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Proving Ground

Test Report No. 612261-04-1, -05-1, & -05-2

TESTING AND EVALUATION OF LARGE SIGNS SLIP BASE SUPPORT ON SLOPE AT MASH TEST LEVEL 3 IMPACT CONDITIONS

Sponsored by

Roadside Safety Pooled Fund

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16. Abstract

The purpose of the tests reported herein was to assess the performance of the large sign slip base support according to the safety-performance evaluation guidelines included in the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*), Second Edition (*1*). The crash tests were performed in accordance with *MASH* Test 3-62, which for this project included three crash tests with the following criteria:

For Tests 612261-04-1 & -05-1

- ***MASH* Test 3-62:** A 2270P vehicle weighing 5000 lb impacting the support structure while traveling at 62 mi/h and 0 degrees.

For Test 612261-05-2

- ***MASH* Test 3-62:** A 2270P vehicle weighing 5000 lb impacting the support structure while traveling at 62 mi/h and 25 degrees.

This report provides details on the large sign slip base support, the crash tests and results, and the performance assessment of the large sign slip base support for *MASH* 3-62 support structure evaluation criteria.

The large sign slip base support met the performance criteria for *MASH* 3-62 support structures.

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The results reported herein apply only to the article tested. The full-scale crash tests were performed according to TTI Proving Ground quality procedures and American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware, Second Edition (*MASH*) guidelines and standards.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lb/in^2

*SI is the symbol for the International System of Units

Chapter 1. INTRODUCTION

The purpose of the tests reported herein was to assess the performance of a large sign slip base sign support system according to the safety-performance evaluation guidelines included in the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*), Second Edition (*1*). The crash tests were performed in accordance with *MASH* Test 3-62, which for this project included three crash tests with criteria as discussed in Chapter 3.

A unique aspect of this investigation included assessment of the large slip base sign support system on a fill slope. Large guide signs are typically installed on sloped terrain with the mounting height referenced to the traveled way. The initial crash tests of the system were performed on flat, level ground to establish baseline MASH impact performance for the system. As described herein, the impact of the initial design did not result in activation of the fuse plate below the sign panel. The design of the sign support system was subsequently modified and retested to determine if fuse plate activation could be achieved. The final test was performed with the slip base installed on a 6H:1V fill slope to investigate the influence of the slope on impact performance. The presence of the fill slope results in an increase in the height of the sign relative to the local ground and a higher impact location on the support relative to what is typical in an impact on flat, level ground. There was interest in understanding if this elevated impact point resulted in a change in slip base or fuse plate activation. Details of these crash tests are described herein.

Chapter 2. SYSTEM DETAILS

2.1. TEST ARTICLE AND INSTALLATION DETAILS

Crash Test 612261-05-1

The installation was comprised of a large, aluminum sign consisting of four panels spliced together to form the completed sign panel. The two center panels each measured 78-inches tall × 60-inches wide, and the two outer panels each measured 78-inches tall × 51- inches wide for a total width of 18 ft-6 inches. Two longitudinal aluminum stiffeners were attached to the back of the aluminum sign panel. The sign panel assembly was mounted 84 inches from grade to the bottom of the sign on two W6×12 steel posts spaced at 10 ft-10 inches center to center. The overall height of the installation measured 13 ft-6 inches. Each support post had a slip base connection located 4 inches above grade, and a fuse plate/hinge plate connection located 84 inches above grade at the bottom edge of the sign panel. Each post was embedded 32 inches into a 24-inch diameter × 72-inch deep reinforced concrete foundation.

Figure 2.1 presents the overall information on the large sign slip base support, and Figure 2.2 thru Figure 2.7 provide photographs of the installation for crash tests 612261-05-1.

Crash Test 612261-04-1

In test 612261-05-1, the fuse plate below the sign panel did not activate. This was concluded to be a function of the stiffness of the sign panel and the design of the fuse plate. State DOT standards for large guide signs were reviewed to understand the variations in sign panel configuration and fuse plate design for the W6×12 support. An extruded aluminum sign panel was selected to replace the aluminum sheet metal panel used in test 612261-05-1. The stiffer extruded aluminum sign panel will develop more moment in the support post and be more likely to activate the fuse plate. A different fuse plate design was also incorporated into the design. The fuse plate was designed for use with a W6×12 support but had a reduced tensile capacity compared to the fuse plate design used in test 612261-05-1.

The installation for test 612261-04-1 was comprised of a large sign consisting of six 12-inch wide extruded aluminum panels that were 18 ft-6 inches long. These panels were fastened together to provide a sign panel with a total height of 72 inches. A vertical steel stiffener was used at the center of the sign panel. The sign was mounted 84 inches from grade to the bottom of the sign on two W6×12 steel posts spaced at 10 ft-10 inches center to center providing an overall height of the installation of 13 ft-0 inches. Each support post had a modified fuse plate/hinge plate connection located 84 inches above grade at the bottom edge of the sign panel. The fuse plate activation holes were similar, but the fuse plate thickness was reduced from 3/8 inch to ¼ inch. All other details, including the slip base and foundation, were the same as those for test 612261-05-1.

Figure 2.8 presents the overall information on the large sign slip base support, and Figure 2.9 thru Figure 2.14 provide photographs of the installation for crash tests 612261-04-1

Crash Test 612261-05-2

The sign support system for test 612261-05-2 was placed on a 6H:1V slope. The post nearest the traveled way was offset 42 inches from the breakpoint of the slope, and the sign system was installed perpendicular to the edge of the roadway. The placement on slope resulted in the support post nearest the roadway being 7 ¾ inches longer and the farther support post being 28 ¾ inches longer that those used in test 612261-04-1 on flat, level ground. The top surfaces of the concrete foundations were sloped to match the 6H:1V slope. Other details of the sign support system were similar to those used in test 612261-04-1.

Figure 2.15 presents the overall information on the large sign slip base support, and Figure 2.16 thru Figure 2.19 provide photographs of the installation for crash test 612261-05-2.

Appendix A provides further details on the large sign slip base support systems that were tested. Drawings were provided by the Texas A&M Transportation Institute (TTI) Proving Ground, and construction was performed by TTI Proving Ground personnel.

2.2. DESIGN MODIFICATIONS DURING TESTS

No modifications were made to the installation during the testing phase other than those discussed in Section 2.1.

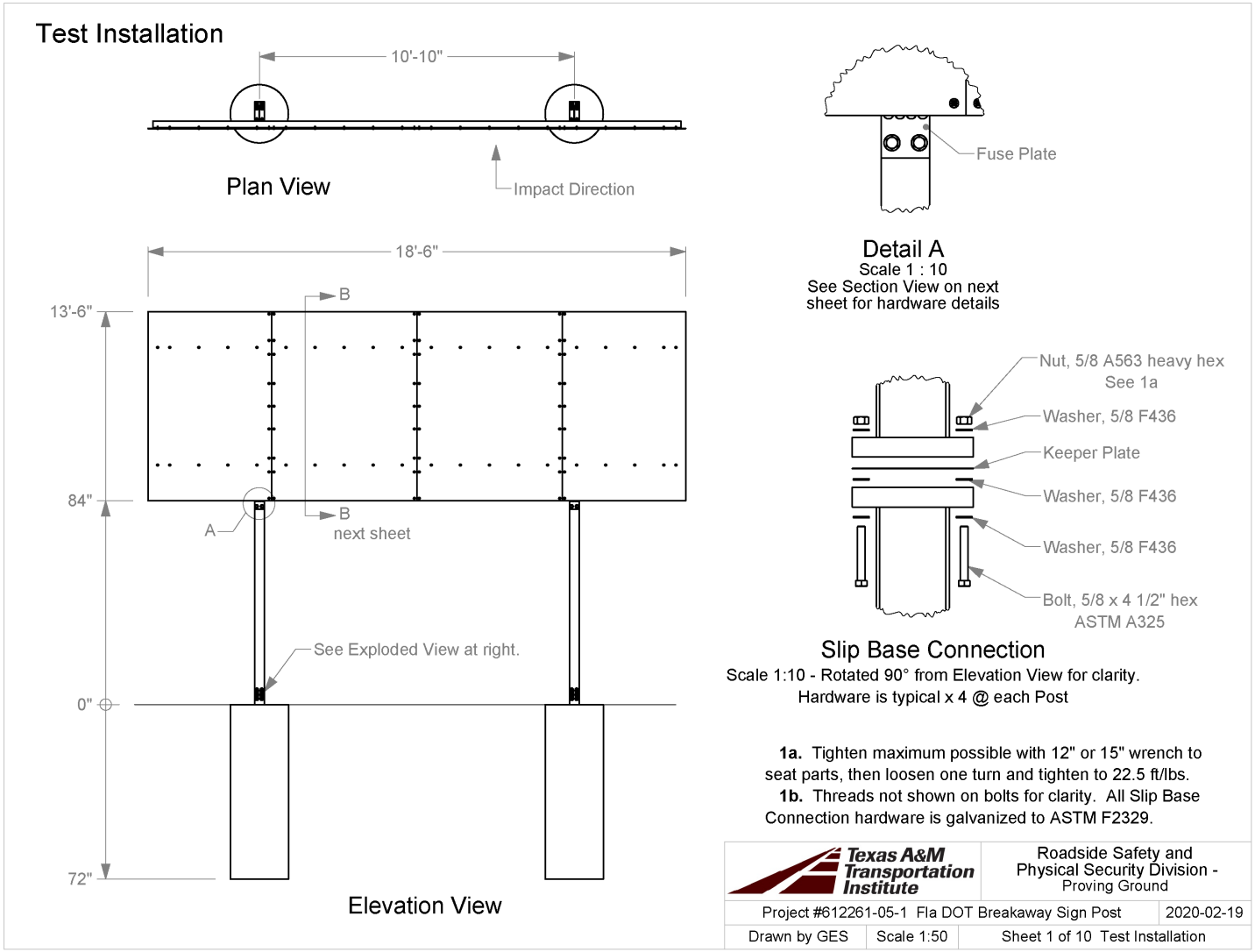


Figure 2.1. Details of Large Sign Slip Base Support for Crash Tests 612261-05-1.

Figure 2.2. Large Sign Slip Base Support from the Impact Side Prior to Testing 612261-05-1.

Figure 2.3. Large Sign Slip Base Support from Opposite of the Impact Side Prior to Testing 612261-05-1.

Figure 2.4. Front Plate of the Large Sign Slip Base Support Prior to Testing 612261-05-1.

Figure 2.5. Hinge Plate of the Large Sign Slip Base Support Prior to Testing 612261-05-1.

Figure 2.6. Base of the Large Sign Slip Base Support Prior to Testing 612261-05-1.

Figure 2.7. Opposite of the Impact Side of the Base of the Large Sign Slip Base Support Prior to Testing 612261-05-1.

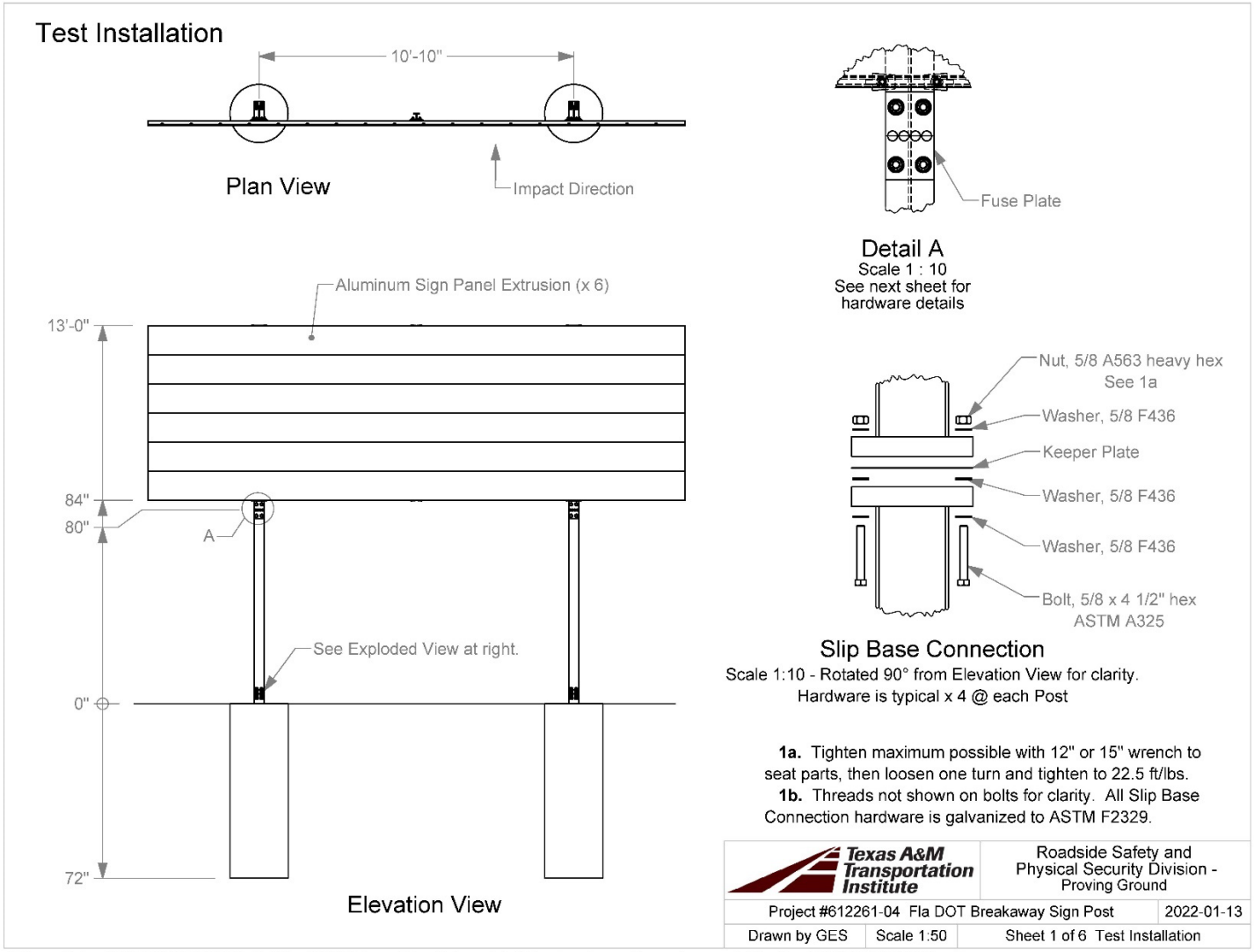


Figure 2.8. Details of Large Sign Slip Base Support for Crash Tests 612261-04-1.

Figure 2.9. Large Sign Slip Base Support from the Impact Side Prior to Testing 612261-04-1.

Figure 2.10. Large Sign Slip Base Support from Opposite of the Impact Side Prior to Testing 612261-04-1.

Figure 2.11. Front Plate of the Large Sign Slip Base Support Prior to Testing 612261-04-1.

Figure 2.12. Hinge Plate of the Large Sign Slip Base Support Prior to Testing 612261-04-1.

Figure 2.13. Impact Side of the Base of the Large Sign Slip Base Support Prior to Testing 612261-04-1.

Figure 2.14. Opposite of the Impact Side of the Base of the Large Sign Slip Base Support Prior to Testing 612261-04-1.

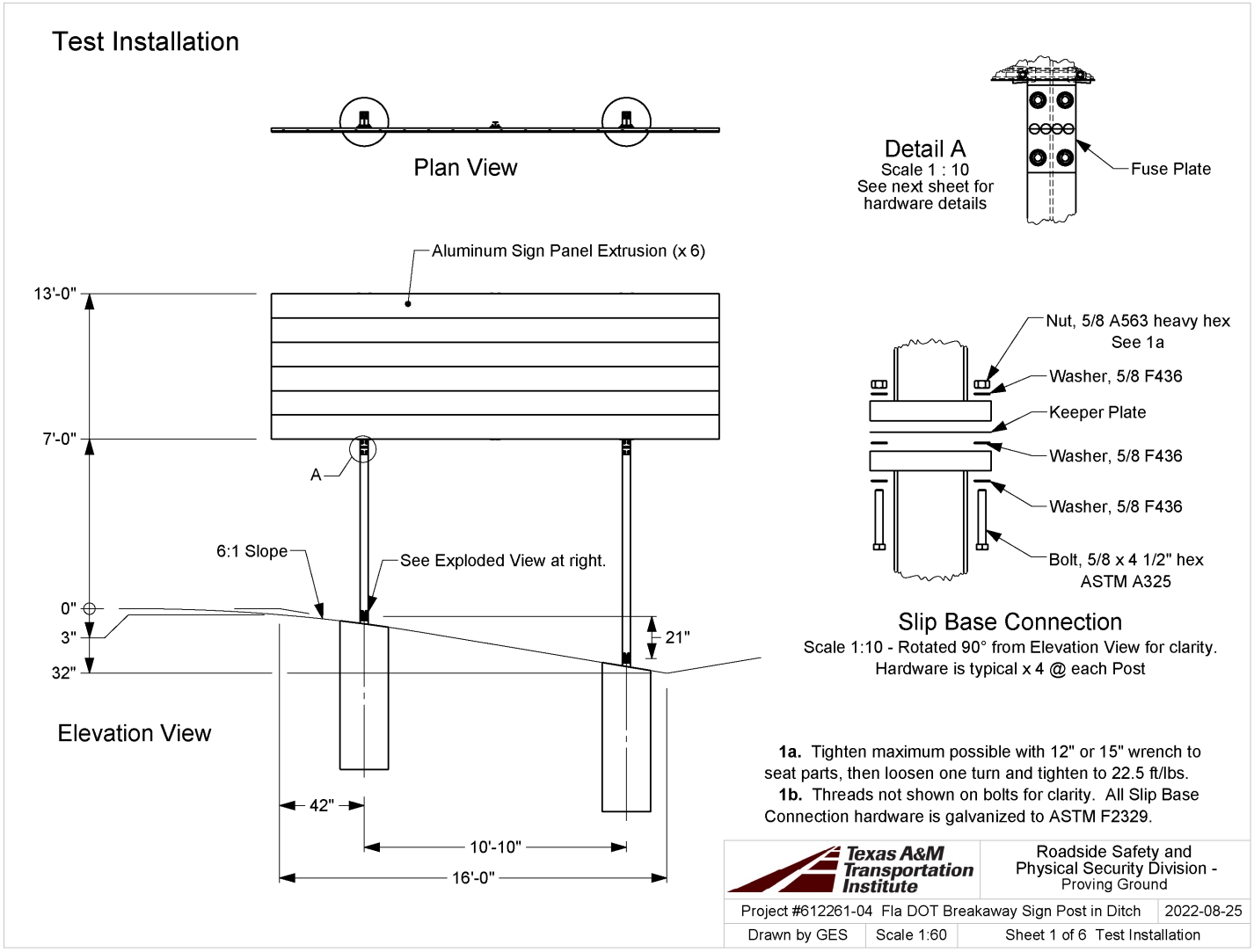


Figure 2.15. Details of Large Sign Slip Base Support for Crash Test 612261-05-2.

Figure 2.16. Large Sign Slip Base Support on a Slope Prior to Testing 612261-05-2.

Figure 2.17. Large Sign Slip Base Support on a Slope In-line with the Impact Path Prior to Testing 612261-05-2.

Figure 2.18. Front Plate of the Large Sign Slip Base Support on a Slope Prior to Testing 612261-05-2.

Figure 2.19. Hinge Plate of the Large Sign Slip Base Support on a Slope Prior to Testing 612261-05-2.

Figure 2.20. Front View of the Base of the Large Sign Slip Base Support on a Slope Prior to Testing 612261-05-2.

Figure 2.21. Side View of the Base of the Large Sign Slip Base Support on a Slope Prior to Testing 612261-05-2.

2.3. MATERIAL SPECIFICATIONS

Appendix B provides material certification documents for the materials used to install/construct the large sign slip base support systems.

Table 2.1 shows the average compressive strength of the concrete for test 612261-05-1 on the day of the test, March 3, 2020. The same footers were used for crash test 612261-04-1, which was performed on March 16, 2022, (almost 2 years later); thus, the concrete strength of the footers would have been the same if not greater at that later date.

Table 2.1. Concrete Strength for Crash Test 612261-05-1.

Location	Design Strength (psi)	Avg. Strength (psi)	Age (days)	Detailed Location
Footers	4000	4107	11	100% of footers

Table 2.2 shows the average compressive strength of the concrete for test 612261-05-2 on November 7, 2022, three days prior to the day of the crash test of November 10, 2022.

Table 2.2. Concrete Strength for Crash Test 612261-05-2.

Location	Design Strength (psi)	Avg. Strength (psi)	Age (days)	Detailed Location
Footers	3000	3150	33	100% of footers

Chapter 3. TEST REQUIREMENTS AND EVALUATION CRITERIA

3.1. CRASH TEST PERFORMED/MATRIX

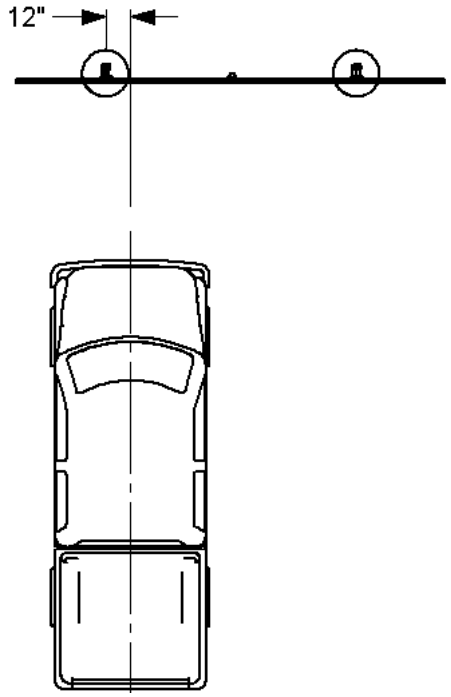
Table 3.1 shows the test conditions and evaluation criteria for *MASH* test 3-62 for support structures. MASH Section 2.2.4.1 recommends selecting a critical impact angle (CIA) within the range of 0 to 25 degrees. The target critical impact angles (CIAs) are intended to represent the worst-case impact condition consistent with the manner in which the sign support will be installed on the roadway and judged to have the greatest potential for test failure. The CIA is selected.

The target CIA for test 612261-05-1 and test 612261-04-1 on flat level ground was 0 degrees. This angle was selected based on historical testing experience and to maximize interaction between the vehicle and support post after activation of the slip base. The target CIA for test 612261-05-2 on the 6H:1V slope was 25 degrees. The 25-degree angle maximizes elevation of the vehicle off the slope break point and, thus, maximizes the height of impact on the support post. The increased elevation reduces the moment available to activate the fuse plate and increases the moment on the slip base. For each test the quarter-point of the vehicle was aligned with the centerline of one support per the recommendation listed in *MASH* at the time each test was conducted.

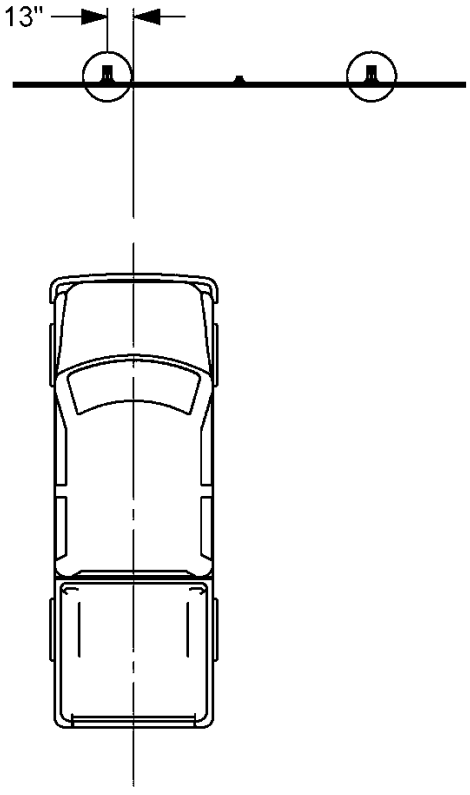
Figure 3.1 shows the target CIA and impact location for *MASH* Test 3-62 on the different large sign slip base support systems.

Table 3.1. Test Conditions and Evaluation Criteria Specified for *MASH* 3-62 Support Structures.

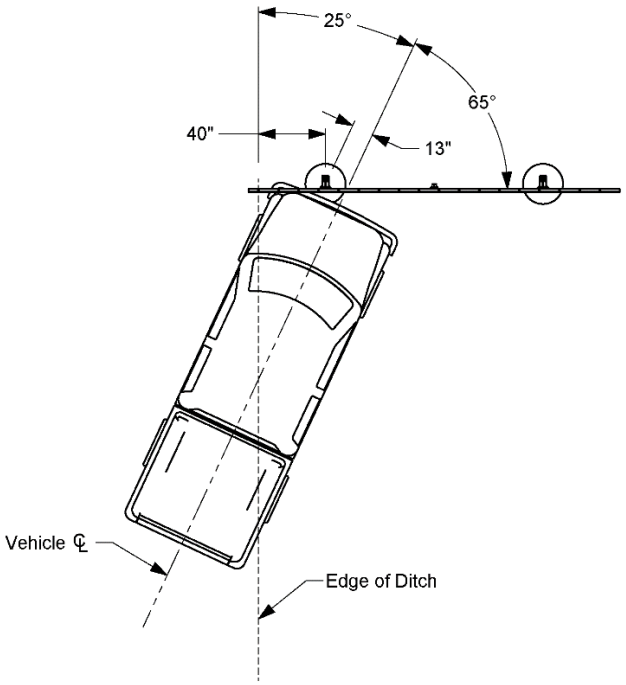
Test Designation	Test Vehicle	Impact Speed	Impact Angle	Evaluation Criteria
3-62	2270P	62 mi/h	CIA	B, D, F, H, I, N



(a). Target CIA and Impact Point for Test 612261-05-1



(b). Target CIA and Impact Point for Test 612261-04-1



(c). Target CIA and Impact Point for Test 612261-05-2

Figure 3.1. Target CIP for *MASH* 3-62 Tests on Large Sign Slip Base Support Systems.

The crash test and data analysis procedures were in accordance with guidelines presented in *MASH*. Chapter 4 presents brief descriptions of these procedures.

3.2. EVALUATION CRITERIA

The appropriate safety evaluation criteria from Tables 2-5 and 5-1 of *MASH* were used to evaluate the crash tests reported herein. Table 3.1 lists the test conditions and evaluation criteria required for *MASH* 3-62, and Table 3.2 provides detailed information on the evaluation criteria.

Table 3.2. Evaluation Criteria Required for *MASH* Testing.

Evaluation Factors	Evaluation Criteria
B.	The test article should readily activate in a predictable manner by breaking away, fracturing, or yielding.
D.	Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.
F.	The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.

Evaluation Factors	Evaluation Criteria
H.	Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 10 ft/s, or maximum allowable value of 16 ft/s.
I.	The occupant ridedown accelerations should satisfy the following: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.
N.	Vehicle trajectory behind the test article is acceptable.

Chapter 4. TEST CONDITIONS

4.1. TEST FACILITY

The full-scale crash tests reported herein were performed at the TTI Proving Ground, an International Standards Organization (ISO)/International Electrotechnical Commission (IEC) 17025-accredited laboratory with American Association for Laboratory Accreditation (A2LA) Mechanical Testing Certificate 2821.01. The full-scale crash tests were performed according to TTI Proving Ground quality procedures, as well as *MASH* guidelines and standards.

The test facilities of the TTI Proving Ground are located on The Texas A&M University System RELLIS Campus, which consists of a 2000-acre complex of research and training facilities situated 10 mi northwest of the flagship campus of Texas A&M University. The site, formerly a United States Army Air Corps base, has large expanses of concrete runways and parking aprons well suited for experimental research and testing in the areas of vehicle performance and handling, vehicle-roadway interaction, highway pavement durability and efficacy, and roadside safety hardware and perimeter protective device evaluation. The sites selected for construction and testing are on and along the edge of an out-of-service apron/runway. The apron/runway consists of an unreinforced jointed-concrete pavement in 12.5-ft × 15-ft blocks nominally 6 inches deep. The aprons were built in 1942, and the joints have some displacement but are otherwise flat and level.

4.2. VEHICLE TOW AND GUIDANCE SYSTEM

For the testing utilizing the 2270P vehicles, each was towed into the test installation using a steel cable guidance and reverse tow system. A steel cable for guiding the test vehicle was tensioned along the path, anchored at each end, and threaded through an attachment to the front wheel of the test vehicle. An additional steel cable was connected to the test vehicle, passed around a pulley near the impact point and through a pulley on the tow vehicle, and then anchored to the ground such that the tow vehicle moved away from the test site. A 2:1 speed ratio between the test and tow vehicle existed with this system. Just prior to impact with the installation, the test vehicle was released and ran unrestrained. The vehicle remained freewheeling (i.e., no steering or braking inputs) until it cleared the immediate area of the test site.

4.3. DATA ACQUISITION SYSTEMS

4.3.1. Vehicle Instrumentation and Data Processing

Each test vehicle was instrumented with a self-contained onboard data acquisition system. The signal conditioning and acquisition system is a multi-channel data acquisition system (DAS) produced by Diversified Technical Systems Inc. The accelerometers, which measure the x, y, and z axis of vehicle acceleration, are strain gauge type with linear millivolt output proportional to acceleration. Angular rate sensors, measuring vehicle roll, pitch, and yaw rates, are ultra-small, solid-state units designed for crash test service. The data acquisition hardware and software conform to the latest SAE J211, Instrumentation for Impact Test. Each of the channels is capable of providing precision amplification, scaling, and filtering based

on transducer specifications and calibrations. During the test, data are recorded from each channel at a rate of 10,000 samples per second with a resolution of one part in 65,536. Once data are recorded, internal batteries back these up inside the unit in case the primary battery cable is severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark and initiates the recording process. After each test, the data are downloaded from the DAS unit into a laptop computer at the test site. The Test Risk Assessment Program (TRAP) software then processes the raw data to produce detailed reports of the test results.

Each DAS is returned to the factory annually for complete recalibration and to ensure that all instrumentation used in the vehicle conforms to the specifications outlined by SAE J211. All accelerometers are calibrated annually by means of an ENDEVCO® 2901 precision primary vibration standard. This standard and its support instruments are checked annually and receive a National Institute of Standards Technology (NIST) traceable calibration. The rate transducers used in the data acquisition system receive calibration via a Genisco Rate-of-Turn table. The subsystems of each data channel are also evaluated annually, using instruments with current NIST traceability, and the results are factored into the accuracy of the total data channel per SAE J211. Calibrations and evaluations are also made anytime data are suspect. Acceleration data are measured with an expanded uncertainty of ±1.7 percent at a confidence factor of 95 percent (k = 2).

TRAP uses the DAS-captured data to compute the occupant/compartment impact velocities, time of occupant/compartment impact after vehicle impact, and highest 10-millisecond (ms) average ridedown acceleration. TRAP calculates change in vehicle velocity at the end of a given impulse period. In addition, maximum average accelerations over 50-ms intervals in each of the three directions are computed. For reporting purposes, the data from the vehicle-mounted accelerometers are filtered with an SAE Class 180-Hz low-pass digital filter, and acceleration versus time curves for the longitudinal, lateral, and vertical directions are plotted using TRAP.

TRAP uses the data from the yaw, pitch, and roll rate transducers to compute angular displacement in degrees at 0.0001-s intervals, and then plots yaw, pitch, and roll versus time. These displacements are in reference to the vehicle-fixed coordinate system with the initial position and orientation being initial impact. Rate of rotation data is measured with an expanded uncertainty of ±0.7 percent at a confidence factor of 95 percent (k = 2).

4.3.2. Anthropomorphic Dummy Instrumentation

According to *MASH*, use of a dummy in the 2270P vehicle is optional, and no dummy was used in the test.

4.3.3. Photographic Instrumentation Data Processing

Photographic coverage of the 612261-05-1 test included three digital high-speed cameras:

- One located with a view perpendicular to the impact path and in line with the test article.
- One placed downstream from the installation at an angle to the left of the installation so that to have a field of view of the interaction of the front of the vehicle with the installation.
- One placed downstream from the installation at an angle to the right of the installation so that to have a field of view of the interaction of the front of the vehicle with the installation.

Photographic coverage of the 612261-04-1 test included two digital high-speed cameras:

- One located with a view perpendicular to the impact path and in line with the test article.
- One placed downstream from the installation at an angle to the left of the installation so that to have a field of view of the interaction of the front of the vehicle with the installation.

Photographic coverage of the 612261-05-2 test included three digital high-speed cameras:

- One located with a view perpendicular to the impact path at impact.
- One placed downstream from the installation at an angle to the left of the installation so that to have a field of view of the interaction of the front of the vehicle with the installation.
- One with an overhead view of the installation at impact.

A flashbulb on the impacting vehicle was activated by a pressure-sensitive tape switch to indicate the instant of contact with the large sign slip base support. The flashbulb was visible from each camera. The video files from these digital high-speed cameras were analyzed to observe phenomena occurring during the collision and to obtain time-event, displacement, and angular data. A digital camera recorded and documented conditions of each test vehicle and the installation before and after the test.

Chapter 5. *MASH* TEST 3-62 (CRASH TEST NO. 612261-05-1)

5.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 5.1 for details on *MASH* impact conditions for this test and Table 5.2 for the exit parameters. Figure 5.1 and Figure 5.2 depict the target impact setup.

Table 5.1. Impact Conditions for *MASH* 3-62 612261-05-1.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	62	±2.5 mi/h	62.4
Impact Angle (deg)	0	±1.5°	0
Kinetic Energy (kip-ft)	594	≥594 kip-ft	656.0
Impact Location	12 inches to the left of the centerline of the vehicle aligned with the center of the left post	± 6 inches	12 inches to the left of the centerline of the vehicle aligned with the center of the left post

Table 5.2. Exit Parameters for *MASH* 3-62 6122561-05-1.

