 Right is higher
Roll Angle at Rear Bumper =	0.2 Right is higher

VEHICLE WHEELBASE = 3730 mm

REMARKS: The seat travel distance was measured to be 260 mm for the driver front seat and 235 mm for the passenger front seat.

Recorded By:  Approved By: 

Date: July 23, 2021

TABLE 2-3

HORIZONTAL IMPACT ANGLE RANGE FOR A AND B PILLARS

VEH. MOD YR/MAKE/MODEL/BODY: 2021 Ford F-150 Crew Cab

VEH. NHTSA NO.: C20210204 VIN: 1FTEW1CP6MKD17763

COLOR: Carbonized Gray VEH. BUILD DATE: December 2020

TEST DATES: July 22-23, 2021 TEST LABORATORY: MGA Research Corp.

OBSERVERS: Helen Kaleto, Ryan Jones, David Burkett, Kurt Reichert

HORIZONTAL IMPACT ANGLE RANGE FOR A AND B PILLARS

	HORIZONTAL ANGLE SPECIFIED RANGE	MINIMUM HORIZONTAL ANGLE	MAXIMUM HORIZONTAL ANGLE
A-PILLAR	L 195º-255º	L 200.5º	L 251.4º
	R 105º-165º	R 108.9º	R 160.7°
B-PILLAR	L 195º-345º	L 199.8º	L 298.6º
	R 15º-165º	R 62.1°	R 160.0º

AS DETERMINED USING THE PROCEDURES SPECIFIED IN S8.13.4.1

REMARKS:

Recorded By: _____ Approved By: Helen A. Kaleto

Date: July 23, 2021

TABLE 2-4

VERTICAL IMPACT ANGLE RANGES

VEH. MOD YR/MAKE/MODEL/BODY: 2021 Ford F-150 Crew Cab

VEH. NHTSA NO.: C20210204 VIN: 1FTEW1CP6MKD17763

COLOR: Carbonized Gray VEH. BUILD DATE: December 2020

TEST DATES: July 22-23, 2021 TEST LABORATORY: MGA Research Corp.

OBSERVERS: Helen Kaleto, Ryan Jones, David Burkett, Kurt Reichert

VERTICAL IMPACT ANGLE RANGES

		VERTICAL ANGLE SPECIFIED RANGE	MINIMUM VERTICAL ANGLE	MAXIMUM VERTICAL ANGLE
FRONT HEADER	FH1	L 0º-50º	L 0º	L 50º
		R 0º-50º	R 0º	R 50º
	FH2	L 0º-50º	L 0º	L 50º
		R 0º-50º	R 0º	R 50º
SIDE RAIL	SR1	L 0º-50º	L 0º	L 40º
		R 0º-50º	R 0º	R 40º
	SR2A	L 0º-50º	L 0º	L 40º
		R 0º-50º	R 0º	R 40º
	SR2B	L 0º-50º	L 0º	L 40º
		R 0º-50º	R 0º	R 40º
	SR3-1	L 0º-50º	L 0º	L 30º
		R 0º-50º	R 0º	R 30º
REAR HEADER	RH	L 0º-50º	L 0º	L 24º
		R 0º-50º	R 0º	R 24º
A-PILLAR	AP1	L -5º-50º	L -5º	L 20º
		R -5º-50º	R -5º	R 20º
	AP2	L -5º-50º	L -5º	L 35°
		R -5º-50º	R -5º	R 35°

		VERTICAL ANGLE SPECIFIED RANGE	MINIMUM VERTICAL ANGLE	MAXIMUM VERTICAL ANGLE
	AP3	L -5º-50º	L -5º	L -2°
		R -5º-50º	R -5º	R -2°
B-PILLAR	BP1	L -10º-50º	L -10º	L 15°
		R -10º-50º	R -10º	R 15°
	BP2*	L 0º-50º	L 0º	L 10º
		R 0º-50º	R 0º	R 10º
	BP3	L -10º-50º	L -10º	L -4º
		R -10º-50º	R -10º	R -4º
	BP4	L -10º-50º	L -10º	L -4º
		R -10º-50º	R -10º	R -4º
REAR PILLAR	RP1	L -10º-50º	L -10º	L 7º
		R -10º-50º	R -10º	R 7º
	RP2	L -10º-50º	L -10º	L -3º
		R -10º-50º	R -10º	R -3º
UPPER ROOF 1		0º-50º	0º	37º
UPPER ROOF 2		0º-50º	0º	37º
UPPER ROOF 3		0º-50º	0º	38º
UPPER ROOF 4		0º-50º	0º	50º
UPPER ROOF 5		0º-50º	0º	37º
UPPER ROOF 6		0º-50º	0º	37º
UPPER ROOF 7		0º-50º	0º	50º
UPPER ROOF 8		0º-50º	0º	50º
UPPER ROOF 9		0º-50º	0º	50º
UPPER ROOF 10		0º-50º	0º	37º
UPPER ROOF 11		0º-50º	0º	37º
UPPER ROOF 12		0º-50º	0º	37º

As determined using the Procedures specified in S8.13.4.2.

*Target BP2 is located on a seat belt anchorage.

Recorded By: _____ Approved By: _____

Date: July 23, 2021

TABLE 2-5

TARGET MEASUREMENTS

VEH. MOD YR/MAKE/MODEL/BODY: 2021 Ford F-150 Crew Cab

VEH. NHTSA NO.: C20210204 VIN: 1FTEW1CP6MKD17763

COLOR: Carbonized Gray VEH. BUILD DATE: December 2020

TEST DATES: July 22-23, 2021 TEST LABORATORY: MGA Research Corp.

OBSERVERS: Helen Kaleto, Ryan Jones, David Burkett, Kurt Reichert

Measurement	Description	Left Side	Right Side
M	Seat Fore/Aft Travel (Front seats)	260 mm	235 mm
Tº	Horizontal < {CG-F1 (Left Seat) to (Right A-Pillar)}	108.6º	--
A1º	360º - Tº	251.4º	--
Wº	Horizontal < {CG-2 (Left Seat) to (Left A-Pillar)}	200.5º	--
A2º	A2º = Wº	200.5º	--
Uº	Horizontal < {CG-2 (Left Seat) to (Left B-Pillar)}	298.6º	--
B1º	B1º = Uº	298.6º	--
Vº	Horizontal < {CG-R (Left Seat) to (Left B-Pillar)}	199.8º	--
B2º	B2º = Vº	199.8º	--
Wº (right)	Horizontal < {CG-F2 (Right Seat) to (Right A-Pillar)}	--	160.7º
A1º (right)	A1º (right) = Wº (right)	--	160.7°
Tº (right)	Horizontal < {CG-F1 (Right Seat) to (Left A-Pillar)}	--	251.1°
A2º (right)	360º-Tº (right)	--	108.9º
V º (right)	Horizontal < {CG-R (Right Seat) to (Right B-Pillar)}	--	160.0º
B1º (right)	B1º (right) = Vº (right)	--	160.0º
Uº (right)	Horizontal < {CG-F2 (Right Seat) to (Right B-Pillar)}	--	62.1º
B2º (right)	B2º (right) = Uº (right)	--	62.1º
J	A-Pillar {(Plane 3) – (Plane 5)}	325.7 mm	326.4 mm
J/2	J ÷ 2	162.9 mm	163.2 mm
D1	Upper Roof {(Plane A) – (Plane B)}	1954.5 mm	
D1/2	D1 ÷ 2	977.3 mm	
D2	Upper Roof {(Plane C) – (Plane D)}	1440.3 mm	
D2/2	D2 ÷ 2	720.2 mm	

Measurement	Description	Left Side	Right Side
.35D1	.35 x D1	684.1 mm	
.35D2	.35 x D2	504.1 mm	
N	B-Pillar {(BPR) – (lowest point on daylight opening forward of B-Pillar)}	563.6 mm	570.2 mm
N/2	B-Pillar {(BP3) – (lowest point on daylight opening forward of B-Pillar)}	281.8 mm	285.1 mm
N/4	B-Pillar {(BP4) – (lowest point on daylight opening forward of B-Pillar)}	140.9 mm	142.6 mm
D	R-Pillar (Point 7 – Point M)	856 mm	854 mm
3D/7	3 D / 7	366.9 mm	366.0 mm

As determined using the Procedures specified in S10.1-10.13.

SgRP Locations (world coordinates)						
	Left (mm)			Right (mm)		
	x	y	z	x	y	z
Front	3110.0	-459.0	1060.0	3110.0	459.0	1060.0
Rear	4135.0	-465.0	1022.7	4135.0	465.0	1022.7

SgRP Locations (vehicle coordinates)						
	Left (mm)			Right (mm)		
	x	y	z	x	y	z
Front	3110.0	-459.0	1060.0	3110.0	459.0	1060.0
Rear	4135.0	-465.0	1022.7	4135.0	465.0	1022.7

CG- Locations (world coordinates)						
	Left (mm)			Right (mm)		
	X	y	z	x	y	z
CG-F1	3010.0	-459.0	1720.0	3035.0	459.0	1720.0
CG-F2	3270.0	-459.0	1720.0	3270.0	459.0	1720.0
CG-R	4295.0	-465.0	1682.7	4295.0	465.0	1682.7

REFERENCE FOR VEHICLE COORDINATE SYSTEM (measured in millimeters):

LH RR OB Seat Mount (x, y, z) = 3283.0, -664.9, 748.5

LH RR Upper Striker (x, y, z) = 4375.3, -898.1, 1135.4

RH FR Lower Striker (x, y, z) = 3384.5, 896.8, 1099.8

REMARKS:

Recorded By: _____ Approved By: _____

Date: July 23, 2021

TABLE 2-6

SUMMARY OF TARGETING RESULTS

VEH. MOD YR/MAKE/MODEL/BODY: 2021 Ford F-150 Crew Cab

VEH. NHTSA NO.: C20210204 VIN: 1FTEW1CP6MKD17763

COLOR: Carbonized Gray VEH. BUILD DATE: December 2020

TEST DATES: July 22-23, 2021 TEST LABORATORY: MGA Research Corp.

OBSERVERS: Helen Kaleto, Ryan Jones, David Burkett, Kurt Reichert

SUMMARY OF TARGETING RESULTS								
Target	Location (mm)			Horizontal Angle (deg)	Vertical Angle (deg)	Relocation (Yes/No)	Extension (# of 25 mm Spheres)	Impact (Yes/No)
	x	Y	z					
A-Pillar Left Side								
AP1	2841.0	-632.8	1856.1	251	20	No	--	No
AP2	2731.6	-685.5	1768.9	201	35	No	--	No
AP3	2654.2	-663.9	1694.1	201	-2	No	--	No
A-Pillar Right Side								
AP1	2837.5	634.8	1854.2	109	20	No	--	Yes
AP2	2726.6	684.8	1767.1	160	35	No	--	No
AP3	2005.0	647.4	1645.0	160	-2	No	--	No
B-Pillar Left Side								
BP1	3459.6	-561.1	1920.5	--	--	Yes	--	--
REL	3459.9	-576.8	1905.4	270	15	--	1	No
BP2	3460.9	-687.4	1652.0	270	10	No	--	Yes
BP3	3393.1	-731.9	1639.5	288	-4	No	--	No
BP4	3548.5	-790.9	1499.9	--	--	Yes	--	--
REL	3539.2	-758.1	1535.9	298	-4	--	2	No
B-Pillar Right Side								
BP1	3460.4	560.9	1922.9	--	--	Yes	--	--
REL	3461.8	575.2	1907.2	90	15	--	1	Yes
BP2	3459.5	690.3	1649.7	90	10	No	--	No
BP3	3396.3	732.6	1638.8	72	-4	No	--	Yes
BP4	3548.4	792.3	1497.6	--	--	Yes	--	--
REL	3539.9	759.7	1531.5	63	-4	--	2	No
Rear Pillar Left Side								
RP1	4371.4	-603.3	1907.9	--	--	Yes	--	--
REL	4349.1	-606.2	1908.0	270	7	--	1	No
RP2	4443.5	-670.5	1736.3	270	-3	No	--	Yes

SUMMARY OF TARGETING RESULTS								
Target	Location (mm)			Horizontal Angle (deg)	Vertical Angle (deg)	Relocation (Yes/No)	Extension (# of 25 mm Spheres)	Impact (Yes/No)
	x	Y	z					
Rear Pillar Right Side								
RP1	4367.9	601.4	1914.3	--	--	Yes	--	--
REL	4344.2	606.8	1909.6	90	7	--	1	No
RP2	4443.9	674.4	1736.0	90	-3	No	--	No
Front Header Left Side								
FH1	2752.9	-543.2	1886.1	180	50	No	--	Yes
FH2	2713.0	-401.2	1894.0	180	50	No	--	No
Front Header Right Side								
FH1	2750.7	543.1	1887.3	180	50	No	--	No
FH2	2713.4	401.2	1894.3	180	50	No	--	No
Side Rail Left Side								
SR1	2990.2	-594.8	1927.7	--	--	Yes	--	--
REL	2989.9	-616.5	1884.9	270	40	--	2	Yes
SR2A	3140.5	-581.9	1914.1	270	40	No	--	No
SR2B	3159.9	-582.4	1915.3	270	40	No	--	No
SR3-1	3610.4	-579.1	1927.3	270.0	30	No	--	No
Side Rail Right Side								
SR1	2987.0	597.6	1922.6	--	--	Yes	--	--
REL	2988.7	615.9	1882.5	90	40	--	2	No
SR2A	3137.3	581.7	1914.1	90	40	No	--	No
SR2B	3159.7	583.3	1914.6	90	40	No	--	Yes
SR3-1	3609.4	580.7	1923.9	90	30	No	--	No
Rear Header Left Side								
RH	4402.3	-464.7	1934.8	0	24	No	--	No
Rear Header Right Side								
RH	4400.5	465.5	1934.8	0	24	No	--	Yes
Upper Roof Left Side								
UR1	3000.1	-494.8	1951.5	270	37	No	--	No
UR2@SR2	3149.7	-498.6	1970.7	270	37	No	--	Yes
UR3@BP	3459.9	-499.0	1939.8	270	38	No	--	Yes
UR4	3857.7	-407.2	1999.3	270	50	No	--	No
UR5	4050.4	-497.8	1993.5	270	37	No	--	No
UR6	4229.6	-498.5	1991.0	0	37	No	--	No
Upper Roof Right Side								
UR7@SR1	3000.7	468.6	1953.6	90	50	No	--	Yes
UR8	3150.4	441.6	1975.6	90	50	No	--	No
UR9	3455.3	455.9	1941.3	90	50	No	--	No

SUMMARY OF TARGETING RESULTS								
Target	Location (mm)			Horizontal Angle (deg)	Vertical Angle (deg)	Relocation (Yes/No)	Extension (# of 25 mm Spheres)	Impact (Yes/No)
	x	Y	z					
UR10	3609.5	496.3	1988.0	90	37	No	--	No
UR11	3778.8	496.6	1993.7	90	37	No	--	No
UR12	4227.4	495.5	1991.7	90	37	No	--	No

As determined using the Procedures specified in S10.1-10.13.

Recorded By:

Approved By: Helen A. Kaleto

Date: July 23, 2021

3.0 TEST DATA (Including Acceleration and Velocity Plots)

Test U21298 Data

mga research corporation

FMVSS 201U
Test No.: U21298 Report No.: G21I7-001.5
Customer: NHTSA Date: 7/23/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 8 Time: 11:02:56

Horizontal Approach Angle: 109 deg Temperature: 21.6 °C

Vertical Approach Angle: 20 deg Humidity: 47.7 %RH

Impact Form ID No.: H37 Impact Form Mass: 4.58 kg

Target Location: AP1

Additional Description:

Test Results

Impact Velocity: 18.97 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	302.41	89.3	95.3	6
HIC 15	302.41	89.3	95.3	6
HIC (d)	394.56	89.3	95.3	6

3 ms Clip = 76.88 G , Time 1 = 90.65 ms , Time 2 = 93.65 ms

Impact Location on FMH: 19 mm Above Pt. 0 , 0 mm Lateral of Pt. 0

Post-Test Comments: No Visible Damage

Test Series Performed By: RJ, KR

Recorded By: Approved By:

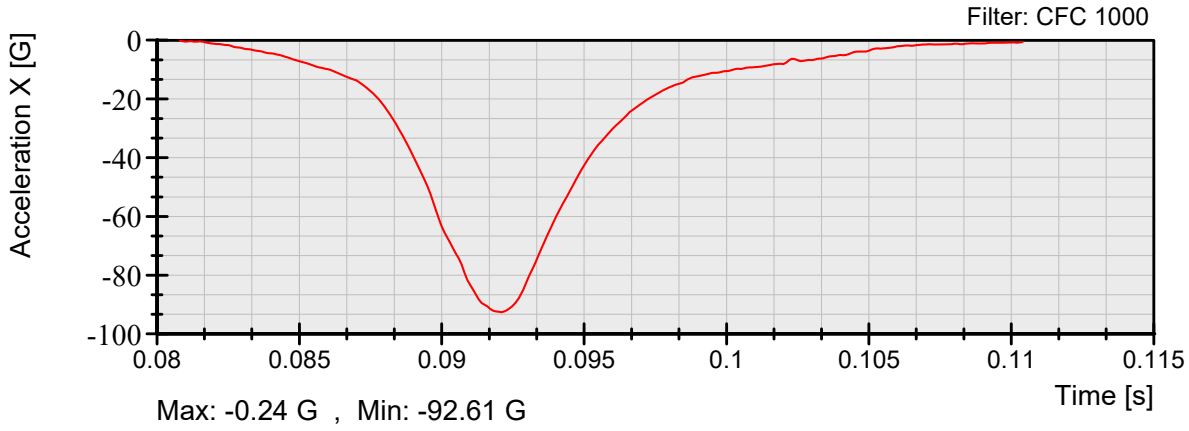
Date: 7/23/2021

mga research corporation

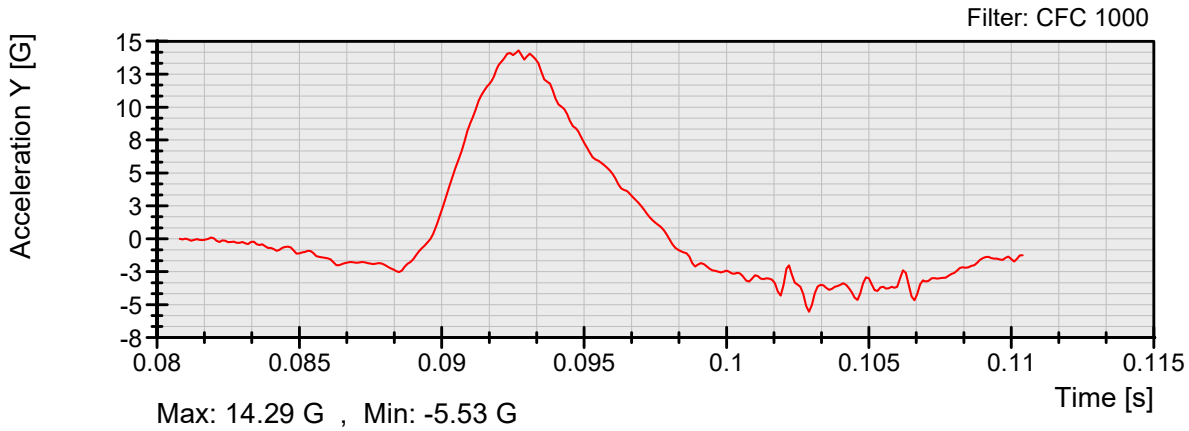
FMVSS 201U

Test No.: U21298
Customer: NHTSA

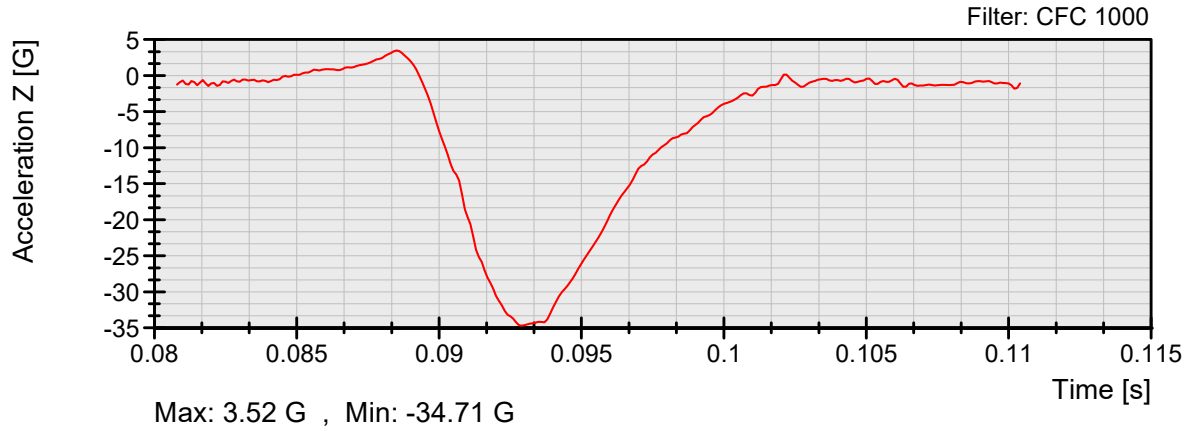
Report No.: G21I7-001.5
Date: 7/23/2021



Max: -0.24 G , Min: -92.61 G



Max: 14.29 G , Min: -5.53 G

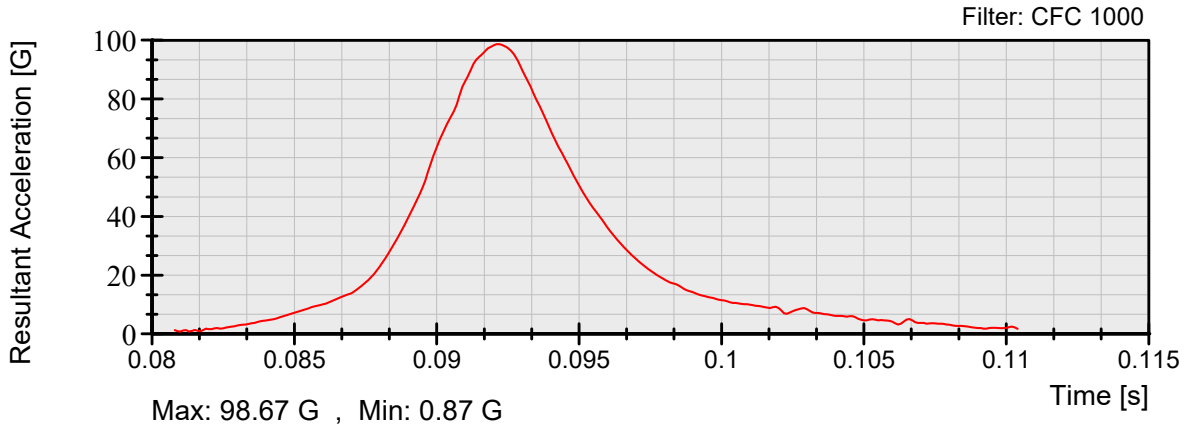


Max: 3.52 G , Min: -34.71 G

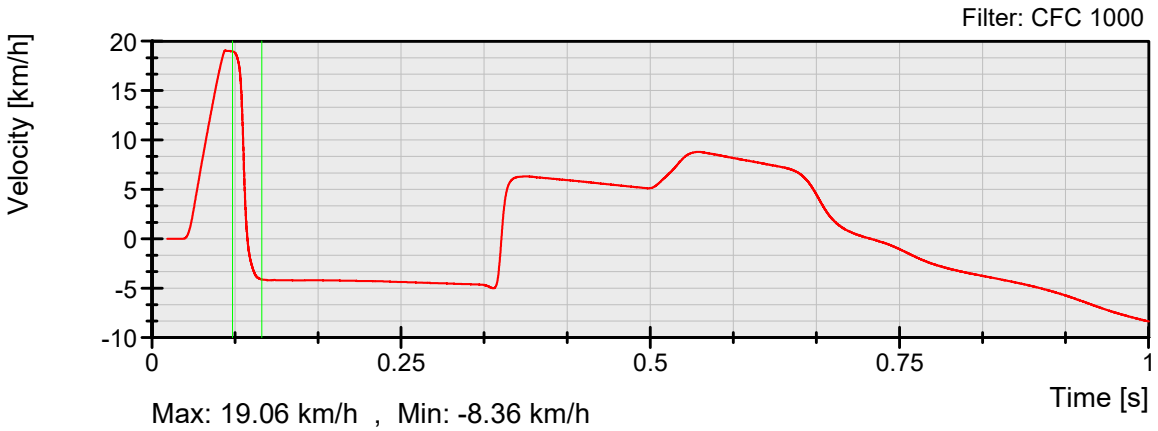
mga research corporation

FMVSS 201U

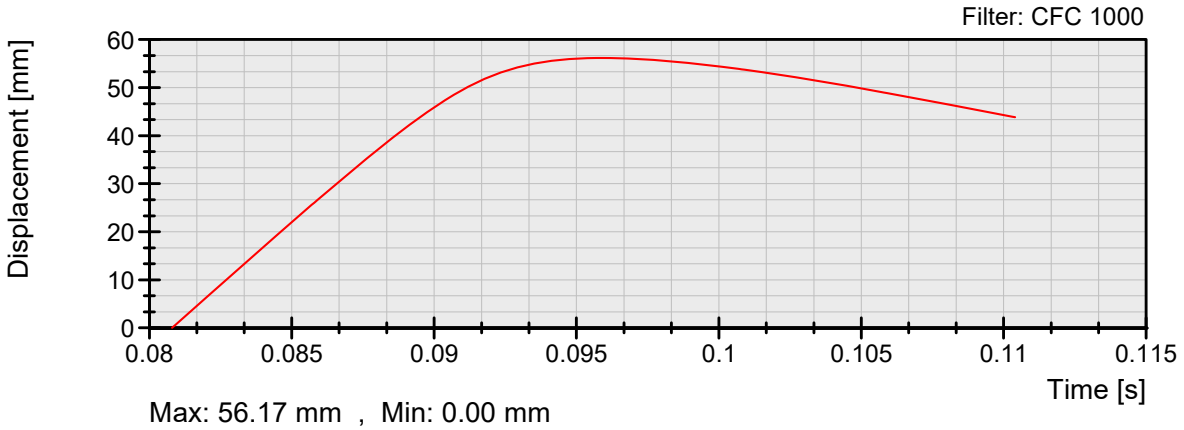
Test No.: U21298
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/23/2021



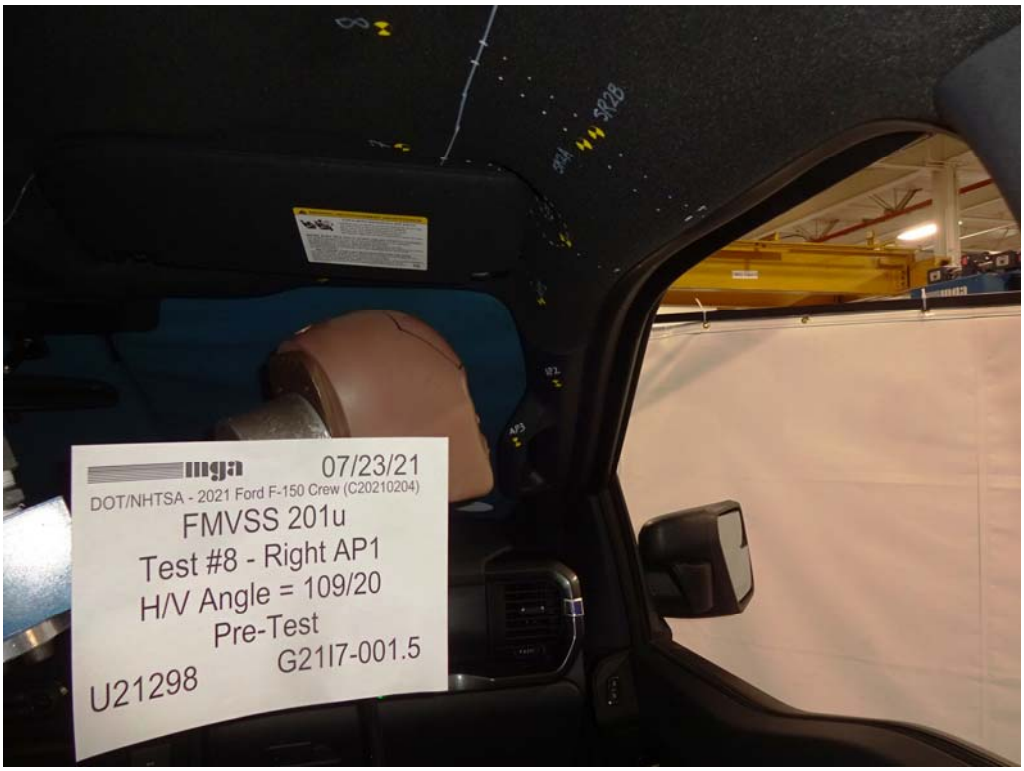
Max: 98.67 G , Min: 0.87 G



Max: 19.06 km/h , Min: -8.36 km/h



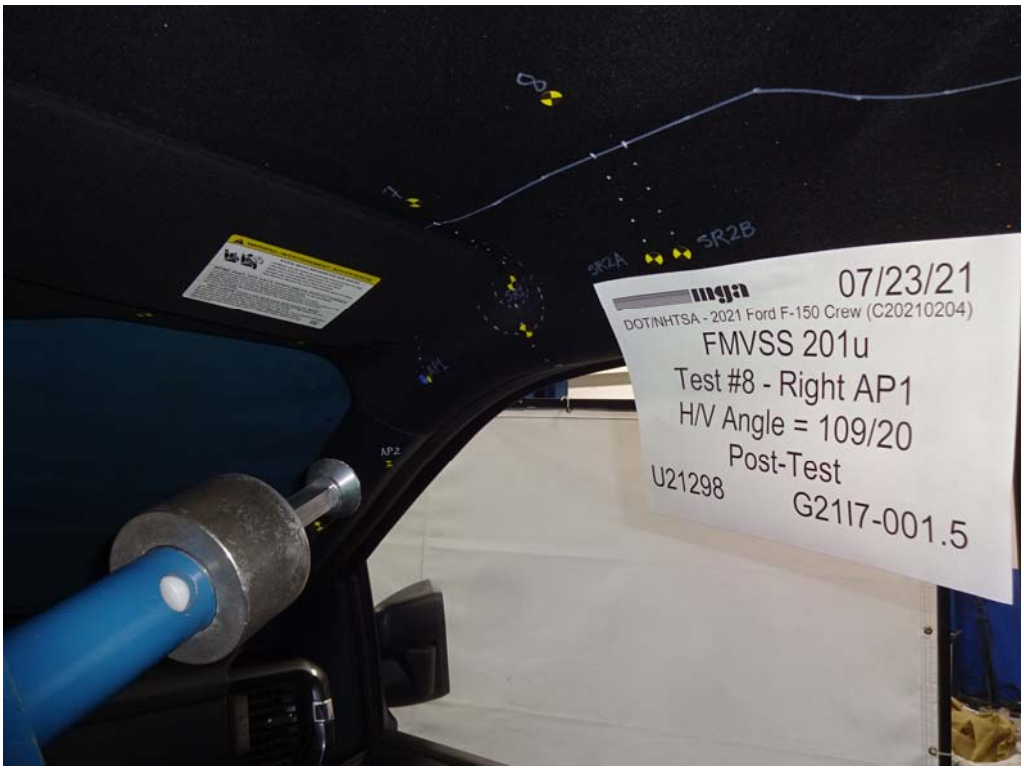
Max: 56.17 mm , Min: 0.00 mm



Pre-Test Photograph No. 1 of Test U21298

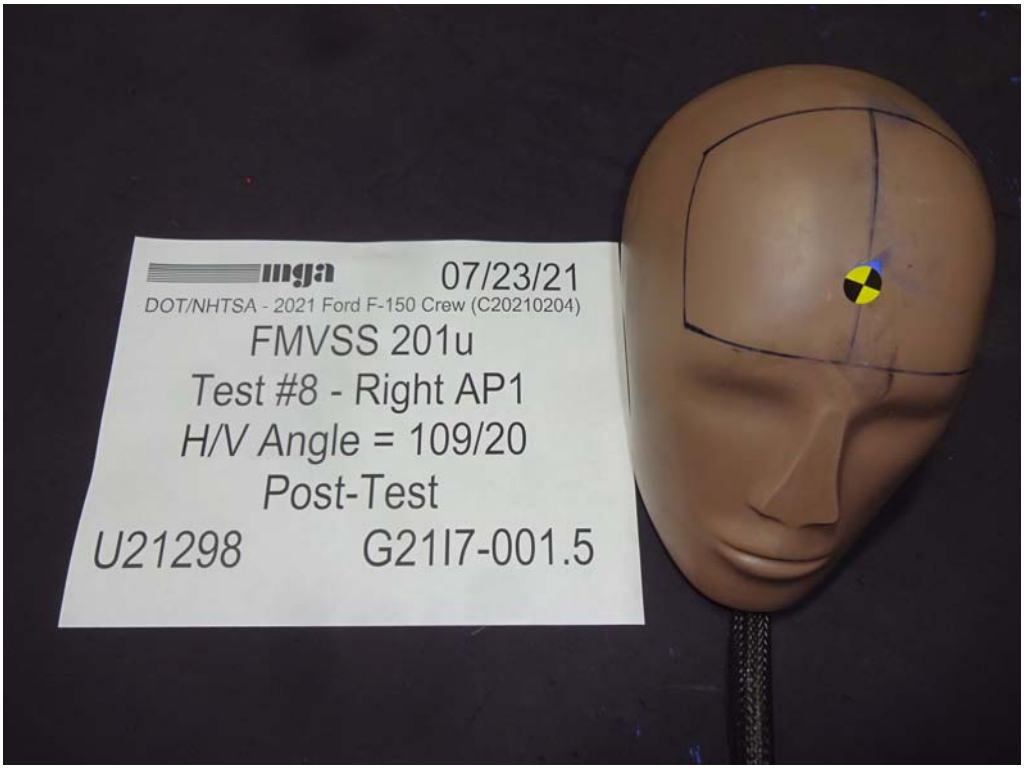
Pre-Test Photograph No. 2 of Test U21298

Post-Test Photograph No. 1 of Test U21298



Post-Test Photograph No. 2 of Test U21298

Post-Test Photograph No. 3 of Test U21298



Post-Test Photograph No. 4 of Test U21298

Test U21301 Data

mga research corporation

FMVSS 201U
Test No.: U21301 Report No.: G21I7-001.5
Customer: NHTSA Date: 7/23/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 11 Time: 16:12:33

Horizontal Approach Angle: 90 deg Temperature: 20.6 °C

Vertical Approach Angle: 15 deg Humidity: 47.4 %RH

Impact Form ID No.: H37 Impact Form Mass: 4.58 kg

Target Location: BP1

Additional Description:

Test Results

Impact Velocity: 19.11 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	372.72	88.2	95.4	7.2
HIC 15	372.72	88.2	95.4	7.2
HIC (d)	447.6	88.2	95.4	7.2

3 ms Clip = 84.61 G , Time 1 = 90.47 ms , Time 2 = 93.47 ms

Impact Location on FMH: 38 mm Above Pt. 0 , 5 Left mm Lateral of Pt. 0

Post-Test Comments: No Visible Damage

Test Series Performed By: RJ, KR

Recorded By: Approved By:

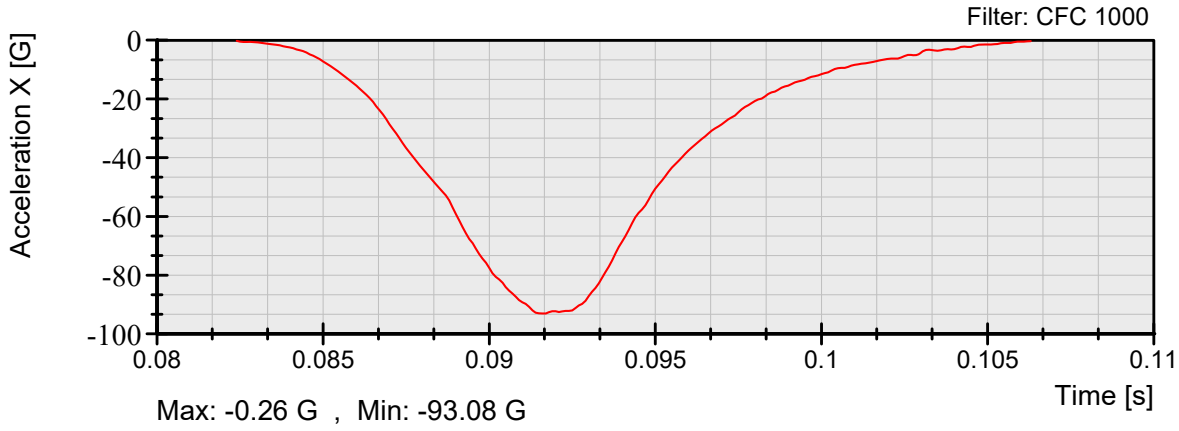
Date: 7/23/2021

mga research corporation

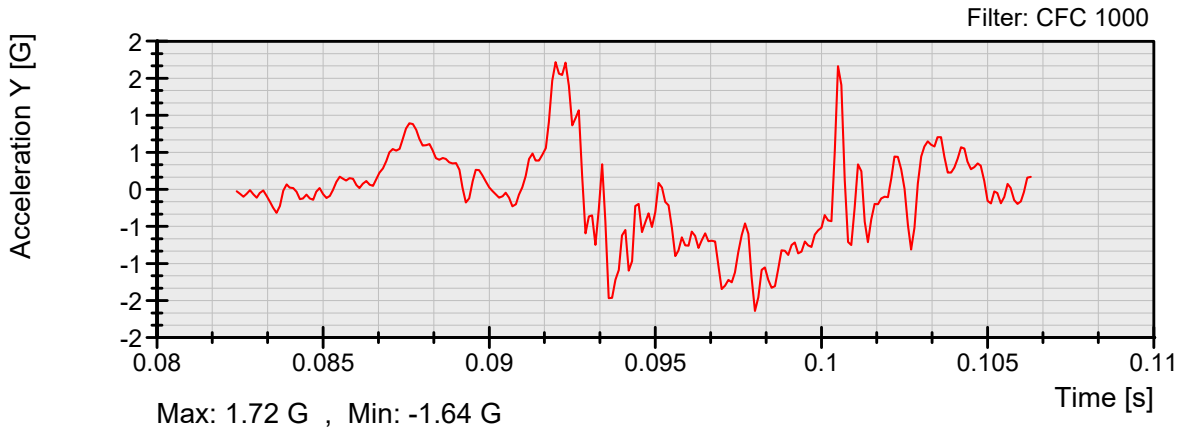
FMVSS 201U

Test No.: U21301
Customer: NHTSA

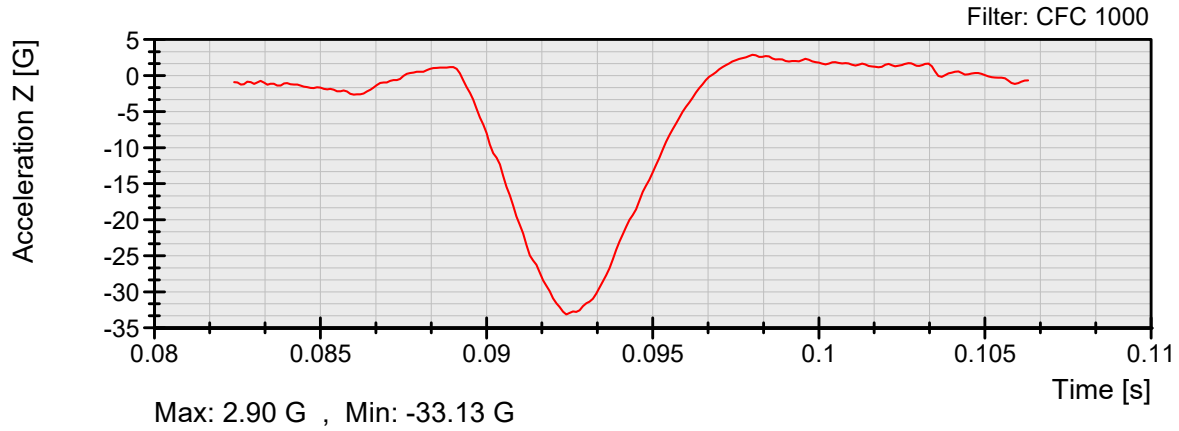
Report No.: G21I7-001.5
Date: 7/23/2021



Max: -0.26 G , Min: -93.08 G



Max: 1.72 G , Min: -1.64 G

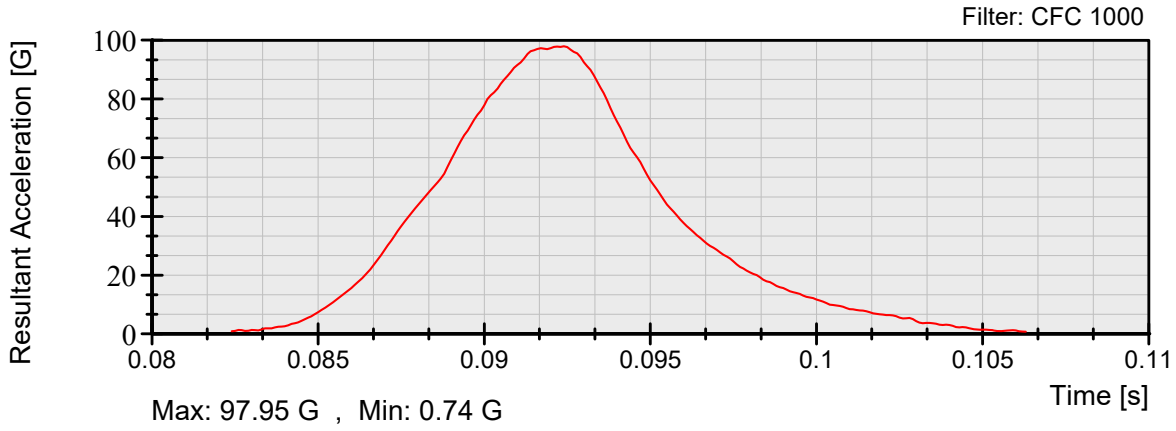


Max: 2.90 G , Min: -33.13 G

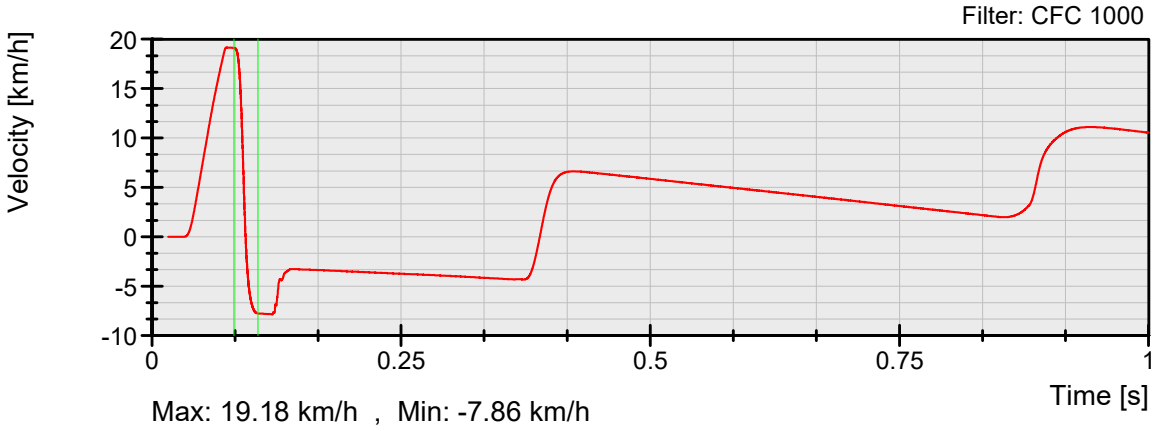
mga research corporation

FMVSS 201U

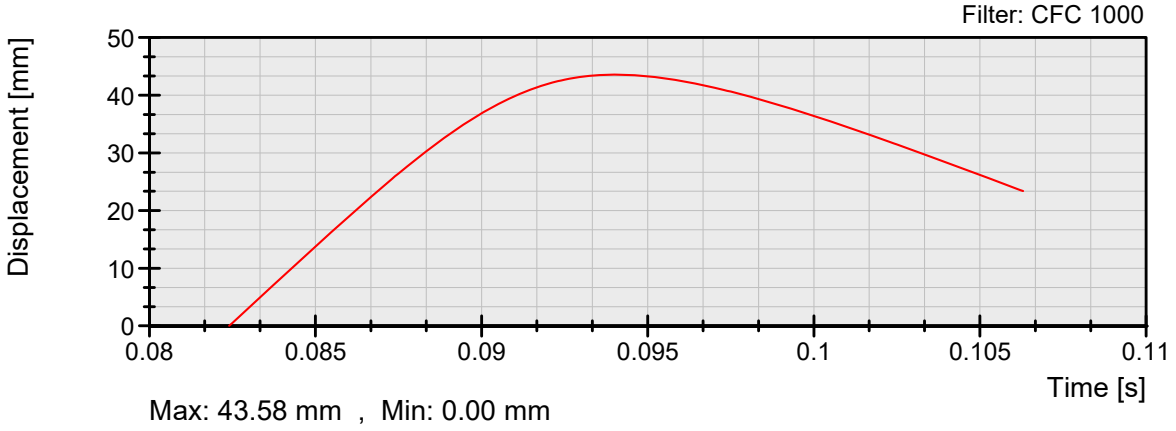
Test No.: U21301
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/23/2021



