TTI: 9-1002-12

MASH TL-3 TESTING AND EVALUATION OF THE TXDOT T131RC BRIDGE RAIL TRANSITION

ACCREDITED
ISO 17025 Laboratory
Testing Certificate # 2821.01

Crash testing performed at:
TTI Proving Ground
3100 SH 47, Building 7091
Bryan, TX 77807

Test Report 9-1002-12-4

Cooperative Research Program

TEXAS A&M TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM
COLLEGE STATION, TEXAS

TEXAS DEPARTMENT OF TRANSPORTATION

in cooperation with the
Federal Highway Administration and the
Texas Department of Transportation
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16. Abstract

This project designed and crash tested a transition design for the Texas Department of Transportation (TxDOT) T131RC Bridge Rail that would meet the strength and safety performance criteria for Test Level 3 of American Association of State Highway Official's (AASHTO) Manual for Assessing Safety Hardware (*MASH*).

The TxDOT T131RC Bridge Rail Transition contained and redirected the 1100C vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic rail deflection was 7.4 inches. No detached elements, fragments, or other debris were present to penetrate or to show potential for penetrating the occupant compartment, or to present hazard to others. Maximum occupant compartment deformation was 2.5 inches in the left door at occupant hip height. The 1100C vehicle remained upright during and after the collision event. Occupant risk factors were within the limits specified in *MASH*. The 1100C crossed the exit box within the limits specified in *MASH*.

The TxDOT T131RC Bridge Rail Transition contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 8.4 inches. No detached elements, fragments, or other debris were present to penetrate or to show potential for penetrating the occupant compartment, or to present hazard to others. Maximum occupant compartment deformation was 0.25 inch in the left door at occupant hip height. The 2270P vehicle remained upright during and after the collision event. Occupant risk factors were within the limits specified in *MASH*. The 22270P vehicle crossed the exit box within the limits specified in *MASH*. The TxDOT T131RC Bridge Rail Transition performed acceptably as a *MASH* TL-3 transition.

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Report 9-1002-12-4
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Project Title: Roadside Safety Device Crash Testing Program

Performed in cooperation with the
Texas Department of Transportation
and the
Federal Highway Administration

October 2012

TEXAS A&M TRANSPORTATION INSTITUTE
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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, and its contents are not intended for construction, bidding, or permit purposes. In addition, the above listed agencies assume no liability for its contents or use thereof. The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report. The engineer in charge of the project was Roger P. Bligh, P.E. (Texas, #78550).

TTI PROVING GROUND DISCLAIMER

The results of the crash testing reported herein apply only to the article being tested.

ACCREDITED
ISO 17025 Laboratory
Testing Certificate # 2821.01

Crash testing performed at:
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This research project was conducted under a cooperative program between the Texas A&M Transportation Institute, the Texas Department of Transportation, and the Federal Highway Administration. The TxDOT project director for this research was Rory Meza, P.E., Design Division. John Holt, P.E., with the Bridge Division served as project advisor and was also actively involved in all aspects of this research including design conceptualization. The TxDOT research engineer was Wade Odell, P.E., with the Research and Technology Implementation Office. The authors acknowledge and appreciate the guidance and assistance of these individuals.

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CHAPTER 1. INTRODUCTION

1.1 INTRODUCTION

This project was set up to provide the Texas Department of Transportation (TxDOT) with a mechanism to quickly and effectively evaluate high-priority issues related to roadside safety devices. Roadside safety devices shield motorists from roadside hazards such as non-traversable terrain and fixed objects. To maintain the desired level of safety for the motoring public, these safety devices must be designed to accommodate a variety of site conditions, placement locations, and a changing vehicle fleet. Periodically, there is a need to assess the compliance of existing safety devices with current vehicle testing criteria and develop new devices that address identified needs.

Under this project, roadside safety issues are identified and prioritized for investigation. Each roadside safety issue is addressed with a separate work plan, and the results are summarized in individual test reports.

