FINAL REPORT NUMBER 201UI-MGA-20-5

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

BAYERISCHE MOTOREN WERKE AG
2020 BMW 330i
NHTSA No. C20204100

MGA RESEARCH CORPORATION
446 Executive Drive
Troy, Michigan 48083

Test Dates: September 10-11, 2020
Report Date: September 22, 2020

FINAL REPORT

PREPARED FOR:

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

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Approval Date: _____

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		14. Sponsoring Agency Code NEF-200	
15. Supplementary Notes			
16. Abstract A compliance test series was conducted on the subject 2020 BMW 330I, NHTSA No. C20204100, 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 September 10-11, 2020 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 2020 BMW 330i.

Tests were conducted on September 10-11, 2020 on a 2020 BMW 330i, manufactured by Bayerische Motoren Werke AG.

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 MGATP201U_FRAME#2 dated May 8, 2012.

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 MGATP201U_Test Series dated November 9, 2009.

2.0 COMPLIANCE TEST DATA SUMMARY

The 2020 BMW 330i was equipped with A, B, and rear pillars, a fixed seat belt anchorage on the B-pillars, grab handles located on the front driver, front passenger, rear driver, and rear passenger side rails, 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	UR2@SR1	UR9@SR2A
AP3	SR2A	UR5@SR3-1	UR10@BP
BP1	RH	UR7@x=1396	UR12@SR3-2

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: 2020 BMW 330i

VEH. NHTSA NO.: C20204100 VIN: WBA5R1C0XLFH53825

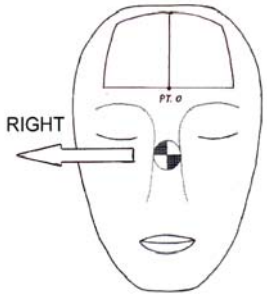
COLOR: Jet Black VEH. BUILD DATE: July, 2019

TEST DATES: September 10-11, 2020 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	Left	253	30	18.89	432.1	352.1	21	3L
AP3	Right	158	46	18.34	363.2	260.8	22	5L
BP1	Left	270	17	18.46	488.7	427.1	65	4L
BP3	Right	78	6	24.23	787.8	823.6	16	25R
SR2A	Left	270	50	19.26	456.7	384.8	19	1R
RH	Left	0	50	23.49	589.3	560.6	20	0
UR2@SR1	Left	270	50	23.94	630.7	615.4	45	0
UR5@SR3-1	Left	270	50	23.64	614.3	593.6	52	0
UR7@x=1396	Right	90	50	23.64	696.8	703.1	57	1L
UR9@SR2A	Right	90	50	24.14	639.9	627.6	45	6L
UR10@BP	Right	90	50	23.92	756.5	782.1	46	3R
UR12@SR3-2	Right	90	50	23.71	592.3	564.5	36	5L

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.

SR2A Left: Grab handle displaced; headliner deformation.
UR2@SR1 Left: Grab handle displaced; headliner deformation.
UR5@SR3-1 Left: Grab handle displaced; headliner deformation.
UR9@SR2A Right: Grab handle displaced; headliner deformation.
UR10@BP Right: Headliner deformation.
UR12@SR3-2 Right: Grab handle displaced; headliner deformation.

REMARKS:

The targets listed were impacted in the following order:

Left: AP1, SR2A, UR2@SR1, BP1, UR5@SR3-1, RH

Right: AP3, UR7@x=1396, UR9@SR2A, , BP3, UR10@BP, UR12@SR3-2

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: September 11, 2020

TABLE 2-2

GENERAL TEST AND VEHICLE PARAMETER DATA

VEH. MOD YR/MAKE/MODEL/BODY: 2020 BMW 330i

VEH. NHTSA NO.: C20204100 VIN: WBA5R1C0XLFH53825

COLOR: Jet Black VEH. BUILD DATE: July, 2019

TEST DATES: September 10-11, 2020 TEST LABORATORY: MGA Research Corp.

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

INTERIOR TRIM INFORMATION: A, B, and rear pillars, a fixed seat belt anchorage on the B-pillars, grab handles located on the front driver, front passenger, rear driver, and rear passenger side rails, and a front overhead console.

SUNROOF INFORMATION:

Installed: _X_Yes ___ No

Operation: _X_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: 05/21/2020; Odometer Reading 449 miles

DATA FROM VEHICLE'S CERTIFICATION LABEL:

Vehicle Manufactured By: Bayerische Motoren Werke AG

Date of Manufacture: July, 2019; VIN: WBA5R1C0XLFH53825

GVWR: 2080.0 kg; GAWR FRONT: 995.0 kg;

GAWR REAR: 1160.0 kg;

DATA FROM TIRE PLACARD:

Tire Pressure with Maximum Capacity Vehicle Load:

FRONT: 220 kPa REAR: 260 kPa

Recommended Tire Size: Front 225/45R18 XL

Recommended Cold Tire Pressure:

FRONT: 220 kPa REAR: 260 kPa

Size of Tire on Test Vehicle: Front 225/45R18 XL

Type of Spare Tire: N/A; Space Saver: _____; Standard_____

VEHICLE CAPACITY DATA:

Type of Front Seats: Bench__; Bucket X; Split Bench __

Number of Occupants: Front 2; Rear 3; TOTAL 5

VEHICLE CAPACITY WEIGHT:

Vehicle Capacity Weight (VCW) = 375 kg

No. of Occupants x 68 kg = 340 kg

Rated Cargo/Luggage Weight (RCLW) = 35 kg (difference)

Maximum Test Cargo/Luggage Weight = 136 kg

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

Right Front =	406.5 kg	Right Rear =	393.0 kg
Left Front =	407.0 kg	Left Rear =	380.0 kg
TOTAL FRONT =	813.5 kg	TOTAL REAR =	773.0 kg
% Total Weight =	51.3 %	% Total Weight =	48.7 %

TOTAL DELIVERED WEIGHT = 1586.5 kg

CALCULATION OF VEHICLE'S TARGET TEST WEIGHT:

Total Delivered Weight = 1586.5 kg

Max. Test Cargo/Luggage Weight = 35.0 kg

Target Test Weight = 1621.5 kg

WEIGHT OF TEST VEHICLE FULLY LOADED:

Right Front =	405.5 kg	Right Rear =	412.5 kg
Left Front =	406.5 kg	Left Rear =	397.0 kg
TOTAL FRONT =	812.0 kg	TOTAL REAR =	809.5 kg
% Total Weight =	50.1 %	% Total Weight =	49.9 %

TOTAL TEST WEIGHT = 1621.5 kg

Weight of ballast secured in vehicle's cargo area = 35 kg

TEST VEHICLE ATTITUDE:

AS DELIVERED:
Right Front 708 mm; Left Front 705 mm;
Right Rear 703 mm; Left Rear 707 mm;
Pitch Angle at Right Door Sill = 1.1 Rear is higher
Pitch Angle at Left Door Sill = 1.2 Rear is higher
Roll Angle at Front Bumper = 0.0
Roll Angle at Rear Bumper = 0.2 Left is higher

FULLY LOADED:
Right Front 704 mm; Left Front 701 mm;
Right Rear 698 mm; Left Rear 698 mm;
Pitch Angle at Right Door Sill = 1.3 Rear is higher
Pitch Angle at Left Door Sill = 1.4 Rear is higher
Roll Angle at Front Bumper = 0.1 Left is higher
Roll Angle at Rear Bumper = 0.1 Left is higher

AS TARGETED:
Right Front 885 mm; Left Front 886 mm;
Right Rear 875 mm; Left Rear 874 mm;
Pitch Angle at Right Door Sill = 1.3 Rear is higher
Pitch Angle at Left Door Sill = 1.2 Rear is higher
Roll Angle at Front Bumper = 0.0
Roll Angle at Rear Bumper = 0.1 Left is higher

AS TESTED ON RIGHT SIDE:

Pitch Angle at Right Door Sill =	1.2 Rear is higher
Pitch Angle at Left Door Sill =	1.2 Rear is higher
Roll Angle at Front Bumper =	0.1 Left is higher
Roll Angle at Rear Bumper =	0.1 Left is higher

AS TESTED ON LEFT SIDE:

Pitch Angle at Right Door Sill =	1.3 Rear is higher
Pitch Angle at Left Door Sill =	1.2 Rear is higher
Roll Angle at Front Bumper =	0.0
Roll Angle at Rear Bumper =	0.1 Left is higher

VEHICLE WHEELBASE = 2860 mm

REMARKS: The seat travel distance was measured to be 250 mm for the driver front seat and 250 mm for the passenger front seat.

Recorded By: _____ Approved By: _____

Date: September 8, 2020

TABLE 2-3

HORIZONTAL IMPACT ANGLE RANGE FOR A AND B PILLARS

VEH. MOD YR/MAKE/MODEL/BODY: 2020 BMW 330i

VEH. NHTSA NO.: C20204100 VIN: WBA5R1C0XLFH53825

COLOR: Jet Black VEH. BUILD DATE: July, 2019

TEST DATES: September 10-11, 2020 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 201.6º	L 253.0º
	R 105º-165º	R 107.0º	R 158.5º
B-PILLAR	L 195º-345º	L 202.8º	L 283.6º
	R 15º-165º	R 77.8º	R 157.0º

AS DETERMINED USING THE PROCEDURES SPECIFIED IN S8.13.4.1

REMARKS:

Recorded By: _____ Approved By: _____

Date: September 11, 2020

TABLE 2-4

VERTICAL IMPACT ANGLE RANGES

VEH. MOD YR/MAKE/MODEL/BODY: 2020 BMW 330i

VEH. NHTSA NO.: C20204100 VIN: WBA5R1C0XLFH53825

COLOR: Jet Black VEH. BUILD DATE: July, 2019

TEST DATES: September 10-11, 2020 TEST LABORATORY: MGA Research Corp.

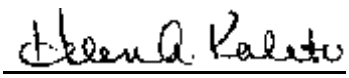
OBSERVERS: Helen Kaleto, Ryan Jones, David Burkett, Kurt Reichert

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 50º
		R 0º-50º	R 0º	R 50º
	SR2A	L 0º-50º	L 0º	L 50º
		R 0º-50º	R 0º	R 50º
	SR2B	L 0º-50º	L 0º	L 50º
		R 0º-50º	R 0º	R 50º
	SR3-1	L 0º-50º	L 0º	L 50º
		R 0º-50º	R 0º	R 50º
	SR3-2	L 0º-50º	L 0º	L 50º
		R 0º-50º	R 0º	R 50º
REAR HEADER	RH	L 0º-50º	L 0º	L 50º
		R 0º-50º	R 0º	R 50º
A-PILLAR	AP1	L -5º-50º	L -5º	L 30º
		R -5º-50º	R -5º	R 30º

		VERTICAL ANGLE SPECIFIED RANGE	MINIMUM VERTICAL ANGLE	MAXIMUM VERTICAL ANGLE
	AP2	L -5º-50º	L -5º	L 50º
		R -5º-50º	R -5º	R 50º
	AP3	L -5º-50º	L -5º	L 46º
		R -5º-50º	R -5º	R 46º
B-PILLAR	BP1	L -10º-50º	L -10º	L 17º
		R -10º-50º	R -10º	R 17º
	BP2*	L 0º-50º	L 0º	L 15º
		R 0º-50º	R 0º	R 15º
	BP3*	L -10º-50º	L 0º	L 6º
		R -10º-50º	R 0º	R 6º
	BP4	L -10º-50º	L -10º	L 0º
		R -10º-50º	R -10º	R 0º
REAR PILLAR	RP1	L -10º-50º	L -10º	L 15º
		R -10º-50º	R -10º	R 15º
	RP2	L -10º-50º	L -10º	L 2º
		R -10º-50º	R -10º	R 2º
UPPER ROOF 1		0º-50º	0º	50º
UPPER ROOF 2		0º-50º	0º	50º
UPPER ROOF 3		0º-50º	0º	50º
UPPER ROOF 4		0º-50º	0º	50º
UPPER ROOF 5		0º-50º	0º	50º
UPPER ROOF 6		0º-50º	0º	50º
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	50º
UPPER ROOF 11		0º-50º	0º	50º

As determined using the Procedures specified in S8.13.4.2. *Targets BP2 and BP3 are seat belt anchorage locations.

Recorded By:  Approved By: 

Date: September 11, 2020

TABLE 2-5

TARGET MEASUREMENTS

VEH. MOD YR/MAKE/MODEL/BODY: 2020 BMW 330i

VEH. NHTSA NO.: C20204100 VIN: WBA5R1C0XLFH53825

COLOR: Jet Black VEH. BUILD DATE: July, 2019

TEST DATES: September 10-11, 2020 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)	250 mm	250 mm
Tº	Horizontal < {CG-F1 (Left Seat) to (Right A-Pillar)}	107.0º	--
A1º	360º - Tº	253.0º	--
Wº	Horizontal < {CG-2 (Left Seat) to (Left A-Pillar)}	201.6º	--
A2º	A2º = Wº	201.6º	--
Uº	Horizontal < {CG-2 (Left Seat) to (Left B-Pillar)}	283.6º	--
B1º	B1º = Uº	283.6º	--
Vº	Horizontal < {CG-R (Left Seat) to (Left B-Pillar)}	202.8º	--
B2º	B2º = Vº	202.8º	--
Wº (right)	Horizontal < {CG-F2 (Right Seat) to (Right A-Pillar)}	--	158.5º
A1º (right)	A1º (right) = Wº (right)	--	158.5º
T º (right)	Horizontal < {CG-F1 (Right Seat) to (Left A-Pillar)}	--	253.0º
A2º (right)	360º-Tº (right)	--	107.0º
V º (right)	Horizontal < {CG-R (Right Seat) to (Right B-Pillar)}	--	157.0º
B1º (right)	B1º (right) = Vº (right)	--	157.0º
Uº (right)	Horizontal < {CG-F2 (Right Seat) to (Right B-Pillar)}	--	77.8º
B2º (right)	B2º (right) = Uº (right)	--	77.8º
J	A-Pillar {(Plane 3) – (Plane 5)}	313.0 mm	317.5 mm
J/2	J ÷ 2	156.5 mm	158.8 mm
D1	Upper Roof {(Plane A) – (Plane B)}	1457.7 mm	
D1/2	D1 ÷ 2	728.9 mm	
D2	Upper Roof {(Plane C) – (Plane D)}	1151.1 mm	

Measurement	Description	Left Side	Right Side
D2/2	D2 ÷ 2	575.6 mm	
.35D1	.35 x D1	510.2 mm	
.35D2	.35 x D2	402.9 mm	
N	B-Pillar {(BPR) – (lowest point on daylight opening forward of B-Pillar)}	382.5 mm	383.8 mm
N/2	B-Pillar {(BP3) – (lowest point on daylight opening forward of B-Pillar)}	191.3 mm	191.9 mm
N/4	B-Pillar {(BP4) – (lowest point on daylight opening forward of B-Pillar)}	95.6 mm	96.0 mm
D	R-Pillar (Point 7 – Point M)	670.0 mm	670.0 mm
3D/7	3 D / 7	287.1 mm	287.1 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	1524.0	-375.0	173.0	1524.0	375.0	173.0
Rear	2352.0	-340.0	185.0	2352.0	340.0	185.0

SgRP Locations (vehicle coordinates)						
	Left (mm)			Right (mm)		
	x	y	z	x	y	z
Front	1524.0	-375.0	173.0	1524.0	375.0	173.0
Rear	2352.0	-340.0	185.0	2352.0	340.0	185.0

CG- Locations (world coordinates)						
	Left (mm)			Right (mm)		
	x	y	z	x	y	z
CGF1	1434.0	-375.0	833.0	1434.0	375.0	833.0
CGF2	1684.0	-375.0	833.0	1684.0	375.0	833.0
CGR	2512.0	-340.0	845.0	2512.0	340.0	845.0

REFERENCE FOR VEHICLE COORDINATE SYSTEM (measured in millimeters):

LH FR OB seat bolt hole (x, y, z) = 1200, -603.0, -21.6

LH FB upper striker (x, y, z) = 1666.5, -772.0, 435.7

RH FR lower striker (x, y, z) = 1658.2, 774.3, 400.8

REMARKS:

Recorded By: _____ Approved By: _____

Date: September 11, 2020

TABLE 2-6

SUMMARY OF TARGETING RESULTS

VEH. MOD YR/MAKE/MODEL/BODY: 2020 BMW 330i

VEH. NHTSA NO.: C20204100 VIN: WBA5R1C0XLFH53825

COLOR: Jet Black VEH. BUILD DATE: July, 2019

TEST DATES: September 10-11, 2020 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	1311.6	-522.5	968.0	--	--	Yes	--	Yes
REL	1336.8	-525.4	926.7	253	30	--	2	--
AP2	1246.8	-566.4	880.9	202	50	No	--	No
AP3	1118.5	-588.7	812.2	202	46	No	--	No
A-Pillar Right Side								
AP1	1312.1	515.4	975.4	--	--	Yes	--	--
REL	1336.8	524.0	930.0	107	30	--	1	No
AP2	1261.6	559.8	888.0	158	50	No	--	No
AP3	1127.7	589.9	817.4	158	46	No	--	Yes
B-Pillar Left Side								
BP1	1822.0	-468.9	1000.7	270	17	No	--	Yes
BP2	1800.1	-594.1	785.5	270	15	No	--	No
BP3	1772.2	-591.0	809.0	283	6	No	--	Yes
BP4	1857.8	-651.9	714.1	225	0	No	--	No
B-Pillar Right Side								
BP1	1823.9	469.0	1002.2	90	17	No	--	No
BP2	1801.6	595.0	784.4	90	15	No	--	No
BP3	1771.3	591.7	811.3	78	6	No	--	No
BP4	1857.0	650.0	716.7	135	0	No	--	No
Rear Pillar Left Side								
RP1	2505.1	-485.7	987.2	270	15	No	--	No
RP2	2726.9	-576.4	837.9	--	--	Yes	--	--
REL	2728.6	-535.8	898.8	270	2	--	3	No
Rear Pillar Right Side								
RP1	2504.2	485.7	987.0	90	15	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					
RP2	2727.2	577.4	838.0	--	--	Yes	--	--
REL	2728.5	538.0	899.2	90	2	--	3	No
Front Header Left Side								
FH1	1243.6	-405.3	963.0	180	50	No	--	No
FH2	1222.7	-256.2	965.8	180	50	No	--	No
Front Header Right Side								
FH1	1241.8	398.7	962.3	180	50	No	--	No
FH2	1224.4	249.0	966.1	180	50	No	--	No
Side Rail Left Side								
SR1	1462.2	-488.4	972.1	270	50	No	--	No
SR2A	1612.2	-484.2	988.3	270	50	No	--	Yes
SR2B	1522.6	-491.4	1007.7	--	--	Yes	--	--
REL	1521.1	-518.2	966.5	270	50	--	2	No
SR3-1	2159.8	-474.2	992.2	270	50	No	--	No
SR3-2	2334.4	-481.1	981.6	270	50	No	--	No
Side Rail Right Side								
SR1	1461.5	489.3	971.7	90	50	No	--	No
SR2A	1611.9	483.9	988.5	90	50	No	--	No
SR2B	1524.2	489.3	1009.6	--	--	Yes	--	--
REL	1524.5	518.6	967.7	90	50	--	2	No
SR3-1	2158.7	475.0	992.0	90	50	No	--	No
SR3-2	2334.4	479.5	981.8	90	50	No	--	No
Rear Header Left Side								
RH	2588.4	-339.6	1015.4	0	50	No	--	Yes
Rear Header Right Side								
RH	2590.0	339.4	1014.7	0	50	No	--	No
Upper Roof Left Side								
UR1@x=1392	1392.0	-393.9	984.9	270	50	No	--	No
UR2@SR1	1485.6	-394.0	997.2	270	50	No	--	Yes
UR3@SR2A	1620.8	-393.1	1008.8	270	50	No	--	No
UR4@BP	1814.1	-394.1	1009.5	270	50	No	--	No
UR5@SR3-1	2161.4	-391.1	1009.4	270	50	No	--	Yes
UR6@SR3-2	2334.3	-394.6	1010.5	270	50	No	--	No
Upper Roof Right Side								
UR7@x=1396	1395.5	394.8	986.6	90	50	No	--	Yes
UR8@SR1	1485.9	393.7	997.4	90	50	No	--	No
UR9@SR2A	1621.9	393.5	1010.3	90	50	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					
UR10@BP	1816.0	393.1	1010.4	90	50	No	--	Yes
UR11@SR3-1	2162.2	391.6	1010.3	90	50	No	--	No
UR12@SR3-2	2336.1	390.8	1013.7	90	50	No	--	Yes

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

Recorded By: _____ Approved By: _____

Date: September 11, 2020

3.0 TEST DATA (Including Acceleration and Velocity Plots)

Test U20147 Data

FMVSS 201U
Test No.: U20147 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/9/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 1 Time: 15:20:56

Horizontal Approach Angle: 253 deg Temperature: 23.5 °C

Vertical Approach Angle: 30 deg Humidity: 49.6 %RH

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

Target Location: Left AP1

Additional Description:

Test Results

Impact Velocity: 18.89 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	352.11	88.5	92.8	4.3
HIC 15	352.11	88.5	92.8	4.3
HIC (d)	432.05	88.5	92.8	4.3

3 ms Clip = 80.54 G , Time 1 = 89.09 ms , Time 2 = 92.09 ms

Impact Location on FMH: 21 mm Above Pt. 0 , 3 Left mm Lateral of Pt. 0

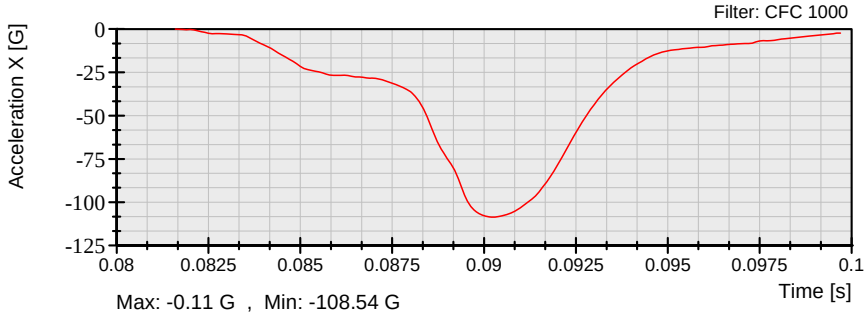
Post-Test Comments: No visible damage.

Test Series Performed By: DB, KR

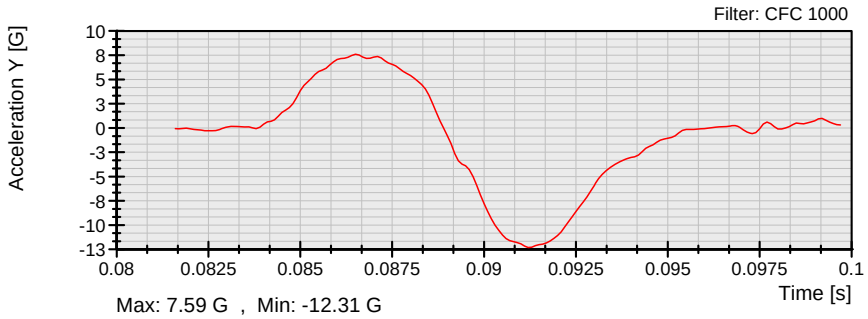
Recorded By: Approved By:

Date: 9/9/2020

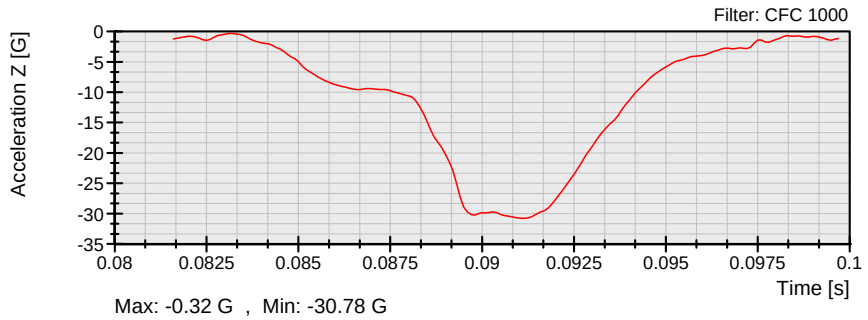
FMVSS 201U
Test No.: U20147 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/9/2020



Max: -0.11 G , Min: -108.54 G

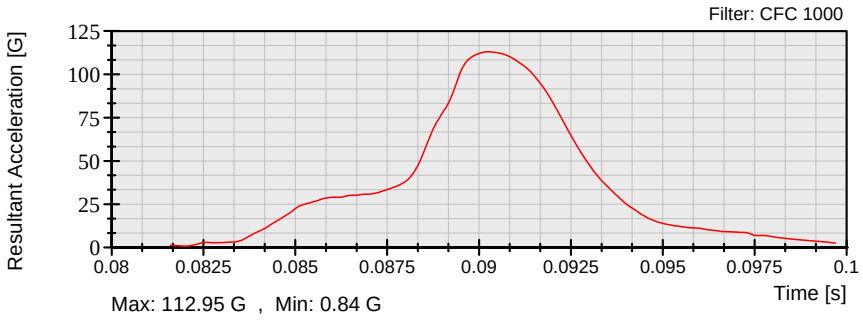


Max: 7.59 G , Min: -12.31 G

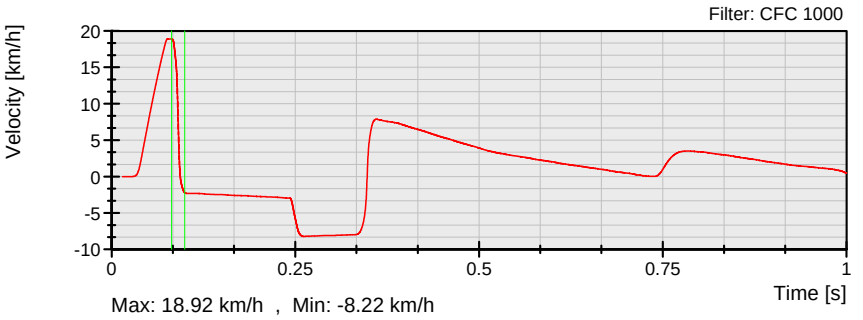


Max: -0.32 G , Min: -30.78 G

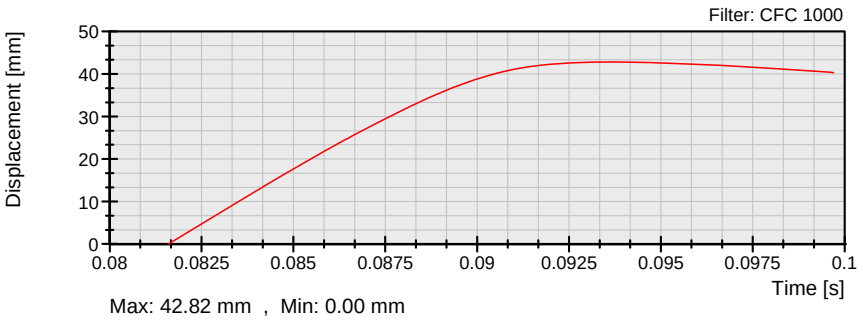
FMVSS 201U
Test No.: U20147 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/9/2020



Max: 112.95 G , Min: 0.84 G

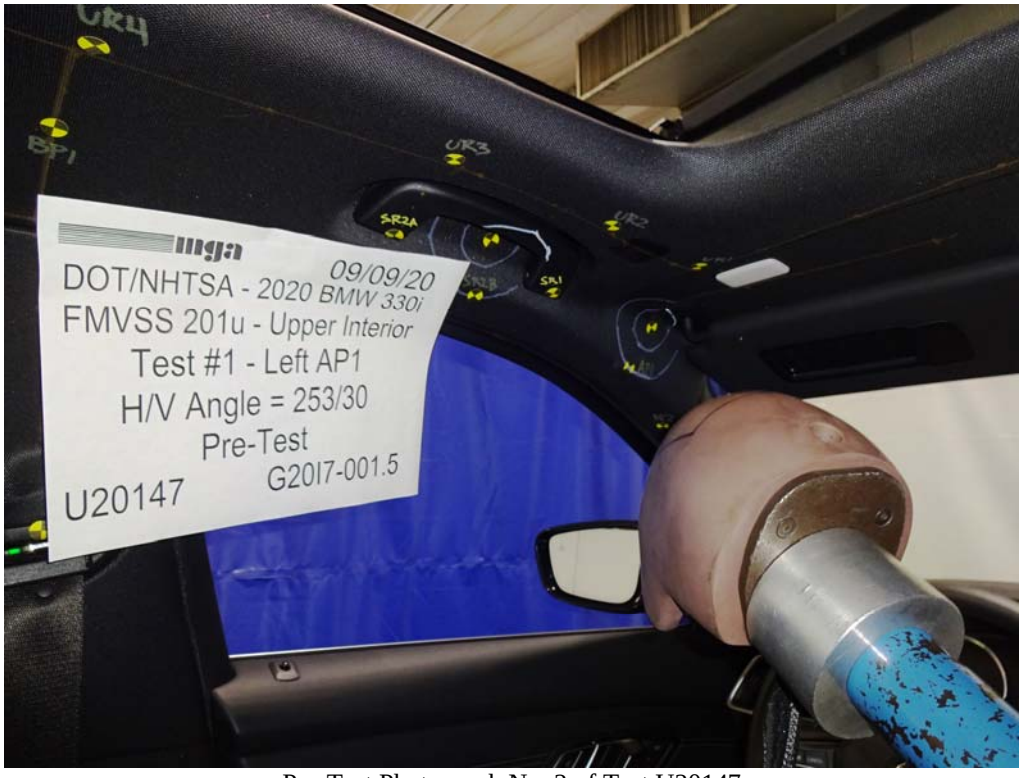


Max: 18.92 km/h , Min: -8.22 km/h



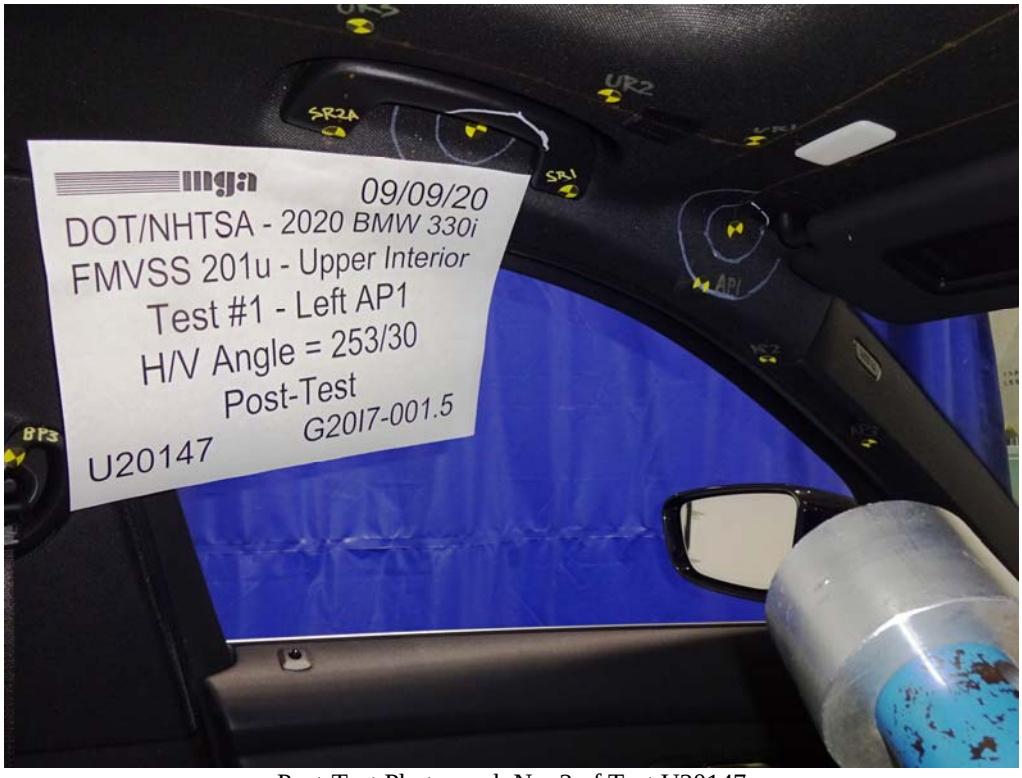
Max: 42.82 mm , Min: 0.00 mm

Pre-Test Photograph No. 1 of Test U20147



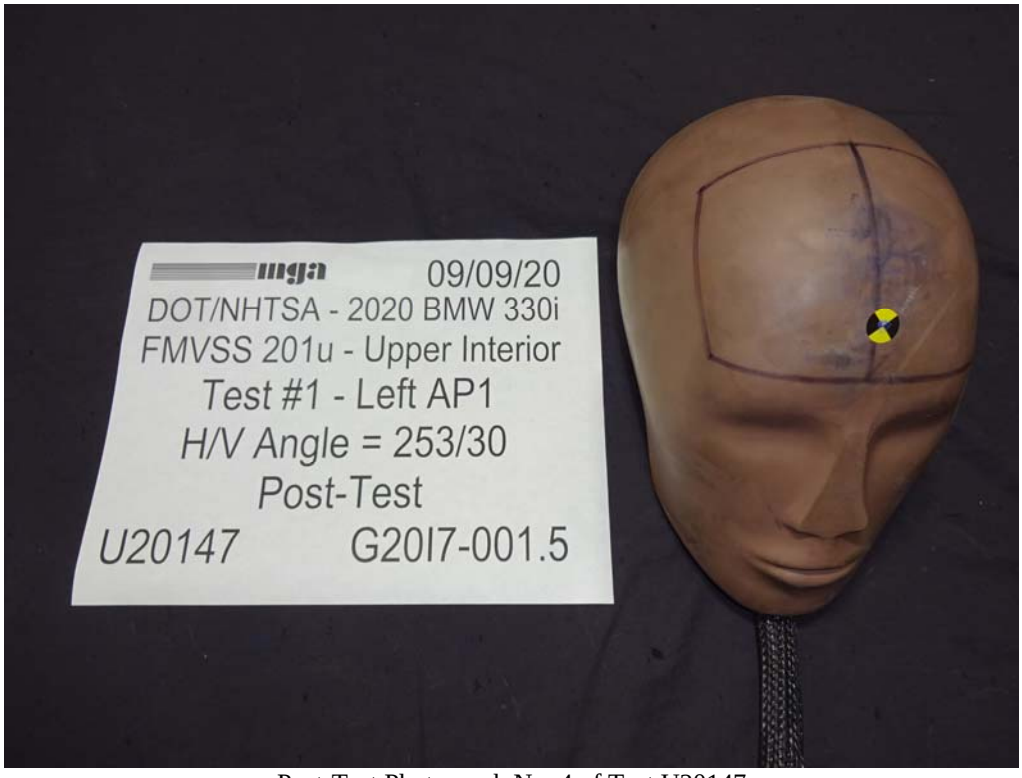
Pre-Test Photograph No. 2 of Test U20147