Max: 97.95 G , Min: 0.74 G

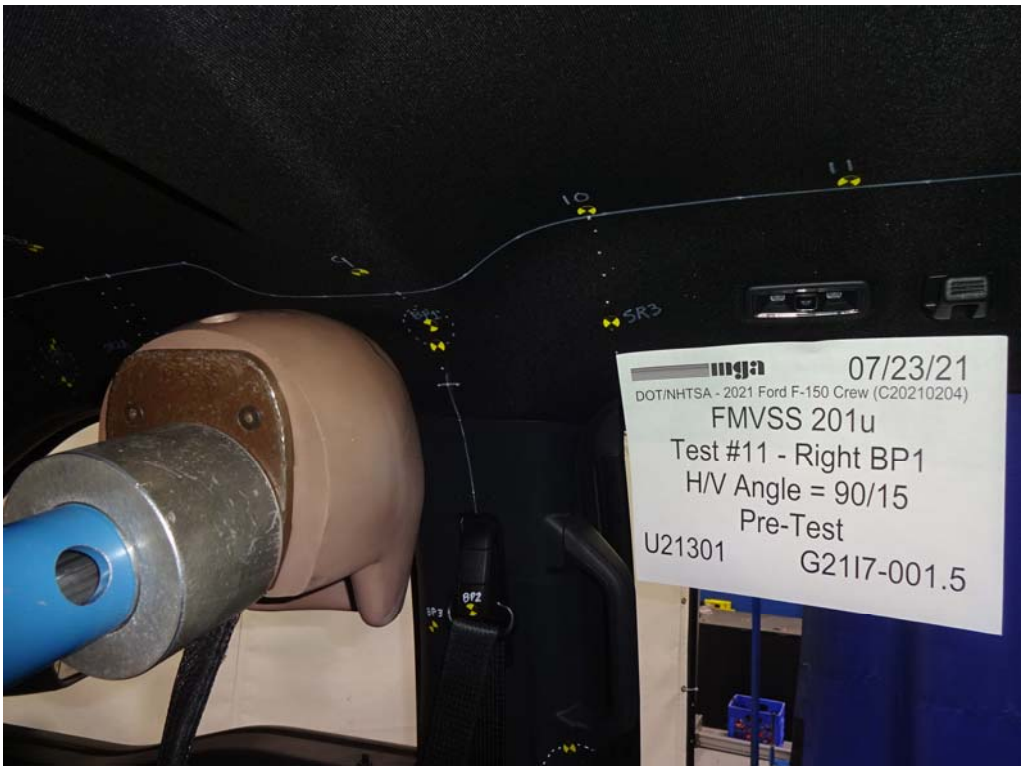


Max: 19.18 km/h , Min: -7.86 km/h

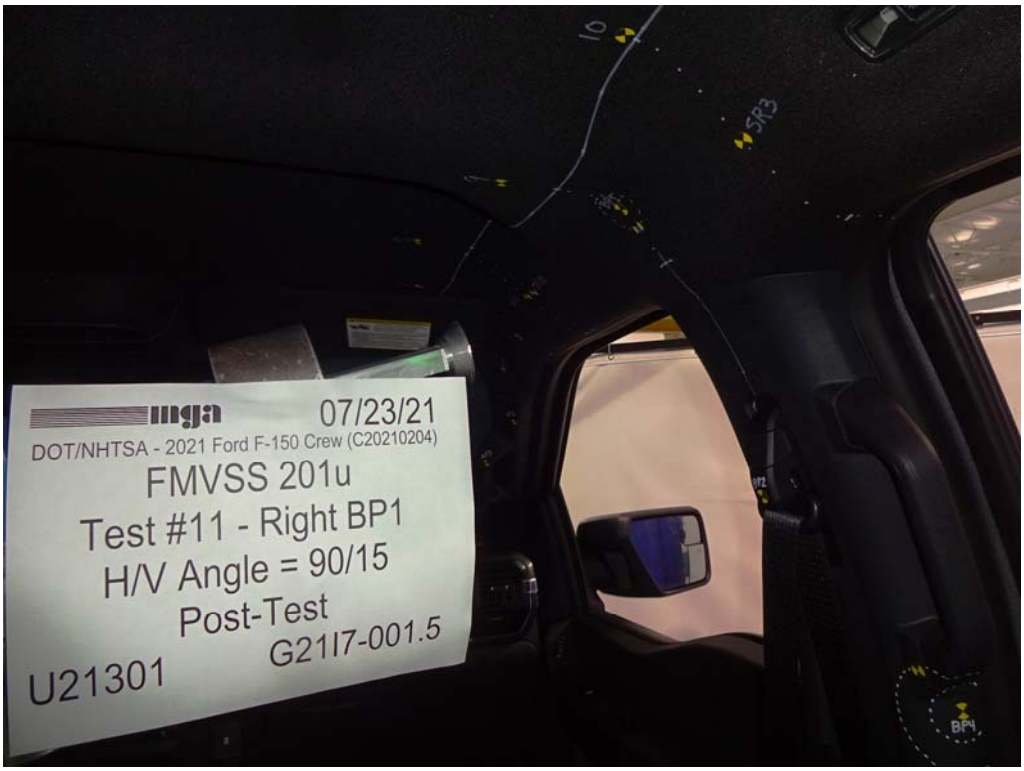


Max: 43.58 mm , Min: 0.00 mm

Pre-Test Photograph No. 1 of Test U21301



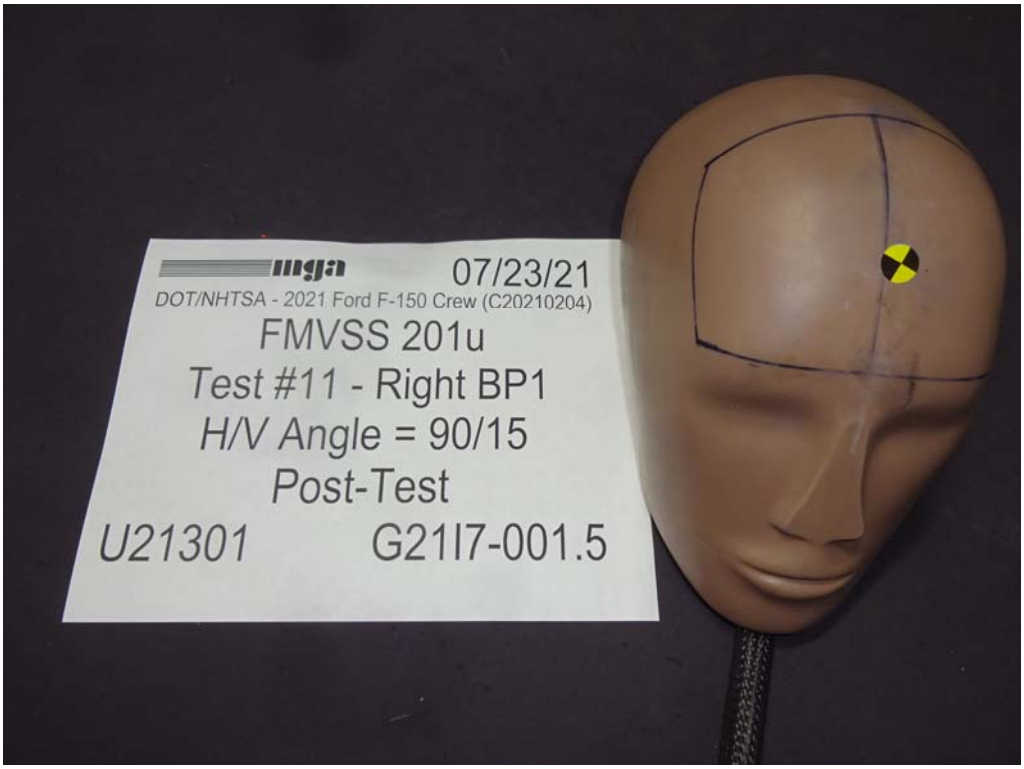
Pre-Test Photograph No. 2 of Test U21301



Post-Test Photograph No. 1 of Test U21301

Post-Test Photograph No. 2 of Test U21301

Post-Test Photograph No. 3 of Test U21301



Post-Test Photograph No. 4 of Test U21301

Test U21294 Data

mga research corporation

FMVSS 201U
Test No.: U21294
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/22/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 4
Time: 14:38:21

Horizontal Approach Angle: 270 deg
Temperature: 21.2 °C

Vertical Approach Angle: 10 deg
Humidity: 40.4 %RH

Impact Form ID No.: H35
Impact Form Mass: 4.55 kg

Target Location: Left BP2

Additional Description:

Test Results

Impact Velocity: 24 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	552.41	74.1	82.8	8.7
HIC 15	552.41	74.1	82.8	8.7
HIC (d)	583.17	74.1	82.8	8.7

3 ms Clip = 96.23 G , Time 1 = 77.18 ms , Time 2 = 80.18 ms

Impact Location on FMH: 17 mm Above Pt. 0 , 1 Left mm Lateral of Pt. 0

Post-Test Comments: Seat belt adjuster broken

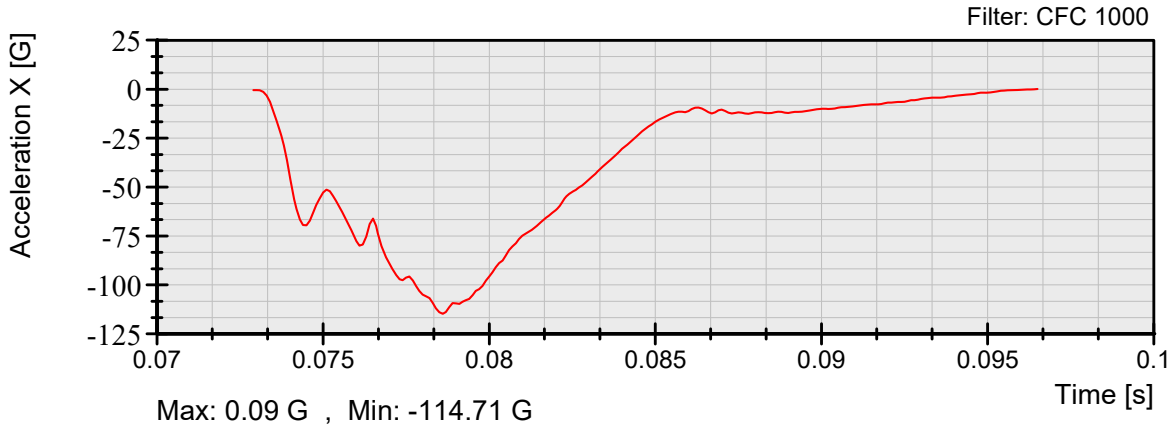
Test Series Performed By: RJ, KR

Recorded By:
Approved By:
Date: 7/22/2021

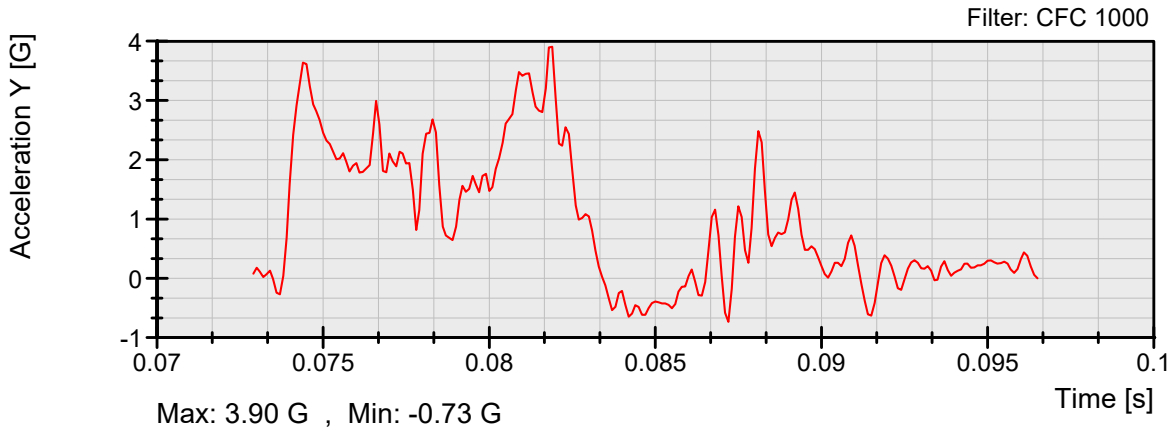
mga research corporation

FMVSS 201U

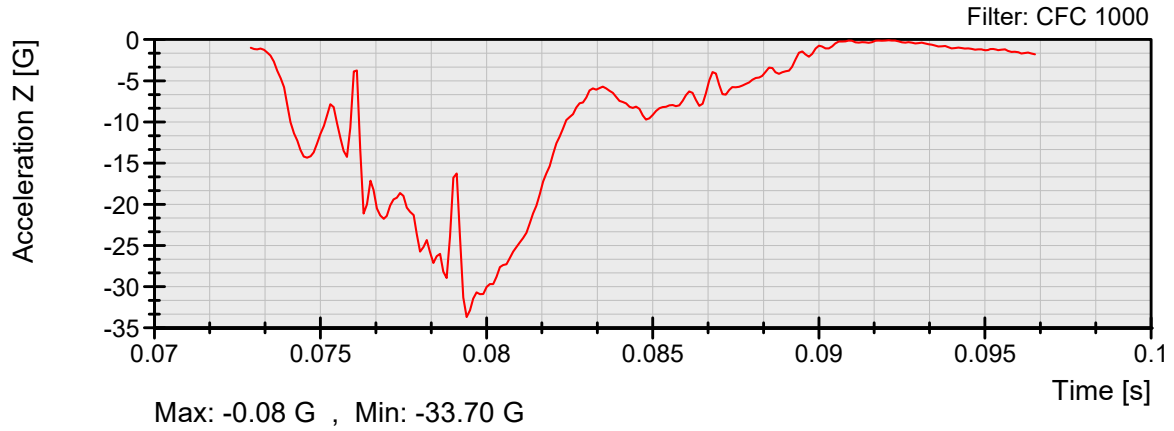
Test No.: U21294
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/22/2021



Max: 0.09 G , Min: -114.71 G



Max: 3.90 G , Min: -0.73 G



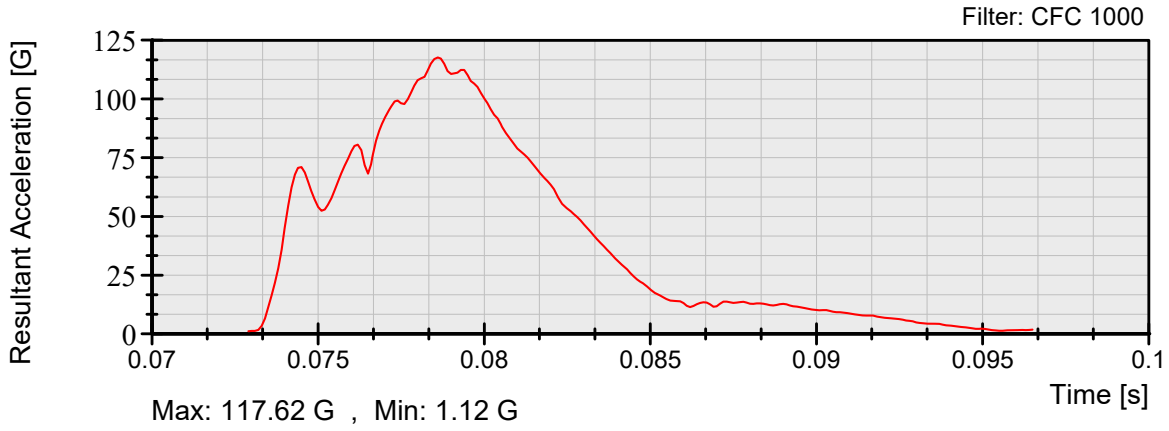
Max: -0.08 G , Min: -33.70 G

mga research corporation

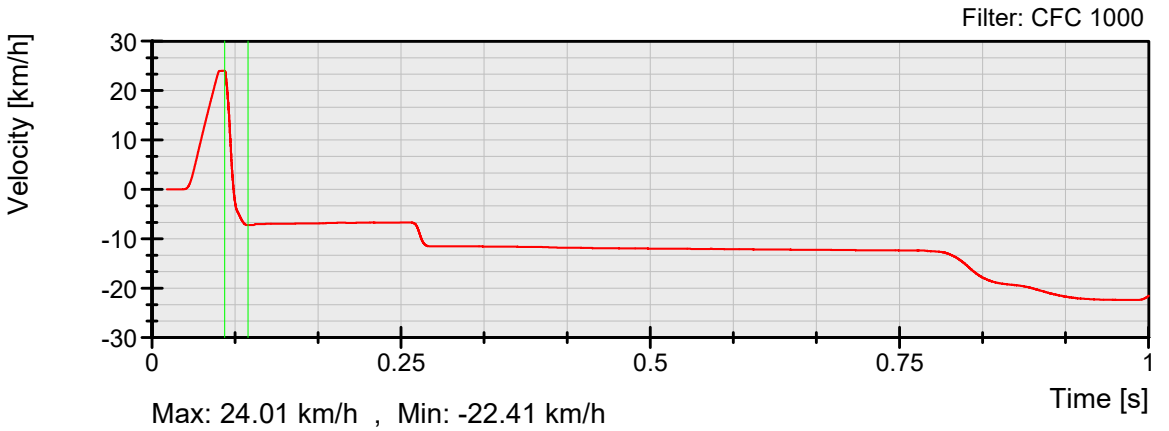
FMVSS 201U

Test No.: U21294
Customer: NHTSA

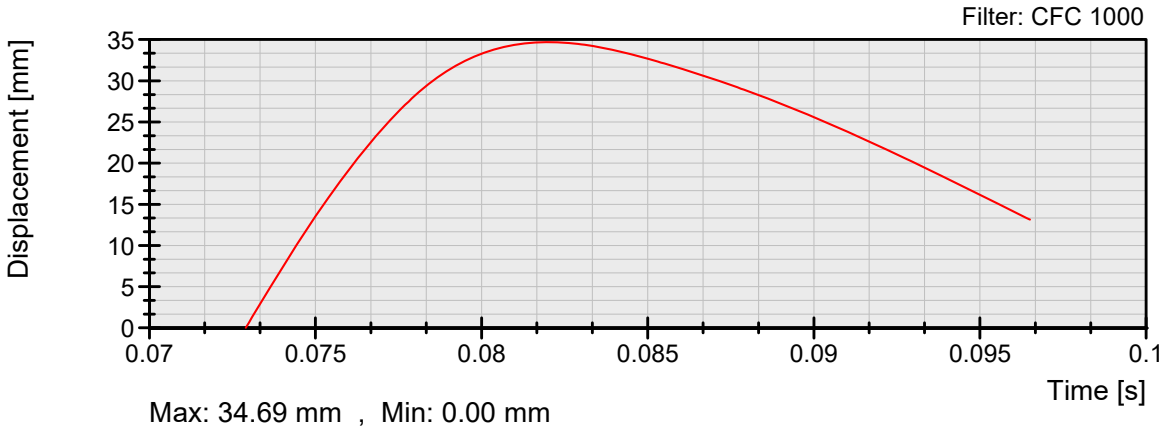
Report No.: G21I7-001.5
Date: 7/22/2021



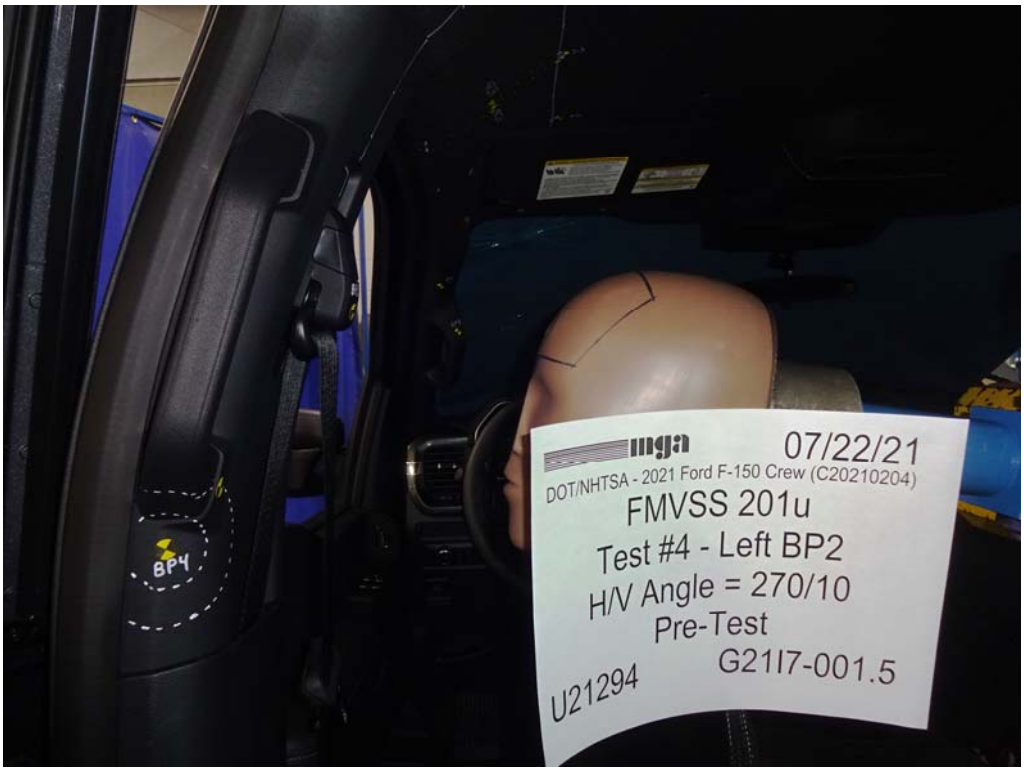
Max: 117.62 G , Min: 1.12 G



Max: 24.01 km/h , Min: -22.41 km/h

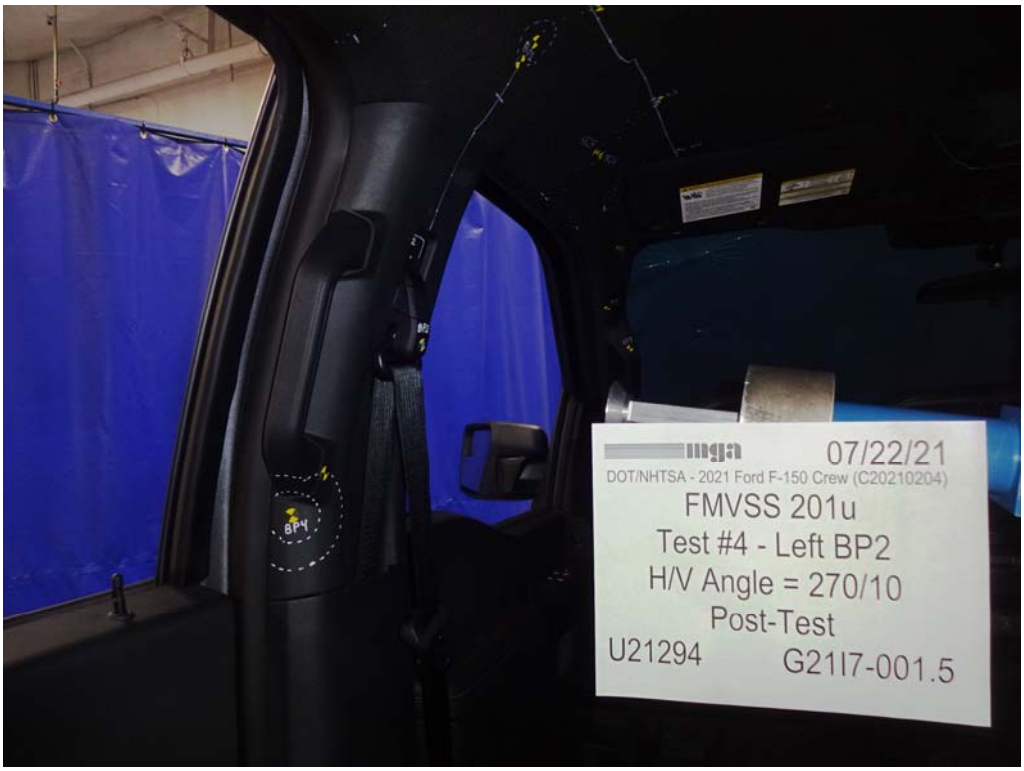


Max: 34.69 mm , Min: 0.00 mm



Pre-Test Photograph No. 1 of Test U21294

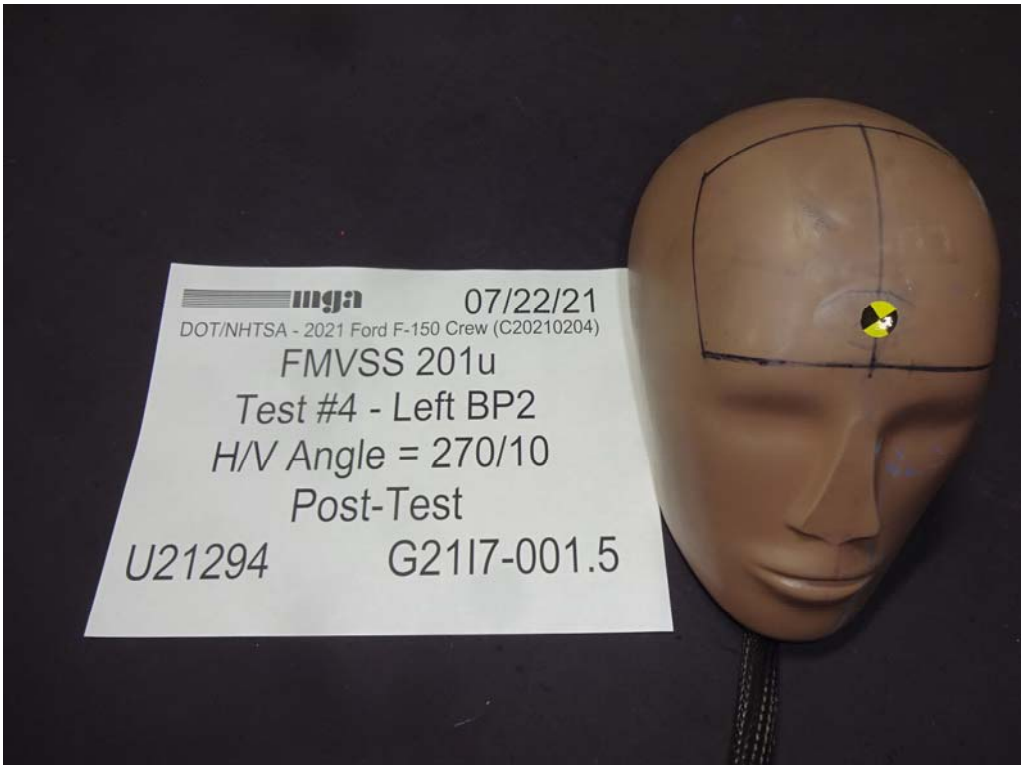
Pre-Test Photograph No. 2 of Test U21294



Post-Test Photograph No. 1 of Test U21294

Post-Test Photograph No. 2 of Test U21294

Post-Test Photograph No. 3 of Test U21294



Post-Test Photograph No. 4 of Test U21294

Test U21302 Data

mga research corporation

FMVSS 201U
Test No.: U21302 Report No.: G21I7-001.5
Customer: NHTSA Date: 7/23/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 12 Time: 17:00:42

Horizontal Approach Angle: 72 deg Temperature: 21.0 °C

Vertical Approach Angle: -4 deg Humidity: 49.0 %RH

Impact Form ID No.: H38 Impact Form Mass: 4.55 kg

Target Location: BP3

Additional Description:

Test Results

Impact Velocity: 24.32 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	816.12	74.7	82.1	7.4
HIC 15	816.12	74.7	82.1	7.4
HIC (d)	782.13	74.7	82.1	7.4

3 ms Clip = 110.73 G , Time 1 = 77.21 ms , Time 2 = 80.21 ms

Impact Location on FMH: 19 mm Above Pt. 0 , 2 Left mm Lateral of Pt. 0

Post-Test Comments: No Visible Damage

Test Series Performed By: RJ, KR

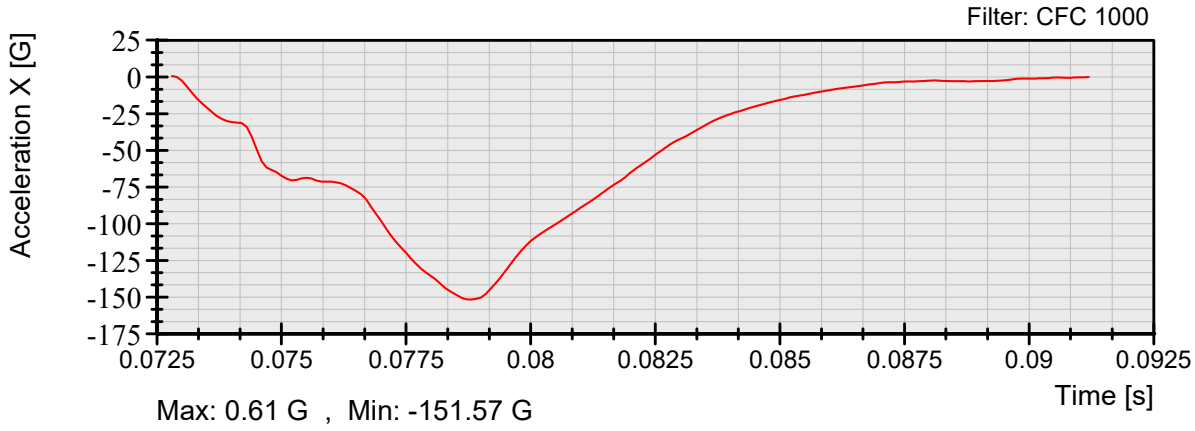
Recorded By: Approved By:

Date: 7/23/2021

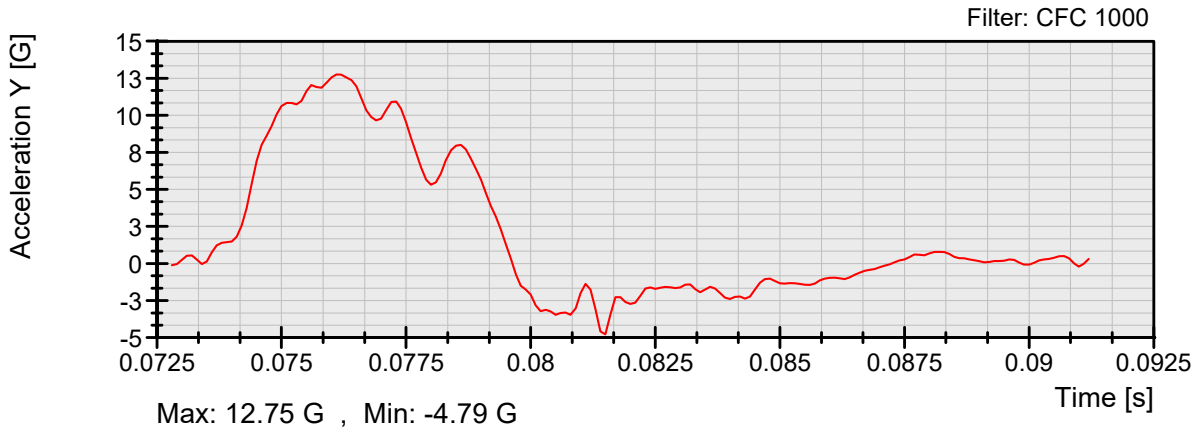
mga research corporation

FMVSS 201U

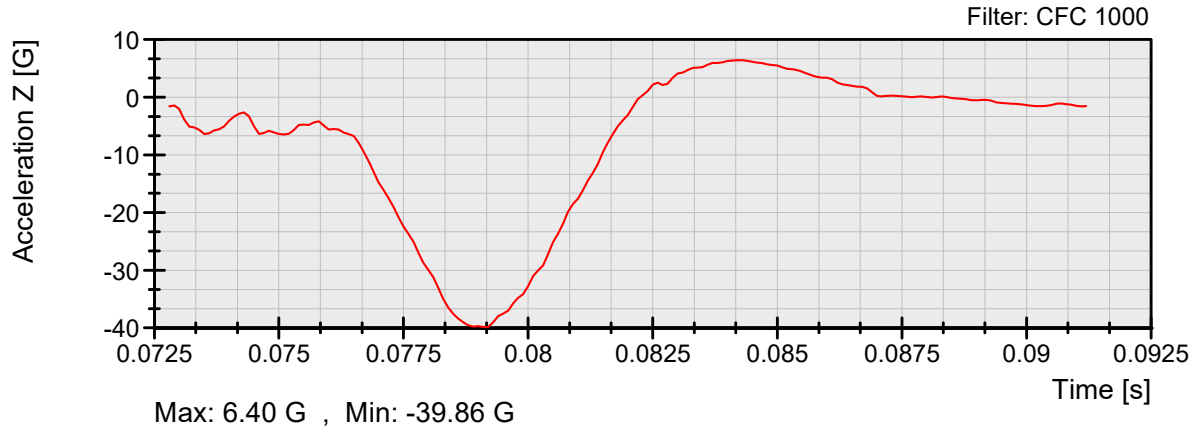
Test No.: U21302
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/23/2021



Max: 0.61 G , Min: -151.57 G



Max: 12.75 G , Min: -4.79 G

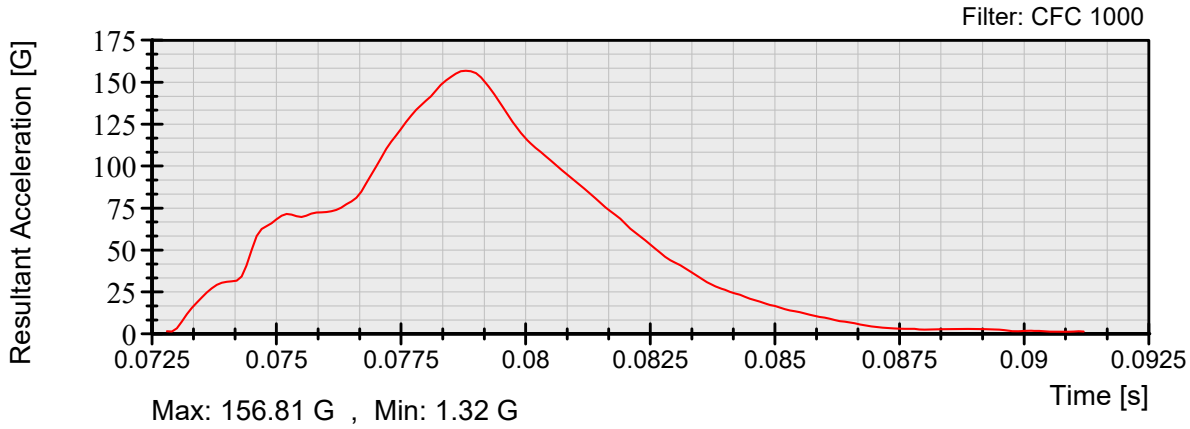


Max: 6.40 G , Min: -39.86 G

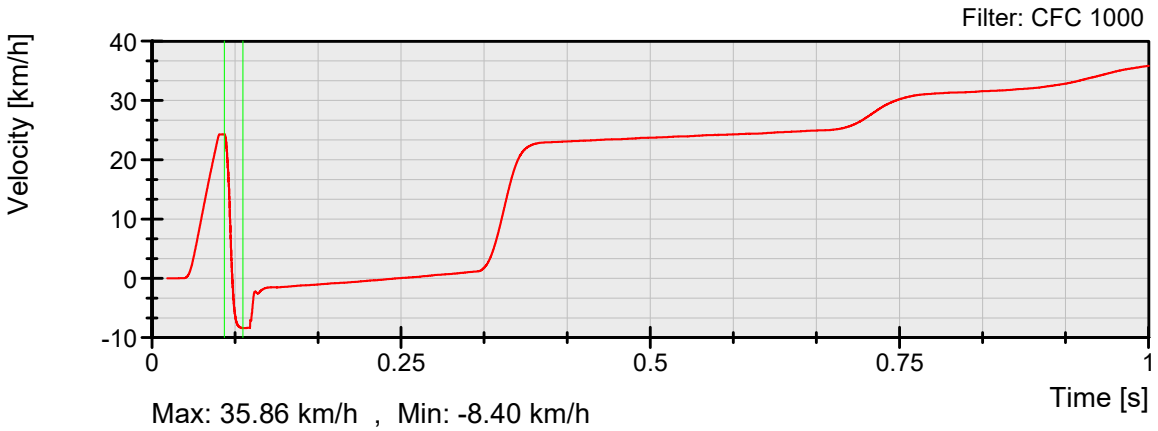
mga research corporation

FMVSS 201U

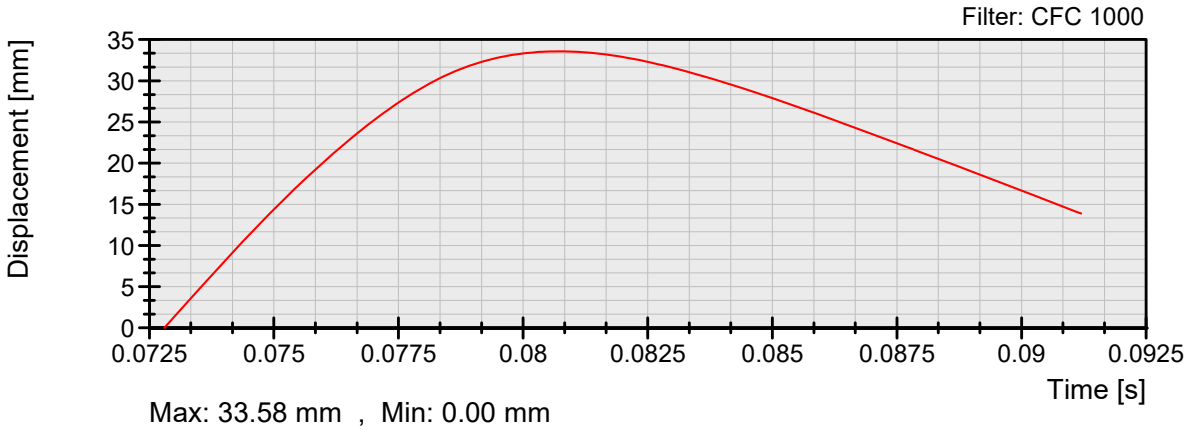
Test No.: U21302
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/23/2021