Exit Parameter	Measured
Speed (mi/h)	60.0
Brakes applied post impact (s)	1.6
Vehicle at rest position	309 ft downstream of impact point In-line with the impact path 5° left
Comments:	Vehicle remained upright and stable.

Figure 5.1. Large Sign Slip Base Support/Test Vehicle Geometrics for Test 6122561-05-1.

Figure 5.2. Large Sign Slip Base Support/Test Vehicle Impact Location 6122561-05-1.

5.2. WEATHER CONDITIONS

Table 5.3 provides the weather conditions for 6122561-05-1.

Table 5.3. Weather Conditions 6122561-05-1.

Date of Test	2020-03-03 AM
Wind Speed (mi/h)	3
Wind Direction (deg)	360
Temperature (°F)	72
Relative Humidity (%)	92
Vehicle Traveling (deg)	170

5.3. TEST VEHICLE

Figure 5.3 and Figure 5.4 show the 2014 RAM 1500 used for the crash test. Table 5.4 shows the vehicle measurements. Figure C.1 in Appendix C.1 gives additional dimensions and information on the vehicle.

Figure 5.3. Impact Side of Test Vehicle before Test 6122561-05-1.

Figure 5.4. Opposite Impact Side of Test Vehicle before Test 6122561-05-1.

Table 5.4. Vehicle Measurements 6122561-05-1.

Test Parameter	*MASH*	Allowed Tolerance	Measured
Dummy (if applicable)[a] (lb)	165	N/A	N/A
Inertial Weight (lb)	5000	± 110	5040
Gross Static[a] (lb)	5000	± 110	5040
Wheelbase (inches)	148	±12	140.5
Front Overhang (inches)	39	±3	40.0
Overall Length (inches)	237	±13	227.5
Overall Width (inches)	78	±2	78.5
Hood Height (inches)	43	±4	46.0
Track Width[b] (inches)	67	±1.5	68.25
CG aft of Front Axle[c] (inches)	63	±4	61.3
CG above Ground[c,d] (inches)	28	≥28	29.25

[a] If a dummy is used, the gross static vehicle mass includes the mass of the dummy.
[b] Average of front and rear axles.
[c] For test inertial mass.
[d] 2270P vehicle must meet minimum CG height requirement.

5.4. TEST DESCRIPTION

Table 5.5 lists events that occurred during Test No. 6122561-05-1. Figures C.4, C.5, and C.6 in Appendix C.2 present sequential photographs during the test.

Table 5.5. Events during Test 6122561-05-1.

Time (s)	Events
0.0000	Vehicle contacted support post
0.0020	Base of left post began to slip
0.0060	Base of left post became free from base at grade
0.0820	Vehicle was no longer in contact with support post
0.3290	Vehicle was completely clear of sign

5.5. DAMAGE TO TEST INSTALLATION

The left support slip base activated at impact. The field side bolts dislodged from the fuse plate at impact. The sign panel detached from the right-side support post and landed 6 feet to the right of impact. The left support post and part of the sign panel landed 22 feet to the right and 11 feet downstream. The right support did not activate and was leaning to the left 9.75 degrees from vertical, with a slight clockwise twist. Figure 5.5 and Figure 5.6 show the damage to the large sign slip base support system.

Figure 5.5. Large Sign Slip Base Support after Test at Impact Location 6122561-05-1.

Figure 5.6. Left/Driver Large Sign Slip Base Support after Test at the Left Support Base 6122561-05-1.

5.6. DAMAGE TO TEST VEHICLE

Figure 5.7 and Figure 5.8 show the damage sustained by the vehicle. Figure 5.9 and Figure 5.10 show the interior of the test vehicle. Table 5.6 and Table 5.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures C.2 and C.3 in Appendix C.1 provide exterior crush and occupant compartment measurements.

Figure 5.7. Impact Side of Test Vehicle after Test 6122561-05-1.

Figure 5.8. Rear Impact Side of Test Vehicle after Test 6122561-05-1.

Figure 5.9. Overall Interior of Test Vehicle after Test 6122561-05-1.

Figure 5.10. Interior Roof of Test Vehicle after Test 6122561-05-1.

Table 5.6. Occupant Compartment Deformation 6122561-05-1.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	0.0 inches
Windshield	≤3.0 inches	0.0 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0.0 inches
Foot Well/Toe Pan	≤9.0 inches	0.0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0.0 inches
Side Front Panel	≤12.0 inches	0.0 inches
Front Door (above Seat)	≤9.0 inches	0.0 inches
Front Door (below Seat)	≤12.0 inches	0.0 inches

Table 5.7. Exterior Vehicle Damage 6122561-05-1.

Side Windows	Side windows remained intact.
Maximum Exterior Deformation	8 inches in the front plane at bumper height
VDS	12FC3
CDC	12FCEW3
Fuel Tank Damage	None
Description of Damage to Vehicle:	The front bumper, hood, grill, both headlights, radiator and support, and left side fender were damaged. The front bumper had a 9-inch × 14 inch dent 12 inches left of center that was 9 inches deep. The hood had a 24-inch × 16-inch dent 12 inches left of center that pushed the hood back 5 inches. The left side fender had a 21-inch × 8-inch dent that was 1.5 inches deep. There was no damage to the fuel tank or oil pan.

5.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 5.8. Figure C.7 in Appendix C.3 shows the vehicle angular displacements, and Figures C.8 through C.10 in Appendix C.4 show acceleration versus time traces.

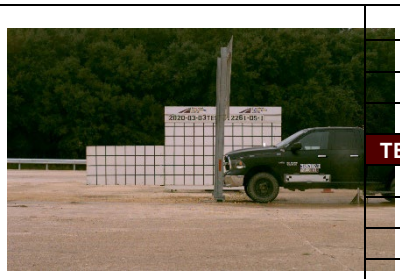
Table 5.8. Occupant Risk Factors for Test 6122561-05-1.

Test Parameter	*MASH*	Measured	Time
OIV, Longitudinal (ft/s)	≤16.0 *10.0* [a.]	3.4	0.7128 seconds on front of interior
OIV, Lateral (ft/s)	N/A	1.9	0.7128 seconds on front of interior
Ridedown Accelearation, Longitudinal (g)	≤20.49 *15.0*	0.3	0.8482 - 0.8582 seconds
Ridedown, Acceleration, Lateral (g)	≤20.49 *15.0*	1.0	0.7512 - 0.7612 seconds
THIV (m/s)	N/A	1.2	0.7095 seconds on front of interior
ASI	N/A	0.2	0.0164 - 0.0664 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal (g)	N/A	-1.8	0.0007 - 0.0507 seconds
50-ms MA Lateral (g)	N/A	0.6	0.7353 - 0.7853 seconds
50-ms MA Vertical (g)	N/A	-0.8	0.1490 - 0.1990 seconds
Roll (deg)	≤75	2	1.4227 seconds
Pitch (deg)	≤75	3	1.4632 seconds
Yaw (deg)	N/A	2	1.5000 seconds

[a.] *Values in italics are the preferred MASH values*

5.8. TEST SUMMARY

Figure 5.11 summarizes the results of *MASH* Test 6122561-05-1.



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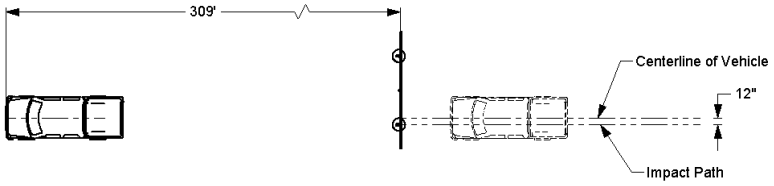
Test Agency	Texas A&M Transportation Institute (TTI)		
Test Standard/Test No.	*MASH* 2016, Test 3-62		
TTI Project No.	6122561-05-1		
Test Date	2020-03-07		
TEST ARTICLE			
Type	Support Structure		
Name	Large Sign Slip Base Support with Fuse Plate		
Height	13 ft - 6 inches		
Key Materials	4 section aluminum sign panel, Two W6×12 ASTM A36 steel support posts		
Soil Type and Condition	AASHTO M147-17, Grading D Crushed Concrete		
TEST VEHICLE			
Type/Designation	2270P		
Year, Make and Model	2014 RAM 1500		
Inertial Weight (lb)	5040		
Dummy (lb)	N/A		
Gross Static (lb)	5040		
IMPACT CONDITIONS			
Impact Speed (mi/h)	62.4		
Impact Angle (deg)	0		
Impact Location	12 inches to the left of the centerline of the vehicle aligned with the center of the left post		
Kinetic Energy (kip-ft)	656.0		
EXIT CONDITIONS			
Exit Speed (mi/h)	60.0		
Stopping Distance	309 ft downstream In-line with the impact path		
VEHICLE DAMAGE			
VDS	12FC3		
CDC	12FCEW3		
Max. Ext. Deformation	8		
Max Occupant Compartment Deformation	No occupant compartment deformation		
OCCUPANT RISK VALUES			
Long. OIV (ft/s)	3.4	Max 50-ms Long. (g)	-1.8
Lat. OIV (ft/s)	1.9	Max 50-ms Lat. (g)	0.6
Long. Ridedown (g)	0.3	Max 50-ms Vert. (g)	-0.8
Lat. Ridedown (g)	1.0	Max Roll (deg)	2
THIV (m/s)	1.2	Max Pitch (deg)	3
ASI	0.2	Max Yaw (deg)	2



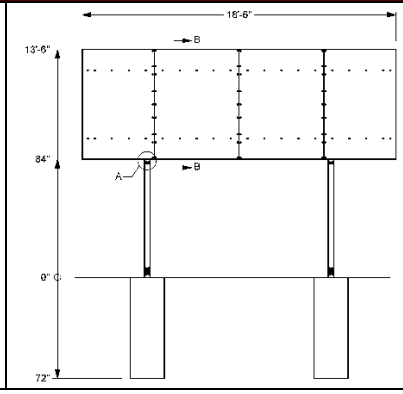


Figure 5.11. Summary of Results for *MASH* Test 3-62 on Large Sign Slip Base Support.

Chapter 6. *MASH* TEST 3-62 (CRASH TEST NO. 612261-04-1)

6.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 6.1 for details on *MASH* impact conditions for this test and Table 6.2 for the exit parameters. Figure 6.1 and Figure 6.2 depict the target impact setup.

Table 6.1. Impact Conditions for *MASH* 3-62 612261-04-1.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	62	±2.5 mi/h	61.4
Impact Angle (deg)	0	±1.5°	0
Kinetic Energy (kip-ft)	594	≥594 kip-ft	638.2
Impact Location	13 inches to the left of the centerline of the vehicle aligned with the center of the left post	± 6 inches	13 inches to the left of the centerline of the vehicle aligned with the center of the left post

Table 6.2. Exit Parameters for *MASH* 3-62 612261-04-1.

Exit Parameter	Measured
Speed (mi/h)	61.3
Brakes applied post impact (s)	2.0
Vehicle at rest position	345 ft downstream of impact point In-line with the installation
Comments:	Vehicle remained upright and stable.

Figure 6.1. Large Sign Slip Base Support/Test Vehicle Geometrics for Test 612261-04-1.

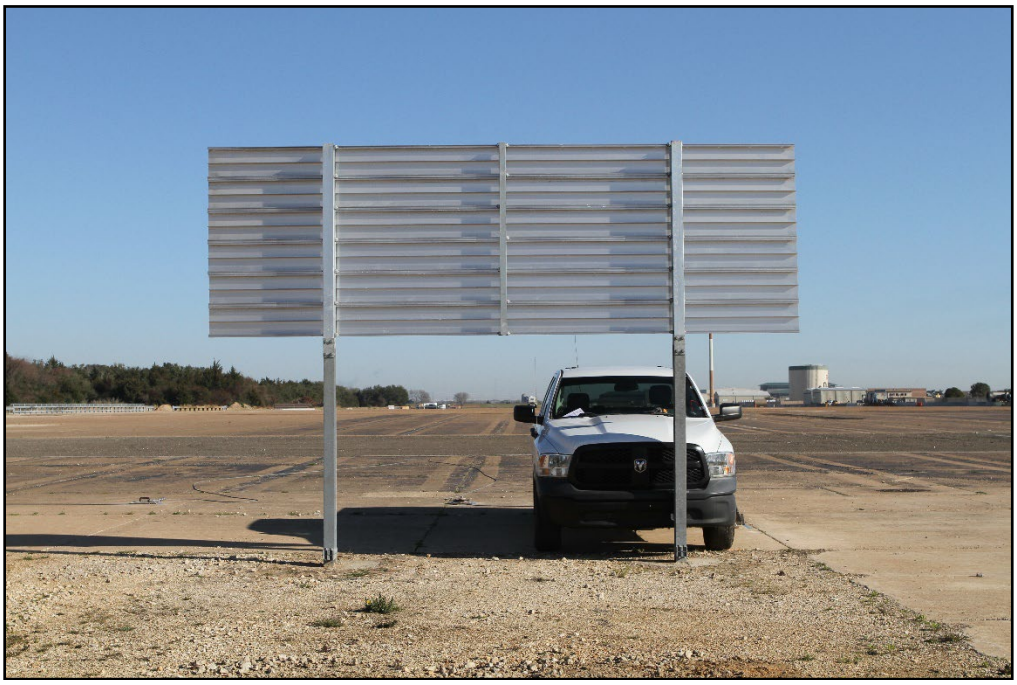


Figure 6.2. Large Sign Slip Base Support/Test Vehicle Impact Location 612261-04-1.

6.2. WEATHER CONDITIONS

Table 6.3 provides the weather conditions for 612261-04-1.

Table 6.3. Weather Conditions 612261-04-1.

Date of Test	2022-03-16 PM
Wind Speed (mi/h)	7
Wind Direction (deg)	173
Temperature (°F)	71
Relative Humidity (%)	59
Vehicle Traveling (deg)	170

6.3. TEST VEHICLE

Figure 6.3 and Figure 6.4 show the 2016 RAM 1500 used for the crash test. Table 6.4 shows the vehicle measurements. Figure D.1 in Appendix D.1 gives additional dimensions and information on the vehicle.

Figure 6.3. Impact Side of Test Vehicle before Test 612261-04-1.

Figure 6.4. Opposite Impact Side of Test Vehicle before Test 612261-04-1.

Table 6.4. Vehicle Measurements 612261-04-1.

Test Parameter	*MASH*	Allowed Tolerance	Measured
Dummy (if applicable)[a] (lb)	165	N/A	N/A
Inertial Weight (lb)	5000	± 110	5064
Gross Static[a] (lb)	5000	± 110	5064
Wheelbase (inches)	148	±12	140.5
Front Overhang (inches)	39	±3	40.0
Overall Length (inches)	237	±13	227.5
Overall Width (inches)	78	±2	78.5
Hood Height (inches)	43	±4	46.0
Track Width[b] (inches)	67	±1.5	68.25
CG aft of Front Axle[c] (inches)	63	±4	60.9
CG above Ground[c,d] (inches)	28	≥28	28.25

[a] If a dummy is used, the gross static vehicle mass includes the mass of the dummy.
[b] Average of front and rear axles.
[c] For test inertial mass.
[d] 2270P vehicle must meet minimum CG height requirement.

6.4. TEST DESCRIPTION

Table 6.5 lists events that occurred during Test No. 612261-04-1. Figures D.4 and D.5 in Appendix D.2 present sequential photographs during the test.

Table 6.5. Events during Test 612261-04-1.

Time (s)	Events
0.0000	Vehicle contacted the support post
0.0020	Left sign post base began to release
0.0100	Left sign post impact-side fuse plate began to separate
0.1150	Bottom edge of upper section of activated fuse plate on left sign post contacted roof
0.1960	Vehicle exited the installation at 61.3mi/h

6.5. DAMAGE TO TEST INSTALLATION

The sign panel released from the support posts and landed 20 feet downstream from impact. The front fuse plate on the left support post fractured, and the support post released from the slip base, landing 40 feet downstream from impact. The front fuse plate on the right support post fractured, but the support post did not release from the slip base, causing a lean of the upper section of the support post of 8 degrees to the left. Figure 6.5 and Figure 6.6 show the damage to the large sign slip base support.

Figure 6.5. Large Sign Slip Base Support after Test at Impact Location 612261-04-1.

Figure 6.6. Impacted Post of the Large Sign Slip Base Support after Test 612261-04-1.

6.6. DAMAGE TO TEST VEHICLE

Figure 6.7 and Figure 6.8 show the damage sustained by the vehicle. Figure 6.9 and Figure 6.10 show the interior of the test vehicle. Table 6.6 and Table 6.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures D.2 and D.3 in Appendix D.1 provide exterior crush and occupant compartment measurements.

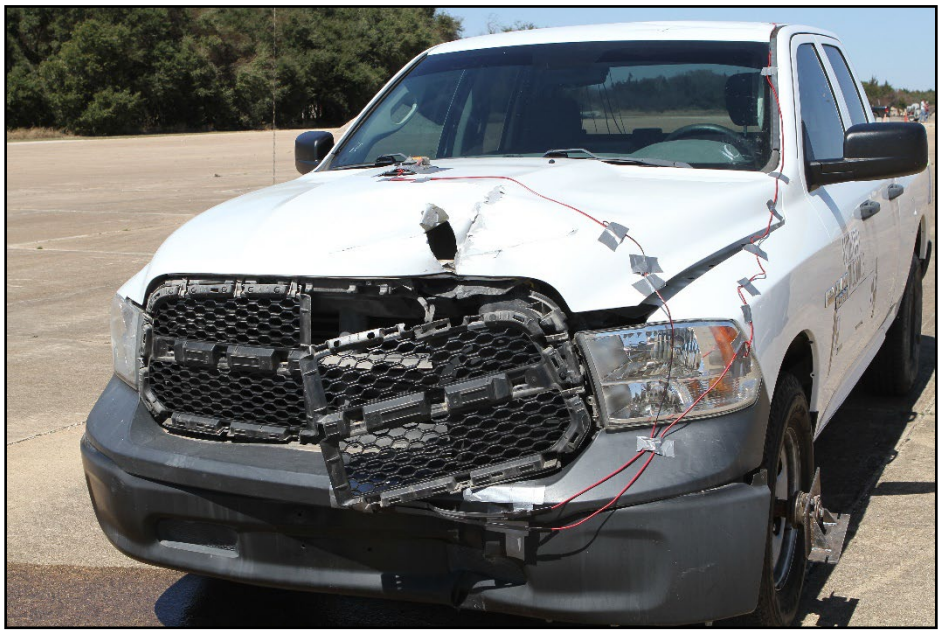


Figure 6.7. Impact Side of Test Vehicle after Test 612261-04-1.

Figure 6.8. Roof Damage on Test Vehicle after Test 612261-04-1.

Figure 6.9. Overall Interior of Test Vehicle after Test 612261-04-1.

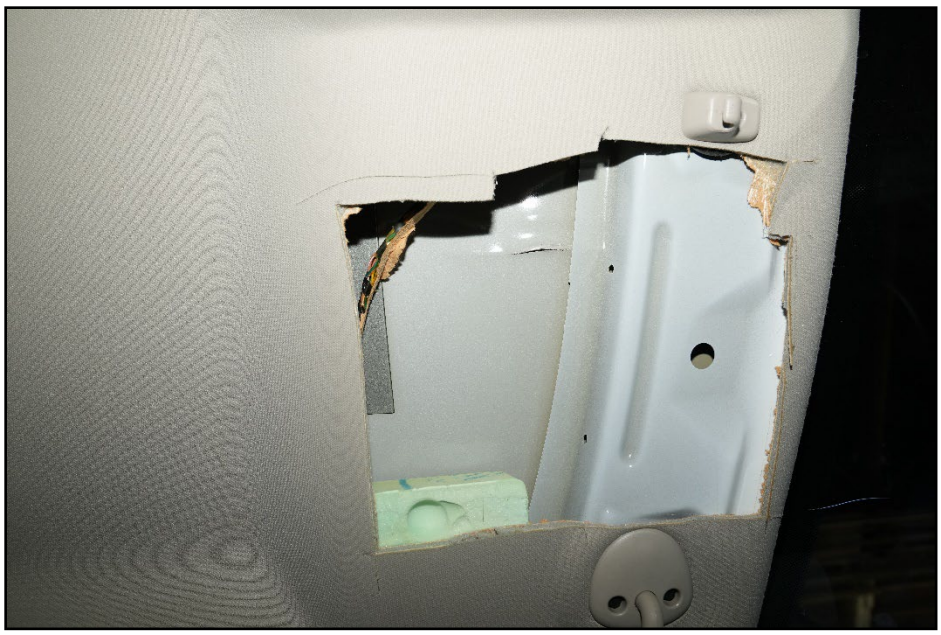


Figure 6.10. Interior of Test Vehicle Roof on Impact Side after Test 612261-04-1.

Table 6.6. Occupant Compartment Deformation 612261-04-1.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	1 inch
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 6.7. Exterior Vehicle Damage 612261-04-1.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	4 inches in the front plane at bumper height
VDS	12FC2
CDC	12FCAW1
Fuel Tank Damage	None
Description of Damage to Vehicle:	The front bumper, hood, grill, and roof were damaged. The front bumper had an 18-inch × 12-inch dent that was 4 inches deep, 13 inches to the left of the vehicle's centerline. The hood had a 22-inch ×13-inch dent that was 1.5 inches deep, 13 inches to the left of the vehicle's centerline. The roof had an 8-inch square dent with a cut that was 0.0625 inches wide and 1-inch long, 12 inches to the left of the vehicle's centerline. Fuel tank and Oil pan were not damaged.

6.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 6.8. Figure D.6 in Appendix D.3 shows the vehicle angular displacements, and Figures D.7 through D.9 in Appendix D.4 show acceleration versus time traces.

Table 6.8. Occupant Risk Factors for Test 612261-04-1.

Test Parameter	*MASH*	Measured	Time
OIV, Longitudinal (ft/s)	≤16.0 *10.0* [a.]	2.4	0.8107 seconds on front of interior
OIV, Lateral (ft/s)	N/A	0.6	0.8107 seconds on front of interior
Ridedown, Longitudinal (g)	≤20.49 *15.0*	0.3	0.8167 - 0.8267 seconds
Ridedown, Lateral (g)	≤20.49 *15.0*	0.4	0.9454 - 0.9554 seconds
THIV (m/s)	N/A	0.8	0.8115 seconds on front of interior
ASI	N/A	0.2	0.0107 - 0.0607 seconds
50-ms MA Longitudinal (g)	N/A	-1.4	0.0000 - 0.0500 seconds
50-ms MA Lateral (g)	N/A	-0.4	0.0870 - 0.1370 seconds
50-ms MA Vertical (g)	N/A	-1.1	0.2658 - 0.3158 seconds
Roll (deg)	≤75	4	1.9999 seconds
Pitch (deg)	≤75	4	1.9914 seconds
Yaw (deg)	N/A	3	1.9999 seconds

[a.] *Values in italics are the preferred MASH values*

6.8. TEST SUMMARY

Figure 6.11 summarizes the results of *MASH* Test 612261-04-1. Though the roof did have a cut that went through the metal, it was determined that the due to the angle and direction of contact and the shape of the part contacting the roof there was no danger for penetration into the occupant compartment.

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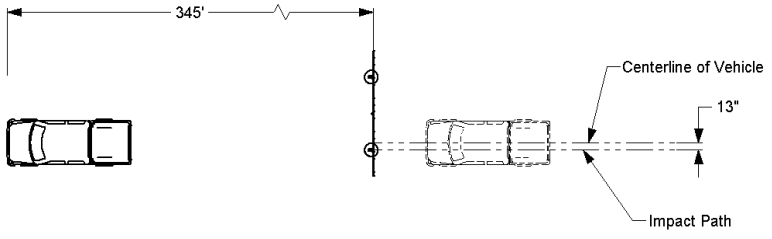
0.300 s

Test Agency	Texas A&M Transportation Institute (TTI)		
Test Standard/Test No.	*MASH* 2016, Test 3-62		
TTI Project No.	612261-04-1		
Test Date	2022-03-16		
TEST ARTICLE			
Type	Support Structure		
Name	Large Sign Slip Base Support with Fuse Plate		
Height	13 ft - 0 inches		
Key Materials	Extruded aluminum sign panel w/ 6 Horiz Sections Two W6×12 ASTM A36 steel support posts		
Soil Type and Condition	AASHTO M147-17 Grading D Crushed Concrete		
TEST VEHICLE			
Type/Designation	2270P		
Year, Make and Model	2016 RAM 1500		
Inertial Weight (lb)	5064		
Dummy (lb)	N/A		
Gross Static (lb)	5064		
IMPACT CONDITIONS			
Impact Speed (mi/h)	61.4		
Impact Angle (deg)	0		
Impact Location	13 inches to the left of the centerline of the vehicle aligned with the center of the left post		
Kinetic Energy (kip-ft)	638.2		
EXIT CONDITIONS			
Exit Speed (mi/h)	61.3		
Stopping Distance	345 ft downstream In-line with the installation		
VEHICLE DAMAGE			
VDS	12FC2		
CDC	12FCAW1		
Max. Ext. Deformation	4		
Max Occupant Compartment Deformation	1-inch in the roof		
OCCUPANT RISK VALUES			
Long. OIV (ft/s)	2.4	Max 50-ms Long. (g)	-1.4
Lat. OIV (ft/s)	0.6	Max 50-ms Lat. (g)	-0.4
Long. Ridedown (g)	0.3	Max 50-ms Vert. (g)	-1.1
Lat. Ridedown (g)	0.4	Max Roll (deg)	4
THIV (m/s)	0.8	Max Pitch (deg)	4
ASI	0.2	Max Yaw (deg)	3



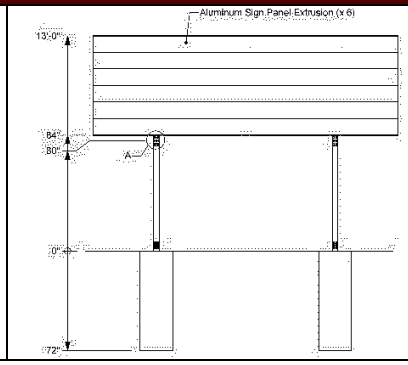


Figure 6.11. Summary of Results for *MASH* Test 3-62 on Large Sign Slip Base Support.

Chapter 7. *MASH* TEST 3-62 (CRASH TEST NO. 612261-05-2)

7.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 7.1 for details on *MASH* impact conditions for this test and Table 7.2 for the exit parameters. Figure 7.1 and Figure 7.2 depict the target impact setup.

Table 7.1. Impact Conditions for *MASH* 3-62 612261-05-2.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	62	± 2.5 mi/h	64.3
Impact Angle (deg)	25	± 1.5°	26.5
Kinetic Energy (kip-ft)	594	≥594 kip-ft	691.8
Impact Location	13 inches to the left of the centerline of the vehicle aligned with the center of the left post	± 6 inches	14 inches to the left of the centerline of the vehicle aligned with the center of the left post

Table 7.2. Exit Parameters for *MASH* 3-62 612261-05-2.

Exit Parameter	Measured
Speed (mi/h)	60.4
Brakes applied post impact (s)	1.3
Vehicle at rest position	266 ft downstream of impact point 19 ft to the field side 50° right
Comments:	Vehicle remained upright and stable.

Figure 7.1. Large Sign Slip Base Support/Test Vehicle Geometrics for Test 612261-05-2.

Figure 7.2. Large Sign Slip Base Support/Test Vehicle Impact Location 612261-05-2.

7.2. WEATHER CONDITIONS

Table 7.3 provides the weather conditions for 612261-05-2.

Table 7.3. Weather Conditions 612261-05-2.

Date of Test	2022-11-10 AM
Wind Speed (mi/h)	7
Wind Direction (deg)	151
Temperature (°F)	77
Relative Humidity (%)	82
Vehicle Traveling (deg)	325

7.3. TEST VEHICLE

Figure 7.3 and Figure 7.4 show the 2018 RAM 1500 used for the crash test. Table 7.4 shows the vehicle measurements. Figure E.1 in Appendix E.1 gives additional dimensions and information on the vehicle.

Figure 7.3. Impact Side of Test Vehicle before Test 612261-05-2.

Figure 7.4. Opposite Impact Side of Test Vehicle before Test 612261-05-2.

Table 7.4. Vehicle Measurements 612261-05-2.

Test Parameter	*MASH*	Allowed Tolerance	Measured
Dummy (if applicable)[a] (lb)	165	N/A	N/A
Inertial Weight (lb)	5000	± 110	5005
Gross Static[a] (lb)	5000	± 110	5005
Wheelbase (inches)	148	±12	140.5
Front Overhang (inches)	39	±3	40.0
Overall Length (inches)	237	±13	227.5
Overall Width (inches)	78	±2	78.5
Hood Height (inches)	43	±4	46.0
Track Width[b] (inches)	67	±1.5	68.25
CG aft of Front Axle[c] (inches)	63	±4	61.0
CG above Ground[c,d] (inches)	28	≥28	28.75

[a] If a dummy is used, the gross static vehicle mass includes the mass of the dummy.
[b] Average of front and rear axles.
[c] For test inertial mass.
[d] 2270P vehicle must meet minimum CG height requirement.

7.4. TEST DESCRIPTION

Table 7.5 lists events that occurred during Test No. 612261-05-2. Figures E.4, E.5, and E.6 in Appendix E.2 present sequential photographs during the test.

Table 7.5. Events during Test 612261-05-2.

Time (s)	Events
0.0000	Vehicle contacted the left support post
0.0030	Left support post slip base began to release
0.0080	Fuse plate connection on left support post began to fracture
0.0940	Fuse plate connection on right support post began to fracture
0.1140	Lower edge of upper section of left support post contacted roof near windshield and A-pillar
0.1510	Vehicle lost contact with the sign and its components.

7.5. DAMAGE TO TEST INSTALLATION

The left side impacted support post slip base activated and the fuse plate fractured. The sign panel released from the non-impacted right side support post and was deformed. The fuse plate activated on the non-impacted right side support post and a bolt connecting the support post to the hinge plate sheared. Figure 7.5 and Figure 7.6 show the damage to the large sign slip base support.

Figure 7.5. Large Sign Slip Base Support after Test at Impact Location 612261-05-2.

Figure 7.6. Large Sign Slip Base Support after Test at the Impacted Support 612261-05-2.

7.6. DAMAGE TO TEST VEHICLE

Figure 7.7 and Figure 7.8 show the damage sustained by the vehicle. Figure 7.9 and Figure 7.10 show the interior of the test vehicle. Table 7.6 and Table 7.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures E.2 and E.3 in Appendix E.1 provide exterior crush and occupant compartment measurements.

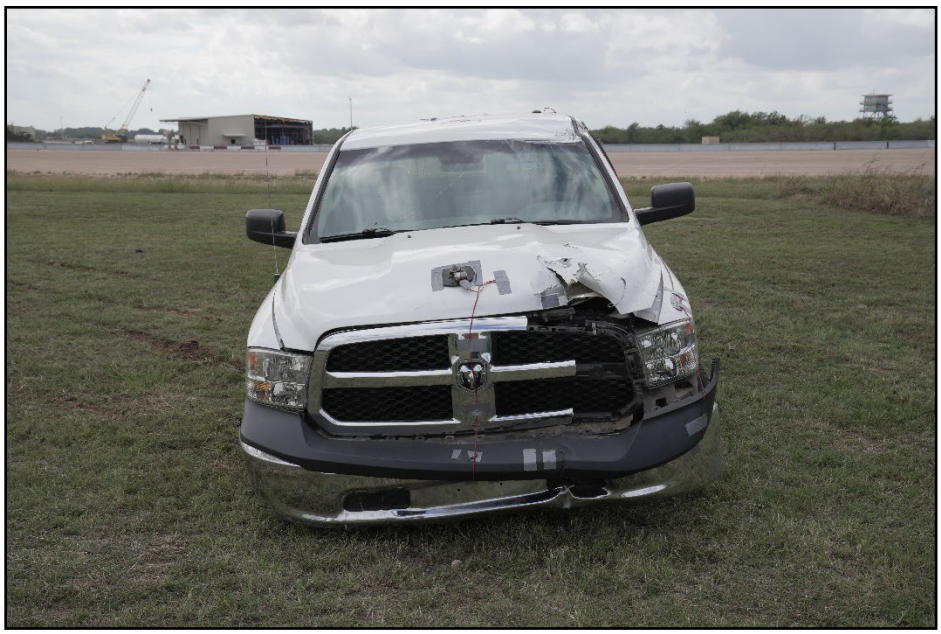


Figure 7.7. Impact Side of Test Vehicle after Test 612261-05-2.

Figure 7.8. Rear Impact Side of Test Vehicle after Test 612261-05-2.

Figure 7.9. Roof of Test Vehicle after Test 612261-05-2.

Figure 7.10. Interior of Test Vehicle after Test 612261-05-2.

Table 7.6. Occupant Compartment Deformation 612261-05-2.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	1.9 inches
Windshield	≤3.0 inches	0.5 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 7.7. Exterior Vehicle Damage 612261-05-2.

Side Windows	The side windows remained intact
Maximum Exterior Deformation	11 inches in the front plane at bumper height
VDS	12FL2
CDC	12FLAW2
Fuel Tank Damage	None
Description of Damage to Vehicle:	The front bumper, hood, grill, right lower control arm, right tire, windshield, roof and left upper A-pillar were damaged. The windshield had a 17.5-inch × 3.25-inch fold that was 0.5 inches deep, but there was no cut or tear in the laminate. The roof had a 19-inch × 16-inch dent that was 1.9 inches deep, and had two cuts, one measuring 3 inches × 0.25 inches and the other 1.5 inches × 0.125 inches. The left upper a-pillar had 3 small rips with a 1-inch deep dent. No damage to fuel tank or oil pan.

7.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 7.8. Figure E.7 in Appendix E.3 shows the vehicle angular displacements, and Figures E.8 through E.10 in Appendix E.4 show acceleration versus time traces.

Table 7.8. Occupant Risk Factors for Test 612261-05-2.