Post-Test Photograph No. 1 of Test U20147



Post-Test Photograph No. 2 of Test U20147

Post-Test Photograph No. 3 of Test U20147



Post-Test Photograph No. 4 of Test U20147

Test U20153 Data

mga research corporation

FMVSS 201U
Test No.: U20153 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 7 Time: 09:10:12

Horizontal Approach Angle: 158 deg Temperature: 22.7 °C

Vertical Approach Angle: 46 deg Humidity: 42.7 %RH

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

Target Location: Right AP3

Additional Description:

Test Results

Impact Velocity: 18.34 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	260.79	83.1	92.6	9.5
HIC 15	260.79	83.1	92.6	9.5
HIC (d)	363.15	83.1	92.6	9.5

3 ms Clip = 56.84 G , Time 1 = 87.4 ms , Time 2 = 90.4 ms

Impact Location on FMH: 22 mm Above Pt. 0 , 5 Left mm Lateral of Pt. 0

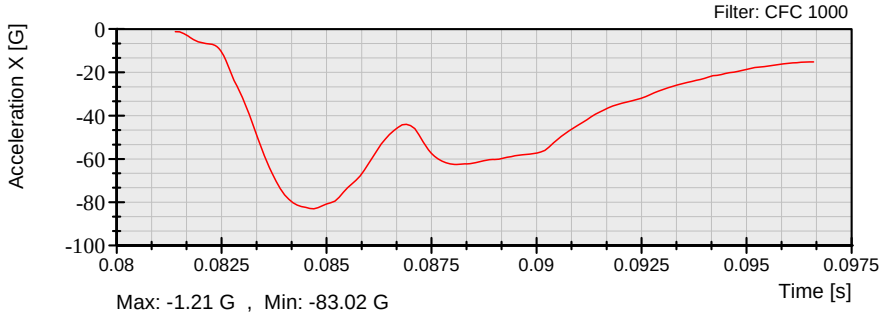
Post-Test Comments: No visible damage.

Test Series Performed By: DB, KR

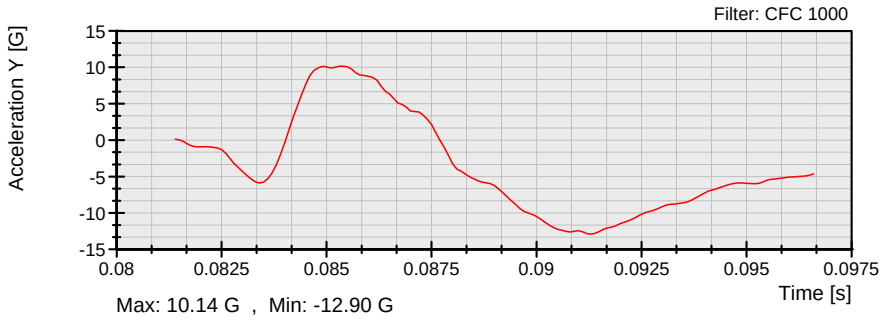
Recorded By: Approved By:

Date: 9/11/2020

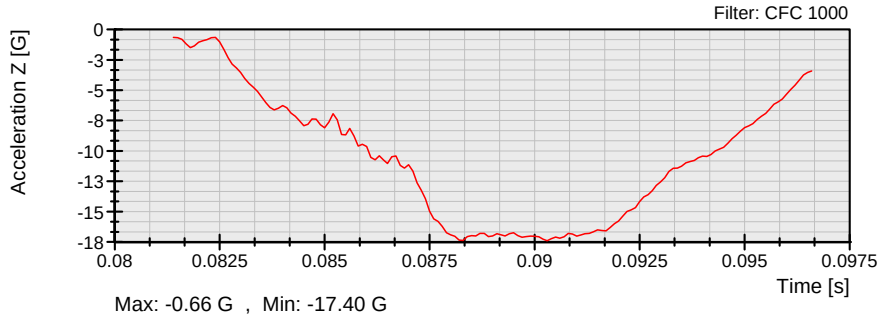
FMVSS 201U
Test No.: U20153 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: -1.21 G , Min: -83.02 G

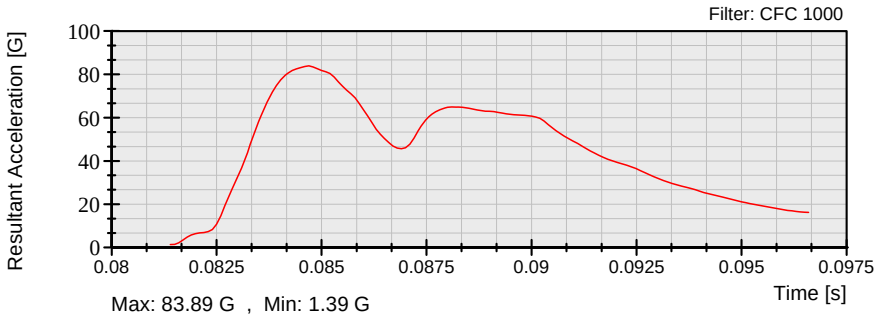


Max: 10.14 G , Min: -12.90 G

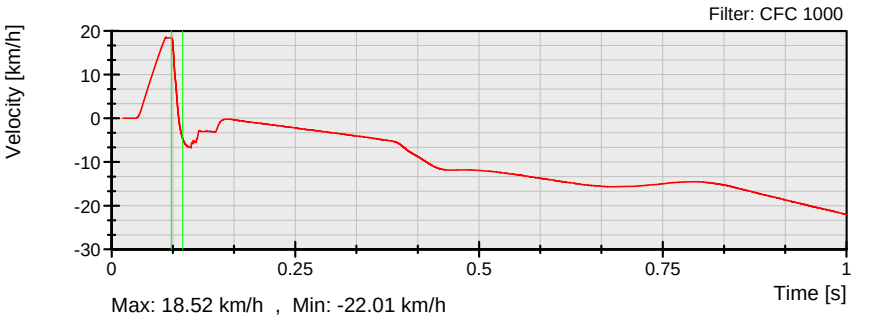


Max: -0.66 G , Min: -17.40 G

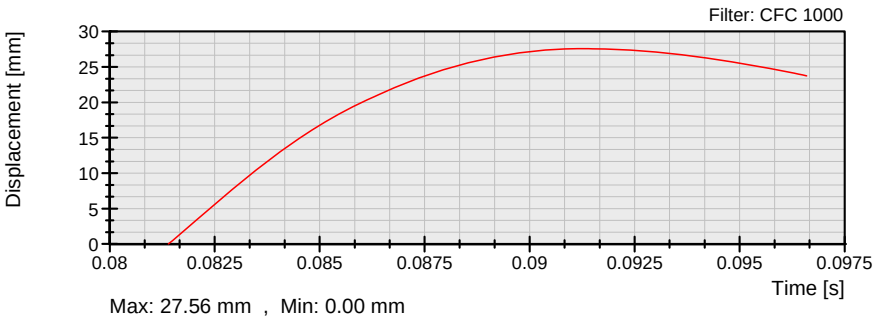
FMVSS 201U
Test No.: U20153 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: 83.89 G , Min: 1.39 G

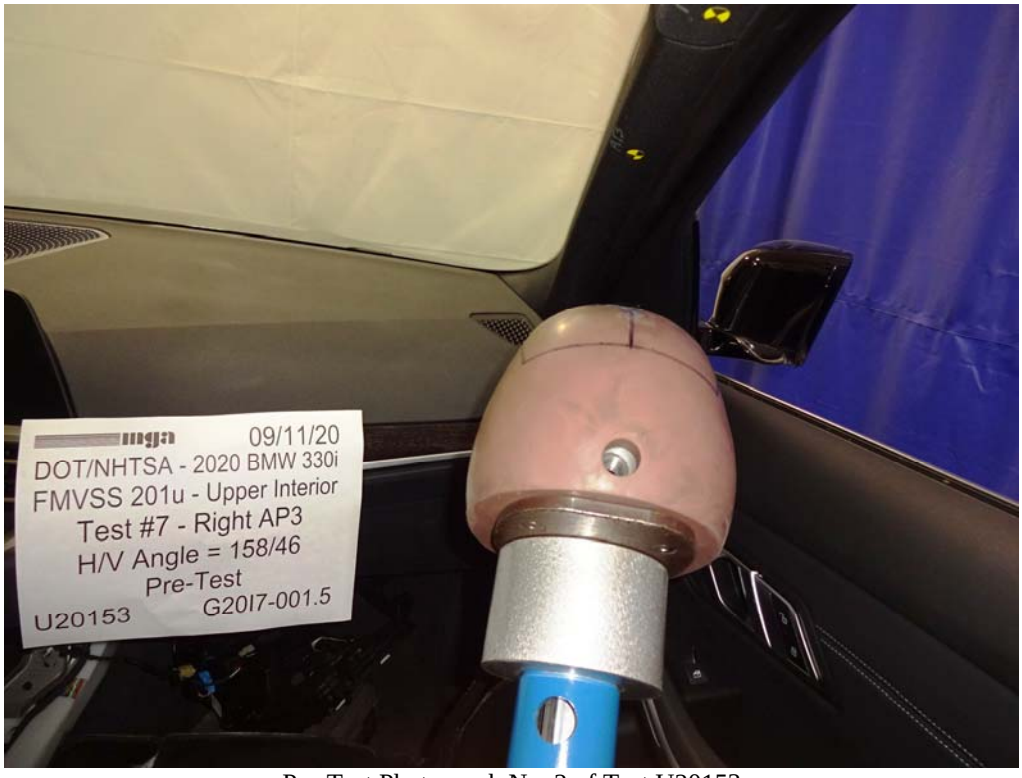


Max: 18.52 km/h , Min: -22.01 km/h



Max: 27.56 mm , Min: 0.00 mm

Pre-Test Photograph No. 1 of Test U20153



Pre-Test Photograph No. 2 of Test U20153

Post-Test Photograph No. 1 of Test U20153

Post-Test Photograph No. 2 of Test U20153

Post-Test Photograph No. 3 of Test U20153

Post-Test Photograph No. 4 of Test U20153

Test U20150 Data

mga research corporation

FMVSS 201U
Test No.: U20150 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 4 Time: 10:06:32

Horizontal Approach Angle: 270 deg Temperature: 23.0 °C

Vertical Approach Angle: 17 deg Humidity: 49.9 %RH

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

Target Location: Left BP1

Additional Description:

Test Results

Impact Velocity: 18.46 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	427.13	90.8	97.9	7.1
HIC 15	427.13	90.8	97.9	7.1
HIC (d)	488.65	90.8	97.9	7.1

3 ms Clip = 89.04 G , Time 1 = 92.5 ms , Time 2 = 95.5 ms

Impact Location on FMH: 65 mm Above Pt. 0 , 4 Left mm Lateral of Pt. 0

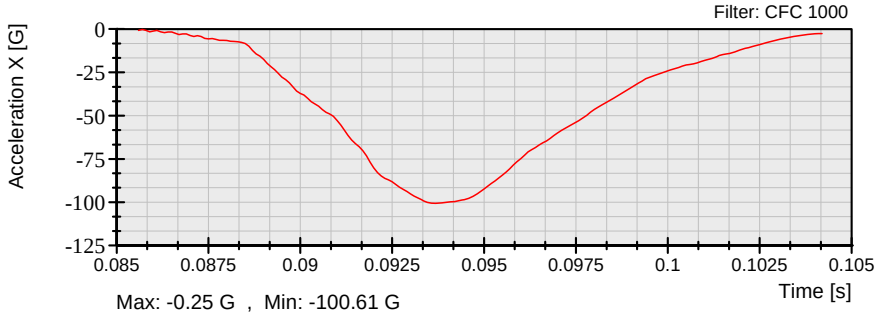
Post-Test Comments: No visible damage.

Test Series Performed By: DB, KR

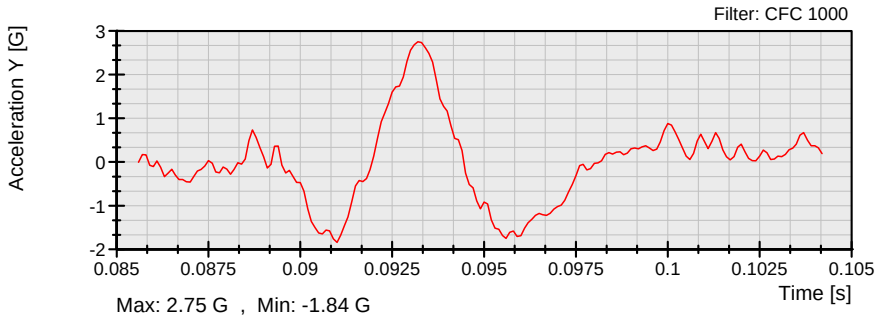
Recorded By: Approved By:

Date: 9/10/2020

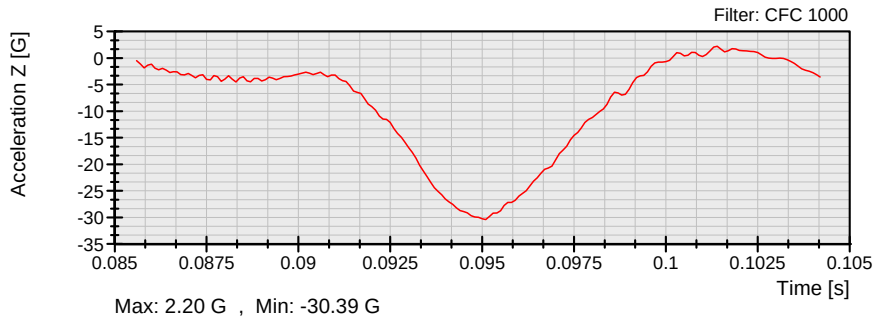
FMVSS 201U
Test No.: U20150 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020



Max: -0.25 G , Min: -100.61 G

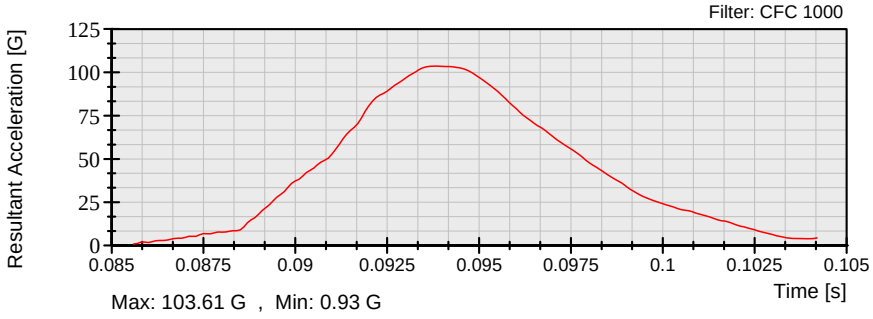


Max: 2.75 G , Min: -1.84 G

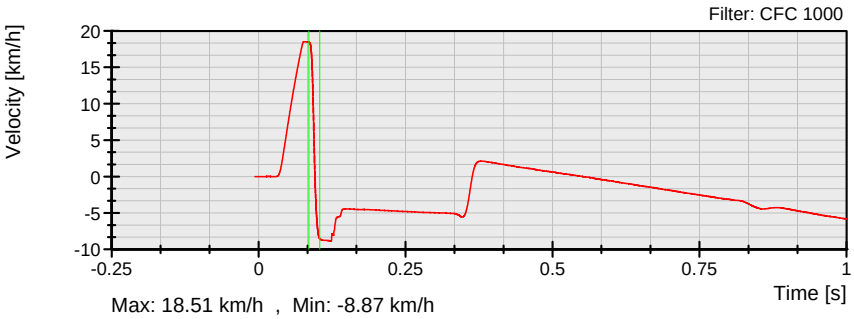


Max: 2.20 G , Min: -30.39 G

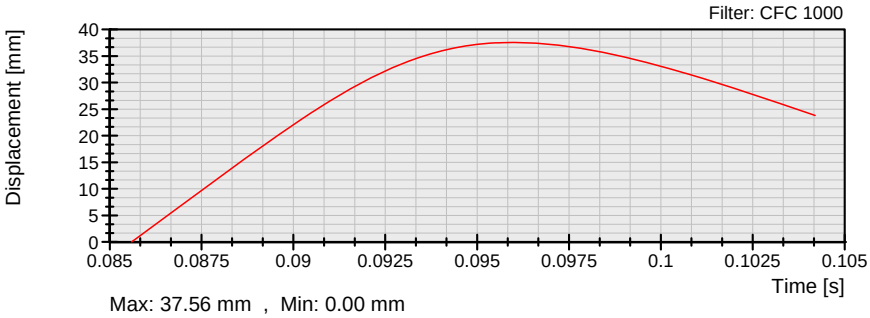
FMVSS 201U
Test No.: U20150 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020



Max: 103.61 G , Min: 0.93 G

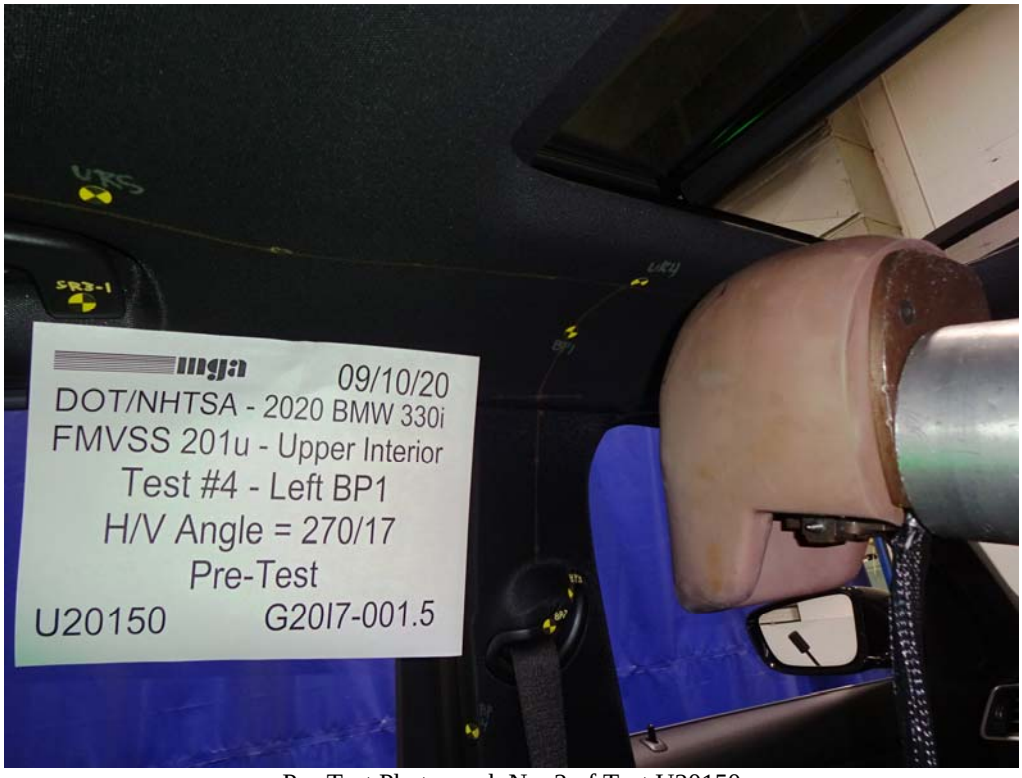


Max: 18.51 km/h , Min: -8.87 km/h



Max: 37.56 mm , Min: 0.00 mm

Pre-Test Photograph No. 1 of Test U20150

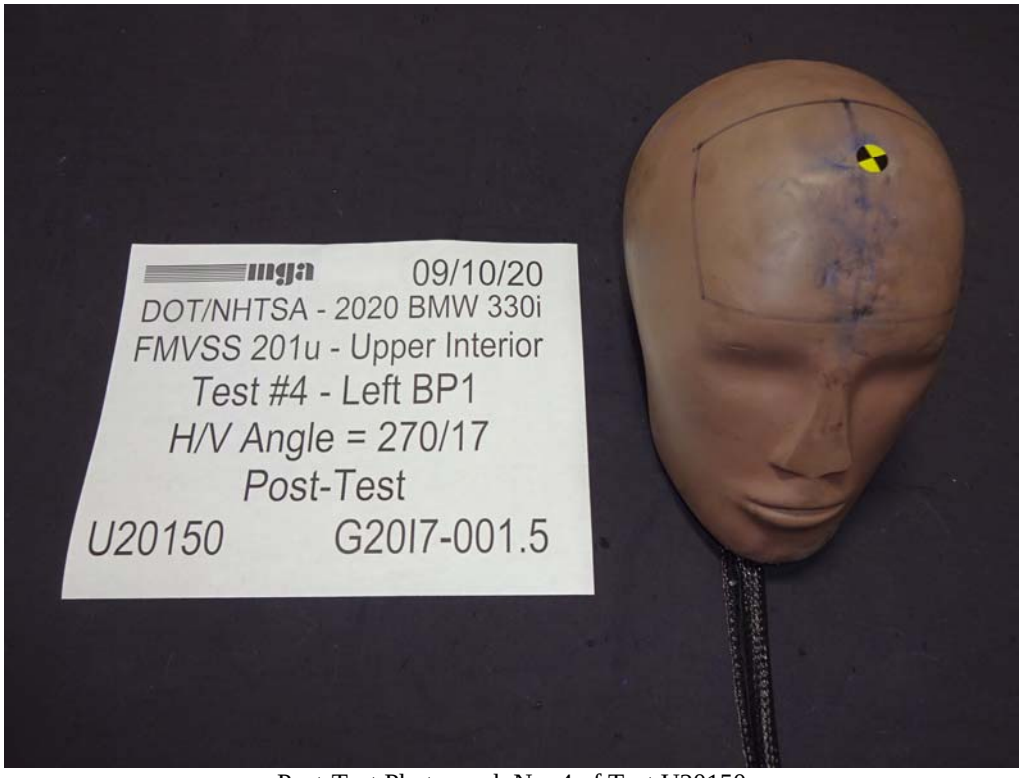


Pre-Test Photograph No. 2 of Test U20150

Post-Test Photograph No. 1 of Test U20150

Post-Test Photograph No. 2 of Test U20150

Post-Test Photograph No. 3 of Test U20150



Post-Test Photograph No. 4 of Test U20150

Test U20156 Data

FMVSS 201U
Test No.: U20156 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 10 Time: 14:01:24

Horizontal Approach Angle: 78 deg Temperature: 22.6 °C

Vertical Approach Angle: 6 deg Humidity: 42.4 %RH

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

Target Location: Right BP3

Additional Description:

Test Results

Impact Velocity: 24.23 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	823.61	76.4	83.9	7.5
HIC 15	823.61	76.4	83.9	7.5
HIC (d)	787.78	76.4	83.9	7.5

3 ms Clip = 117.46 G , Time 1 = 78.16 ms , Time 2 = 81.16 ms

Impact Location on FMH: 16 mm Above Pt. 0 , 25 Right mm Lateral of Pt. 0

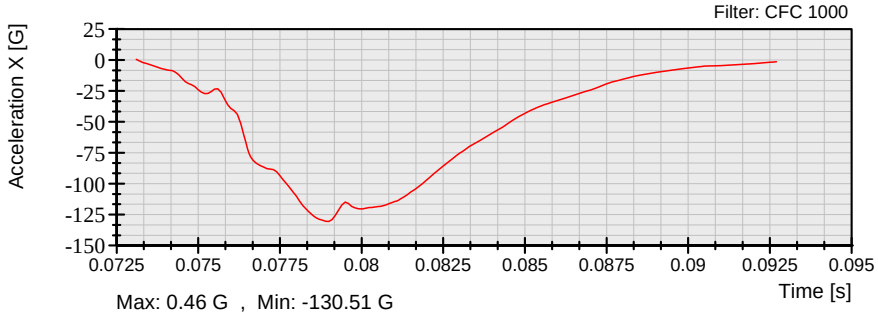
Post-Test Comments: No visible damage.