Max: 156.81 G , Min: 1.32 G

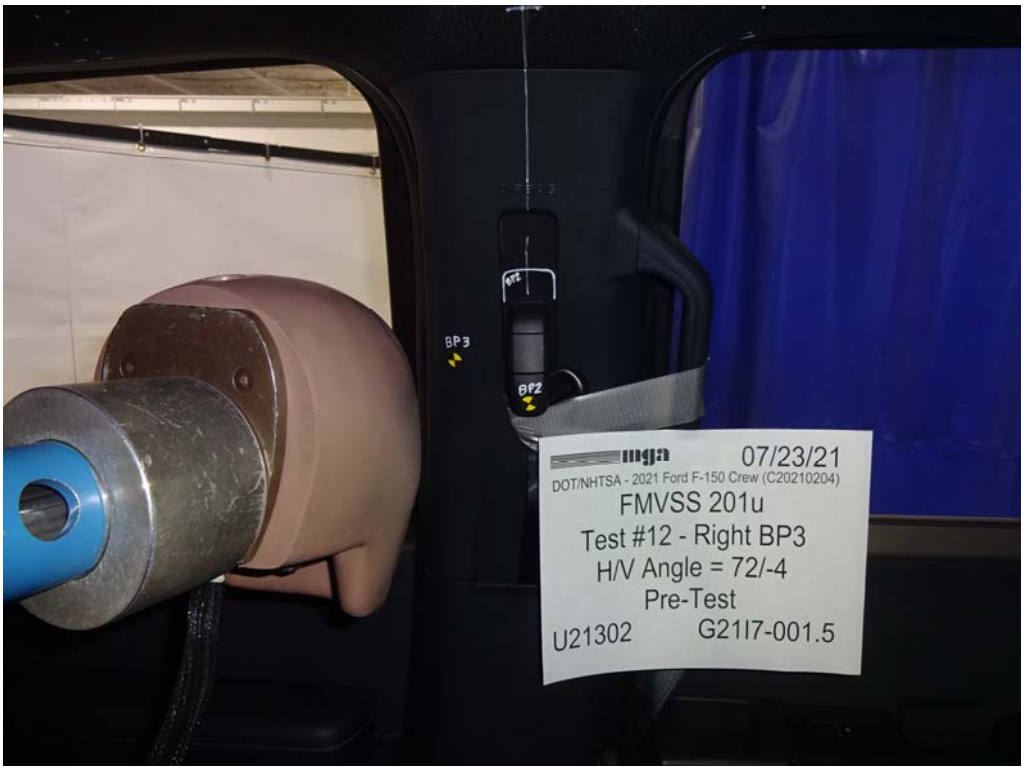


Max: 35.86 km/h , Min: -8.40 km/h

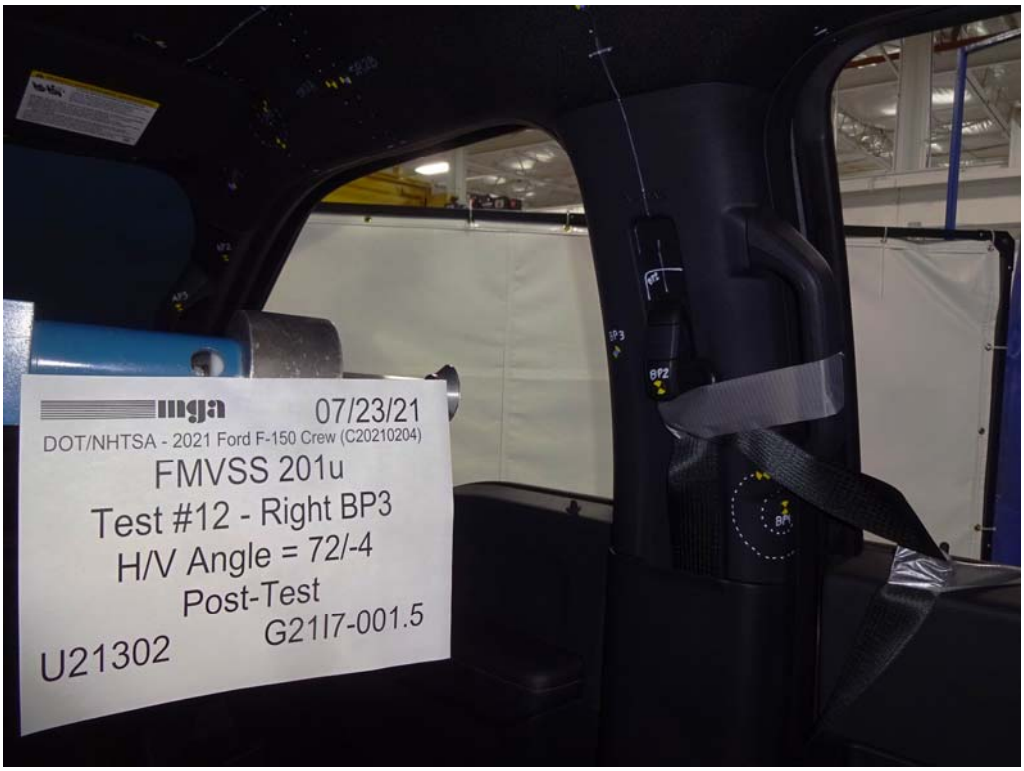


Max: 33.58 mm , Min: 0.00 mm

Pre-Test Photograph No. 1 of Test U21302

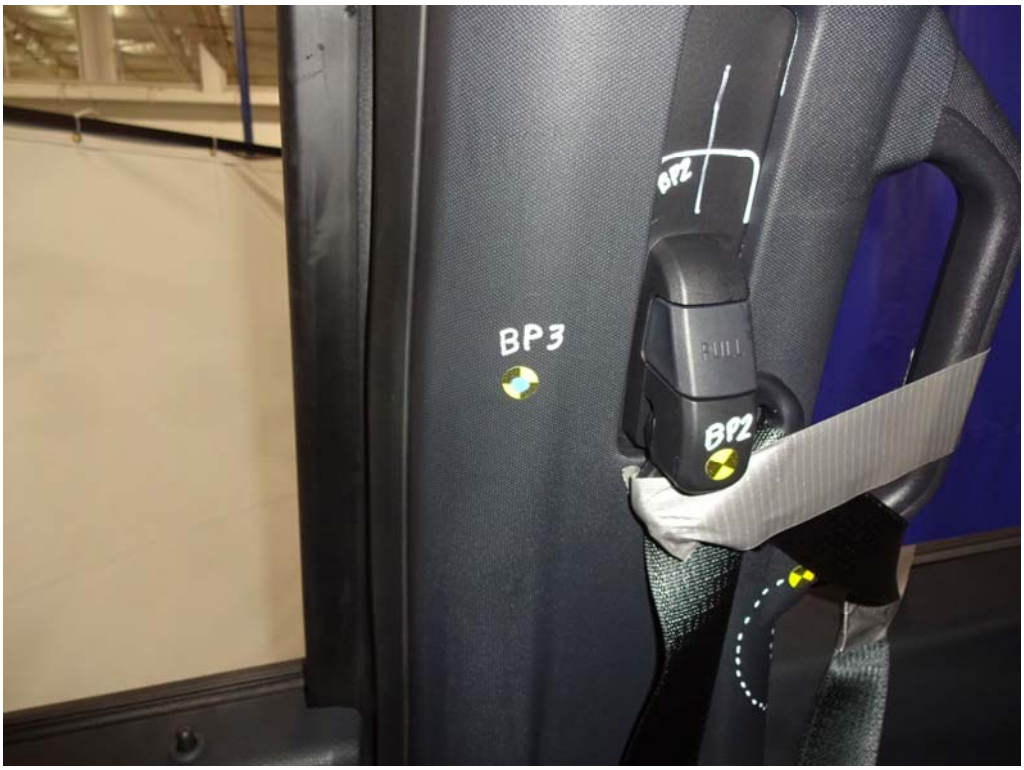


Pre-Test Photograph No. 2 of Test U21302

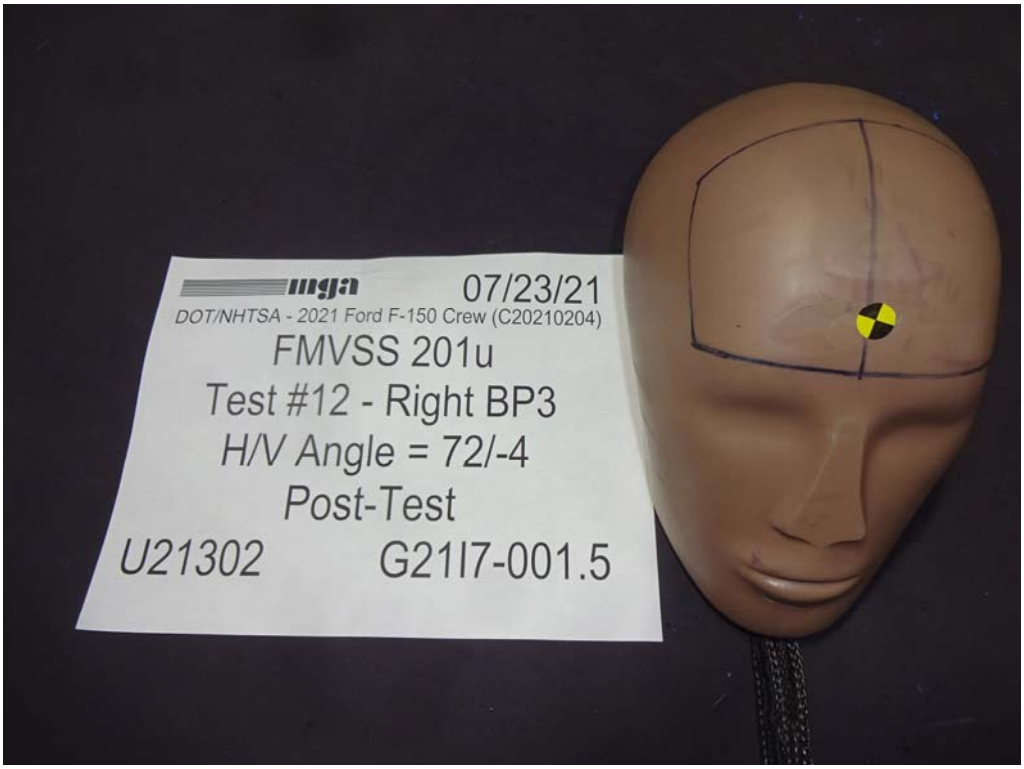


Post-Test Photograph No. 1 of Test U21302

Post-Test Photograph No. 2 of Test U21302



Post-Test Photograph No. 3 of Test U21302



Post-Test Photograph No. 4 of Test U21302

Test U21291 Data

mga research corporation

FMVSS 201U
Test No.: U21291 Report No.: G21I7-001.5
Customer: NHTSA Date: 7/22/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 1 Time: 10:06:01

Horizontal Approach Angle: 180 deg Temperature: 22.0 °C

Vertical Approach Angle: 50 deg Humidity: 44.7 %RH

Impact Form ID No.: H35 Impact Form Mass: 4.55 kg

Target Location: Left FH1

Additional Description:

Test Results

Impact Velocity: 23.71 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	984.65	76.8	79.4	2.6
HIC 15	984.65	76.8	79.4	2.6
HIC (d)	909.28	76.8	79.4	2.6

3 ms Clip = 86.12 G , Time 1 = 76.68 ms , Time 2 = 79.68 ms

Impact Location on FMH: 28 mm Above Pt. 0 , 17 Left mm Lateral of Pt. 0

Post-Test Comments: No visible damage. Windshield cracked after test

Test Series Performed By: RJ, KR

Recorded By: Approved By:

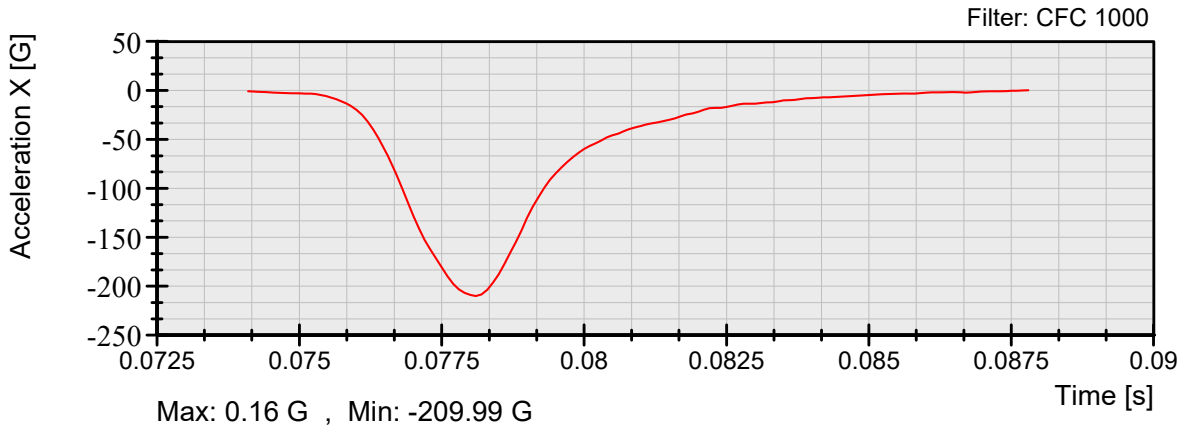
Date: 7/22/2021

mga research corporation

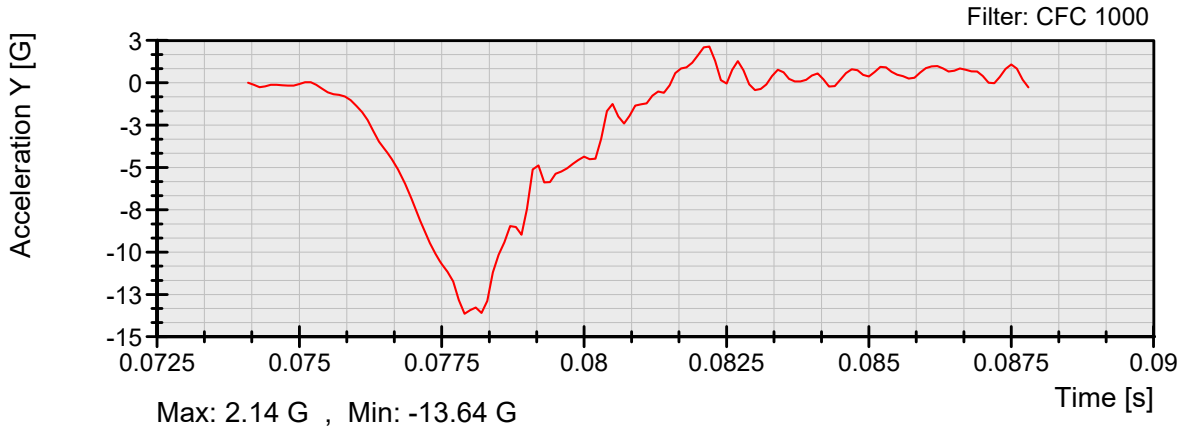
FMVSS 201U

Test No.: U21291
Customer: NHTSA

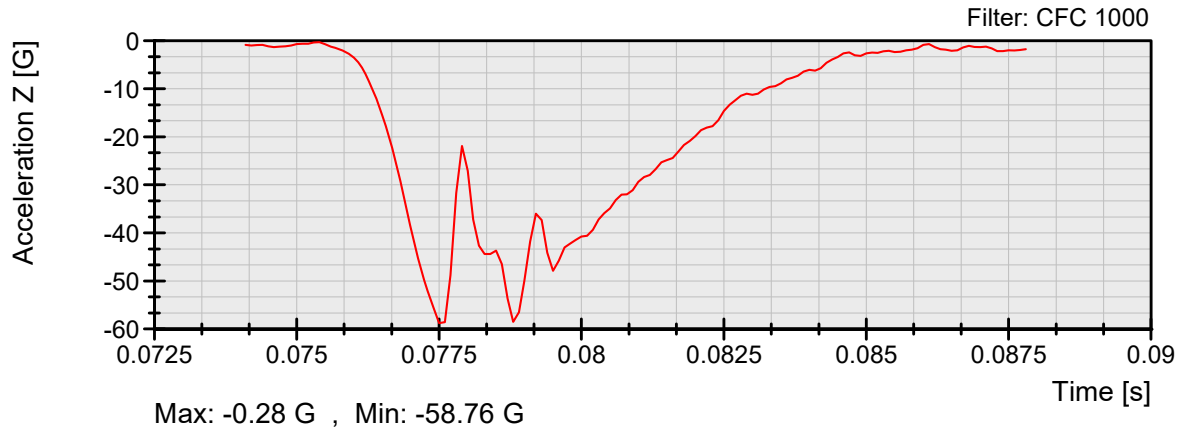
Report No.: G21I7-001.5
Date: 7/22/2021



Max: 0.16 G , Min: -209.99 G



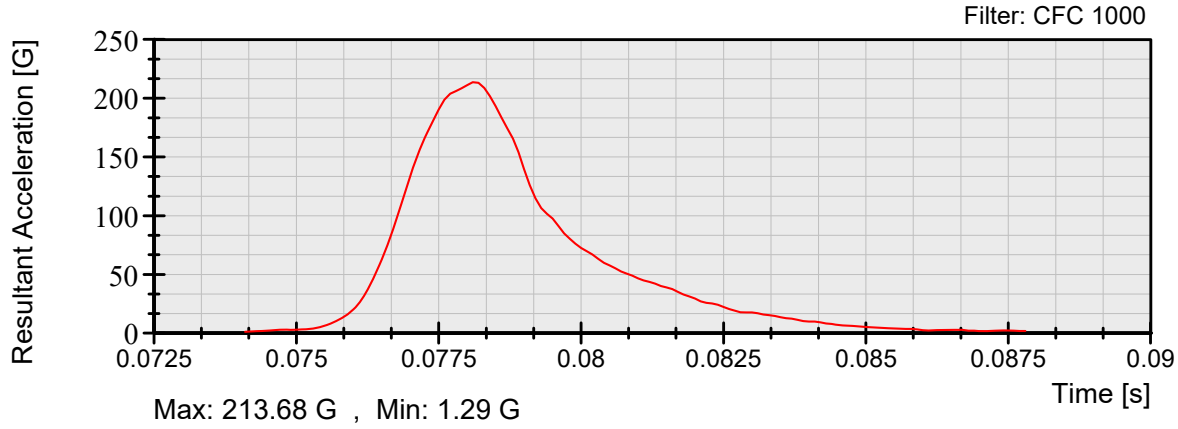
Max: 2.14 G , Min: -13.64 G



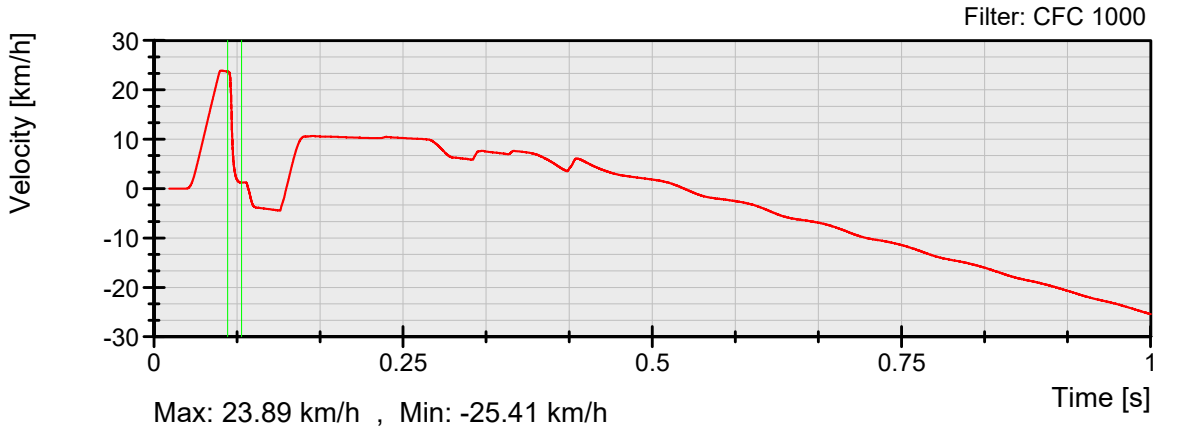
Max: -0.28 G , Min: -58.76 G

mga research corporation

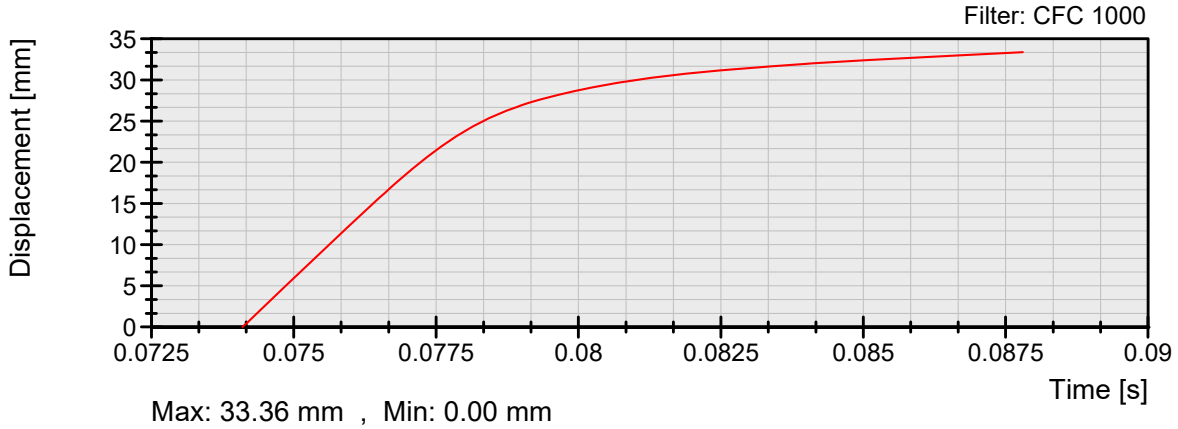
FMVSS 201U
Test No.: U21291
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/22/2021



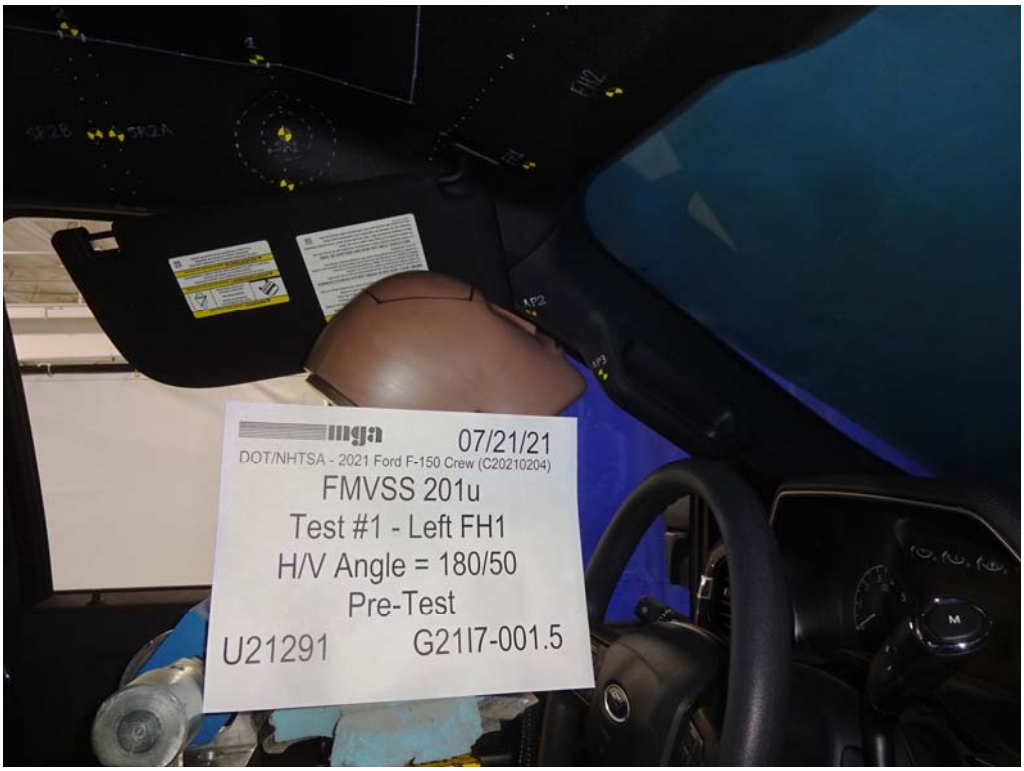
Max: 213.68 G , Min: 1.29 G



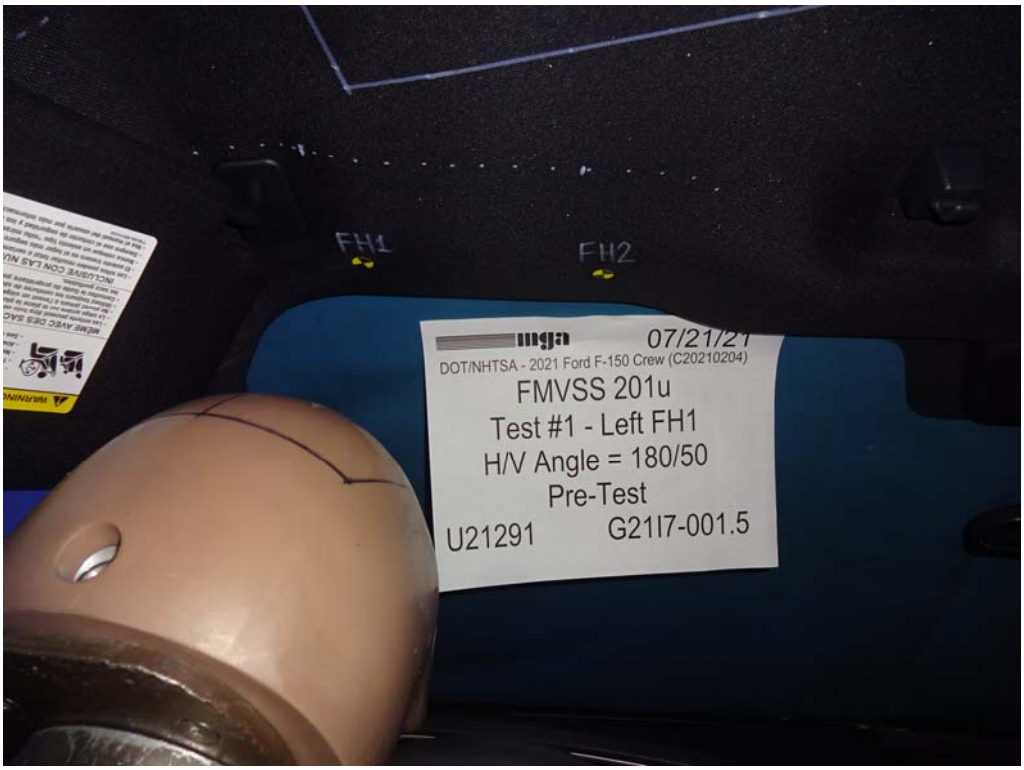
Max: 23.89 km/h , Min: -25.41 km/h



Max: 33.36 mm , Min: 0.00 mm



Pre-Test Photograph No. 1 of Test U21291

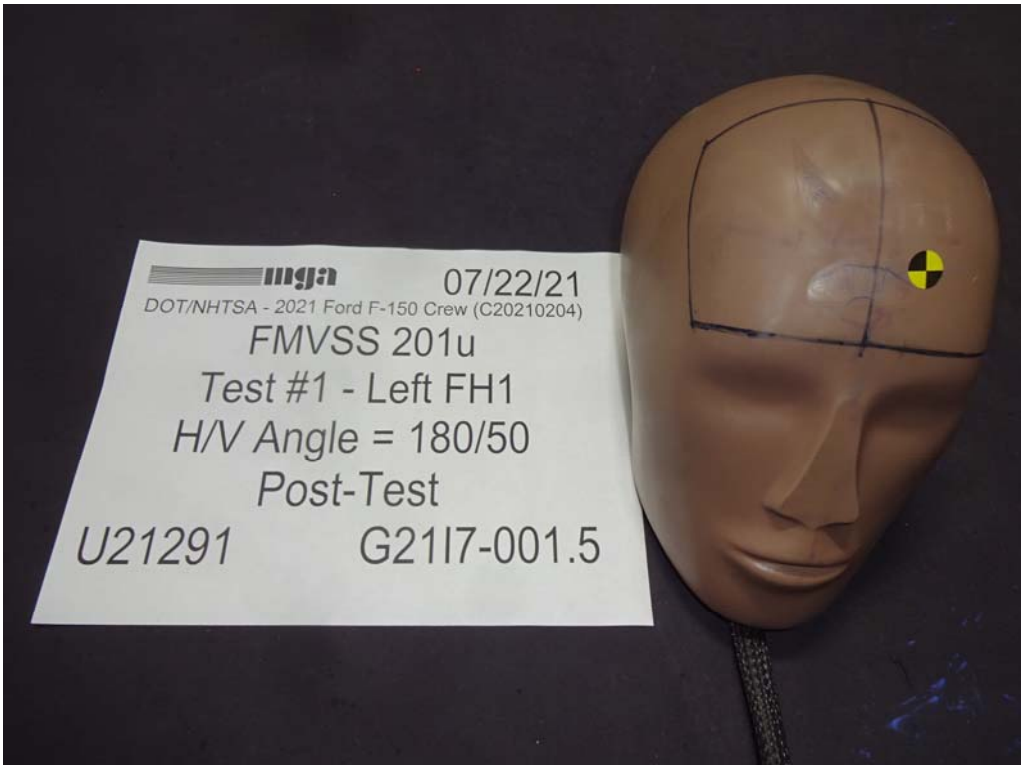


Pre-Test Photograph No. 2 of Test U21291

Post-Test Photograph No. 1 of Test U21291

Post-Test Photograph No. 2 of Test U21291

Post-Test Photograph No. 3 of Test U21291



Post-Test Photograph No. 4 of Test U21291

Test U21297 Data

mga research corporation

FMVSS 201U
Test No.: U21297 Report No.: G21I7-001.5
Customer: NHTSA Date: 7/23/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 7 Time: 10:00:38

Horizontal Approach Angle: 0 deg Temperature: 21.0 °C

Vertical Approach Angle: 24 deg Humidity: 41.4 %RH

Impact Form ID No.: H35 Impact Form Mass: 4.55 kg

Target Location: Right RH

Additional Description:

Test Results

Impact Velocity: 23.39 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	625.06	75.2	83.6	8.4
HIC 15	625.06	75.2	83.6	8.4
HIC (d)	637.98	75.2	83.6	8.4

3 ms Clip = 100.37 G , Time 1 = 78.23 ms , Time 2 = 81.23 ms

Impact Location on FMH: 19 mm Above Pt. 0 , 1 Right mm Lateral of Pt. 0

Post-Test Comments: No visible damage.

Test Series Performed By: DB

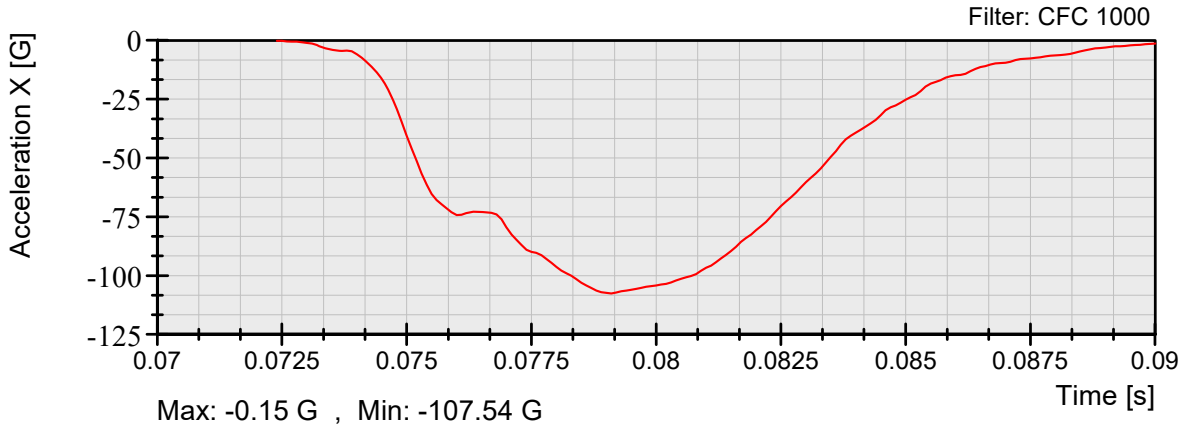
Recorded By: Approved By:

Date: 7/23/2021

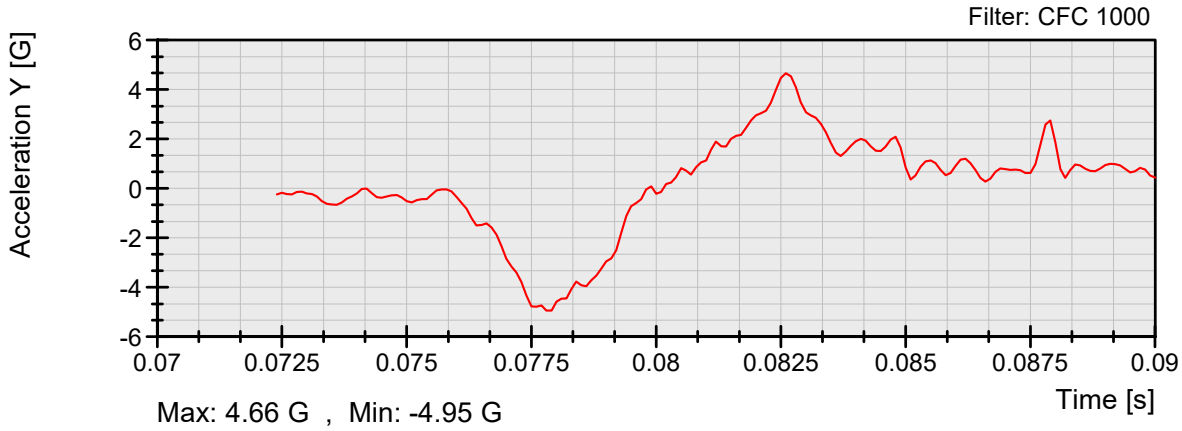
mga research corporation

FMVSS 201U

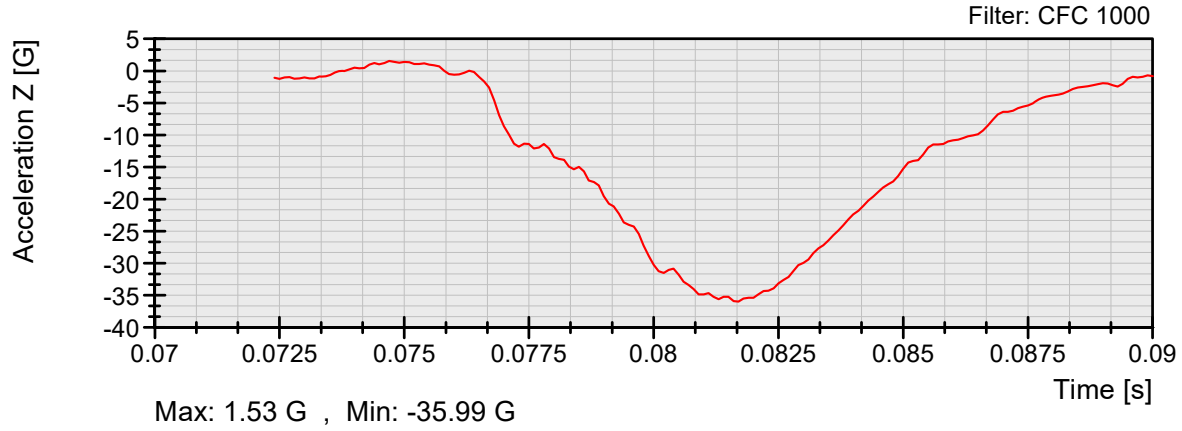
Test No.: U21297
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/23/2021



Max: -0.15 G , Min: -107.54 G



Max: 4.66 G , Min: -4.95 G

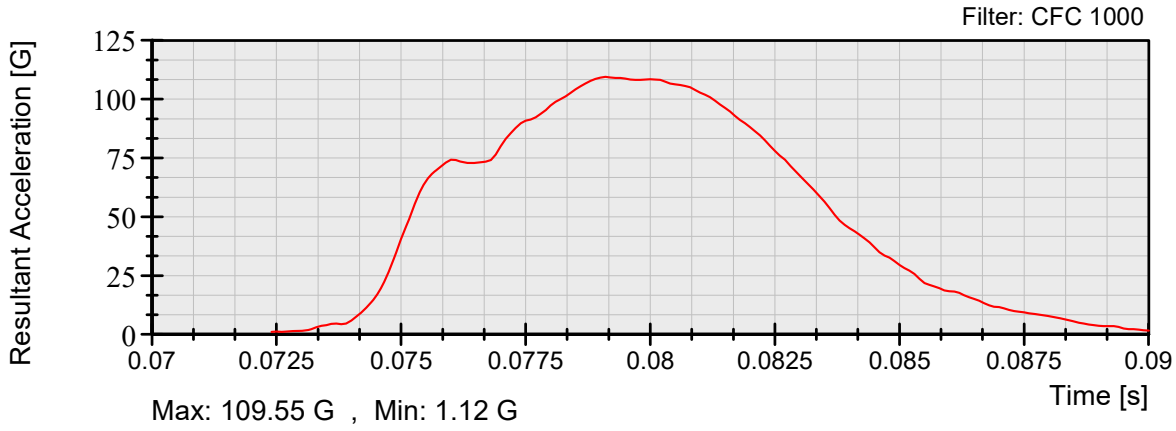


Max: 1.53 G , Min: -35.99 G

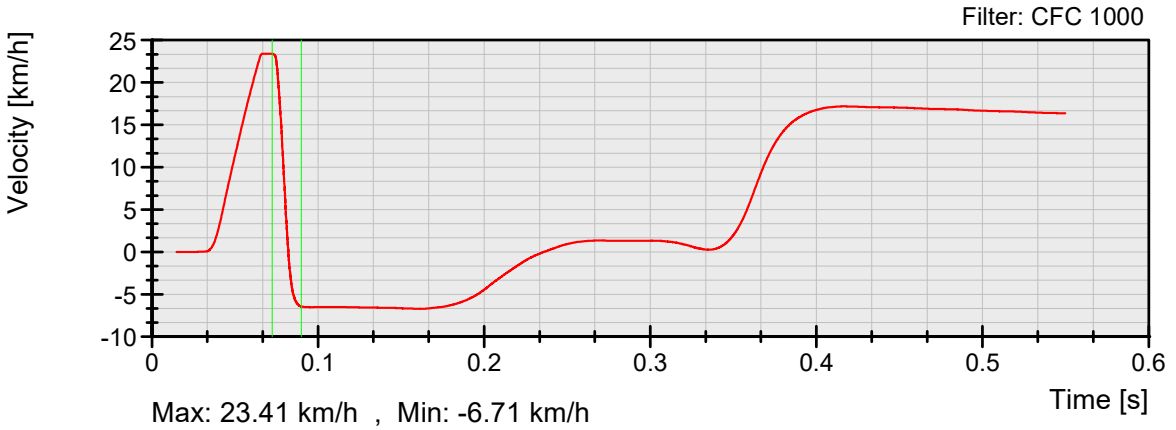
mga research corporation

FMVSS 201U

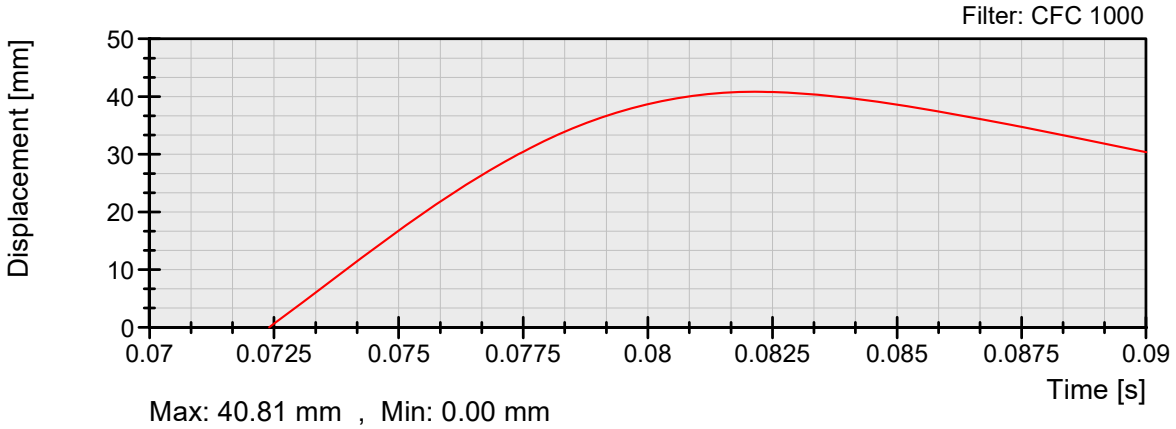
Test No.: U21297
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/23/2021



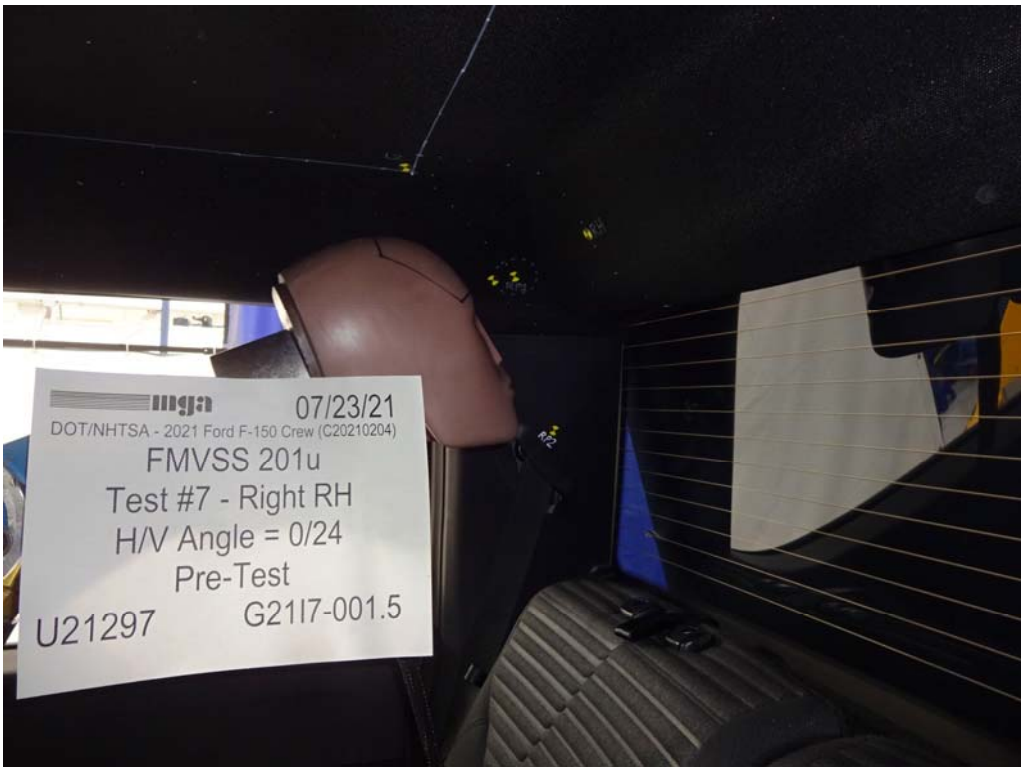
Max: 109.55 G , Min: 1.12 G



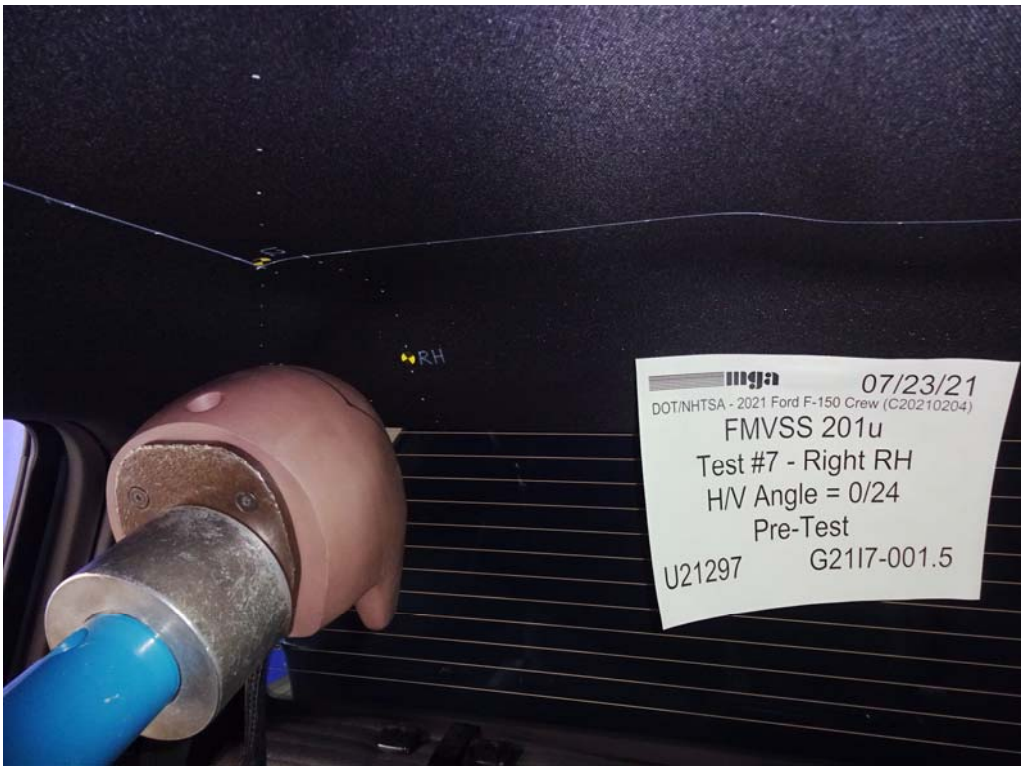
Max: 23.41 km/h , Min: -6.71 km/h



Max: 40.81 mm , Min: 0.00 mm

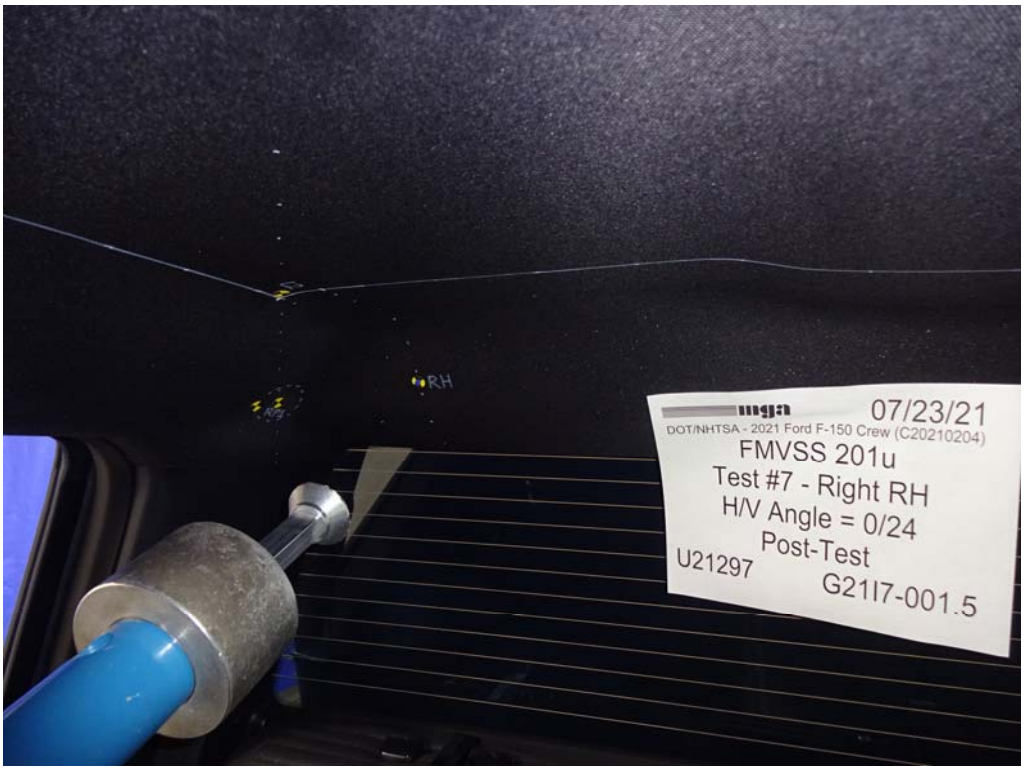


Pre-Test Photograph No. 1 of Test U21297

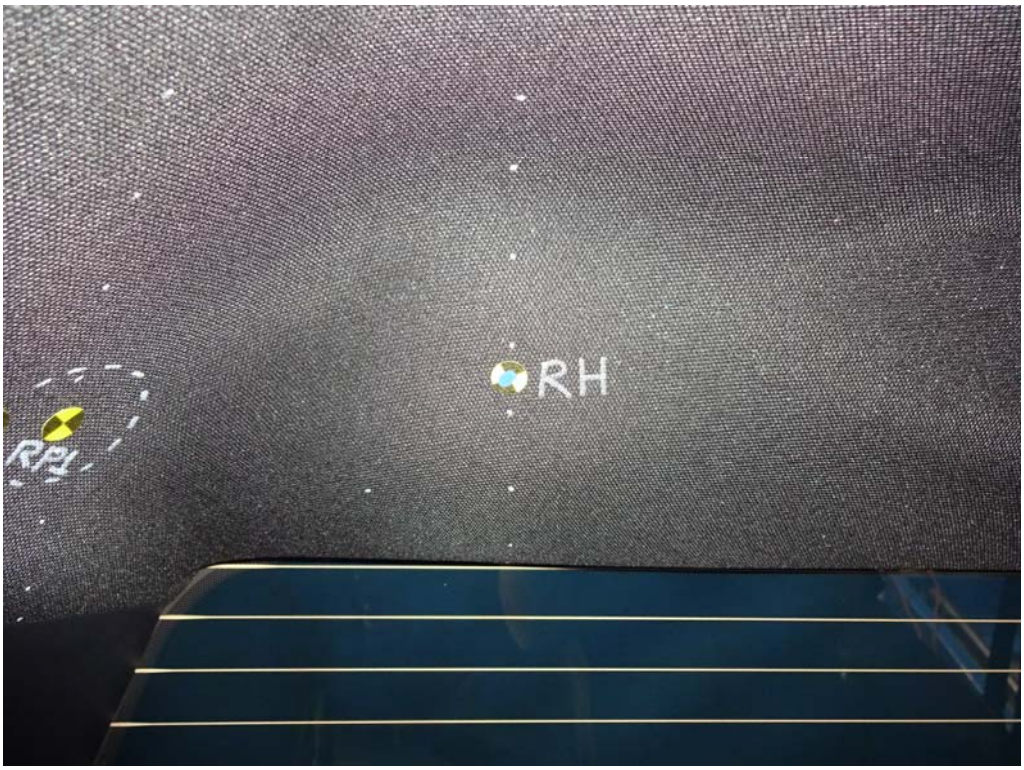


Pre-Test Photograph No. 2 of Test U21297

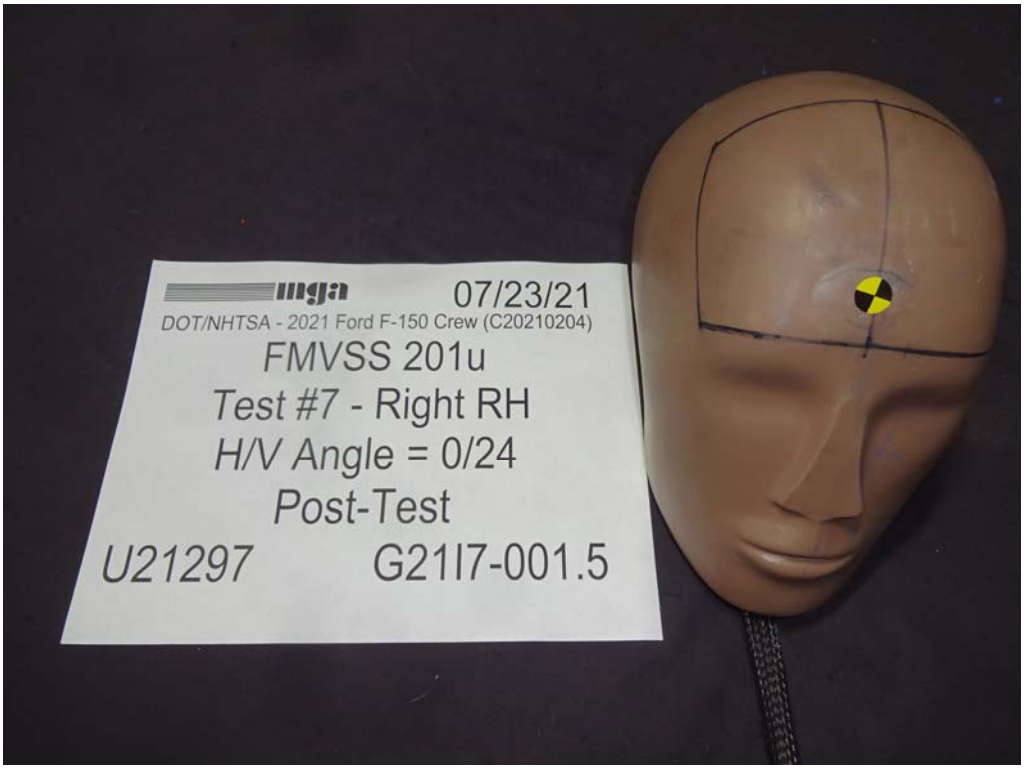
Post-Test Photograph No. 1 of Test U21297



Post-Test Photograph No. 2 of Test U21297



Post-Test Photograph No. 3 of Test U21297



Post-Test Photograph No. 4 of Test U21297

Test U21296 Data

mga research corporation

FMVSS 201U

Test No.: U21296 Report No.: G21I7-001.5

Customer: NHTSA Date: 7/22/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 6 Time: 16:48:44

Horizontal Approach Angle: 270 deg Temperature: 21.0 °C

Vertical Approach Angle: -3 deg Humidity: 41.4 %RH

Impact Form ID No.: H38 Impact Form Mass: 4.55 kg

Target Location: RP2

Additional Description:

Test Results

Impact Velocity: 23.94 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	702.15	77	83.7	6.7
HIC 15	702.15	77	83.7	6.7
HIC (d)	696.15	77	83.7	6.7

3 ms Clip = 105.46 G , Time 1 = 78.97 ms , Time 2 = 81.97 ms

Impact Location on FMH: 22 mm Above Pt. 0 , 9 Left mm Lateral of Pt. 0

Post-Test Comments: No visible damage.