Test Parameter	*MASH*	Measured	Time
OIV, Longitudinal (ft/s)	≤16.0 *10.0* [a.]	9.2	0.4928 seconds on front of interior
OIV, Lateral (ft/s)	N/A	3.3	0.4928 seconds on front of interior
Ridedown acceleration, Longitudinal (g)	≤20.49 *15.0*	0.9	0.5197 - 0.5297 seconds
Ridedown acceleration, Lateral (g)	≤20.49 *15.0*	0.6	0.5084 - 0.5184 seconds
THIV (m/s)	N/A	3.0	0.4923 seconds on front of interior
ASI	N/A	0.5	0.4011 - 0.4511 seconds
50-ms MA Longitudinal (g)	N/A	-2.1	0.4102 - 0.4602 seconds
50-ms MA Lateral (g)	N/A	-1.3	0.3965 - 0.4465 seconds
50-ms MA Vertical (g)	N/A	-4.6	0.3572 - 0.4072 seconds
Roll (deg)	≤75	25	1.0000 seconds
Pitch (deg)	≤75	7	0.6591 seconds
Yaw (deg)	N/A	3	0.5264 seconds

13. *Values in italics are the preferred MASH values*

7.8. TEST SUMMARY

MASH evaluation criteria D states that the test article should not penetrate, or show the potential to penetrate into the occupant compartment. There were two small tears in the roof, however it was determined through analysis of the high speed video and a special arbitration committee, that the direction of the force generated by the sign panel was primarily parallel with the impact path, and that the test article would not penetrate into the occupant compartment or pose any significant risk to the occupants of the vehicle. Figure 7.11 summarizes the results of *MASH* Test 612261-05-2.

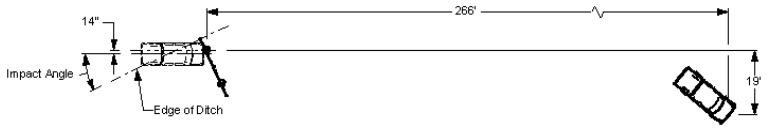
0.000 s

0.100 s

0.200 s

0.300 s

Test Agency	Texas A&M Transportation Institute (TTI)		
Test Standard/Test No.	*MASH* 2016, Test 3-62		
TTI Project No.	612261-05-2		
Test Date	2022-11-10		
TEST ARTICLE			
Type	Support Structure		
Name	Large Sign Slip Base Support with Fuse Plate		
Height	13 ft-0 inches		
Key Materials	Extruded aluminum sign panel w/ 6 Horiz Sections Two W6×12 ASTM A36 steel support posts		
Soil Type and Condition	6H:1V slope; AASHTO M147-17, Grading D Crushed Concrete		
TEST VEHICLE			
Type/Designation	2270P		
Year, Make and Model	2018 RAM 1500		
Inertial Weight (lb)	5005		
Gross (lb)	5005		
IMPACT CONDITIONS			
Impact Speed (mi/h)	64.3		
Impact Angle (deg)	26.5		
Impact Location	14 inches to the left of the centerline of the vehicle aligned with the center of the left post		
Kinetic Energy (kip-ft)	691.8		
EXIT CONDITIONS			
Exit Speed (mi/h)	60.4		
Stopping Distance	266 ft downstream 19 ft to the field side		
VEHICLE DAMAGE			
VDS	12FL2		
CDC	12FLAW2		
Max. Ext. Deformation	11 inches		
Max Occupant Compartment Deformation	1.9 inches in the roof		
OCCUPANT RISK VALUES			
Long. OIV (ft/s)	9.2	Max 50-ms Long. (g)	-2.1
Lat. OIV (ft/s)	3.3	Max 50-ms Lat. (g)	-1.3
Long. Ridedown (g)	0.9	Max 50-ms Vert. (g)	-4.6
Lat. Ridedown (g)	0.6	Max Roll (deg)	25
THIV (m/s)	3.0	Max Pitch (deg)	7
ASI	0.5	Max Yaw (deg)	3



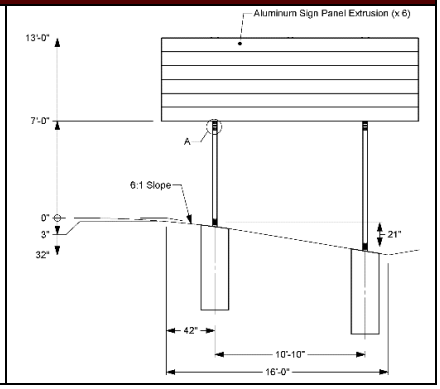


Figure 7.11. Summary of Results for *MASH* Test 3-62 on Large Sign Slip Base Support.

Chapter 8. SUMMARY AND CONCLUSIONS

8.1. ASSESSMENT OF TEST RESULTS

The crash tests reported herein were performed in accordance with *MASH* 3-62, which involves three tests, on the large sign slip base support.

8.2. CONCLUSIONS

Table 8.1 shows that the different configurations of large sign slip base support systems met the performance criteria for *MASH* 3-62 support structures.

Table 8.1. Assessment Summary for *MASH* 3-62 Tests on Large Sign Slip Base Support.

Evaluation Criteria	Description	Test No. 6122561-05-1	Test No. 612261-04-1	Test No. 612261-05-2
B	Test Article Activated as Desired	S	S	S
D	No Penetration into Occupant Compartment	S	S	S
F	Roll and Pitch Limit	S	S	S
H	OIV Threshold	S	S	S
I	Ridedown Threshold	S	S	S
N	Trajectory Behind is Acceptable	S	S	S
Overall		Pass	Pass	Pass

Note: S = Satisfactory
[1] See Table 3.2 for details

8.3. DISCUSSION

Two configuration of a large guide sign slip base support system with similar support posts and slip base designs performed differently when impacted following MASH Test 3-62 conditions. While both configurations satisfied MASH criteria, the fuse plate activation differed. In the initial system tested with an aluminum sheet metal sign panel and a 3/8-inch thick fuse plate, the fuse plate did not activate. After activation of the fuse plate, the sign panel twisted, and the entire support post rotated above the vehicle.

In a test subsequent with an extruded aluminum sign panel and a ¼-inch fuse plate, the fuse plate activated as designed. The lower post section rotated up about the hinge plate and the vehicle passed under the system. It was noted that the unsupported sign panel had a tendency to drop, allowing the bottom edge of the upper section of support to contact the roof of the pickup truck as it traveled beneath the system. This behavior is likely accentuated in a dual support post system with a wide post spacing. Systems with more than two posts, narrower sign panels, and/or taller mounting height would reduce or eliminate this interaction.

During an encroachment of a vehicle onto a slope or ditch, the elevation of the encroaching vehicle above the local terrain will depend on variables such as speed, angle, steepness of slope, and degree of rounding at the slope break point. The trajectory of the vehicle bumper may increase above its equilibrium condition established on flat, level ground. Vehicle interaction with a support post at a higher elevation relative to the local ground may potentially change the activation characteristics of the slip base and/or fuse plate.

As noted herein, MASH criteria were satisfied when the system with the extruded aluminum sign panel was tested on a 6H:1V slope. The offset of the impacted post from the slope break point was 42 inches, which provided a drop in elevation at the support of 7 inches. Sign support systems installed further from the break point on a 6H:1V slope or on a steeper slope will have additional drop in elevation. As noted, the degree of slope, sign support offset from the slope, and degree of slope rounding at the slope break point can create variations in the location of vehicle impact with the support. This project is considered a first step in understanding the behavior of large guide signs on slopes. Additional research is recommended to further evaluate the influence of these variables on impact performance of large sign support systems.

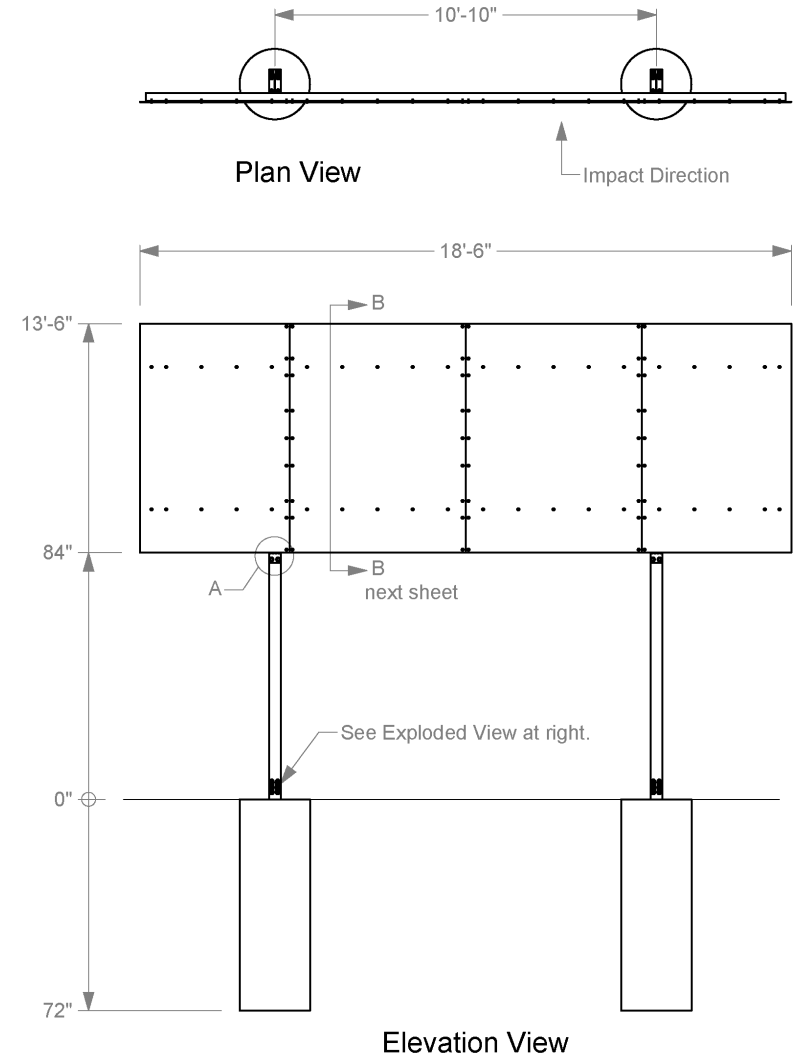
REFERENCES

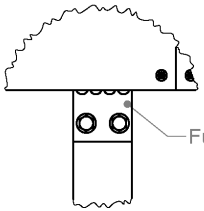
1. AASHTO. *Manual for Assessing Roadside Safety Hardware*, Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.

APPENDIX A. DETAILS OF LARGE SIGN SLIP BASE SUPPORT

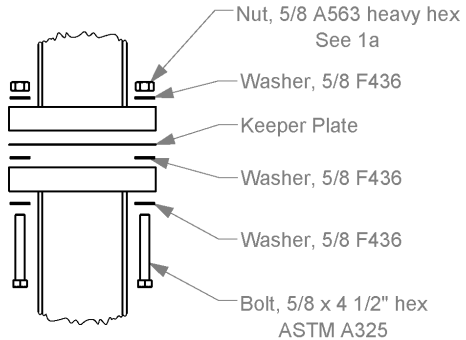
A.1. DETAILS FOR TEST 612261-05-1

Test Installation





Detail A
Scale 1 : 10
See Section View on next sheet for hardware details

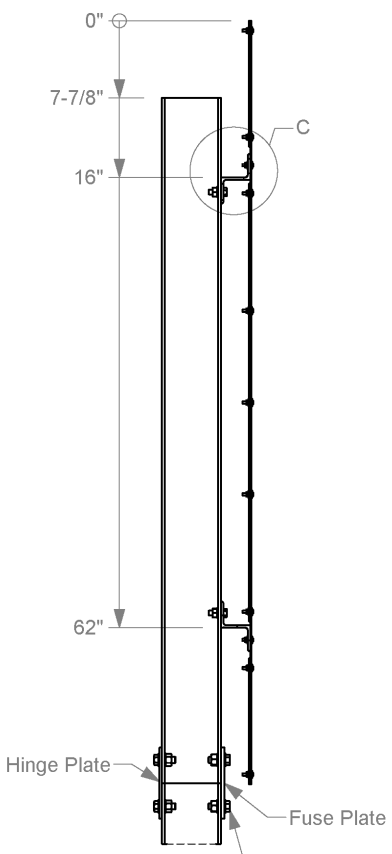


Slip Base Connection
Scale 1:10 - Rotated 90° from Elevation View for clarity.
Hardware is typical x 4 @ each Post

1a. Tighten maximum possible with 12" or 15" wrench to seat parts, then loosen one turn and tighten to 22.5 ft/lbs.
1b. Threads not shown on bolts for clarity. All Slip Base Connection hardware is galvanized to ASTM F2329.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-05-1 Fla DOT Breakaway Sign Post		2020-02-19
Drawn by GES	Scale 1:50	Sheet 1 of 10 Test Installation

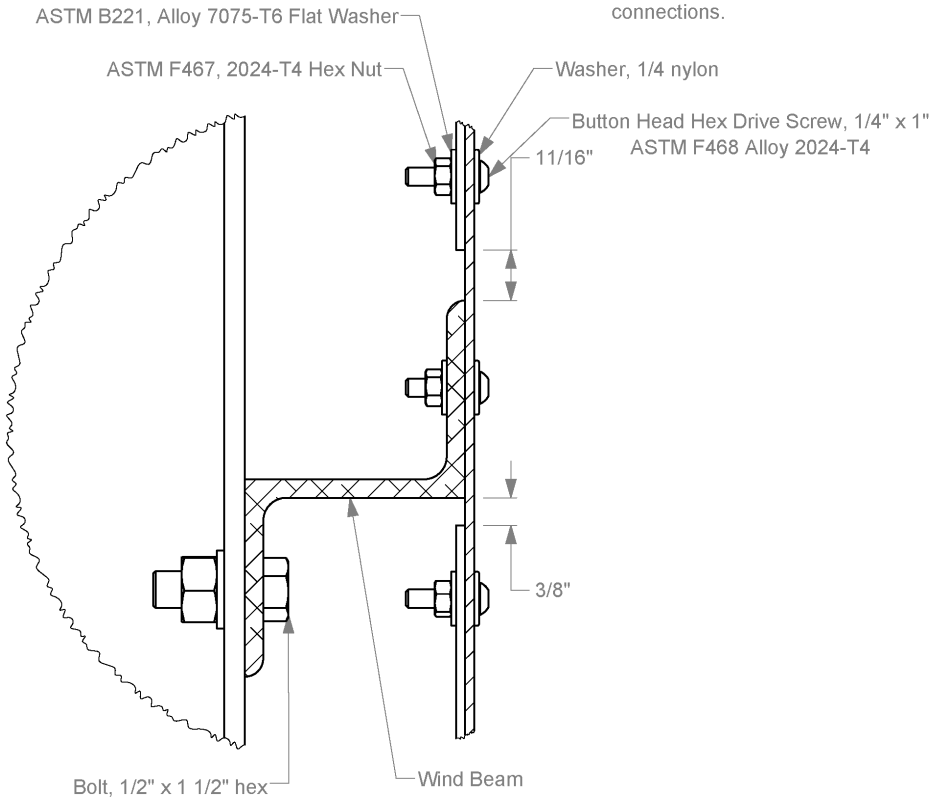
Section View



Section B-B
Scale 1 : 15

Bolt, 5/8 x 1 3/4" hex ASTM A325
with two F436 Washers and A563 Heavy Hex Nut,
Typ x 8 @ each Post

This hardware is typical for all sign panel to Wind Beam and Backing Strip connections.



Detail C
Scale 1 : 2

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-05-1 Fla DOT Breakaway Sign Post		2020-02-19
Drawn by GES	Scale 1:15	Sheet 2 of 10 Section View

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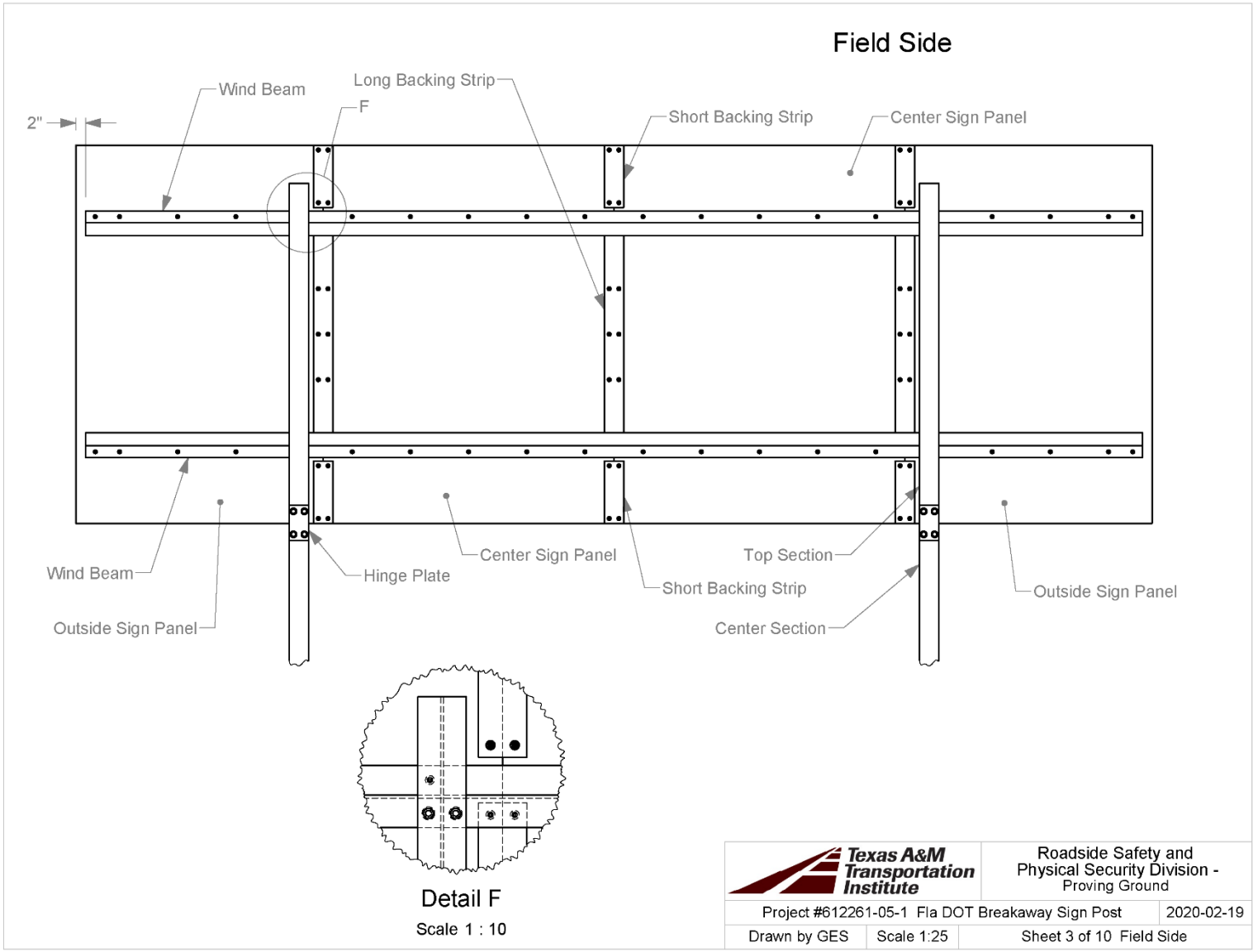

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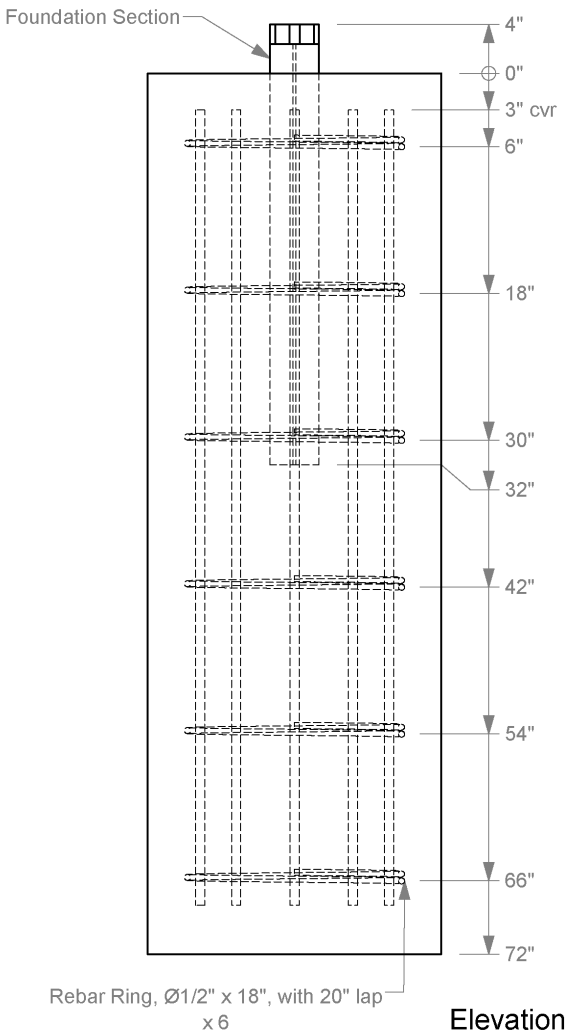
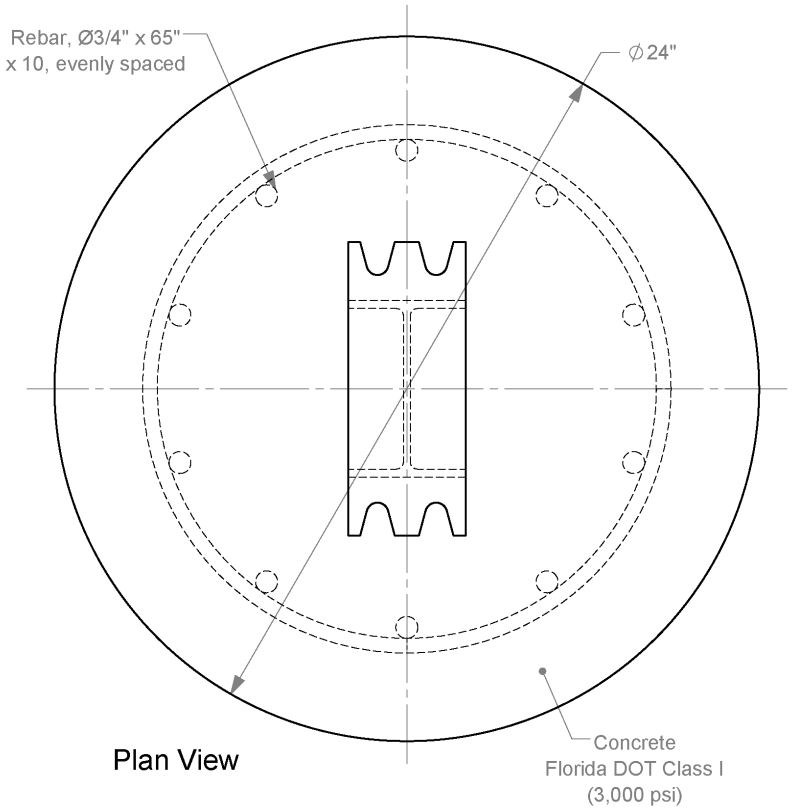


Elevation View

Foundation



Plan View

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-05-1 Fla DOT Breakaway Sign Post		2020-02-19
Drawn by GES	Scale 1:12	Sheet 4 of 10 Foundation

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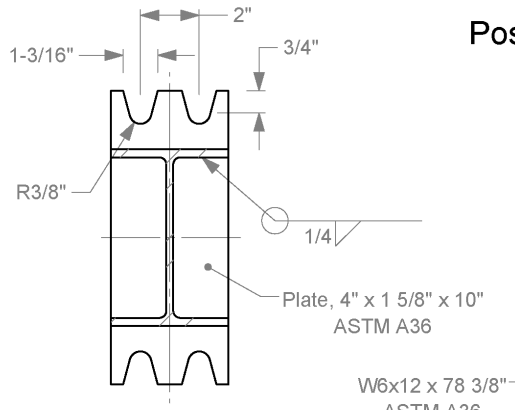
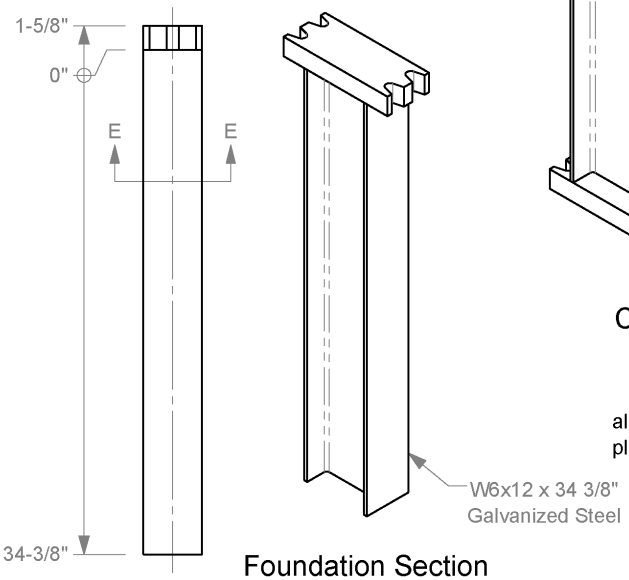
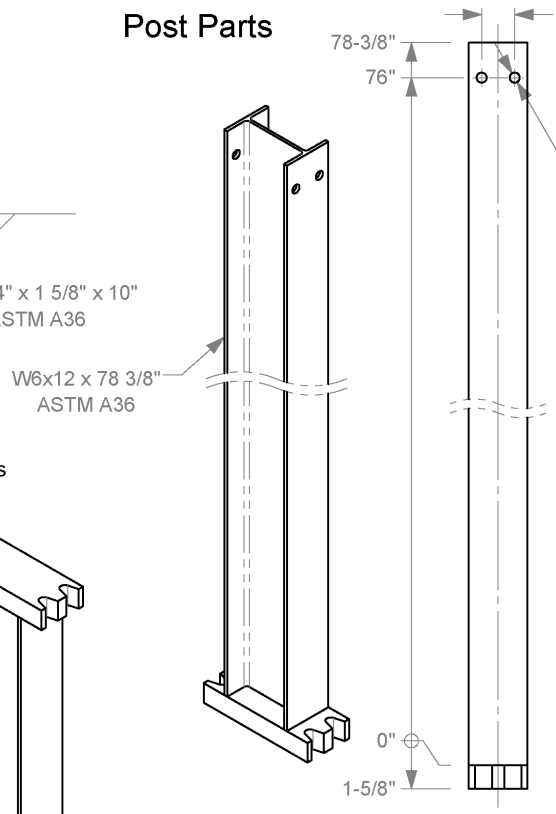
Post Parts



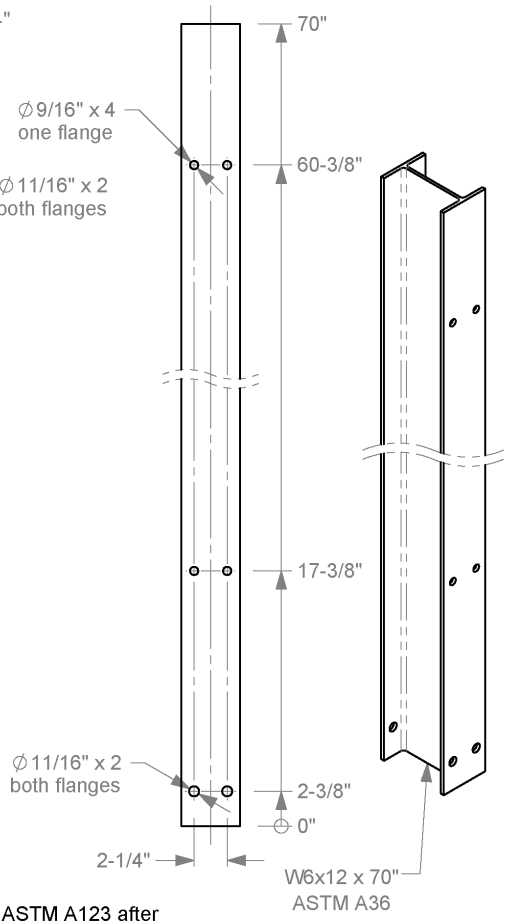
Section E-E
Scale 1 : 5
Typical Center and Bottom Sections



Foundation Section



Center Section



Top Section

5a. Hot-dip galvanize post parts to ASTM A123 after all fabrication. Remove all drips, runs, or beads on base plates within washer contact areas (including saw cuts).

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-05-1 Fla DOT Breakaway Sign Post		2020-02-19
Drawn by GES	Scale 1:10	Sheet 5 of 10 Post Parts

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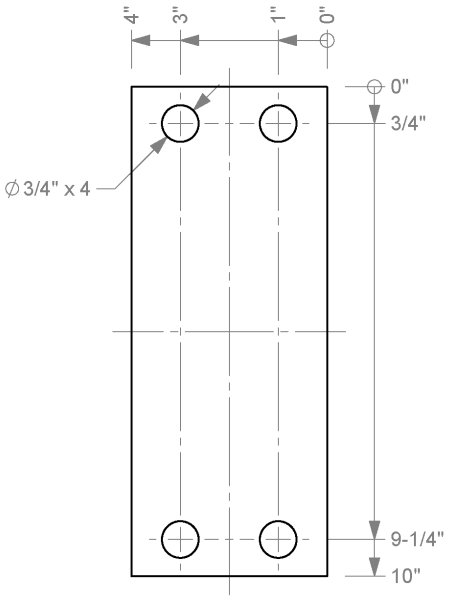
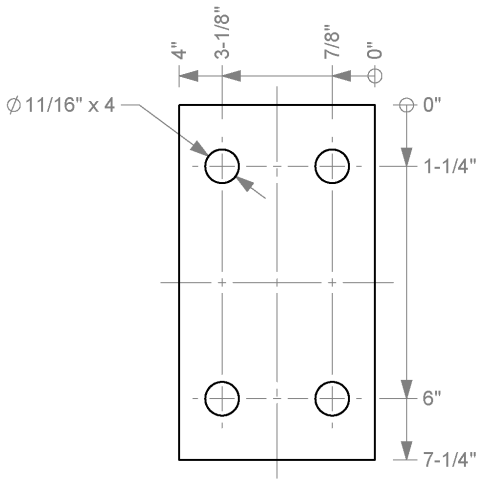
Plates



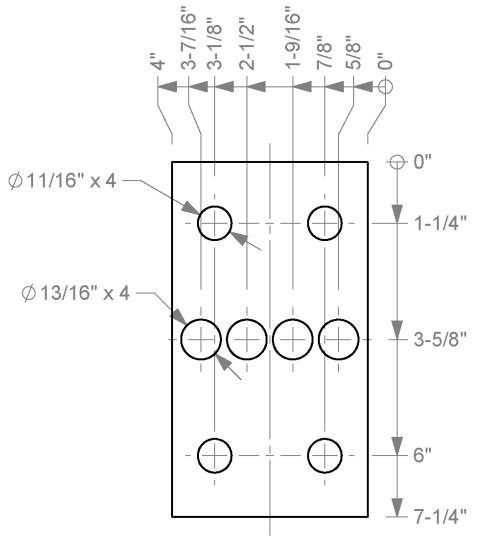
Keeper Plate

4" x 0.0149" (28 gauge) x 10"



Hinge Plate

Plate, 4" x 1/4" x 7 1/4"
ASTM A36



Fuse Plate

Plate, 4" x 3/8" x 7 1/4"
ASTM A36

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-05-1 Fla DOT Breakaway Sign Post		2020-02-19
Drawn by GES	Scale 1:3	Sheet 6 of 10 Plates