Test Series Performed By: DB, KR

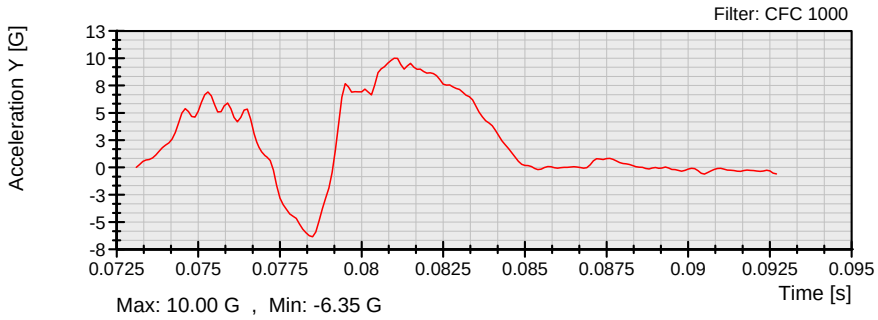
Recorded By: Approved By:

Date: 9/11/2020

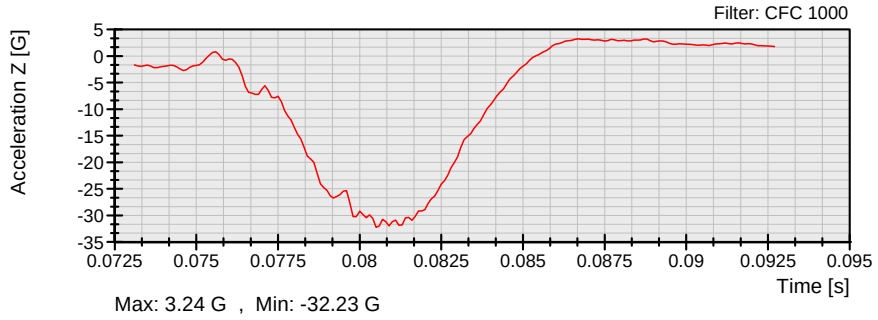
FMVSS 201U
Test No.: U20156 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: 0.46 G , Min: -130.51 G

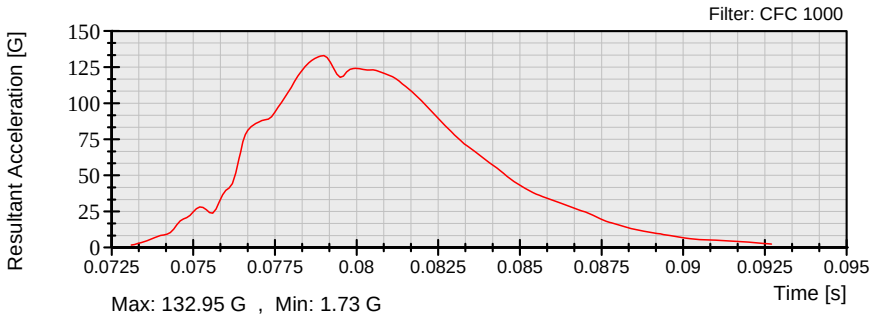


Max: 10.00 G , Min: -6.35 G

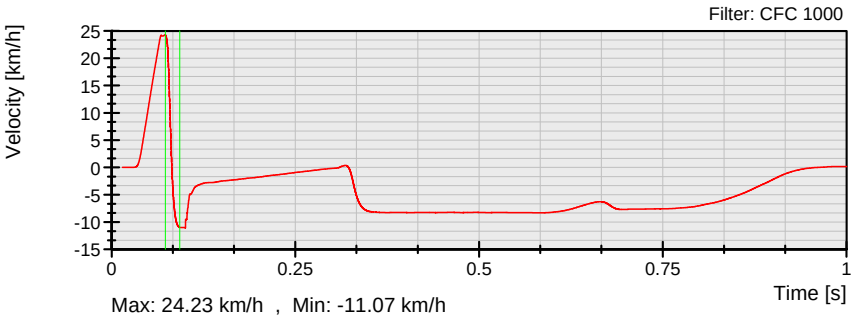


Max: 3.24 G , Min: -32.23 G

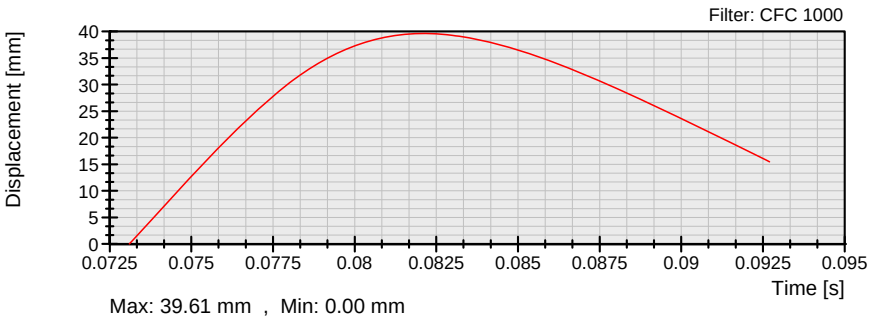
FMVSS 201U
Test No.: U20156 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: 132.95 G , Min: 1.73 G



Max: 24.23 km/h , Min: -11.07 km/h



Max: 39.61 mm , Min: 0.00 mm

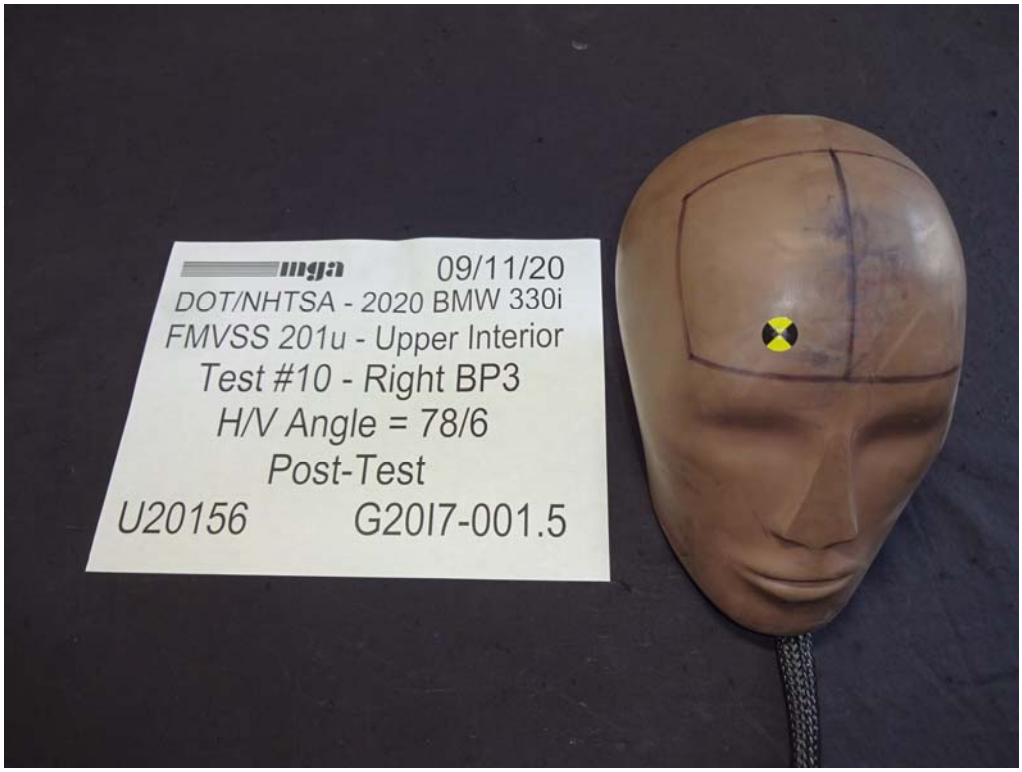
Pre-Test Photograph No. 1 of Test U20156

Pre-Test Photograph No. 2 of Test U20156

Post-Test Photograph No. 1 of Test U20156

Post-Test Photograph No. 2 of Test U20156

Post-Test Photograph No. 3 of Test U20156



Post-Test Photograph No. 4 of Test U20156

Test U20148 Data

FMVSS 201U
Test No.: U20148 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/9/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 2 Time: 16:02:12

Horizontal Approach Angle: 270 deg Temperature: 23.5 °C

Vertical Approach Angle: 50 deg Humidity: 50.7 %RH

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

Target Location: Left SR2A

Additional Description:

Test Results

Impact Velocity: 19.26 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	384.81	83.9	93	9.1
HIC 15	384.81	83.9	93	9.1
HIC (d)	456.73	83.9	93	9.1

3 ms Clip = 87.6 G , Time 1 = 88.3 ms , Time 2 = 91.3 ms

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

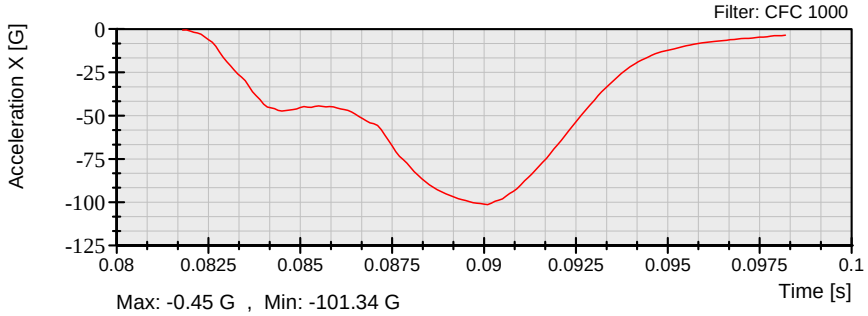
Post-Test Comments: Grab handle displaced; Headliner deformation.

Test Series Performed By: DB, KR

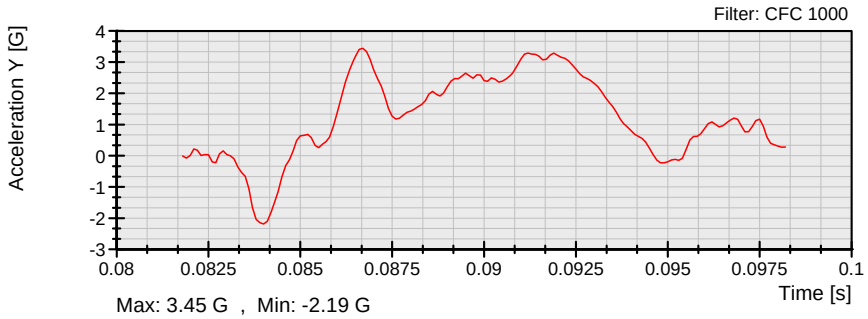
Recorded By: Approved By:

Date: 9/9/2020

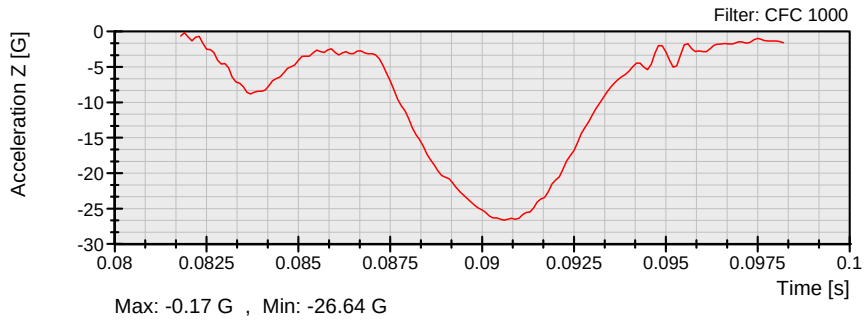
FMVSS 201U
Test No.: U20148 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/9/2020



Max: -0.45 G , Min: -101.34 G

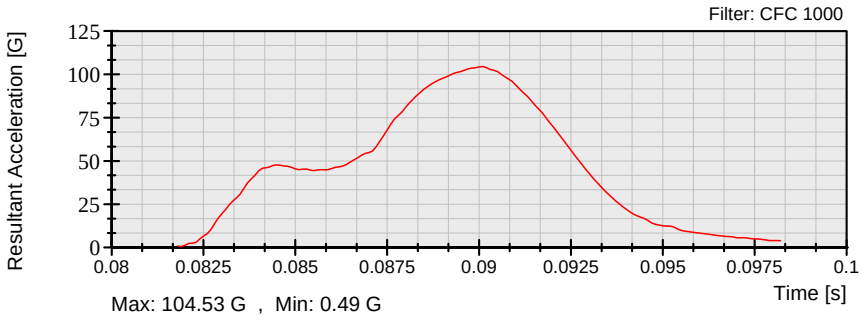


Max: 3.45 G , Min: -2.19 G

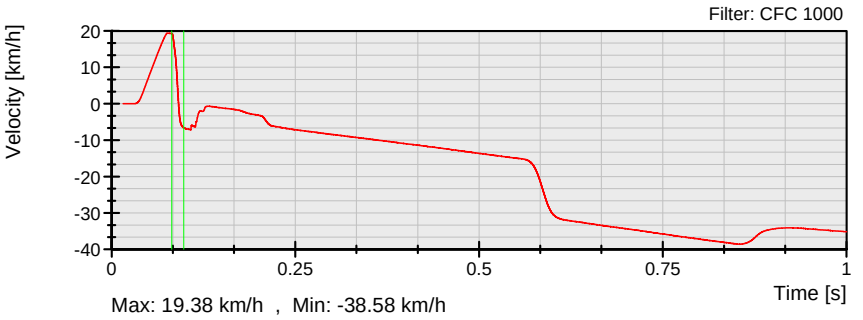


Max: -0.17 G , Min: -26.64 G

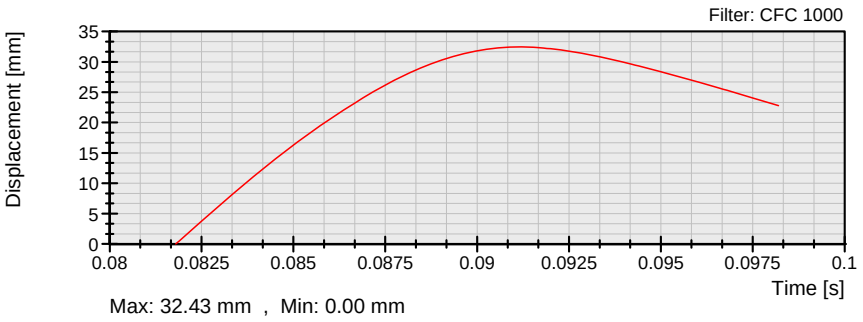
FMVSS 201U
Test No.: U20148 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/9/2020



Max: 104.53 G , Min: 0.49 G



Max: 19.38 km/h , Min: -38.58 km/h

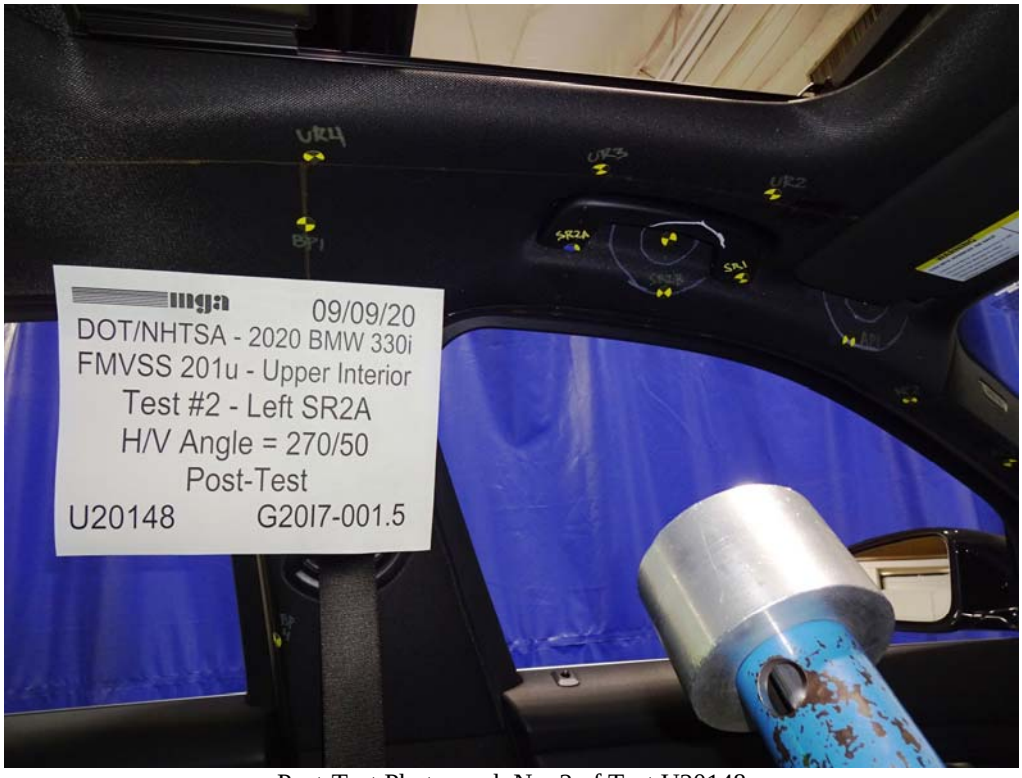


Max: 32.43 mm , Min: 0.00 mm

Pre-Test Photograph No. 1 of Test U20148

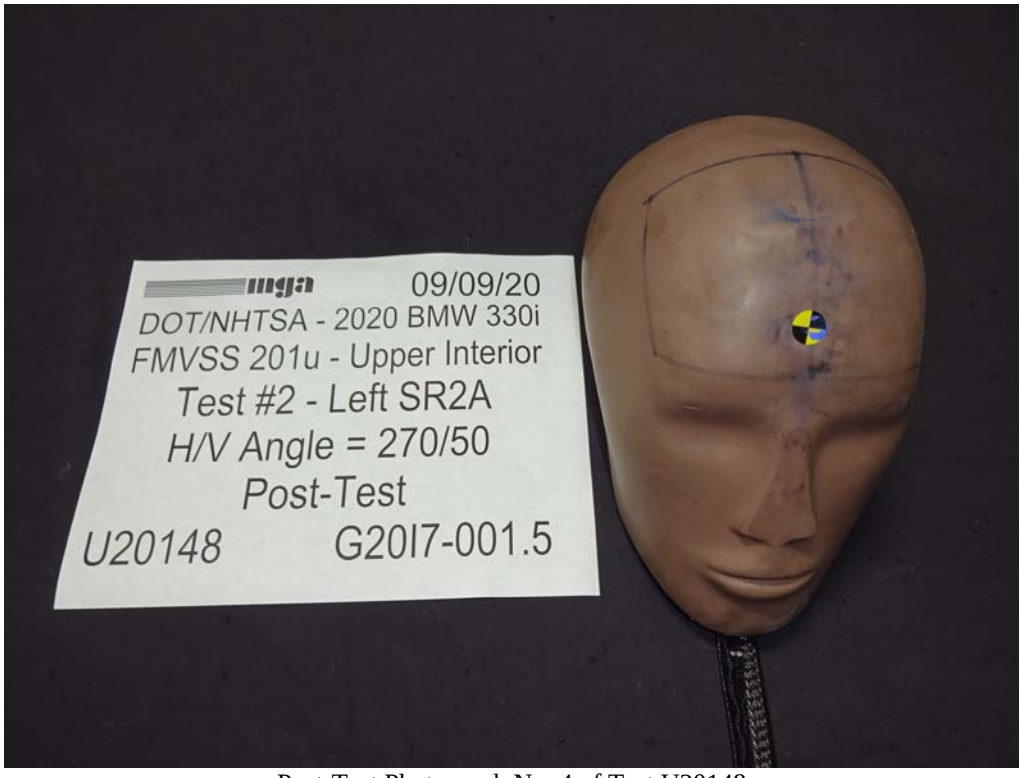
Pre-Test Photograph No. 2 of Test U20148

Post-Test Photograph No. 1 of Test U20148



Post-Test Photograph No. 2 of Test U20148

Post-Test Photograph No. 3 of Test U20148



Post-Test Photograph No. 4 of Test U20148

Test U20152 Data

FMVSS 201U
Test No.: U20152 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 6 Time: 14:40:52

Horizontal Approach Angle: 0 deg Temperature: 22.6 °C

Vertical Approach Angle: 50 deg Humidity: 52.4 %RH

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

Target Location: Left RH

Additional Description:

Test Results

Impact Velocity: 23.49 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	560.59	76.9	85.1	8.2
HIC 15	560.59	76.9	85.1	8.2
HIC (d)	589.34	76.9	85.1	8.2

3 ms Clip = 96.84 G , Time 1 = 77.9 ms , Time 2 = 80.9 ms

Impact Location on FMH: 20 mm Above Pt. 0 , 0 mm Lateral of Pt. 0

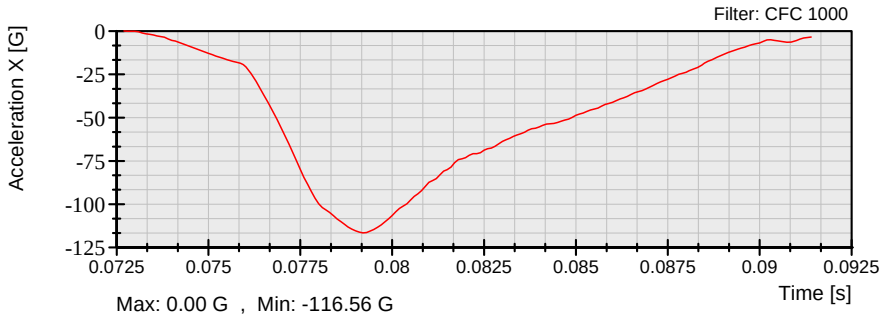
Post-Test Comments: No visible damage.

Test Series Performed By: DB, KR

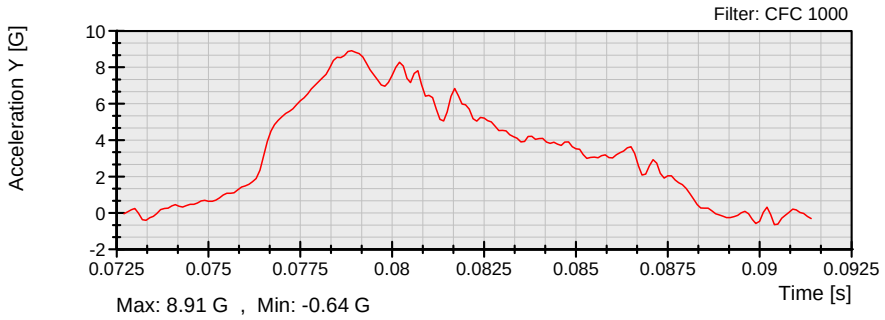
Recorded By: Approved By:

Date: 9/10/2020

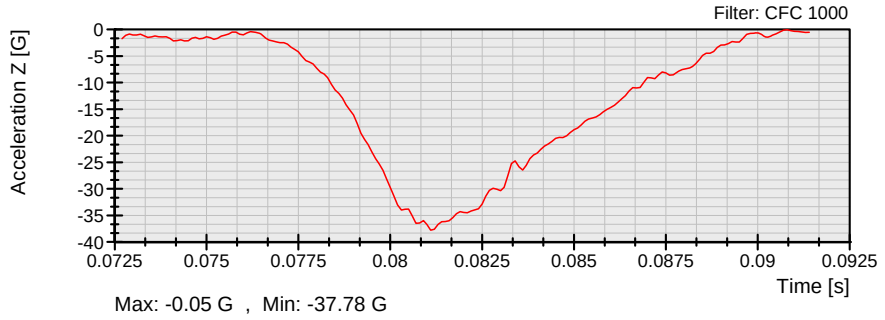
FMVSS 201U
Test No.: U20152 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020



Max: 0.00 G , Min: -116.56 G

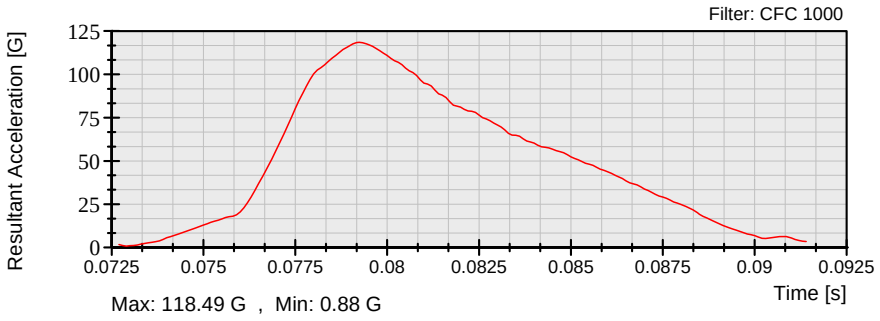


Max: 8.91 G , Min: -0.64 G

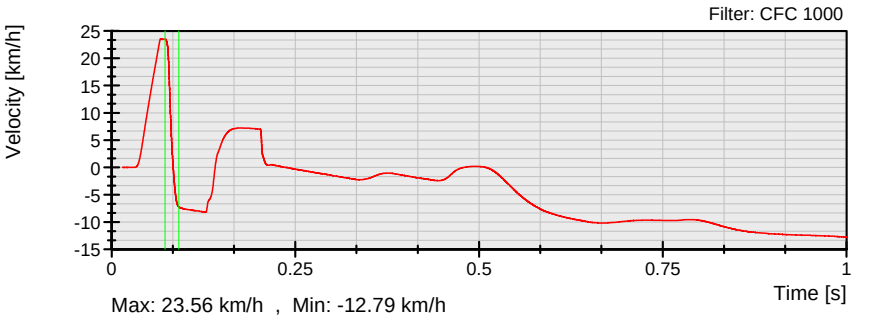


Max: -0.05 G , Min: -37.78 G

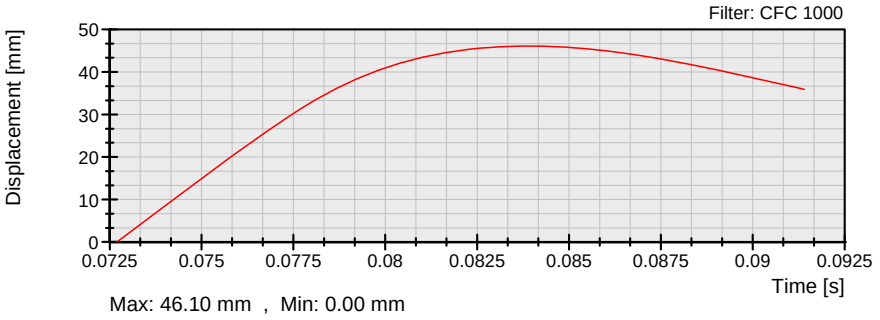
FMVSS 201U
Test No.: U20152 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020



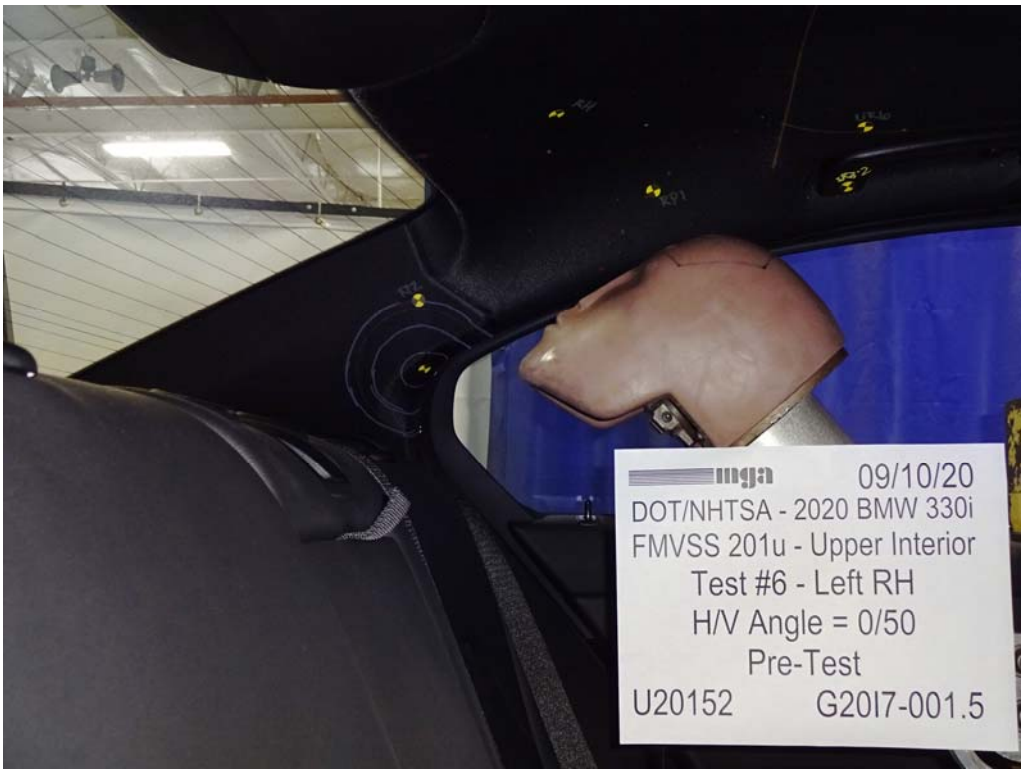
Max: 118.49 G , Min: 0.88 G



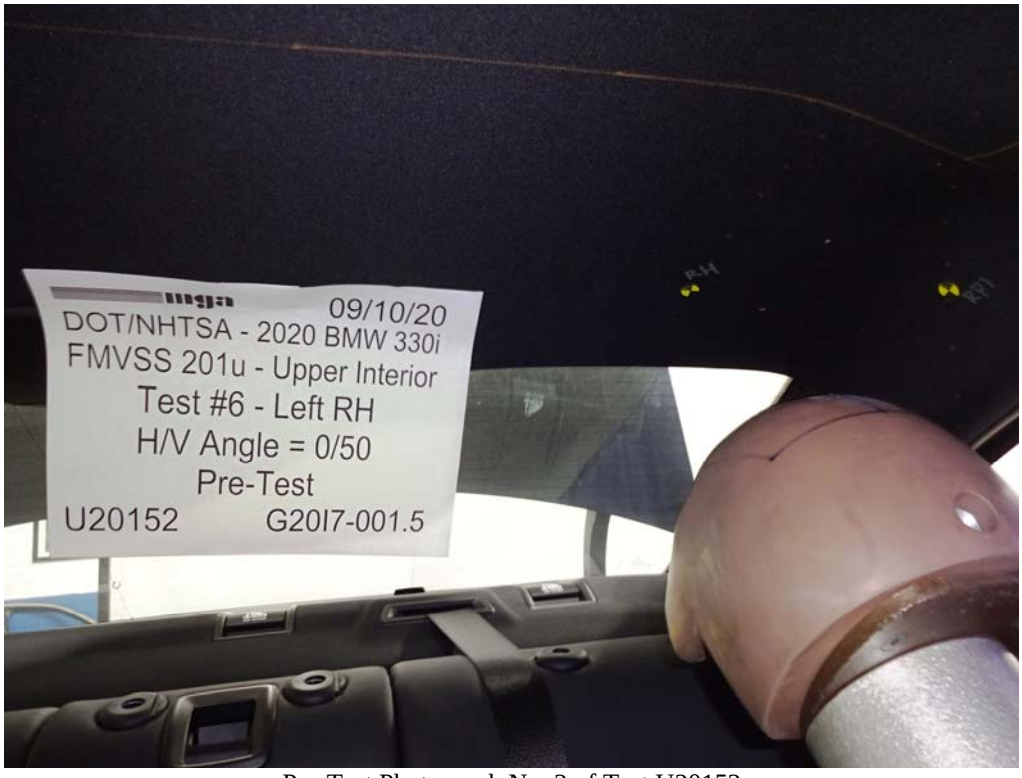
Max: 23.56 km/h , Min: -12.79 km/h



Max: 46.10 mm , Min: 0.00 mm



Pre-Test Photograph No. 1 of Test U20152

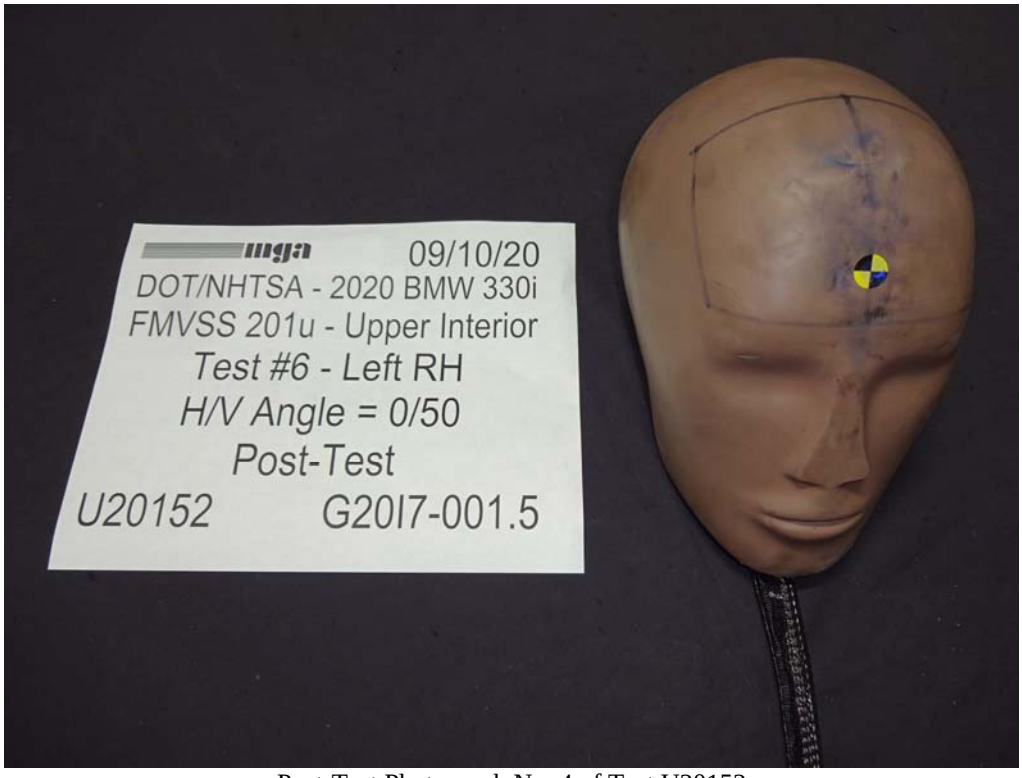


Pre-Test Photograph No. 2 of Test U20152

Post-Test Photograph No. 1 of Test U20152

Post-Test Photograph No. 2 of Test U20152

Post-Test Photograph No. 3 of Test U20152



Post-Test Photograph No. 4 of Test U20152

Test U20149 Data

FMVSS 201U
Test No.: U20149 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 3 Time: 09:15:33

Horizontal Approach Angle: 270 deg Temperature: 23.1 °C

Vertical Approach Angle: 50 deg Humidity: 49.2 %RH

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

Target Location: Left UR2@SR1

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	615.37	79.1	88.3	9.2
HIC 15	615.37	79.1	88.3	9.2
HIC (d)	630.67	79.1	88.3	9.2

3 ms Clip = 83.03 G , Time 1 = 80.33 ms , Time 2 = 83.33 ms

Impact Location on FMH: 45 mm Above Pt. 0 , 0 mm Lateral of Pt. 0

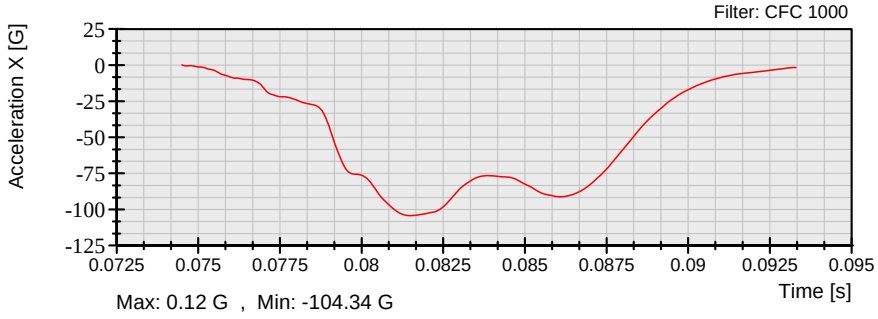
Post-Test Comments: Grab handle displaced; Headliner deformation.