Test Series Performed By: RJ, KR

Recorded By: Approved By:

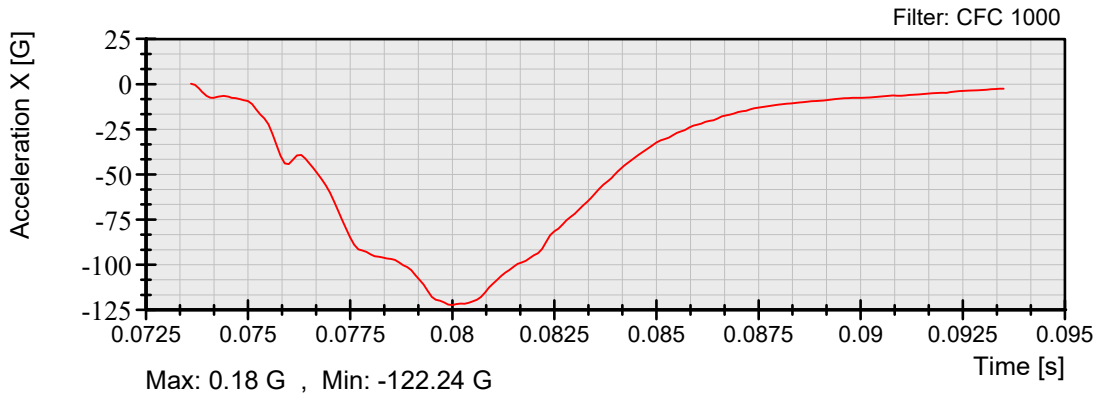
Date: 7/22/2021

mga research corporation

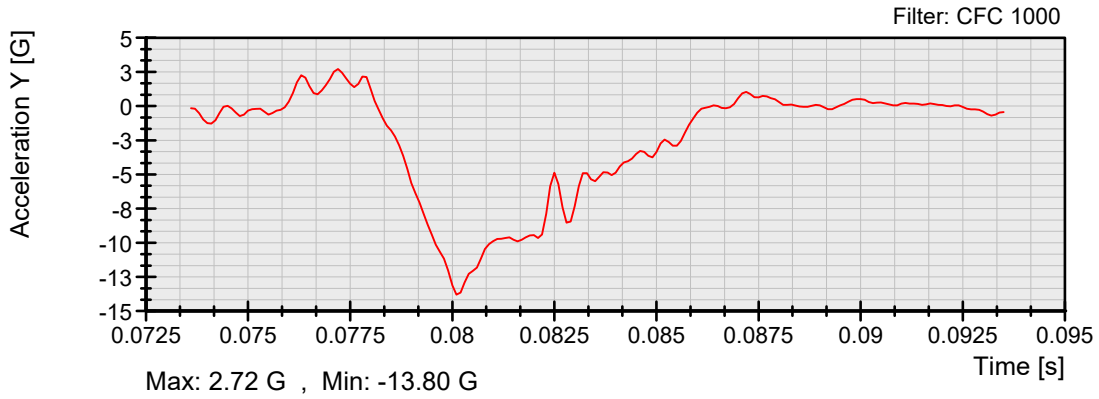
FMVSS 201U

Test No.: U21296 Report No.: G21I7-001.5

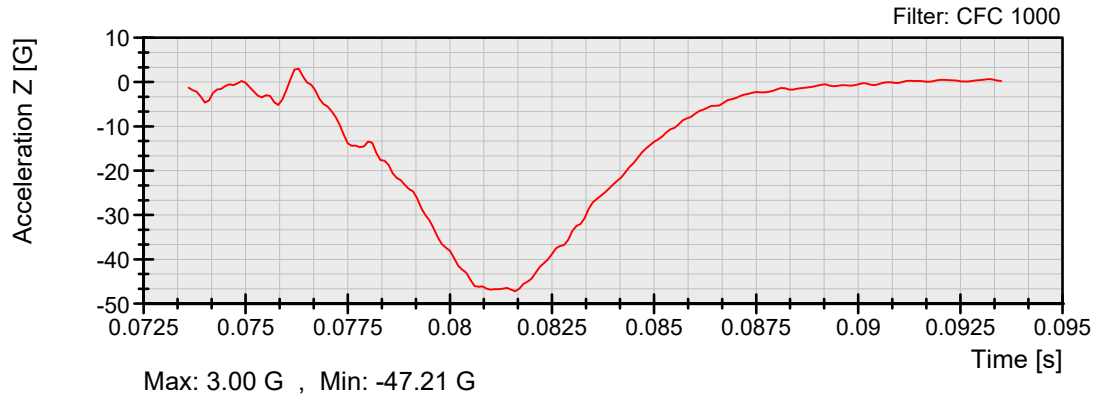
Customer: NHTSA Date: 7/22/2021



Max: 0.18 G , Min: -122.24 G



Max: 2.72 G , Min: -13.80 G



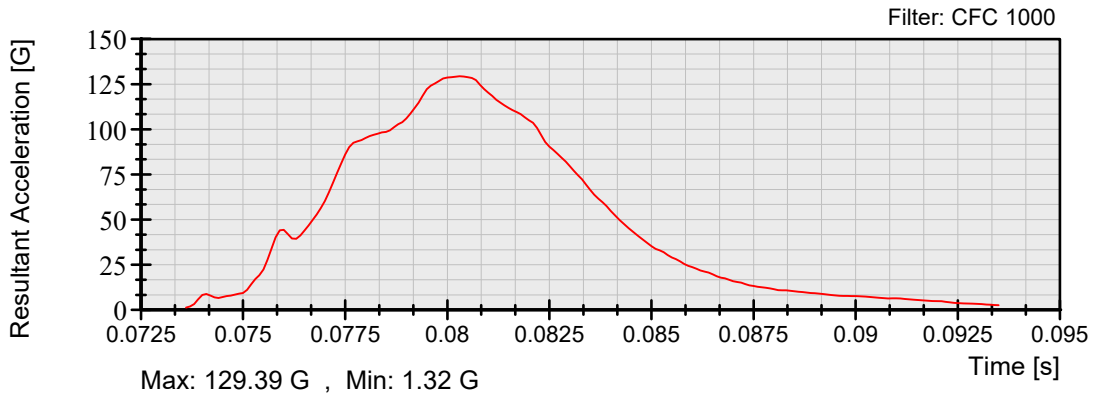
Max: 3.00 G , Min: -47.21 G

mga research corporation

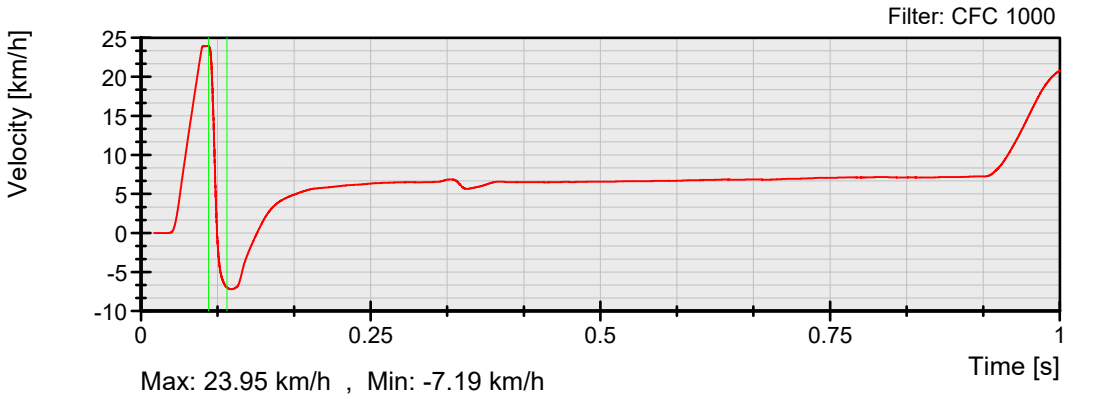
FMVSS 201U

Test No.: U21296 Report No.: G21I7-001.5

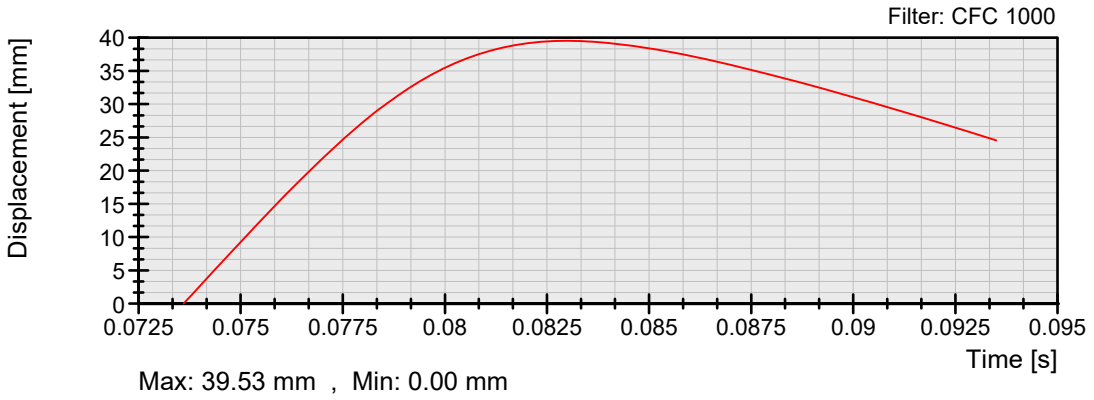
Customer: NHTSA Date: 7/22/2021



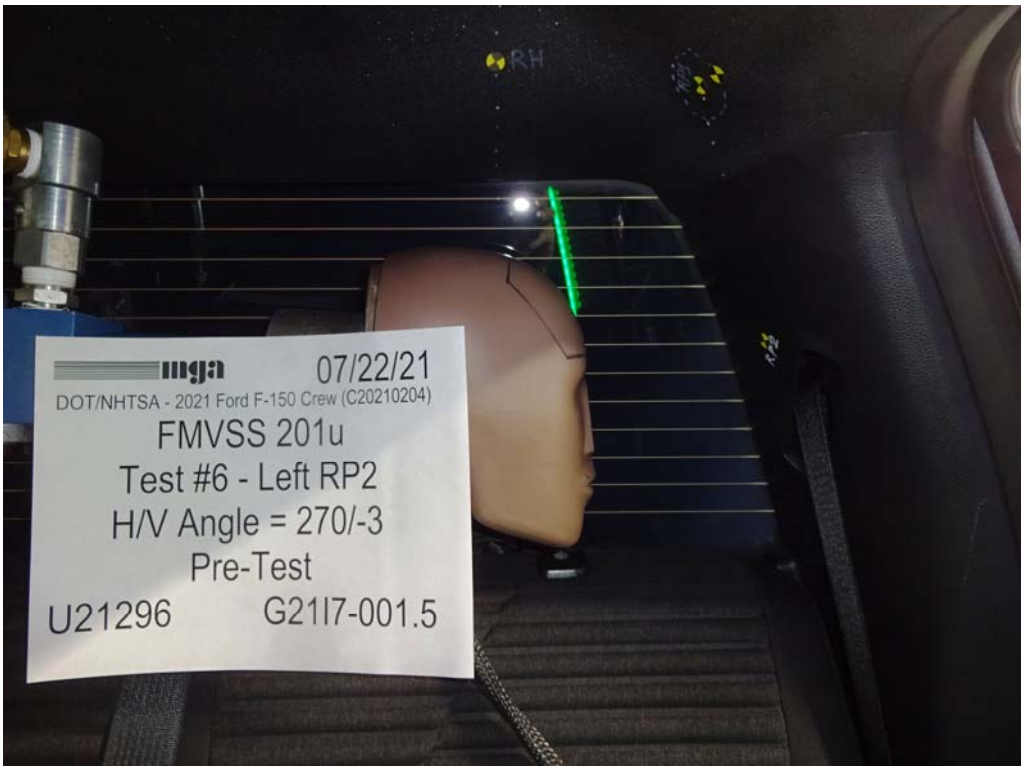
Max: 129.39 G , Min: 1.32 G



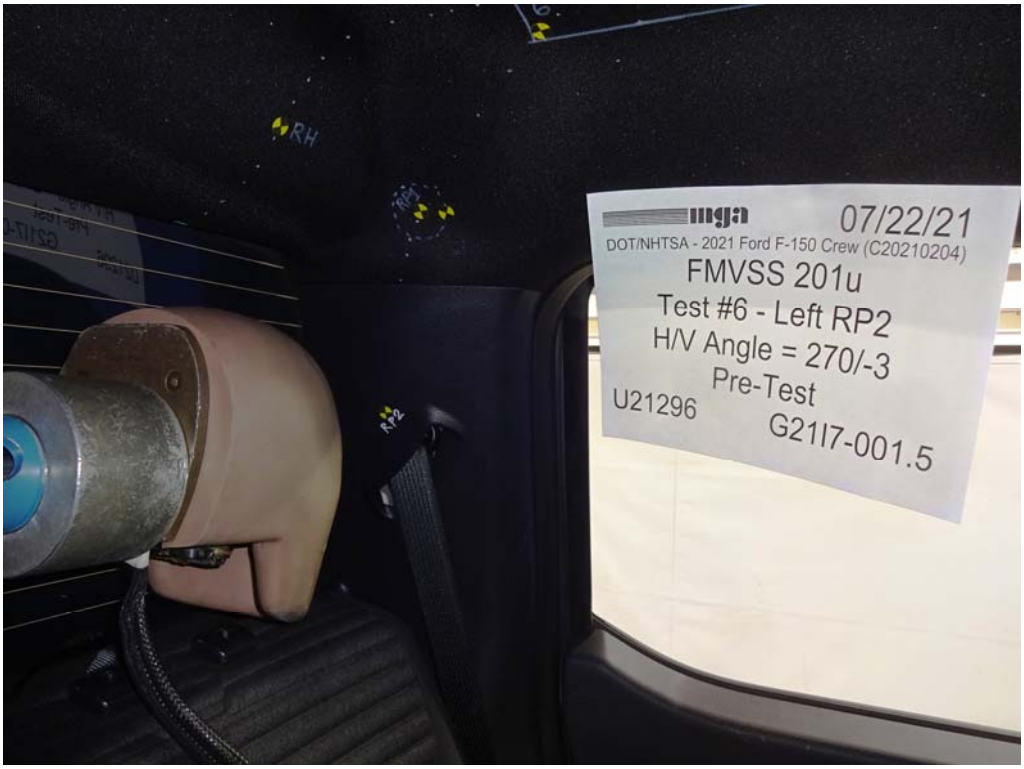
Max: 23.95 km/h , Min: -7.19 km/h



Max: 39.53 mm , Min: 0.00 mm



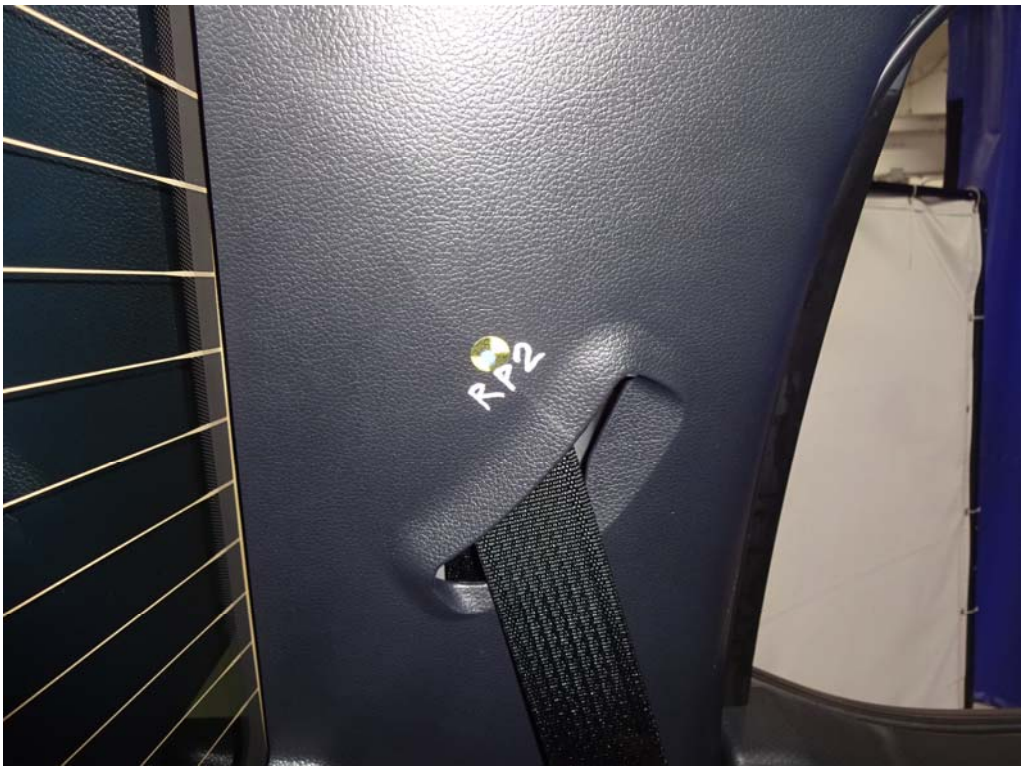
Pre-Test Photograph No. 1 of Test U21296



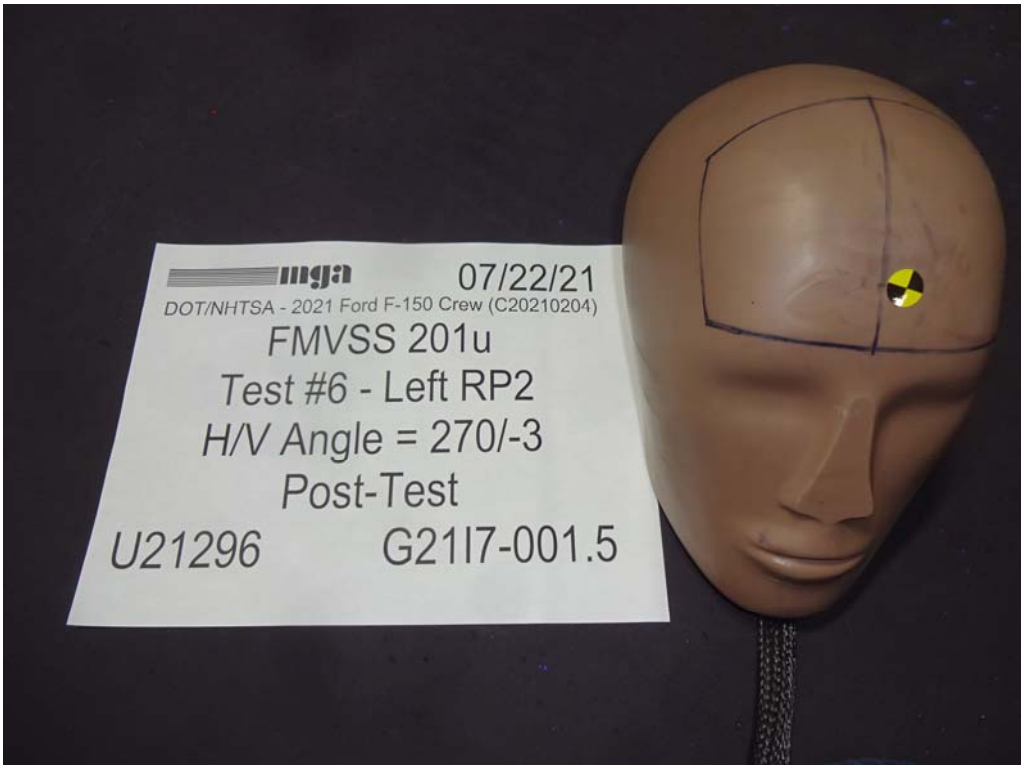
Pre-Test Photograph No. 2 of Test U21296

Post-Test Photograph No. 1 of Test U21296

Post-Test Photograph No. 2 of Test U21296



Post-Test Photograph No. 3 of Test U21296



Post-Test Photograph No. 4 of Test U21296

Test U21293 Data

mga research corporation

FMVSS 201U
Test No.: U21293
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/22/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 3

Time: 11:45:36

Horizontal Approach Angle: 270 deg

Temperature: 21.9 °C

Vertical Approach Angle: 40 deg

Humidity: 42.7 %RH

Impact Form ID No.: H38

Impact Form Mass: 4.55 kg

Target Location: Left SR1

Additional Description:

Test Results

Impact Velocity: 18.96 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	330.79	87.2	93.2	6
HIC 15	330.79	87.2	93.2	6
HIC (d)	415.97	87.2	93.2	6

3 ms Clip = 66.22 G , Time 1 = 88.54 ms , Time 2 = 91.54 ms

Impact Location on FMH: 19 mm Above Pt. 0 , 4 Right mm Lateral of Pt. 0

Post-Test Comments: No visible damage

Test Series Performed By: RJ, KR

Recorded By: [signature]

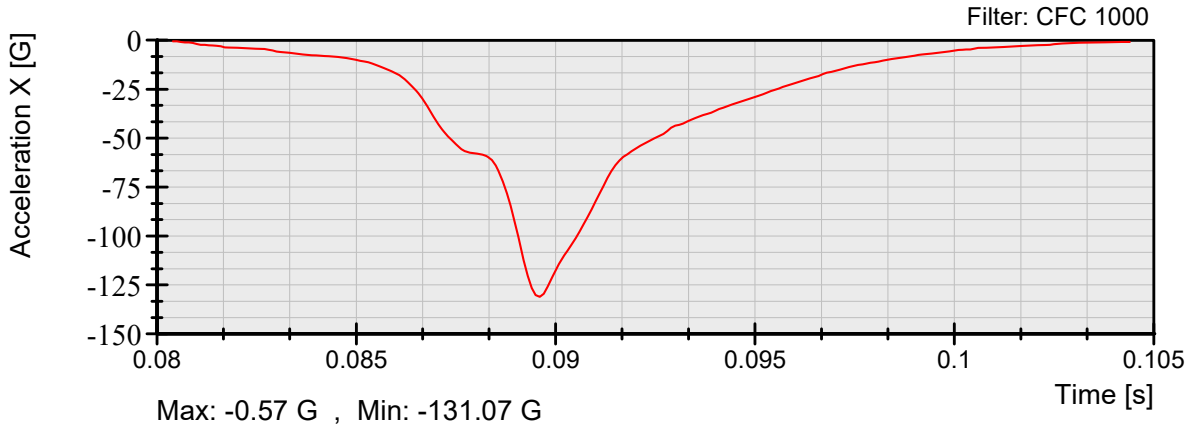
Approved By: [signature]

Date: 7/22/2021

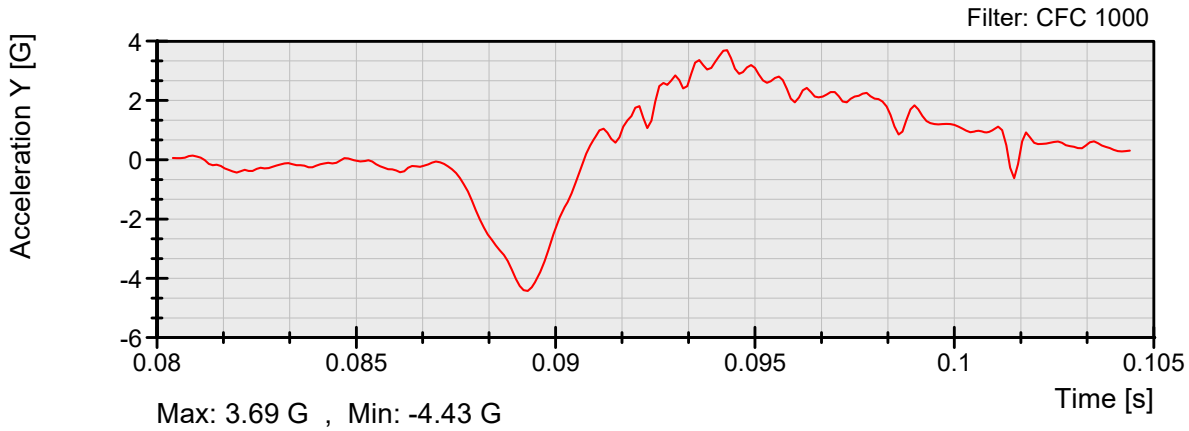
mga research corporation

FMVSS 201U

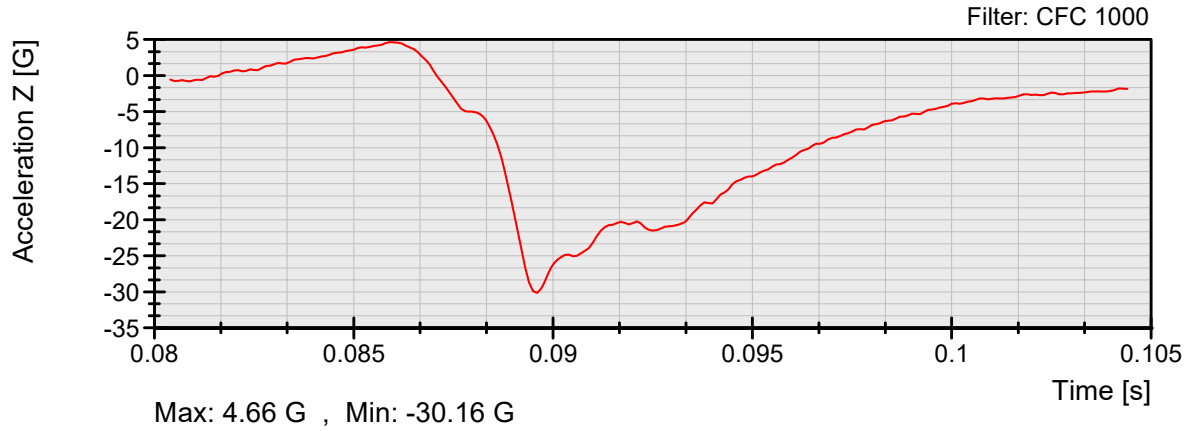
Test No.: U21293
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/22/2021



Max: -0.57 G , Min: -131.07 G



Max: 3.69 G , Min: -4.43 G

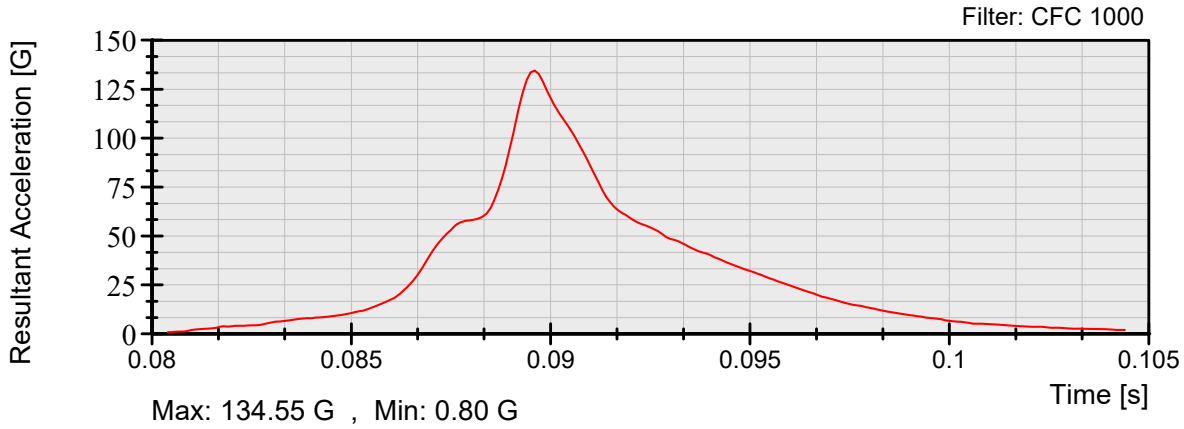


Max: 4.66 G , Min: -30.16 G

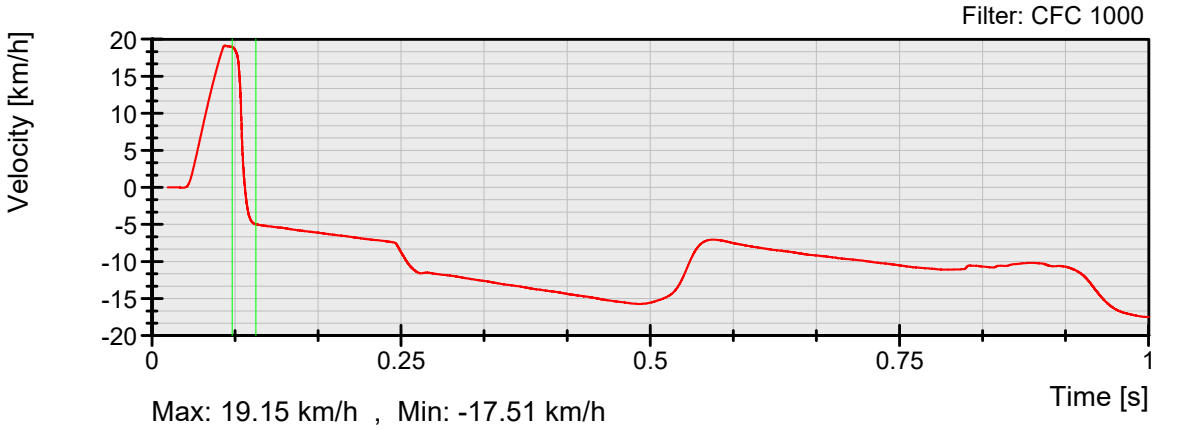
mga research corporation

FMVSS 201U

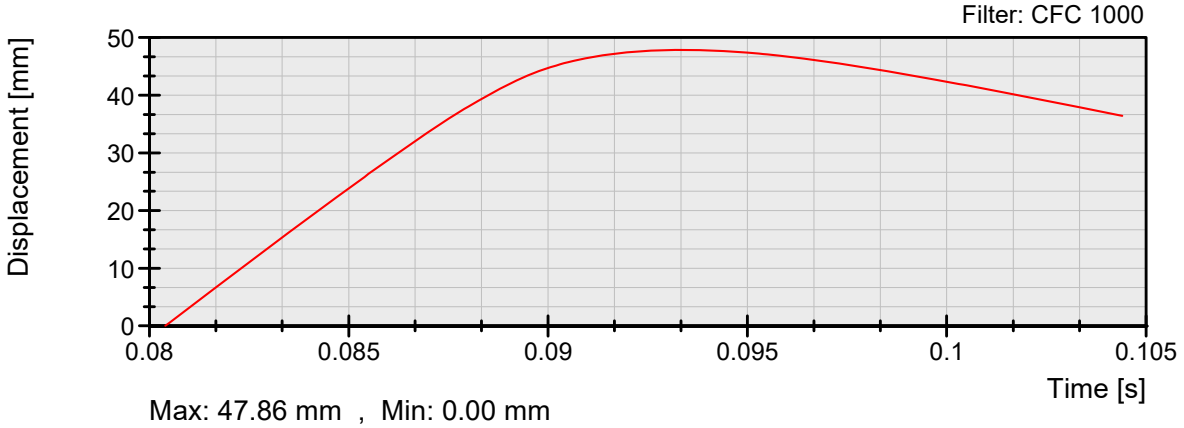
Test No.: U21293
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/22/2021



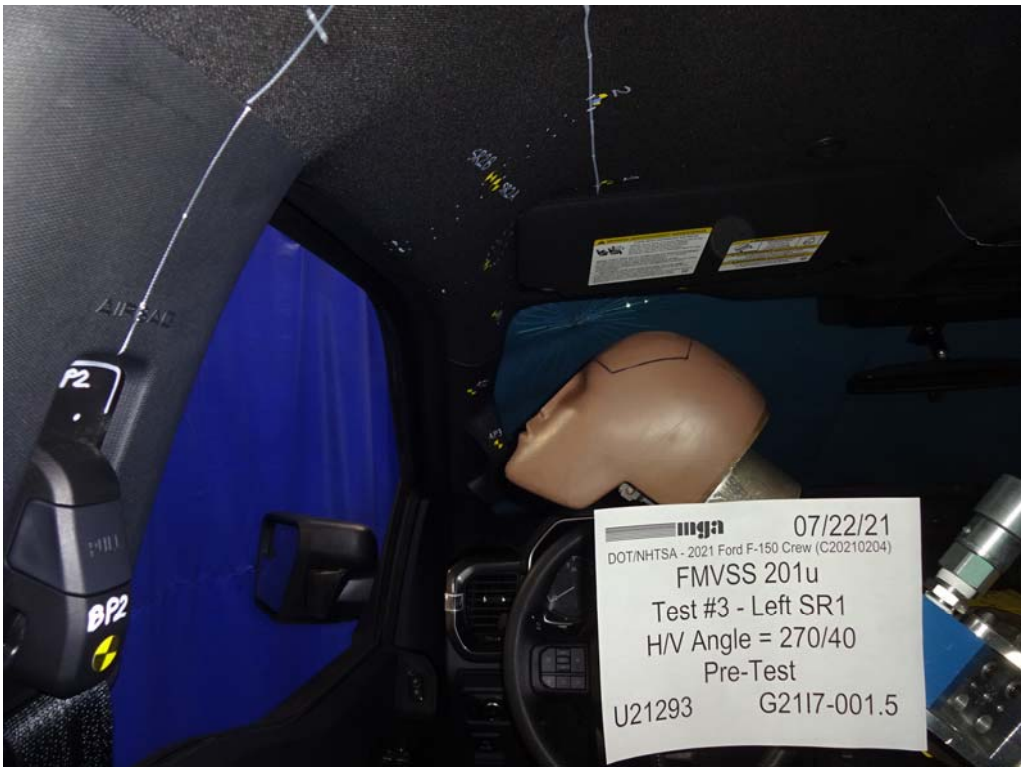
Max: 134.55 G , Min: 0.80 G



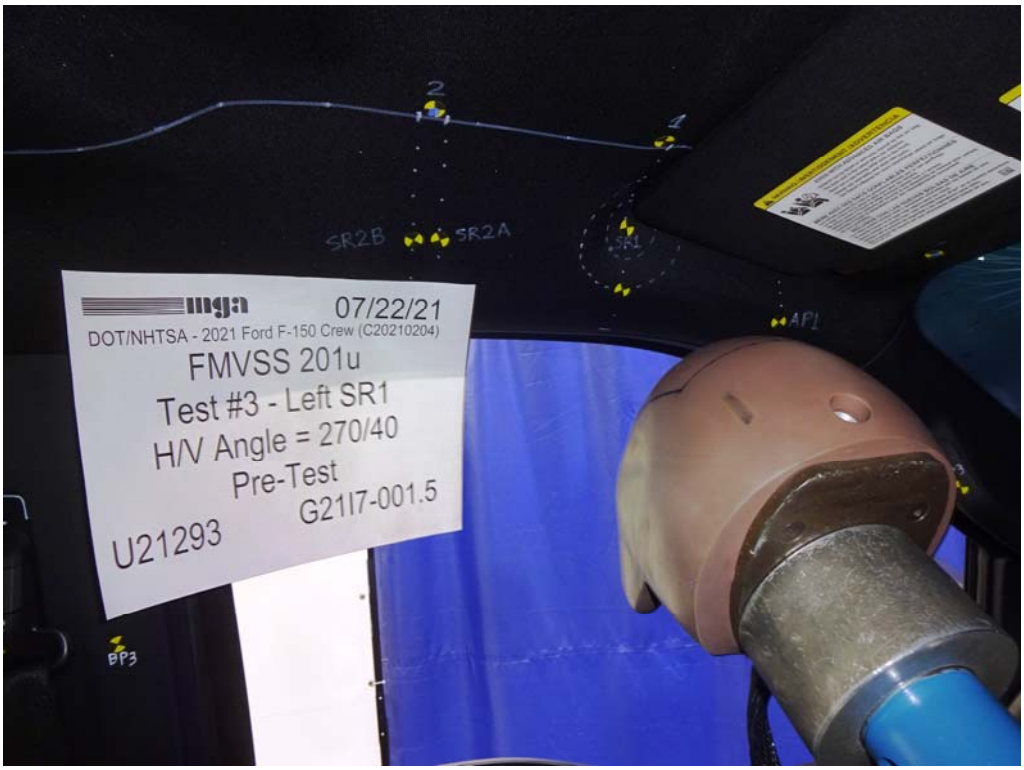
Max: 19.15 km/h , Min: -17.51 km/h



Max: 47.86 mm , Min: 0.00 mm



Pre-Test Photograph No. 1 of Test U21293

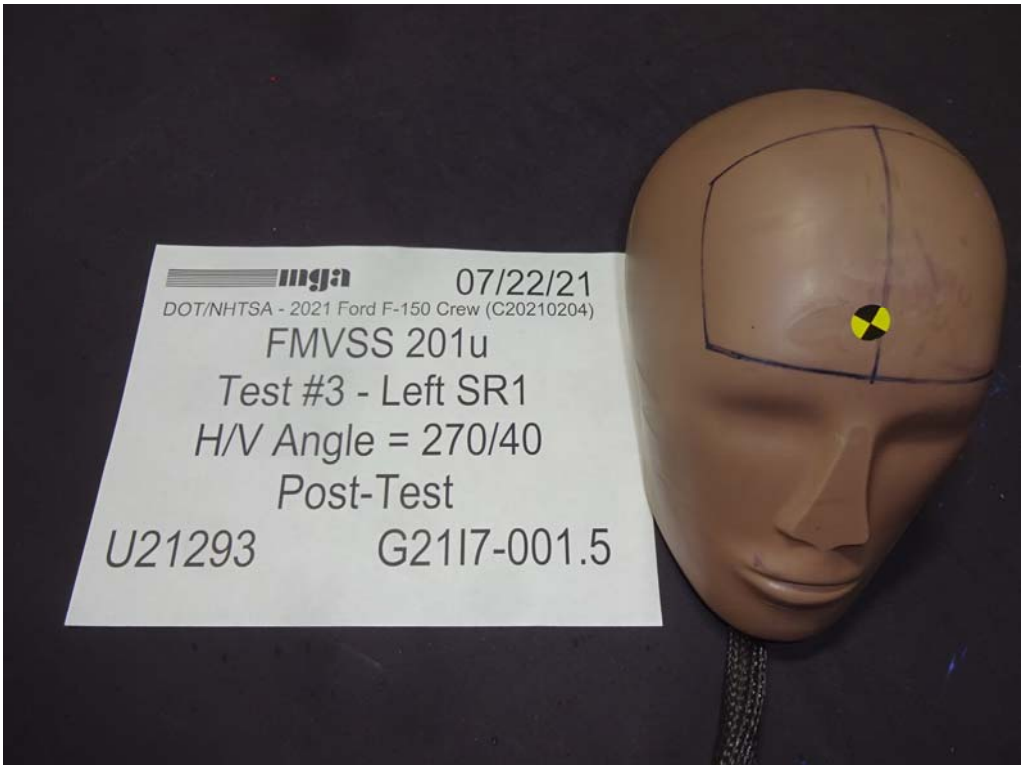


Pre-Test Photograph No. 2 of Test U21293

Post-Test Photograph No. 1 of Test U21293

Post-Test Photograph No. 2 of Test U21293

Post-Test Photograph No. 3 of Test U21293



Post-Test Photograph No. 4 of Test U21293

Test U21300 Data

mga research corporation

FMVSS 201U
Test No.: U21300 Report No.: G21I7-001.5
Customer: NHTSA Date: 7/23/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 10 Time: 15:12:56