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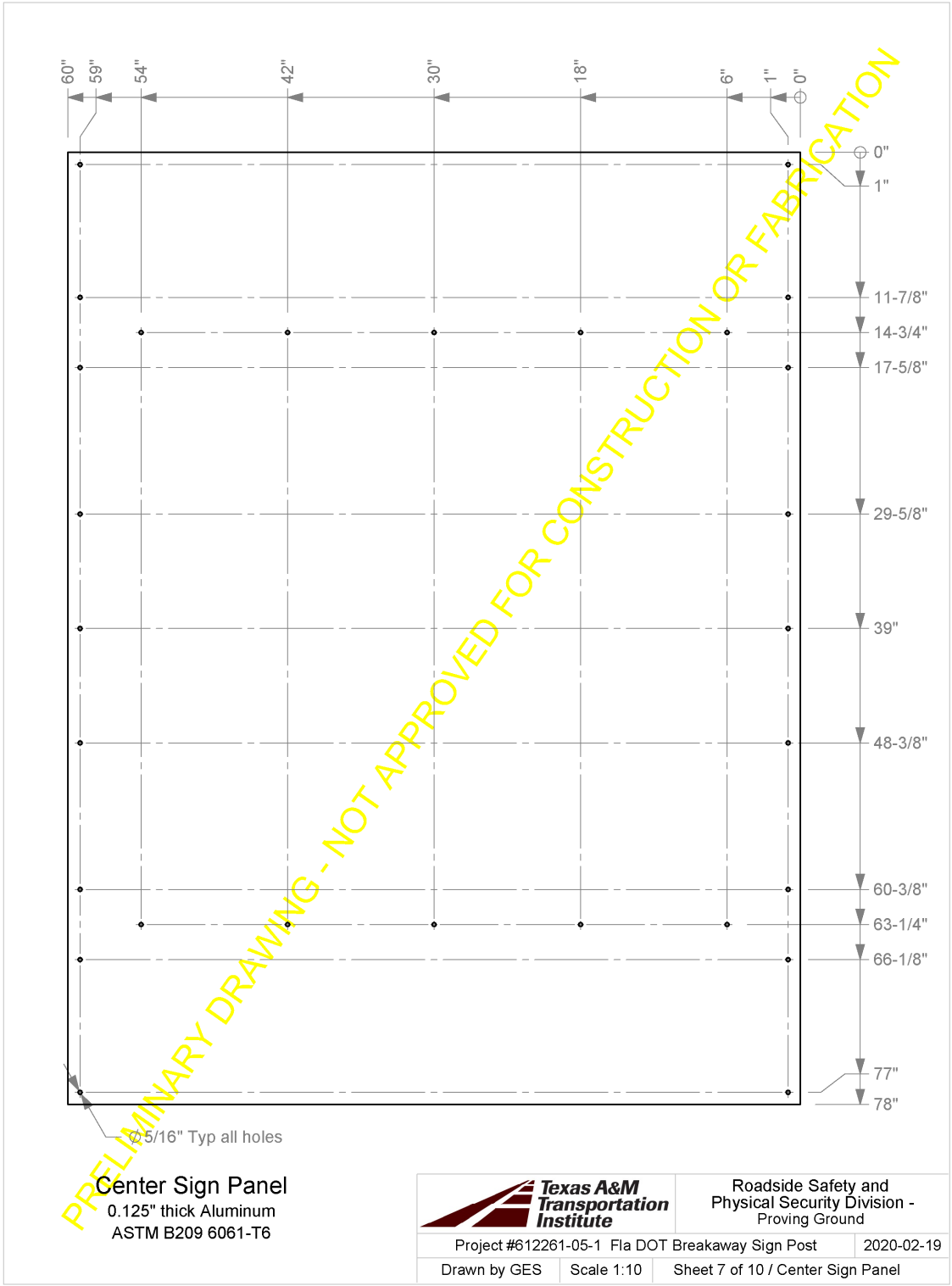
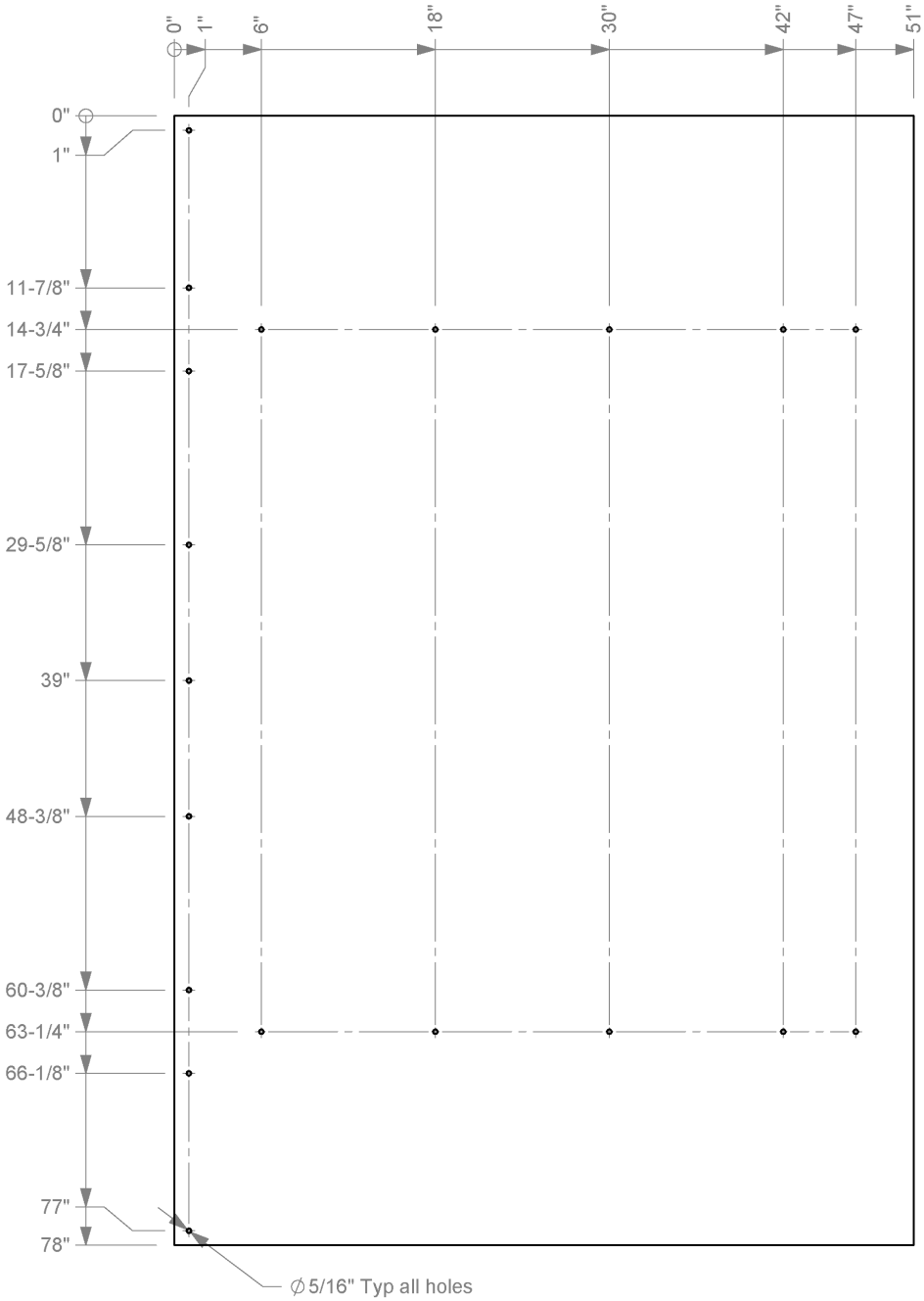




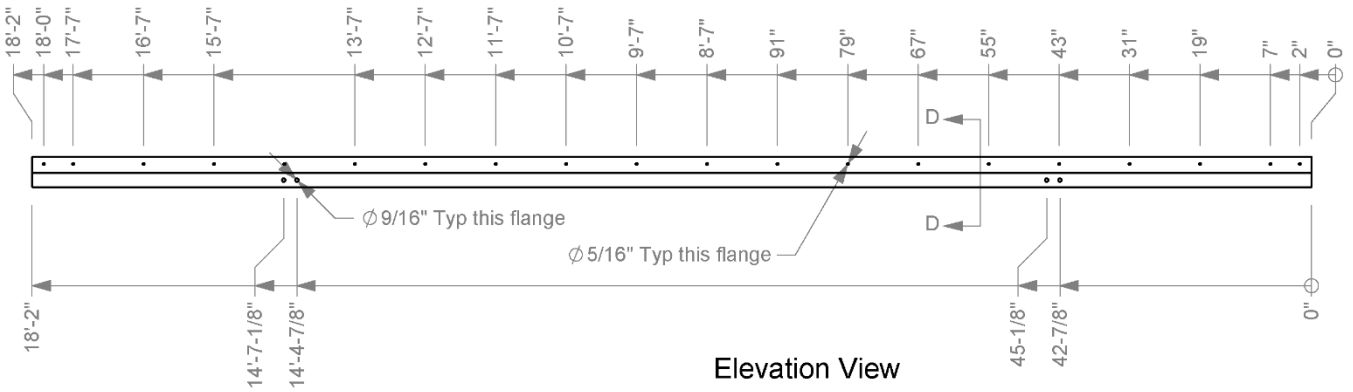
Outside Sign Panel
0.125" thick Aluminum
ASTM B209 6061-T6

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-05-1 Fla DOT Breakaway Sign Post		2020-02-19
Drawn by GES	Scale 1:10	Sheet 8 of 10 / Outside Sign Panel

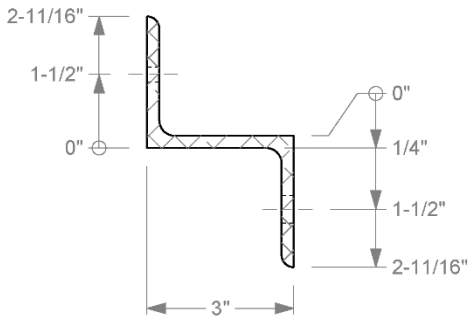
Q:\Accreditation-17025-2017\EIR-000 Project Files\612261 - FDoT Sign - Dobrovolny\-05 (3-62 Tests)\Draffing, 612261 flat ground\612621 Drawing

Wind Beam

ASTM B308, Alloy 6061-T6 Aluminum
2.33 lbs/ft



Elevation View

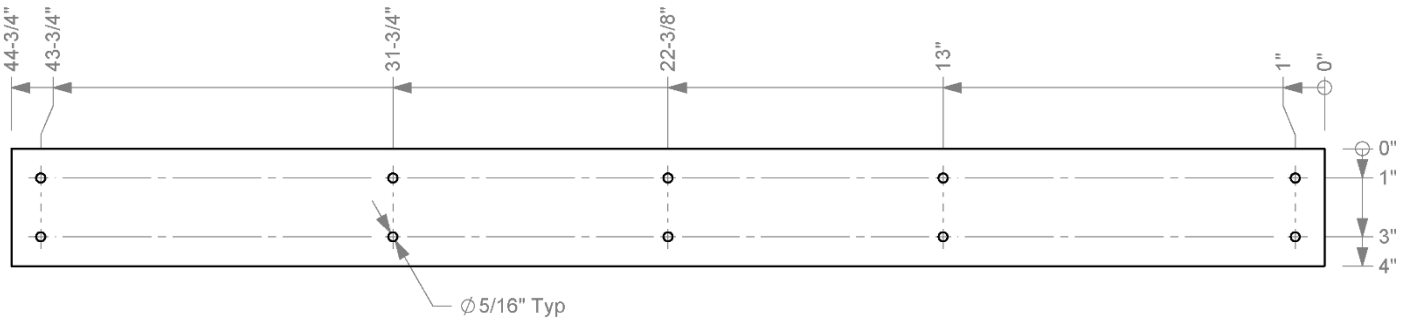


Section D-D
Scale 1 : 3

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-05-1 Fla DOT Breakaway Sign Post		2020-02-19
Drawn by GES	Scale 1:25	Sheet 9 of 10 Wind Beam

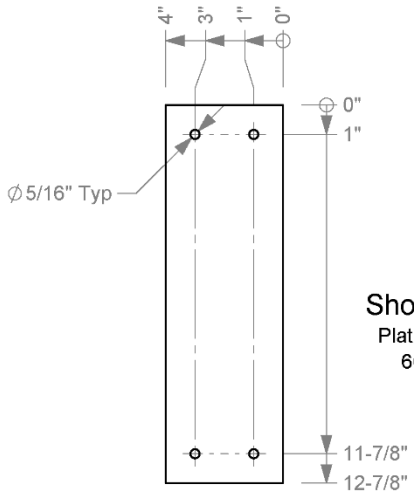
Q:\Accreditation-17025-2017\EIR-000 Project Files\612261 - FDoT Sign - Dobrovolny\-05 (3-62 Tests)\Drafting, 612261 flat ground\612621 Drawing

Backing Strips



Long Backing Strip

Plate, 4" x 1/8" x 44 3/4"
6061-T6 Aluminum



Short Backing Strip

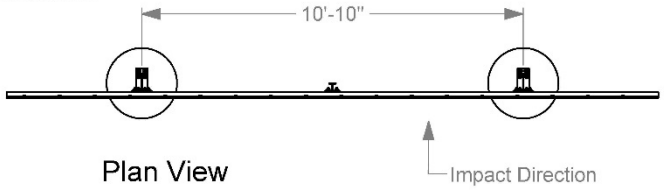
Plate, 4" x 1/8" x 12 7/8"
6061-T6 Aluminum

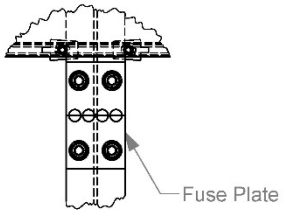
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-05-1 Fla DOT Breakaway Sign Post		2020-02-19
Drawn by GES	Scale 1:5	Sheet 10 of 10 Backing Strips

Q:\Accreditation-17025-2017\EIR-000 Project Files\612261 - FDoT Sign - Dobrovolny\-05 (3-62 Tests)\Drafting, 612261 flat ground\612621 Drawing

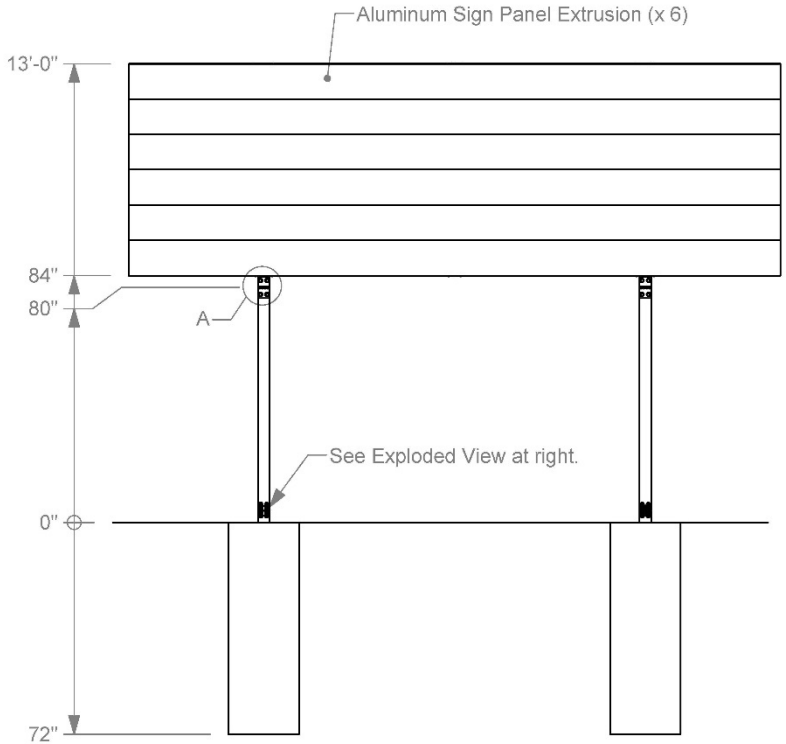
A.2. DETAILS FOR TEST 612261-04-1

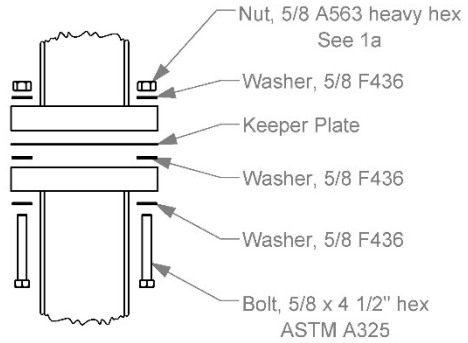
Test Installation





Detail A
Scale 1 : 10
See next sheet for hardware details





Slip Base Connection
Scale 1:10 - Rotated 90° from Elevation View for clarity.
Hardware is typical x 4 @ each Post

1a. Tighten maximum possible with 12" or 15" wrench to seat parts, then loosen one turn and tighten to 22.5 ft/lbs.
1b. Threads not shown on bolts for clarity. All Slip Base Connection hardware is galvanized to ASTM F2329.

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-04 Fla DOT Breakaway Sign Post			2022-01-13
Drawn by GES	Scale 1:50	Sheet 1 of 6 Test Installation	

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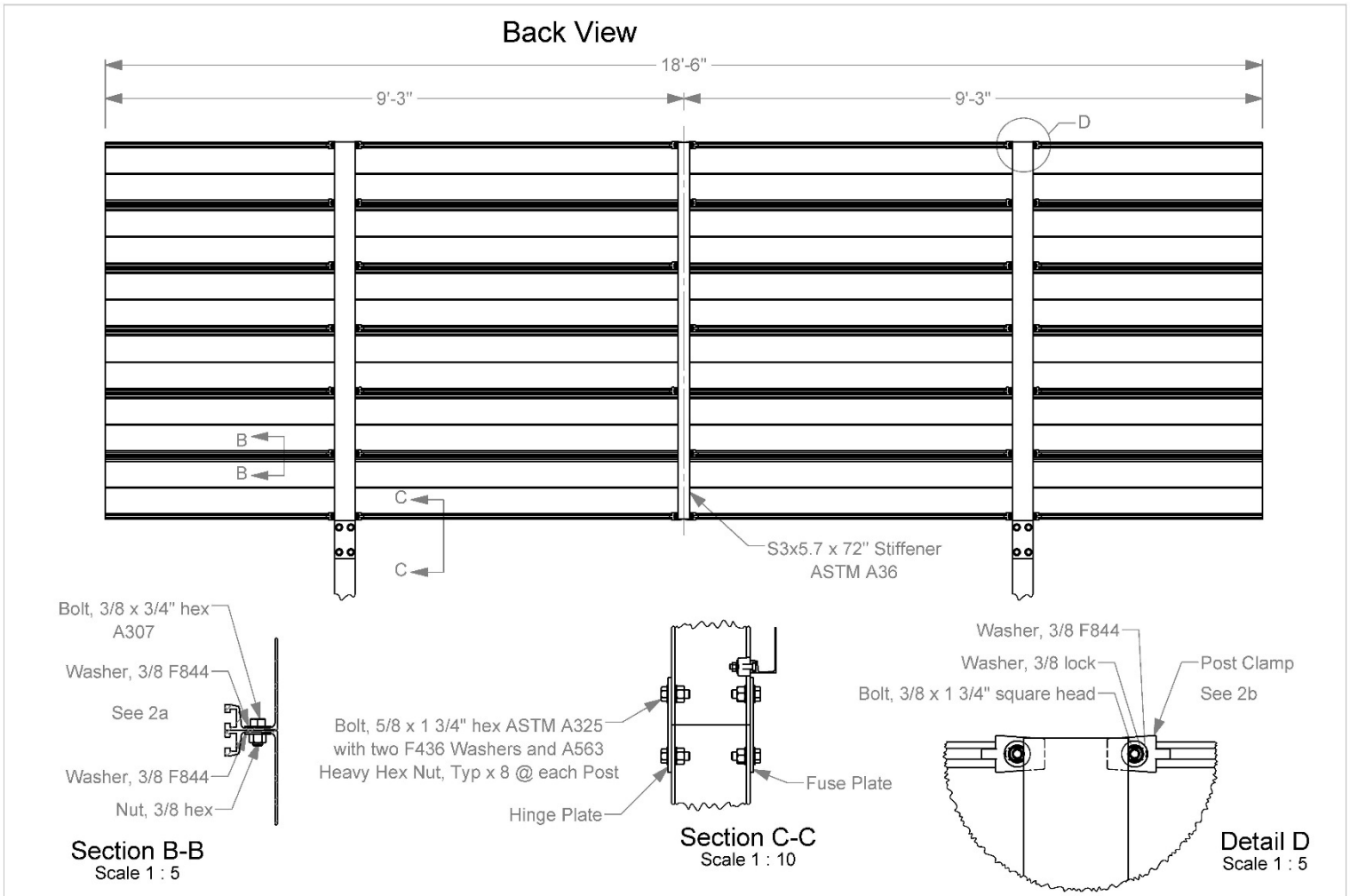
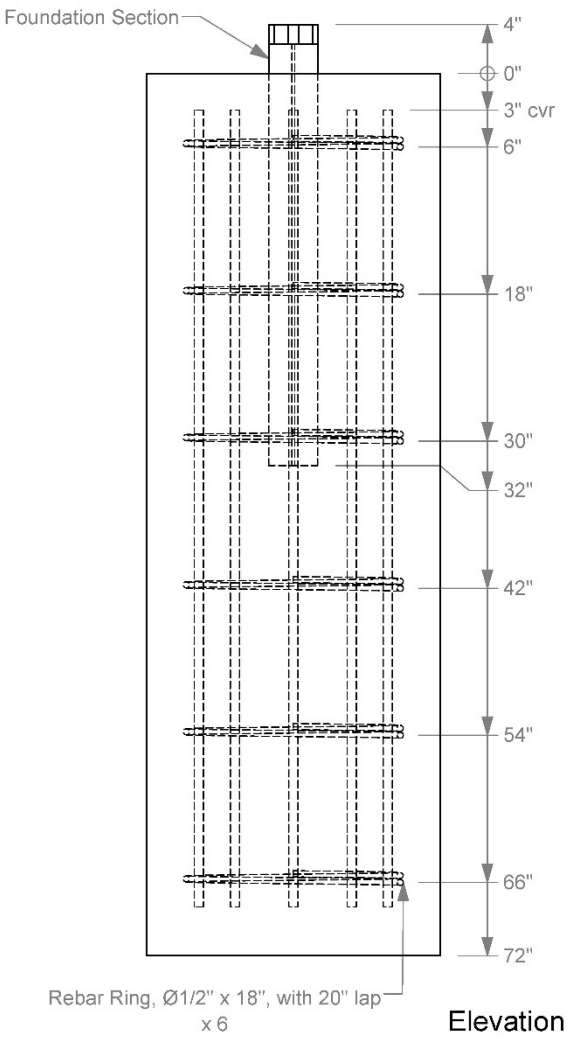


2a. Bolts at Sign Panel joints at 24" spacing. Stagger Bolts in alternating rows (holes in panels are at 12").

2b. Post Clamps at 12" spacing on each side of each Post. Post Clamps at each side of Stiffener at top and bottom and on alternating sides of Stiffener at Sign Panel joints.

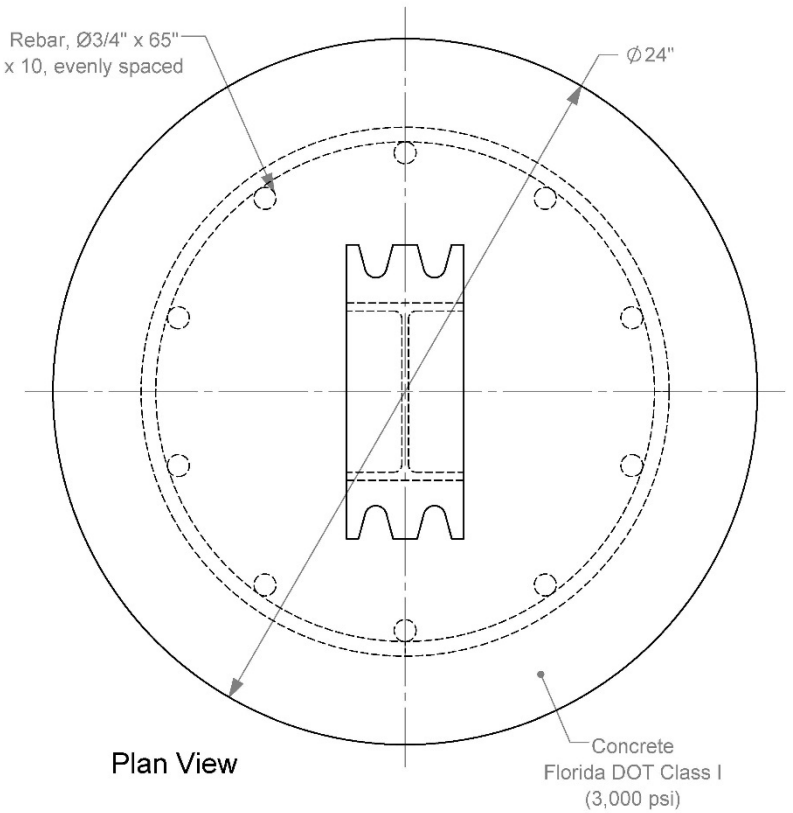
Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground
Project #612261-04 Fla DOT Breakaway Sign Post		2022-01-13
Drawn by GES	Scale 1:25	Sheet 2 of 6 Back View

Q:\Accreditation-17025-2017\EIR-000 Project Files\612261-Large Signs-Dobrovolny\-04 (we have to use these sub accounts)\Drafting, 612261-04\612621 Drawing



Elevation View

Foundation



Plan View

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground
Project #612261-04 Fla DOT Breakaway Sign Post		2022-01-13
Drawn by GES	Scale 1:12	Sheet 3 of 6 Foundation

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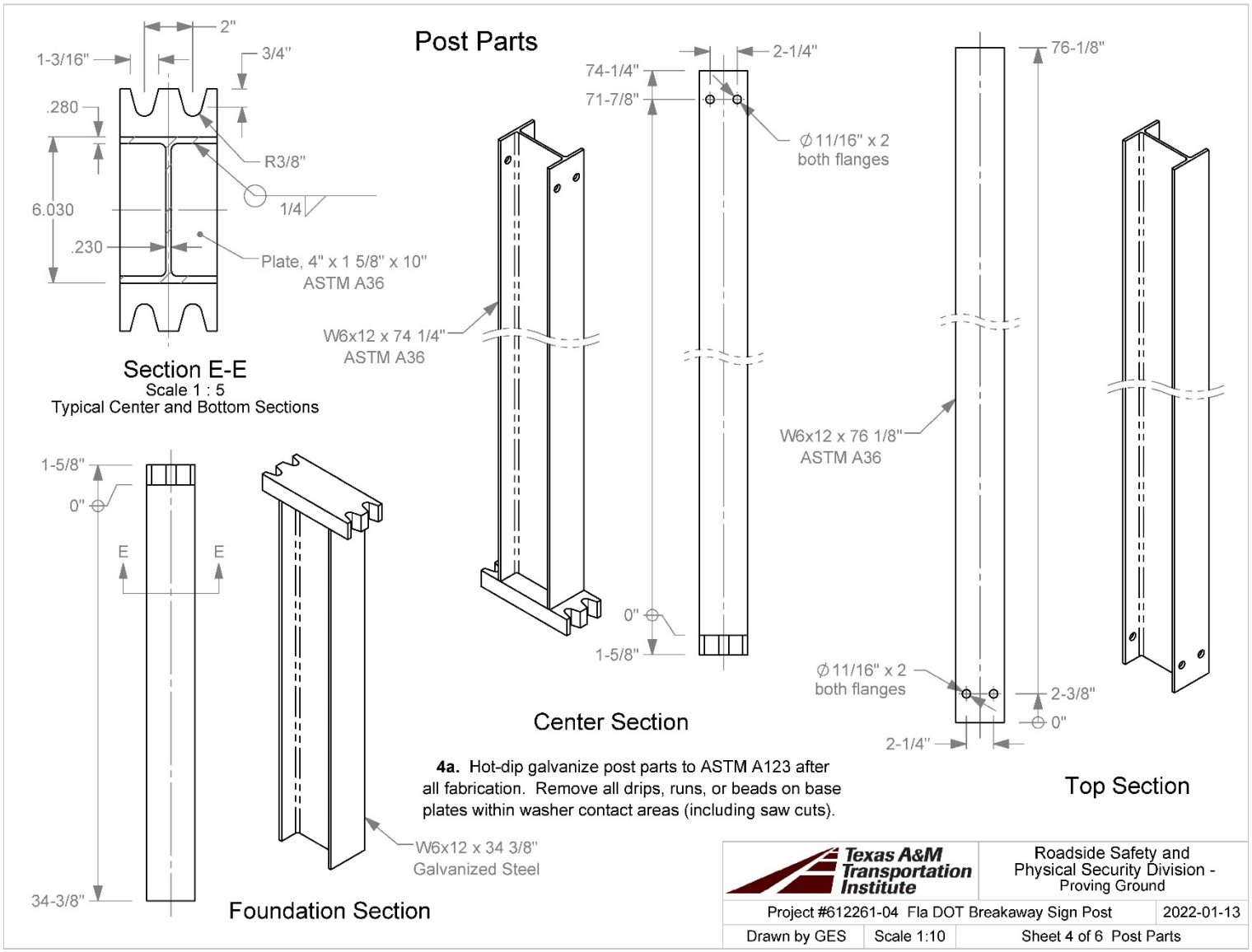
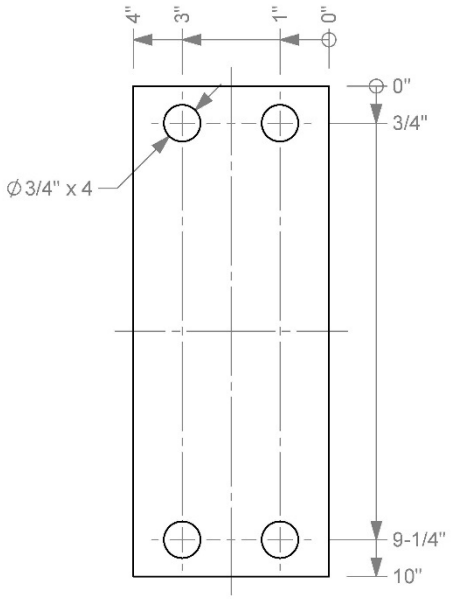
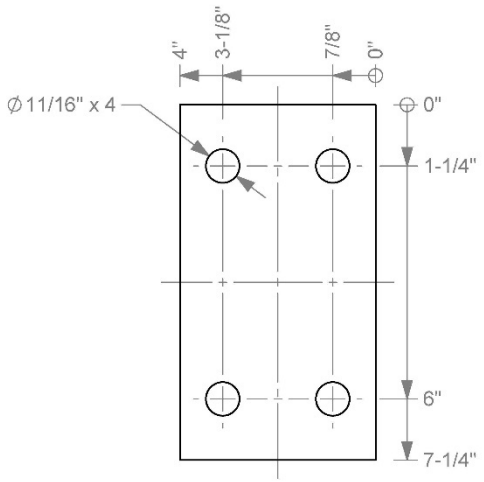


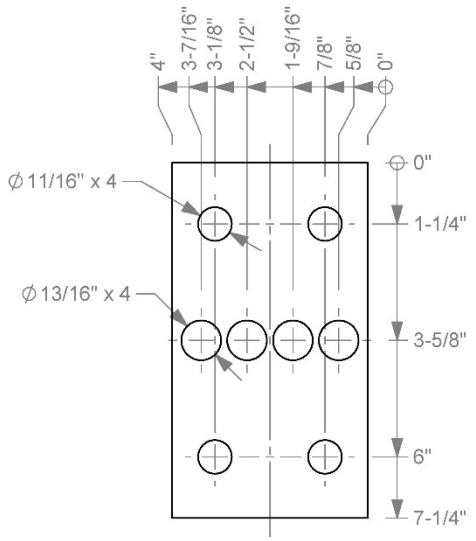
Plates



Keeper Plate
4" x 0.0149" (28 gauge) x 10"



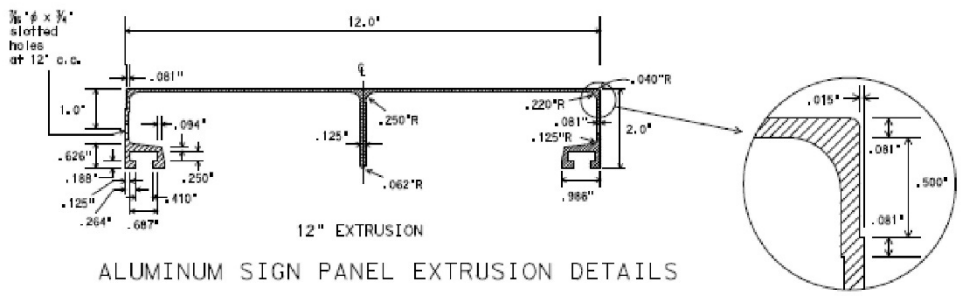
Hinge Plate
Plate, 4" x 1/4" x 7 1/4"
ASTM A36



Fuse Plate
Plate, 4" x 1/4" x 7 1/4"
ASTM A36

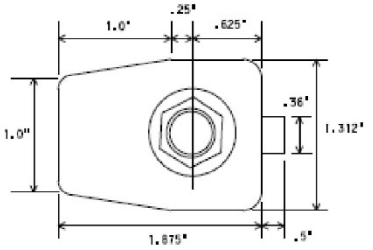
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-04 Fla DOT Breakaway Sign Post		2022-01-13
Drawn by GES	Scale 1:3	Sheet 5 of 6 Plates

Q:\Accreditation-17025-2017\EIR-000 Project Files\612261-Large Signs-Dobrovolny\-04 (we have to use these sub accounts)\Drafting, 612261-04\612621 Drawing

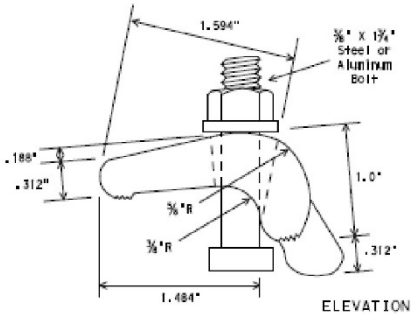


12" EXTRUSION

ALUMINUM SIGN PANEL EXTRUSION DETAILS



PLAN



ELEVATION

POST CLAMP

6a. Details on this sheet are copied from Tx DoT drawing sheet # SMD (2-1) 08, September 2008 revision.