Test Series Performed By: DB, KR

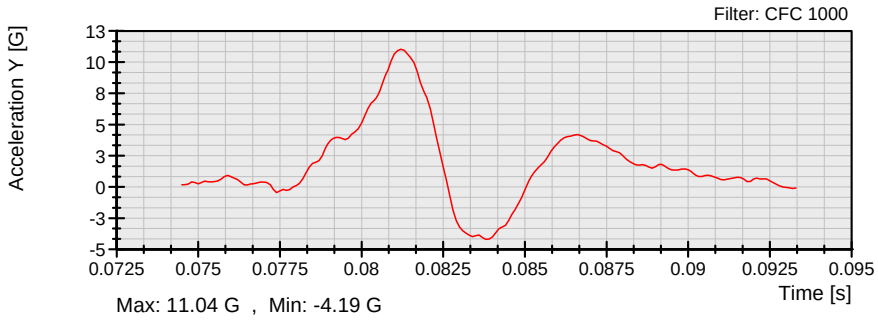
Recorded By: Approved By:

Date: 9/10/2020

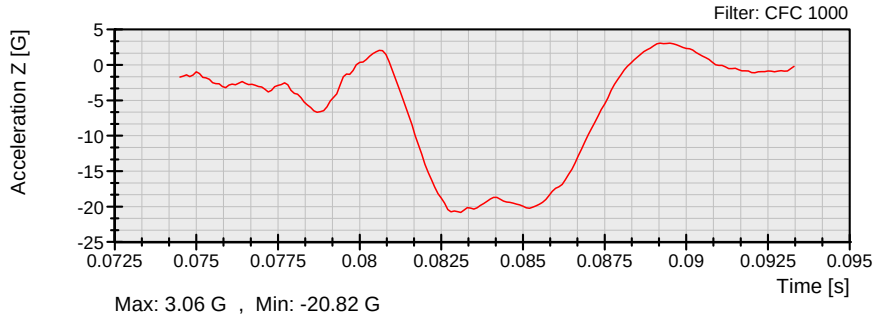
FMVSS 201U
Test No.: U20149 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020



Max: 0.12 G , Min: -104.34 G

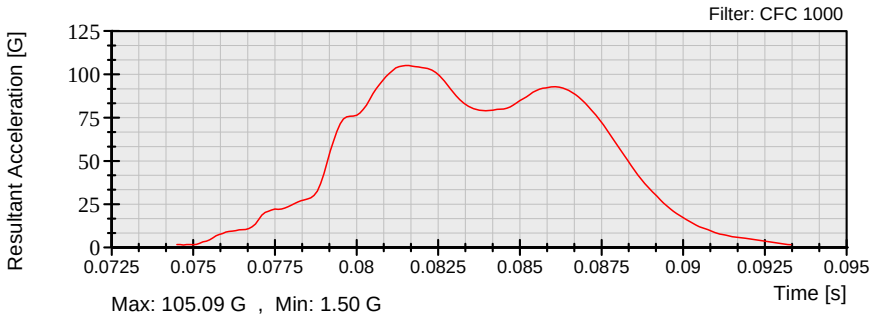


Max: 11.04 G , Min: -4.19 G

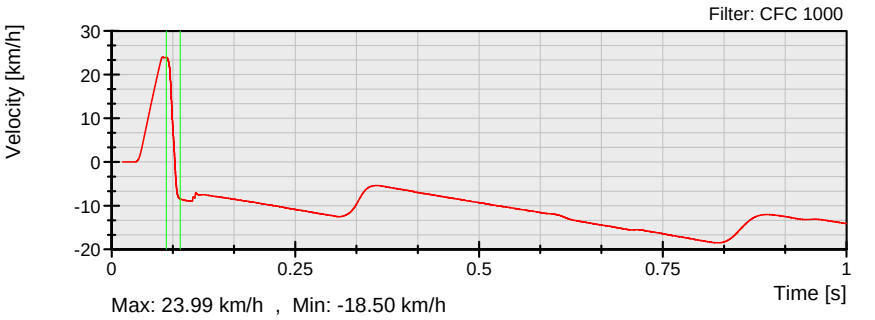


Max: 3.06 G , Min: -20.82 G

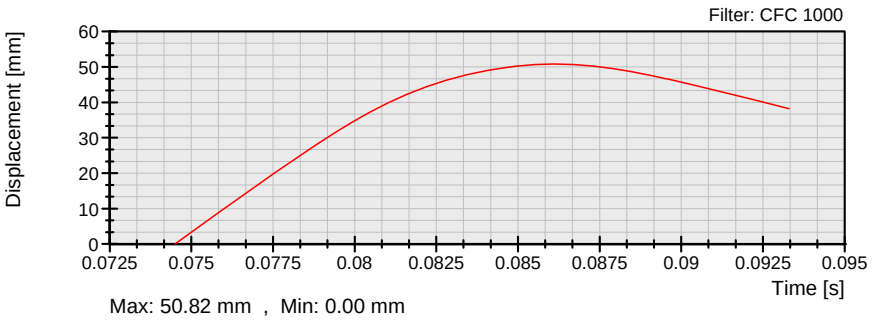
FMVSS 201U
Test No.: U20149 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020



Max: 105.09 G , Min: 1.50 G



Max: 23.99 km/h , Min: -18.50 km/h



Max: 50.82 mm , Min: 0.00 mm

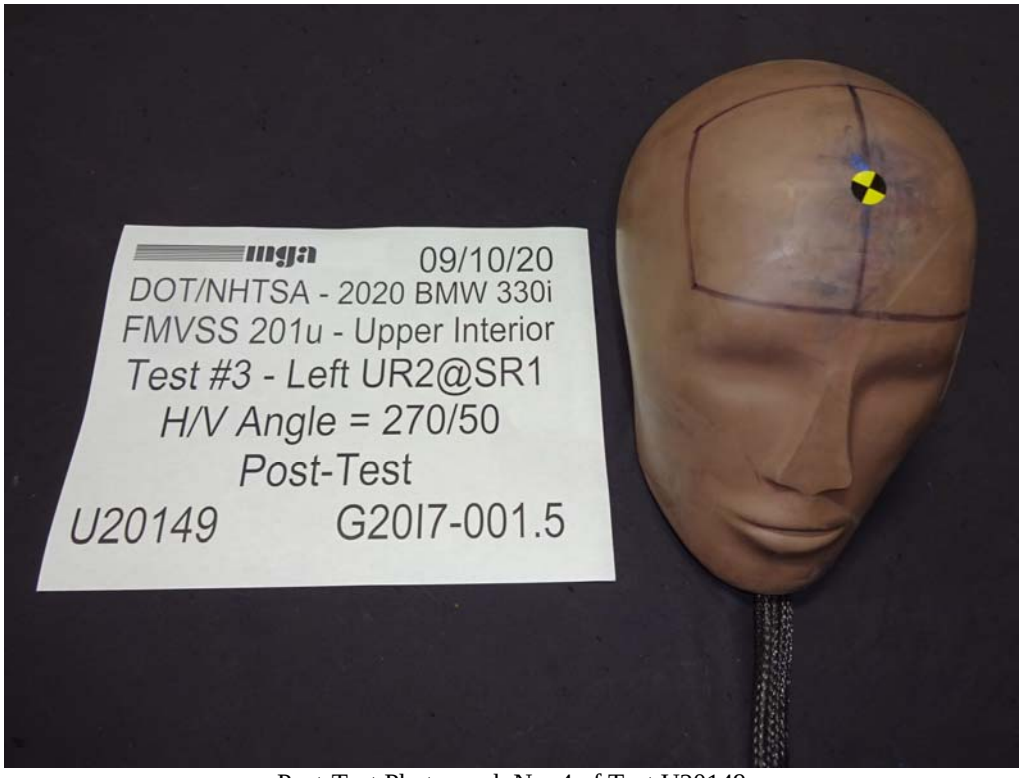
Pre-Test Photograph No. 1 of Test U20149

Pre-Test Photograph No. 2 of Test U20149

Post-Test Photograph No. 1 of Test U20149

Post-Test Photograph No. 2 of Test U20149

Post-Test Photograph No. 3 of Test U20149



Post-Test Photograph No. 4 of Test U20149

Test U20151 Data

FMVSS 201U
Test No.: U20151 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 5 Time: 13:07:39

Horizontal Approach Angle: 270 deg Temperature: 22.9 °C

Vertical Approach Angle: 50 deg Humidity: 47.6 %RH

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

Target Location: Left UR5@SR3-1

Additional Description:

Test Results

Impact Velocity: 23.64 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	593.64	77.7	87.7	10
HIC 15	593.64	77.7	87.7	10
HIC (d)	614.28	77.7	87.7	10

3 ms Clip = 90.09 G , Time 1 = 81.2 ms , Time 2 = 84.2 ms

Impact Location on FMH: 52 mm Above Pt. 0 , 0 mm Lateral of Pt. 0

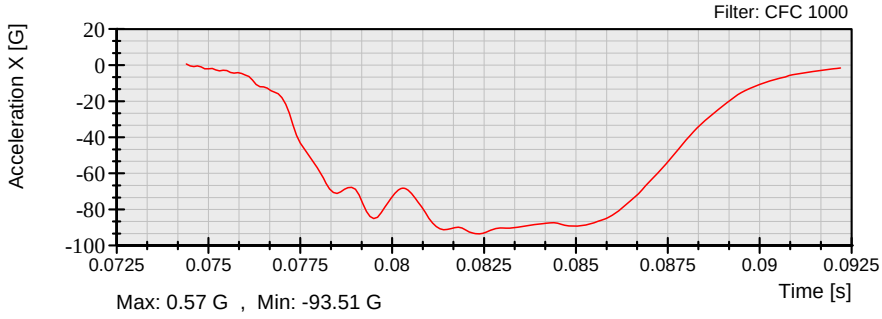
Post-Test Comments: Grab handle displaced; Headliner deformation.

Test Series Performed By: DB, KR

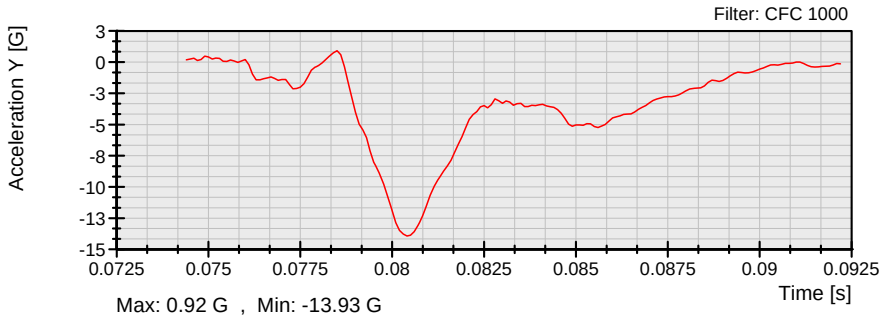
Recorded By: Approved By:

Date: 9/10/2020

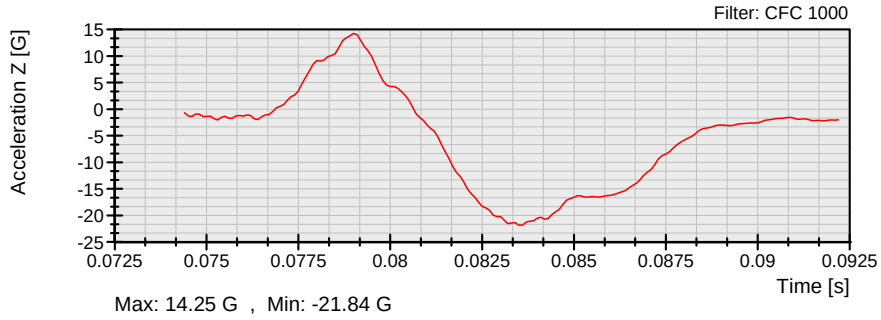
FMVSS 201U
Test No.: U20151 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020



Max: 0.57 G , Min: -93.51 G

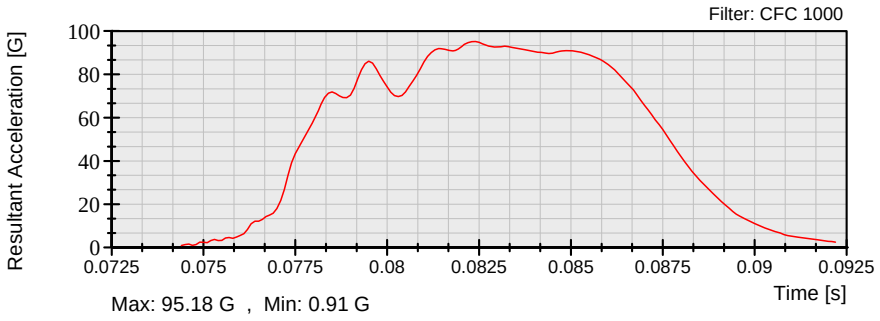


Max: 0.92 G , Min: -13.93 G

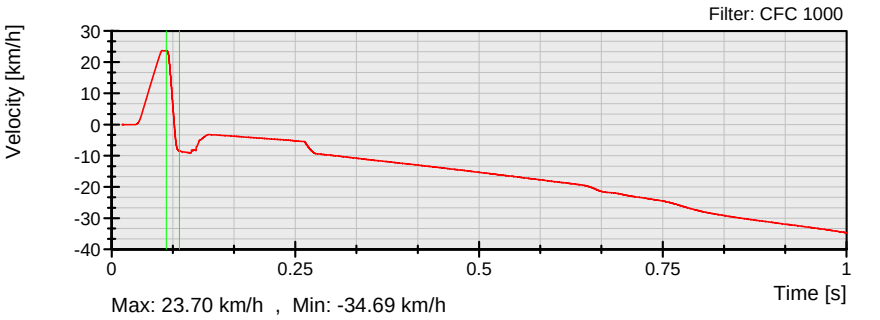


Max: 14.25 G , Min: -21.84 G

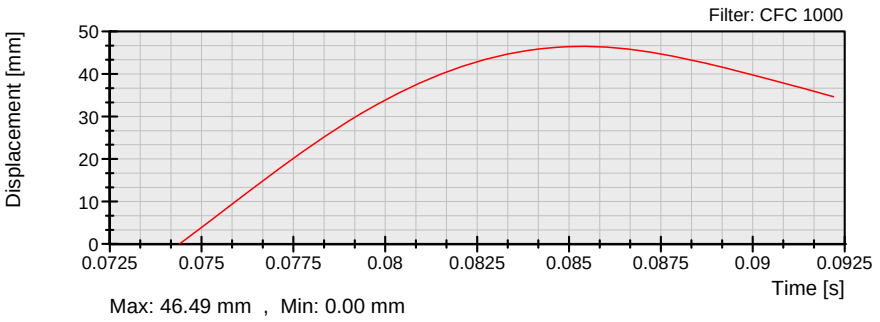
FMVSS 201U
Test No.: U20151 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/10/2020



Max: 95.18 G , Min: 0.91 G

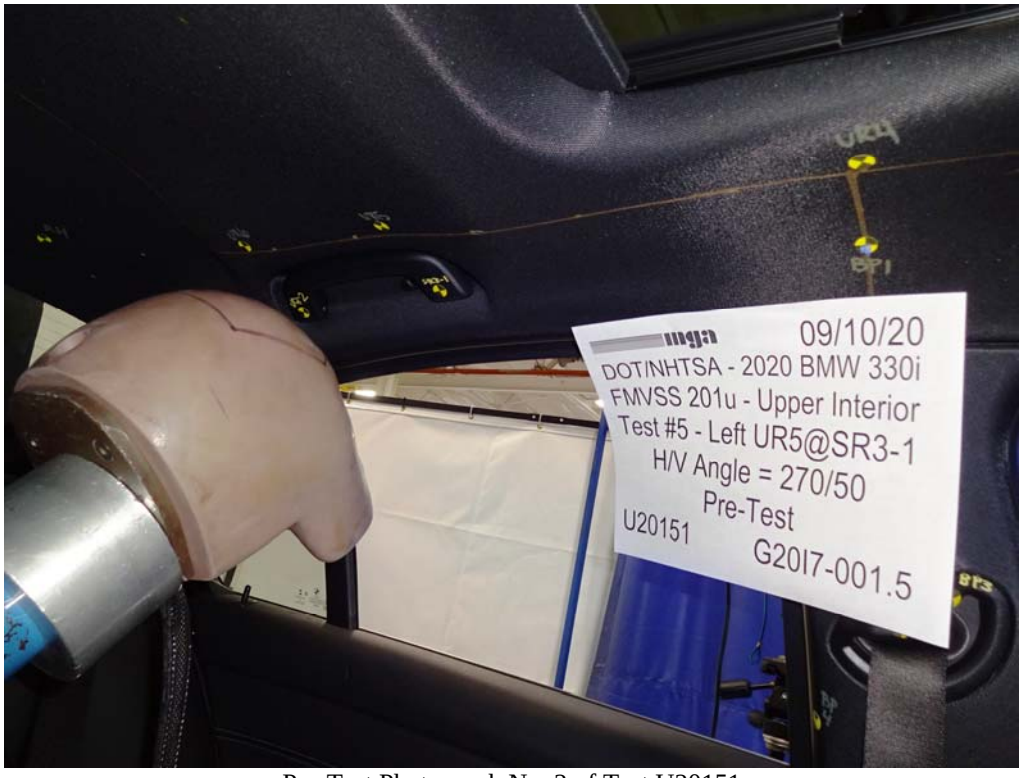


Max: 23.70 km/h , Min: -34.69 km/h



Max: 46.49 mm , Min: 0.00 mm

Pre-Test Photograph No. 1 of Test U20151

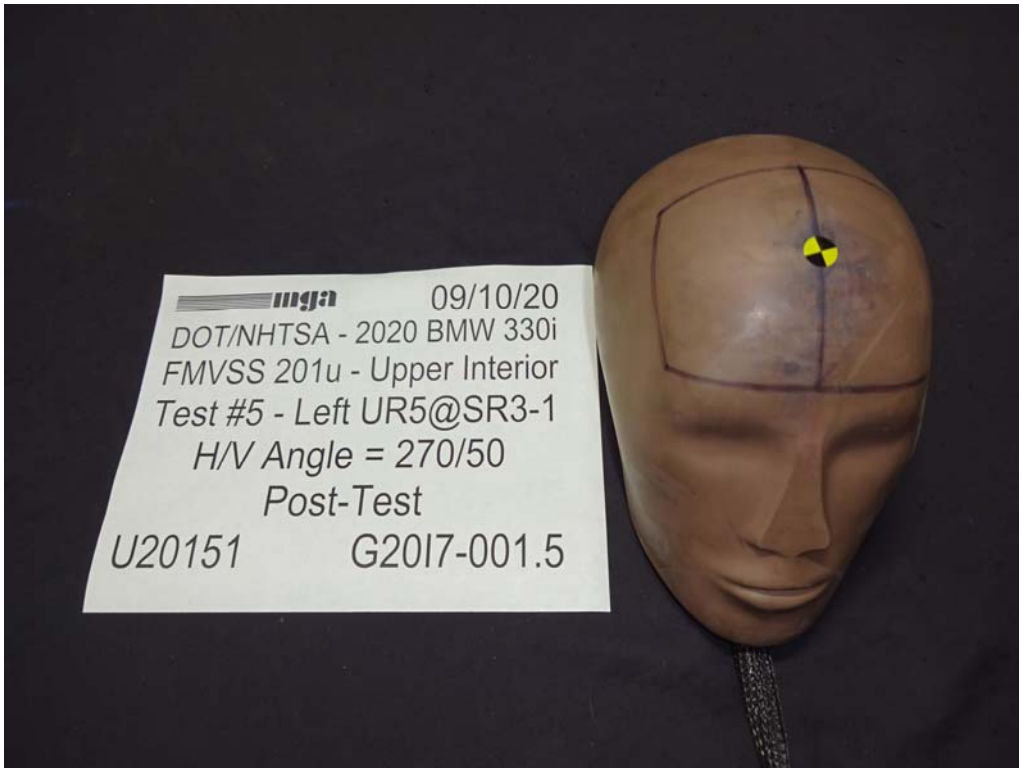


Pre-Test Photograph No. 2 of Test U20151

Post-Test Photograph No. 1 of Test U20151

Post-Test Photograph No. 2 of Test U20151

Post-Test Photograph No. 3 of Test U20151



Post-Test Photograph No. 4 of Test U20151

Test U20154 Data

FMVSS 201U
Test No.: U20154 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 8 Time: 09:58:07

Horizontal Approach Angle: 90 deg Temperature: 21.6 °C

Vertical Approach Angle: 50 deg Humidity: 42.1 %RH

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

Target Location: Right UR7@X=1396

Additional Description:

Test Results

Impact Velocity: 23.64 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	703.05	78.8	87	8.2
HIC 15	703.05	78.8	87	8.2
HIC (d)	696.83	78.8	87	8.2

3 ms Clip = 93.23 G , Time 1 = 83.13 ms , Time 2 = 86.13 ms

Impact Location on FMH: 57 mm Above Pt. 0 , 1 Left mm Lateral of Pt. 0

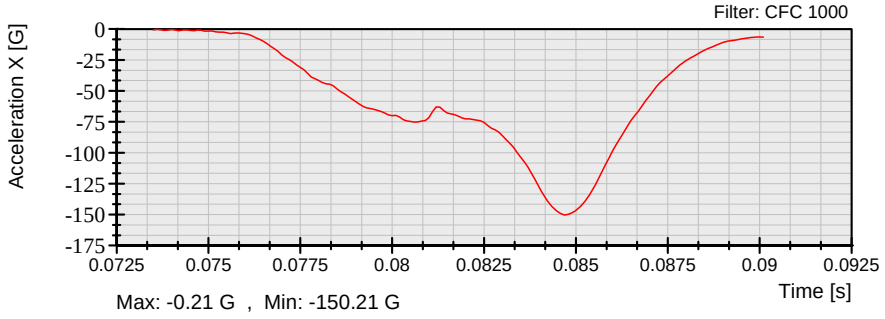
Post-Test Comments: No visible damage.

Test Series Performed By: DB, KR

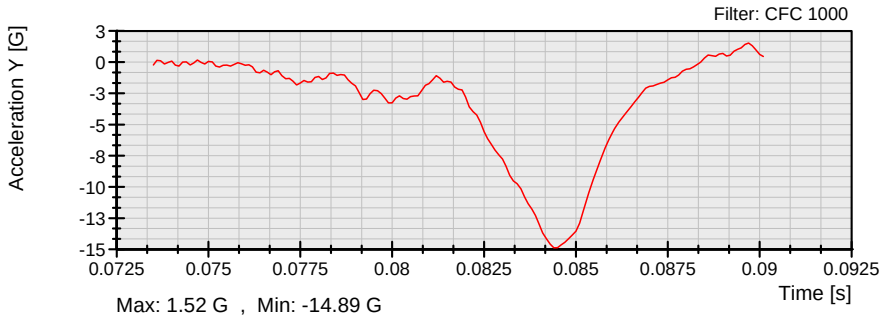
Recorded By: Approved By:

Date: 9/11/2020

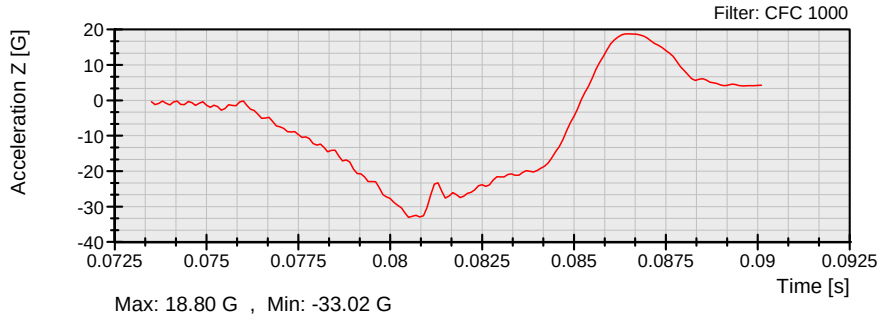
FMVSS 201U
Test No.: U20154 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: -0.21 G , Min: -150.21 G

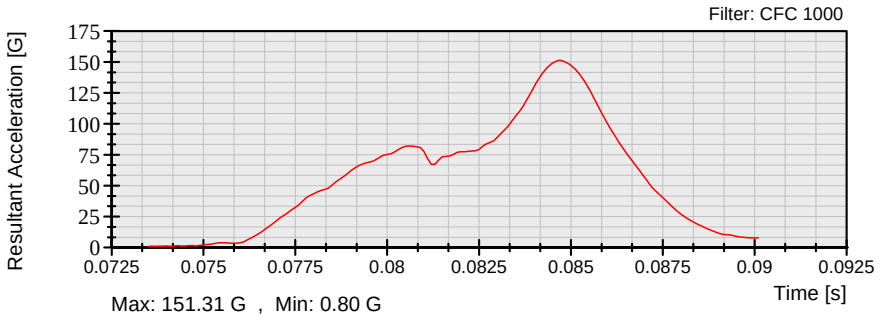


Max: 1.52 G , Min: -14.89 G

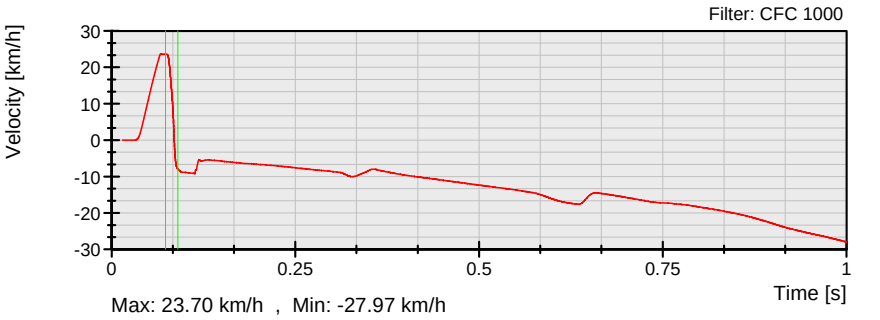


Max: 18.80 G , Min: -33.02 G

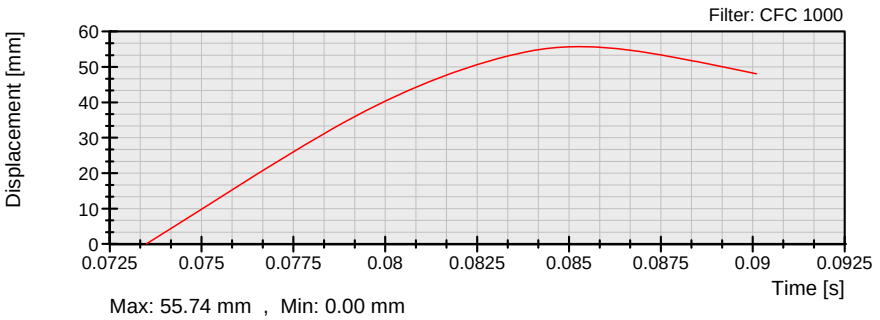
FMVSS 201U
Test No.: U20154 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: 151.31 G , Min: 0.80 G



Max: 23.70 km/h , Min: -27.97 km/h



Max: 55.74 mm , Min: 0.00 mm

Page 3 of 3

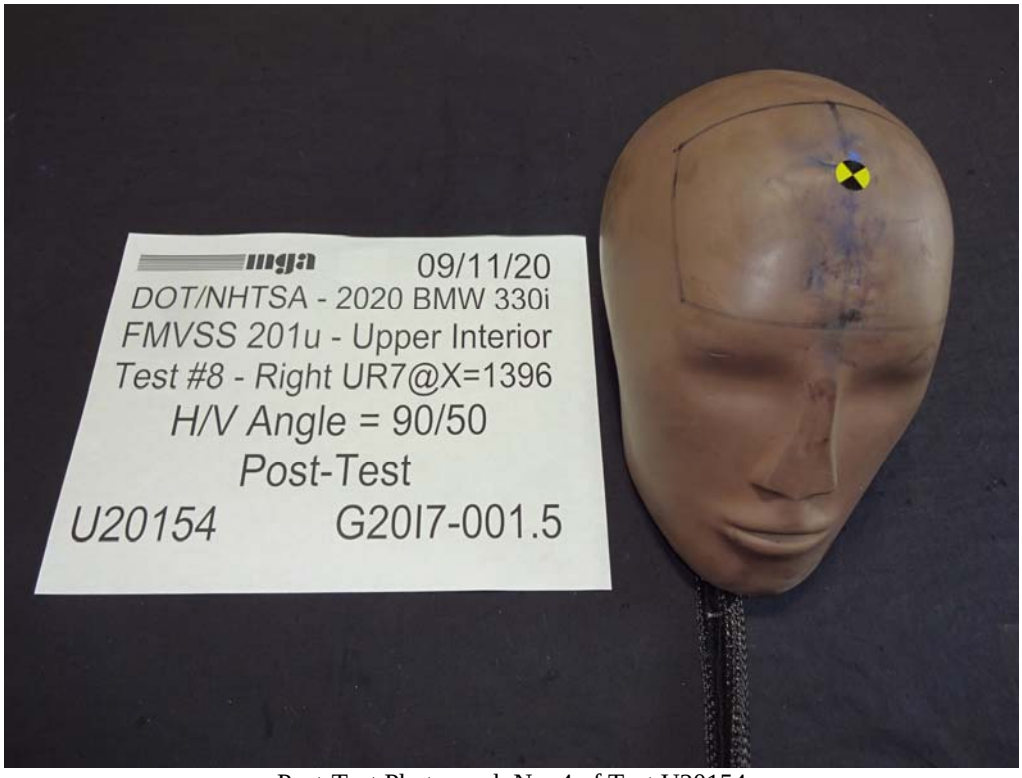
Pre-Test Photograph No. 1 of Test U20154

Pre-Test Photograph No. 2 of Test U20154

Post-Test Photograph No. 1 of Test U20154

Post-Test Photograph No. 2 of Test U20154

Post-Test Photograph No. 3 of Test U20154



Post-Test Photograph No. 4 of Test U20154

Test U20155 Data

FMVSS 201U
Test No.: U20155 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 9 Time: 10:43:02

Horizontal Approach Angle: 90 deg Temperature: 21.1 °C

Vertical Approach Angle: 50 deg Humidity: 43.3 %RH

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

Target Location: Right UR9@SR2A

Additional Description:

Test Results

Impact Velocity: 24.14 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	627.62	75.6	85	9.4
HIC 15	627.62	75.6	85	9.4
HIC (d)	639.92	75.6	85	9.4

3 ms Clip = 84.11 G , Time 1 = 81.03 ms , Time 2 = 84.03 ms

Impact Location on FMH: 45 mm Above Pt. 0 , 6 Left mm Lateral of Pt. 0

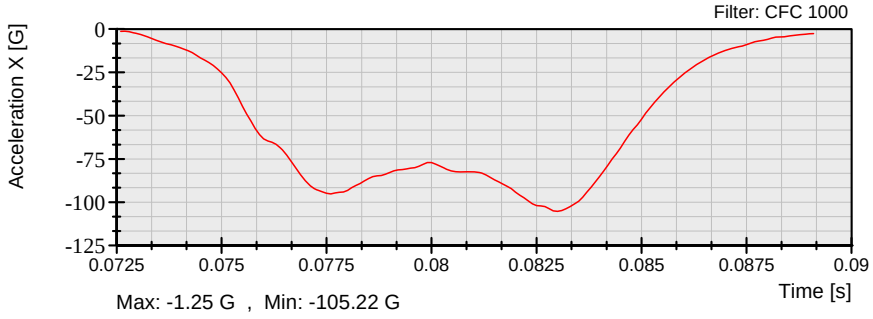
Post-Test Comments: Grab handle displaced; Headliner deformation.