Horizontal Approach Angle: 90 deg Temperature: 20.8 °C

Vertical Approach Angle: 40 deg Humidity: 47.7 %RH

Impact Form ID No.: H35 Impact Form Mass: 4.55 kg

Target Location: SR2B

Additional Description:

Test Results

Impact Velocity: 19.34 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	582.67	86	89.4	3.4
HIC 15	582.67	86	89.4	3.4
HIC (d)	606	86	89.4	3.4

3 ms Clip = 86.81 G , Time 1 = 86.11 ms , Time 2 = 89.11 ms

Impact Location on FMH: 19 mm Above Pt. 0 , 2 Left mm Lateral of Pt. 0

Post-Test Comments: No Visible Damage

Test Series Performed By: RJ, KR

Recorded By: Approved By:

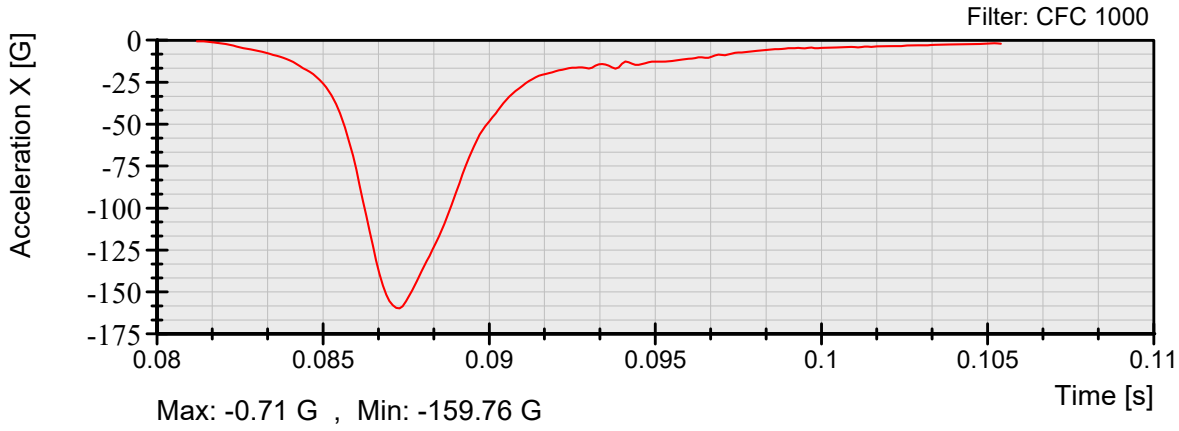
Date: 7/23/2021

mga research corporation

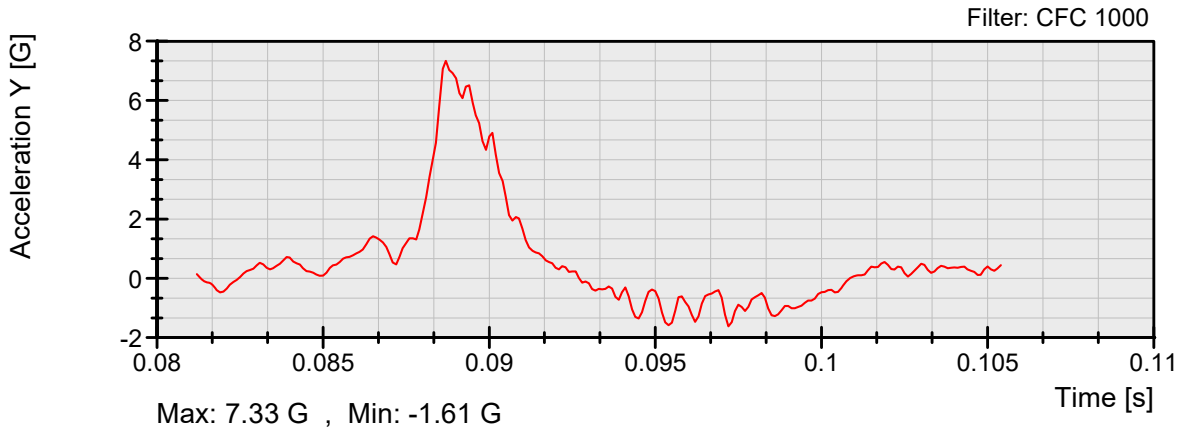
FMVSS 201U

Test No.: U21300
Customer: NHTSA

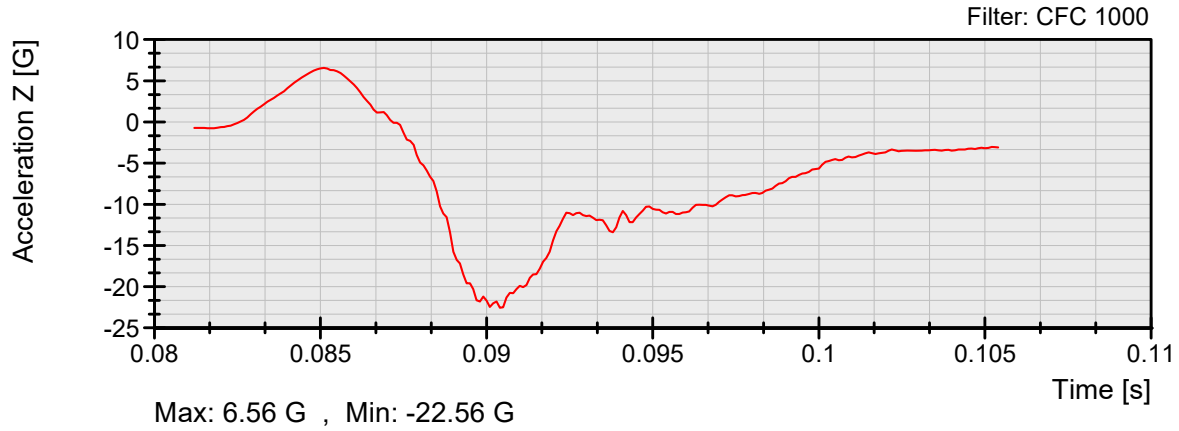
Report No.: G21I7-001.5
Date: 7/23/2021



Max: -0.71 G , Min: -159.76 G



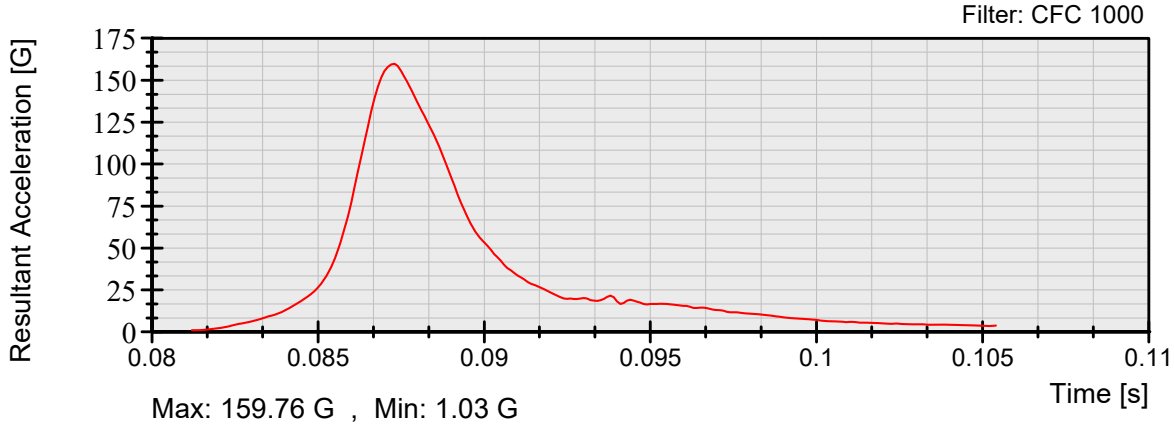
Max: 7.33 G , Min: -1.61 G



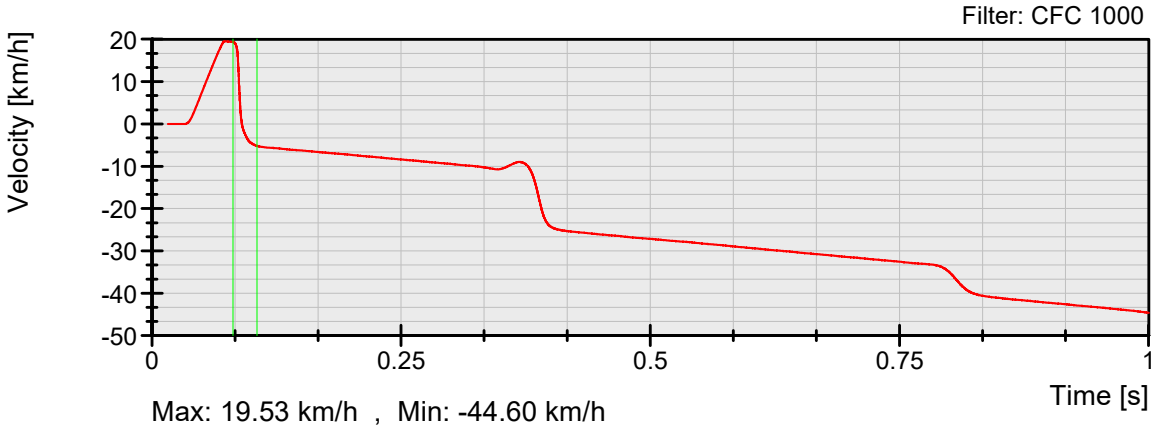
Max: 6.56 G , Min: -22.56 G

mga research corporation

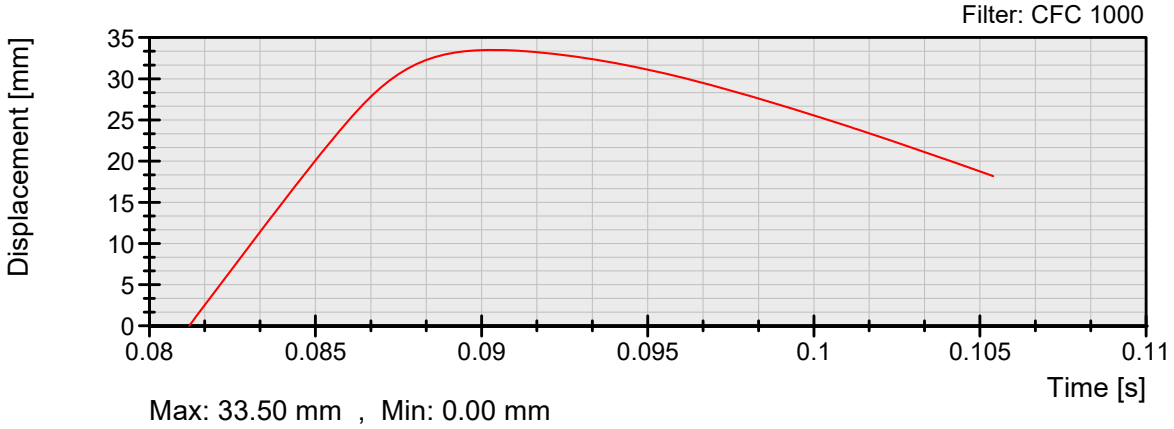
FMVSS 201U
Test No.: U21300
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/23/2021



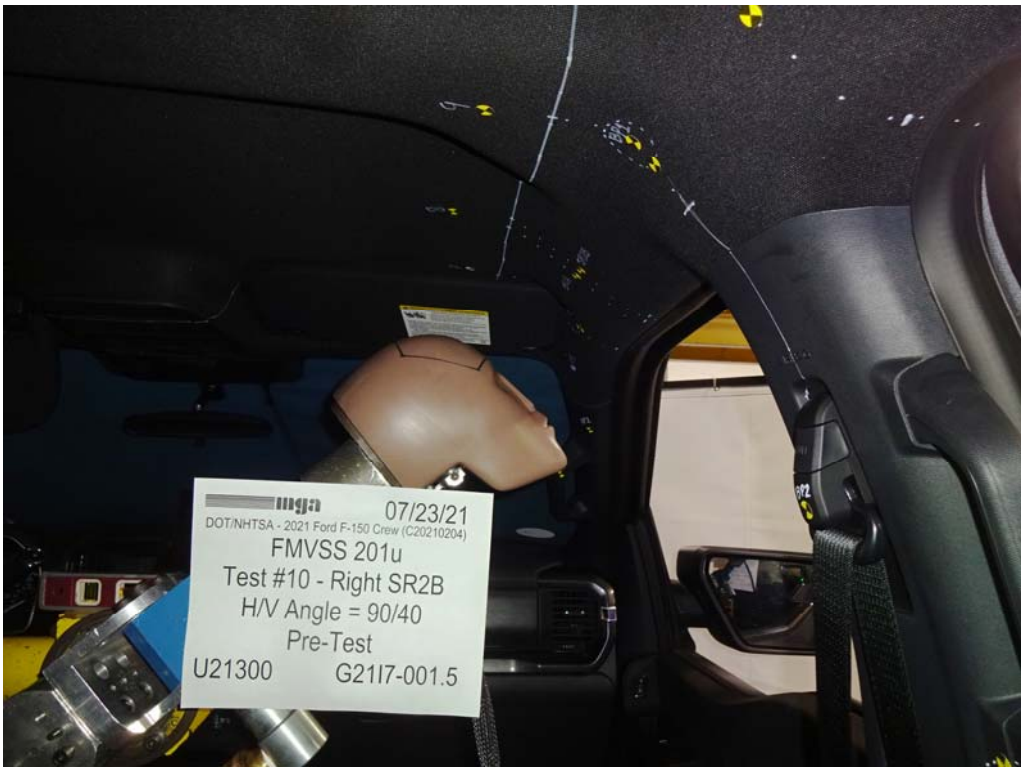
Max: 159.76 G , Min: 1.03 G



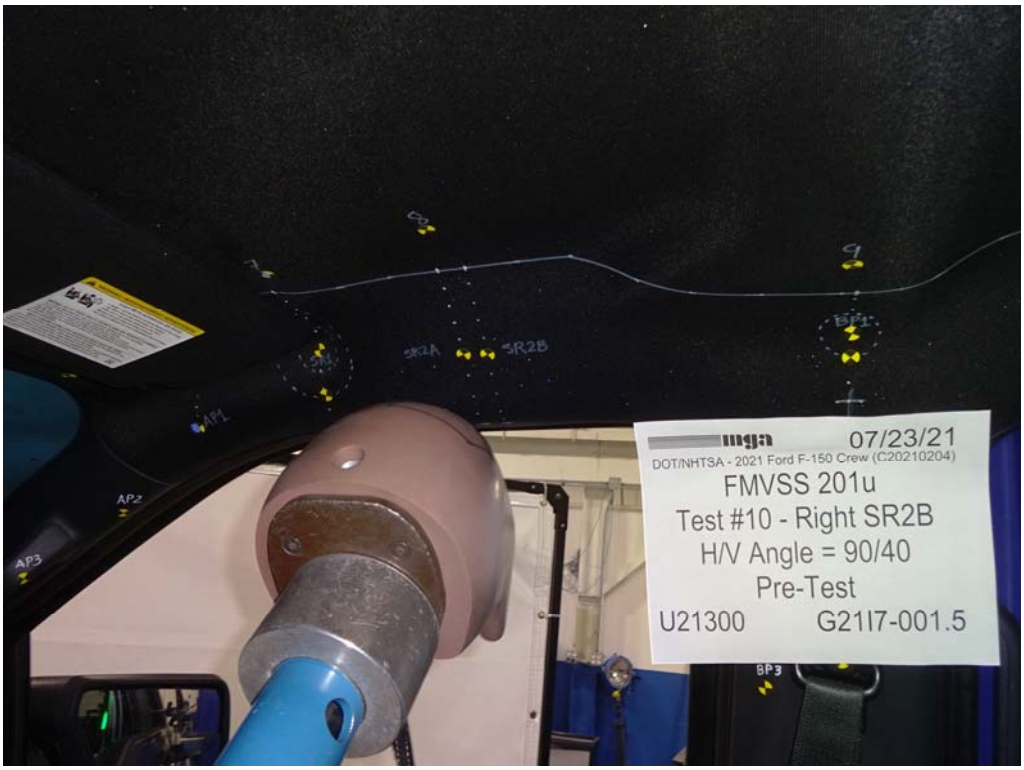
Max: 19.53 km/h , Min: -44.60 km/h



Max: 33.50 mm , Min: 0.00 mm

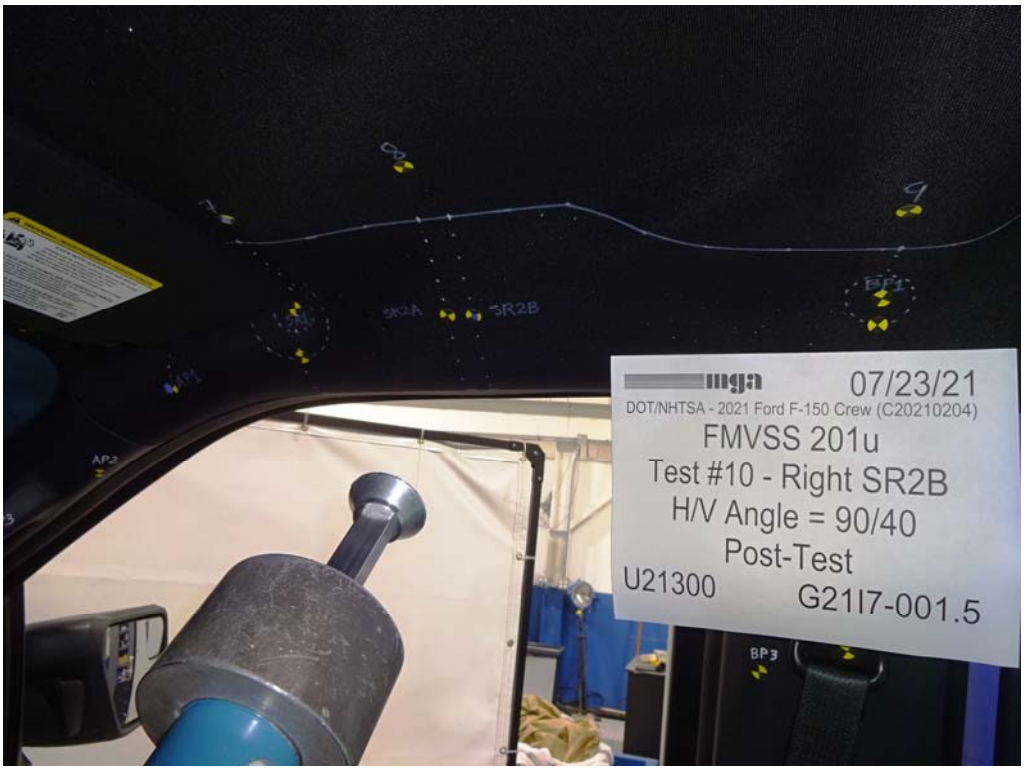


Pre-Test Photograph No. 1 of Test U21300



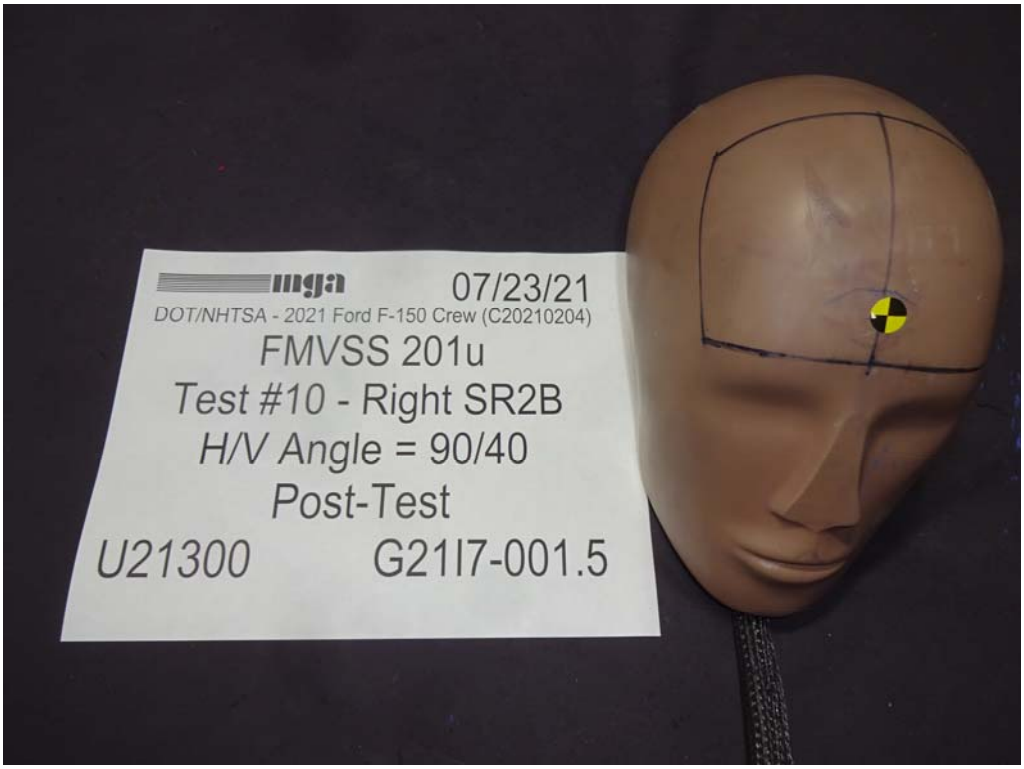
Pre-Test Photograph No. 2 of Test U21300

Post-Test Photograph No. 1 of Test U21300



Post-Test Photograph No. 2 of Test U21300

Post-Test Photograph No. 3 of Test U21300



Post-Test Photograph No. 4 of Test U21300

Test U21292 Data

mga research corporation

FMVSS 201U
Test No.: U21292
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/22/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 2
Time: 11:04:45

Horizontal Approach Angle: 270 deg
Temperature: 21.9 °C

Vertical Approach Angle: 37 deg
Humidity: 43.1 %RH

Impact Form ID No.: H37
Impact Form Mass: 4.58 kg

Target Location: Left UR2 @ SR2

Additional Description:

Test Results

Impact Velocity: 23.37 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	1043.6	81.1	85.1	4
HIC 15	1043.6	81.1	85.1	4
HIC (d)	953.75	81.1	85.1	4

3 ms Clip = 122.22 G , Time 1 = 81.61 ms , Time 2 = 84.61 ms

Impact Location on FMH: 46 mm Above Pt. 0 , 0 mm Lateral of Pt. 0

Post-Test Comments: No visible damage

Test Series Performed By: RJ, KR

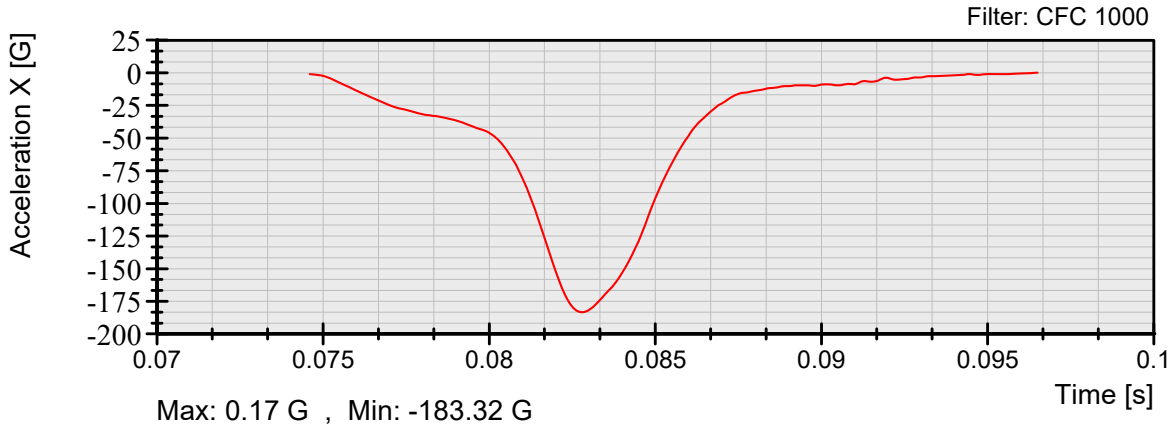
Recorded By: [signature]
Approved By: [signature]

Date: 7/22/2021

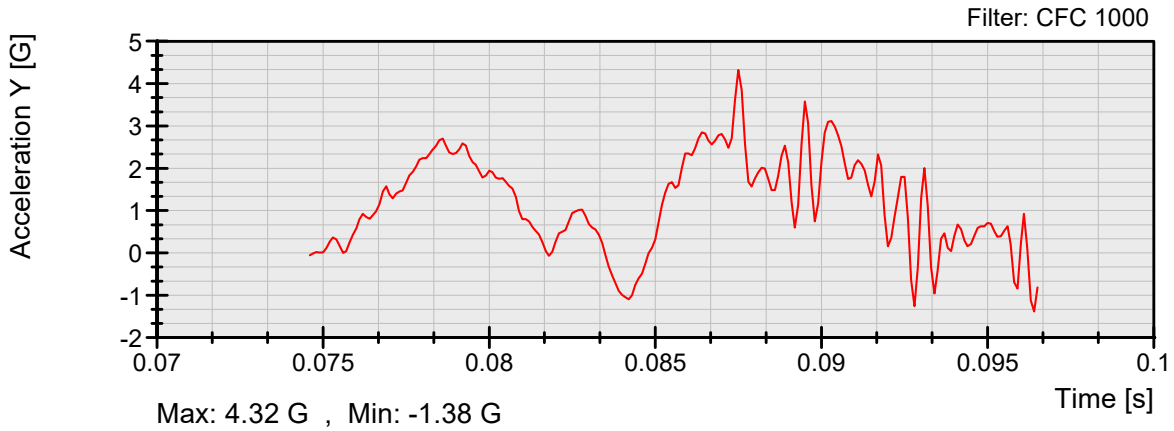
mga research corporation

FMVSS 201U

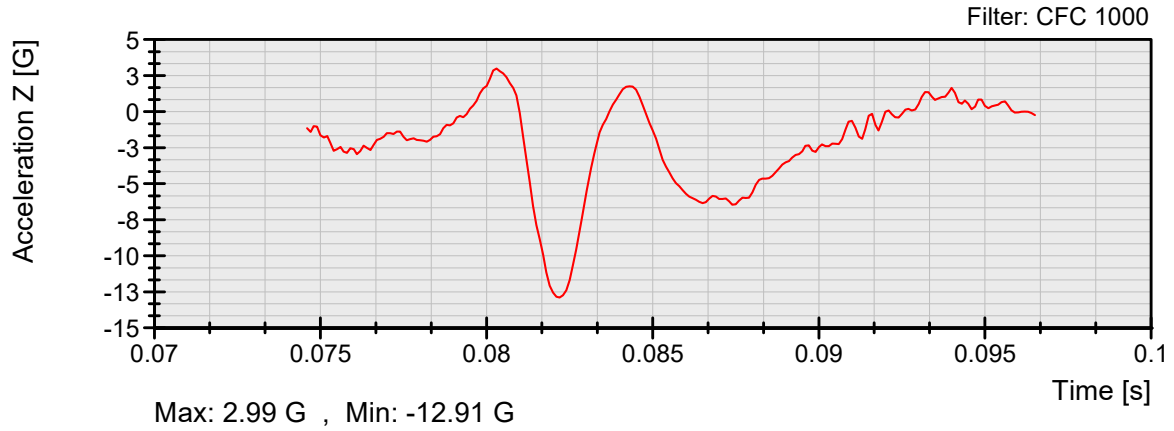
Test No.: U21292
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/22/2021



Max: 0.17 G , Min: -183.32 G



Max: 4.32 G , Min: -1.38 G



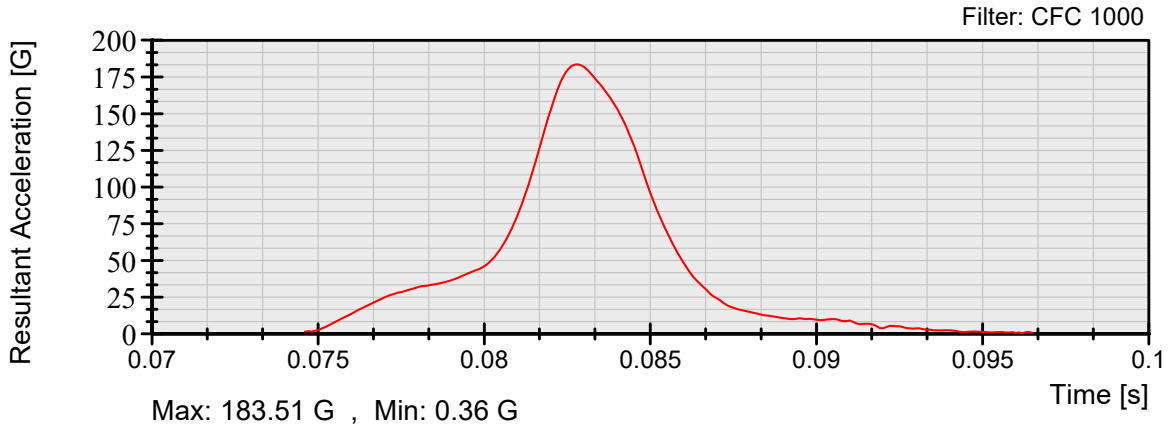
Max: 2.99 G , Min: -12.91 G

mga research corporation

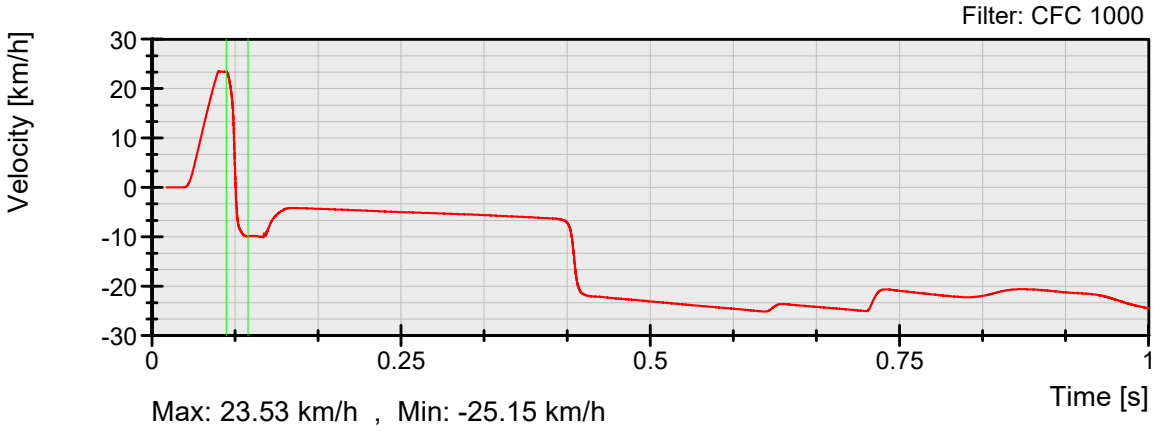
FMVSS 201U

Test No.: U21292
Customer: NHTSA

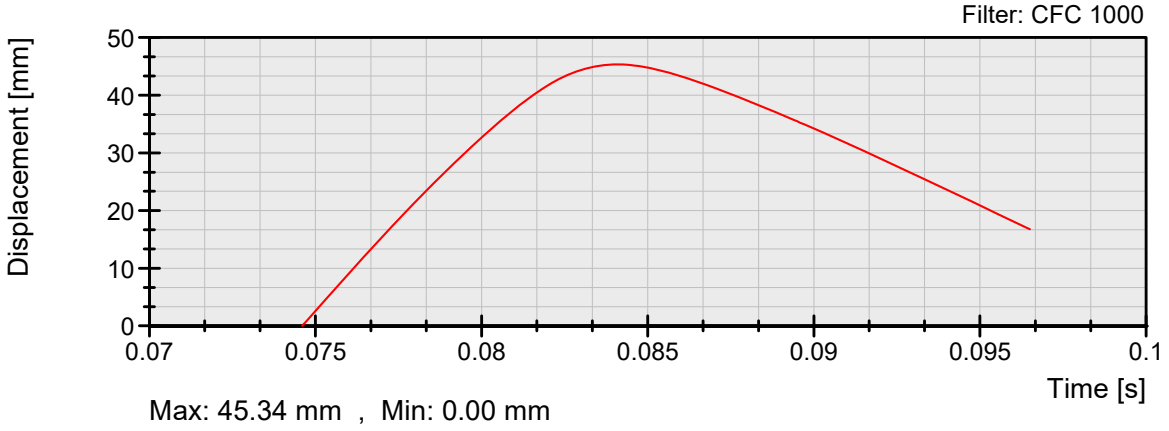
Report No.: G21I7-001.5
Date: 7/22/2021



Max: 183.51 G , Min: 0.36 G



Max: 23.53 km/h , Min: -25.15 km/h

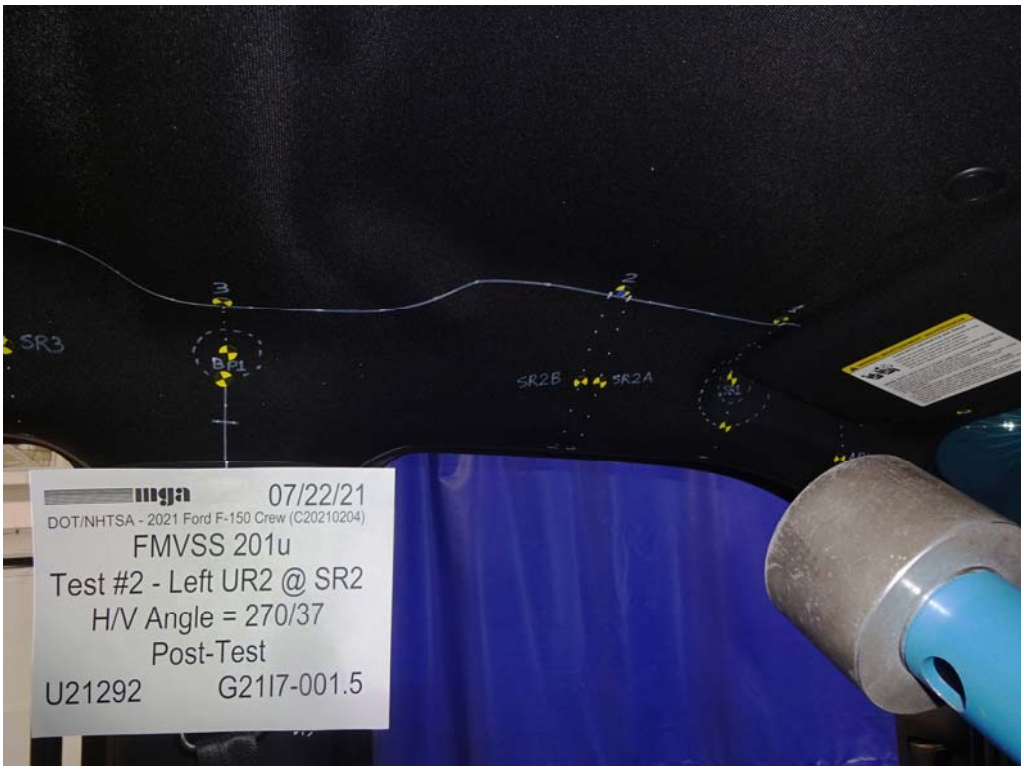


Max: 45.34 mm , Min: 0.00 mm

Pre-Test Photograph No. 1 of Test U21292

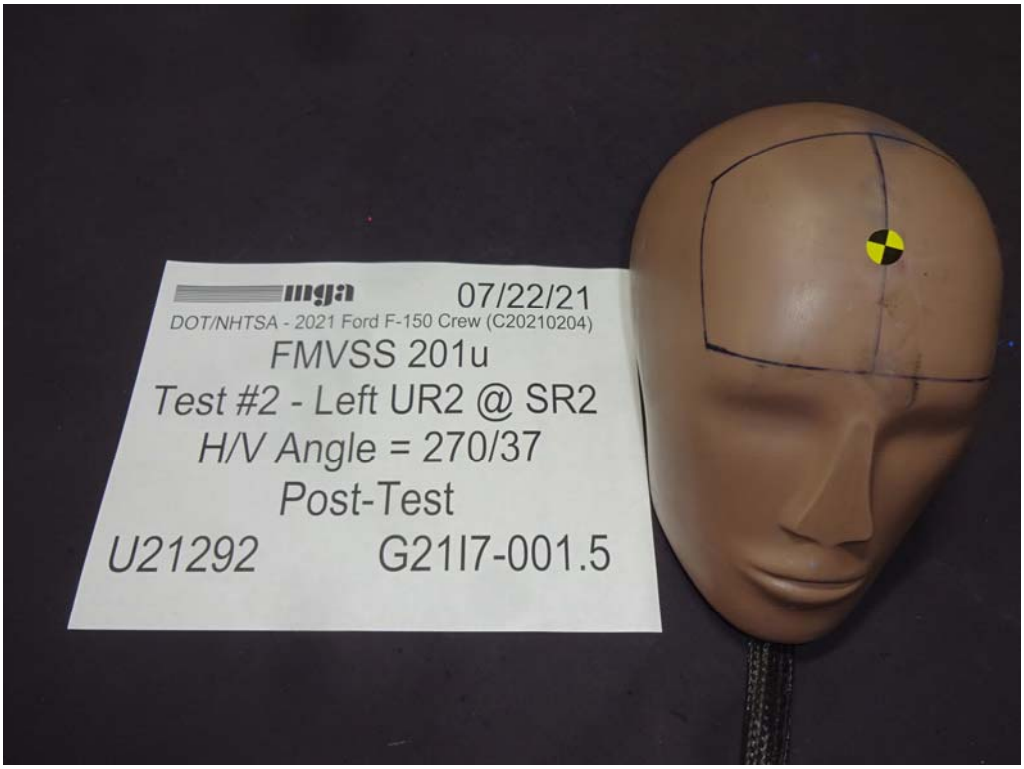
Pre-Test Photograph No. 2 of Test U21292

Post-Test Photograph No. 1 of Test U21292



Post-Test Photograph No. 2 of Test U21292

Post-Test Photograph No. 3 of Test U21292



Post-Test Photograph No. 4 of Test U21292

Test U21295 Data

mga research corporation

FMVSS 201U
Test No.: U21295 Report No.: G21I7-001.5
Customer: NHTSA Date: 7/22/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 5 Time: 15:48:23

Horizontal Approach Angle: 270 deg Temperature: 21.3 °C

Vertical Approach Angle: 38 deg Humidity: 39.5 %RH

Impact Form ID No.: H37 Impact Form Mass: 4.58 kg

Target Location: Left UR3 @ BP

Additional Description:

Test Results

Impact Velocity: 23.8 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	1063.3	79.4	84.7	5.3
HIC 15	1063.3	79.4	84.7	5.3
HIC (d)	968.61	79.4	84.7	5.3

3 ms Clip = 129.12 G , Time 1 = 80.57 ms , Time 2 = 83.57 ms

Impact Location on FMH: 58 mm Above Pt. 0 , 2 Right mm Lateral of Pt. 0

Post-Test Comments:

Test Series Performed By: RJ, KR

Recorded By: Approved By:

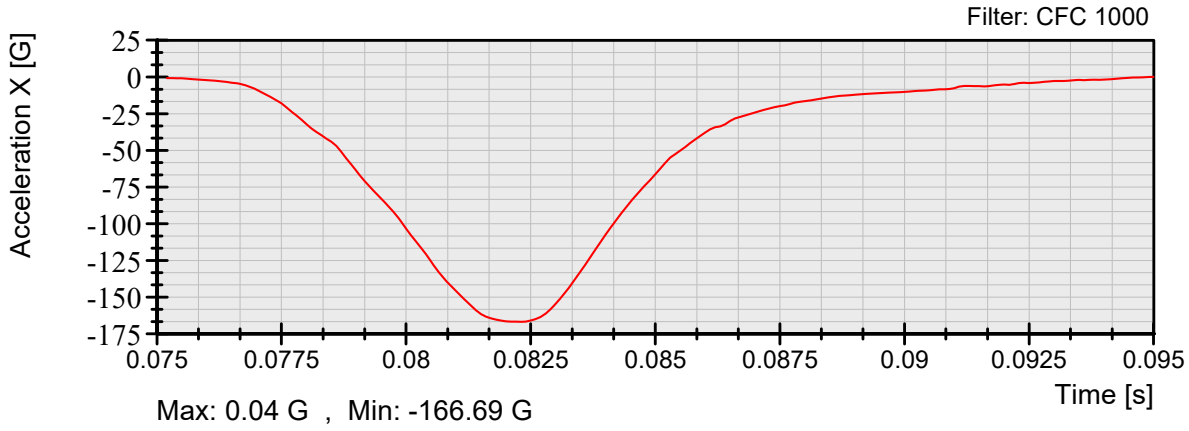
Date: 7/22/2021

mga research corporation

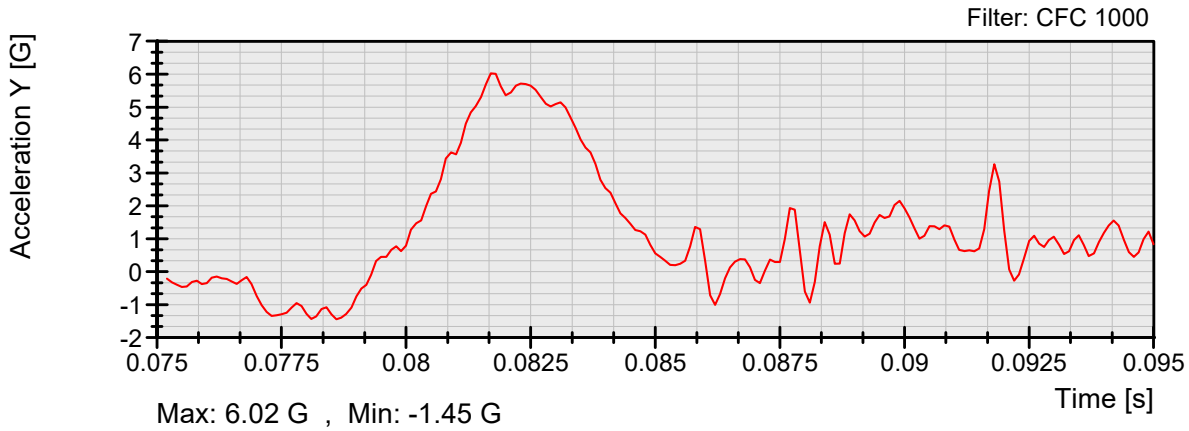
FMVSS 201U

Test No.: U21295
Customer: NHTSA

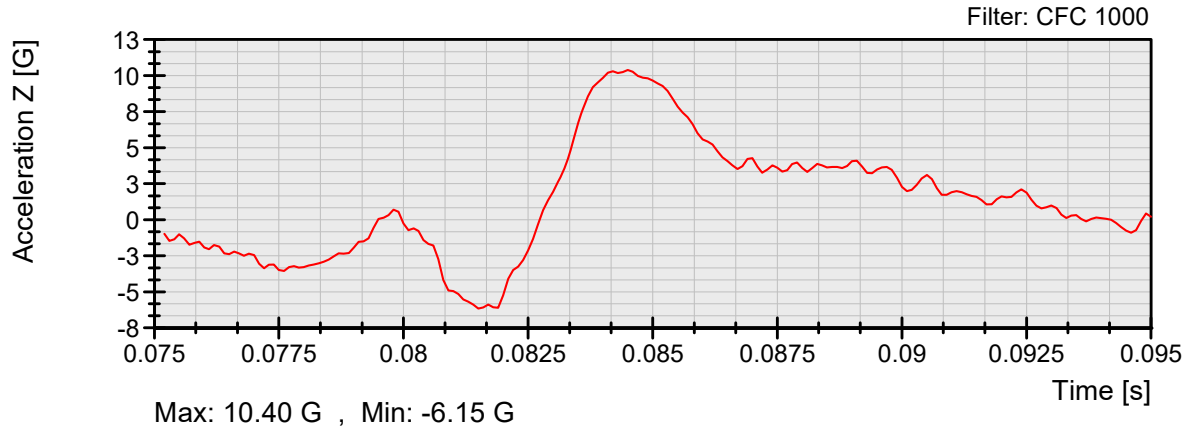
Report No.: G21I7-001.5
Date: 7/22/2021



Max: 0.04 G , Min: -166.69 G



Max: 6.02 G , Min: -1.45 G

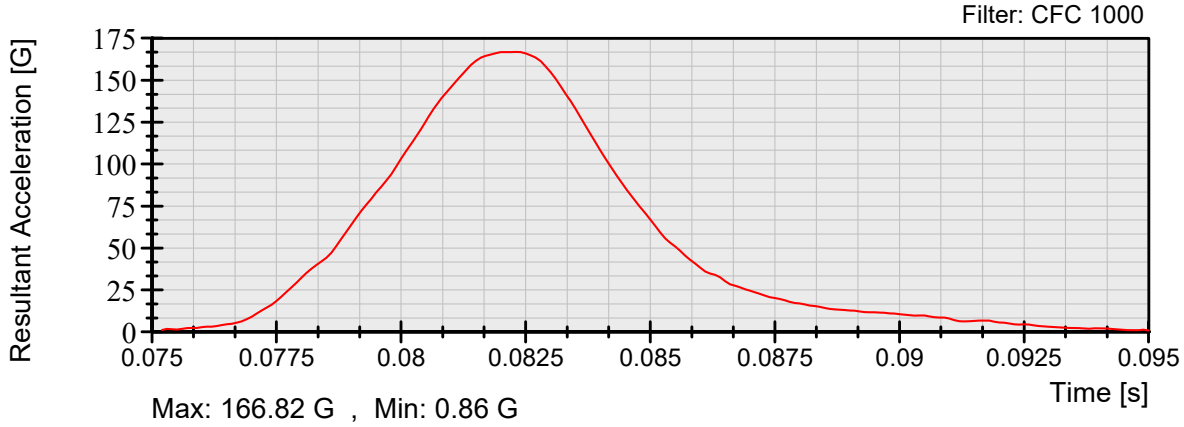


Max: 10.40 G , Min: -6.15 G

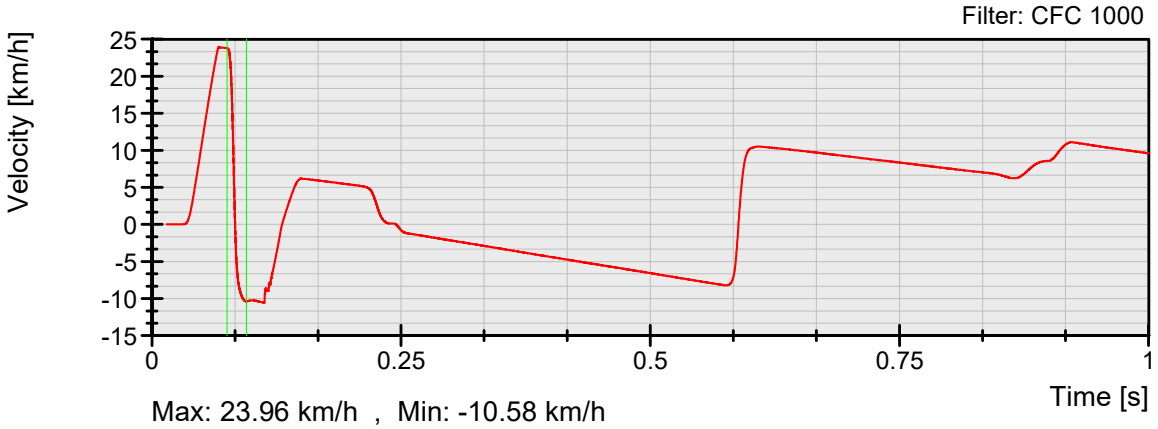
mga research corporation

FMVSS 201U

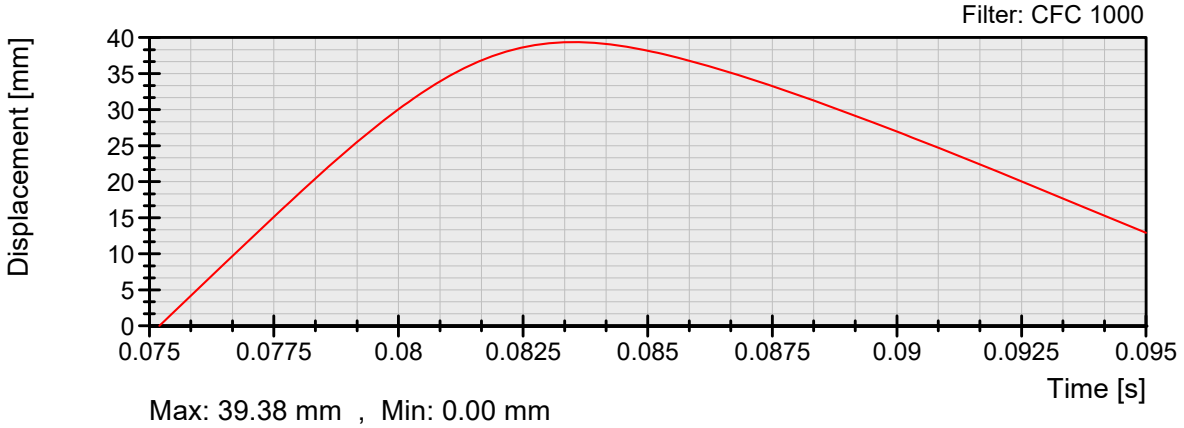
Test No.: U21295
Customer: NHTSA
Report No.: G21I7-001.5
Date: 7/22/2021