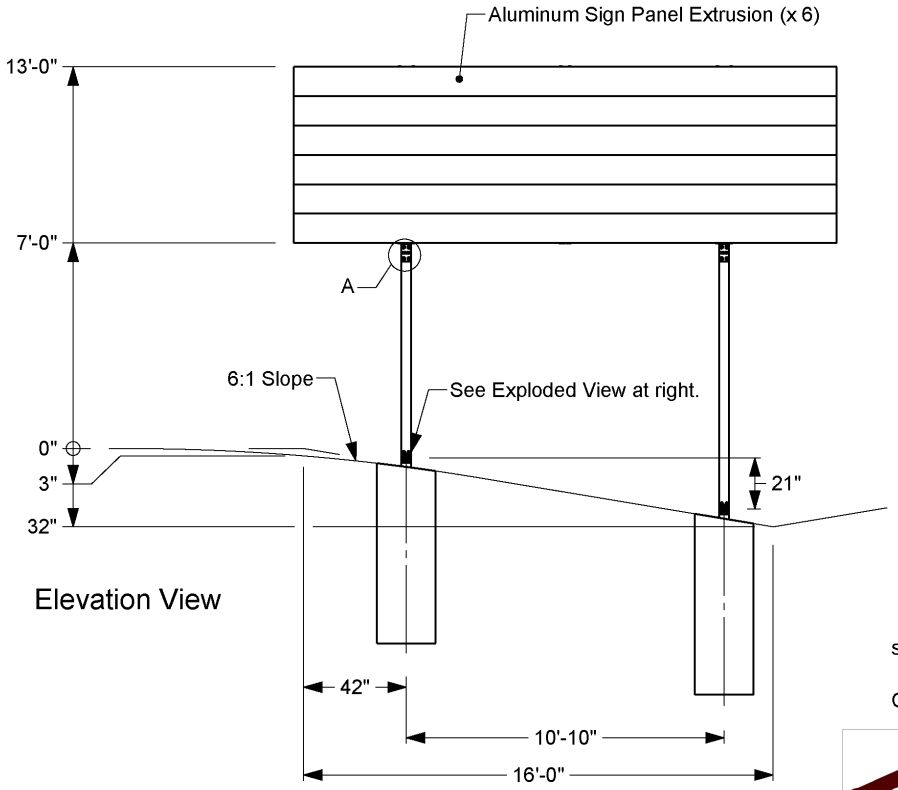
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-04 Fla DOT Breakaway Sign Post		2022-01-13
Drawn by GES	Scale 1:50	Sheet 6 of 6 Post Clamp and Sign Panels

Q:\Accreditation-17025-2017\EIR-000 Project Files\612261-Large Signs-Dobrovolny\-04 (we have to use these sub accounts)\Drafting, 612261-04\612621 Drawing

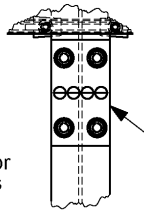
A.3. DETAILS FOR TEST 612261-05-2

Test Installation

Plan View

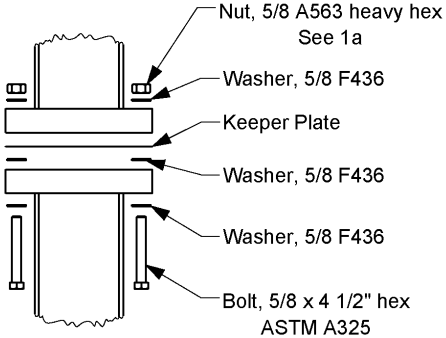


Elevation View



Detail A
Scale 1 : 10
See next sheet for hardware details

Fuse Plate

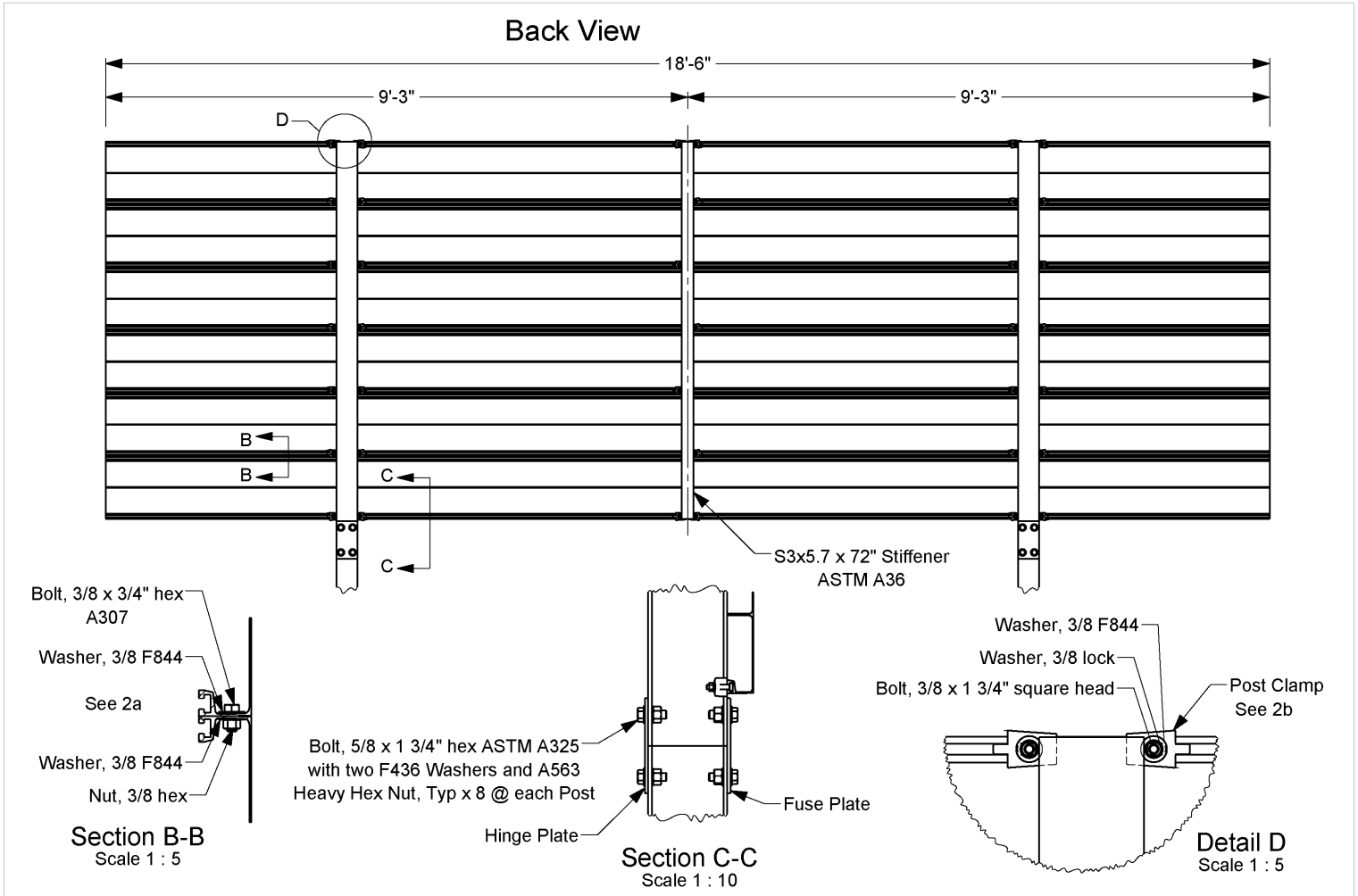


Slip Base Connection
Scale 1:10 - Rotated 90° from Elevation View for clarity.
Hardware is typical x 4 @ each Post

1a. Tighten maximum possible with 12" or 15" wrench to seat parts, then loosen one turn and tighten to 22.5 ft/lbs.
1b. Threads not shown on bolts for clarity. All Slip Base Connection hardware is galvanized to ASTM F2329.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-04 Fla DOT Breakaway Sign Post in Ditch		2022-08-25
Drawn by GES	Scale 1:60	Sheet 1 of 6 Test Installation

Q:\Accreditation-17025-2017\EIR-000 Project Files\612261-Large Signs-Dobrovolny\-04 (we have to use these sub accounts)\05-2 - on slope\Drafting, on slope\612621-04-2 Drawing



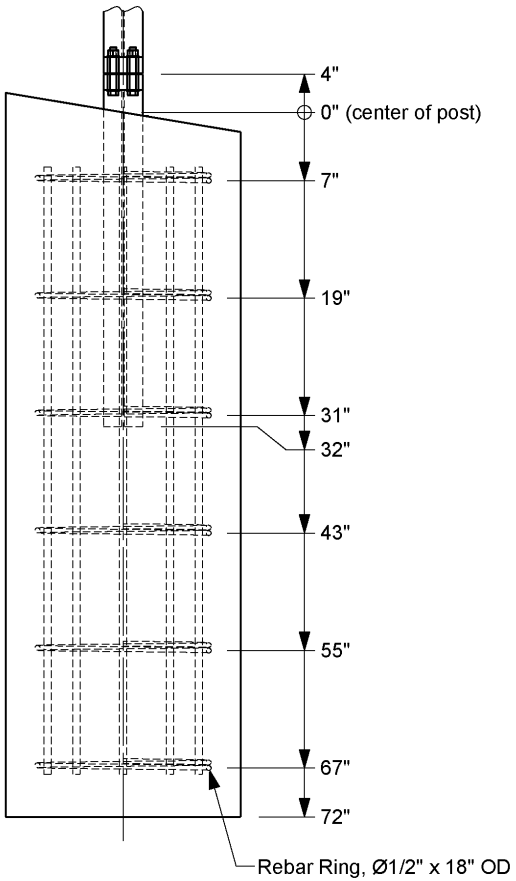
2a. Bolts at Sign Panel joints at 24" spacing. Stagger Bolts in alternating rows (holes in panels are at 12").

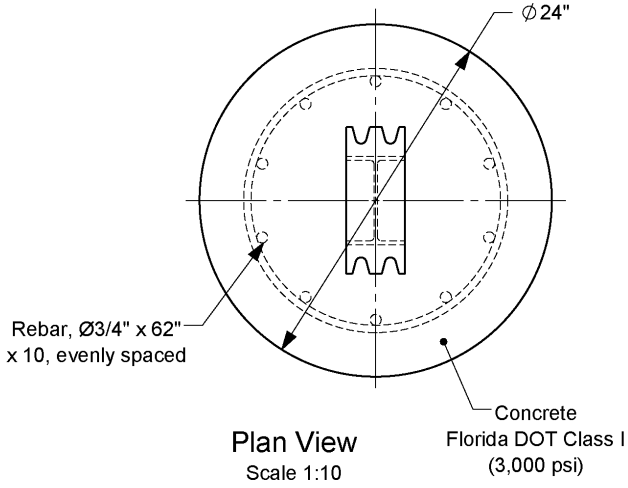
2b. Post Clamps at 12" spacing on each side of each Post. Post Clamps at each side of Stiffener at top and bottom and on alternating sides of Stiffener at Sign Panel joints.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-04 Fla DOT Breakaway Sign Post in Ditch		2022-08-25
Drawn by GES	Scale 1:25	Sheet 2 of 6 Back View

Q:\Accreditation-17025-2017\EIR-000 Project Files\612261-Large Signs-Dobrovolny\-04 (we have to use these sub accounts)\05-2 - on slope\Drafting, on slope\612621-04-2 Drawing

Foundation

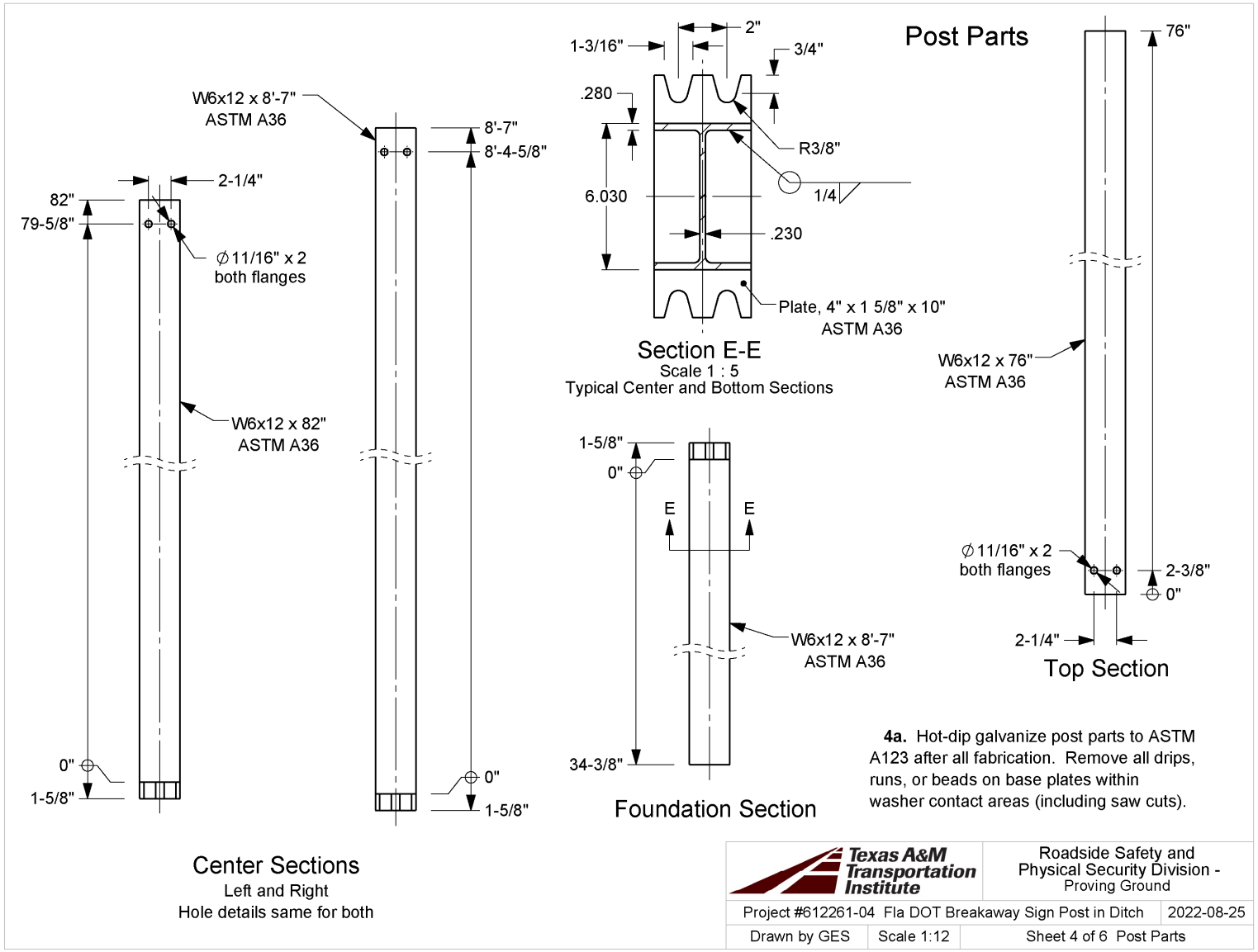




Plan View
Scale 1:10

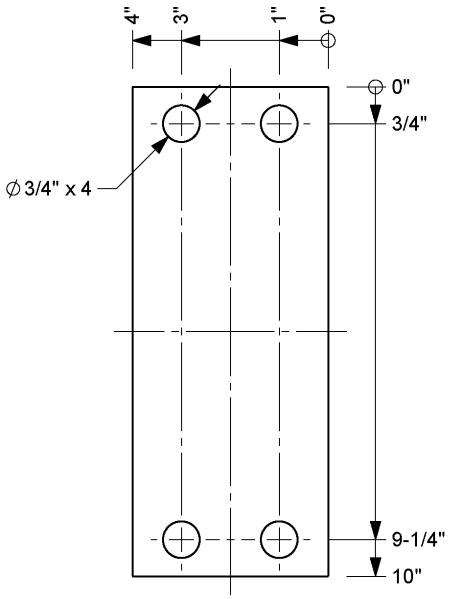
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-04 Fla DOT Breakaway Sign Post in Ditch		2022-08-25
Drawn by GES	Scale 1:15	Sheet 3 of 6 Foundation

Q:\Accreditation-17025-2017\EIR-000 Project Files\612261-Large Signs-Dobrovolny\-04 (we have to use these sub accounts)\05-2 - on slope\Drafting, on slope\612621-04-2 Drawing

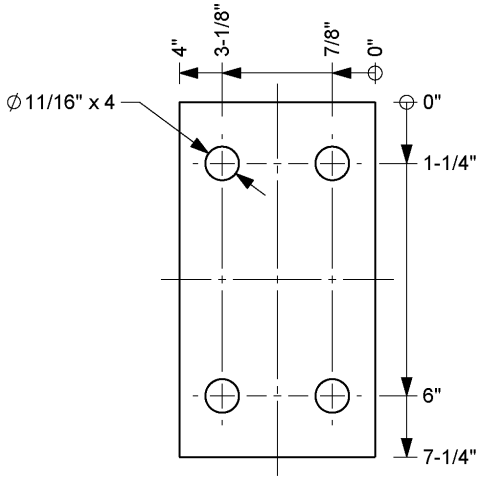


Q:\Accreditation-17025-2017\EIR-000 Project Files\612261-Large Signs-Dobrovolny\-04 (we have to use these sub accounts)\05-2 - on slope\Drafting, on slope\612621-04-2 Drawing

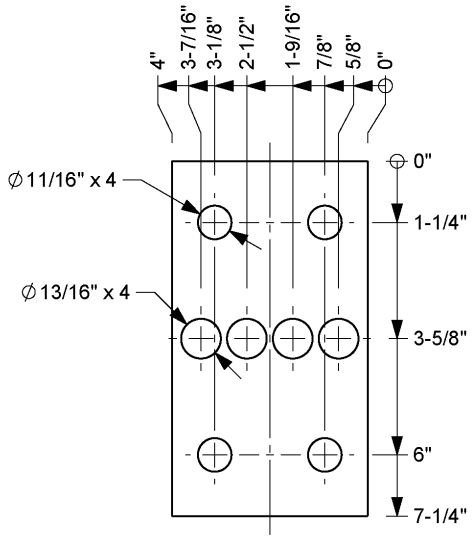
Plates



Keeper Plate
4" x 0.0149" (28 gauge) x 10"



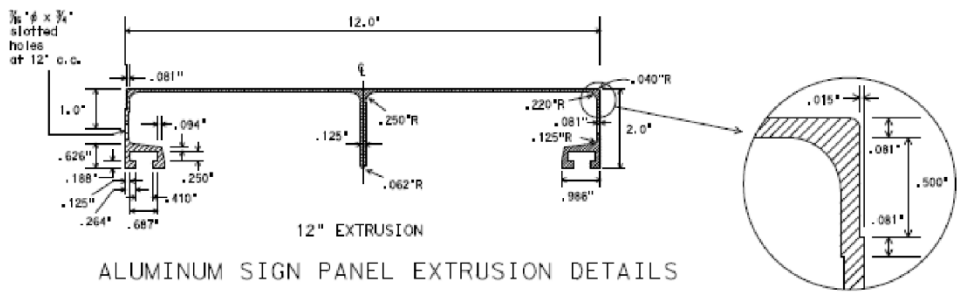
Hinge Plate
Plate, 4" x 1/4" x 7 1/4"
ASTM A36



Fuse Plate
Plate, 4" x 1/4" x 7 1/4"
ASTM A36

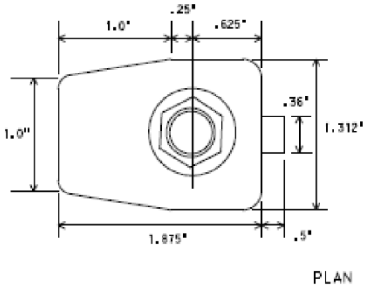
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-04 Fla DOT Breakaway Sign Post in Ditch		2022-08-25
Drawn by GES	Scale 1:3	Sheet 5 of 6 Plates

Q:\Accreditation-17025-2017\EIR-000 Project Files\612261-Large Signs-Dobrovolny\-04 (we have to use these sub accounts)\05-2 - on slope\Drafting, on slope\612621-04-2 Drawing

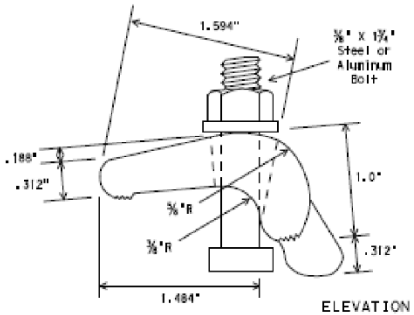


12" EXTRUSION

ALUMINUM SIGN PANEL EXTRUSION DETAILS



PLAN



ELEVATION

POST CLAMP

6a. Details on this sheet are copied from Tx DoT drawing sheet # SMD (2-1) 08, September 2008 revision.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612261-04 Fla DOT Breakaway Sign Post in Ditch		2022-08-25
Drawn by GES	Scale 1:50	Sheet 6 of 6 Post Clamp and Sign Panels

Q:\Accreditation-17025-2017\EIR-000 Project Files\612261-Large Signs-Dobrovolny\-04 (we have to use these sub accounts)\05-2 - on slope\Drafting, on slope\612621-04-2 Drawing

APPENDIX B. SUPPORTING CERTIFICATION DOCUMENTS

B.1. SUPPORTING CERTIFICATION DOCUMENTS FOR 612261-05-1

Griffin Trade Group, LLC
Phone: 281-970-6030
Fax: 281-970-6024
12777 Jones Rd. Suite 315
Houston, TX 77375

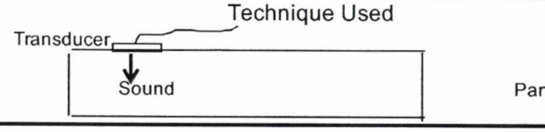
UT CERTIFIED TEST REPORT

Date Received: 9/13/19	Specification: SA578 LVL C 100% Scan	Report #: GTG-UT-751	
Date Complete: 9/13/19		Rev.	
		Release# GTC144342	
	Procedure: Griffin Trade Group UT-01		
	Deviations: N/A	Page 1 of 1	
	UT Instrument: RFD 30	Serial# :12110701	
	Couplant: Water	Calibration Due: 5/22/20	
	Batch #: N/A		

Material	Dimensions	Slab #/ID#	Heat #		Surface	Reject	Acceptable
					RESULTS		
⇨ SA/A51670 N	1-5/8 120 420	02A	S27592		ROUGH	0	1
SA/A51670 N	1-1/2 120 240	03A	S25206		ROUGH	0	1

CALIBRATION BLOCKS				**TRANSDUCERS**				
DBS	Calibration	Serial #	Reflector size	Serial #	Brand	Size	Degree	Frequency
Longitudinal								
77	80% FSH	N/A	1/8" FBH	B14808	Britek	1"	0	2.25 Mhz

Technique Used



Comments:

All tests are performed using calibrated equipment on samples provided by Griffin Trade Group, unless noted in the data section. This data applies only to samples tested by Griffin Trade Group, LLC. This test report may be reproduced in its entirety without permission from Grffin Trade Group, LLC. All requirements of Grffin Trade Group, LLC Quality Operating Procedures, Dated 1/16/2014 have been fulfilled.

Tested By: Jarrod Harris ASNT Level II Date: 9/13/19

Signature: [signature]

CERTIFIED INSPECTION REPORT

Arconic

DAVENPORT WORKS 4879 State Street Bettendorf, IA 52722

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

This test report shall not be reproduced except in full, without the written approval of the Quality Department. No alteration, addition or other change is authorized to be made to this certificate. The recording of false, fictitious , or otherwise fraudulent statements or entries on this certificate by any recipient may be punished as a felony under applicable law.

Per:

Nandu Srinivasan
Manufacturing Director - Davenport & Satellites

Terrence Thom
Quality Assurance Manager

3897372 0

Ship Date	B.L. No.	Invoice No.	Arconic No.	Item	
2019-10-25	12230801	00000	1001138561-1		DP-38561-02-1
P.O. No./Govt Contract No.		Customer	Arconic Item		
M2099341		RYERSON - NORCROSS G041099726R12		GB8	

Ship To: RYERSON PROCUREMENT CORP
4405 SOUTH OLD PEACHTREE ROAD
GOLD BUILDING
NORCROSS 30071 GA

Item Description
0.125 IN TK (+0.0000 -.0070) X 60.0 IN W (+.0625 -
.0625) CAT X 44274 (N) A/T 6061-T6 COIL SHEET
FOR DISTRIBUTORS TOLERANCE GUARANTEED 160002225. AMS4027 REV N ASME-SB-209 REV 15 ASTMB209 REV 14 {(NOT MARKED)}
LIGHTLY OILED COIL SIZES: ID 20 IN COIL WGTS:
MIN 5000 LB MAX 7500 LB MAX GROSS
SKID WGT: 8000 LB QUAN TOL +/-25 %
CQR 0214659 REV 12 CUST REQ 19-09-15 *** W/E 19-09-21 ***

Num	Package Ticket	Lot	Weight	Quantity	UOM	Inspector Clock Numbers
1	634228	726311	4647	1	PC	47441 27586

Notes for CQR: 0214659.12
PRODUCT PRODUCED TO THE REQUIREMENTS OF AMS4027 REV N ALSO MEET THE REQUIREMENTS OF AMS-QQ-A-250_11 ORIGINAL REVISIO N DATED 1997-08-01.

CQR: 0214659.12 - -Specification Limits ----------

Tmpr	Dir		UTS KSI	TYS KSI	EL4D PCT
T6	Long Transv.	Max			
		Min	42.0	35.0	10

Chemical Composition		SI	FE	CU	MN	MG	CR	ZN	TI	Other Each	Other Total	Aluminum
	Max	0.8	0.7	0.40	0.15	1.2	0.35	0.25	0.15	0.05	0.15	
Alloy 6061	Min	0.40		0.15		0.8	0.04					REMAIN

Lot: 726311 - Mechanical, Physical, Metallography, Quantometer Results ----------

Tmpr	Dir	No->	UTS	TYS	EL4D
		Test	KSI	KSI	PCT
T6	Long Transv.	2	47.4	41.1	14

01-09-2020 23:55 Load - 3492395 BL - 3876821 blr466

Custom Fabricators Heat - 59089275

Cust. PO - CF19-25210 Order - 18147108

GERDAU

US-ML-MIDLOTHIAN
300 WARD ROAD
MIDLOTHIAN, TX 76065
USA

CERTIFIED MATERIAL TEST REPORT

Page 1/1

CUSTOMER SHIP TO	CUSTOMER BILL TO	GRADE	SHAPE / SIZE	DOCUMENT ID:
KLOECKNER METALS US 4606 SINGLETON BLVD DALLAS,TX 75212-3502 USA	KLOECKNER METALS CORPORATION 500 COLONIAL CENTER PKWY ROSWELL,GA 30076-8853 USA	A992/A572-50	Wide Flange Beam / 6 X 12# / 150 X 18.0	0000395918

LENGTH	PCS	WEIGHT	HEAT / BATCH
40'00"	89	42,720 LB	59089275/02

SALES ORDER	CUSTOMER MATERIAL N°
8365961/000010	B612W401400

SPECIFICATION / DATE or REVISION
ASTM A6-17
ASTM A709-17
ASTM A992-11 (2015), A572-15
CSA G40.21-13 345WM

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
7452718	1327-0000351754	12/23/2019

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	Sn %	V %	Nb %	Al %
0.12	1.06	0.016	0.010	0.24	0.44	0.10	0.20	0.024	0.009	0.007	0.018	0.004

CHEMICAL COMPOSITION

CEqyA6 %
0.38

MECHANICAL PROPERTIES

YS 0.2% PSI	UTS PSI	YS MPa	UTS MPa	Y/T rati %	G/L Inch
59660	73972	411	510	0.810	8.000
60741	76489	419	527	0.790	8.000

MECHANICAL PROPERTIES

G/L mm	Elong. %
200.0	23.30
200.0	22.70

COMMENTS / NOTES

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. Weld repair has not been performed on this material. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR
Phone: (409) 267-1071 Email: Bhaskar.Yalamanchili@gerdau.com

WADE LUMPKINS
QUALITY ASSURANCE MGR.
Phone: 972-779-3118 Email: Wade.Lumpkins@gerdau.com

01-09-2020 23:55 Load - 3492395 BL - 3876821 blr466

Custom Fabricators Heat - 59089275

Cust. PO - CF19-25210 Order - 18147108

GERDAU

US-ML-MIDLOTHIAN
300 WARD ROAD
MIDLOTHIAN, TX 76065
USA

CERTIFIED MATERIAL TEST REPORT

Page 1/1

CUSTOMER SHIP TO	CUSTOMER BILL TO	GRADE	SHAPE / SIZE	DOCUMENT ID:
KLOECKNER METALS US 4606 SINGLETON BLVD DALLAS,TX 75212-3502 USA	KLOECKNER METALS CORPORATION 500 COLONIAL CENTER PKWY ROSWELL,GA 30076-8853 USA	A992/A572-50	Wide Flange Beam / 6 X 12# / 150 X 18.0	0000395918

LENGTH	PCS	WEIGHT	HEAT / BATCH
40'00"	89	42,720 LB	59089275/02

SALES ORDER	CUSTOMER MATERIAL N°
8365961/000010	B612W401400

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
7452718	1327-0000351754	12/23/2019

SPECIFICATION / DATE or REVISION
ASTM A6-17
ASTM A709-17
ASTM A992-11 (2015), A572-15
CSA G40.21-13 345WM

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	Sn %	V %	Nb %	Al %
0.12	1.06	0.016	0.010	0.24	0.44	0.10	0.20	0.024	0.009	0.007	0.018	0.004

CHEMICAL COMPOSITION

CEqyA6 %
0.38

MECHANICAL PROPERTIES

YS 0.2% PSI	UTS PSI	YS MPa	UTS MPa	Y/T rati %	G/L Inch
59660	73972	411	510	0.810	8.000
60741	76489	419	527	0.790	8.000

MECHANICAL PROPERTIES

G/L mm	Elong. %
200.0	23.30
200.0	22.70

COMMENTS / NOTES

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. Weld repair has not been performed on this material. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR
Phone: (409) 267-1071 Email: Bhaskar.Yalamanchili@gerdau.com

WADE LUMPKINS
QUALITY ASSURANCE MGR.
Phone: 972-779-3118 Email: Wade.Lumpkins@gerdau.com

Eastern Metal Supply, Inc.
9400 Telge Rd; Houston, TX 77095
1-800-996-6061 (281) 656-2297-fax

Certification of Compliance

To:		DATE	
Customer PO# CF19-25210	Customer Name CUSTOM FABRICATORS & REPAIR	EMS	

Product Identification

Product Code	Description of Material Furnished	Quantity	
	6061T6 MF STRUCTURAL ZEE BAR		
12-61-201	3X2.688X1/4X25'	3 PCS	

Mechanical Properties (representation)

Specification	Ultimate Strength KSI	Yield Strength KSI	Elongation Percent

Chemical Composition Limits of Wrought Aluminum Alloys

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zin/	TI
1100	.95 SI + FE		0.50+0.20	0.05			0.10	
3003	0.60	0.70	0.50+0.20	1.0-1.5			0.10	
5052	0.25	0.40	0.10	0.10	2.2-2.8	0.15-0.35	0.10	
6005	0.6-0.9	0.35	0.10	0.10	0.4-0.6	0.10	0.10	0.10
6061	0.4-0.8	0.70	0.15-0.4	0.15	0.8-1.2	0.04-0.35	0.25	0.15
6063	0.20-0.60	0.35 max.	0.10	0.10 max.	0.45-0.90	0.10 max.	0.10 max.	0.10 max.
6105	0.75-0.85	0-0.25	0-.05	0-0.50	.55-.70	0-0.05	0-0.05	0.01-0.05

Composition in percent maximum, unless shown in range – Mechanical properties are LBs/SQ IN

This form indicates that the above material was processed in accordance with the specifications listed, as reported by the manufacturer.

Signature: Sally Gentry **Date:** 02/04/20

Eastern Metal Supply, Inc.
9400 Telge Rd; Houston, TX 77095
1-800-996-6061 (281) 656-2297-fax

Certification of Compliance

To:		DATE	02/04/20
Customer PO# CF19-25210	Customer Name CUSTOM FABRICATORS & REPAIR	EMS	

Product Identification

Product Code	Description of Material Furnished	Quantity	
	6061T6 MF STRUCTURAL ZEE BAR		
12-61-201	3X2.688X1/4X25'	1 PCS	

Mechanical Properties (representation)

Specification	Ultimate Strength KSI	Yield Strength KSI	Elongation Percent

Chemical Composition Limits of Wrought Aluminum Alloys

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zin/	TI
1100	.95 SI + FE		0.50+0.20	0.05			0.10	
3003	0.60	0.70	0.50+0.20	1.0-1.5			0.10	
5052	0.25	0.40	0.10	0.10	2.2-2.8	0.15-0.35	0.10	
6005	0.6-0.9	0.35	0.10	0.10	0.4-0.6	0.10	0.10	0.10
6061	0.4-0.8	0.70	0.15-0.4	0.15	0.8-1.2	0.04-0.35	0.25	0.15
6063	0.20-0.60	0.35 max.	0.10	0.10 max.	0.45-0.90	0.10 max.	0.10 max.	0.10 max.
6105	0.75-0.85	0-0.25	0-.05	0-0.50	.55-.70	0-0.05	0-0.05	0.01-0.05

Composition in percent maximum, unless shown in range – Mechanical properties are LBs/SQ IN

This form indicates that the above material was processed in accordance with the specifications listed, as reported by the manufacturer.