Test Series Performed By: DB, KR

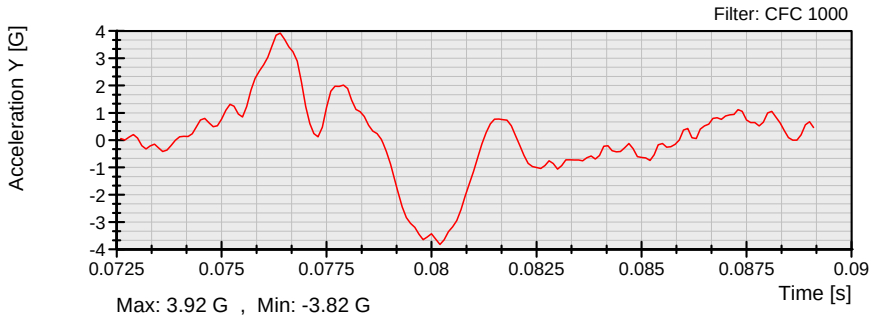
Recorded By: Approved By:

Date: 9/11/2020

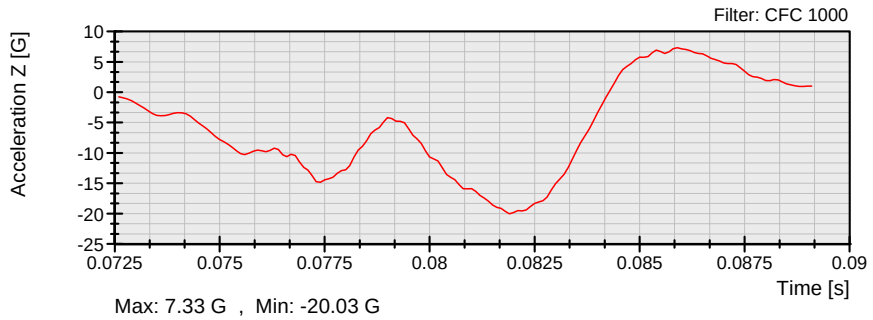
FMVSS 201U
Test No.: U20155 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: -1.25 G , Min: -105.22 G

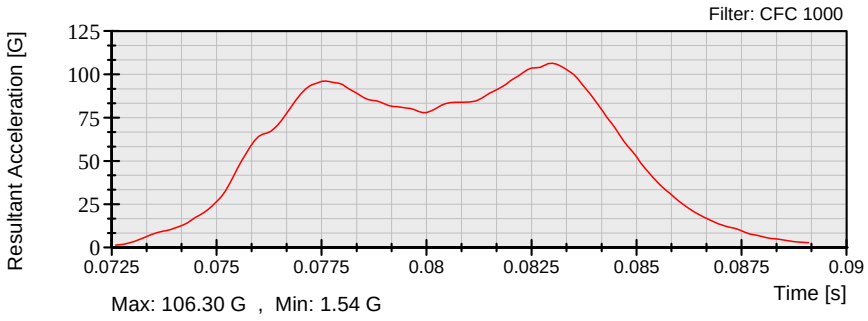


Max: 3.92 G , Min: -3.82 G

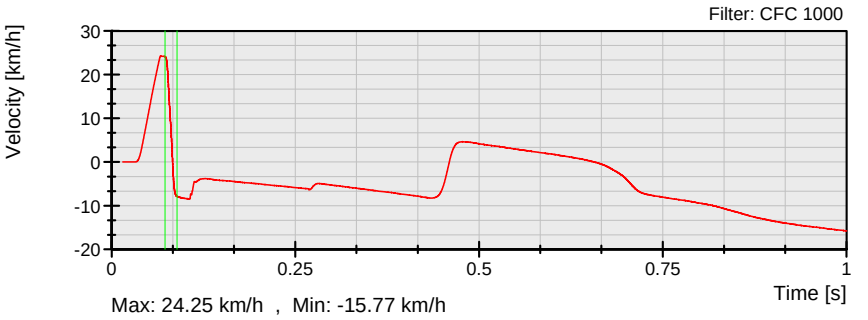


Max: 7.33 G , Min: -20.03 G

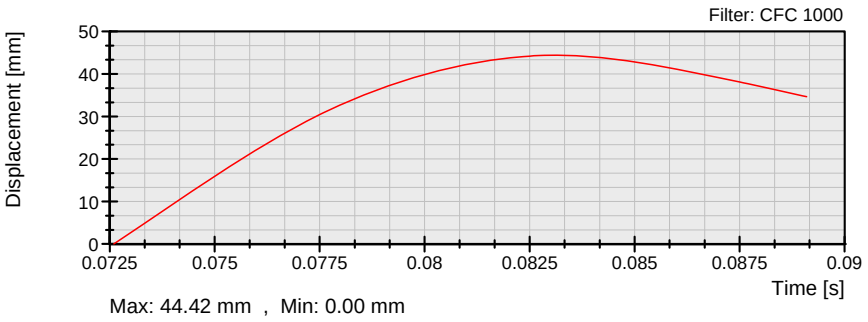
FMVSS 201U
Test No.: U20155 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: 106.30 G , Min: 1.54 G



Max: 24.25 km/h , Min: -15.77 km/h

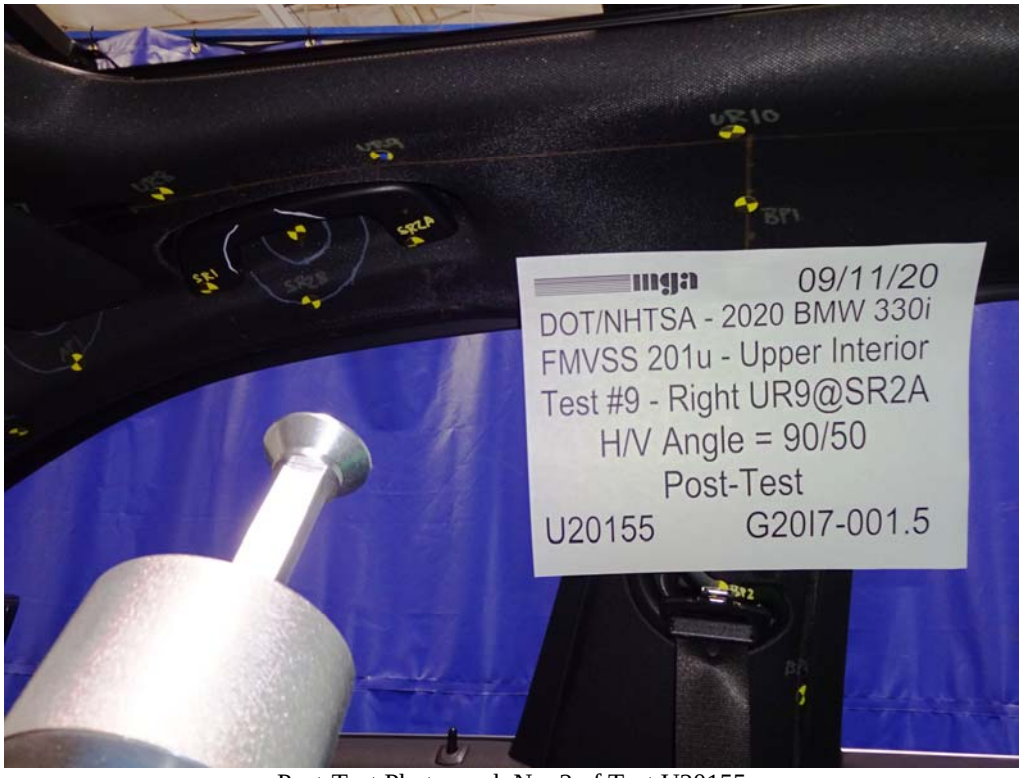


Max: 44.42 mm , Min: 0.00 mm

Pre-Test Photograph No. 1 of Test U20155

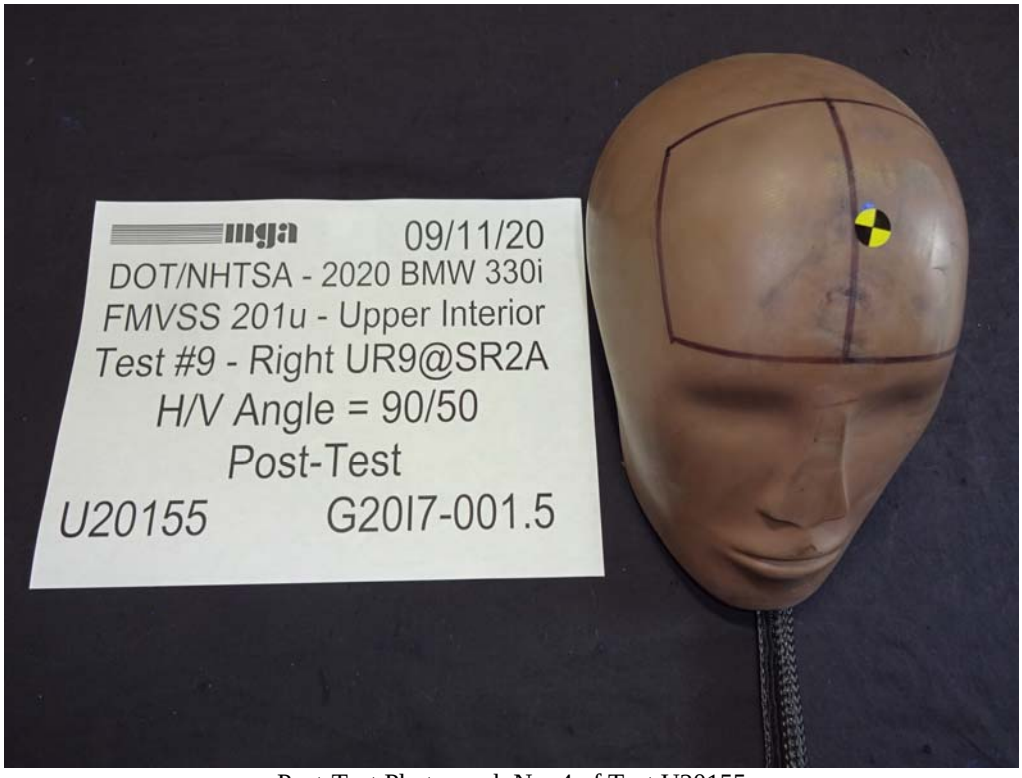
Pre-Test Photograph No. 2 of Test U20155

Post-Test Photograph No. 1 of Test U20155



Post-Test Photograph No. 2 of Test U20155

Post-Test Photograph No. 3 of Test U20155



Post-Test Photograph No. 4 of Test U20155

Test U20157 Data

FMVSS 201U
Test No.: U20157 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 11 Time: 14:57:10

Horizontal Approach Angle: 90 deg Temperature: 22.5 °C

Vertical Approach Angle: 50 deg Humidity: 40.1 %RH

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

Target Location: Right UR10@BP

Additional Description:

Test Results

Impact Velocity: 23.92 km/h

HIC Type	HIC Value	Time 1 (ms)	Time 2 (ms)	Delta-T (ms)
HIC 36	782.12	76.9	84.7	7.8
HIC 15	782.12	76.9	84.7	7.8
HIC (d)	756.48	76.9	84.7	7.8

3 ms Clip = 114.36 G , Time 1 = 79.23 ms , Time 2 = 82.23 ms

Impact Location on FMH: 46 mm Above Pt. 0 , 3 Right mm Lateral of Pt. 0

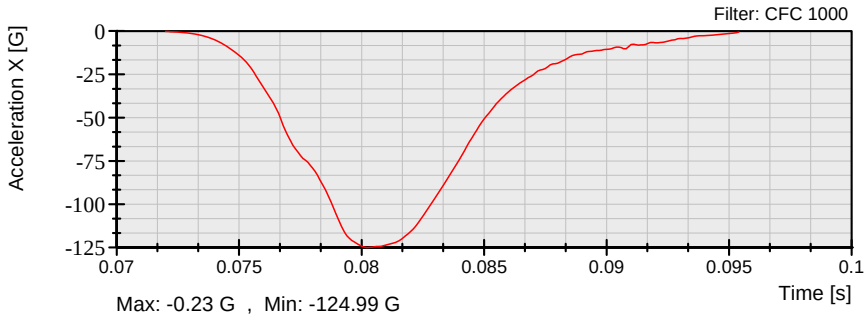
Post-Test Comments: Headliner deformation.

Test Series Performed By: DB, KR

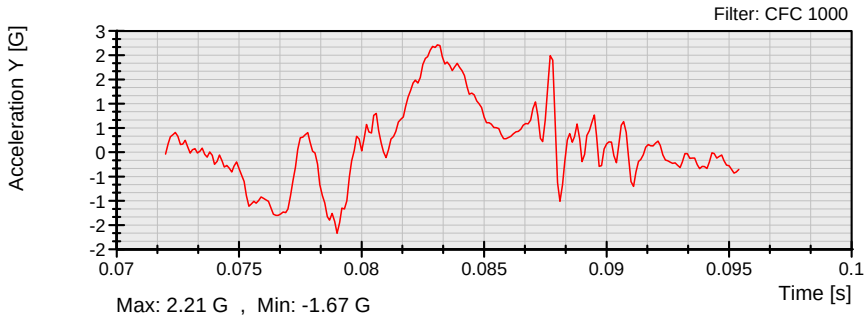
Recorded By: Approved By:

Date: 9/11/2020

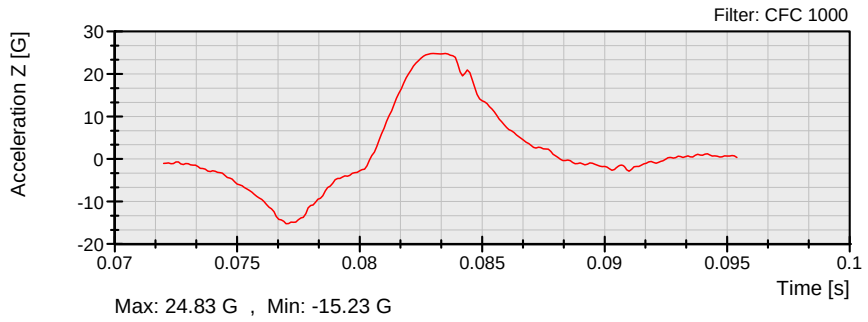
FMVSS 201U
Test No.: U20157 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: -0.23 G , Min: -124.99 G

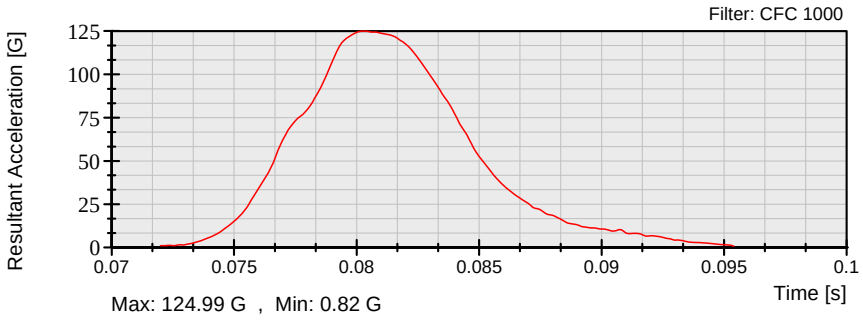


Max: 2.21 G , Min: -1.67 G

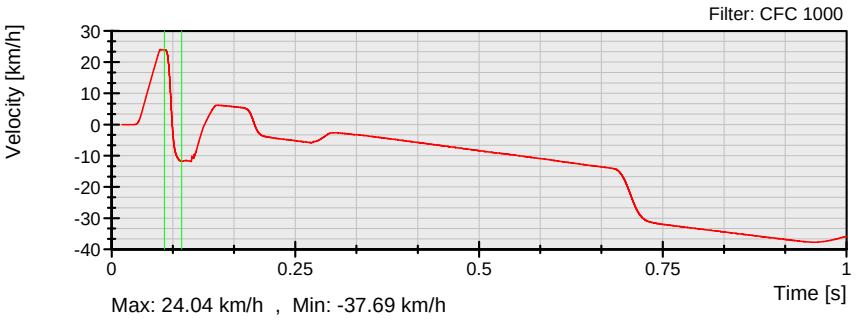


Max: 24.83 G , Min: -15.23 G

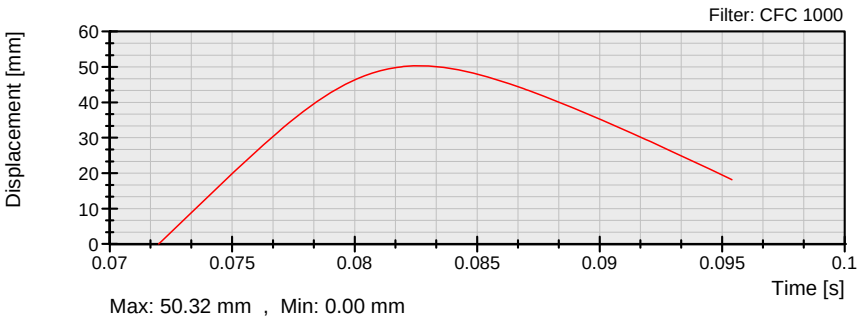
FMVSS 201U
Test No.: U20157 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: 124.99 G , Min: 0.82 G



Max: 24.04 km/h , Min: -37.69 km/h



Max: 50.32 mm , Min: 0.00 mm

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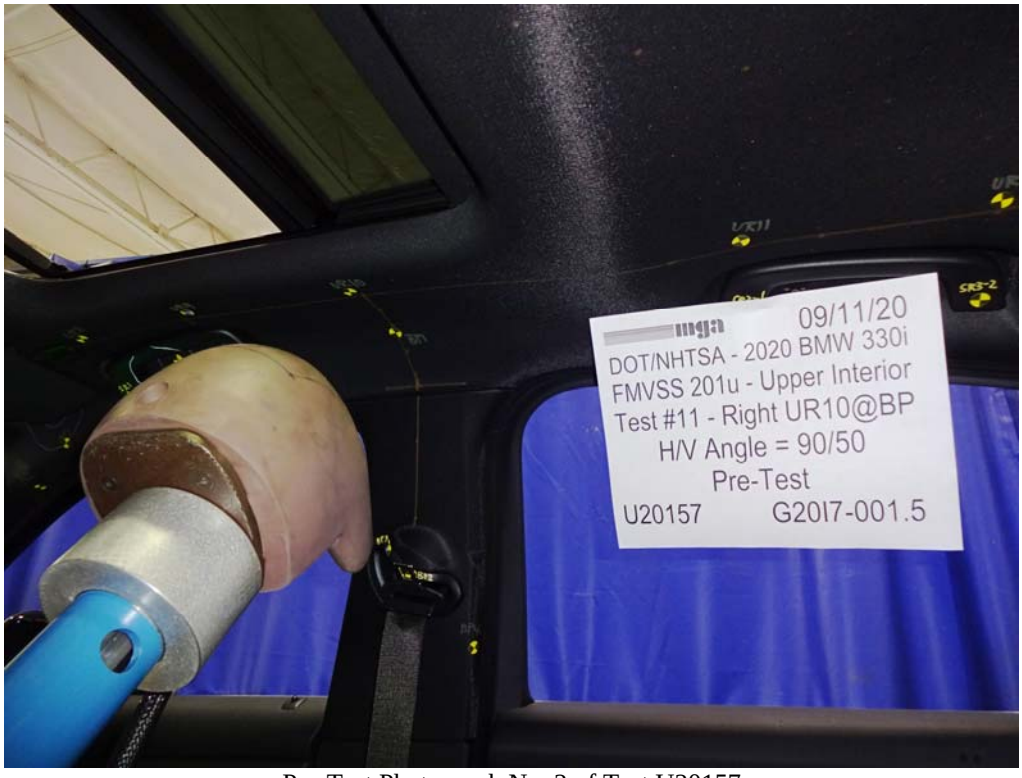
Pre-Test Photograph No. 1 of Test U20157

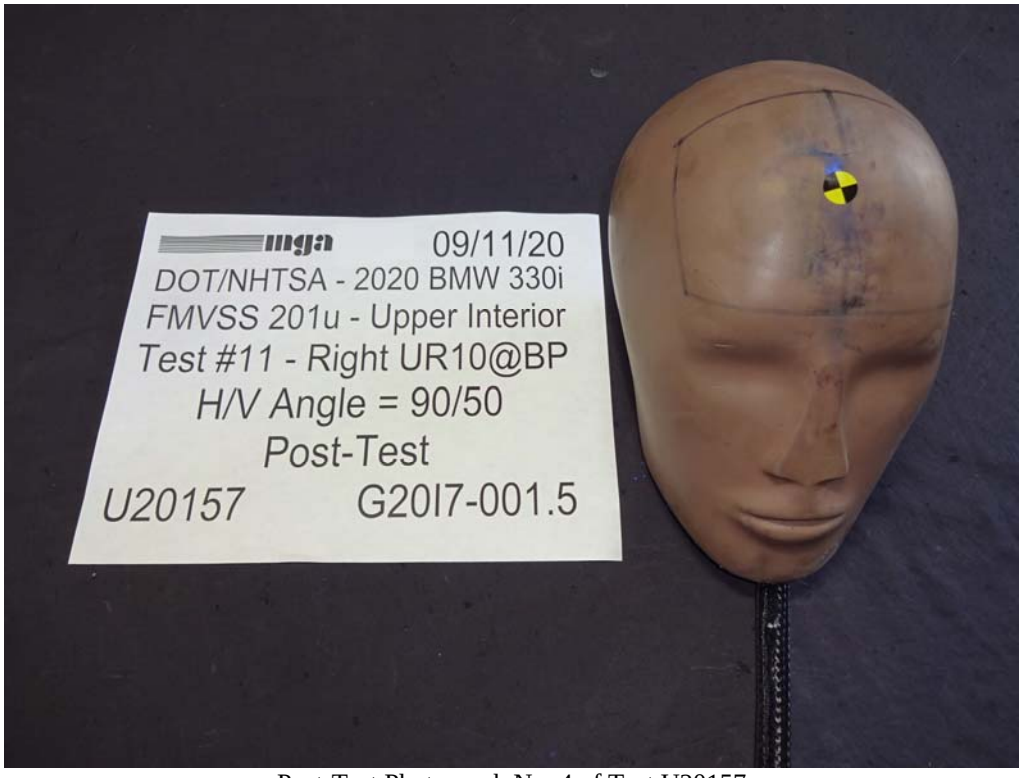


Pre-Test Photograph No. 2 of Test U20157

Post-Test Photograph No. 1 of Test U20157

Post-Test Photograph No. 2 of Test U20157

Post-Test Photograph No. 3 of Test U20157



Post-Test Photograph No. 4 of Test U20157

Test U20158 Data

mga research corporation

FMVSS 201U
Test No.: U20158 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020

Summary of the Test

Setup Information

Sample Description: 2020 BMW 330i

Test Sequence No.: 12 Time: 15:37:47

Horizontal Approach Angle: 90 deg Temperature: 22.6 °C

Vertical Approach Angle: 50 deg Humidity: 40.0 %RH

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

Target Location: Right UR12@SR3-2

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	564.48	76.8	85.3	8.5
HIC 15	564.48	76.8	85.3	8.5
HIC (d)	592.28	76.8	85.3	8.5

3 ms Clip = 97.84 G , Time 1 = 78.45 ms , Time 2 = 81.84 ms

Impact Location on FMH: 36 mm Above Pt. 0 , 5 Left mm Lateral of Pt. 0

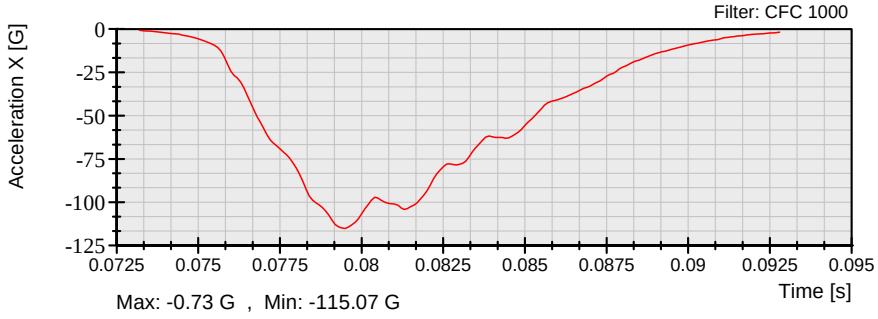
Post-Test Comments: Grab handle displaced; Headliner deformation.

Test Series Performed By: DB, KR

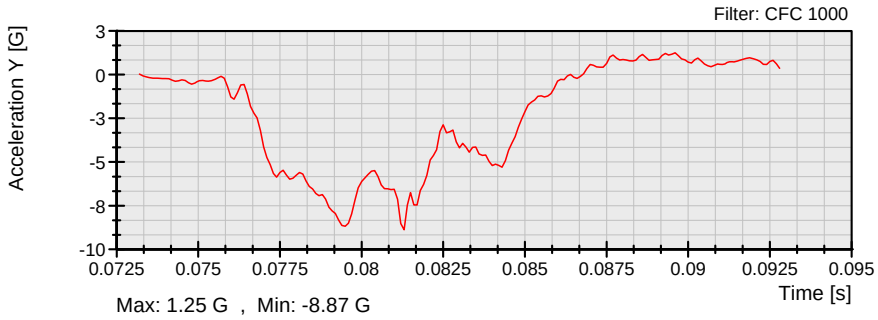
Recorded By: Approved By:

Date: 9/11/2020

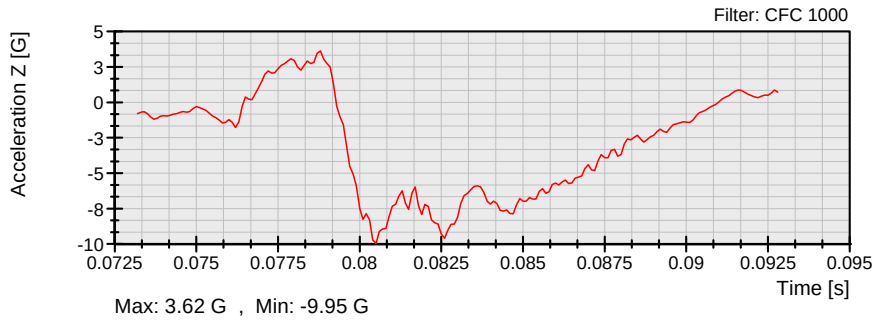
FMVSS 201U
Test No.: U20158 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: -0.73 G , Min: -115.07 G

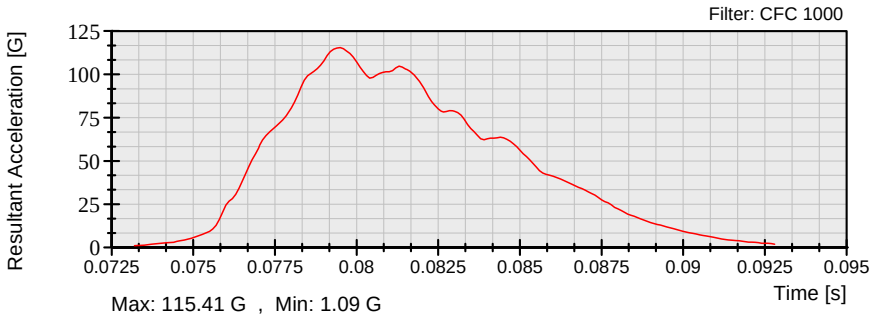


Max: 1.25 G , Min: -8.87 G

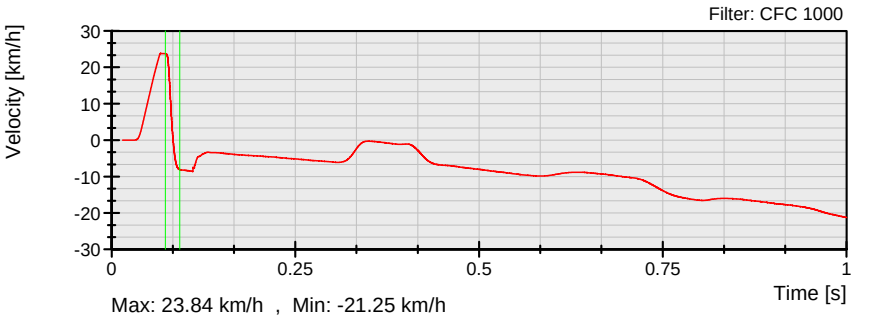


Max: 3.62 G , Min: -9.95 G

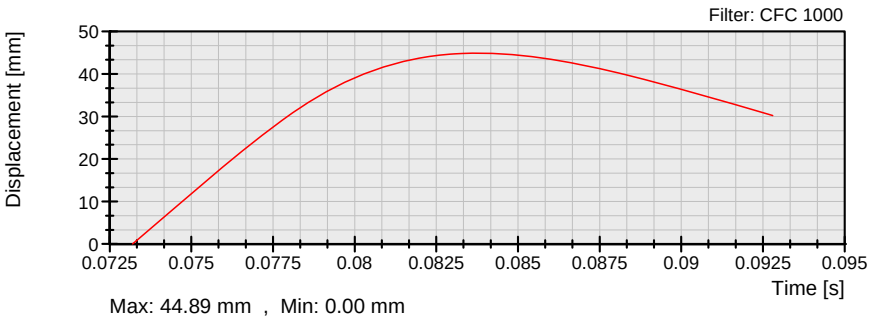
FMVSS 201U
Test No.: U20158 Report No.: G20I7-001.5
Customer: NHTSA Date: 9/11/2020