Max: 166.82 G , Min: 0.86 G



Max: 23.96 km/h , Min: -10.58 km/h



Max: 39.38 mm , Min: 0.00 mm

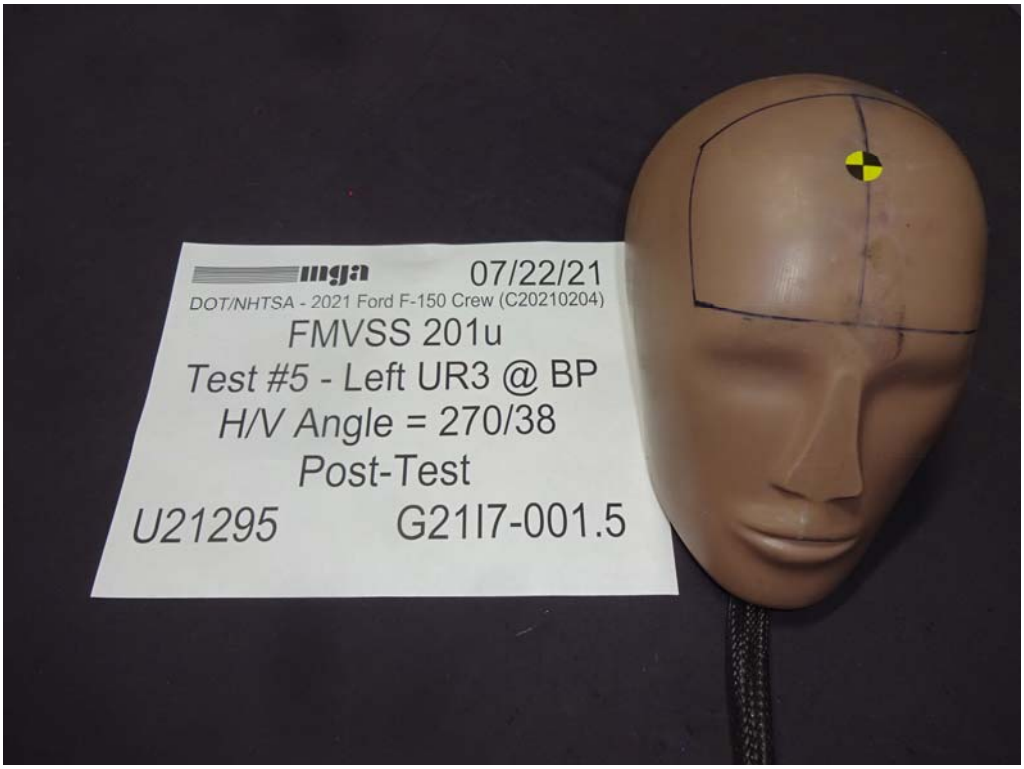
Pre-Test Photograph No. 1 of Test U21295

Pre-Test Photograph No. 2 of Test U21295

Post-Test Photograph No. 1 of Test U21295

Post-Test Photograph No. 2 of Test U21295

Post-Test Photograph No. 3 of Test U21295



Post-Test Photograph No. 4 of Test U21295

Test U21299 Data

mga research corporation

FMVSS 201U
Test No.: U21299 Report No.: G21I7-001.5
Customer: NHTSA Date: 7/23/2021

Summary of the Test

Setup Information

Sample Description: 2021 Ford F-150

Test Sequence No.: 9 Time: 11:40:49

Horizontal Approach Angle: 90 deg Temperature: 21.0 °C

Vertical Approach Angle: 50 deg Humidity: 47.4 %RH

Impact Form ID No.: H38 Impact Form Mass: 4.55 kg

Target Location: UR7 @ SR1

Additional Description:

Test Results

Impact Velocity: 24.03 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	801.65	80.9	85.3	4.4
HIC 15	801.65	80.9	85.3	4.4
HIC (d)	771.21	80.9	85.3	4.4

3 ms Clip = 101.46 G , Time 1 = 81.29 ms , Time 2 = 84.86 ms

Impact Location on FMH: 47 mm Above Pt. 0 , 0 mm Lateral of Pt. 0

Post-Test Comments: Headliner Deformation

Test Series Performed By: RJ, KR

Recorded By: Approved By:

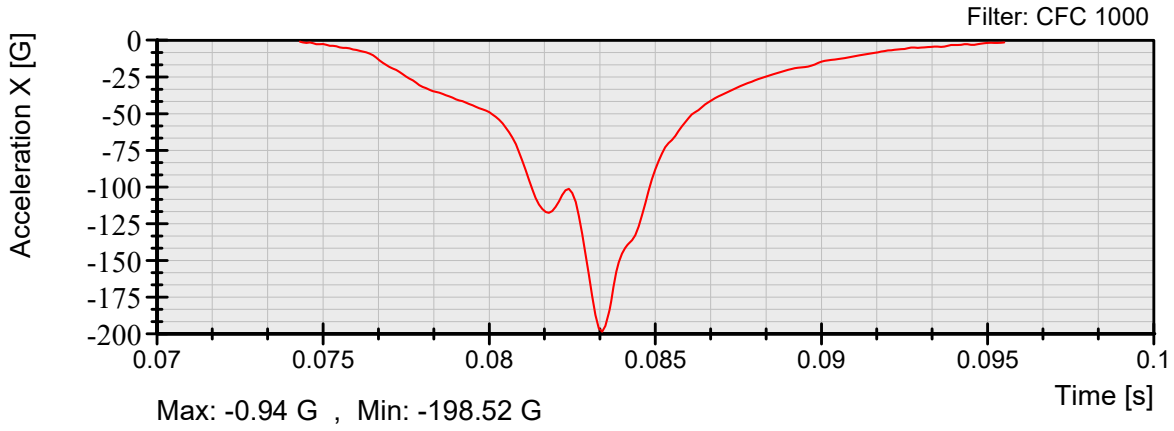
Date: 7/23/2021

mga research corporation

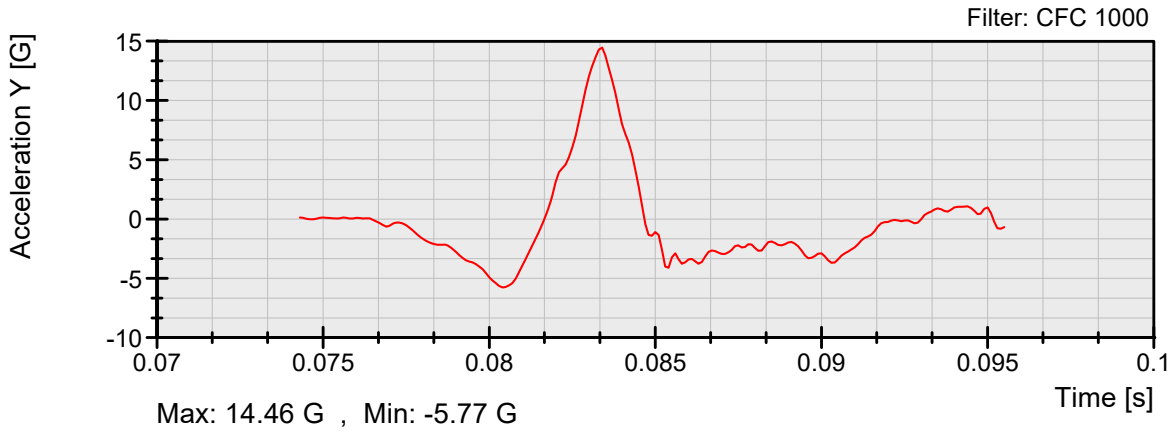
FMVSS 201U

Test No.: U21299
Customer: NHTSA

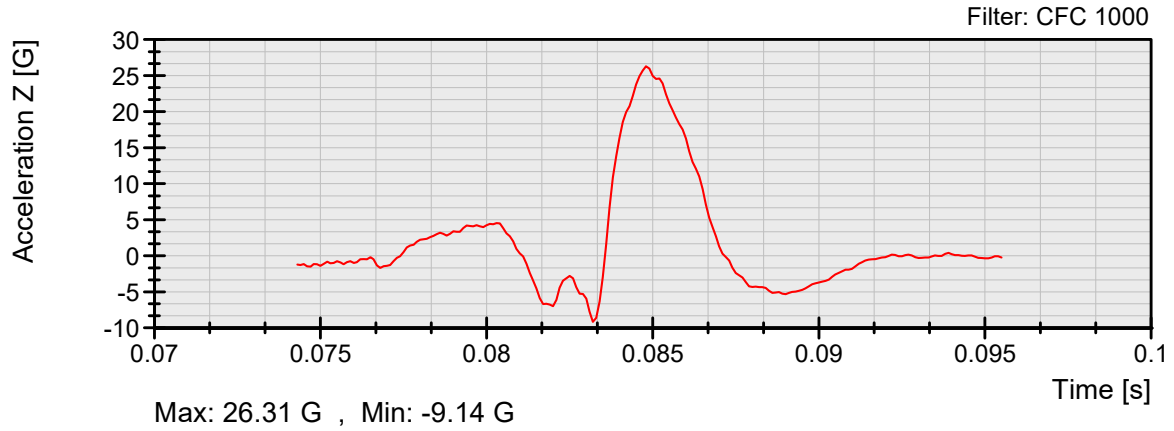
Report No.: G21I7-001.5
Date: 7/23/2021



Max: -0.94 G , Min: -198.52 G



Max: 14.46 G , Min: -5.77 G



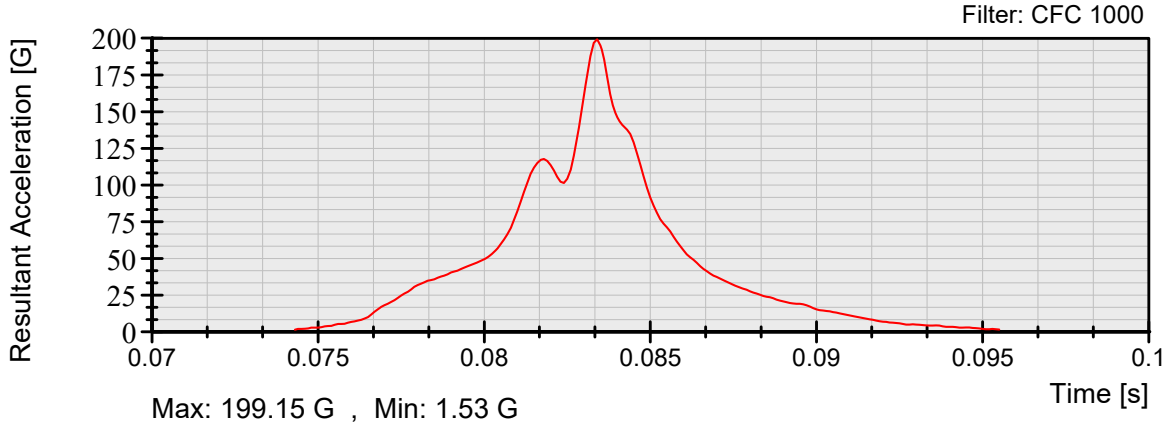
Max: 26.31 G , Min: -9.14 G

mga research corporation

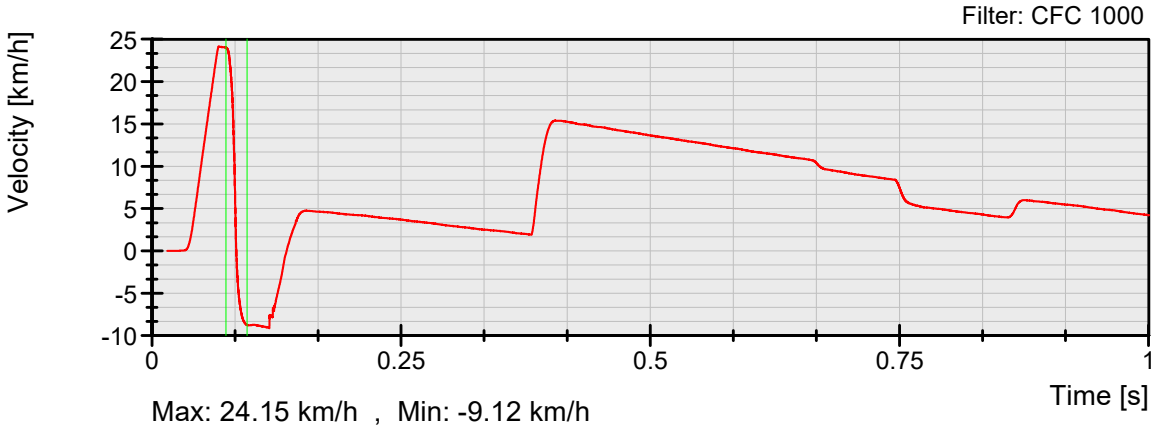
FMVSS 201U

Test No.: U21299
Customer: NHTSA

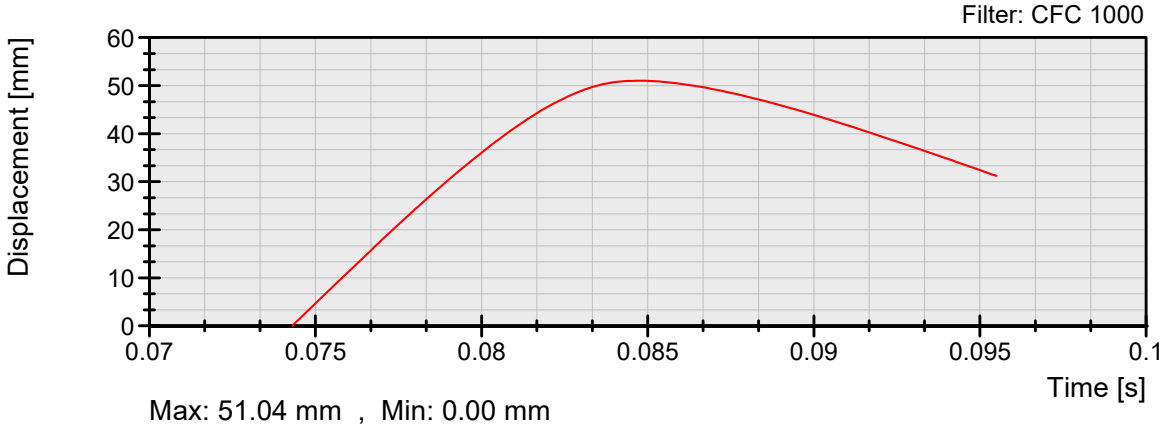
Report No.: G21I7-001.5
Date: 7/23/2021



Max: 199.15 G , Min: 1.53 G



Max: 24.15 km/h , Min: -9.12 km/h



Max: 51.04 mm , Min: 0.00 mm

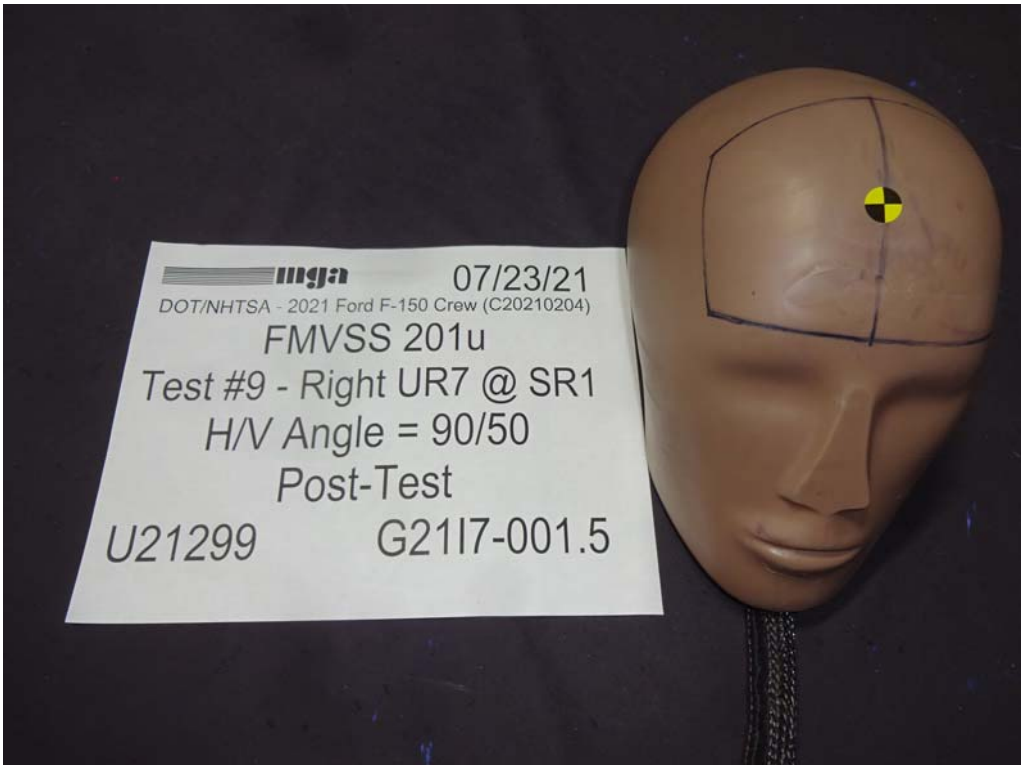
Pre-Test Photograph No. 1 of Test U21299

Pre-Test Photograph No. 2 of Test U21299

Post-Test Photograph No. 1 of Test U21299

Post-Test Photograph No. 2 of Test U21299

Post-Test Photograph No. 3 of Test U21299



Post-Test Photograph No. 4 of Test U21299

4.0 TEST EQUIPMENT LIST AND CALIBRATION INFORMATION

The following section lists the test equipment for the compliance test series. Items marked with an asterisk are calibrated by an external lab. An additional summary table is given for the pre and post-test calibration data for the Free Motion Headforms. The temperature trace to confirm testing was conducted between 66ºF and 78ºF (19ºC – 26ºC) is included in Appendix A. Calibration certificates can be found in Appendix B.

TABLE 4-1 LIST OF ITEMS USED

ITEM	MANUFACTURER NAME	MODEL #	FUNCTION OF ITEM	ACCURACY	CAL. INTERVAL
Head Drop Tower (includes test frame and DAS)	MGA Research Corp.	MGA-100-DC	FMH Calibration	N/A	N/A
Accelerometers	Endevco	7264-2000	Acceleration Data	±0.5%	Annual
FMVSS 201U Test Frame (includes the propulsion control system, actuator, test frame, and DAS)	TDAS	LM0212	Test System	±0.5%	Annual
Free Motion Headforms	UTAMA UTAMA UTAMA	035 037 038	Test Device	N/A	Pre and Post-Test Series
High Speed Video	Vision Research	Miro Ex4	Record Event	N/A	N/A
*FARO™	Faro Technologies	R10-02-13-11437	Targeting	0.1 mm	Annual
Measuring Devices: - Tape Measure - Plumb Bobs - Digital Inclinometer	 Staney N/A Mitutoyo	 TPM007-58 -- MGA00821	 Measurement Targeting FMH setup Horizontal Measurement	 1 mm N/A 0.5°	Annual
*Temperature/RH Data Logger	Madgetech	R205342	Record Temperature and Humidity	± 1°C ± 1% RH	Annual
* Scale	Detecto	MGA00783	Weigh FMH Head	± 0.01 lb	Annual
*Vehicle Scale	Intercomp	0128MA14010	Weighing Vehicle	± .5 kg	Annual

Each headform was calibrated by an engineer after the headform had soaked in an environment of 66ºF to 78ºF (19ºC to 26ºC) for a period of at least four hours.

Each headform was found to comply with the performance criteria under Part 572L for pre and post-test calibrations. That is, the peak resultant acceleration was between 225 and 275 G's, the peak lateral acceleration was less than 15 G's, the headform weighed between 9.9 and 10.1 lbs., the pulse was determined to be unimodal, and there was no major damage to the headform.

TABLE 4-2 FMH CALIBRATION SUMMARY

FMH Serial #		Headform Calibration Date	Weight (kg)	Temp (ºC)	% Humidity	Peak Resultant Acceleration (G's)	Peak Lateral Acceleration (G's)	Unimodal
35	Pre	07/21/2021	4.55	21.5	41.9	267.4	3.7	Yes
35	Post	07/26/2021	4.55	21.6	45.8	241.4	7.8	Yes
37	Pre	07/21/2021	4.58	21.6	42.3	266.6	3.6	Yes
37	Post	07/26/2021	4.58	20.7	47.4	269.2	9.9	Yes
38	Pre	07/21/2021	4.55	21.5	42.3	272.1	5.0	Yes
38	Post	07/26/2021	4.55	20.6	49.0	270.5	10.0	Yes

4-1 Pre-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H35006 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/21/2021

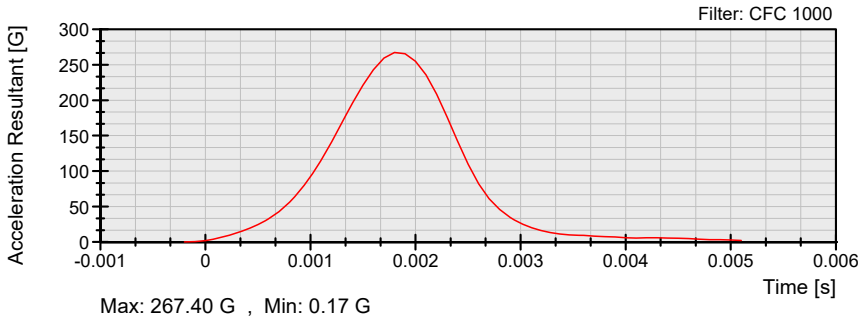
Summary of Results:

Impact Form ID No.: H35

Item Description	Result	Requirement
Temperature (°C)	21.5 °C	19ºC and 26ºC
Humidity (%RH)	41.9 % RH	10% to 70% RH
Impact Form Mass (kg)	4.55 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	267.40 G	225 to 275 G
Peak Y-Acceleration (G)	3.68 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: RJ

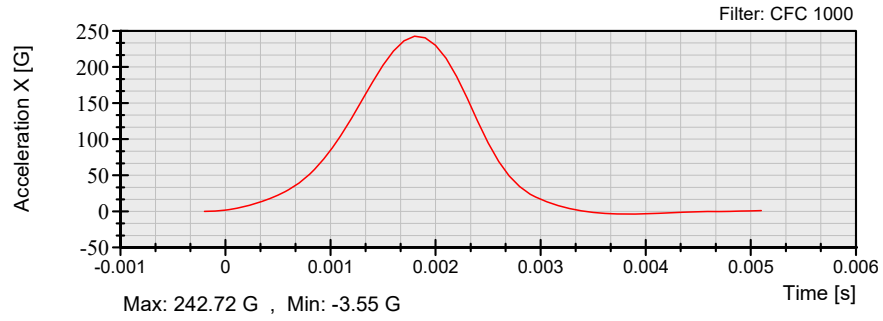
Comments: Pre-Test



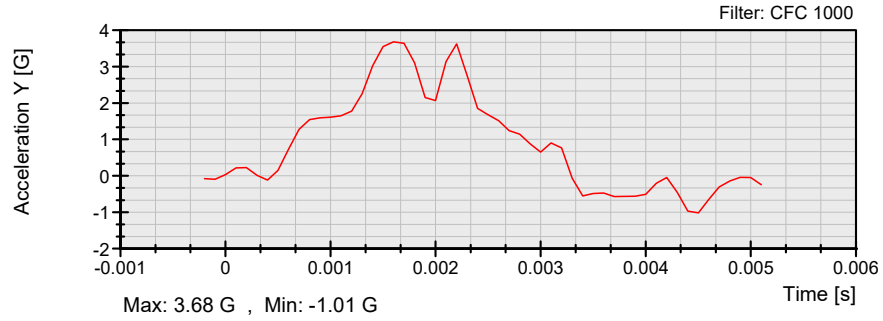
Max: 267.40 G , Min: 0.17 G

Calibration Series: FMVSS 201U FMH

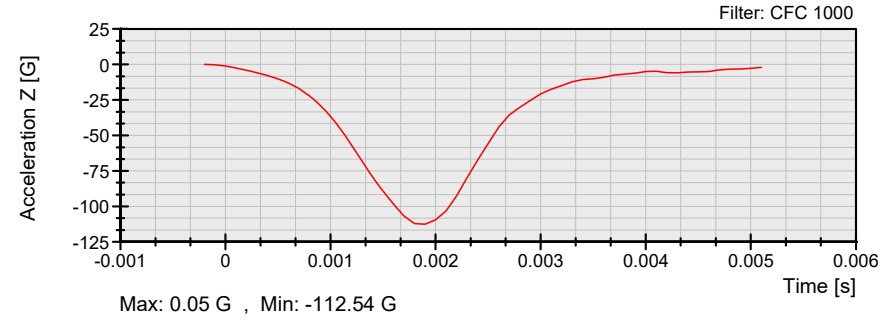
Test No.: H35006 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/21/2021



Max: 242.72 G , Min: -3.55 G



Max: 3.68 G , Min: -1.01 G



Max: 0.05 G , Min: -112.54 G

Page 2 of 2

Recorded and Approved By: _____
Date: July 21, 2021

4-2 Post-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H35007 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/26/2021

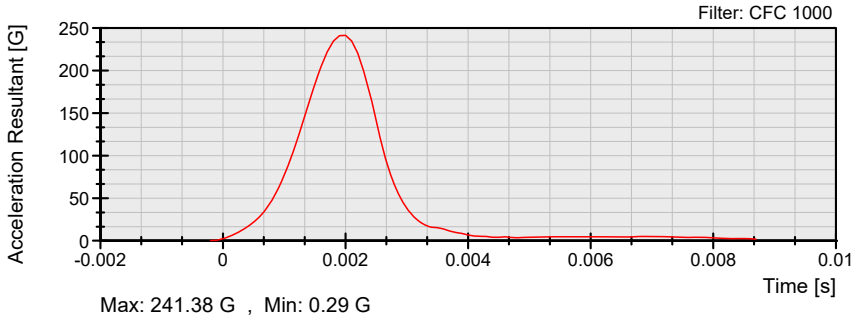
Summary of Results:

Impact Form ID No.: H35

Item Description	Result	Requirement
Temperature (°C)	21.6 °C	19ºC and 26ºC
Humidity (%RH)	45.8 % RH	10% to 70% RH
Impact Form Mass (kg)	4.55 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	241.38 G	225 to 275 G
Peak Y-Acceleration (G)	7.83 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: KR

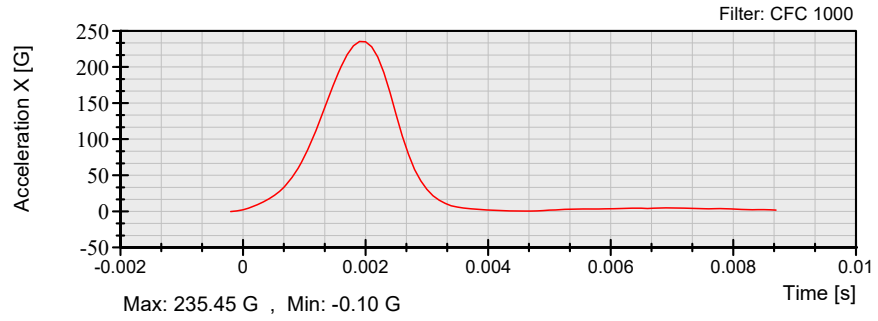
Comments: Post-Test



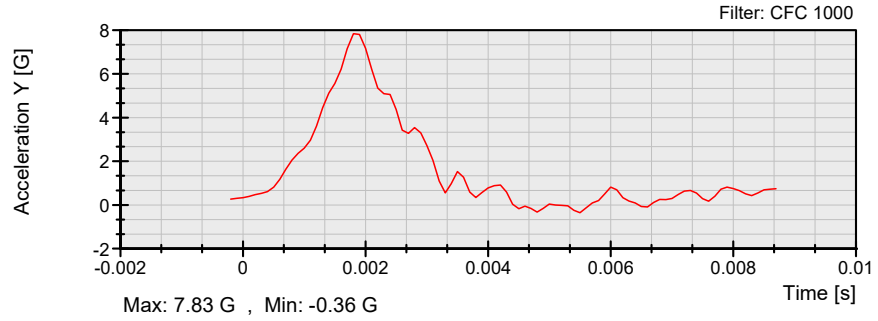
Max: 241.38 G , Min: 0.29 G

Calibration Series: FMVSS 201U FMH

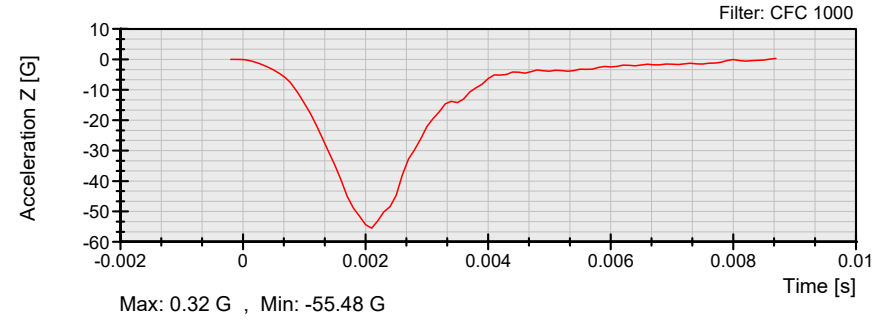
Test No.: H35007 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/26/2021



Max: 235.45 G , Min: -0.10 G



Max: 7.83 G , Min: -0.36 G



Max: 0.32 G , Min: -55.48 G

Page 2 of 2

Recorded By: Kurt Reichert **Approved By:**
Date: July 26, 2021

4-3 Pre-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H37006 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/21/2021

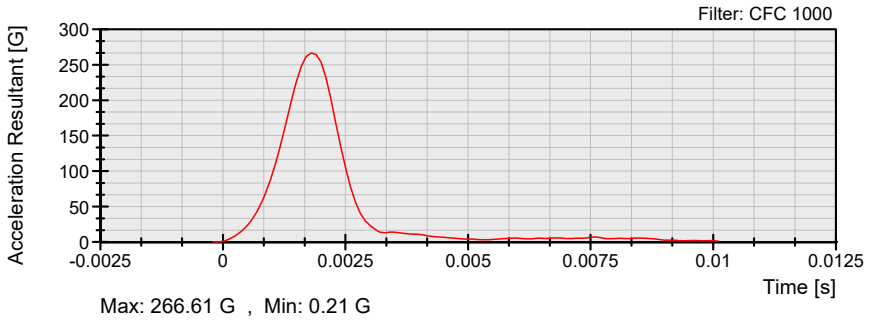
Summary of Results:

Impact Form ID No.: H37

Item Description	Result	Requirement
Temperature (°C)	21.6 °C	19ºC and 26ºC
Humidity (%RH)	42.3 % RH	10% to 70% RH
Impact Form Mass (kg)	4.58 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	266.61 G	225 to 275 G
Peak Y-Acceleration (G)	3.61 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: RJ

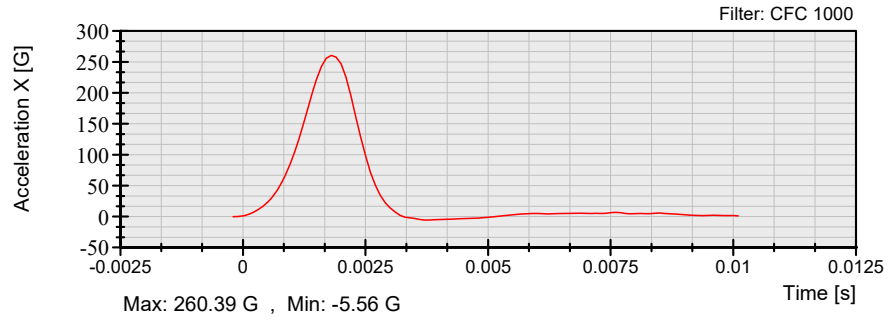
Comments: Pre-Test



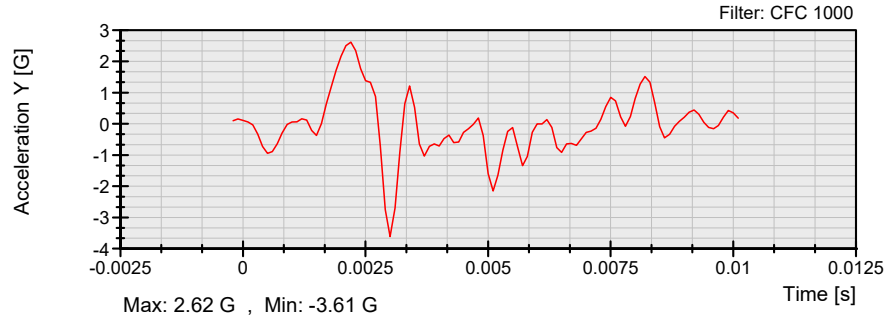
Max: 266.61 G , Min: 0.21 G

Calibration Series: FMVSS 201U FMH

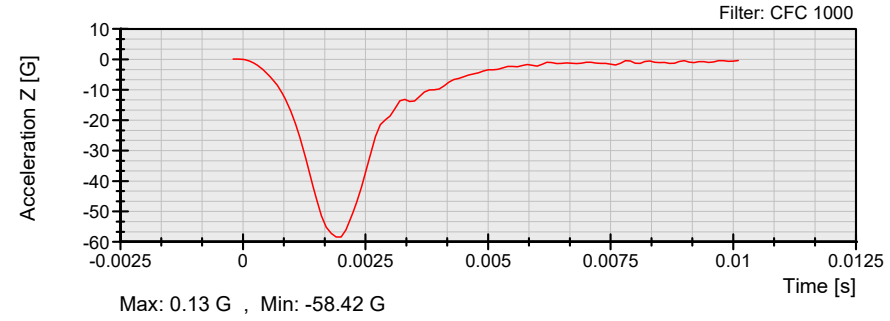
Test No.: H37006 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/21/2021



Max: 260.39 G , Min: -5.56 G



Max: 2.62 G , Min: -3.61 G



Max: 0.13 G , Min: -58.42 G

Page 2 of 2

Recorded and Approved By: _____

Date: July 21, 2021

4-4 Post-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H37007 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/26/2021

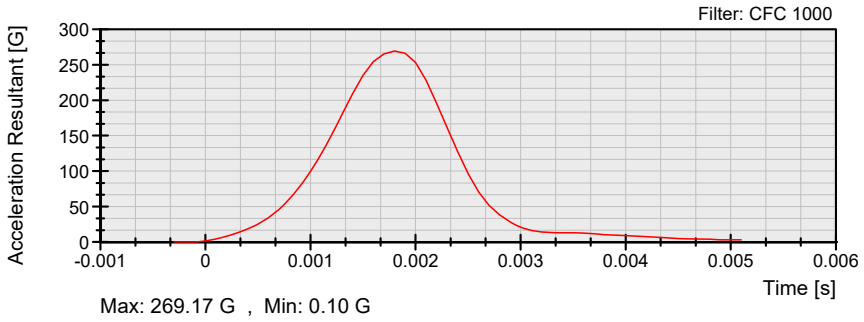
Summary of Results:

Impact Form ID No.: H37

Item Description	Result	Requirement
Temperature (°C)	20.7 °C	19ºC and 26ºC
Humidity (%RH)	47.4 % RH	10% to 70% RH
Impact Form Mass (kg)	4.58 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	269.17 G	225 to 275 G
Peak Y-Acceleration (G)	9.88 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: KR

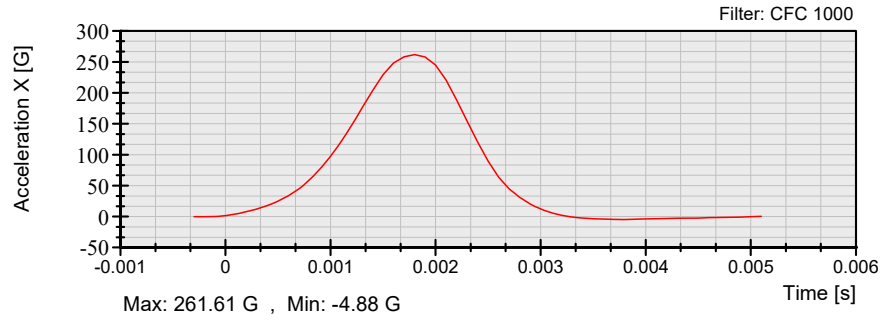
Comments: Post-Test



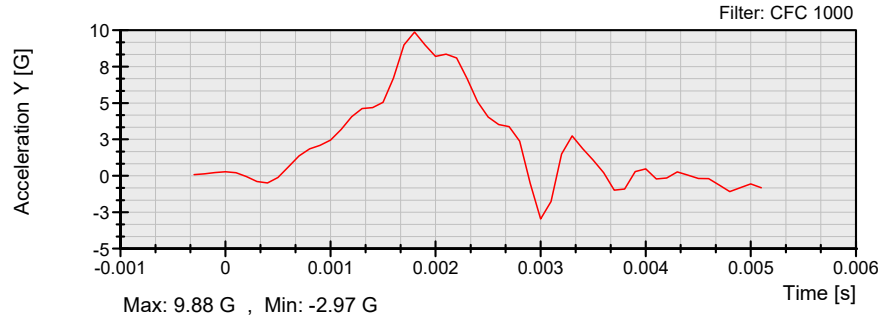
Max: 269.17 G , Min: 0.10 G

Calibration Series: FMVSS 201U FMH

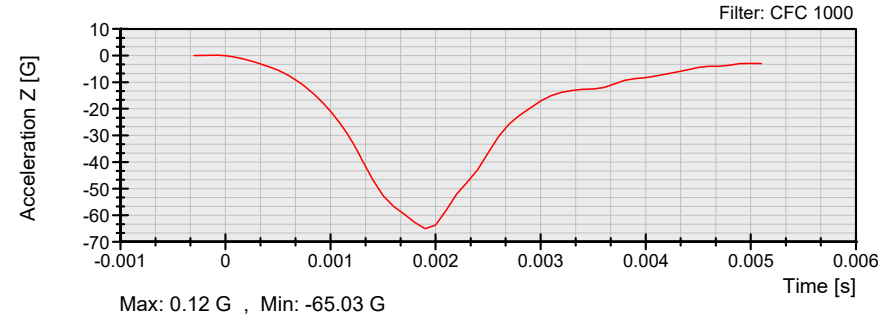
Test No.: H37007 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/26/2021



Max: 261.61 G , Min: -4.88 G



Max: 9.88 G , Min: -2.97 G



Max: 0.12 G , Min: -65.03 G

Recorded By: Kurt Reichert **Approved By:**
Date: July 26, 2021

4-5 Pre-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H38006 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/21/2021

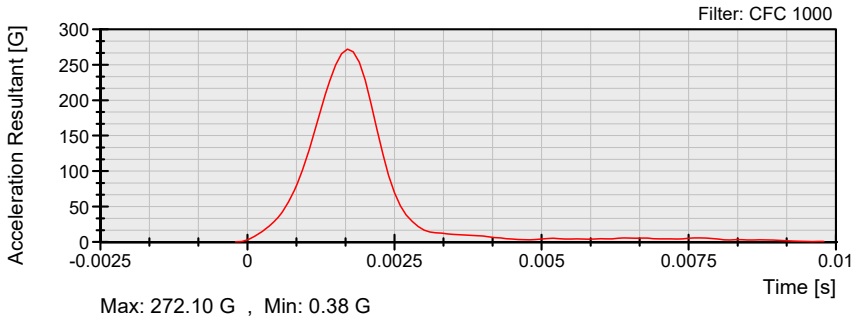
Summary of Results:

Impact Form ID No.: H38

Item Description	Result	Requirement
Temperature (°C)	21.5 °C	19ºC and 26ºC
Humidity (%RH)	42.3 % RH	10% to 70% RH
Impact Form Mass (kg)	4.55 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	272.10 G	225 to 275 G
Peak Y-Acceleration (G)	4.97 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: RJ