Signature: Sally Gentry **Date:** 02/19/20

JSW Steel (USA) INC.
5200,East McKinney Road,
BAYTOWN, TX 77523

METALLURGICAL TEST REPORT

MET - 04 Rev. No.: 3 Rev. Date:02/27/2018

6/27/2019

Bulletin	Order Item	Heat	PO No.	Shipping Mode		Order Dimensions	Slab Origin	TC No.
T057248	JSW12607-01	S27592		TRUCK		1.625x120x420	MEXICO	T057248-7592-1

Plates Certified for the Following grades	Specifications	Marking Instructions
ASTM-A516-70, ASME-SA516-70 2017 EDITION PN LCVN	PLATE NORMALIZED AT 1650 °F FOR 50 MINS	Stencil in 2 location(s); X Loc. 18 Y Loc. 30; CUST; MADEINUSA PN PO; DIM GRADE; FREIGHT ORDERITEM PLATEID SHIPWEEK SLABID TRANSMODE Stamp in 2 location(s); X Loc. 18 Y Loc. 12; Slab ID; Slab ID; Slab ID
Hot Rolled Carbon Steel Plates Plates Manufactured In the USA		

Sold To:

Ship To:

Test	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	N	V	B	Ti	Nb	Ca	CE
LADLE	0.20	1.11	0.011	0.001	0.19	0.006	0.017	0.013	0.000	0.002	0.034	0.0028	0.004	0.0002	0.002	0.002	0.0021	0.39

Carbon Equivalent CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15

PCM = C + Si/30 + Mn/20 + Cu/20 + Ni/60+ Cr/20 + Mo/15 + V/10 + 5B

Plate	Slab Identity	Gauge Tested	Test Cond	Test Dir.	Yield Point	Tensile Stgth.	Elong in 2"	YS/UTS Ratio	Yield Strenght Determind At	Impact Test (LCVN) Full Energy in Ft/Lb °F								
										Temp	Test1	Test2	Test3	Avg	Test1	Test2	Test3	Avg
1135470A	02A	1.6250	PN	T	51	74	29.0%	0.69	0.2%	-50	49	40	42	44				

Plates Certified For The Above Tests

Material	Thick(IN)	Width (IN)	Len(IN)	Wgt(LB)
1135470A	1.6250	120.000	420.00	23226.840

Material	Thick(IN)	Width(IN)	Len (IN)	Wgt(LB)

Material	Thick(IN)	Width(IN)	Len(IN)	Wgt(LB)

9 / 20 / 2019

SFI-GRAY STEEL

Customer Name:

Customer PO #:

Thickness: 1 5/8" SFI PO #: 702844

Heat & Slab: S27592-02A

Plate #: 58561

DIN: EN 10204 2004 3.1 This is to certify that the product decribed herein was manufactured, sampled, and tested in accordance with the specifications and requirements in such specifications. Fine Grain, Si-Al Fully Killed Steel. We certify that delivery of this product with the requirement of the specification and purchase order received from customer. DRC Conflict Free. Does not contain Hg . No intentional addition of Pb, Se or S

Cheyenne Lee

cheyenne lee 22813837845 cheyenne.lee@jswsteel.us

2023-05-30

99

TR No. 612261-04-1, -05-1, & -05-2

Texas A&M Transportation Institute Proving Ground 3100 SH 47, Bldg 7091 Bryan, TX 77807 Texas A&M University College Station, TX 77843 Phone 979-845-6375	QF 7.3-01 Concrete Sampling	Doc. No. QF 7.3-01	Issue Date: 2018-06-18
Quality Form	Prepared by: Wanda L. Menges Approved by: Darrell L. Kuhn	Revision: 6	Page: 1 of 1

Project No: 612261-05-1 **Casting Date:** 2/21/2002 **Mix Design (psi):** 4000

Name of Technician Taking Sample: TERRACON

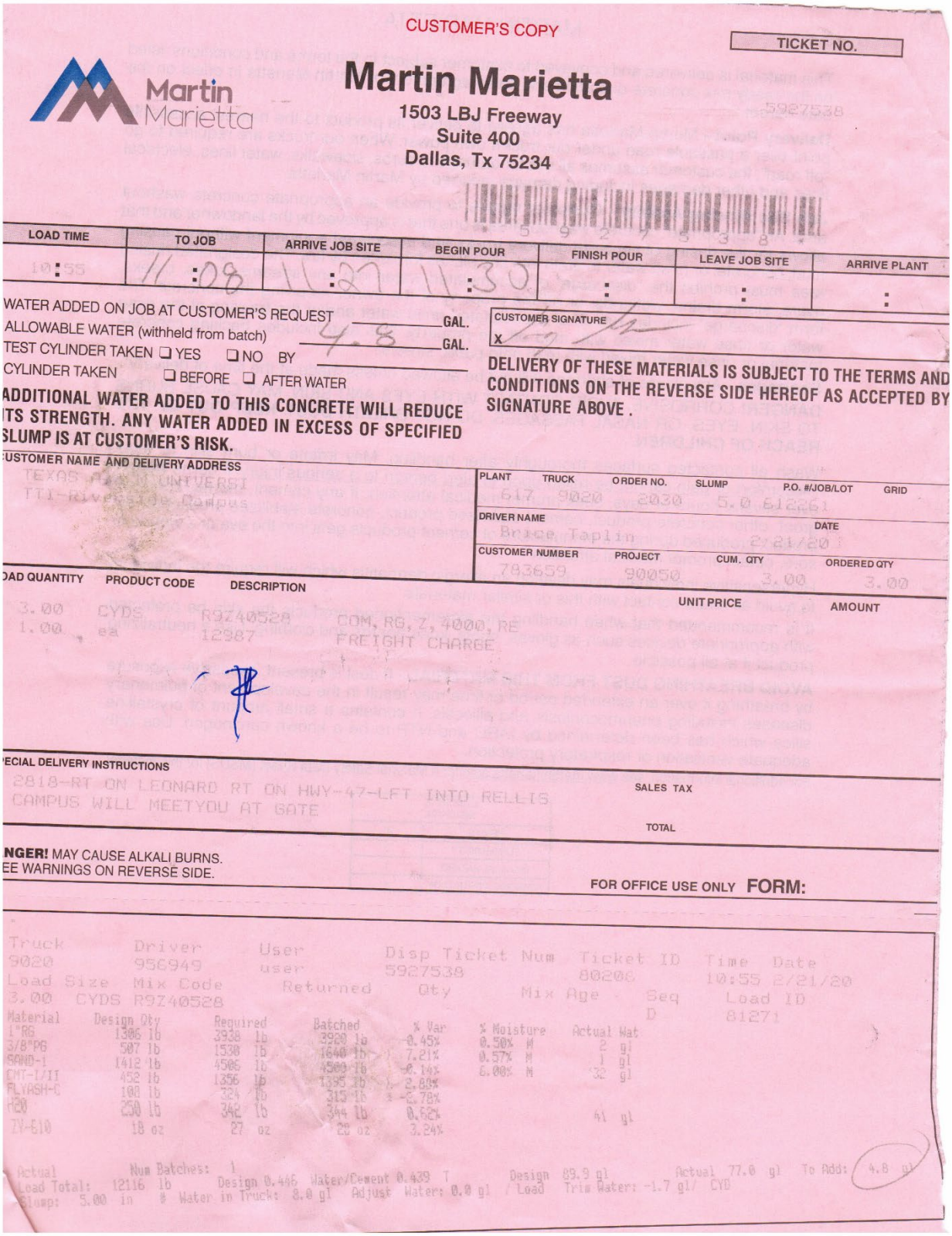
Name of Technician Breaking Sample: TERRACON

Signature of Technician Taking Sample: TERRACON

Signature of Technician Breaking Sample: TERRACON

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	9020	5927538	100% of footers

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average
T1 - SEE ATTACHED SHEETS FROM TERRACON					



CUSTOMER'S COPY

TICKET NO. 5927538

Martin Marietta

Martin Marietta

1503 LBJ Freeway
Suite 400
Dallas, Tx 75234

LOAD TIME	TO JOB	ARRIVE JOB SITE	BEGIN POUR	FINISH POUR	LEAVE JOB SITE	ARRIVE PLANT
10:55	11:08	11:27	11:30	:	:	:

WATER ADDED ON JOB AT CUSTOMER'S REQUEST _____ GAL.
ALLOWABLE WATER (withheld from batch) 4.8 GAL.
TEST CYLINDER TAKEN ❑ YES ❑ NO BY _____
CYLINDER TAKEN ❑ BEFORE ❑ AFTER WATER

ADDITIONAL WATER ADDED TO THIS CONCRETE WILL REDUCE ITS STRENGTH. ANY WATER ADDED IN EXCESS OF SPECIFIED SLUMP IS AT CUSTOMER'S RISK.

CUSTOMER SIGNATURE
X

DELIVERY OF THESE MATERIALS IS SUBJECT TO THE TERMS AND CONDITIONS ON THE REVERSE SIDE HEREOF AS ACCEPTED BY SIGNATURE ABOVE .

CUSTOMER NAME AND DELIVERY ADDRESS
TEXAS A&M UNIVERSI
TTI-Riverside Campus

PLANT	TRUCK	ORDER NO.	SLUMP	P.O. #/JOB/LOT	GRID
617	9020	2030	5.0	612261	

DRIVER NAME: Brice Taplin
DATE: 2/21/20

CUSTOMER NUMBER	PROJECT	CUM. QTY	ORDERED QTY
783659	90050	3.00	3.00

LOAD QUANTITY	PRODUCT CODE	DESCRIPTION	UNIT PRICE	AMOUNT
3.00 CYDS	R9Z40528	COM,RG,Z,4000,RE		
1.00 ea	12987	FREIGHT CHARGE		

SPECIAL DELIVERY INSTRUCTIONS
2818-RT ON LEONARD RT ON HWY-47-LFT INTO RELLIS CAMPUS WILL MEETYOU AT GATE

SALES TAX
TOTAL

DANGER! MAY CAUSE ALKALI BURNS.
SEE WARNINGS ON REVERSE SIDE.

FOR OFFICE USE ONLY **FORM:**

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
9020	956949	user	5927538	80206	10:55	2/21/20

Load Size 3.00 CYDS | Mix Code R9Z40528 | Returned | Qty | Mix Age | Seq D | Load ID 81271

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
1"RG	1306 lb	3938 lb	3920 lb	-0.45%	0.50% M	2 gl
3/8"PG	507 lb	1530 lb	1640 lb	7.21%	0.57% M	1 gl
SAND-1	1412 lb	4506 lb	4500 lb	-0.14%	6.00% M	32 gl
CMT-I/II	452 lb	1356 lb	1395 lb	2.80%		
FLYASH-C	108 lb	324 lb	315 lb	-2.78%		
H2O	250 lb	342 lb	344 lb	0.62%		41 gl
ZY-510	18 oz	27 oz	28 oz	3.24%		

Actual Load Total: 12116 lb | Num Batches: 1 | Design 0.446 Water/Cement 0.439 | Design 89.9 gl | Actual 77.0 gl | To Add: 4.8 gl
Slump: 5.00 in | # Water in Truck: 8.0 gl | Adjust Water: 0.0 gl / Load | Trim Water: -1.7 gl/ CYD

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0095
Service Date: 02/21/20
Report Date: 03/03/20 Revision 1 - 11-day results
Task: PO #612261

Terracon
6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767 Reg No: F-3272

Client

Texas Transportation Institute
Attn: Gary Gerke
TTI Business Office
3135 TAMU
College Station, TX 77843-3135

Project

Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 4,000 psi @ 28 days

Mix ID: R9Z40528
Supplier: Martin Marietta
Batch Time: 1055 **Plant:** 617
Truck No.: 9020 **Ticket No.:** 5927538

Sample Information

Sample Date: 02/21/20 **Sample Time:** 1150
Sampled By: Matcek, James
Weather Conditions: Partly cloudy
Accumulative Yards: 3/3 **Batch Size (cy):** 3
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: Center of pad
Placement Location: Concrete pad for road sign

Field Test Data

Test	Result	Specification
Slump (in):	5	Not Specified
Air Content (%):	2.1	Not Specified
Concrete Temp. (F):	68	40 - 95
Ambient Temp. (F):	55	40 - 95
Plastic Unit Wt. (pcf):	148.3	Not Specified
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Specimen ID	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Maximum Load (lbs)	Compressive Strength (psi)	Fracture Type	Tested By
1	A	6.01	28.37	02/25/20	03/03/20	11 F	110,230	3,890	1	BJA
1	B	6.01	28.37	02/25/20	03/03/20	11 F	111,470	3,930	1	BJA
1	C	6.01	28.37	02/25/20	03/03/20	11 F	127,750	4,500	1	BJA
1	D			02/25/20		Hold				

Initial Cure: Outside Plastic Lids **Final Cure:** Field Cured

Comments: **F = Field Cured**

(Vehicle charge shown on Report No. A1171057.0094.)

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).
Terracon Rep.: Matcek, James **Start/Stop:** 1230-1330
Reported To:
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Andrea Allen
(1) Texas Transportation Institute, Bill Griffith

Reviewed By: Andrea Allen
Project Manager

Test Methods: ASTM C 31, ASTM C143, ASTM C231, ASTM C1064

B.2. SUPPORTING CERTIFICATION DOCUMENTS FOR 612261-04-1

JSW Steel (USA) INC.
5200,East McKinney Road,
BAYTOWN, TX 77523

METALLURGICAL TEST REPORT

MET - 04 Rev. No.: 3 Rev. Date:02/27/2018

6/27/2019

Bulletin	Order Item	Heat	PO No.	Shipping Mode		Order Dimensions	Slab Origin	TC No.
T057248	JSW12607-01	S27592		TRUCK		1.625x120x420	MEXICO	T057248-7592-1

Plates Certified for the Following grades	Specifications	Marking Instructions
ASTM-A516-70, ASME-SA516-70 2017 EDITION PN LCVN Hot Rolled Carbon Steel Plates Plates Manufactured In the USA	PLATE NORMALIZED AT 1650 °F FOR 50 MINS	Stencil in 2 location(s); X Loc. 18 Y Loc. 30; CUST; MADEINUSA PN PO; DIM GRADE; FREIGHT ORDERITEM PLATEID SHIPWEEK SLABID TRANSMODE Stamp in 2 location(s); X Loc. 18 Y Loc. 12; Slab ID; Slab ID; Slab ID

Sold To:

Ship To:

Test	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	N	V	B	Ti	Nb	Ca	CE
LADLE	0.20	1.11	0.011	0.001	0.19	0.006	0.017	0.013	0.000	0.002	0.034	0.0028	0.004	0.0002	0.002	0.002	0.0021	0.39

Carbon Equivalent CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15

PCM = C + Si/30 + Mn/20 + Cu/20 + Ni/60+ Cr/20 + Mo/15 + V/10 + 5B

Plate	Slab Identity	Gauge Tested	Test Cond	Test Dir.	Yield Point	Tensile Stgth.	Elong in 2"	YS/UTS Ratio	Yield Strenght Determind At	Impact Test (LCVN) Full Energy in Ft/Lb °F								
										Temp	Test1	Test2	Test3	Avg	Test1	Test2	Test3	Avg
1135470A	02A	1.6250	PN	T	51	74	29.0%	0.69	0.2%	-50	49	40	42	44				

Plates Certified For The Above Tests

Material	Thick(IN)	Width (IN)	Len(IN)	Wgt(LB)	Material	Thick(IN)	Width(IN)	Len (IN)	Wgt(LB)	Material	Thick(IN)	Width(IN)	Len(IN)	Wgt(LB)
1135470A	1.6250	120.000	420.00	23226.840										

9 / 20 / 2019

SFI-GRAY STEEL

Customer Name:

Customer PO #:

Thickness: 1 5/8" SFI PO #: 702844

Heat & Slab: S27592-02A

Plate #: 58561

DIN: EN 10204 2004 3.1 This is to certify that the product decribed herein was manufactured, sampled, and tested in accordance with the specifications and requirements in such specifications. Fine Grain, Si-Al Fully Killed Steel. We certify that delivery of this product with the requirement of the specification and purchase order received from customer. DRC Conflict Free. Does not contain Hg . No intentional addition of Pb, Se or S

Cheyenne Lee

cheyenne lee 22813837845 cheyenne.lee@jswsteel.us

Griffin Trade Group, LLC

Phone: 281-970-6030
Fax: 281-970-6024

12777 Jones Rd. Suite 315
Houston, TX 77375

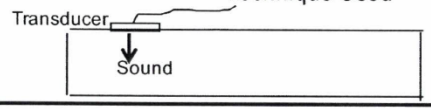
UT CERTIFIED TEST REPORT

Date Received: 9/13/19	Specification: SA578 LVL C 100% Scan		Report #: GTG-UT-751 Rev.		
Date Complete: 9/13/19			Release# GTC144342		
	Procedure: Griffin Trade Group UT-01				
	Deviations: N/A		Page 1 of 1		
	UT Instrument: RFD 30 Couplant: Water		Serial# :12110701 Calibration Due: 5/22/20		
	Batch #: N/A		**RESULTS**		

Material	Dimensions	Slab #/ID#	Heat #		Surface	Reject	Acceptable
SA/A51670 N	1-5/8 120 420	02A	S27592		ROUGH	0	1
SA/A51670 N	1-1/2 120 240	03A	S25206		ROUGH	0	1

CALIBRATION BLOCKS				TRANSDUCERS				
DBS	Calibration	Serial #	Reflector size	Serial #	Brand	Size	Degree	Frequency
Longitudinal								
77	80% FSH	N/A	1/8" FBH	B14808	Britek	1"	0	2.25 Mhz

Technique Used



Comments:

All tests are performed using calibrated equipment on samples provided by Griffin Trade Group, unless noted in the data section. This data applies only to samples tested by Griffin Trade Group, LLC. This test report may be reproduced in its entirety without permission from Grffin Trade Group, LLC. All requirements of Grffin Trade Group, LLC Quality Operating Procedures, Dated 1/16/2014 have been fulfilled.

Tested By: Jarrod Harris ASNT Level II Date: 9/13/19

Signature:

EXTRUSIONS, LTD.

CERTIFICATE OF ANALYSIS
MECHANICAL AND CHEMICAL PROPERTIES

P.O. Box 218
Olney, Texas 76374

Customer: Centerline Supply, LTD

Date: 15-Dec-21

Job # 320866

Customer P.O. PO2008214

Die No: 15752

Item	Description	Quantity Shipped Feet	Pieces
1	Aluminum Extrusion 30' 12" PANEL Heat # CTX54149	2520	84

Chemical Analysis (%):

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Other
6063	0.49	0.2	0.03	0.04	0.46	0.008	0.008	0.009	

Alloy	*Tensile Strength:*	
6063/T6	Ultimate-	33,208
	Yield-	30,446
	Elongation-	9.70%

This is to certify that above test results comply with ASTM B221.

TOWER EXTRUSIONS, LTD.

Quality Control Supervisor

Phone: (940) 564-5681

Fax: (940) 564-5033

01-09-2020 23:55 Load - 3492395 BL - 3876821 blr466

Custom Fabricators Heat - 59089275

Cust. PO - CF19-25210 Order - 18147108

GERDAU

US-ML-MIDLOTHIAN
300 WARD ROAD
MIDLOTHIAN, TX 76065
USA

CERTIFIED MATERIAL TEST REPORT

Page 1/1

CUSTOMER SHIP TO	CUSTOMER BILL TO	GRADE	SHAPE / SIZE	DOCUMENT ID:
KLOECKNER METALS US 4606 SINGLETON BLVD DALLAS,TX 75212-3502 USA	KLOECKNER METALS CORPORATION 500 COLONIAL CENTER PKWY ROSWELL,GA 30076-8853 USA	A992/A572-50	Wide Flange Beam / 6 X 12# / 150 X 18.0	0000395918

LENGTH	PCS	WEIGHT	HEAT / BATCH
40'00"	89	42,720 LB	59089275/02

SALES ORDER	CUSTOMER MATERIAL N°
8365961/000010	B612W401400

SPECIFICATION / DATE or REVISION
ASTM A6-17
ASTM A709-17
ASTM A992-11 (2015), A572-15
CSA G40.21-13 345WM

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
7452718	1327-0000351754	12/23/2019

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	Sn %	V %	Nb %	Al %
0.12	1.06	0.016	0.010	0.24	0.44	0.10	0.20	0.024	0.009	0.007	0.018	0.004

CHEMICAL COMPOSITION

CEqyA6 %
0.38

MECHANICAL PROPERTIES

YS 0.2% PSI	UTS PSI	YS MPa	UTS MPa	Y/T rati %	G/L Inch
59660	73972	411	510	0.810	8.000
60741	76489	419	527	0.790	8.000

MECHANICAL PROPERTIES

G/L mm	Elong. %
200.0	23.30
200.0	22.70

COMMENTS / NOTES

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. Weld repair has not been performed on this material. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR
Phone: (409) 267-1071 Email: Bhaskar.Yalamanchili@gerdau.com

WADE LUMPKINS
QUALITY ASSURANCE MGR.
Phone: 972-779-3118 Email: Wade.Lumpkins@gerdau.com

B.3. SUPPORTING CERTIFICATION DOCUMENTS FOR 612261-05-2

NUCOR STEEL - BERKELEY
1455 Hagan Avenue
Huger, SC 29450
Phone: (843) 336-6000

CERTIFIED MILL TEST REPORT

3/09/22 4:55:21

100% EAF MELTED AND MANUFACTURED IN THE USA
Structural sections produced by Nucor-Berkeley are cast and hot rolled to a fully killed and fine grain practice.
Mercury not intentionally added at any point during manufacturing.

SPECIFICATIONS: Tested in accordance with ASTM specification A6/A6M-21 and A370-21. Tested in accordance with EN10204-2004-3.1.
Quality Manual Rev #16 (4-30-21).
AASHTO : m270-345M270-50-19
ASME : SA-36 13
ASTM : A992-20:/A36-19/A529-19-50/A5725021T1/A7093621/A7095021
CSA : G40.21-44w/G40.21-50w/G40.2150WM

Description Part #	Heat# Grade(s) Test/Heat JW	Yield/ Tensile Ratio	Yield (PSI) (MPa)	Tensile (PSI) (MPa)	Elong %	C Cr ******	Mn Mo Ti	P Sn ******	S B ******	Si V N	Cu Nb ******	Ni ****** CI	CE1 CE2 Pcm
W6X12	1201608	.84	56700	67900	26.93	.06	.82	.007	.016	.18	.07	.03	.22
020' 00.00'	A992-20		391	468		.03	.01	.0041	.0001	.002	.029		.2512
W150X18.0		.83	56400	68000	26.37		.001			.0040		2.08	.1181
006.0960m			389	469									
376120020													

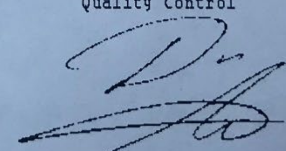
48 Pc(s) 11,520 lbs Customer PO: 4500526026 BoL#: 1617073

Elongation based on 8' (20.32cm) gauge length. 'No Weld Repair' was peformed.
CI = 26.01Cu+3.88Ni+1.20Cr+1.49Si+17.28P-(7.29Cu*Ni)-(9.10Ni*P)-33.39(Cu*Cu)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B
CE1 = C+(Mn/6)+((Cr+Mo+V)/5)+((Ni+Cu)/15)

'All mechanical testing is performed by the Quality testing lab, which is independent of the production departments'
CE2 = C+((Mn+Si)/6)+((Cr+Mo+V+Cb)/5)+((Ni+Cu)/15)

Nucor certifies that the contents of this report are accurate and correct. All test results and operations performed by the material manufacturer are in compliance with material specifications, and when designated by the Purchaser, meet applicable specifications.

Dmitri Nassyrov
Metallurgist/
Quality Control



Texas A&M Transportation Institute	QF 7.3-01 Concrete Sampling	Doc. No. QF 7.3-01	Revision Date: 2020-07-29
Quality Form	Revised by: B.L. Griffith Approved by: D. L. Kuhn	Revision: 7	Page: 1 of 1

Project No: 612261 **Casting Date:** 10/5/2022 **Mix Design (psi):** 3000

Name of Technician Taking Sample	Terracon	Name of Technician Breaking Sample	Terracon
Signature of Technician Taking Sample	Terracon	Signature of Technician Breaking Sample	Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	106	123612	100% of sign footers

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average

TEXCRETE
Redi-mix Concrete Company

REMIT PAYMENT TO:
P.O. BOX138
KURTEN, TX 77862

TEXCRETE

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

18935 Circle Lake Dr.
Pinehurst, TX 77362

123612

BCS DISPATCH - 979-316-2906
PINEHURST DISPATCH - 936-232-5815
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO
AVENUE A, RELLIS CAMPUS, BRYAN TX

RT 2818, RT HWY 21, LT SILVER HILL, RT AT "T", RT HWY 47, LT INTO RELLIS CAMPUS GO ALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
9:30	FN9302000300	3.00	3.00	PO#	JOSHEPH	106	69137
DATE	**PROJECT**	**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
10/5/22	FDOT	3.00	3.00			3.00 in	67319

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
3.00 CY	FN9302000300	COM, 3000, RG, 3", 1		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

Tax
Prev. AMT
Ticket Total

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
9:41	9:55	10:52			

FINISH UNLOADING	LEFT JOB	ARRIVED AT PLANT	ON SITE TESTING
			TESTING LAB: TERRACON GESSNER CME OTHER

TESTED		AIR	CYLINDERS
☐ YES	☐ NO		

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

Contains Portland Cement, Wear Rubber Boots and Gloves. PROLONGED CONTACT MAY CAUSE BURNS. Avoid Contact With Eyes and Prolonged Contact with Skin. In Case of Contact with Skin or Eyes, Rinse Thoroughly With Water. If Irritation Persists. Get Medical Attention. **KEEP CHILDREN AWAY.**

CONCRETE is a PERISHABLE COMMODITY and BECOMES THE PROPERTY of the PURCHASER UPON LEAVING the PLANT. ANY CHANGES or CANCELLATION of ORIGINAL INSTRUCTIONS MUST be TELEPHONED to the OFFICE BEFORE LOADING starts. The undersigned promises to pay all costs, including reasonable attorney's fees incurred in collecting any sums owed.

All accounts not paid within 30 days of delivery will bear interest at the rate of 18% per annum. Not Responsible For Reactive Aggregate or Color Quality. No Claim Allowed Unless Made at Time Material is Delivered.
A $25.00 Service Charge and Loss of the Cash Discounted will be Collected on all Returned Checks. Demerge charge after 90 min. will be $100.00/hr.

PROPERTY DAMAGE RELEASE
(TO BE SIGNED IF DELIVERY TO BE MADE INSIDE CURB LINE)

Dear Customer - The driver of this truck in presenting this RELEASE to you for your signature is of the opinion that the size and weight of this truck may possibly cause damage to the premises and/or adjacent property if he places the material in this load where you desire it. It is our wish to help you in everyway that we can, but in order to do this the driver is requesting that you sign this RELEASEreleving him and this supplier from any responsibility from damage that may occur to the premises and or adjacent property, buildings, sidewalks, driveways, curbs, etc. by the delivery of this material and that you also agree to help him remove mud from the wheels of his vehicle so that he will not liter the public streets. Further as additional consideration: the undersigned agrees to indemnify and hold harmless the driver of this truck and this supplier for any and all damage to the premises and /or adjacent property which may be claimed by anyone to have arisen out of delivery of this order SIGNED:

X _____

Excessive Water is Detrimental to Concrete Performance.
H_20 Added by Request/Authorized By:

_____GAL X_____

WEIGHMASTER

Surcharge for credit cards

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE HEALTH WARNING NOTICE AND SUPPLIER WILL NOT BE RESPONSIBLE FOR ANY DAMAGE CAUSED WHEN DELIVERING INSIDE CURB LINE.

LOAD RECEIVED BY

X _____

123612

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0250
Service Date: 10/05/22
Report Date: 11/10/22
Task: PO# 612261-01

Terracon
6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767 Reg No: F-3272

Client
Texas Transportation Institute
Attn: Bill Griffith
TTI Business Office
3135 TAMU
College Station, TX 77843-3135

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information
Specified Strength: 3,000 psi @ 28 days

Mix ID: Fn930200300
Supplier: Texcrete
Batch Time: 0930 **Plant:** 2
Truck No.: 106 **Ticket No.:** 67319

Sample Information
Sample Date: 10/05/22 **Sample Time:** 1020
Sampled By: Brian Maass
Weather Conditions: Clear light wind
Accumulative Yards: 3/3 **Batch Size (cy):** 10
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: West pier
Placement Location: Piers - South runway

Field Test Data

Test	Result	Specification
Slump (in):	2 1/2	
Air Content (%):	3.8	
Concrete Temp. (F):	83	
Ambient Temp. (F):	80	
Plastic Unit Wt. (pcf):	147.7	
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	6.00	28.27		11/07/22	33 F	86,620	3,060	4	SCG
1	B	Good	6.00	28.27		11/07/22	33 F	81,420	2,880	4	SCG
1	C	Good	6.00	28.27		11/07/22	33 F	99,290	3,510	4	SCG
1	D	Good					Hold			2	SCG

Initial Cure: Outside Plastic Lids **Final Cure:** Field Cured **Sample Description:** 6-inch diameter cylinders

Comments: **F = Field Cured**
Note: Reported air content does not include Aggregate Correction Factor (ACF).

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).

Terracon Rep.: Brian Maass
Start/Stop: 0945-1145
Reported To:
Contractor: MBC Management
Report Distribution:
(1) Texas Transportation Institute, Bill Griffith

Reviewed By: Alexander Dunigan
Project Manager

Test Methods: ASTM C 31, ASTM C143, ASTM C231, ASTM C1064

APPENDIX C. *MASH* TEST 3-62 (CRASH TEST NO. 6122561-05-1)

C.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2020-3-3 Test No.: 612261-05-01 VIN No.: 1C6RR6GT2ES293323

Year: 2014 Make: RAM Model: 1500

Tire Size: 265/70 R 17 Tire Inflation Pressure: 35 psi

Tread Type: Highway Odometer: 152503

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

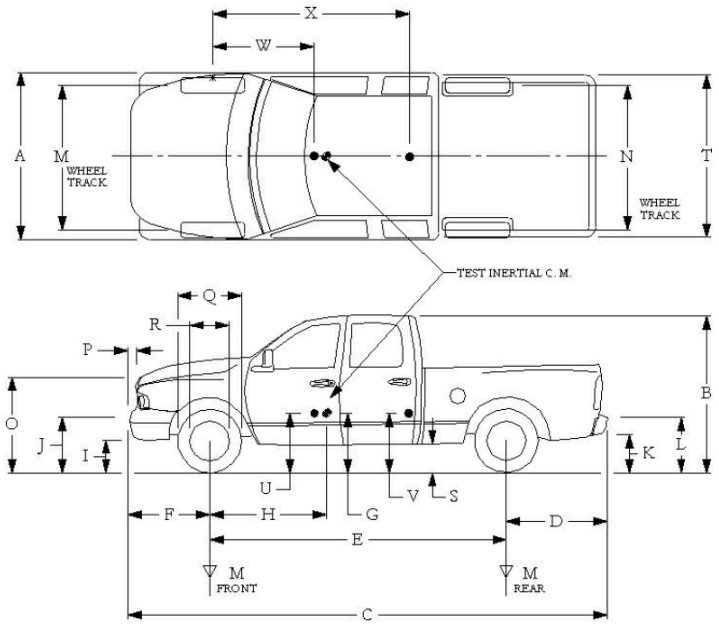
NOTES: None

Engine Type: V-8
Engine CID:

Transmission Type:
☑ Auto or ☐ Manual
☐ FWD ☑ RWD ☐ 4WD

Optional Equipment:
None

Dummy Data:
Type: No dummy
Mass: 0 lb
Seat Position: NA



Geometry: inches

A	78.50	F	40.00	K	20.00	P	3.00	U	26.75
B	74.00	G	29.25	L	30.00	Q	30.50	V	30.25
C	227.50	H	61.27	M	68.50	R	18.00	W	61.25
D	44.00	I	11.75	N	68.00	S	13.00	X	79.00
E	140.50	J	27.00	O	46.00	T	77.00		

Wheel Center Height Front	14.75	Wheel Well Clearance (Front)	6.00	Bottom Frame Height - Front	12.50
Wheel Center Height Rear	14.75	Wheel Well Clearance (Rear)	9.25	Bottom Frame Height - Rear	22.50

RANGE LIMIT: A=78 ±2 inches; C=237 ±13 inches; E=148 ±12 inches; F=39 ±3 inches; G = > 28 inches; H = 63 ±4 inches; O=43 ±4 inches; (M+N)/2=67 ±1.5 inches

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2900	2842	2842
Back	3900	M_{rear}	2020	2198	2198
Total	6700	M_{Total}	4920	5040	5040

(Allowable Range for TIM and GSM = 5000 lb ±110 lb)

Mass Distribution:
lb LF: 1442 RF: 1400 LR: 1133 RR: 1065

Figure C.1. Vehicle Properties for Test No. 6122561-05-1.

Date:	2020-03-03	Test No.:	612261-05-01	VIN No.:	1C6RR6GT2ES293323
Year:	2014	Make:	RAM	Model:	1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L***	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max**** Crush								
1	Front plane at bmp ht	4	8	32	2	8	3	-	-	-	-12
	Measurements recorded										
	☑ **inches or** ☐ **mm**										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

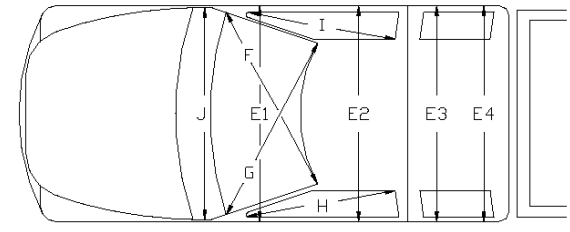
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

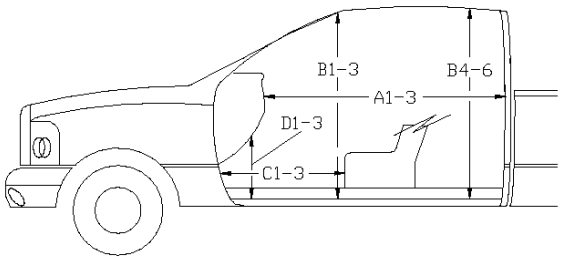
***Measure and document on the vehicle diagram the location of the maximum crush.

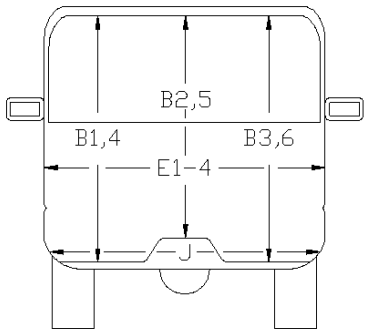
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure C.2. Exterior Crush Measurements for Test No. 6122561-05-1.

Date:	2020-03-03	Test No.:	612261-05-01	VIN No.:	1C6RR6GT2ES293323
Year:	2014	Make:	RAM	Model:	1500







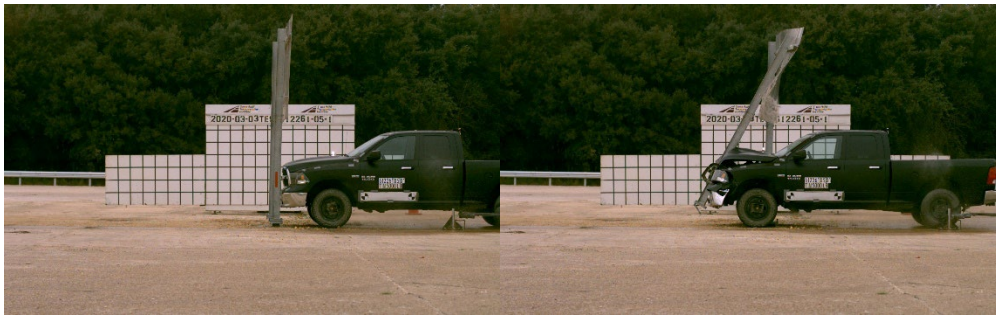
*Lateral area across the cab from driver's side kickpanel to passenger's side kickpanel.