Max: 115.41 G , Min: 1.09 G



Max: 23.84 km/h , Min: -21.25 km/h



Max: 44.89 mm , Min: 0.00 mm

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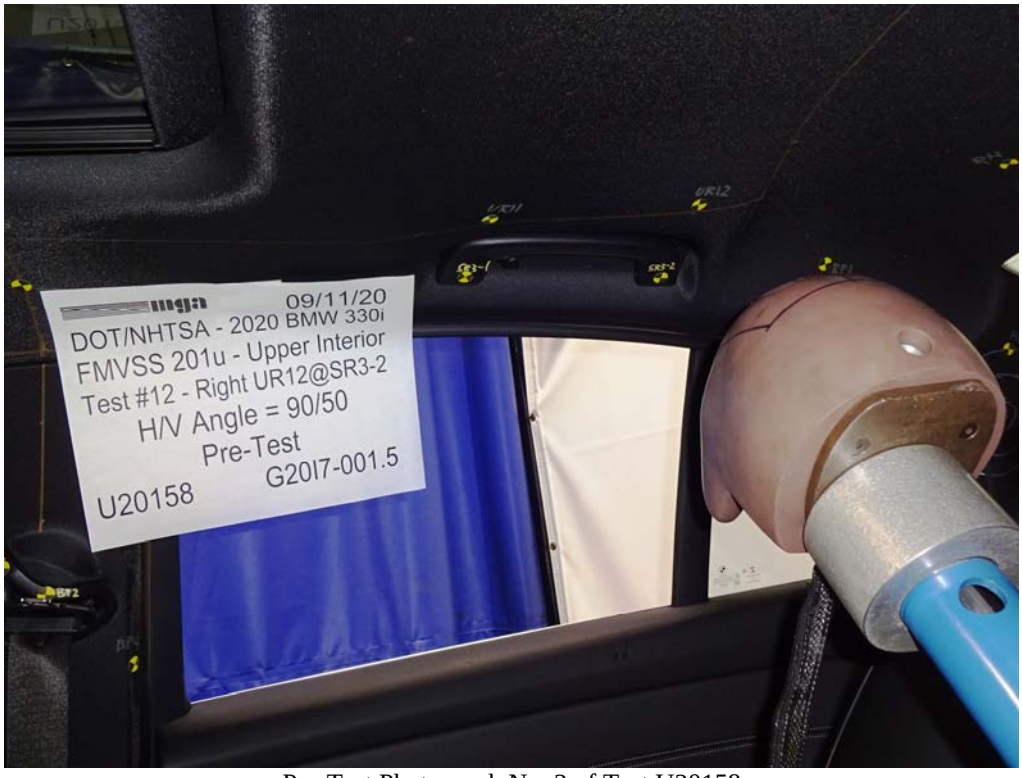
Pre-Test Photograph No. 1 of Test U20158



Pre-Test Photograph No. 2 of Test U20158

Post-Test Photograph No. 1 of Test U20158

Post-Test Photograph No. 2 of Test U20158

Post-Test Photograph No. 3 of Test U20158

Post-Test Photograph No. 4 of Test U20158

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	C10-02-03-01351	Targeting	0.1 mm	Annual
Measuring Devices: - Tape Measure - Plumb Bobs - Digital Protractor	 Staney N/A Mitutoyo	 TPM006-93 -- MGA00712	 Measurement Targeting FMH setup Horizontal Measurement	 1 mm N/A 0.5°	Annual
*Temperature/RH Data Logger	Madgetech	R20561	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	09/09/2020	4.55	23.7	51.3	2.52	245.61	Yes
35	Post	09/16/2020	4.55	21.3	44.2	1.57	259.12	Yes
37	Pre	09/09/2020	4.58	23.5	51.5	3.68	271.44	Yes
37	Post	09/16/2020	4.58	21.5	45.1	7.83	273.53	Yes
38	Pre	09/10/2020	4.55	22.3	53.7	4.65	260.09	Yes
38	Post	09/16/2020	4.55	21.6	44.4	13.96	263.03	Yes

4-1 Pre-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H35008 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/09/2020

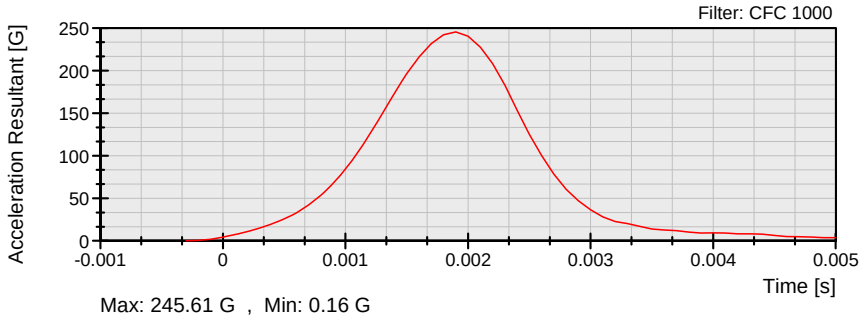
Summary of Results:

Impact Form ID No.: H35

Item Description	Result	Requirement
Temperature (°C)	23.7 °C	19ºC and 26ºC
Humidity (%RH)	51.3 % RH	10% to 70% RH
Impact Form Mass (kg)	4.55 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	245.61 G	225 to 275 G
Peak Y-Acceleration (G)	2.52 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: DB

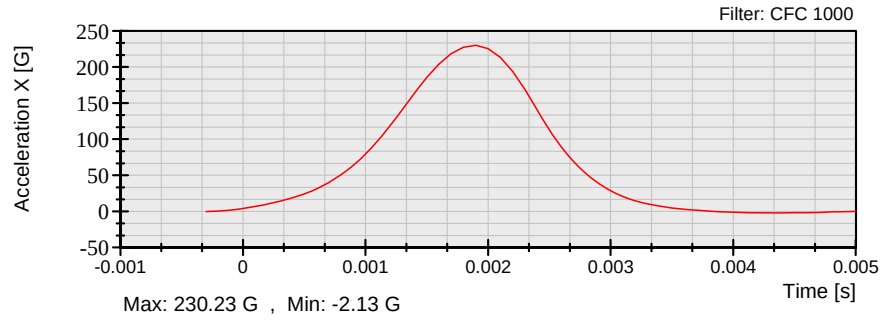
Comments: Pre-Test



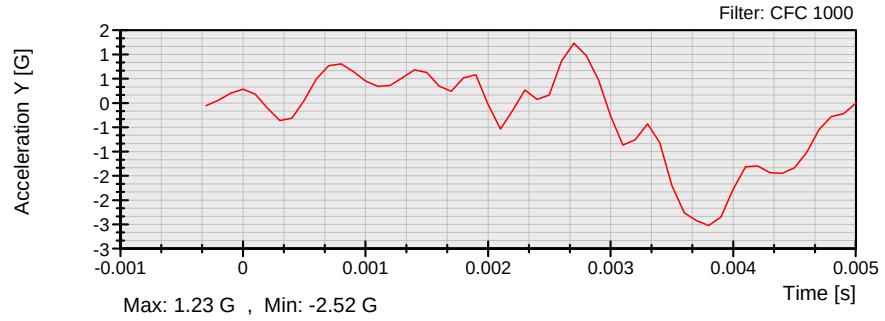
Max: 245.61 G , Min: 0.16 G

Calibration Series: FMVSS 201U FMH

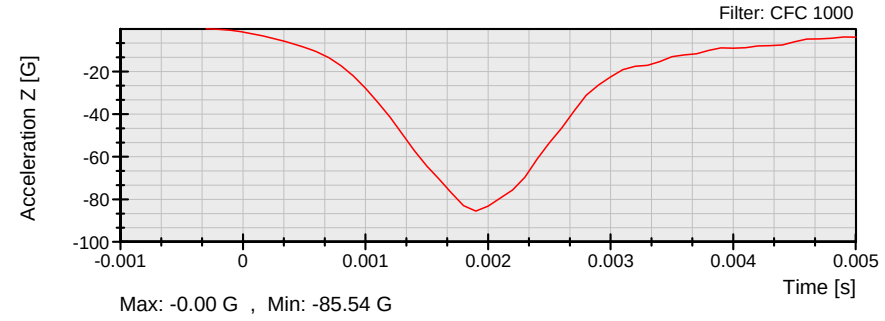
Test No.: H35008 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/09/2020



Max: 230.23 G , Min: -2.13 G



Max: 1.23 G , Min: -2.52 G



Max: -0.00 G , Min: -85.54 G

Page 2 of 2

Recorded By: _____ **Approved By:** _____
Date: September 16, 2020

4-2 Post-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H35009 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/16/2020

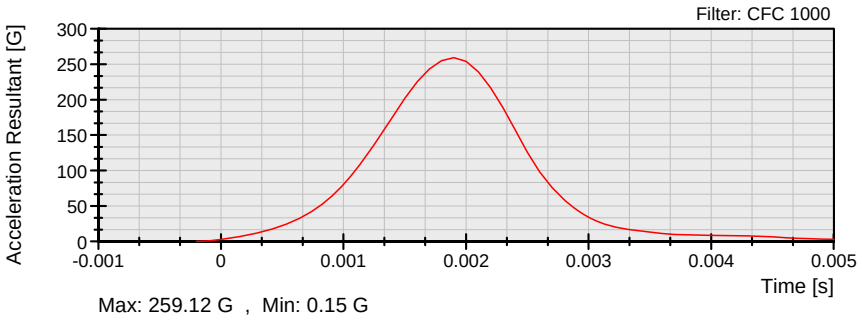
Summary of Results:

Impact Form ID No.: H35

Item Description	Result	Requirement
Temperature (°C)	21.3 °C	19ºC and 26ºC
Humidity (%RH)	44.2 % RH	10% to 70% RH
Impact Form Mass (kg)	4.55 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	259.12 G	225 to 275 G
Peak Y-Acceleration (G)	1.57 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: DB

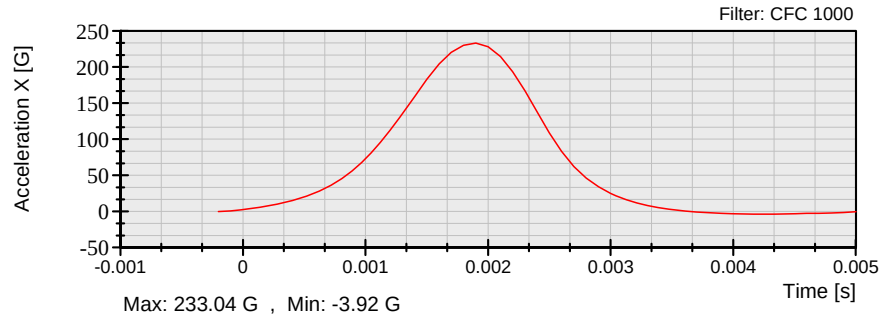
Comments: Post-Test



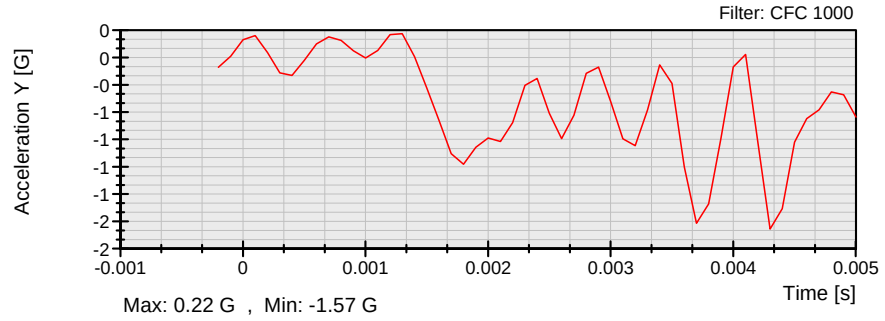
Max: 259.12 G , Min: 0.15 G

Calibration Series: FMVSS 201U FMH

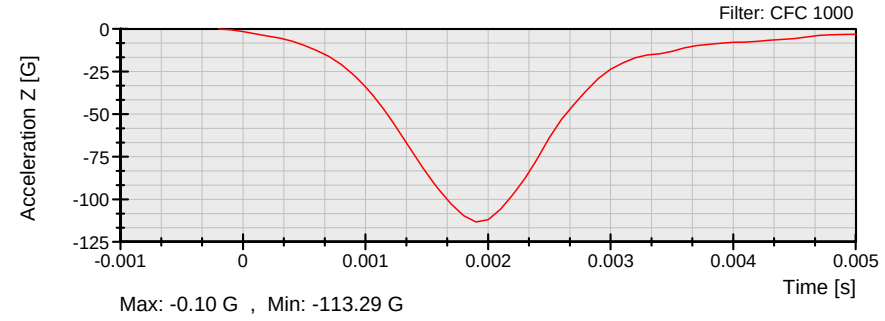
Test No.: H35009 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/16/2020



Max: 233.04 G , Min: -3.92 G



Max: 0.22 G , Min: -1.57 G



Max: -0.10 G , Min: -113.29 G

Page 2 of 2

Recorded By: _____ **Approved By:** _____
Date: September 16, 2020

4-3 Pre-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H37008 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/09/2020

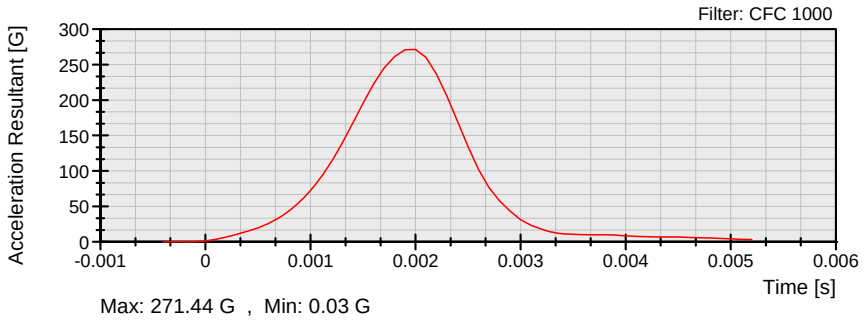
Summary of Results:

Impact Form ID No.: H37

Item Description	Result	Requirement
Temperature (°C)	23.5 °C	19ºC and 26ºC
Humidity (%RH)	51.5 % RH	10% to 70% RH
Impact Form Mass (kg)	4.58 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	271.44 G	225 to 275 G
Peak Y-Acceleration (G)	3.68 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: DB

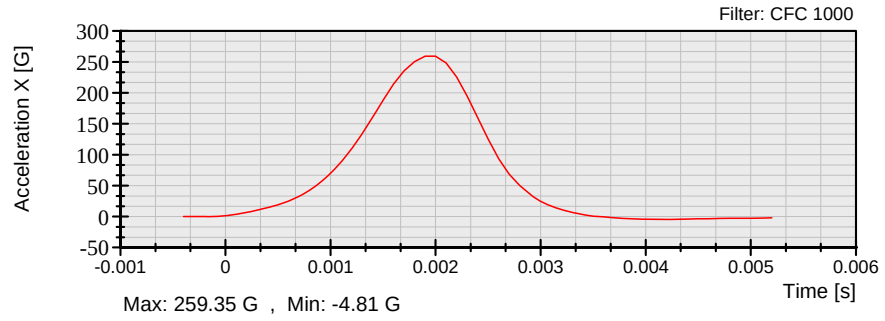
Comments: Pre-Test



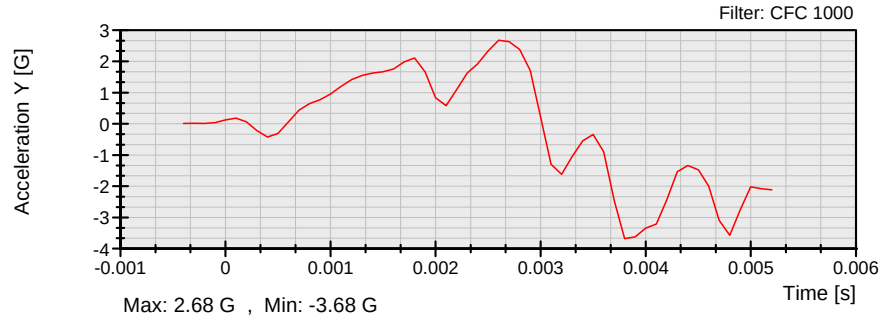
Max: 271.44 G , Min: 0.03 G

Calibration Series: FMVSS 201U FMH

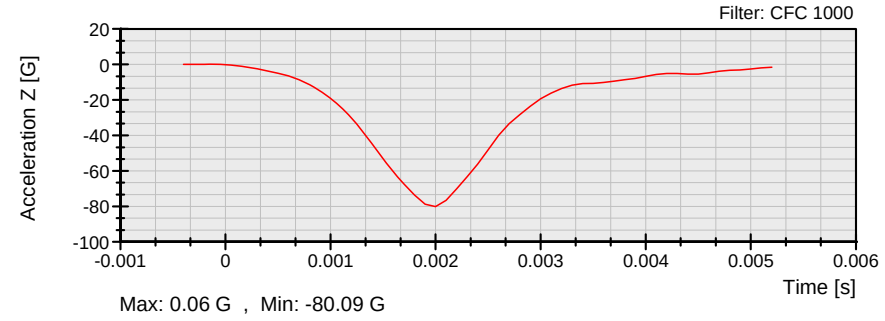
Test No.: H37008 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/09/2020



Max: 259.35 G , Min: -4.81 G



Max: 2.68 G , Min: -3.68 G



Max: 0.06 G , Min: -80.09 G

Page 2 of 2

Recorded By: _____ **Approved By:** _____
Date: September 9, 2020

4-4 Post-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H37009 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/16/2020

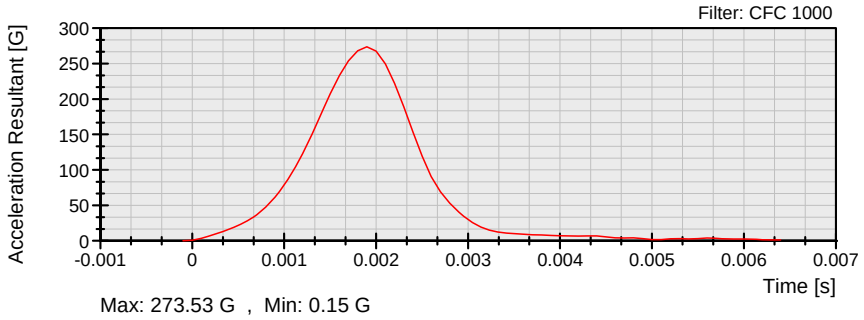
Summary of Results:

Impact Form ID No.: H37

Item Description	Result	Requirement
Temperature (°C)	21.5 °C	19ºC and 26ºC
Humidity (%RH)	45.1 % RH	10% to 70% RH
Impact Form Mass (kg)	4.58 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	273.53 G	225 to 275 G
Peak Y-Acceleration (G)	7.83 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: DB

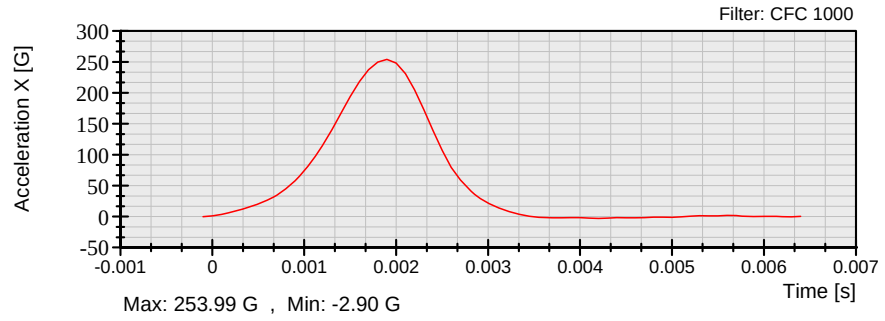
Comments: Post-Test



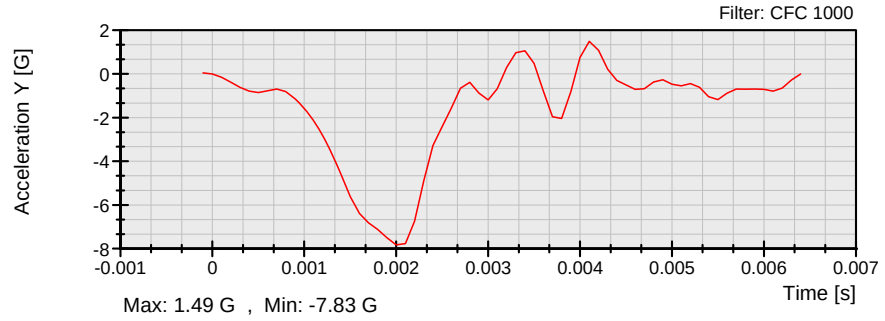
Max: 273.53 G , Min: 0.15 G

Calibration Series: FMVSS 201U FMH

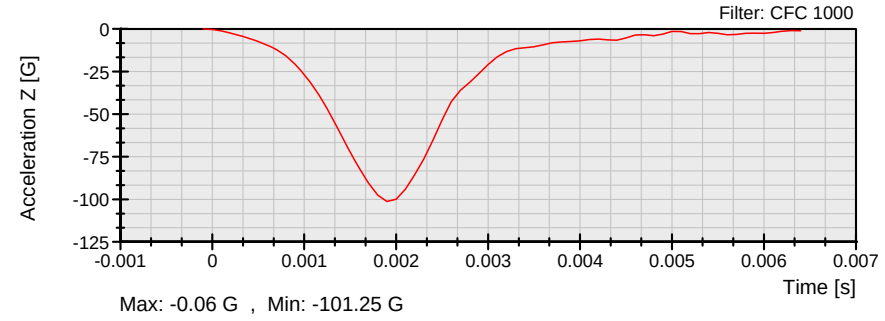
Test No.: H37009 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/16/2020



Max: 253.99 G , Min: -2.90 G



Max: 1.49 G , Min: -7.83 G



Max: -0.06 G , Min: -101.25 G

Page 2 of 2

Recorded By: _____ **Approved By:** _____
Date: September 16, 2020

4-5 Pre-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H38008 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/10/2020

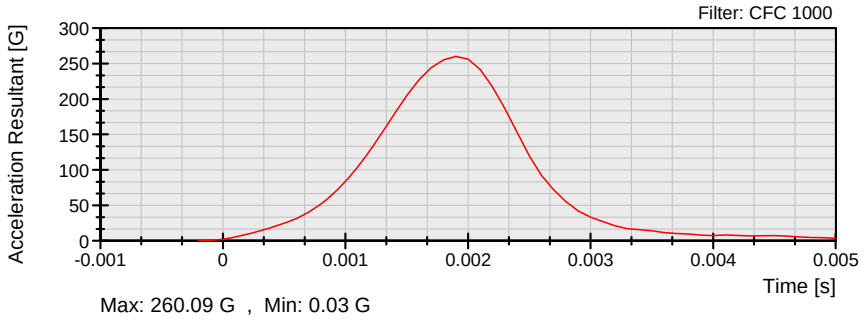
Summary of Results:

Impact Form ID No.: H38

Item Description	Result	Requirement
Temperature (°C)	22.3 °C	19ºC and 26ºC
Humidity (%RH)	53.7 % RH	10% to 70% RH
Impact Form Mass (kg)	4.55 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	260.09 G	225 to 275 G
Peak Y-Acceleration (G)	4.65 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: DB

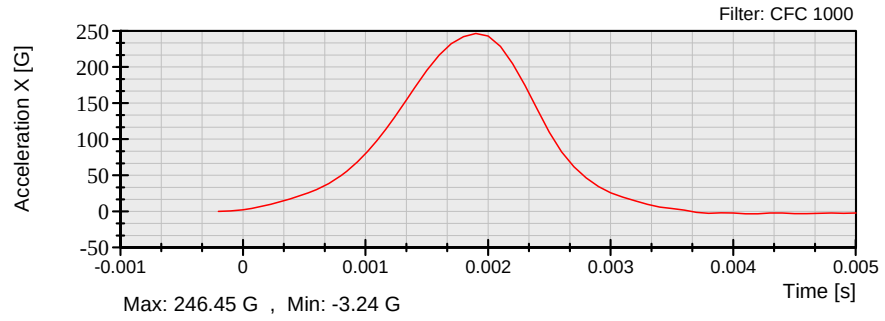
Comments: Pre-Test



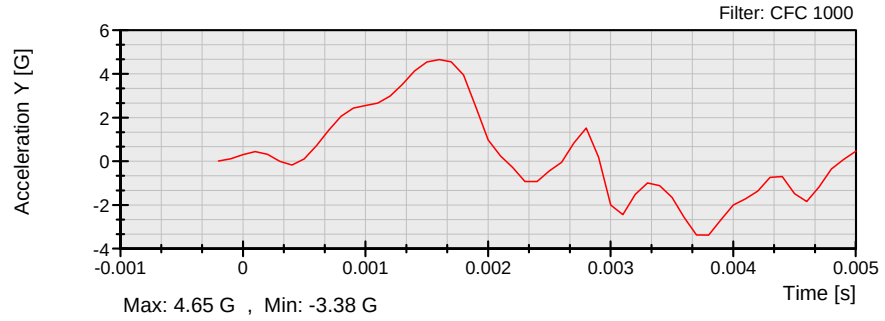
Max: 260.09 G , Min: 0.03 G

Calibration Series: FMVSS 201U FMH

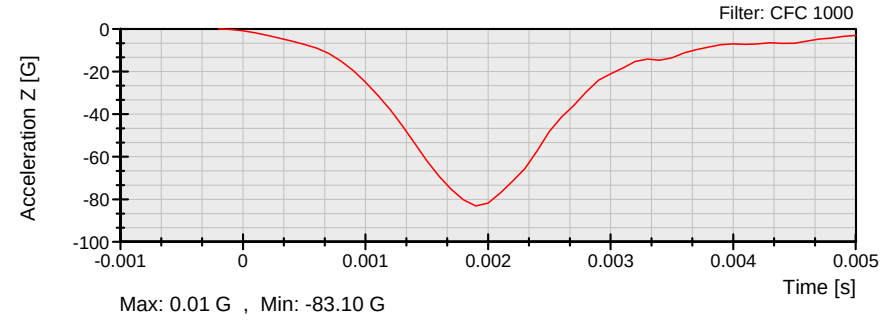
Test No.: H38008 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/10/2020



Max: 246.45 G , Min: -3.24 G



Max: 4.65 G , Min: -3.38 G



Max: 0.01 G , Min: -83.10 G

Page 2 of 2

Recorded By: _____ **Approved By:** _____
Date: September 10, 2020

4-6 Post-Test Calibration

Calibration Series: FMVSS 201U FMH

Test No.: H38009 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/16/2020

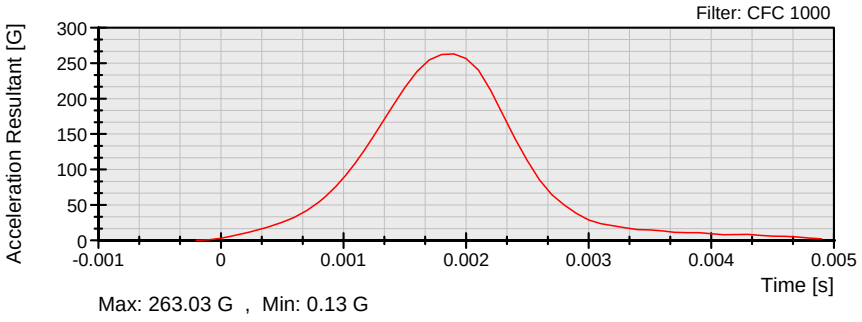
Summary of Results:

Impact Form ID No.: H38

Item Description	Result	Requirement
Temperature (°C)	21.6 °C	19ºC and 26ºC
Humidity (%RH)	44.4 % RH	10% to 70% RH
Impact Form Mass (kg)	4.55 kg	4.54 ± 0.05 kg
Resultant Acceleration (G)	263.03 G	225 to 275 G
Peak Y-Acceleration (G)	13.96 G	< 15 G
Unimodal?	Yes	Yes

Calibration Performed By: DB

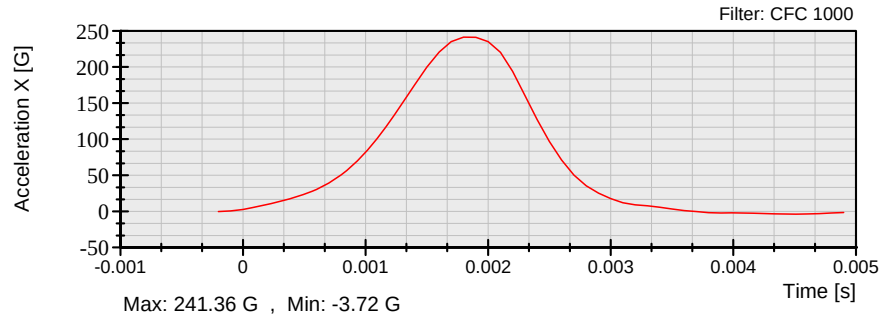
Comments: Post-Test



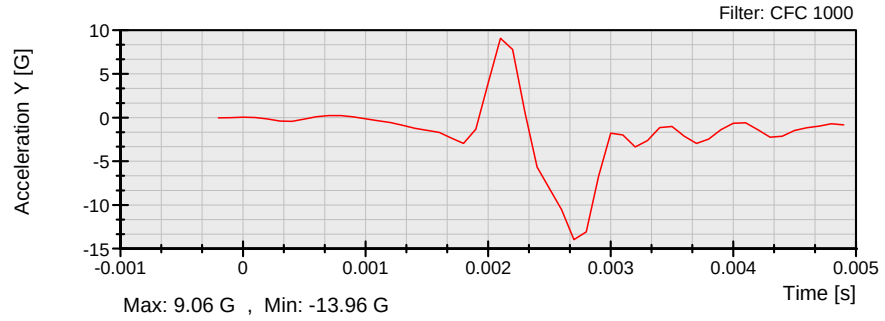
Max: 263.03 G , Min: 0.13 G

Calibration Series: FMVSS 201U FMH

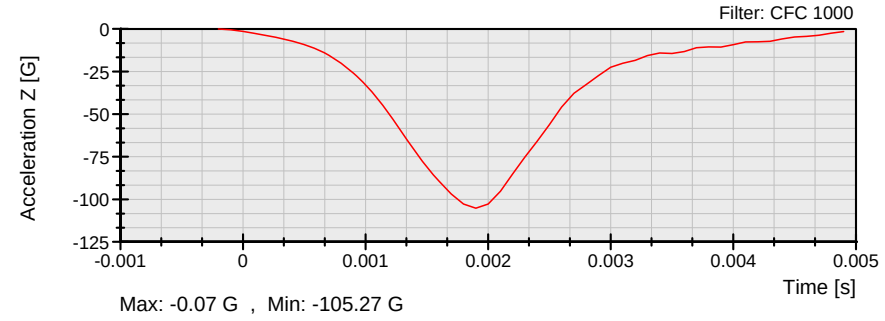
Test No.: H38009 Report No.: G20I7-001.5
Customer: NHTSA Date: 09/16/2020