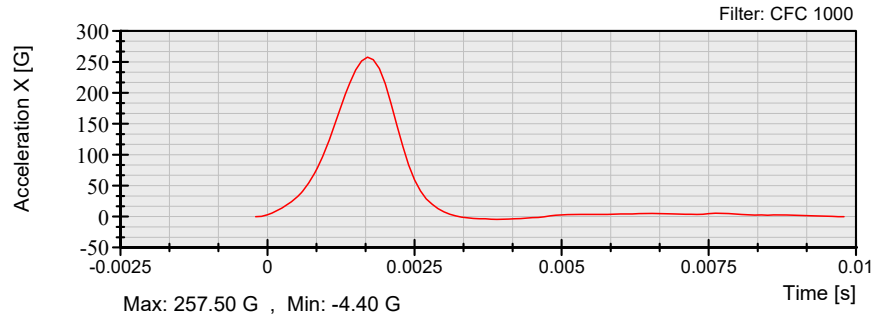
Comments: Pre-Test



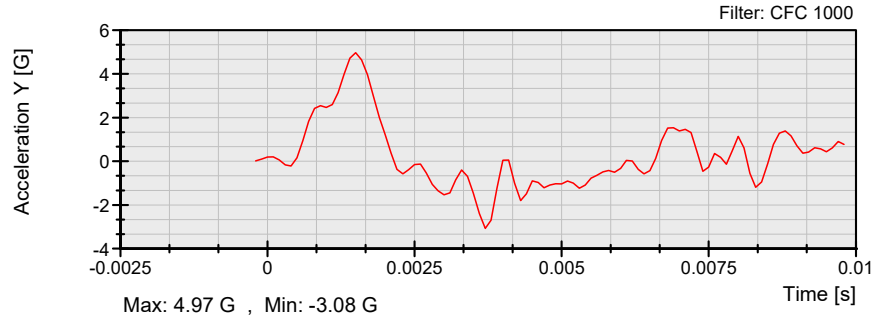
Max: 272.10 G , Min: 0.38 G

Calibration Series: FMVSS 201U FMH

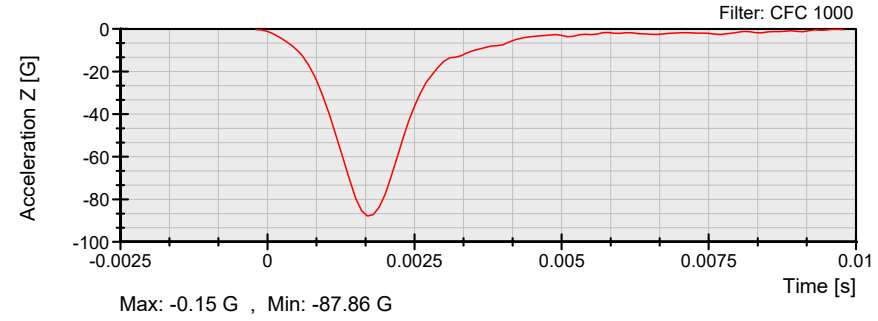
Test No.: H38006 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/21/2021



Max: 257.50 G , Min: -4.40 G



Max: 4.97 G , Min: -3.08 G



Max: -0.15 G , Min: -87.86 G

Page 2 of 2

Recorded and Approved By: _____
Date: July 21, 2021

4-6 Post-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H38007 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/26/2021

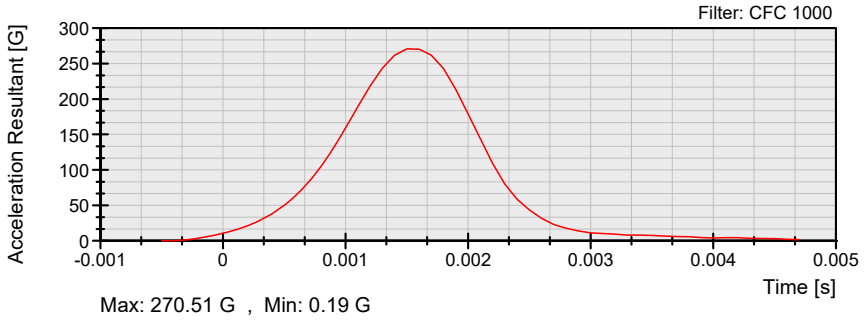
Summary of Results:

Impact Form ID No.: H38

Item Description	Result	Requirement
Temperature (°C)	20.6 °C	19ºC and 26ºC
Humidity (%RH)	49.0 % RH	10% to 70% RH
Impact Form Mass (kg)	4.55 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	270.51 G	225 to 275 G
Peak Y-Acceleration (G)	10.01 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: KR

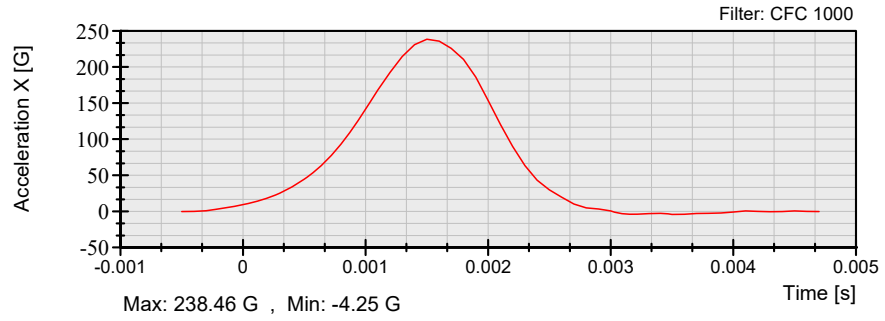
Comments: Post-Test



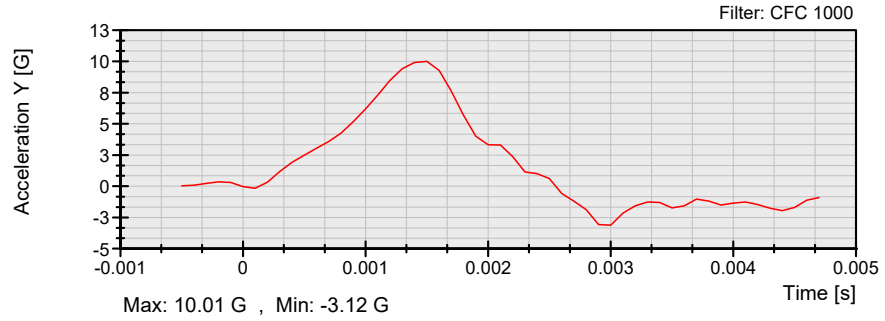
Max: 270.51 G , Min: 0.19 G

Calibration Series: FMVSS 201U FMH

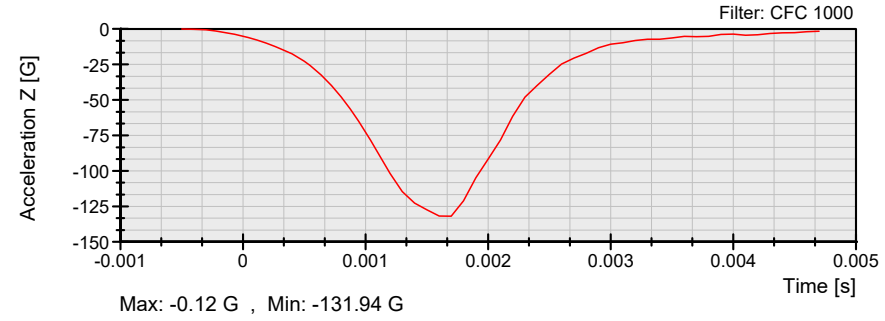
Test No.: H38007 Report No.: G21I7-001.5
Customer: DOT/NHTSA Date: 07/26/2021



Max: 238.46 G , Min: -4.25 G



Max: 10.01 G , Min: -3.12 G



Max: -0.12 G , Min: -131.94 G

Page 2 of 2

Recorded By: Kurt Reichert **Approved By:**

Date: July 26, 2021

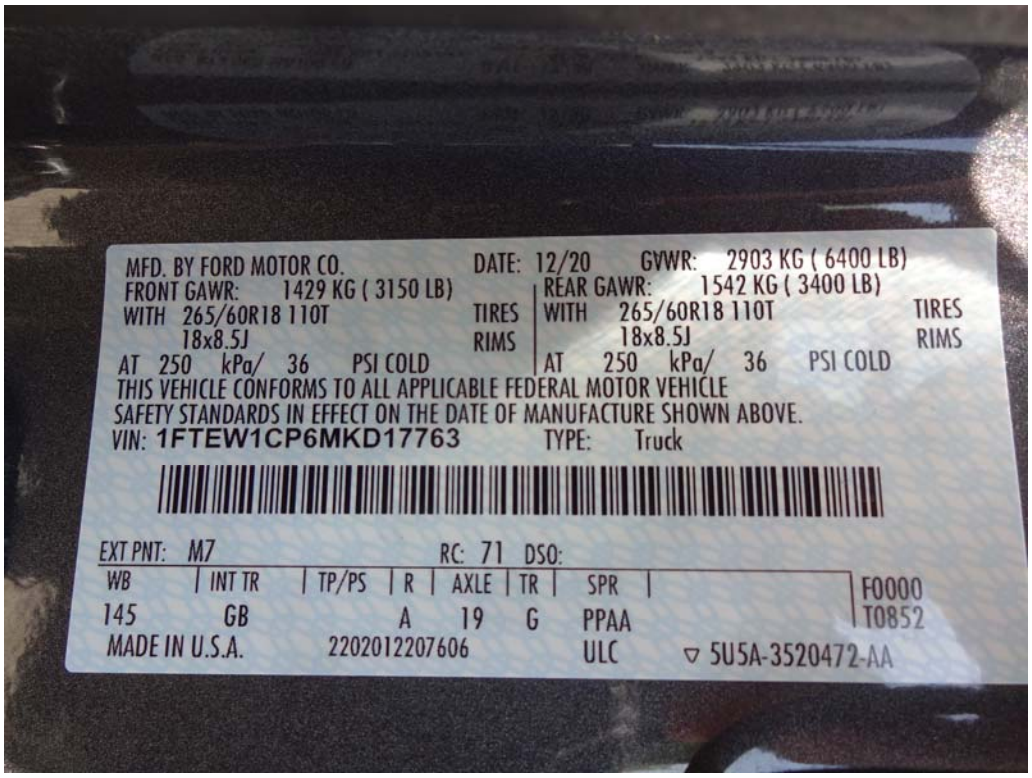
5.0 PHOTOGRAPHS

As Delivered – Left Side View

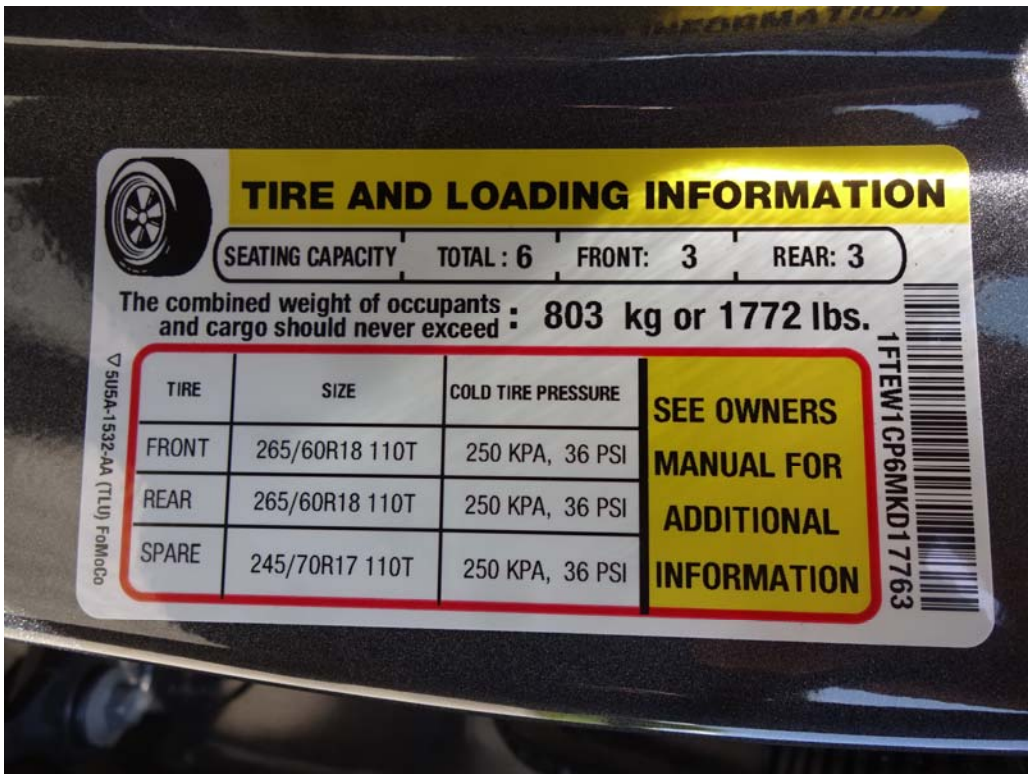
As Delivered – Right Side View

As Delivered – ¾ Front View From Left Side

As Delivered – ¾ Rear View From Right Side



As Delivered – Vehicle's Certification Label

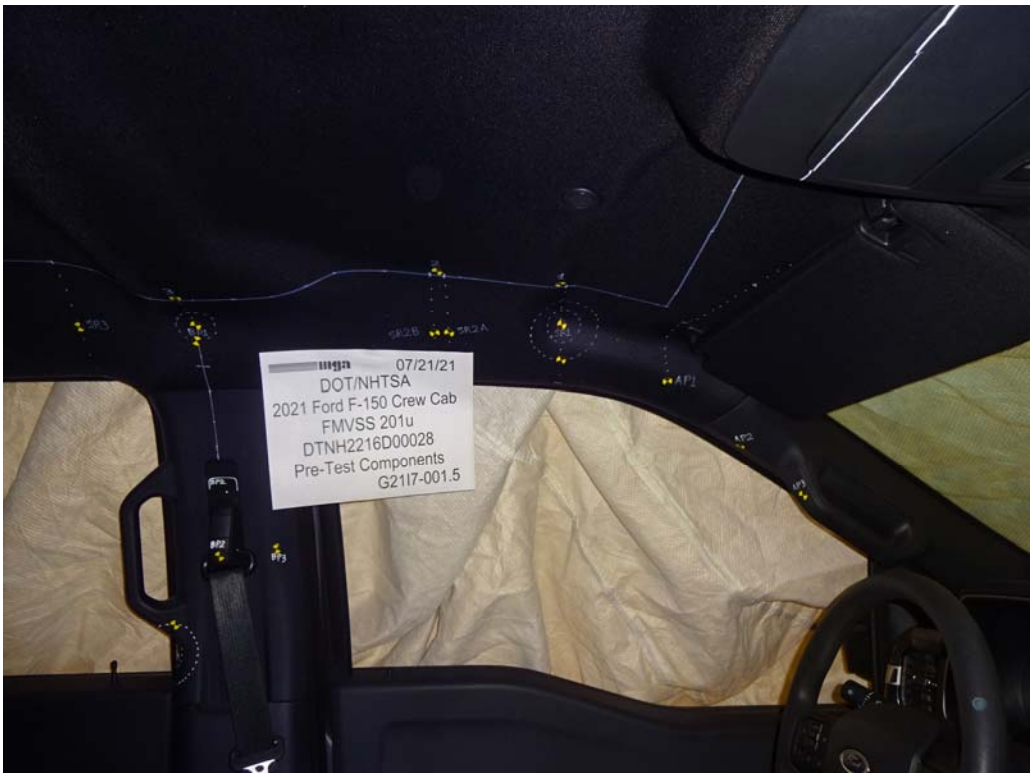


As Delivered – Vehicle's Tire Information Label

Pre-Test Component Photographs

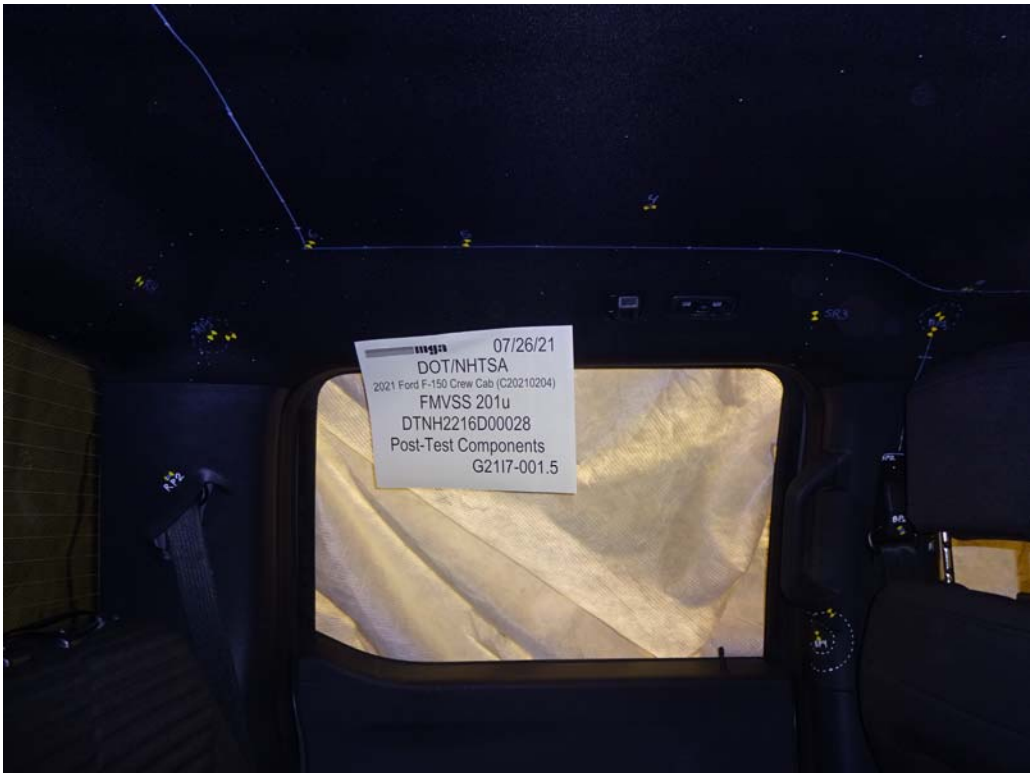

07/21/21
DOT/NHTSA
2021 Ford F-150 Crew Cab
FMVSS 201u
DTNH2216D00028
Pre-Test Components
G21I7-001.5


07/21/21
DOT/NHTSA
2021 Ford F-150 Crew Cab
FMVSS 201u
DTNH2216D00028
Pre-Test Components
G21I7-001.5


07/21/21
DOT/NHTSA
2021 Ford F-150 Crew Cab
FMVSS 201u
DTNH2216D00028
Pre-Test Components
G21I7-001.5

Post-Test Component Photographs

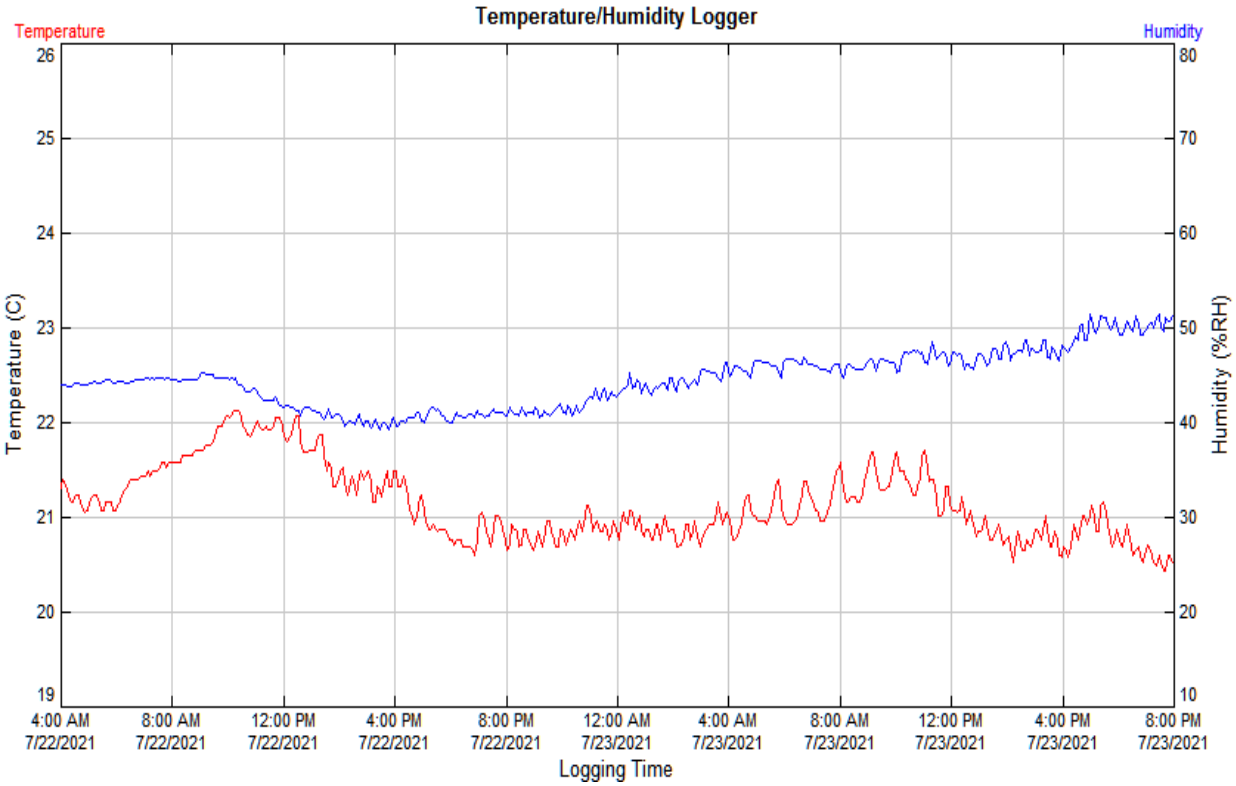

07/26/21
DOT/NHTSA
2021 Ford F-150 Crew Cab (C20210204)
FMVSS 201u
DTNH2216D00028
Post-Test Components
G21I7-001.5


07/26/21
DOT/NHTSA
2021 Ford F-150 Crew Cab (C20210204)
FMVSS 201u
DTNH2216D00028
Post-Test Components
G21I7-001.5


07/26/21
DOT/NHTSA
2021 Ford F-150 Crew Cab (C20210204)
FMVSS 201u
DTNH2216D00028
Post-Test Components
G21I7-001.5

Appendix A – Temperature Trace

C20210204
2021 Ford F-150 Crew Cab
FMVSS 201U



Appendix B – Calibration Certificates

Diversified Technical Systems, Inc.
25881 Meadowbrook Road, Novi, MI 48375 USA
Phone: +1 248 513 6050 • Fax: +1 248 513 6051
www.dtsweb.com

ACCREDITED
Calibration CERT# 3007.01

Calibration and Test Report

Model # : TDAS PRO LAB SIM	**CERTIFICATE NUMBER:**	Date Received: 28 April 2021
Serial # : LM0212	20210430LM0212	Date Calibrated: 30 April 2021
Firmware: 07E4		
Procedure: TDAS PRO SIM Calibration, Rev 8.3	**Issued:**	Item Received: In Tolerance
Order: 65602	30 April 2021	Item Returned: In Tolerance
Customer: MGA Research - Elliot Drive		
2839 Elliott Drive	**Next Calibration:**	Temperature: 75°F / 23.7°C
Troy, MI, 48083, USA	30 April 2022	Humidity: 32 %

This instrument has been processed and calibrated in accordance with the DTS Quality Assurance Manual and ISO/IEC 17025. DTS has been audited by the American Association for Laboratory Accreditation (A2LA) and found in compliance with ISO/IEC 17025. Accredited calibrations performed within the DTS Scope of Accreditation are indicated by the presence of the A2LA Logo and Certificate Number on this Certificate of Calibration. Timing and frequency response meet the requirements of SAE J211 and ISO 6487.

DTS reference standards are tested and calibrated in accordance with the DTS Quality Assurance System, and traceable to a National Metrology Institute (NMI) such as National Institute of Standards and Technology (NIST). Uncertainties have been estimated at an approximately 95 percent confidence level (k=2). Simple acceptance is used as defined in ILAC G8 with a TUR > 4:1 unless otherwise noted.

The reported data is the raw recorded data and is not corrected for uncertainty or environmental effects. Any number of factors can cause a unit to drift out of tolerance at any time following its calibration. This report only applies only to the item(s) identified above, and shall not be reproduced except in full, without the written approval of DTS. Limitations on the uses of this instrument are detailed in the manufacturer's operating instructions.

Standards Used

ID #	Manufacturer	Model #	Description	Cal Date	Due Date
6606	Keysight	34420A	Nano Volt, Micro-Ohm Meter, 7.5 Digit	7-Aug-2020	7-Aug-2021
CAL215	DTS	CALSTAT	Calibration Station	1-Sep-2020	1-Sep-2021

Results

Test Description	As Received / As Returned
Visual Examination	PASS
Communication to TDAS Rack Bus	PASS
Timebase Calibration	PASS
Internal Calibration Source Calibration	PASS
Excitation Calibration	PASS
Amplitude/Gain Calibration	PASS
AC Filter Response Calibration	PASS
Diagnostic Shunt Performance Test	PASS
Sensor ID Performance Test	PASS
Internal Self-Checks	PASS

Calibration Site:
DTS-MI
25881 Meadowbrook Road
Novi, MI 48375 USA

Calibrated By: Alex Czilok
Calibration Technician

5/7/21

DTS

Measurement Data
As Received

Serial #: LM0212
Order #: 65602
Date: 30 April 2021

Timebase Calibration

Std (Hz)	UUT (Hz)	Dev (Hz)	Dev (ppm)	U (ppm)	Limits (ppm)	PASS/ FAIL
999.99	1000.02	0.02551	25.5	2.3E+01	+/-100	Pass

Internal Calibration Source

UUT (mV)	Std (mV)	U (mV)	MIN (mV)	MAX (mV)	PASS/ FAIL
0	-0.02197	4.6E-02	-2.5	2.5	Pass
1200	1200.02	8.2E-02	1197.5	1202.5	Pass
2400	2399.94	9.6E-02	2397.5	2402.5	Pass

Excitation Calibration, 5V

Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
1	4977.1	4977.3	0.25	2.0E-01	0.01	+/-0.5	Pass
2	4974.6	4973.2	-1.41	2.0E-01	-0.03	+/-0.5	Pass
3	4996.9	4997.2	0.37	2.0E-01	0.01	+/-0.5	Pass
4	5005.5	5005.8	0.29	2.0E-01	0.01	+/-0.5	Pass
5	5001.9	5002.4	0.47	2.0E-01	0.01	+/-0.5	Pass
6	4979.8	4980.2	0.47	2.0E-01	0.01	+/-0.5	Pass
7	4990.1	4990.6	0.42	2.0E-01	0.01	+/-0.5	Pass
8	4978.2	4978.9	0.74	2.0E-01	0.01	+/-0.5	Pass

Excitation Calibration, 10V

Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
1	9975.5	9976.4	0.84	4.0E-01	0.01	+/-0.5	Pass
2	9969.3	9968.7	-0.68	4.0E-01	-0.01	+/-0.5	Pass
3	9984.9	9985.3	0.44	4.0E-01	0.00	+/-0.5	Pass
4	10010.7	10012.0	1.29	4.0E-01	0.01	+/-0.5	Pass
5	10009.4	10011.2	1.78	4.0E-01	0.02	+/-0.5	Pass
6	9975.0	9975.8	0.83	4.0E-01	0.01	+/-0.5	Pass
7	9983.4	9983.9	0.48	4.0E-01	0.00	+/-0.5	Pass
8	9969.7	9970.8	1.03	4.0E-01	0.01	+/-0.5	Pass

Excitation Diagnostic, 5V

Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
1	4977.1	4966.1	-11.0	4.6E+00	-0.22	+/-1.5	Pass
2	4974.6	4984.5	9.8	4.6E+00	0.20	+/-1.5	Pass
3	4996.9	5006.5	9.6	4.6E+00	0.19	+/-1.5	Pass
4	5005.5	5018.0	12.5	4.6E+00	0.25	+/-1.5	Pass
5	5001.9	5011.4	9.5	4.6E+00	0.19	+/-1.5	Pass
6	4979.8	4993.9	14.2	4.6E+00	0.28	+/-1.5	Pass
7	4990.1	5001.9	11.8	4.6E+00	0.24	+/-1.5	Pass
8	4978.2	4987.6	9.4	4.6E+00	0.19	+/-1.5	Pass

Excitation Diagnostic, 10V

Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
1	9975.5	9944.2	-31.3	5.4E+00	-0.31	+/-1.5	Pass
2	9969.3	9981.0	11.6	5.4E+00	0.12	+/-1.5	Pass
3	9984.9	9992.8	7.9	5.4E+00	0.08	+/-1.5	Pass
4	10010.7	10015.9	5.2	5.4E+00	0.05	+/-1.5	Pass
5	10009.4	10014.7	5.3	5.4E+00	0.05	+/-1.5	Pass
6	9975.0	9983.8	8.9	5.4E+00	0.09	+/-1.5	Pass
7	9983.4	9995.8	12.4	5.4E+00	0.12	+/-1.5	Pass
8	9969.7	9975.1	5.4	5.4E+00	0.05	+/-1.5	Pass

Excitation Source Output, 5V

Parameter	Chan	UUT (mV)	U (mV)	MIN (mV)	MAX (mV)	PASS/ FAIL
350 Ohm Load	1	4977.1	2.0E-01	4950	5050	Pass
" "	2	4974.6	2.0E-01	4950	5050	Pass
" "	3	4996.9	2.0E-01	4950	5050	Pass
" "	4	5005.5	2.0E-01	4950	5050	Pass
" "	5	5001.9	2.0E-01	4950	5050	Pass
" "	6	4979.8	2.0E-01	4950	5050	Pass
" "	7	4990.1	2.0E-01	4950	5050	Pass
" "	8	4978.2	2.0E-01	4950	5050	Pass
Rated Load	1	4974.4	1.9E-01	4900	5100	Pass
" "	2	4970.5	1.9E-01	4900	5100	Pass
" "	3	4992.8	1.9E-01	4900	5100	Pass
" "	4	5003.1	1.9E-01	4900	5100	Pass
" "	5	4999.0	1.9E-01	4900	5100	Pass
" "	6	4977.2	1.9E-01	4900	5100	Pass
" "	7	4986.6	1.9E-01	4900	5100	Pass
" "	8	4974.6	1.9E-01	4900	5100	Pass
Short Recovery	1	4978.9	1.9E-01	4900	5100	Pass
" "	2	4974.9	1.9E-01	4900	5100	Pass
" "	3	4996.1	1.9E-01	4900	5100	Pass
" "	4	5004.7	1.9E-01	4900	5100	Pass
" "	5	5001.1	1.9E-01	4900	5100	Pass
" "	6	4979.1	1.9E-01	4900	5100	Pass
" "	7	4989.5	1.9E-01	4900	5100	Pass
" "	8	4977.5	1.9E-01	4900	5100	Pass

Excitation Source Output, 10V

Parameter	Chan	UUT (mV)	U (mV)	MIN (mV)	MAX (mV)	PASS/ FAIL
350 Ohm Load	1	9975.5	4.0E-01	9950	10050	Pass
" "	2	9969.3	4.0E-01	9950	10050	Pass
" "	3	9984.9	4.0E-01	9950	10050	Pass
" "	4	10010.7	4.0E-01	9950	10050	Pass
" "	5	10009.4	4.0E-01	9950	10050	Pass
" "	6	9975.0	4.0E-01	9950	10050	Pass
" "	7	9983.4	4.0E-01	9950	10050	Pass
" "	8	9969.7	4.0E-01	9950	10050	Pass
Rated Load	1	9976.5	4.0E-01	9900	10100	Pass
" "	2	9970.9	4.0E-01	9900	10100	Pass
" "	3	9986.5	4.0E-01	9900	10100	Pass
" "	4	10011.8	4.0E-01	9900	10100	Pass
" "	5	10010.9	4.0E-01	9900	10100	Pass
" "	6	9976.1	4.0E-01	9900	10100	Pass
" "	7	9984.9	4.0E-01	9900	10100	Pass
" "	8	9971.2	4.0E-01	9900	10100	Pass
Overload	1	9974.8	4.0E-01	9800	10200	Pass
" "	2	9969.2	4.0E-01	9800	10200	Pass
" "	3	9983.6	4.0E-01	9800	10200	Pass
" "	4	10009.2	4.0E-01	9800	10200	Pass
" "	5	10007.3	4.0E-01	9800	10200	Pass
" "	6	9974.1	4.0E-01	9800	10200	Pass
" "	7	9982.0	4.0E-01	9800	10200	Pass
" "	8	9968.7	4.0E-01	9800	10200	Pass
Short Recovery	1	9975.4	4.0E-01	9800	10200	Pass
" "	2	9969.2	4.0E-01	9800	10200	Pass
" "	3	9984.9	4.0E-01	9800	10200	Pass
" "	4	10009.7	4.0E-01	9800	10200	Pass
" "	5	10008.2	4.0E-01	9800	10200	Pass
" "	6	9974.8	4.0E-01	9800	10200	Pass
" "	7	9982.8	4.0E-01	9800	10200	Pass
" "	8	9969.4	4.0E-01	9800	10200	Pass

DTS

Measurement Data
As Received

Serial #: LM0212
Order #: 65602
Date: 30 April 2021

DC Amplitude/Gain Accuracy

Gain	Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
8	1	-693.4	-693.7	-0.32	1.0E-01	-0.03	+/-0.5	Pass
"	1	-343.3	-343.5	-0.16	7.8E-02	-0.02	+/-0.5	Pass
"	1	340.7	340.8	0.15	8.3E-02	0.01	+/-0.5	Pass
"	1	685.0	685.4	0.32	9.3E-02	0.03	+/-0.5	Pass
"	2	-693.4	-693.7	-0.31	1.0E-01	-0.03	+/-0.5	Pass
"	2	-343.3	-343.4	-0.11	7.8E-02	-0.01	+/-0.5	Pass
"	2	340.7	340.8	0.11	8.3E-02	0.01	+/-0.5	Pass
"	2	685.0	685.3	0.29	9.3E-02	0.03	+/-0.5	Pass
"	3	-693.4	-693.8	-0.41	1.0E-01	-0.04	+/-0.5	Pass
"	3	-343.3	-343.5	-0.18	7.8E-02	-0.02	+/-0.5	Pass
"	3	340.7	340.9	0.22	8.3E-02	0.02	+/-0.5	Pass
"	3	685.0	685.5	0.44	9.3E-02	0.04	+/-0.5	Pass
"	4	-693.4	-693.8	-0.45	1.0E-01	-0.04	+/-0.5	Pass
"	4	-343.3	-343.5	-0.21	7.8E-02	-0.02	+/-0.5	Pass
"	4	340.7	340.9	0.24	8.3E-02	0.02	+/-0.5	Pass
"	4	685.0	685.5	0.46	9.3E-02	0.05	+/-0.5	Pass
"	5	-693.4	-693.8	-0.44	1.0E-01	-0.04	+/-0.5	Pass
"	5	-343.3	-343.5	-0.23	7.8E-02	-0.02	+/-0.5	Pass
"	5	340.7	340.9	0.21	8.3E-02	0.02	+/-0.5	Pass
"	5	685.0	685.5	0.44	9.3E-02	0.04	+/-0.5	Pass
"	6	-693.4	-693.8	-0.40	1.0E-01	-0.04	+/-0.5	Pass
"	6	-343.3	-343.5	-0.20	7.8E-02	-0.02	+/-0.5	Pass
"	6	340.7	340.8	0.16	8.3E-02	0.02	+/-0.5	Pass
"	6	685.0	685.4	0.34	9.3E-02	0.03	+/-0.5	Pass
"	7	-693.4	-693.8	-0.45	1.0E-01	-0.04	+/-0.5	Pass
"	7	-343.3	-343.5	-0.18	7.8E-02	-0.02	+/-0.5	Pass
"	7	340.7	340.9	0.27	8.3E-02	0.03	+/-0.5	Pass
"	7	685.0	685.6	0.52	9.3E-02	0.05	+/-0.5	Pass
"	8	-693.4	-693.9	-0.47	1.0E-01	-0.05	+/-0.5	Pass
"	8	-343.3	-343.5	-0.19	7.8E-02	-0.02	+/-0.5	Pass
"	8	340.7	340.9	0.22	8.3E-02	0.02	+/-0.5	Pass
"	8	685.0	685.5	0.48	9.3E-02	0.05	+/-0.5	Pass
16	1	-215.04	-215.17	-0.129	6.3E-02	-0.04	+/-0.5	Pass
"	1	-107.05	-107.09	-0.048	4.8E-02	-0.02	+/-0.5	Pass
"	1	106.25	106.32	0.070	5.0E-02	0.02	+/-0.5	Pass
"	1	212.42	212.54	0.115	7.9E-02	0.04	+/-0.5	Pass
"	2	-215.04	-215.13	-0.093	6.3E-02	-0.03	+/-0.5	Pass
"	2	-107.05	-107.09	-0.043	4.8E-02	-0.01	+/-0.5	Pass
"	2	106.25	106.31	0.057	5.0E-02	0.02	+/-0.5	Pass
"	2	212.42	212.53	0.113	7.9E-02	0.04	+/-0.5	Pass
"	3	-215.04	-215.21	-0.170	6.3E-02	-0.05	+/-0.5	Pass
"	3	-107.05	-107.12	-0.071	4.8E-02	-0.02	+/-0.5	Pass
"	3	106.25	106.33	0.086	5.0E-02	0.03	+/-0.5	Pass
"	3	212.42	212.56	0.139	7.9E-02	0.04	+/-0.5	Pass
"	4	-215.04	-215.16	-0.125	6.3E-02	-0.04	+/-0.5	Pass
"	4	-107.05	-107.11	-0.065	4.8E-02	-0.02	+/-0.5	Pass
"	4	106.25	106.31	0.064	5.0E-02	0.02	+/-0.5	Pass
"	4	212.42	212.55	0.129	7.9E-02	0.04	+/-0.5	Pass
"	5	-215.04	-215.14	-0.101	6.3E-02	-0.03	+/-0.5	Pass
"	5	-107.05	-107.09	-0.045	4.8E-02	-0.01	+/-0.5	Pass
"	5	106.25	106.34	0.086	5.0E-02	0.03	+/-0.5	Pass
"	5	212.42	212.55	0.128	7.9E-02	0.04	+/-0.5	Pass
"	6	-215.04	-215.18	-0.141	6.3E-02	-0.05	+/-0.5	Pass
"	6	-107.05	-107.12	-0.078	4.8E-02	-0.03	+/-0.5	Pass
"	6	106.25	106.32	0.068	5.0E-02	0.02	+/-0.5	Pass
"	6	212.42	212.57	0.149	7.9E-02	0.05	+/-0.5	Pass
"	7	-215.04	-215.17	-0.133	6.3E-02	-0.04	+/-0.5	Pass
"	7	-107.05	-107.12	-0.074	4.8E-02	-0.02	+/-0.5	Pass
"	7	106.25	106.32	0.074	5.0E-02	0.02	+/-0.5	Pass
"	7	212.42	212.56	0.138	7.9E-02	0.04	+/-0.5	Pass
"	8	-215.04	-215.16	-0.117	6.3E-02	-0.04	+/-0.5	Pass
"	8	-107.05	-107.11	-0.062	4.8E-02	-0.02	+/-0.5	Pass
"	8	106.25	106.34	0.090	5.0E-02	0.03	+/-0.5	Pass
"	8	212.42	212.56	0.144	7.9E-02	0.05	+/-0.5	Pass

DC Amplitude/Gain Accuracy

Gain	Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
32	1	-107.05	-107.10	-0.057	1.8E-02	-0.04	+/-0.5	Pass
"	1	-53.08	-53.10	-0.020	1.3E-02	-0.01	+/-0.5	Pass
"	1	52.82	52.86	0.037	1.3E-02	0.02	+/-0.5	Pass
"	1	106.25	106.32	0.072	1.6E-02	0.05	+/-0.5	Pass
"	2	-107.05	-107.10	-0.058	1.8E-02	-0.04	+/-0.5	Pass
"	2	-53.08	-53.11	-0.034	1.3E-02	-0.02	+/-0.5	Pass
"	2	52.82	52.85	0.028	1.3E-02	0.02	+/-0.5	Pass
"	2	106.25	106.33	0.074	1.6E-02	0.05	+/-0.5	Pass
"	3	-107.05	-107.11	-0.064	1.8E-02	-0.04	+/-0.5	Pass
"	3	-53.08	-53.13	-0.050	1.3E-02	-0.03	+/-0.5	Pass
"	3	52.82	52.86	0.045	1.3E-02	0.03	+/-0.5	Pass
"	3	106.25	106.33	0.079	1.6E-02	0.05	+/-0.5	Pass
"	4	-107.05	-107.12	-0.076	1.8E-02	-0.05	+/-0.5	Pass
"	4	-53.08	-53.12	-0.036	1.3E-02	-0.02	+/-0.5	Pass
"	4	52.82	52.87	0.051	1.3E-02	0.03	+/-0.5	Pass
"	4	106.25	106.32	0.072	1.6E-02	0.05	+/-0.5	Pass
"	5	-107.05	-107.11	-0.064	1.8E-02	-0.04	+/-0.5	Pass
"	5	-53.08	-53.11	-0.032	1.3E-02	-0.02	+/-0.5	Pass
"	5	52.82	52.83	0.016	1.3E-02	0.01	+/-0.5	Pass
"	5	106.25	106.33	0.079	1.6E-02	0.05	+/-0.5	Pass
"	6	-107.05	-107.12	-0.075	1.8E-02	-0.05	+/-0.5	Pass
"	6	-53.08	-53.11	-0.032	1.3E-02	-0.02	+/-0.5	Pass
"	6	52.82	52.86	0.037	1.3E-02	0.02	+/-0.5	Pass
"	6	106.25	106.32	0.069	1.6E-02	0.04	+/-0.5	Pass
"	7	-107.05	-107.12	-0.074	1.8E-02	-0.05	+/-0.5	Pass
"	7	-53.08	-53.11	-0.030	1.3E-02	-0.02	+/-0.5	Pass
"	7	52.82	52.87	0.051	1.3E-02	0.03	+/-0.5	Pass
"	7	106.25	106.33	0.081	1.6E-02	0.05	+/-0.5	Pass
"	8	-107.05	-107.11	-0.055	1.8E-02	-0.04	+/-0.5	Pass
"	8	-53.08	-53.11	-0.032	1.3E-02	-0.02	+/-0.5	Pass
"	8	52.82	52.86	0.044	1.3E-02	0.03	+/-0.5	Pass
"	8	106.25	106.32	0.073	1.6E-02	0.05	+/-0.5	Pass
128	1	-26.594	-26.655	-0.0611	5.6E-03	-0.16	+/-1.5	Pass
"	1	-13.323	-13.353	-0.0298	4.4E-03	-0.08	+/-1.5	Pass
"	1	13.243	13.275	0.0319	4.3E-03	0.08	+/-1.5	Pass
"	1	26.337	26.398	0.0612	6.8E-03	0.16	+/-1.5	Pass
"	2	-26.594	-26.658	-0.0639	5.6E-03	-0.16	+/-1.5	Pass
"	2	-13.323	-13.354	-0.0311	4.4E-03	-0.08	+/-1.5	Pass
"	2	13.243	13.275	0.0326	4.3E-03	0.08	+/-1.5	Pass
"	2	26.337	26.399	0.0617	6.8E-03	0.16	+/-1.5	Pass
"	3	-26.594	-26.655	-0.0614	5.6E-03	-0.16	+/-1.5	Pass
"	3	-13.323	-13.355	-0.0317	4.4E-03	-0.08	+/-1.5	Pass
"	3	13.243	13.275	0.0327	4.3E-03	0.08	+/-1.5	Pass
"	3	26.337	26.399	0.0621	6.8E-03	0.16	+/-1.5	Pass
"	4	-26.594	-26.658	-0.0640	5.6E-03	-0.16	+/-1.5	Pass
"	4	-13.323	-13.357	-0.0336	4.4E-03	-0.09	+/-1.5	Pass
"	4	13.243	13.276	0.0333	4.3E-03	0.09	+/-1.5	Pass
"	4	26.337	26.402	0.0646	6.8E-03	0.17	+/-1.5	Pass
"	5	-26.594	-26.658	-0.0614	5.6E-03	-0.16	+/-1.5	Pass
"	5	-13.323	-13.356	-0.0333	4.4E-03	-0.09	+/-1.5	Pass
"	5	13.243	13.276	0.0330	4.3E-03	0.08	+/-1.5	Pass
"	5	26.337	26.398	0.0610	6.8E-03	0.16	+/-1.5	Pass
"	6	-26.594	-26.656	-0.0623	5.6E-03	-0.16	+/-1.5	Pass
"	6	-13.323	-13.354	-0.0306	4.4E-03	-0.08	+/-1.5	Pass
"	6	13.243	13.275	0.0327	4.3E-03	0.08	+/-1.5	Pass
"	6	26.337	26.400	0.0625	6.8E-03	0.16	+/-1.5	Pass
"	7	-26.594	-26.658	-0.0641	5.6E-03	-0.16	+/-1.5	Pass
"	7	-13.323	-13.356	-0.0332	4.4E-03	-0.09	+/-1.5	Pass
"	7	13.243	13.275	0.0326	4.3E-03	0.08	+/-1.5	Pass
"	7	26.337	26.402	0.0651	6.8E-03	0.17	+/-1.5	Pass
"	8	-26.594	-26.658	-0.0639	5.6E-03	-0.16	+/-1.5	Pass
"	8	-13.323	-13.356	-0.0325	4.4E-03	-0.08	+/-1.5	Pass
"	8	13.243	13.275	0.0320	4.3E-03	0.08	+/-1.5	Pass
"	8	26.337	26.399	0.0622	6.8E-03	0.16	+/-1.5	Pass