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	65.00	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	45.00	0.00
B2	38.00	38.00	0.00
B3	45.00	45.00	0.00
B4	39.50	39.50	0.00
B5	43.00	43.00	0.00
B6	39.50	39.50	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	58.50	0.00
E2	63.50	63.50	0.00
E3	63.50	63.50	0.00
E4	63.50	63.50	0.00
F	59.00	59.00	0.00
G	59.00	59.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	25.00	25.00	0.00

Figure C.3. Occupant Compartment Measurements for Test No. 6122561-05-1.

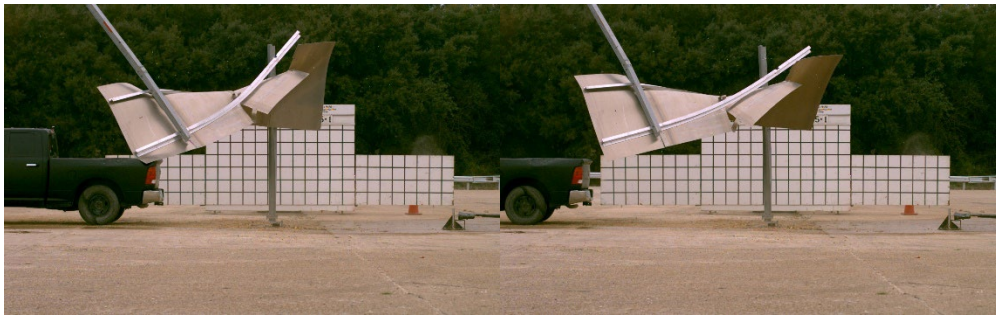
C.2. SEQUENTIAL PHOTOGRAPHS



(a) 0.000 s (b) 0.100 s

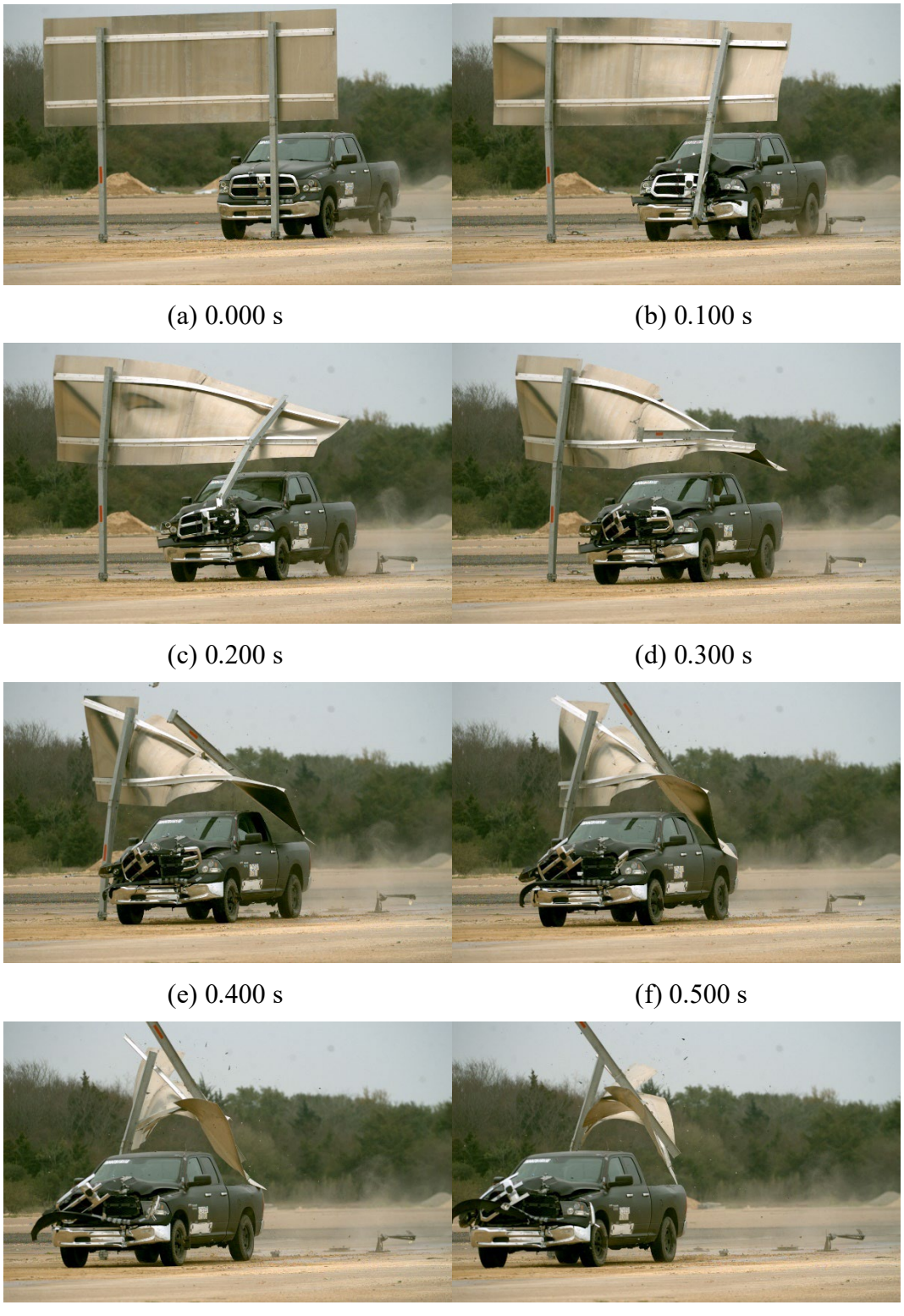
(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s



(g) 0.600 s (h) 0.700 s

Figure C.4. Sequential Photographs for Test No. 6122561-05-1 (Right Angle Views).



(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure C.5. Sequential Photographs for Test No. 6122561-05-1 (Left Oblique Views).

(a) 0.000 s (b) 0.100 s

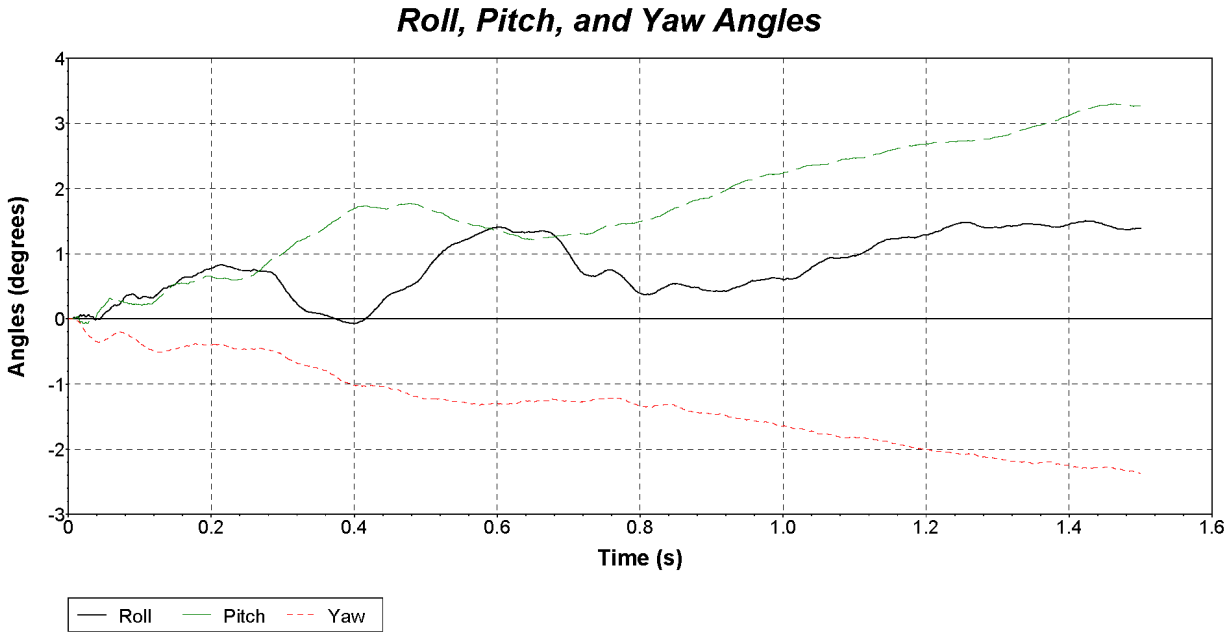
(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

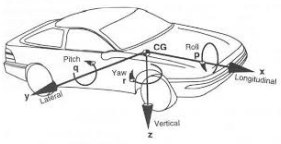
Figure C.6. Sequential Photographs for Test No. 6122561-05-1 (Right Oblique Views).

C.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

1. Yaw.
2. Pitch.
3. Roll.



Test Number: 612261-05-1
Test Standard Test Number: *MASH* Test 3-62
Test Article: Large Sign Slip Base
Test Vehicle: 2014 RAM 1500
Inertial Mass: 5040 lb
Gross Mass: 5040 lb
Impact Speed: 62.4 mi/h
Impact Angle: 0°

Figure C.7. Vehicle Angular Displacements for Test No. 6122561-05-1.

C.4. VEHICLE ACCELERATIONS

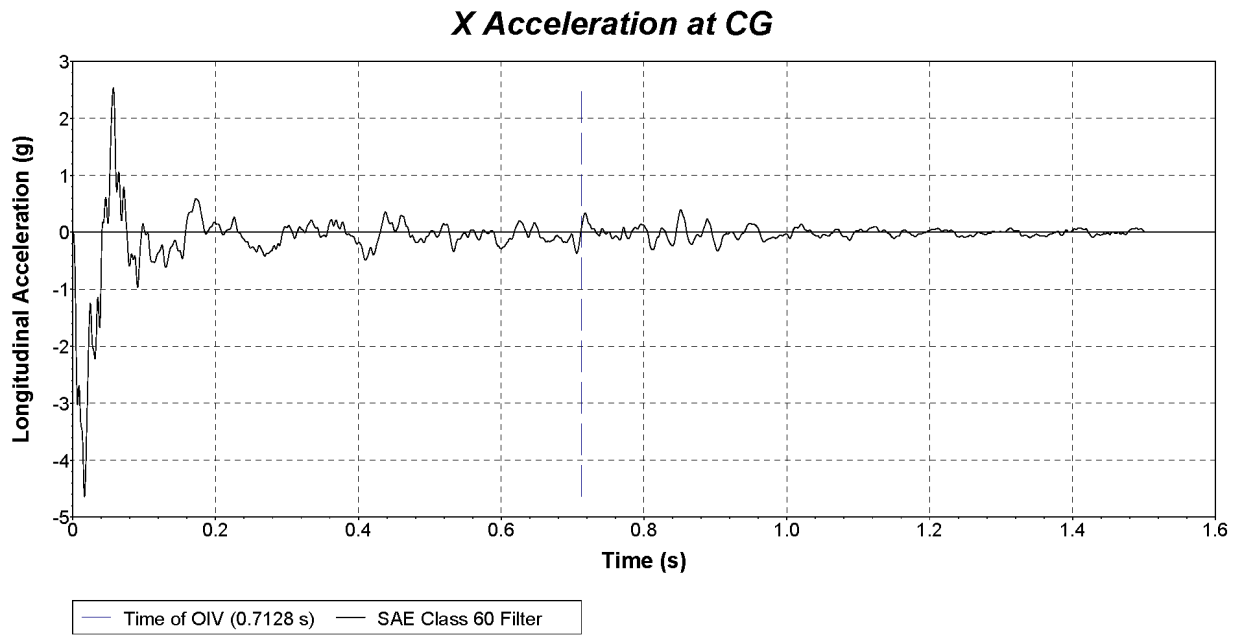


Figure C.8. Vehicle Longitudinal Accelerometer Trace for Test No. 6122561-05-1 (Accelerometer Located at Center of Gravity).

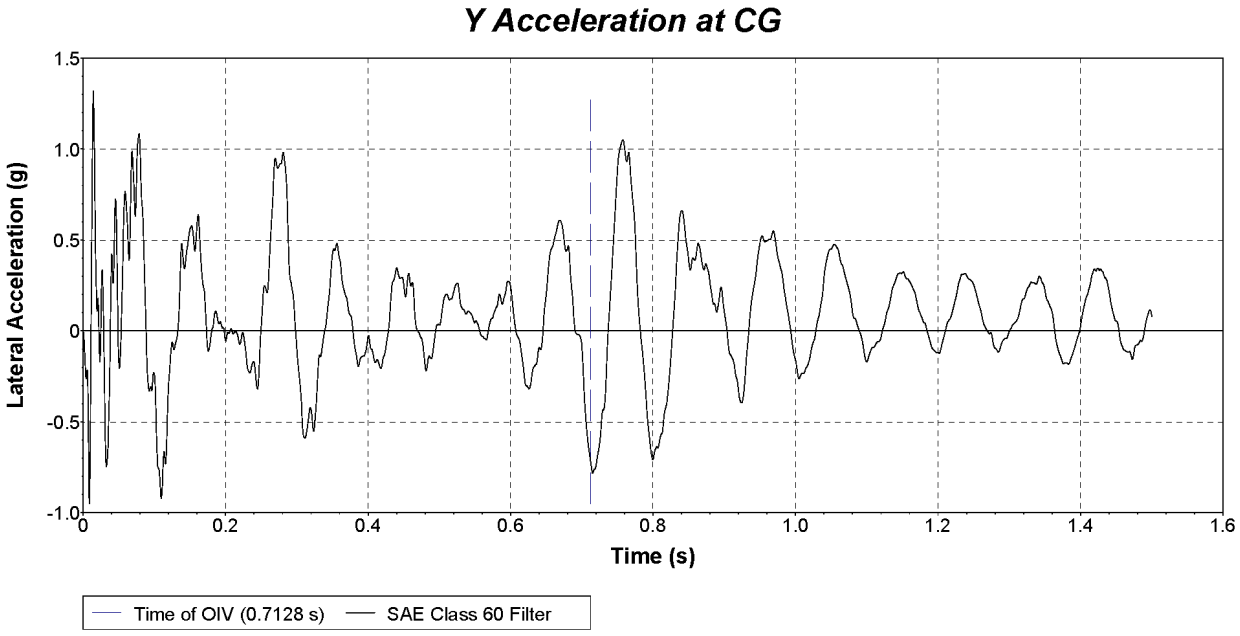


Figure C.9. Vehicle Lateral Accelerometer Trace for Test No. 6122561-05-1 (Accelerometer Located at Center of Gravity).

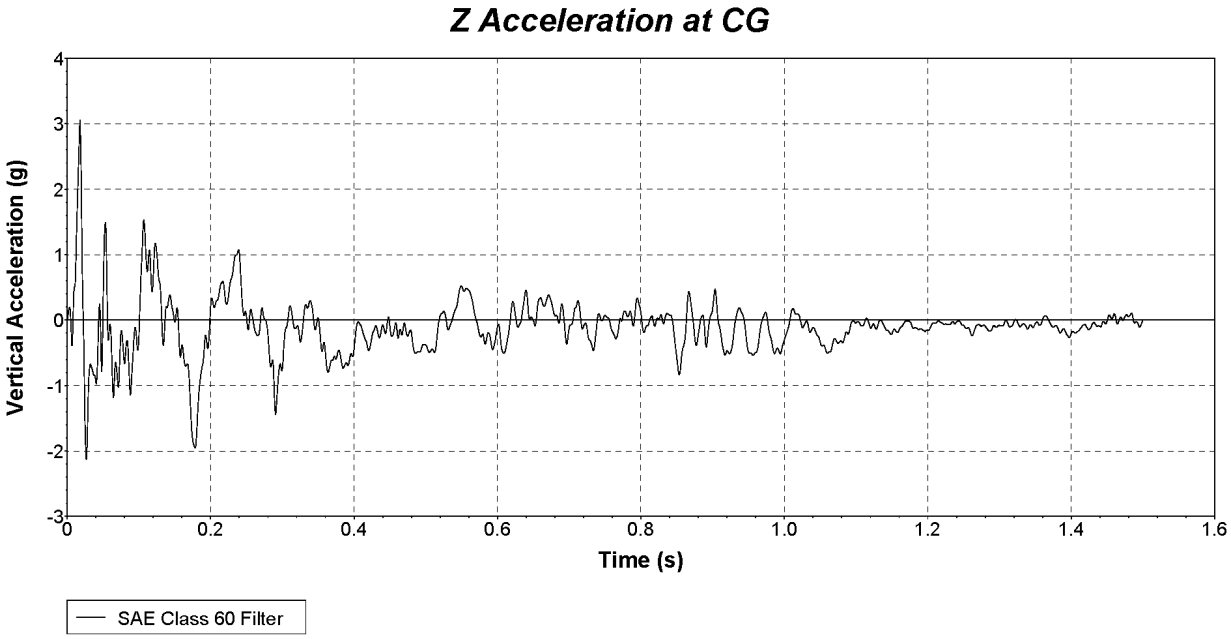


Figure C.10. Vehicle Vertical Accelerometer Trace for Test No. 6122561-05-1 (Accelerometer Located at Center of Gravity).

APPENDIX D. *MASH* TEST 3-62 (CRASH TEST NO. 612261-04-1)

D.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2022-03-16 Test No.: 612261-04-1 VIN No.: 1C6RR6FT1GS382076

Year: 2016 Make: RAM Model: 1500

Tire Size: 265/70 R 17 Tire Inflation Pressure: 35 psi

Tread Type: Highway Odometer: 90178

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

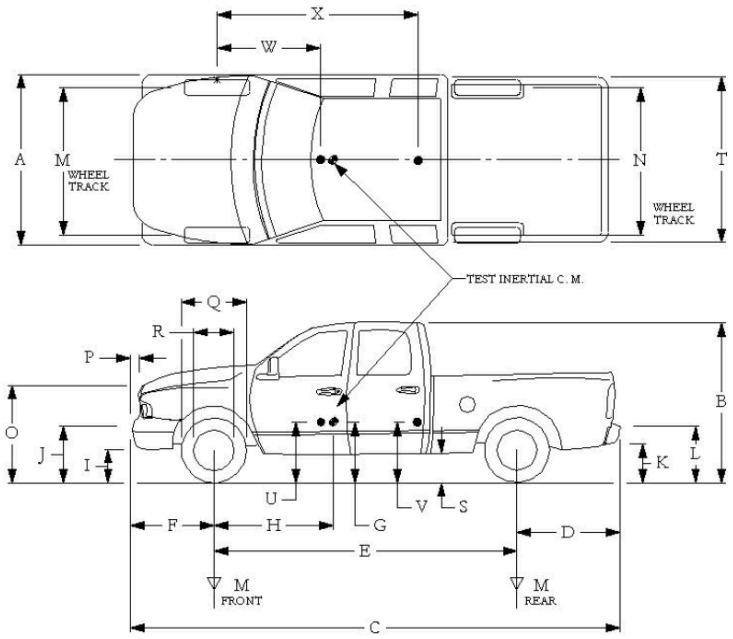
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

Transmission Type:
☑ Auto or ☐ Manual
☐ FWD ☑ RWD ☐ 4WD

Optional Equipment:
None

Dummy Data:
Type: NONE
Mass: 0 lb
Seat Position:



Geometry: inches

A	78.50	F	40.00	K	20.00	P	3.00	U	26.75
B	74.00	G	28.25	L	30.00	Q	30.50	V	30.25
C	227.50	H	60.86	M	68.50	R	18.00	W	60.80
D	44.00	I	11.75	N	68.00	S	13.00	X	79.00
E	140.50	J	27.00	O	46.00	T	77.00		

Wheel Center Height Front	14.75	Wheel Well Clearance (Front)	6.00	Bottom Frame Height - Front	12.50
Wheel Center Height Rear	14.75	Wheel Well Clearance (Rear)	9.25	Bottom Frame Height - Rear	22.50

RANGE LIMIT: A=78 ±2 inches; C=237 ±13 inches; E=148 ±12 inches; F=39 ±3 inches; G = > 28 inches; H = 63 ±4 inches; O=43 ±4 inches; (M+N)/2=67 ±1.5 inches

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2960	2871	2871
Back	3900	M_{rear}	2087	2193	2193
Total	6700	M_{Total}	5047	5064	5064

(Allowable Range for TIM and GSM = 5000 lb ±110 lb)

Mass Distribution:
lb LF: 1449 RF: 1422 LR: 1108 RR: 1085

Figure D.1. Vehicle Properties for Test No. 612261-04-1.

Date:	2022-03-16	Test No.:	612261-04-1	VIN No.:	1C6RR6FT1GS382076
Year:	2016	Make:	RAM	Model:	1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
1	AT FT BUMPER	4	4	18							-13
	Measurements recorded										
	☐ inches or ☐ mm										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

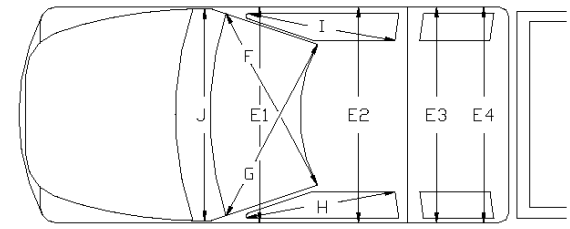
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

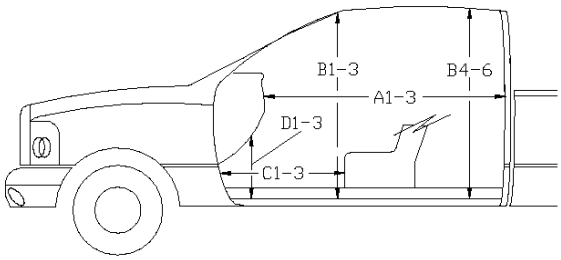
***Measure and document on the vehicle diagram the location of the maximum crush.

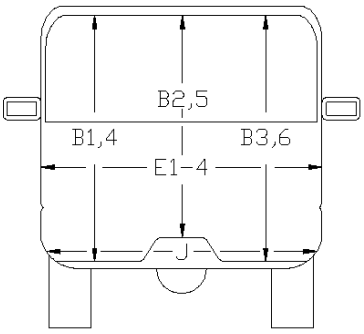
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure D.2. Exterior Crush Measurements for Test No. 612261-04-1.

Date:	2022-03-16	Test No.:	612261-04-1	VIN No.:	1C6RR6FT1GS382076
Year:	2016	Make:	RAM	Model:	1500







*Lateral area across the cab from driver's side kickpanel to passenger's side kickpanel.

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	65.00	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	44.00	-1.00
B2	38.00	38.00	0.00
B3	45.00	45.00	0.00
B4	39.50	39.50	0.00
B5	43.00	43.00	0.00
B6	39.50	39.50	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	58.50	0.00
E2	63.50	63.50	0.00
E3	63.50	63.50	0.00
E4	63.50	63.50	0.00
F	59.00	59.00	0.00
G	59.00	59.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	25.00	25.00	0.00

Figure D.3. Occupant Compartment Measurements for Test No. 612261-04-1.

D.2. SEQUENTIAL PHOTOGRAPHS

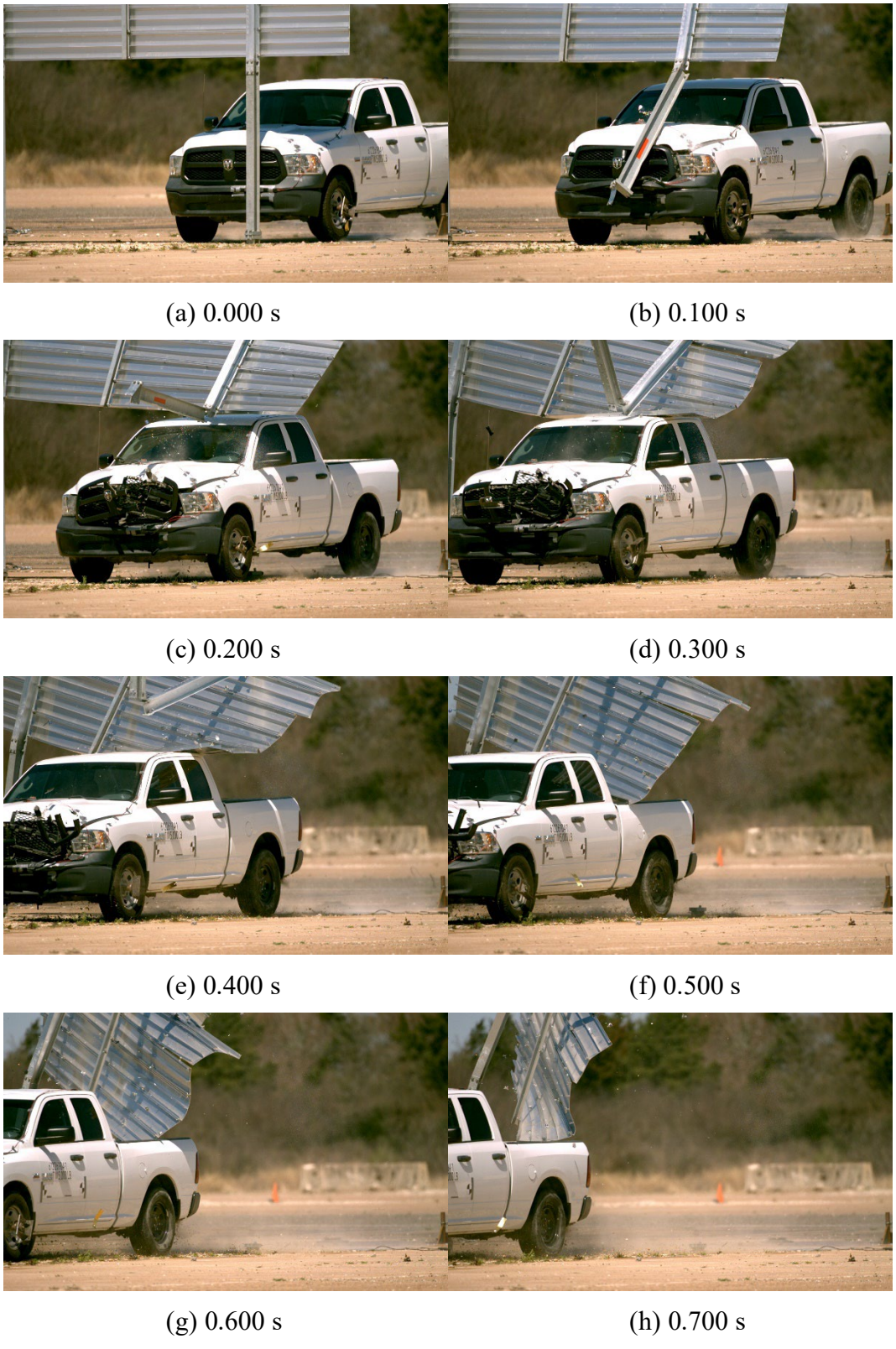
(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure D.4. Sequential Photographs for Test No. 612261-04-1 (Right Angle Views).



(a) 0.000 s (b) 0.100 s

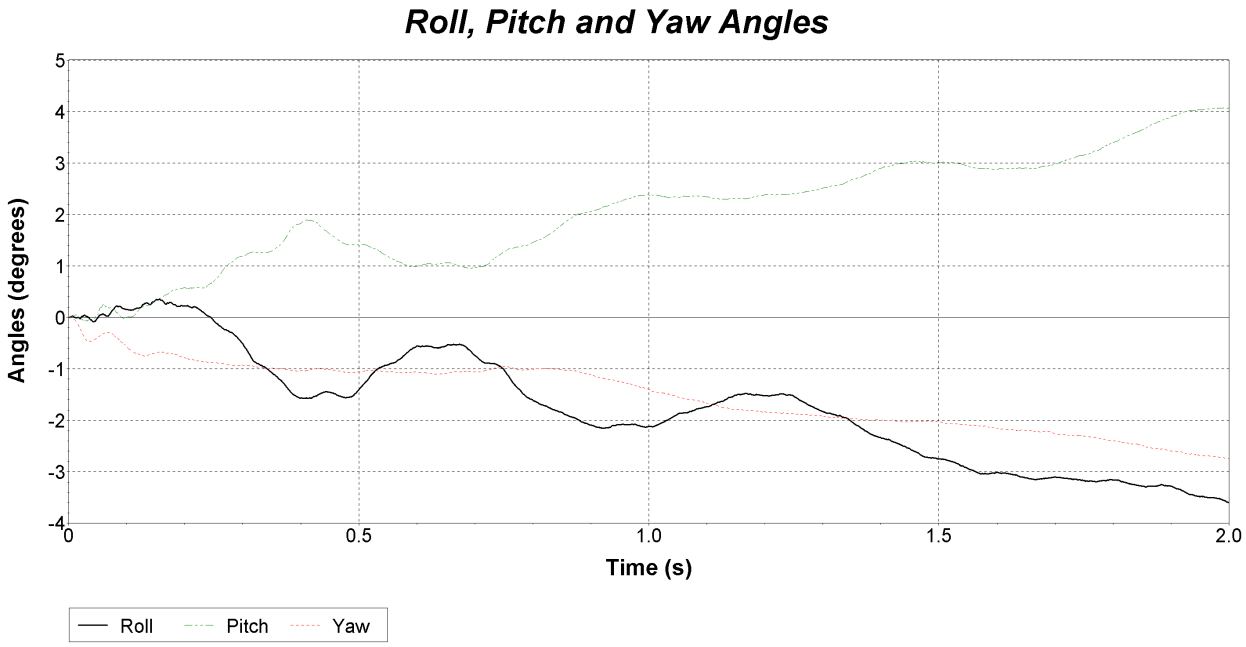
(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

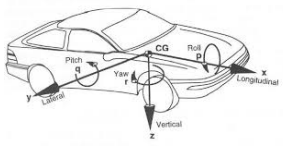
Figure D.5. Sequential Photographs for Test No. 612261-04-1 (Left Oblique Views).

D.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

4. Yaw.
5. Pitch.
6. Roll.



Test Number: 612261-04-1
Test Standard Test Number: *MASH* Test 3-62
Test Article: Large Sign Slip Base
Test Vehicle: 2016 Ram 1500
Inertial Mass: 5064 lb
Gross Mass: 5064 lb
Impact Speed: 61.4 mi/h
Impact Angle: 0°

Figure D.6. Vehicle Angular Displacements for Test No. 612261-04-1.

D.4. VEHICLE ACCELERATIONS

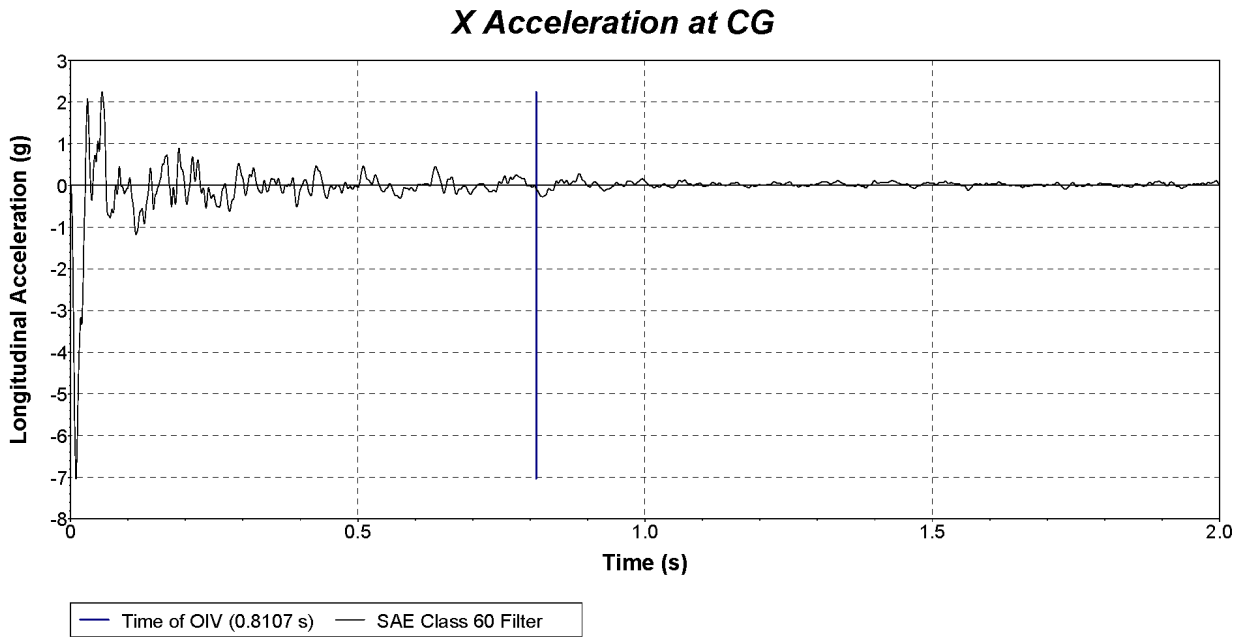


Figure D.7. Vehicle Longitudinal Accelerometer Trace for Test No. 612261-04-1 (Accelerometer Located at Center of Gravity).