Max: 241.36 G , Min: -3.72 G



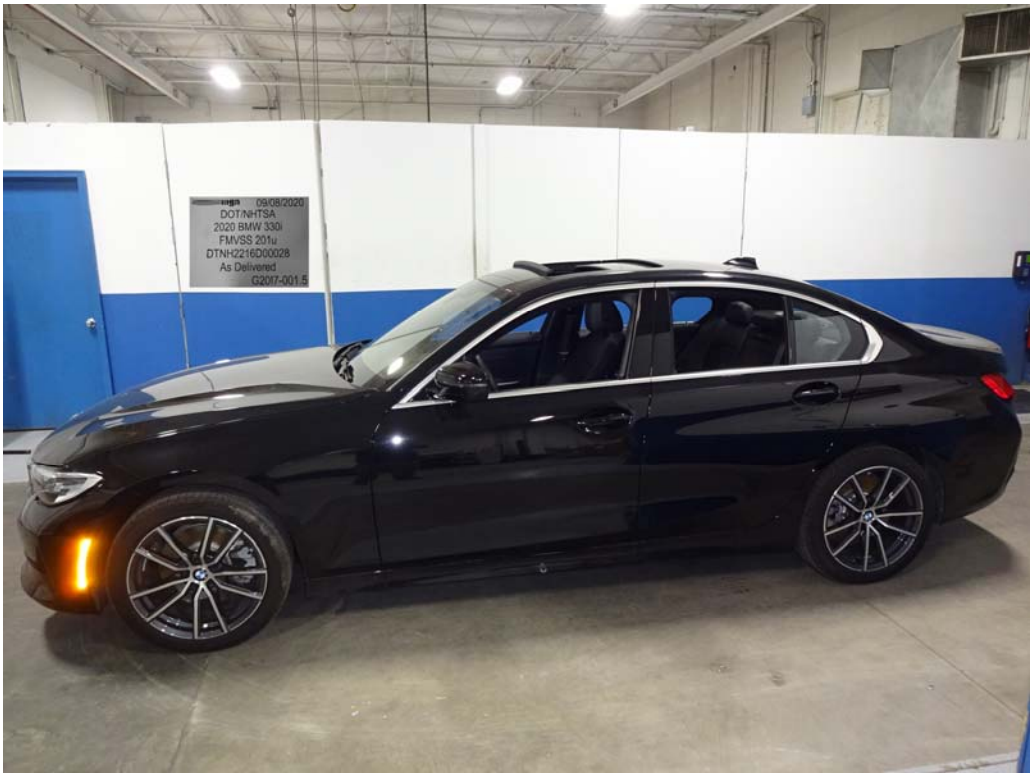
Max: 9.06 G , Min: -13.96 G



Max: -0.07 G , Min: -105.27 G

Recorded By: _____ **Approved By:** _____
Date: September 16, 2020

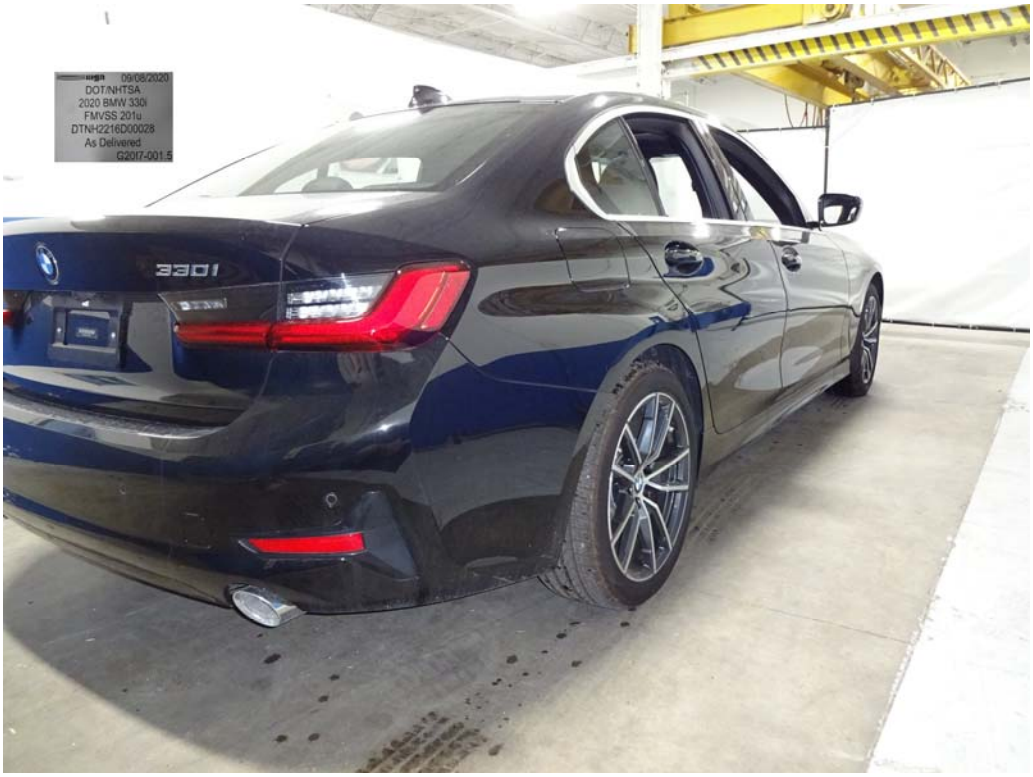
5.0 PHOTOGRAPHS



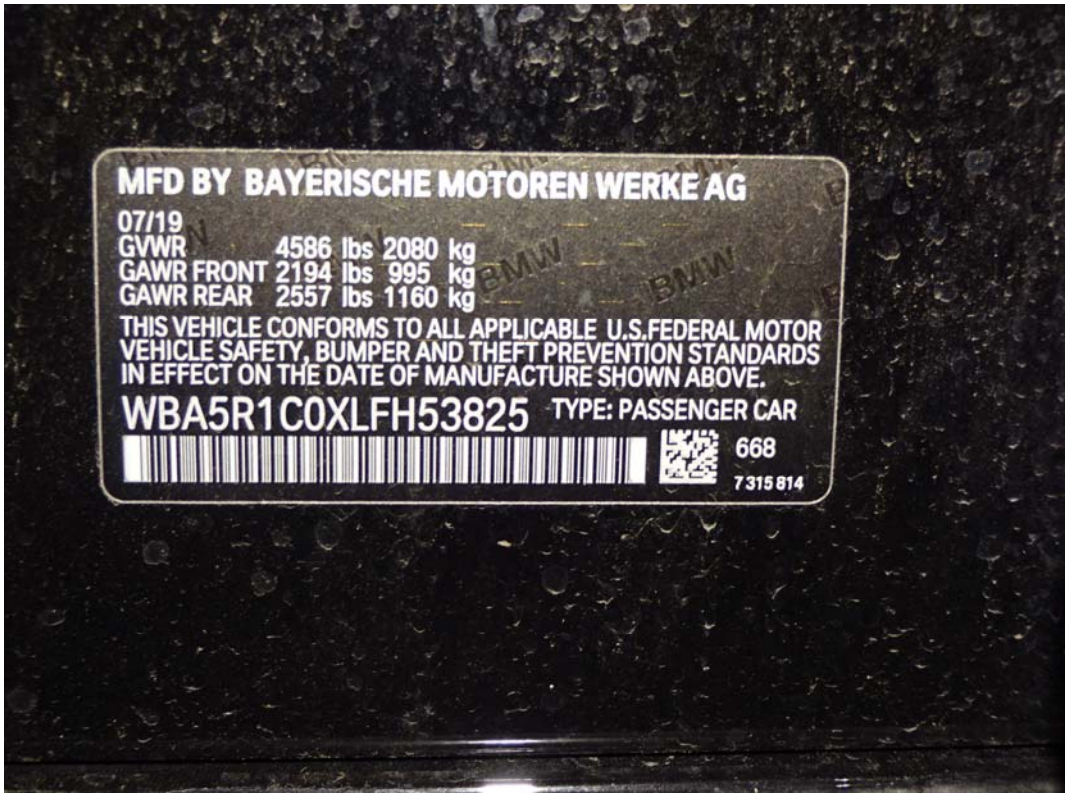
As Delivered – Left Side View

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


09/09/20
DOT/NHTSA
2020 BMW 330
FMVSS 201u
DTNH2216D00028
Pre-Test Components
G20I7-001.5


09/09/20
DOT/NHTSA
2020 BMW 330
FMVSS 201u
DTNH2216D00028
Pre-Test Components
G20I7-001.5


09/09/20
DOT/NHTSA
2020 BMW 330
FMVSS 201u
DTNH2216D00028
Pre-Test Components
G20I7-001.5


09/09/20
DOT/NHTSA
2020 BMW 330
FMVSS 201u
DTNH2216D00028
Pre-Test Components
G20I7-001.5

Post-Test Component Photographs

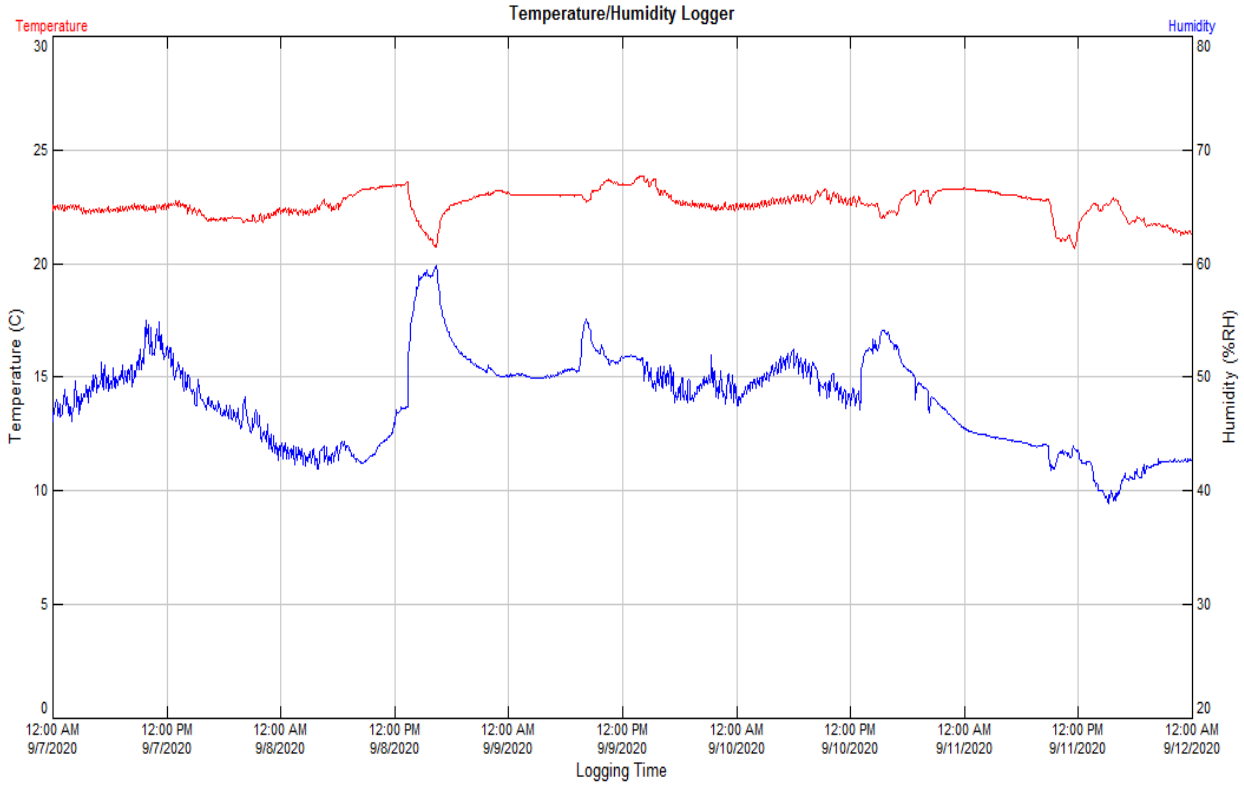

09/15/2020
DOT/NHTSA
2020 BMW 330i
FMVSS 201u
DTNH2216D00028
Post-Test Components
G20I7-001.5


09/15/2020
DOT/NHTSA
2020 BMW 330i
FMVSS 201u
DTNH2216D00028
Post-Test Components
G20I7-001.5

Post-Test Photograph No. 6

Appendix A – Temperature Trace

C20204100
2020 BMW 330i
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# 3097.01

Calibration and Test Report

Model # :	TDAS PRO LAB SIM	CERTIFICATE NUMBER:	Date Received: 18 May 2020
Serial # :	LM0212	20200518LM0212	Date Calibrated: 18 May 2020
Firmware:	07E4		
Procedure:	TDAS PRO SIM Calibration, Rev 8.01	Issued:	Item Received: In Tolerance
Order:	63414	18 May 2020	Item Returned: In Tolerance
Customer:	MGA Research Corporation		
	33653 Dequindre	Next Calibration:	Temperature: 74°F / 23.5°C
	Troy, MI, 48083, USA	18 May 2021	Humidity: 46 %

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 processed 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). All calibrations have been performed using processes having a test uncertainty ratio of four or more times greater than the unit calibrated, unless otherwise noted on the report. Uncertainties have been estimated at a 95 percent confidence level (k=2). Calibration at a 4:1 TUR provides reasonable confidence that the instrument is within the manufacturer's published specifications.

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
3915	Agilent	34420A	Nano Volt, Micro-Ohm Meter, 7.5 Digit	8-Nov-2019	8-Nov-2020
CAL218	DTS	CALSTAT	Calibration Station	19-Sep-2019	19-Sep-2020

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: Craig Myers
Craig Myers
Senior Engineering Technician

5/22/2020

DTS

Measurement Data
As Received

Serial #: LM0212
Order #: 63414
Date: 18 May 2020

Timebase Calibration

Std (Hz)	UUT (Hz)	Dev (Hz)	Dev (ppm)	U (ppm)	Limits (ppm)	PASS/ FAIL
999.99	1000.02	0.02288	22.9	2.3E+01	+/-100	Pass

Internal Calibration Source

UUT (mV)	Std (mV)	U (mV)	MIN (mV)	MAX (mV)	PASS/ FAIL
0	-0.02598	4.6E-02	-2.5	2.5	Pass
1200	1199.92	6.2E-02	1197.5	1202.5	Pass
2400	2399.73	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	4976.8	4977.3	0.50	2.0E-01	0.01	+/-0.5	Pass
2	4973.7	4973.2	-0.47	2.0E-01	-0.01	+/-0.5	Pass
3	4996.8	4997.2	0.44	2.0E-01	0.01	+/-0.5	Pass
4	5005.1	5005.8	0.63	2.0E-01	0.01	+/-0.5	Pass
5	5001.8	5002.4	0.57	2.0E-01	0.01	+/-0.5	Pass
6	4979.9	4980.2	0.29	2.0E-01	0.01	+/-0.5	Pass
7	4990.2	4990.6	0.38	2.0E-01	0.01	+/-0.5	Pass
8	4978.3	4978.9	0.57	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	9975.9	9976.4	0.49	4.0E-01	0.00	+/-0.5	Pass
2	9969.4	9968.7	-0.72	4.0E-01	-0.01	+/-0.5	Pass
3	9985.4	9985.3	-0.08	4.0E-01	0.00	+/-0.5	Pass
4	10011.6	10012.0	0.45	4.0E-01	0.00	+/-0.5	Pass
5	10010.8	10011.2	0.39	4.0E-01	0.00	+/-0.5	Pass
6	9975.5	9975.8	0.33	4.0E-01	0.00	+/-0.5	Pass
7	9984.6	9983.9	-0.74	4.0E-01	-0.01	+/-0.5	Pass
8	9970.2	9970.8	0.53	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	4976.8	4970.1	-6.7	4.6E+00	-0.14	+/-1.5	Pass
2	4973.7	4984.5	10.8	4.6E+00	0.22	+/-1.5	Pass
3	4996.8	5006.5	9.7	4.6E+00	0.19	+/-1.5	Pass
4	5005.1	5018.0	12.9	4.6E+00	0.26	+/-1.5	Pass
5	5001.8	5011.4	9.6	4.6E+00	0.19	+/-1.5	Pass
6	4979.9	4989.9	10.0	4.6E+00	0.20	+/-1.5	Pass
7	4990.2	5006.0	15.8	4.6E+00	0.32	+/-1.5	Pass
8	4978.3	4987.6	9.2	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	9975.9	9944.2	-31.7	5.4E+00	-0.32	+/-1.5	Pass
2	9969.4	9981.0	11.6	5.4E+00	0.12	+/-1.5	Pass
3	9985.4	9996.8	11.4	5.4E+00	0.11	+/-1.5	Pass
4	10011.6	10020.0	8.4	5.4E+00	0.08	+/-1.5	Pass
5	10010.8	10018.8	8.0	5.4E+00	0.08	+/-1.5	Pass
6	9975.5	9983.8	8.4	5.4E+00	0.08	+/-1.5	Pass
7	9984.6	9995.8	11.1	5.4E+00	0.11	+/-1.5	Pass
8	9970.2	9979.1	8.9	5.4E+00	0.09	+/-1.5	Pass

Excitation Source Output, 5V

Parameter	Chan	UUT (mV)	U (mV)	MIN (mV)	MAX (mV)	PASS/ FAIL
350 Ohm Load	1	4976.8	2.0E-01	4950	5050	Pass
" "	2	4973.7	2.0E-01	4950	5050	Pass
" "	3	4996.8	2.0E-01	4950	5050	Pass
" "	4	5005.1	2.0E-01	4950	5050	Pass
" "	5	5001.8	2.0E-01	4950	5050	Pass
" "	6	4979.9	2.0E-01	4950	5050	Pass
" "	7	4990.2	2.0E-01	4950	5050	Pass
" "	8	4978.3	2.0E-01	4950	5050	Pass
Rated Load	1	4974.3	1.9E-01	4900	5100	Pass
" "	2	4969.8	1.9E-01	4900	5100	Pass
" "	3	4993.0	1.9E-01	4900	5100	Pass
" "	4	5002.9	1.9E-01	4900	5100	Pass
" "	5	4999.0	1.9E-01	4900	5100	Pass
" "	6	4977.5	1.9E-01	4900	5100	Pass
" "	7	4986.9	1.9E-01	4900	5100	Pass
" "	8	4975.0	1.9E-01	4900	5100	Pass
Short Recovery	1	4976.5	1.9E-01	4900	5100	Pass
" "	2	4973.7	1.9E-01	4900	5100	Pass
" "	3	4996.1	1.9E-01	4900	5100	Pass
" "	4	5004.4	1.9E-01	4900	5100	Pass
" "	5	5001.0	1.9E-01	4900	5100	Pass
" "	6	4979.3	1.9E-01	4900	5100	Pass
" "	7	4989.5	1.9E-01	4900	5100	Pass
" "	8	4977.6	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	9975.9	4.0E-01	9950	10050	Pass
" "	2	9969.4	4.0E-01	9950	10050	Pass
" "	3	9985.4	4.0E-01	9950	10050	Pass
" "	4	10011.6	4.0E-01	9950	10050	Pass
" "	5	10010.8	4.0E-01	9950	10050	Pass
" "	6	9975.5	4.0E-01	9950	10050	Pass
" "	7	9984.6	4.0E-01	9950	10050	Pass
" "	8	9970.2	4.0E-01	9950	10050	Pass
Rated Load	1	9976.6	4.0E-01	9900	10100	Pass
" "	2	9970.7	4.0E-01	9900	10100	Pass
" "	3	9986.9	4.0E-01	9900	10100	Pass
" "	4	10012.5	4.0E-01	9900	10100	Pass
" "	5	10012.1	4.0E-01	9900	10100	Pass
" "	6	9976.4	4.0E-01	9900	10100	Pass
" "	7	9985.9	4.0E-01	9900	10100	Pass
" "	8	9971.5	4.0E-01	9900	10100	Pass
Overload	1	9975.0	4.0E-01	9800	10200	Pass
" "	2	9969.1	4.0E-01	9800	10200	Pass
" "	3	9984.3	4.0E-01	9800	10200	Pass
" "	4	10010.3	4.0E-01	9800	10200	Pass
" "	5	10008.8	4.0E-01	9800	10200	Pass
" "	6	9974.8	4.0E-01	9800	10200	Pass
" "	7	9983.4	4.0E-01	9800	10200	Pass
" "	8	9969.2	4.0E-01	9800	10200	Pass
Short Recovery	1	9975.3	4.0E-01	9800	10200	Pass
" "	2	9968.6	4.0E-01	9800	10200	Pass
" "	3	9985.1	4.0E-01	9800	10200	Pass
" "	4	10010.5	4.0E-01	9800	10200	Pass
" "	5	10009.6	4.0E-01	9800	10200	Pass
" "	6	9975.0	4.0E-01	9800	10200	Pass
" "	7	9983.8	4.0E-01	9800	10200	Pass
" "	8	9969.5	4.0E-01	9800	10200	Pass

DTS

Measurement Data
As Received

Serial #: LM0212
Order #: 63414
Date: 18 May 2020

DC Amplitude/Gain Accuracy

Gain	Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
8	1	-692.3	-692.7	-0.40	1.0E-01	-0.04	+/-0.5	Pass
"	1	-343.0	-343.1	-0.17	7.8E-02	-0.02	+/-0.5	Pass
"	1	341.2	341.4	0.21	8.3E-02	0.02	+/-0.5	Pass
"	1	686.5	686.9	0.41	9.3E-02	0.04	+/-0.5	Pass
"	2	-692.3	-692.7	-0.35	1.0E-01	-0.03	+/-0.5	Pass
"	2	-343.0	-343.2	-0.17	7.8E-02	-0.02	+/-0.5	Pass
"	2	341.2	341.4	0.16	8.3E-02	0.02	+/-0.5	Pass
"	2	686.5	686.8	0.33	9.3E-02	0.03	+/-0.5	Pass
"	3	-692.3	-692.8	-0.46	1.0E-01	-0.05	+/-0.5	Pass
"	3	-343.0	-343.2	-0.20	7.8E-02	-0.02	+/-0.5	Pass
"	3	341.2	341.4	0.20	8.3E-02	0.02	+/-0.5	Pass
"	3	686.5	686.9	0.41	9.3E-02	0.04	+/-0.5	Pass
"	4	-692.3	-692.8	-0.51	1.0E-01	-0.05	+/-0.5	Pass
"	4	-343.0	-343.3	-0.29	7.8E-02	-0.03	+/-0.5	Pass
"	4	341.2	341.4	0.24	8.3E-02	0.02	+/-0.5	Pass
"	4	686.5	686.9	0.46	9.3E-02	0.05	+/-0.5	Pass
"	5	-692.3	-692.8	-0.46	1.0E-01	-0.05	+/-0.5	Pass
"	5	-343.0	-343.2	-0.22	7.8E-02	-0.02	+/-0.5	Pass
"	5	341.2	341.4	0.23	8.3E-02	0.02	+/-0.5	Pass
"	5	686.5	686.9	0.44	9.3E-02	0.04	+/-0.5	Pass
"	6	-692.3	-692.7	-0.40	1.0E-01	-0.04	+/-0.5	Pass
"	6	-343.0	-343.1	-0.15	7.8E-02	-0.02	+/-0.5	Pass
"	6	341.2	341.5	0.25	8.3E-02	0.02	+/-0.5	Pass
"	6	686.5	686.9	0.42	9.3E-02	0.04	+/-0.5	Pass
"	7	-692.3	-692.8	-0.48	1.0E-01	-0.05	+/-0.5	Pass
"	7	-343.0	-343.2	-0.22	7.8E-02	-0.02	+/-0.5	Pass
"	7	341.2	341.4	0.23	8.3E-02	0.02	+/-0.5	Pass
"	7	686.5	687.0	0.50	9.3E-02	0.05	+/-0.5	Pass
"	8	-692.3	-692.7	-0.42	1.0E-01	-0.04	+/-0.5	Pass
"	8	-343.0	-343.2	-0.23	7.8E-02	-0.02	+/-0.5	Pass
"	8	341.2	341.5	0.24	8.3E-02	0.02	+/-0.5	Pass
"	8	686.5	686.9	0.43	9.3E-02	0.04	+/-0.5	Pass
16	1	-214.72	-214.84	-0.117	6.3E-02	-0.04	+/-0.5	Pass
"	1	-106.95	-106.99	-0.041	4.8E-02	-0.01	+/-0.5	Pass
"	1	106.39	106.43	0.041	5.0E-02	0.01	+/-0.5	Pass
"	1	212.87	213.02	0.147	7.9E-02	0.05	+/-0.5	Pass
"	2	-214.72	-214.82	-0.105	6.3E-02	-0.03	+/-0.5	Pass
"	2	-106.95	-107.02	-0.072	4.8E-02	-0.02	+/-0.5	Pass
"	2	106.39	106.43	0.044	5.0E-02	0.01	+/-0.5	Pass
"	2	212.87	213.02	0.150	7.9E-02	0.05	+/-0.5	Pass
"	3	-214.72	-214.86	-0.144	6.3E-02	-0.05	+/-0.5	Pass
"	3	-106.95	-107.04	-0.093	4.8E-02	-0.03	+/-0.5	Pass
"	3	106.39	106.47	0.076	5.0E-02	0.02	+/-0.5	Pass
"	3	212.87	213.04	0.169	7.9E-02	0.05	+/-0.5	Pass
"	4	-214.72	-214.87	-0.151	6.3E-02	-0.05	+/-0.5	Pass
"	4	-106.95	-107.01	-0.063	4.8E-02	-0.02	+/-0.5	Pass
"	4	106.39	106.47	0.083	5.0E-02	0.03	+/-0.5	Pass
"	4	212.87	213.04	0.171	7.9E-02	0.05	+/-0.5	Pass
"	5	-214.72	-214.87	-0.152	6.3E-02	-0.05	+/-0.5	Pass
"	5	-106.95	-106.99	-0.039	4.8E-02	-0.01	+/-0.5	Pass
"	5	106.39	106.46	0.070	5.0E-02	0.02	+/-0.5	Pass
"	5	212.87	213.04	0.171	7.9E-02	0.05	+/-0.5	Pass
"	6	-214.72	-214.86	-0.145	6.3E-02	-0.05	+/-0.5	Pass
"	6	-106.95	-107.02	-0.073	4.8E-02	-0.02	+/-0.5	Pass
"	6	106.39	106.46	0.066	5.0E-02	0.02	+/-0.5	Pass
"	6	212.87	213.04	0.171	7.9E-02	0.05	+/-0.5	Pass
"	7	-214.72	-214.89	-0.177	6.3E-02	-0.06	+/-0.5	Pass
"	7	-106.95	-107.04	-0.093	4.8E-02	-0.03	+/-0.5	Pass
"	7	106.39	106.46	0.066	5.0E-02	0.02	+/-0.5	Pass
"	7	212.87	213.05	0.182	7.9E-02	0.06	+/-0.5	Pass
"	8	-214.72	-214.86	-0.140	6.3E-02	-0.04	+/-0.5	Pass
"	8	-106.95	-107.02	-0.072	4.8E-02	-0.02	+/-0.5	Pass
"	8	106.39	106.47	0.083	5.0E-02	0.03	+/-0.5	Pass
"	8	212.87	213.04	0.175	7.9E-02	0.06	+/-0.5	Pass

DC Amplitude/Gain Accuracy

Gain	Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
32	1	-106.95	-107.04	-0.088	1.8E-02	-0.06	+/-0.5	Pass
"	1	-53.04	-53.08	-0.024	1.3E-02	-0.02	+/-0.5	Pass
"	1	52.86	52.89	0.031	1.3E-02	0.02	+/-0.5	Pass
"	1	106.38	106.46	0.075	1.6E-02	0.05	+/-0.5	Pass
"	2	-106.95	-107.01	-0.060	1.8E-02	-0.04	+/-0.5	Pass
"	2	-53.04	-53.07	-0.033	1.3E-02	-0.02	+/-0.5	Pass
"	2	52.86	52.89	0.033	1.3E-02	0.02	+/-0.5	Pass
"	2	106.38	106.44	0.061	1.6E-02	0.04	+/-0.5	Pass
"	3	-106.95	-107.02	-0.071	1.8E-02	-0.05	+/-0.5	Pass
"	3	-53.04	-53.04	-0.008	1.3E-02	-0.01	+/-0.5	Pass
"	3	52.86	52.88	0.023	1.3E-02	0.01	+/-0.5	Pass
"	3	106.38	106.48	0.093	1.6E-02	0.06	+/-0.5	Pass
"	4	-106.95	-107.04	-0.084	1.8E-02	-0.05	+/-0.5	Pass
"	4	-53.04	-53.08	-0.045	1.3E-02	-0.03	+/-0.5	Pass
"	4	52.86	52.89	0.038	1.3E-02	0.02	+/-0.5	Pass
"	4	106.38	106.46	0.076	1.6E-02	0.05	+/-0.5	Pass
"	5	-106.95	-107.02	-0.067	1.8E-02	-0.04	+/-0.5	Pass
"	5	-53.04	-53.08	-0.040	1.3E-02	-0.03	+/-0.5	Pass
"	5	52.86	52.89	0.038	1.3E-02	0.02	+/-0.5	Pass
"	5	106.38	106.45	0.062	1.6E-02	0.04	+/-0.5	Pass
"	6	-106.95	-107.03	-0.075	1.8E-02	-0.05	+/-0.5	Pass
"	6	-53.04	-53.07	-0.036	1.3E-02	-0.02	+/-0.5	Pass
"	6	52.86	52.89	0.030	1.3E-02	0.02	+/-0.5	Pass
"	6	106.38	106.45	0.069	1.6E-02	0.04	+/-0.5	Pass
"	7	-106.95	-107.04	-0.083	1.8E-02	-0.05	+/-0.5	Pass
"	7	-53.04	-53.06	-0.028	1.3E-02	-0.02	+/-0.5	Pass
"	7	52.86	52.89	0.033	1.3E-02	0.02	+/-0.5	Pass
"	7	106.38	106.47	0.086	1.6E-02	0.05	+/-0.5	Pass
"	8	-106.95	-107.05	-0.093	1.8E-02	-0.06	+/-0.5	Pass
"	8	-53.04	-53.07	-0.035	1.3E-02	-0.02	+/-0.5	Pass
"	8	52.86	52.90	0.039	1.3E-02	0.03	+/-0.5	Pass
"	8	106.38	106.48	0.093	1.6E-02	0.06	+/-0.5	Pass
128	1	-26.567	-26.630	-0.0636	5.6E-03	-0.16	+/-1.5	Pass
"	1	-13.302	-13.335	-0.0326	4.4E-03	-0.08	+/-1.5	Pass
"	1	13.247	13.281	0.0338	4.3E-03	0.09	+/-1.5	Pass
"	1	26.383	26.444	0.0614	6.8E-03	0.16	+/-1.5	Pass
"	2	-26.567	-26.630	-0.0636	5.6E-03	-0.16	+/-1.5	Pass
"	2	-13.302	-13.335	-0.0330	4.4E-03	-0.08	+/-1.5	Pass
"	2	13.247	13.278	0.0309	4.3E-03	0.08	+/-1.5	Pass
"	2	26.383	26.446	0.0631	6.8E-03	0.16	+/-1.5	Pass
"	3	-26.567	-26.635	-0.0678	5.6E-03	-0.17	+/-1.5	Pass
"	3	-13.302	-13.335	-0.0328	4.4E-03	-0.08	+/-1.5	Pass
"	3	13.247	13.282	0.0347	4.3E-03	0.09	+/-1.5	Pass
"	3	26.383	26.449	0.0664	6.8E-03	0.17	+/-1.5	Pass
"	4	-26.567	-26.636	-0.0689	5.6E-03	-0.18	+/-1.5	Pass
"	4	-13.302	-13.338	-0.0359	4.4E-03	-0.09	+/-1.5	Pass
"	4	13.247	13.282	0.0346	4.3E-03	0.09	+/-1.5	Pass
"	4	26.383	26.453	0.0699	6.8E-03	0.18	+/-1.5	Pass
"	5	-26.567	-26.632	-0.0654	5.6E-03	-0.17	+/-1.5	Pass
"	5	-13.302	-13.334	-0.0319	4.4E-03	-0.08	+/-1.5	Pass
"	5	13.247	13.281	0.0338	4.3E-03	0.09	+/-1.5	Pass
"	5	26.383	26.448	0.0653	6.8E-03	0.17	+/-1.5	Pass
"	6	-26.567	-26.630	-0.0635	5.6E-03	-0.16	+/-1.5	Pass
"	6	-13.302	-13.332	-0.0301	4.4E-03	-0.08	+/-1.5	Pass
"	6	13.247	13.279	0.0311	4.3E-03	0.08	+/-1.5	Pass
"	6	26.383	26.445	0.0622	6.8E-03	0.16	+/-1.5	Pass
"	7	-26.567	-26.632	-0.0656	5.6E-03	-0.17	+/-1.5	Pass
"	7	-13.302	-13.335	-0.0326	4.4E-03	-0.08	+/-1.5	Pass
"	7	13.247	13.281	0.0334	4.3E-03	0.09	+/-1.5	Pass
"	7	26.383	26.449	0.0660	6.8E-03	0.17	+/-1.5	Pass
"	8	-26.567	-26.633	-0.0661	5.6E-03	-0.17	+/-1.5	Pass
"	8	-13.302	-13.336	-0.0344	4.4E-03	-0.09	+/-1.5	Pass
"	8	13.247	13.281	0.0334	4.3E-03	0.09	+/-1.5	Pass
"	8	26.383	26.451	0.0688	6.8E-03	0.18	+/-1.5	Pass