DTS

Measurement Data
As Received

Serial #: LM0212
Order #: 65602
Date: 30 April 2021

DC Amplitude/Gain Accuracy

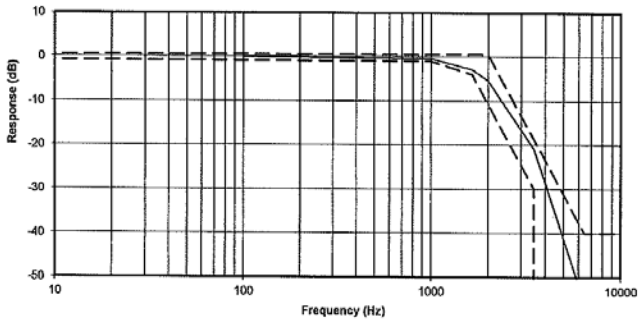
Gain	Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
512	1	-6.678	-6.692	-0.0137	4.4E-03	-0.14	+/-1.5	Pass
"	1	-3.314	-3.321	-0.0063	2.8E-03	-0.06	+/-1.5	Pass
"	1	3.292	3.298	0.0069	2.7E-03	0.07	+/-1.5	Pass
"	1	6.603	6.617	0.0141	4.2E-03	0.14	+/-1.5	Pass
"	2	-6.678	-6.695	-0.0166	4.4E-03	-0.17	+/-1.5	Pass
"	2	-3.314	-3.323	-0.0090	2.8E-03	-0.09	+/-1.5	Pass
"	2	3.292	3.301	0.0094	2.7E-03	0.10	+/-1.5	Pass
"	2	6.603	6.620	0.0172	4.2E-03	0.18	+/-1.5	Pass
"	3	-6.678	-6.695	-0.0165	4.4E-03	-0.17	+/-1.5	Pass
"	3	-3.314	-3.321	-0.0068	2.8E-03	-0.07	+/-1.5	Pass
"	3	3.292	3.300	0.0082	2.7E-03	0.08	+/-1.5	Pass
"	3	6.603	6.617	0.0140	4.2E-03	0.14	+/-1.5	Pass
"	4	-6.678	-6.694	-0.0156	4.4E-03	-0.16	+/-1.5	Pass
"	4	-3.314	-3.321	-0.0068	2.8E-03	-0.07	+/-1.5	Pass
"	4	3.292	3.299	0.0075	2.7E-03	0.08	+/-1.5	Pass
"	4	6.603	6.618	0.0153	4.2E-03	0.16	+/-1.5	Pass
"	5	-6.678	-6.694	-0.0162	4.4E-03	-0.17	+/-1.5	Pass
"	5	-3.314	-3.321	-0.0070	2.8E-03	-0.07	+/-1.5	Pass
"	5	3.292	3.300	0.0086	2.7E-03	0.09	+/-1.5	Pass
"	5	6.603	6.618	0.0149	4.2E-03	0.15	+/-1.5	Pass
"	6	-6.678	-6.696	-0.0174	4.4E-03	-0.18	+/-1.5	Pass
"	6	-3.314	-3.322	-0.0074	2.8E-03	-0.08	+/-1.5	Pass
"	6	3.292	3.298	0.0068	2.7E-03	0.07	+/-1.5	Pass
"	6	6.603	6.618	0.0149	4.2E-03	0.15	+/-1.5	Pass
"	7	-6.678	-6.697	-0.0185	4.4E-03	-0.19	+/-1.5	Pass
"	7	-3.314	-3.323	-0.0088	2.8E-03	-0.09	+/-1.5	Pass
"	7	3.292	3.301	0.0093	2.7E-03	0.10	+/-1.5	Pass
"	7	6.603	6.620	0.0172	4.2E-03	0.18	+/-1.5	Pass
"	8	-6.678	-6.695	-0.0162	4.4E-03	-0.17	+/-1.5	Pass
"	8	-3.314	-3.320	-0.0061	2.8E-03	-0.06	+/-1.5	Pass
"	8	3.292	3.299	0.0079	2.7E-03	0.08	+/-1.5	Pass
"	8	6.603	6.619	0.0162	4.2E-03	0.17	+/-1.5	Pass
2000	1	-1.745	-1.752	-0.0071	4.8E-03	-0.29	+/-1.5	Pass
"	1	-0.874	-0.878	-0.0042	3.2E-03	-0.17	+/-1.5	Pass
"	1	0.868	0.874	0.0052	2.5E-03	0.21	+/-1.5	Pass
"	1	1.740	1.747	0.0069	5.0E-03	0.28	+/-1.5	Pass
"	2	-1.745	-1.750	-0.0049	4.8E-03	-0.19	+/-1.5	Pass
"	2	-0.874	-0.877	-0.0036	3.2E-03	-0.14	+/-1.5	Pass
"	2	0.868	0.871	0.0025	2.5E-03	0.10	+/-1.5	Pass
"	2	1.740	1.746	0.0060	5.0E-03	0.24	+/-1.5	Pass
"	3	-1.745	-1.751	-0.0057	4.8E-03	-0.23	+/-1.5	Pass
"	3	-0.874	-0.877	-0.0027	3.2E-03	-0.11	+/-1.5	Pass
"	3	0.868	0.870	0.0016	2.5E-03	0.07	+/-1.5	Pass
"	3	1.740	1.745	0.0044	5.0E-03	0.18	+/-1.5	Pass
"	4	-1.745	-1.753	-0.0080	4.8E-03	-0.32	+/-1.5	Pass
"	4	-0.874	-0.877	-0.0035	3.2E-03	-0.14	+/-1.5	Pass
"	4	0.868	0.872	0.0033	2.5E-03	0.13	+/-1.5	Pass
"	4	1.740	1.748	0.0072	5.0E-03	0.29	+/-1.5	Pass
"	5	-1.745	-1.751	-0.0056	4.8E-03	-0.23	+/-1.5	Pass
"	5	-0.874	-0.878	-0.0041	3.2E-03	-0.16	+/-1.5	Pass
"	5	0.868	0.873	0.0045	2.5E-03	0.18	+/-1.5	Pass
"	5	1.740	1.748	0.0075	5.0E-03	0.30	+/-1.5	Pass
"	6	-1.745	-1.751	-0.0053	4.8E-03	-0.21	+/-1.5	Pass
"	6	-0.874	-0.877	-0.0035	3.2E-03	-0.14	+/-1.5	Pass
"	6	0.868	0.872	0.0036	2.5E-03	0.15	+/-1.5	Pass
"	6	1.740	1.747	0.0062	5.0E-03	0.25	+/-1.5	Pass
"	7	-1.745	-1.750	-0.0050	4.8E-03	-0.20	+/-1.5	Pass
"	7	-0.874	-0.876	-0.0026	3.2E-03	-0.10	+/-1.5	Pass
"	7	0.868	0.872	0.0033	2.5E-03	0.13	+/-1.5	Pass
"	7	1.740	1.746	0.0060	5.0E-03	0.24	+/-1.5	Pass
"	8	-1.745	-1.749	-0.0039	4.8E-03	-0.16	+/-1.5	Pass
"	8	-0.874	-0.876	-0.0024	3.2E-03	-0.10	+/-1.5	Pass
"	8	0.868	0.871	0.0030	2.5E-03	0.12	+/-1.5	Pass
"	8	1.740	1.745	0.0051	5.0E-03	0.20	+/-1.5	Pass

DTS

Measurement Data
As Received

Serial #: LM0212
Order #: 65602
Date: 30 April 2021

Filter Response vs. SAE J211 Class 1000 Corridor
(All 8 Channels Overlapped)



SAE J211 Class 1000 Filter Response
(2V p-p Sine Input, with Software Filter)

Chan	Input (Hz)	UUT (mV)	U (mV)	UUT (dB)	MIN (dB)	MAX (dB)	PASS/ FAIL
1	100	705.4	8.0E+00	0.00	-0.88	0.50	Pass
1	1000	673.2	8.0E+00	-0.41	-1.00	0.50	Pass
1	1650	509.1	7.5E+00	-2.83	-4.00	0.50	Pass
1	2000	379.9	5.6E+00	-5.38	-10.66	0.50	Pass
1	3496	63.71	4.6E-01	-20.88	-30.00	-18.84	Pass
1	6441	1.167	2.6E-02	-55.63	-inf	-40.00	Pass
2	100	704.8	8.0E+00	0.00	-0.88	0.50	Pass
2	1000	673.2	8.0E+00	-0.40	-1.00	0.50	Pass
2	1650	509.9	7.5E+00	-2.81	-4.00	0.50	Pass
2	2000	380.9	5.6E+00	-5.35	-10.66	0.50	Pass
2	3496	64.24	4.6E-01	-20.80	-30.00	-18.84	Pass
2	6441	1.179	2.6E-02	-55.53	-inf	-40.00	Pass
3	100	705.2	8.0E+00	0.00	-0.88	0.50	Pass
3	1000	673.3	8.0E+00	-0.40	-1.00	0.50	Pass
3	1650	509.6	7.5E+00	-2.82	-4.00	0.50	Pass
3	2000	380.4	5.6E+00	-5.36	-10.66	0.50	Pass
3	3496	63.95	4.6E-01	-20.85	-30.00	-18.84	Pass
3	6441	1.166	2.6E-02	-55.63	-inf	-40.00	Pass
4	100	704.8	8.0E+00	0.00	-0.88	0.50	Pass
4	1000	672.1	8.0E+00	-0.41	-1.00	0.50	Pass
4	1650	507.7	7.5E+00	-2.85	-4.00	0.50	Pass
4	2000	378.5	5.6E+00	-5.40	-10.66	0.50	Pass
4	3496	63.27	4.6E-01	-20.94	-30.00	-18.84	Pass
4	6441	1.165	2.6E-02	-55.64	-inf	-40.00	Pass

SAE J211 Class 1000 Filter Response
(2V p-p Sine Input, with Software Filter)

Chan	Input (Hz)	UUT (mV)	U (mV)	UUT (dB)	MIN (dB)	MAX (dB)	PASS/ FAIL
5	100	705.3	8.0E+00	0.00	-0.88	0.50	Pass
5	1000	673.2	8.0E+00	-0.40	-1.00	0.50	Pass
5	1650	509.4	7.5E+00	-2.83	-4.00	0.50	Pass
5	2000	380.2	5.6E+00	-5.37	-10.66	0.50	Pass
5	3496	63.86	4.6E-01	-20.86	-30.00	-18.84	Pass
5	6441	1.167	2.6E-02	-55.62	-inf	-40.00	Pass
6	100	705.4	8.0E+00	0.00	-0.88	0.50	Pass
6	1000	673.4	8.0E+00	-0.40	-1.00	0.50	Pass
6	1650	509.5	7.5E+00	-2.83	-4.00	0.50	Pass
6	2000	380.3	5.6E+00	-5.37	-10.66	0.50	Pass
6	3496	63.97	4.6E-01	-20.85	-30.00	-18.84	Pass
6	6441	1.178	2.6E-02	-55.54	-inf	-40.00	Pass
7	100	705.6	8.0E+00	0.00	-0.88	0.50	Pass
7	1000	673.4	8.0E+00	-0.41	-1.00	0.50	Pass
7	1650	509.2	7.5E+00	-2.83	-4.00	0.50	Pass
7	2000	380.0	5.6E+00	-5.38	-10.66	0.50	Pass
7	3496	63.75	4.6E-01	-20.88	-30.00	-18.84	Pass
7	6441	1.168	2.6E-02	-55.62	-inf	-40.00	Pass
8	100	705.9	8.0E+00	0.00	-0.88	0.50	Pass
8	1000	672.8	8.0E+00	-0.42	-1.00	0.50	Pass
8	1650	507.9	7.5E+00	-2.86	-4.00	0.50	Pass
8	2000	378.5	5.6E+00	-5.41	-10.66	0.50	Pass
8	3496	63.06	4.6E-01	-20.98	-30.00	-18.84	Pass
8	6441	1.155	2.6E-02	-55.73	-inf	-40.00	Pass

Fixed Filter Response
(2V p-p Sine Input, no Software Filter)

Chan	Input (Hz)	UUT (mV)	U (mV)	UUT (dB)	MIN (dB)	MAX (dB)	PASS/ FAIL
1	4300	497.5	5.7E+00	-3.03	-3.50	-2.50	Pass
2	4300	502.9	5.7E+00	-2.93	-3.50	-2.50	Pass
3	4300	499.5	5.7E+00	-3.00	-3.50	-2.50	Pass
4	4300	493.6	5.7E+00	-3.09	-3.50	-2.50	Pass
5	4300	498.7	5.7E+00	-3.01	-3.50	-2.50	Pass
6	4300	500.4	5.7E+00	-2.98	-3.50	-2.50	Pass
7	4300	497.8	5.7E+00	-3.03	-3.50	-2.50	Pass
8	4300	491.0	5.7E+00	-3.15	-3.50	-2.50	Pass

** End of Report **

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Fax: +1 (716) 685 3886

www.endevco.com

Calibration Certificate

Document number: **58640**
Description: **2 Arm PR accelerometer**
Manufacturer: **ENDEVCO**
Model Number: **7264-2000TZ**
Serial Number: **J58827**

Temperature (°C): 25 , (°F): 77
Relative Humidity (%): 51
Input Resistance (ohms): 2681

ZMO (mV): -7.2
Resonance Frequency (Hz): 25971

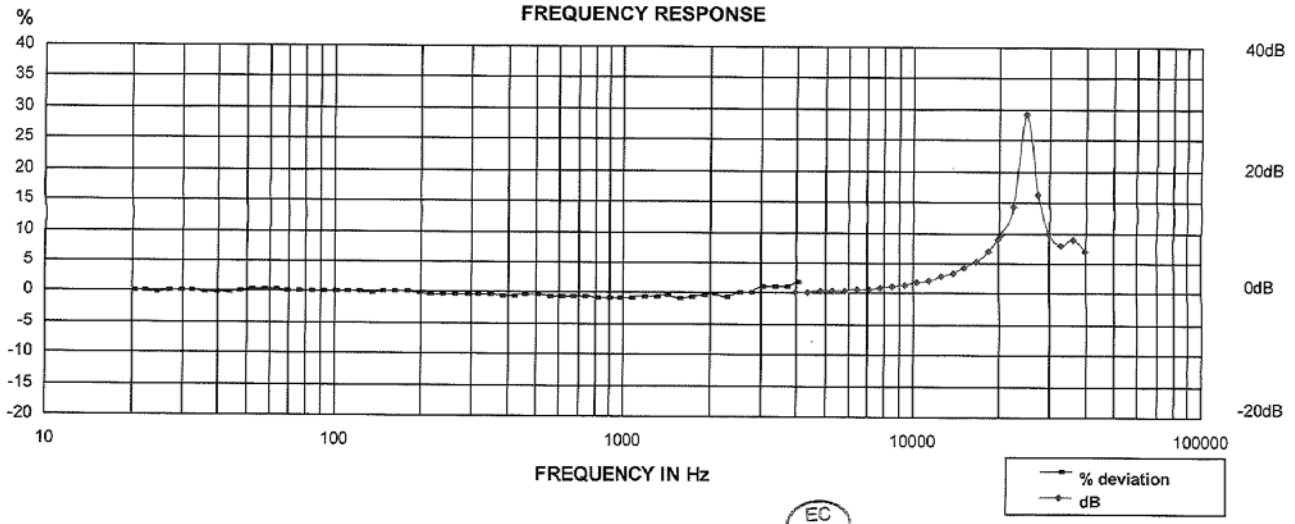
Transverse Sensitivity (%): 1.0

Sensitivity:

0.2742 mV/g @ 100 Hz, 10g pk
0.02796 mV/ m/s² @ 100 Hz, 98 m/s² pk

Excitation: 10.0 V

Notes:



EC 4564

Console S/N:	**AC37**
Exciter name:	2901
Ref Manufacturer:	ENDEVCO
Ref Model number:	2270M7A
Ref Serial number:	AC71
Traceability #:	NIST 683/290325-18
Test Name:	FINAL 2901 REV G

Uncertainty estimate (95% confidence, k=2)

+/- 1.0 %	100.0 Hz Sensitivity
+/- 1.0 %	10.0 < f <= 100.0 Hz
+/- 1.0 %	100.0 < f <= 10000.0 Hz
+/- 2.1 %	10000.0 < f <= 15000.0 Hz
+/- 3.5 %	15000.0 < f <= 20000.0 Hz

By:_____
EBONY COLES
Test Date: 8/24/2020 7:18 AM
Print Date: 8/24/2020

MOC - PR SBU
s/w 11.7

ilac-MRA ACCREDITED CE
CALIBRATION CERT #1862.02

ED421 Rev U
Page 1 of 1

This instrument was tested using comparison calibrations on Endevco's Automated Accelerometer Calibration System (AACS) PN 68357. This calibration is traceable to the National Metrology Institute (NMI: NIST, PTB, etc.) and is in accordance with ISO/IEC 17025-2005 and ANSI/NCSL Z540-1-1994 (MIL-STD 45662A). Test procedure follows CL-TP-004. Transverse Sensitivity, when provided, was calibrated with uncertainty at 0.27% of output.

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www.endevco.com

Calibration Certificate

Document number: 58641
Description: 2 Arm PR accelerometer
Manufacturer: ENDEVCO
Model Number: 7264-2000TZ
Serial Number: J58856

Temperature (°C): 25 , (°F): 77
Relative Humidity (%): 52
Input Resistance (ohms): 2974

ZMO (mV): 9.5
Resonance Frequency (Hz): 25996

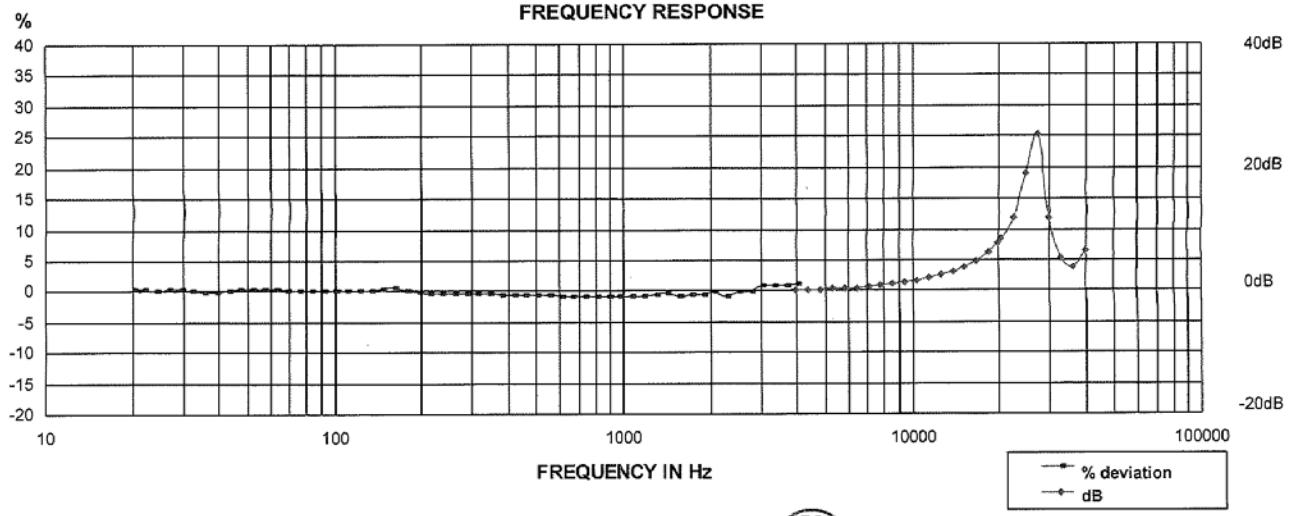
Transverse Sensitivity (%): 0.4

Sensitivity:

0.2746 mV/g @ 100 Hz, 10g pk
0.02800 mV/ m/s² @ 100 Hz, 98 m/s² pk

Excitation: 10.0 V

Notes:



Console S/N:	AC37
Exciter name:	2901
Ref Manufacturer:	ENDEVCO
Ref Model number:	2270M7A
Ref Serial number:	AC71
Traceability #:	NIST 683/290325-18
Test Name:	FINAL 2901 REV G

Uncertainty estimate (95% confidence, k=2)

+/- 1.0 %	100.0 Hz Sensitivity
+/- 1.0 %	10.0 < f <= 100.0 Hz
+/- 1.0 %	100.0 < f <= 10000.0 Hz
+/- 2.1 %	10000.0 < f <= 15000.0 Hz
+/- 3.5 %	15000.0 < f <= 20000.0 Hz

EC 4564

By: EBONY COLES
Test Date: 8/24/2020 7:26 AM
Print Date: 8/24/2020

MOC - PR SBU
s/w 11.7

ilac-MRA A2LA ACCREDITED CE
CALIBRATION CERT #1862.02

ED421 Rev U
Page 1 of 1

This instrument was tested using comparison calibrations on Endevco's Automated Accelerometer Calibration System (AACS) PN 68357. This calibration is traceable to the National Metrology Institute (NMI: NIST, PTB, etc.) and is in accordance with ISO/IEC 17025-2005 and ANSI/NCSL Z540-1-1994 (MIL-STD 45662A). Test procedure follows CL-TP-004. Transverse Sensitivity, when provided, was calibrated with uncertainty at 0.27% of output. This certificate shall not be reproduced, except in full, without written approval of PCB Piezotronics of NC, Inc. d/b/a Endevco.

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED
Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z100586:332861

7264-2000 - ENDEVCO - ACCELEROMETER

SERIAL NUMBER:	J58060	WORK ORDER:	332861
ASSET NUMBER:	Z100586	TEST RESULT:	PASS
CUST ASSET NUMBER:	N/A	PERFORMED ON:	09/09/20
PROCEDURE NAME:	MOD 9155	CAL DUE DATE:	09/09/21
PROCEDURE REV:	1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Jesse Cross	TEMPERATURE:	22 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	44 %
PRIMARY CONTACT:	Scott Arsen		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2194	2194:1486363644	9155 - MODAL SHOP - ACCELEROMETER CAL SYSTEM	04/30/2020	04/30/2021
2270	2270:1505812061	34401A - AGILENT - DIGITAL MULTIMETER	10/13/2019	10/13/2020
2998	529030000004453	42280 - EXTECH - DATA LOGGER	05/08/2020	05/08/2021

QA Signature: John M. Burns Date: 9/9/2020 10:32:50 AM

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z147458:352343

7264-2000 - ENDEVCO - ACCELEROMETER

SERIAL NUMBER:	J58671	WORK ORDER:	352343
ASSET NUMBER:	Z147458	TEST RESULT:	PASS
CUST ASSET NUMBER:	N/A	PERFORMED ON:	12/30/20
PROCEDURE NAME:	MOD 9155	CAL DUE DATE:	12/30/21
PROCEDURE REV:	1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Michael Priestley	TEMPERATURE:	23 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	37 %
PRIMARY CONTACT:	Scott Arsen		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2194	2194:1486363644	9155 - MODAL SHOP - ACCELEROMETER CAL SYSTEM	04/30/2020	04/30/2021
2270	2270:1505812061	34401A - AGILENT - DIGITAL MULTIMETER	10/15/2020	10/15/2021
2998	529030000004453	42280 - EXTECH - DATA LOGGER	05/08/2020	05/08/2021

QA Signature: [signature] Date: 1/4/2021 5:18:51 AM

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www.endevco.com

Calibration Certificate

Document number: **58642**
Description: **2 Arm PR accelerometer**
Manufacturer: **ENDEVCO**
Model Number: **7264-2000TZ**
Serial Number: **J58857**

Temperature (°C): 25 , (°F): 76
Relative Humidity (%): 52
Input Resistance (ohms): 2634

ZMO (mV): 18.5
Resonance Frequency (Hz): 23618

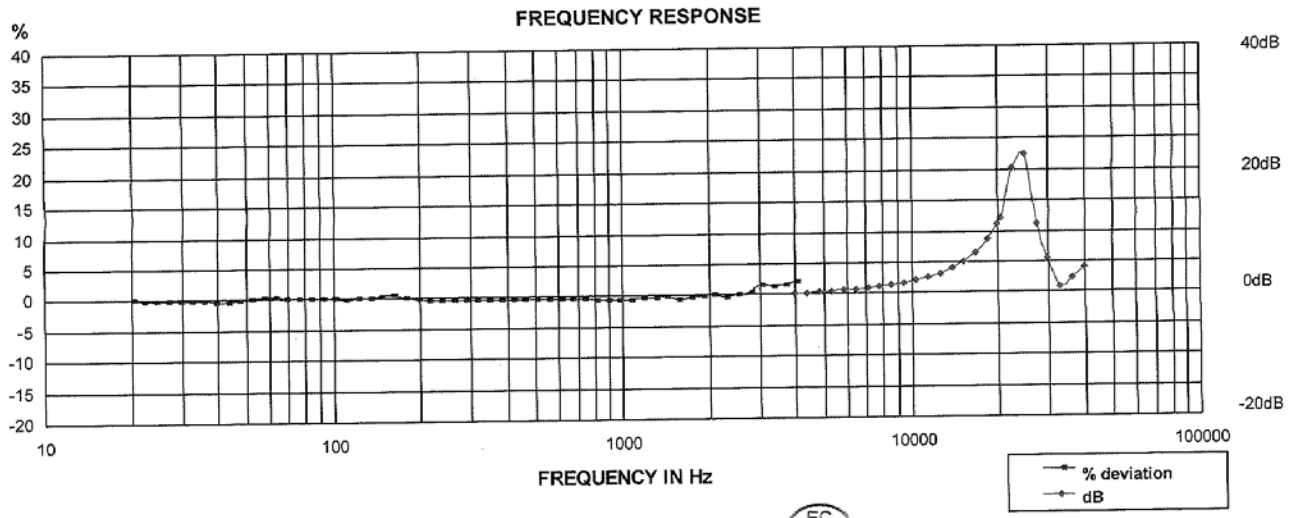
Transverse Sensitivity (%): 0.5

Sensitivity:

0.2730 mV/g @ 100 Hz, 10g pk
0.02784 mV/ m/s² @ 100 Hz, 98 m/s² pk

Excitation: 10.0 V

Notes:



EC 4564

Console S/N:	**AC37**
Exciter name:	2901
Ref Manufacturer:	ENDEVCO
Ref Model number:	2270M7A
Ref Serial number:	AC71
Traceability #:	NIST 683/290325-18
Test Name:	FINAL 2901 REV G

Uncertainty estimate (95% confidence, k=2)

+/- 1.0 %	100.0 Hz Sensitivity
+/- 1.0 %	10.0 < f <= 100.0 Hz
+/- 1.0 %	100.0 < f <= 10000.0 Hz
+/- 2.1 %	10000.0 < f <= 15000.0 Hz
+/- 3.5 %	15000.0 < f <= 20000.0 Hz

By:_____
EBONY COLES
Test Date: 8/24/2020 7:34 AM
Print Date: 8/24/2020

MOC - PR SBU
s/w 11.7

ilac-MRA A2LA ACCREDITED CE
CALIBRATION CERT #1862.02

ED421 Rev U
Page 1 of 1

This instrument was tested using comparison calibrations on Endevco's Automated Accelerometer Calibration System (AACS) PN 68357. This calibration is traceable to the National Metrology Institute (NMI: NIST, PTB, etc.) and is in accordance with ISO/IEC 17025-2005 and ANSI/NCSL Z540-1-1994 (MIL-STD 45662A). Test procedure follows CL-TP-004. Transverse Sensitivity, when provided, was calibrated with uncertainty at 0.27% of output. This certificate shall not be reproduced, except in full, without written approval of PCB Piezotronics of NC, Inc. d/b/a Endevco.

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z93371:349236

7264-2000TZ - ENDEVCO - ACCELEROMETER

SERIAL NUMBER:	J40863	WORK ORDER:	349236
ASSET NUMBER:	Z93371	TEST RESULT:	PASS
CUST ASSET NUMBER:	N/A	PERFORMED ON:	12/04/20
PROCEDURE NAME:	MOD 9155	CAL DUE DATE:	12/04/21
PROCEDURE REV:	1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Michael Priestley	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	33 %
PRIMARY CONTACT:	Scott Arsen		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2194	2194:1486363644	9155 - MODAL SHOP - ACCELEROMETER CAL SYSTEM	04/30/2020	04/30/2021
2270	2270:1505812061	34401A - AGILENT - DIGITAL MULTIMETER	10/15/2020	10/15/2021
2998	529030000004453	42280 - EXTECH - DATA LOGGER	05/08/2020	05/08/2021

QA Signature: John Van Buren Date: 12/7/2020 5:10:50 AM

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED
Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z100585:332864

7264-2000 - ENDEVCO - ACCELEROMETER

SERIAL NUMBER:	J58059	WORK ORDER:	332864
ASSET NUMBER:	Z100585	TEST RESULT:	PASS
CUST ASSET NUMBER:	N/A	PERFORMED ON:	09/09/20
PROCEDURE NAME:	MOD 9155	CAL DUE DATE:	09/09/21
PROCEDURE REV:	1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Jesse Cross	TEMPERATURE:	22 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	44 %
PRIMARY CONTACT:	Scott Arsen		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2194	2194:1486363644	9155 - MODAL SHOP - ACCELEROMETER CAL SYSTEM	04/30/2020	04/30/2021
2270	2270:1505812061	34401A - AGILENT - DIGITAL MULTIMETER	10/13/2019	10/13/2020
2998	529030000004453	42280 - EXTECH - DATA LOGGER	05/08/2020	05/08/2021

QA Signature: John M. Burns Date: 9/9/2020 10:33:12 AM

NovaStar SOLUTIONS
Metrology Management Services

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Calibration Certificate AMENDED

ACCREDITED Calibration #1277.01

Certificate # Z93368:331465

7264-2000TZ - ENDEVCO - ACCELEROMETER

SERIAL NUMBER:	J32173	WORK ORDER:	331465
ASSET NUMBER:	Z93368	TEST RESULT:	PASS
CUST ASSET NUMBER:	N/A	PERFORMED ON:	08/28/20
PROCEDURE NAME:	MOD 9155	CAL DUE DATE:	08/28/21
PROCEDURE REV:	1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Jesse Cross	TEMPERATURE:	22 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	44 %
PRIMARY CONTACT:	Scott Arsen		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	Previous fails due to backend accel template being incorrect. Issue has been amended.
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2194	2194:1486363644	9155 - MODAL SHOP - ACCELEROMETER CAL SYSTEM	04/30/2020	04/30/2021
2270	2270:1505812061	34401A - AGILENT - DIGITAL MULTIMETER	10/13/2019	10/13/2020
2998	529030000004453	42280 - EXTECH - DATA LOGGER	05/08/2020	05/08/2021

QA Signature: Date: 8/31/2020 6:52:42 AM

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED
Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z100587:332852

7264-2000 - ENDEVCO - ACCELEROMETER

SERIAL NUMBER:	J58061	WORK ORDER:	332852
ASSET NUMBER:	Z100587	TEST RESULT:	PASS
CUST ASSET NUMBER:	N/A	PERFORMED ON:	09/09/20
PROCEDURE NAME:	MOD 9155	CAL DUE DATE:	09/09/21
PROCEDURE REV:	1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Jesse Cross	TEMPERATURE:	22 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	44 %
PRIMARY CONTACT:	Scott Arsen		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2194	2194:1486363644	9155 - MODAL SHOP - ACCELEROMETER CAL SYSTEM	04/30/2020	04/30/2021
2270	2270:1505812061	34401A - AGILENT - DIGITAL MULTIMETER	10/13/2019	10/13/2020
2998	529030000004453	42280 - EXTECH - DATA LOGGER	05/08/2020	05/08/2021

QA Signature: Date: 9/9/2020 10:32:29 AM

Calibration Certificate

Model: Prime

Calibration Date: 2021-05-17 (YYYY-MM-DD)

Certificate #: R10021311437-20210517-112P

Serial #: R10-02-13-11437

Measurement Standards Traceability

Kinematic Scale Bar- Short	Asset Number: 4541	Calibration Due Date: 8/8/2021	*SI Traceability: 6805ca2b-29a8-dd9b-fdb4-009c47a8e371
Kinematic Scale Bar- Long	Asset Number: 4540	Calibration Due Date: 8/8/2021	*SI Traceability: 6805ca2b-29a8-dc9b-e271-009c4740f32e
Thermometer	Asset Number: 4279	Calibration Due Date: 6/25/2021	*SI Traceability: 17-C8144C-20-1
Calibration Probe	Asset Number: 4652	Calibration Due Date: 1/30/2022	*SI Traceability:
Reference Sphere	Asset Number: 3873	Calibration Due Date: 1/30/2022	*SI Traceability: 20-449-01939

The artifacts above have been calibrated with a device traceable to the International System of Units (SI) through a National Metrological Institute (NMI) or through an ISO17025 Accredited Laboratory.
See attached data for measurement results.

Calibration Results*

		Specification	Measurement	Result (Pass/Fail)
3 Single Point Articulation Tests at <=20%, 20%-80% and >=80% range	mm	0.042	0.023	PASSED
1 Effective diameter sphere test	mm	0.021	0.003	PASSED
20 Volumetric ball bar tests in 4 quadrants and 2 orientations	mm	+/-0.059	0.036	PASSED

Instrument condition as received (AS FOUND):
Not within specification

Instrument condition outgoing (AS LEFT):
Within specifications

This certificate invalidates all other certificates generated before: 2021-05-17 9:22:03 AM
This certificate shall not be reproduced, except in full, without permission of FARO Technologies, Inc.
The results of this certificate relate only to the items calibrated or tested.
Calibration Standard Used: ASME B89.4.22-2004.

Approved by Technician: Jundee Apaisom
Date: 2021-05-17

FARO Technologies Inc
PH1:1-800-736-2771
PH2:407-333-9911
FAX:407-333-8056
125 Technology Park
Lake Mary, FL 32746
USA

KAR
5/21/21

Cert # L-1147-1 Calibration

ANAB ACCREDITED ISO/IEC 17025 CALIBRATION LABORATORY

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED
Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z52538:359849

PRO 360 - GENERIC - DIGITAL PROTRACTOR

SERIAL NUMBER:	N/A	WORK ORDER:	359849
ASSET NUMBER:	Z52538	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00821	PERFORMED ON:	02/17/21
PROCEDURE NAME:	MIT - PRO 360 - MMC	CAL DUE DATE:	02/17/22
PROCEDURE REV:	1.1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	WILLIAM FRENCH	TEMPERATURE:	22 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	28 %
PRIMARY CONTACT:	Scott Arsen		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

This report may not be reproduced, except in full, without written approval from NovaStar Solutions.

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
2116	2116:1455281491	42280 - EXTECH - DATA LOGGER	03/12/2020	03/12/2021
2222	2222:1494506043	550-050 - YUASA - ROTARY TABLE	05/11/2017	05/11/2022

QA Signature:

Date: 2/17/2021 12:47:22 PM

Tape Measure Calibration Certificate

Reference Steel Rule

Brand: Swanson
S/N: MGA00798
Calibration Date: 12/09/2020

Subject Tape Measure

Brand: Stanley
S/N: TPM007-58
Calibration Date: 01/04/2021

Reference in (mm)	Subject Tape Measure		Difference	
	Pull	Push	Pull	Push
0 (0)	0	0	0	0
4 (100)	100	99	0	-1
8 (200)	200	199	0	-1
12 (300)	300	299	0	-1
16 (400)	400	399	0	-1
20 (500)	500	499	0	-1
24 (600)	600	599	0	-1
28 (700)	700	699	0	-1
32 (800)	800	799	0	-1
35 (875)	875	874	0	-1

If all differences are ± 1/32 of an inch (1 mm), then the tape measure is acceptable.

Pass * Fail _____ Maximum Difference = 1mm

Date: 01/04/2021 Performed By: Scott Arsen

All calibrations are traceable to the National Institute of Standards and Technology. Estimated uncertainty of the measurement is ± 0.164%. All certification data and equipment are on file for inspection at your request. Best uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor k=2.

MADGETECH
WE BUILD DATA LOGGERS

CERTIFICATE OF CALIBRATION

ilac-MRA ANAB ANSI National Accreditation Board ACCREDITED ISO/IEC 17025 CALIBRATION LABORATORY AC-2481

ACCREDITED CERTIFICATE NUMBER: NC-20-08-31-052

Device ID:	MultiChannel	Calibration laboratory environmental conditions:	18 °C – 25 °C, 20 %RH – 55 %RH
Issued to:	MGA Research Corporation Troy, MI 48083 USA	Calibration Date:	2020-08-31
		MadgeTech Calibration Laboratory uses the shared risk approach as defined in ILAC G8 when making compliance statements	

RHTemp1000IS - Temperature - **Serial Number: R20534**

Published Device Specifications **Calibrated using MadgeTech WI No:** 320420

Calibrated Accuracy:	±0.50 °C	**Resolution:**	0.01 °C
Calibrated Accuracy Range:	0 °C to 55 °C		

Channel 1 - Units of °C — Expanded Uncertainty is not applied to Device Error

Temperature Env. Temperature	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device - Standard	DUT Corrected Device As Left	Device Error = Device - Standard	Expanded Uncertainty Expressed at approx. 95% confidence level using coverage factor k = 2
-	25.17	25.16	-0.01	25.17	0.00	0.12

	Initial Correction Values	Applied Correction Values
Gain:	1	1
Offset:	0.036 °C	0.027 °C

RHTemp1000IS - Humidity - **Serial Number: R20534**

Published Device Specifications **Calibrated using MadgeTech WI No:** 320420

Calibrated Accuracy:	±3.0 % RH	**Resolution:**	0.1 % RH
Calibrated Accuracy Range:	25 % RH to 75 % RH		

9/4/2020

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z54487:351708

AP-20 - DETECTO - SCALE

SERIAL NUMBER:	E10807-0187	WORK ORDER:	JW1122220003
ASSET NUMBER:	Z54487	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00783	PERFORMED ON:	12/22/20
PROCEDURE NAME:	122-040	CAL DUE DATE:	12/22/21
PROCEDURE REV:	B	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Jay Wismer	TEMPERATURE:	23 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	34 %
PRIMARY CONTACT:	Scott Arsen		

This instrument has been processed and calibrated in accordance with the NovaStar Solutions Quality System Manual. All calibrations are traceable to the National Institute of Standards and Technology (NIST) or to another National Metrology Institute to the International System of Units (SI units), acceptable intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. The NovaStar Solutions quality system is accredited ISO/IEC 17025 and ANSI/NCSL Z540-1-1994.

The results reported herein apply only to the calibration of the item described above. No sampling plan was used for this calibration.

Where statements of compliance are made, the measurement uncertainty is not factored in unless otherwise noted. Expanded uncertainties are expressed at the approximate 95% level of confidence using a K=2. Due to any number of factors, the recommended due date on the item does not imply continuing conformance to specifications during the recommended interval. Unless otherwise stated the unit under test meets or exceeds manufacturer specifications.

For range and best measurement capability specifications for the standards used to perform this calibration, see the most recent calibration report maintained by this calibration laboratory (available upon request).

AS RECEIVED CONDITION:	In Tolerance	REMARKS:	N/A
AS RETURNED CONDITION:	In Tolerance		
ACTION TAKEN:	FULL CALIBRATION		

Standards Used

Asset #	Cert #	Description	Cal Date	Due Date
1633	1633:1193663229	CLASS 6 - RICE LAKE - 17 PC. WEIGHT SET	07/23/2020	07/23/2021
2116	2116:1455281491	42280 - EXTECH - DATA LOGGER	03/12/2020	03/12/2021
2201	529030000003900	CLASS 6 - RICELAKE - 11 PIECE WEIGHT SET	06/10/2020	06/10/2021

QA Signature: [signature] Date: 12/22/2020 12:35:47 PM

KAR
1/11/21

Standard Scale & Supply Co.
Serving Industry Since 1946

25421 Glendale Ave.
Redford MI 48239
Ph.: 313-255-6700
Fax: 313-255-6799
www.standardscale.com

Calibration Certificate

TEST NO: SS-08-20-6118 **TEST DATE:** 08-20-2020 **NEXT DUE:** August 2021 **PAGE 2 OF** 2

CALIBRATED FOR:
MGA Research
2839 Elliott Ave.
Troy, MI 48083

CALIBRATED BY:
Company: Standard Scale
Technician: NGP
Vehicle ID: 98

CONTACT: David Burkett **PHONE:** 248-560-5201 **FAX:**

ITEMS SERVICED: Intercomp SW500, S/N: 0128MA14010, ID: B, Capacity Per Platform: 700 kg X 0.5 kg

ENVIRONMENTAL FACTORS : Ambient temperature and humidity not recorded.

TEST WEIGHT STANDARDS USED: Vehicle 98 test weights on file. Test report copies available upon request.

All calibrations are performed in compliance with the specifications set forth in N.I.S.T. Handbook 44, "Specifications, Tolerances and Other Technical Requirements for Weighing and Measuring Devices" – current edition, using methods and procedures set forth therein, and also as recommended by the original equipment manufacturers. Calibration services were performed under a controlled Quality Assurance Program, which complies with ISO/IEC 17025:2005. All test weight standards in use for calibration are traceable through the National Institute of Standards and Technology (N.I.S.T) to the International System of Units (SI).

LINEAR CALIBRATION

(to establish proper and correct weighment)

Test Load	Weights Applied	AS FOUND	As Found Error (±)	AS LEFT	As Left Error (±)	Tolerance (±)	Accepted/Rejected	
Zero Balance	0 lb	0.0 kg	--	0.0 kg	--	0.5 kg	ACC	REJ
LEFT FRONT	250 lb	113.5 kg	--	113.5 kg	--	0.5 kg	ACC	REJ
Maximum Test Load	1000 lb	453.5 kg	--	453.5 kg	--	1.0 kg	ACC	REJ
Test Load	Weights Applied	AS FOUND	As Found Error (±)	AS LEFT	As Left Error (±)	Tolerance (±)		
Zero Balance	0 lb	0.0 kg	--	0.0 kg	--	0.5 kg	ACC	REJ
RIGHT FRONT	250 lb	113.5 kg	--	113.5 kg	--	0.5 kg	ACC	REJ
Maximum Test Load	1000 lb	453.5 kg	--	453.5 kg	--	1.0 kg	ACC	REJ
Test Load	Weights Applied	AS FOUND	As Found Error (±)	AS LEFT	As Left Error (±)	Tolerance (±)		
Zero Balance	0 lb	0.0 kg	--	0.0 kg	--	0.5 kg	ACC	REJ
LEFT REAR	250 lb	113.5 kg	--	113.5 kg	--	0.5 kg	ACC	REJ
Maximum Test Load	1000 lb	453.5 kg	--	453.5 kg	--	1.0 kg	ACC	REJ
Test Load	Weights Applied	AS FOUND	As Found Error (±)	AS LEFT	As Left Error (±)	Tolerance (±)		
Zero Balance	0 lb	0.0 kg	--	0.0 kg	--	0.5 kg	ACC	REJ
RIGHT REAR	250 lb	113.5 kg	--	113.5 kg	--	0.5 kg	ACC	REJ
Maximum Test Load	1000 lb	453.5 kg	--	453.5 kg	--	1.0 kg	ACC	REJ

NOTES:

Signed:

NGP
Calibrating Technician

Approved Signatory

CC-006
Rev. W
7-7-17

An ISO/IEC 17025:2005 Accredited Calibration Laboratory

PJLA
Calibration
Accreditation #59180