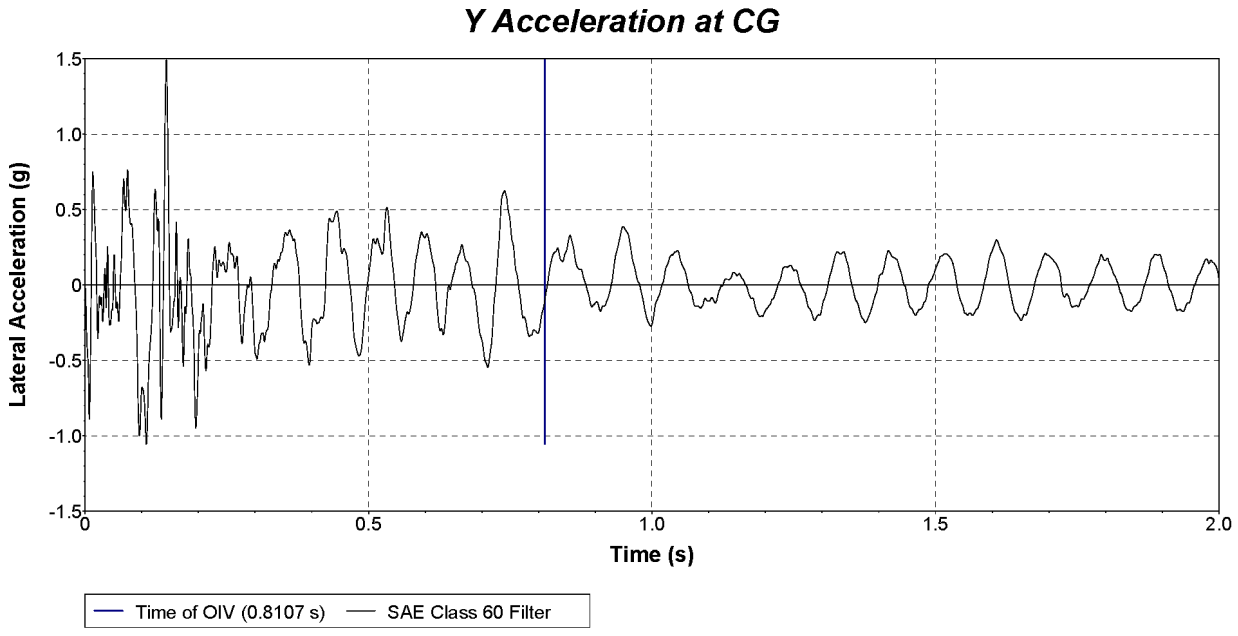


Figure D.8. Vehicle Lateral Accelerometer Trace for Test No. 612261-04-1 (Accelerometer Located at Center of Gravity).

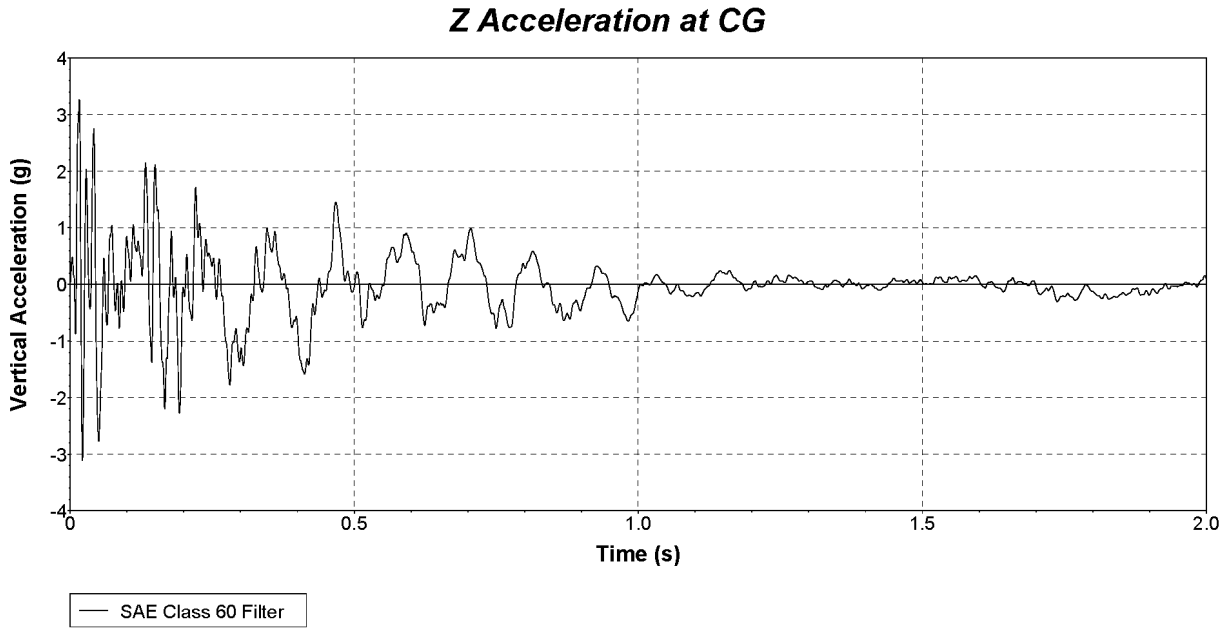


Figure D.9. Vehicle Vertical Accelerometer Trace for Test No. 612261-04-1 (Accelerometer Located at Center of Gravity).

APPENDIX E. *MASH* TEST 3-62 (CRASH TEST NO. 612261-05-2)

E.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2022-11-10 Test No.: 612261-05-2 VIN No.: 1C6RR6FT8JS317779

Year: 2018 Make: RAM Model: 1500

Tire Size: 265/70 R 17 Tire Inflation Pressure: 35 psi

Tread Type: Highway Odometer: 79680

Note any damage to the vehicle prior to test: None

• Denotes accelerometer location.

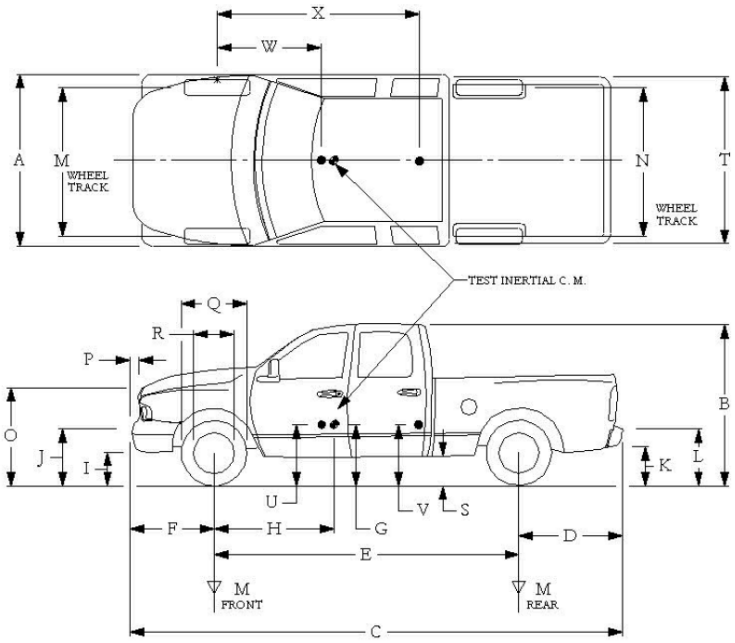
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

Transmission Type:
☑ Auto or ☐ Manual
☐ FWD ☑ RWD ☐ 4WD

Optional Equipment:
None

Dummy Data:
Type: NONE
Mass: lb
Seat Position:



Geometry: inches

A	78.50	F	40.00	K	20.00	P	3.00	U	26.75
B	74.00	G	28.75	L	30.00	Q	30.50	V	30.25
C	227.50	H	61.00	M	68.50	R	18.00	W	61.00
D	44.00	I	11.75	N	68.00	S	13.00	X	79.00
E	140.50	J	27.00	O	46.00	T	77.00		

Wheel Center Height Front	14.75	Wheel Well Clearance (Front)	6.00	Bottom Frame Height - Front	12.50
Wheel Center Height Rear	14.75	Wheel Well Clearance (Rear)	9.25	Bottom Frame Height - Rear	22.50

RANGE LIMIT: A=78 ±2 inches; C=237 ±13 inches; E=148 ±12 inches; F=39 ±3 inches; G = > 28 inches; H = 63 ±4 inches; O=43 ±4 inches; (M+N)/2=67 ±1.5 inches

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2923	2832	2832
Back	3900	M_{rear}	2083	2173	2173
Total	6700	M_{Total}	5006	5005	5005

(Allowable Range for TIM and GSM = 5000 lb ±110 lb)

Mass Distribution:
lb LF: 1376 RF: 1456 LR: 1147 RR: 1026

Figure E.1. Vehicle Properties for Test No. 612261-05-2.

Date: 2022-11-10 Test No.: 612261-05-2 VIN No.: 1C6RR6FT8JS317779

Year: 2018 Make: RAM Model: 1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
1	AT FT BUMPER	4	11	42							-16
	Measurements recorded										
	☑ **inches or** ☐ **mm**										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

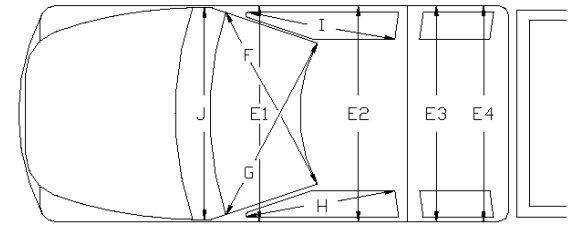
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

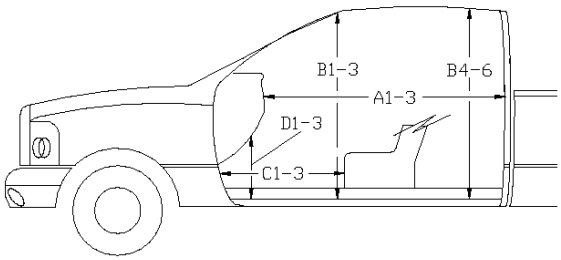
***Measure and document on the vehicle diagram the location of the maximum crush.

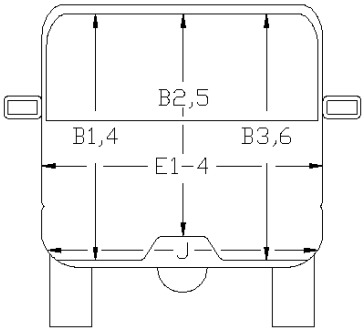
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure E.2. Exterior Crush Measurements for Test No. 612261-05-2.

Date:	2022-11-10	Test No.:	612261-05-2	VIN No.:	1C6RR6FT8JS317779
Year:	2018	Make:	RAM	Model:	1500







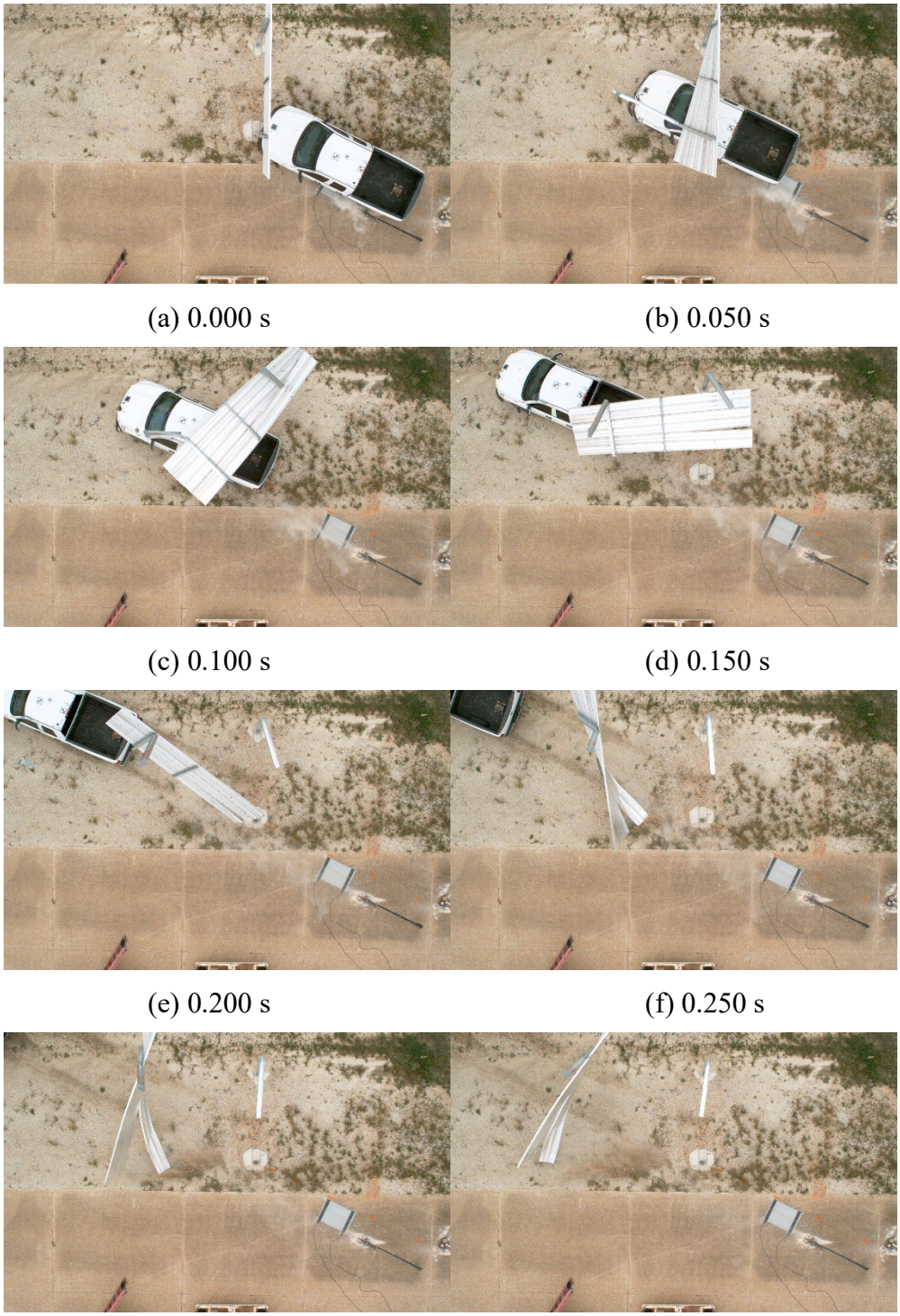
*Lateral area across the cab from driver's side kickpanel to passenger's side kickpanel.

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	65.00	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	43.10	-1.90
B2	38.00	38.00	0.00
B3	45.00	45.00	0.00
B4	39.50	39.50	0.00
B5	43.00	43.00	0.00
B6	39.50	39.50	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	58.50	0.00
E2	63.50	63.50	0.00
E3	63.50	63.50	0.00
E4	63.50	63.50	0.00
F	59.00	59.00	0.00
G	59.00	59.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	25.00	25.00	0.00

Figure E.3. Occupant Compartment Measurements for Test No. 612261-05-2.

E.2. SEQUENTIAL PHOTOGRAPHS



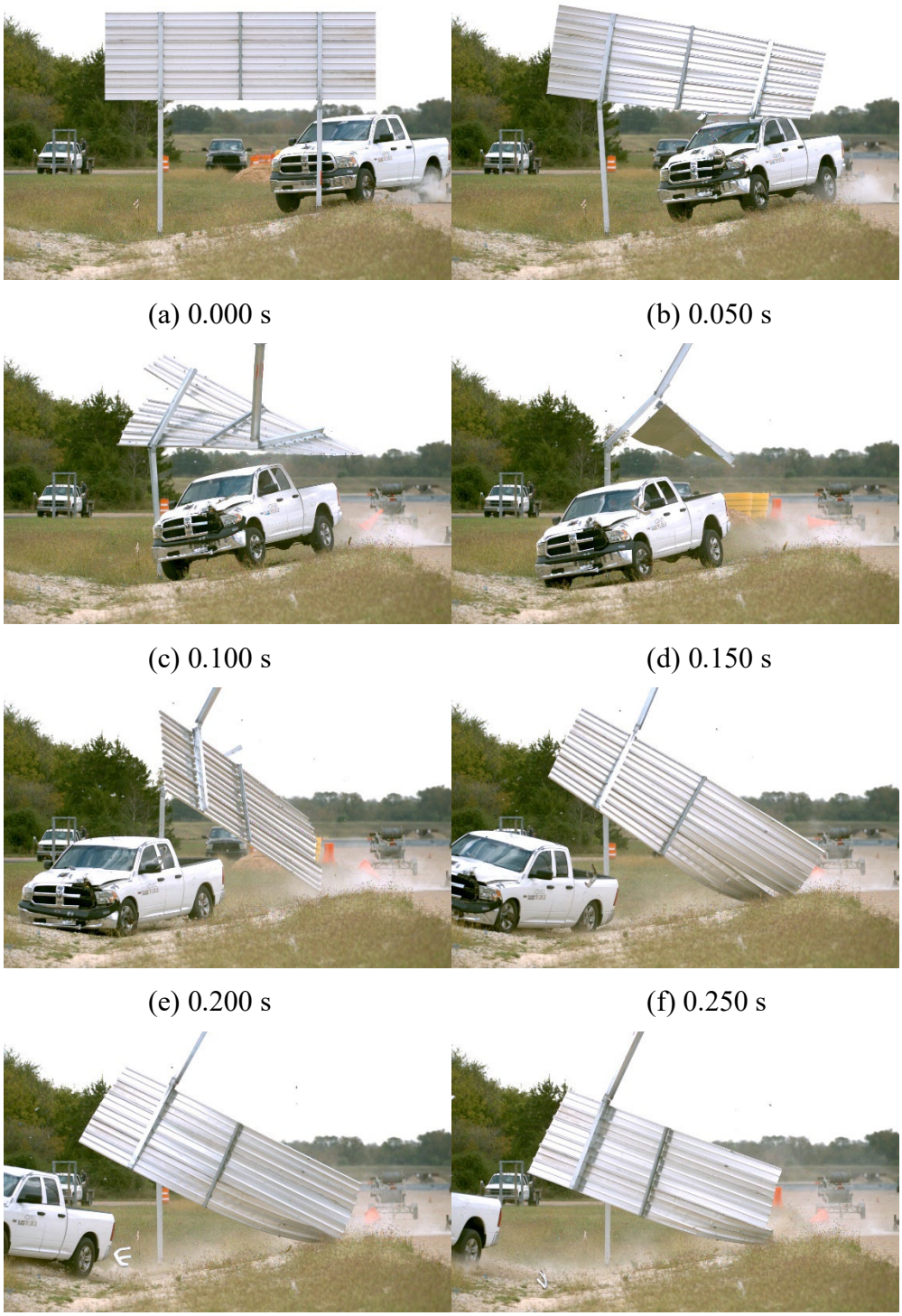
(a) 0.000 s (b) 0.050 s

(c) 0.100 s (d) 0.150 s

(e) 0.200 s (f) 0.250 s

(g) 0.300 s (h) 0.3500 s

Figure E.4. Sequential Photographs for Test No. 612261-05-2 (Overhead Views).



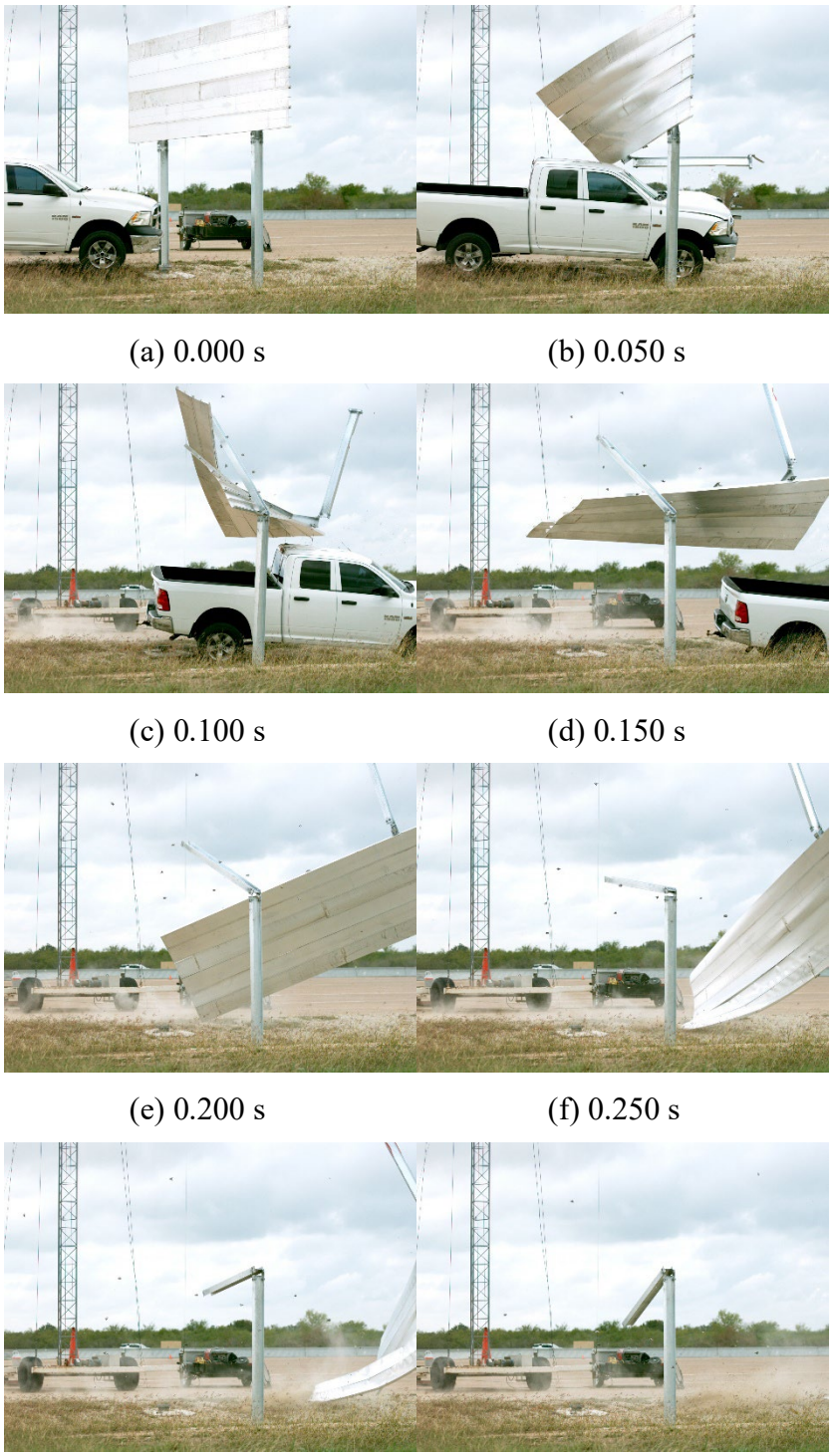
(a) 0.000 s (b) 0.050 s

(c) 0.100 s (d) 0.150 s

(e) 0.200 s (f) 0.250 s

(g) 0.300 s (h) 0.3500 s

Figure E.5. Sequential Photographs for Test No. 612261-05-2 (Frontal Views).



(a) 0.000 s (b) 0.050 s

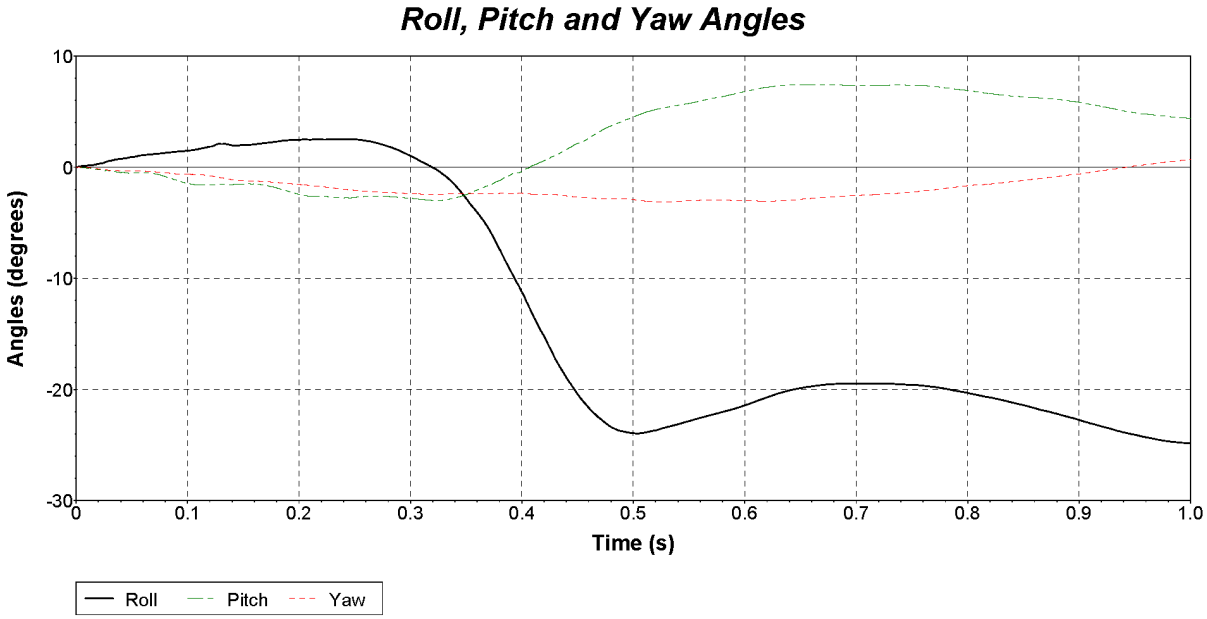
(c) 0.100 s (d) 0.150 s

(e) 0.200 s (f) 0.250 s

(g) 0.300 s (h) 0.3500 s

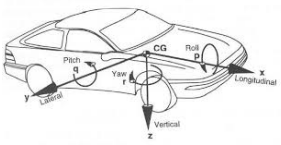
Figure E.6. Sequential Photographs for Test No. 612261-05-2 (Rear Views).

E.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for
determining orientation:

7. Yaw.
8. Pitch.
9. Roll.



Test Number: 612261-05-2
Test Standard Test Number: *MASH* Test 3-62
Test Article: Large Sign Slip Base
Test Vehicle: 2018 RAM 1500
Inertial Mass: 5005 lb
Gross Mass: 5005 lb
Impact Speed: 64.3 mi/h
Impact Angle: 26.5°

Figure E.7. Vehicle Angular Displacements for Test No. 612261-05-2.

E.4. VEHICLE ACCELERATIONS

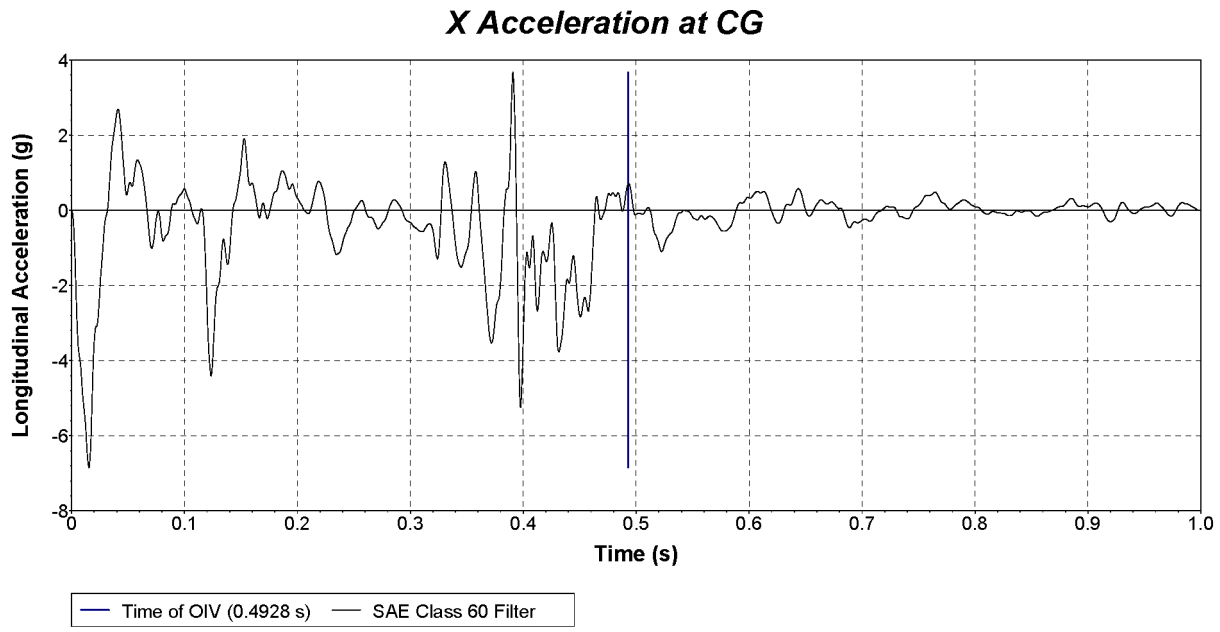


Figure E.8. Vehicle Longitudinal Accelerometer Trace for Test No. 612261-05-2 (Accelerometer Located at Center of Gravity).

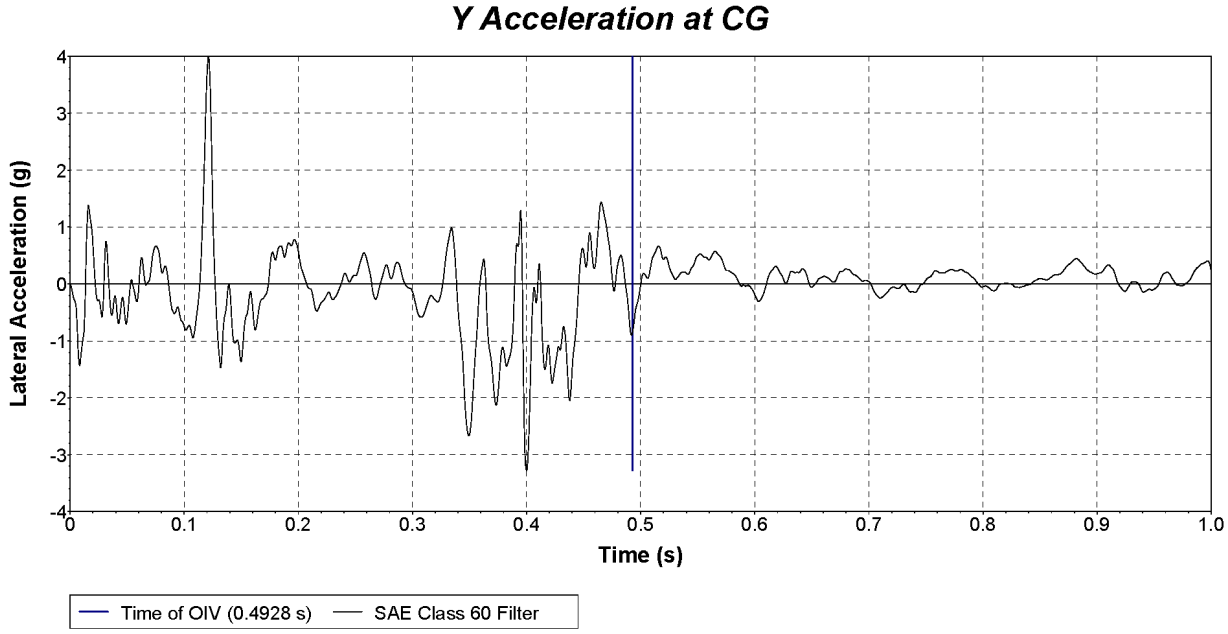


Figure E.9. Vehicle Lateral Accelerometer Trace for Test No. 612261-05-2 (Accelerometer Located at Center of Gravity).

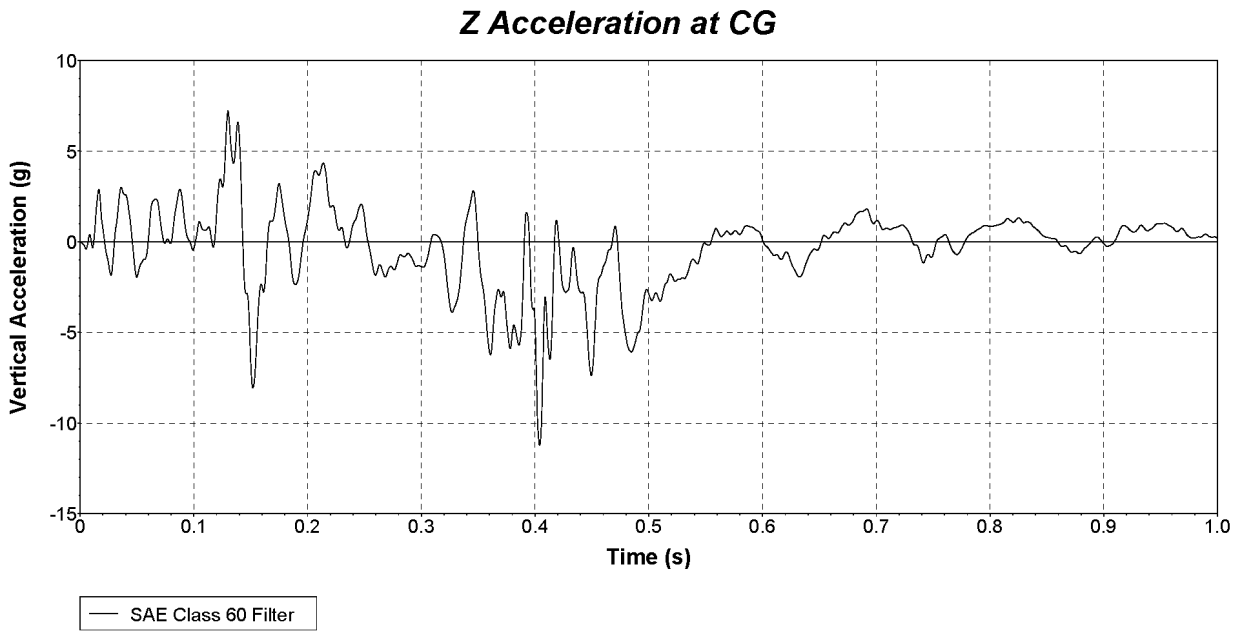


Figure E.10. Vehicle Vertical Accelerometer Trace for Test No. 612261-05-2 (Accelerometer Located at Center of Gravity).