DTS

Measurement Data
As Received

Serial #: LM0212
Order #: 63414
Date: 18 May 2020

DC Amplitude/Gain Accuracy

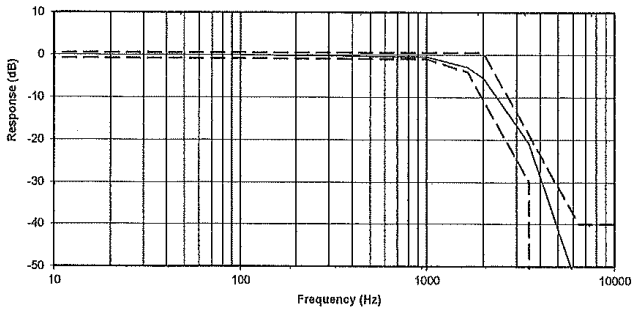
Gain	Chan	Std (mV)	UUT (mV)	Dev (mV)	U (mV)	Dev (%)	Limits (%)	PASS/ FAIL
512	1	-6.664	-6.680	-0.0159	4.4E-03	-0.16	+/-1.5	Pass
"	1	-3.311	-3.318	-0.0071	2.8E-03	-0.07	+/-1.5	Pass
"	1	3.295	3.303	0.0077	2.7E-03	0.08	+/-1.5	Pass
"	1	6.612	6.628	0.0160	4.2E-03	0.16	+/-1.5	Pass
"	2	-6.664	-6.680	-0.0167	4.4E-03	-0.17	+/-1.5	Pass
"	2	-3.311	-3.319	-0.0080	2.8E-03	-0.08	+/-1.5	Pass
"	2	3.295	3.303	0.0081	2.7E-03	0.08	+/-1.5	Pass
"	2	6.612	6.629	0.0167	4.2E-03	0.17	+/-1.5	Pass
"	3	-6.664	-6.682	-0.0182	4.4E-03	-0.19	+/-1.5	Pass
"	3	-3.311	-3.320	-0.0092	2.8E-03	-0.09	+/-1.5	Pass
"	3	3.295	3.304	0.0085	2.7E-03	0.09	+/-1.5	Pass
"	3	6.612	6.630	0.0175	4.2E-03	0.18	+/-1.5	Pass
"	4	-6.664	-6.682	-0.0185	4.4E-03	-0.19	+/-1.5	Pass
"	4	-3.311	-3.320	-0.0089	2.8E-03	-0.09	+/-1.5	Pass
"	4	3.295	3.304	0.0090	2.7E-03	0.09	+/-1.5	Pass
"	4	6.612	6.631	0.0182	4.2E-03	0.19	+/-1.5	Pass
"	5	-6.664	-6.680	-0.0166	4.4E-03	-0.17	+/-1.5	Pass
"	5	-3.311	-3.319	-0.0078	2.8E-03	-0.08	+/-1.5	Pass
"	5	3.295	3.304	0.0084	2.7E-03	0.09	+/-1.5	Pass
"	5	6.612	6.630	0.0172	4.2E-03	0.18	+/-1.5	Pass
"	6	-6.664	-6.678	-0.0148	4.4E-03	-0.15	+/-1.5	Pass
"	6	-3.311	-3.318	-0.0068	2.8E-03	-0.07	+/-1.5	Pass
"	6	3.295	3.303	0.0083	2.7E-03	0.08	+/-1.5	Pass
"	6	6.612	6.628	0.0152	4.2E-03	0.16	+/-1.5	Pass
"	7	-6.664	-6.683	-0.0192	4.4E-03	-0.20	+/-1.5	Pass
"	7	-3.311	-3.319	-0.0081	2.8E-03	-0.08	+/-1.5	Pass
"	7	3.295	3.304	0.0089	2.7E-03	0.09	+/-1.5	Pass
"	7	6.612	6.631	0.0191	4.2E-03	0.20	+/-1.5	Pass
"	8	-6.664	-6.679	-0.0155	4.4E-03	-0.16	+/-1.5	Pass
"	8	-3.311	-3.319	-0.0082	2.8E-03	-0.08	+/-1.5	Pass
"	8	3.295	3.302	0.0072	2.7E-03	0.07	+/-1.5	Pass
"	8	6.612	6.628	0.0160	4.2E-03	0.16	+/-1.5	Pass
2000	1	-1.744	-1.749	-0.0053	4.8E-03	-0.21	+/-1.5	Pass
"	1	-0.873	-0.875	-0.0024	3.2E-03	-0.09	+/-1.5	Pass
"	1	0.870	0.872	0.0023	2.5E-03	0.09	+/-1.5	Pass
"	1	1.741	1.746	0.0050	5.0E-03	0.20	+/-1.5	Pass
"	2	-1.744	-1.752	-0.0078	4.8E-03	-0.31	+/-1.5	Pass
"	2	-0.873	-0.876	-0.0038	3.2E-03	-0.15	+/-1.5	Pass
"	2	0.870	0.873	0.0038	2.5E-03	0.15	+/-1.5	Pass
"	2	1.741	1.748	0.0072	5.0E-03	0.29	+/-1.5	Pass
"	3	-1.744	-1.753	-0.0090	4.8E-03	-0.36	+/-1.5	Pass
"	3	-0.873	-0.875	-0.0028	3.2E-03	-0.11	+/-1.5	Pass
"	3	0.870	0.874	0.0040	2.5E-03	0.16	+/-1.5	Pass
"	3	1.741	1.749	0.0074	5.0E-03	0.30	+/-1.5	Pass
"	4	-1.744	-1.749	-0.0049	4.8E-03	-0.20	+/-1.5	Pass
"	4	-0.873	-0.875	-0.0027	3.2E-03	-0.11	+/-1.5	Pass
"	4	0.870	0.873	0.0035	2.5E-03	0.14	+/-1.5	Pass
"	4	1.741	1.748	0.0062	5.0E-03	0.25	+/-1.5	Pass
"	5	-1.744	-1.752	-0.0075	4.8E-03	-0.30	+/-1.5	Pass
"	5	-0.873	-0.876	-0.0032	3.2E-03	-0.13	+/-1.5	Pass
"	5	0.870	0.874	0.0040	2.5E-03	0.16	+/-1.5	Pass
"	5	1.741	1.749	0.0079	5.0E-03	0.32	+/-1.5	Pass
"	6	-1.744	-1.747	-0.0031	4.8E-03	-0.12	+/-1.5	Pass
"	6	-0.873	-0.874	-0.0012	3.2E-03	-0.05	+/-1.5	Pass
"	6	0.870	0.871	0.0016	2.5E-03	0.06	+/-1.5	Pass
"	6	1.741	1.743	0.0013	5.0E-03	0.05	+/-1.5	Pass
"	7	-1.744	-1.749	-0.0054	4.8E-03	-0.22	+/-1.5	Pass
"	7	-0.873	-0.874	-0.0018	3.2E-03	-0.07	+/-1.5	Pass
"	7	0.870	0.873	0.0037	2.5E-03	0.15	+/-1.5	Pass
"	7	1.741	1.746	0.0052	5.0E-03	0.21	+/-1.5	Pass
"	8	-1.744	-1.750	-0.0065	4.8E-03	-0.26	+/-1.5	Pass
"	8	-0.873	-0.876	-0.0033	3.2E-03	-0.13	+/-1.5	Pass
"	8	0.870	0.872	0.0019	2.5E-03	0.08	+/-1.5	Pass
"	8	1.741	1.748	0.0064	5.0E-03	0.26	+/-1.5	Pass

DTS

Measurement Data
As Received

Serial #: LM0212
Order #: 63414
Date: 18 May 2020

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	702.3	8.0E+00	0.00	-0.88	0.50	Pass
1	1000	670.2	8.0E+00	-0.41	-1.00	0.50	Pass
1	1650	506.8	7.5E+00	-2.83	-4.00	0.50	Pass
1	2000	378.2	5.6E+00	-5.38	-10.66	0.50	Pass
1	3496	63.42	4.6E-01	-20.89	-30.00	-18.84	Pass
1	6441	1.162	2.6E-02	-55.63	-Inf	-40.00	Pass
2	100	701.7	8.0E+00	0.00	-0.88	0.50	Pass
2	1000	670.2	8.0E+00	-0.40	-1.00	0.50	Pass
2	1650	507.6	7.5E+00	-2.81	-4.00	0.50	Pass
2	2000	379.2	5.6E+00	-5.35	-10.66	0.50	Pass
2	3496	63.95	4.6E-01	-20.81	-30.00	-18.84	Pass
2	6441	1.173	2.6E-02	-55.54	-Inf	-40.00	Pass
3	100	702.1	8.0E+00	0.00	-0.88	0.50	Pass
3	1000	670.3	8.0E+00	-0.40	-1.00	0.50	Pass
3	1650	507.3	7.5E+00	-2.82	-4.00	0.50	Pass
3	2000	378.8	5.6E+00	-5.36	-10.66	0.50	Pass
3	3496	63.66	4.6E-01	-20.85	-30.00	-18.84	Pass
3	6441	1.161	2.6E-02	-55.63	-Inf	-40.00	Pass
4	100	701.8	8.0E+00	0.00	-0.88	0.50	Pass
4	1000	669.1	8.0E+00	-0.41	-1.00	0.50	Pass
4	1650	505.4	7.6E+00	-2.85	-4.00	0.50	Pass
4	2000	376.8	5.6E+00	-5.40	-10.66	0.50	Pass
4	3496	62.98	4.6E-01	-20.94	-30.00	-18.84	Pass
4	6441	1.159	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	702.2	8.0E+00	0.00	-0.88	0.50	Pass
5	1000	670.2	8.0E+00	-0.41	-1.00	0.50	Pass
5	1650	507.1	7.5E+00	-2.83	-4.00	0.50	Pass
5	2000	378.5	5.6E+00	-5.37	-10.66	0.50	Pass
5	3496	63.57	4.6E-01	-20.86	-30.00	-18.84	Pass
5	6441	1.162	2.6E-02	-55.63	-Inf	-40.00	Pass
6	100	702.3	8.0E+00	0.00	-0.88	0.50	Pass
6	1000	670.4	8.0E+00	-0.40	-1.00	0.50	Pass
6	1650	507.3	7.5E+00	-2.83	-4.00	0.50	Pass
6	2000	378.6	5.6E+00	-5.37	-10.66	0.50	Pass
6	3496	63.69	4.6E-01	-20.85	-30.00	-18.84	Pass
6	6441	1.173	2.6E-02	-55.55	-Inf	-40.00	Pass
7	100	702.5	8.0E+00	0.00	-0.88	0.50	Pass
7	1000	670.4	8.0E+00	-0.41	-1.00	0.50	Pass
7	1650	507.0	7.5E+00	-2.83	-4.00	0.50	Pass
7	2000	378.3	5.6E+00	-5.38	-10.66	0.50	Pass
7	3496	63.46	4.6E-01	-20.88	-30.00	-18.84	Pass
7	6441	1.163	2.6E-02	-55.62	-Inf	-40.00	Pass
8	100	702.8	8.0E+00	0.00	-0.88	0.50	Pass
8	1000	669.9	8.0E+00	-0.42	-1.00	0.50	Pass
8	1650	505.7	7.5E+00	-2.86	-4.00	0.50	Pass
8	2000	376.8	5.6E+00	-5.41	-10.66	0.50	Pass
8	3496	62.78	4.6E-01	-20.98	-30.00	-18.84	Pass
8	6441	1.149	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	495.2	5.7E+00	-3.04	-3.50	-2.50	Pass
2	4300	500.5	5.7E+00	-2.93	-3.50	-2.50	Pass
3	4300	497.2	5.7E+00	-3.00	-3.50	-2.50	Pass
4	4300	491.4	5.7E+00	-3.10	-3.50	-2.50	Pass
5	4300	496.4	5.7E+00	-3.01	-3.50	-2.50	Pass
6	4300	498.1	5.7E+00	-2.98	-3.50	-2.50	Pass
7	4300	495.5	5.7E+00	-3.03	-3.50	-2.50	Pass
8	4300	488.8	5.7E+00	-3.15	-3.50	-2.50	Pass

** End of Report **

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z93371:289720

ENDEVCO 7264-2000TZ ACCELEROMETER

SERIAL NUMBER:	J40863	WORK ORDER:	289720
ASSET NUMBER:	Z93371	TEST RESULT:	PASS
CUST ASSET NUMBER:	N/A	PERFORMED ON:	11/05/19
PROCEDURE NAME:	MOD 9155	CAL DUE DATE:	11/05/20
PROCEDURE REV:	1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	MICHAEL SCHINKE	TEMPERATURE:	23 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	32 %
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
1489	1489:1193650836	Hewlett Packard 34401A DMM	03/11/2019	03/11/2020
2194	2194:1486363644	MODAL SHOP 9155 ACCELEROMETER CAL SYSTEM	03/22/2019	03/22/2020
2998	529030000004453	EXTECH 42280 DATA LOGGER	05/15/2019	05/15/2020

QA Signature: John McBurney Date: 12/13/2019 5:37:25 AM

SW 01/13/2020

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED
Calibration
#1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z147458:297149

ENDEVCO 7264-2000 ACCELEROMETER

SERIAL NUMBER:	J58671	WORK ORDER:	297149
ASSET NUMBER:	Z147458	TEST RESULT:	PASS
CUST ASSET NUMBER:	N/A	PERFORMED ON:	01/07/20
PROCEDURE NAME:	MOD 9155	CAL DUE DATE:	01/07/21
PROCEDURE REV:	1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Aaron Forrest	TEMPERATURE:	22 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	26 %
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.

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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	MODAL SHOP 9155 ACCELEROMETER CAL SYSTEM	03/22/2019	03/22/2020
2270	2270:1505812061	AGILENT 34401A MULTIMETER	10/13/2019	10/13/2020
2998	529030000004453	EXTECH 42280 DATA LOGGER	05/15/2019	05/15/2020

QA Signature: John Kelleher Date: 1/8/2020 12:21:08 PM

SV 01/13/2020

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED
Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z147459:297153

ENDEVCO 7264-2000 ACCELEROMETER

SERIAL NUMBER:	J58675	WORK ORDER:	297153
ASSET NUMBER:	Z147459	TEST RESULT:	PASS
CUST ASSET NUMBER:	N/A	PERFORMED ON:	01/07/20
PROCEDURE NAME:	MOD 9155	CAL DUE DATE:	01/07/21
PROCEDURE REV:	1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Aaron Forrest	TEMPERATURE:	22 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	31 %
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	MODAL SHOP 9155 ACCELEROMETER CAL SYSTEM	03/22/2019	03/22/2020
2270	2270:1505812061	AGILENT 34401A MULTIMETER	10/13/2019	10/13/2020
2998	529030000004453	EXTECH 42280 DATA LOGGER	05/15/2019	05/15/2020

QA Signature: John Forrest Date: 1/8/2020 12:21:29 PM

1/13/2020

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.

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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 McEwen Date: 9/9/2020 10:33:12 AM

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.

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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 McEwen Date: 9/9/2020 10:32:50 AM

NovaStar SOLUTIONS
Metrology Management Services
35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Calibration Certificate

ACCREDITED Calibration #1277.01

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.

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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

Endevco
PCB Piezotronics of NC, Inc.
10869 Highway 903
Halifax, NC 27839
USA
Tel: +1 (888) 684 0013
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

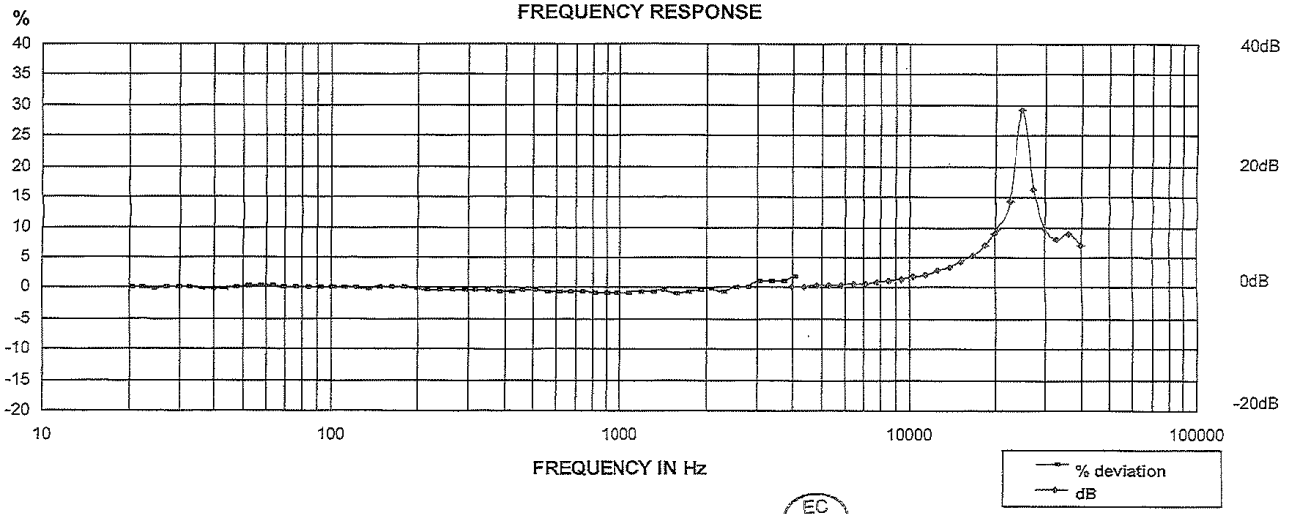
Transverse Sensitivity (%): 1.0

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. This certificate shall not be reproduced, except in full, without written approval of PCB Piezotronics of NC, Inc. d/b/a Endevco.

Endevco
PCB Piezotronics of NC, Inc.
10869 Highway 903
Halifax, NC 27839
USA
Tel: +1 (888) 684 0013
Fax: +1 (716) 685 3886

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

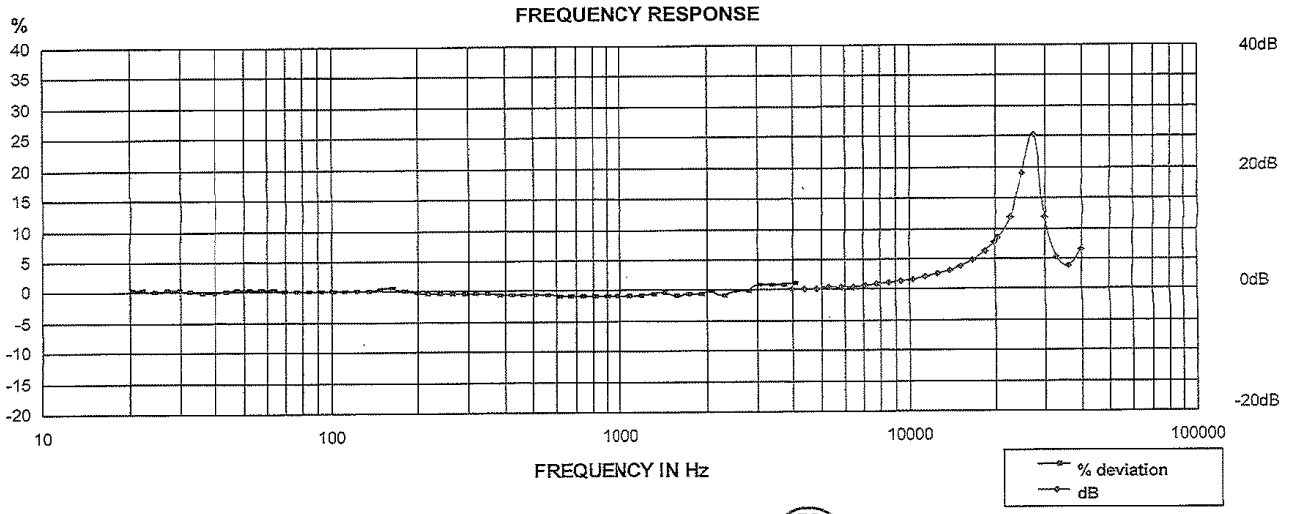
Transverse Sensitivity (%): 0.4

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

ACCREDITED
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.

Endevco
PCB Piezotronics of NC, Inc.
10869 Highway 903
Halifax, NC 27839
USA
Tel: +1 (888) 684 0013
Fax: +1 (716) 685 3886

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

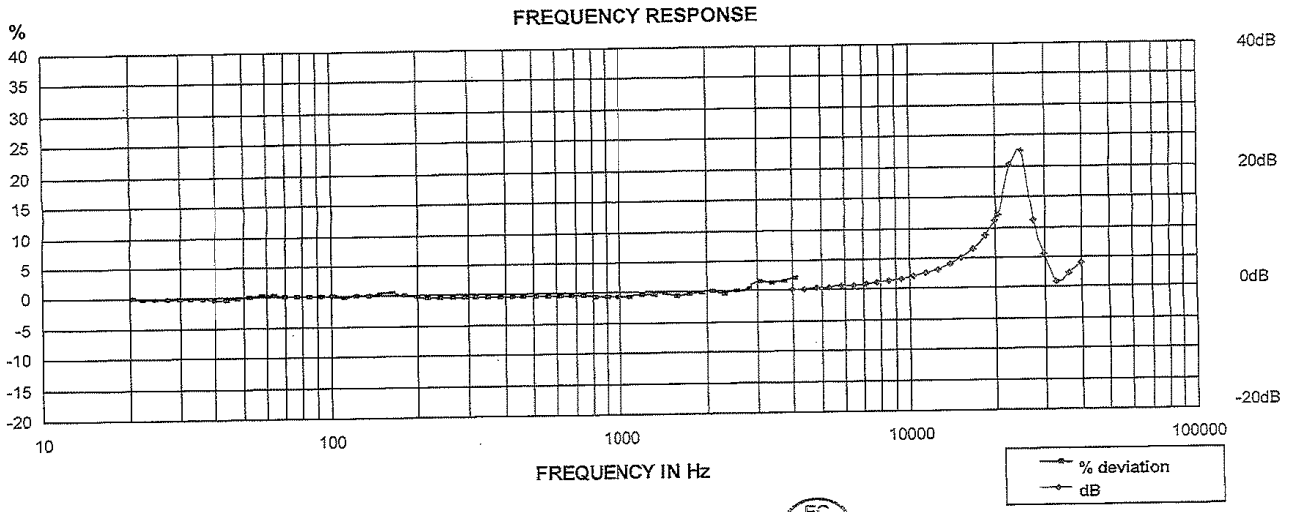
Transverse Sensitivity (%): 0.5

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:



IEC 17025 A564

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.

Dan Brock

Calibration Certificate

Model: Advantage

Calibration Date: 2020-01-10 (YYYY-MM-DD)

Certificate #: C10020301351-20200110-225P

Serial #: C10-02-03-01351

Measurement Standards Traceability

Kinematic Scale Bar- Short	Asset Number: 4543	Calibration Due Date: 4/4/2020	*SI Traceability: 00062977-b7be-5397-5ec8-009267a31fcb
Kinematic Scale Bar- Long	Asset Number: 4693	Calibration Due Date: 4/4/2020	*SI Traceability: 00062977-b7be-5397-8878-009267ba0397
Thermometer	Asset Number: 5338	Calibration Due Date: 7/23/2020	*SI Traceability: KELC-614143
Calibration Probe	Asset Number: 5142	Calibration Due Date: 9/14/2020	*SI Traceability: 19-449-01070
Reference Sphere	Asset Number: 5298	Calibration Due Date: 11/30/2020	*SI Traceability: 19-449-01686

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	0.173	0.075	PASSED
1 Effective diameter sphere test	mm	0.087	0.022	PASSED
20 Volumetric ball bar tests in 4 quadrants and 2 orientations	mm	+/-0.244	0.027	PASSED

Instrument condition as received (AS FOUND):
Within specification

Instrument condition outgoing (AS LEFT):
Within specifications

This certificate invalidates all other certificates generated before: 2020-01-10 9:38:23 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: Neil Maclean
Date: 2020-01-10

FARO Technologies Inc
PH1:248-669-8620
PH2:
FAX:248-669-8656
46998 Magellan Drive
Wixom, MI 48393
USA

KAR
1/13/2020

Cert # L-1147.01-1 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 # Z54482:296699

MITUTOYO PRO 360 DIGITAL PROTRACTOR

SERIAL NUMBER:	06091641	WORK ORDER:	296699
ASSET NUMBER:	Z54482	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00712	PERFORMED ON:	01/03/20
PROCEDURE NAME:	MIT - PRO 360 - MMC	CAL DUE DATE:	01/03/21
PROCEDURE REV:	1.1	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Cody Brent	TEMPERATURE:	25 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	35 %
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.

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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
2116	2116:1455281491	EXTECH 42280 DATA LOGGER	03/11/2019	03/11/2020
2222	2222:1494506043	YUASA 550-050 ROTARY TABLE	05/11/2017	05/11/2022

QA Signature: Date: 1/8/2020 6:28:55 AM

1/10/2020

MICHIGAN OPERATIONS
DATE: 04/18/2019
SUPERCEDES: MGATPTMC.10

DOC. NO.: MGATP_TMC
REVISION NO.: 11
PAGE 3 OF 3

Tape Measure Calibration Certificate

Reference Steel Rule

Brand: SLOANSON
S/N: HEADD798
Calibration Date: 11/6/2019

Subject Tape Measure

Brand: Stanley
S/N: TPM0064793
Calibration Date: 12/9/2019

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: 12/9/2019 Performed By: [signature]

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 ACCREDITED CALIBRATION LABORATORY
AC-2481

ACCREDITED CERTIFICATE NUMBER: NC-19-12-12-083

Device ID:	MultiChannel	Calibration laboratory environmental conditions:	18 °C – 25 °C, 20 %RH – 55 %RH
Calibration Certificate issued to:	MGA Research Corporation 12790 Main Road Attn: Seth Vendelboe Akron, NY 14001 USA	Calibration Date:	2019-12-05
		MadgeTech Calibration Laboratory uses the shared risk approach as defined in ILAC G8 when making compliance statements	

RHTemp1000IS **- Temperature -** **Serial Number: R20561**

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 Corrected Device As Left	Device Error =Device - Standard	Expanded Uncertainty Expressed at approx. 95% confidence level using coverage factor k = 2
	25.24	25.24	0.00	0.12

Applied Correction Values

Gain:	1
Offset:	0.086 °C

RHTemp1000IS **- Humidity -** **Serial Number: R20561**

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		

5/29/2020

Channel 2 - Units of % RH

Expanded Uncertainty is not applied to Device Error

Temperature Env. Temperature	Standard Actual Test Point	DUT Corrected Device As Left	Device Error =Device - Standard	Expanded Uncertainty Expressed at approx. 95% confidence level using coverage factor k = 2
25.2	49.87	49.6	-0.3	1.4
25.2	74.72	74.7	0.0	1.4
30.1	25.27	25.3	0.0	1.4

Applied Correction Values

Gain:	1.0027535
Offset:	-0.76 % RH

Reference Equipment	Serial #	Certificate #	Last Calibration Date	Next Calibration Due
Vaisala HMP155	E0450052	2837-EXT	2019-11-09	2019-12-09

Calibration Notes:

Calibrated By: Deidre DeBourke Date: 2019-12-16

Approved By Quality Inspector: MadgeTech, Inc. QC 2003 Date: 2019-12-16

MadgeTech, Inc. Calibration laboratory located at 6 Warner Road Warner, NH 03278 603-456-2011

The instrument identified was calibrated as a direct comparison to the reference standards listed which are traceable to the International System of Units (SI) through NIST or other National Metrology Institute and did not involve any sampling. Results reported on this certificate relate only to the serial number referenced at the time of calibration and do not imply certification of the device, process, system or technician by ANAB, NIST or any other federal agency. No allowance has been made for the stability of the device due to use, time, or wear. Such allowances would be made by the user. This certificate may not be reproduced, except in full, without written approval by MadgeTech, Inc.

NovaStar SOLUTIONS
Metrology Management Services

Calibration Certificate

ACCREDITED
Calibration #1277.01

35200 Plymouth Rd. / Livonia, MI 48150 / 734.453.8003

Certificate # Z54487;296722

DETECTO AP-20 SCALE

SERIAL NUMBER:	E10807-0187	WORK ORDER:	CB010320001
ASSET NUMBER:	Z54487	TEST RESULT:	PASS
CUST ASSET NUMBER:	MGA00783	PERFORMED ON:	01/03/20
PROCEDURE NAME:	122-040	CAL DUE DATE:	01/03/21
PROCEDURE REV:	B	DATA TYPE:	FOUND-LEFT
CALIBRATED BY:	Cody Brent	TEMPERATURE:	24 °C
CUSTOMER:	MGA RESEARCH - OPERATIONS 2927 ELLIOTT DR TROY, MI 48083	HUMIDITY:	35 %
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	RICE LAKE CLASS 6 17 PC. WEIGHT SET	07/16/2019	07/16/2020
1975	1975;1340272143	RICE LAKE 6 PC. CLASS 6 WEIGHT SET	07/30/2018	07/30/2020
2116	2116;1455281491	EXTECH 42280 DATA LOGGER	03/11/2019	03/11/2020

QA Signature: Drake Matson Date: 1/8/2020 6:44:10 AM

MAR
1/13/2020

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