1.2 BACKGROUND

The TxDOT Type T101RC Bridge Rail has been widely used as a retrofit for obsolete bridge rails mounted on a deck curb. The T101RC was 27 inches in height and anchored to the curb using four adhesive anchors. The height of the posts and the number of bridge rail elements varied depending on the height of the concrete curb. Based on unsatisfactory crash test performance of rail designs of similar height, TxDOT decided to develop a new retrofit bridge rail system that meets the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*) (*1*). This new bridge rail system, known as the TxDOT T131RC Bridge Rail, was successfully crash tested in according with *MASH* Test Level 3 (TL-3) and was recommended for implementation on new or retrofit railing applications (*2*). The implementation of this new bridge rail created a need to develop a transition from standard guardrail to the TxDOT T131RC Bridge Rail.

1.3 OBJECTIVES/SCOPE OF RESEARCH

This project developed a transition for connecting a 31-inch tall W-beam guardrail to the TxDOT T131RC Bridge Rail. The transition was required to meet the impact performance criteria for *MASH* TL-3.

CHAPTER 2. SYSTEM DETAILS

2.1 TEST ARTICLE DESIGN AND CONSTRUCTION

The TxDOT T131RC Bridge Rail Transition consists of a two nested 12 gage thrie beam sections supported by six W6×8.5 posts spaced at 37½ inches on centers. The nested thrie beams connect to a 10 gage asymmetric transition piece on the upstream end. This asymmetric transition section was connected to approximately 56 ft-3 inches of W-beam guardrail with an ET anchor terminal. The nested thrie beam transition was connected to a 10 gage end shoe on the downstream end. This end shoe was anchored to the end of the T131RC Bridge Rail. The overall length of the test installation was approximately 79 ft-6¾ inches.

The height to the top of the W-beam guardrail and transition was 31 inches above finished grade. The end shoe rail of the nested thrie beam sections were attached to the traffic face of the HSS6×6×1/4 tubes used for the T131RC Bridge Rail. Two steel fill blocks were located between the HSS6×6×1/4 tubes and were attached to the T131RC Bridge Rail tubes using two ¾-inch diameter × 20 inches long bolts. These fill blocks were mounted flush to the HSS6×6×¼ tubes in the bridge rail. The fill blocks were fabricated using HSS6×6×¼ tubes and were tapered on the exposed end in the installation. The thrie beam transition end shoe was attached to the end of the T131RC Bridge Rail using three ⅞-inch diameter A325 bolts. The thrie beam end shoe was anchored to the end of the rail and fill blocks near the W6×15 anchor post in the concrete curb. This anchor post was anchored within a 12-inch diameter by 30-inch deep concrete footing. This post and footing was constructed within an 80-inch long concrete curb constructed on the end of the T131RC Bridge Rail test installation.

Texas A&M Transportation Institute (TTI) Proving Ground personnel constructed 80 inches of concrete curb for this project. This concrete curb was 12 inches wide and 11 inches high and closely matched the traffic side face of the concrete curb used for the T131RC Bridge Rail. The concrete curb extended approximately 62 inches from the end of the T131RC Bridge Rail curb and tapered 6 inches back from the traffic side over a distance of 18 inches. The width of the curb was 6 inches at the end. The curb was 11 inches in height above grade and 12 inches below grade. A W6×15 end anchor post was located 60 inches from the centerline of the last T131RC Bridge Rail post located on the bridge rail test installation. This anchor post was cast within a 12-inch diameter by 30-inch deep unreinforced concrete footing. This footing was cast monolithically with the concrete curb. The concrete transition curb was not anchored to the concrete curb or deck for the T131RC Bridge Rail installation. Reinforcement in the concrete curb and footing consisted of #3 "U" shaped stirrups spaced approximately 10 inches on centers. Six #3 longitudinal bars were located within these stirrups. Concrete for the concrete curb and footing was specified to be 3600 psi.

Figure 2.1 gives overall details of the TxDOT T131RC Bridge Rail Transition, and a complete set of drawings can be found in Appendix A. Figure 2.2 shows photographs of the completed installation prior to testing.

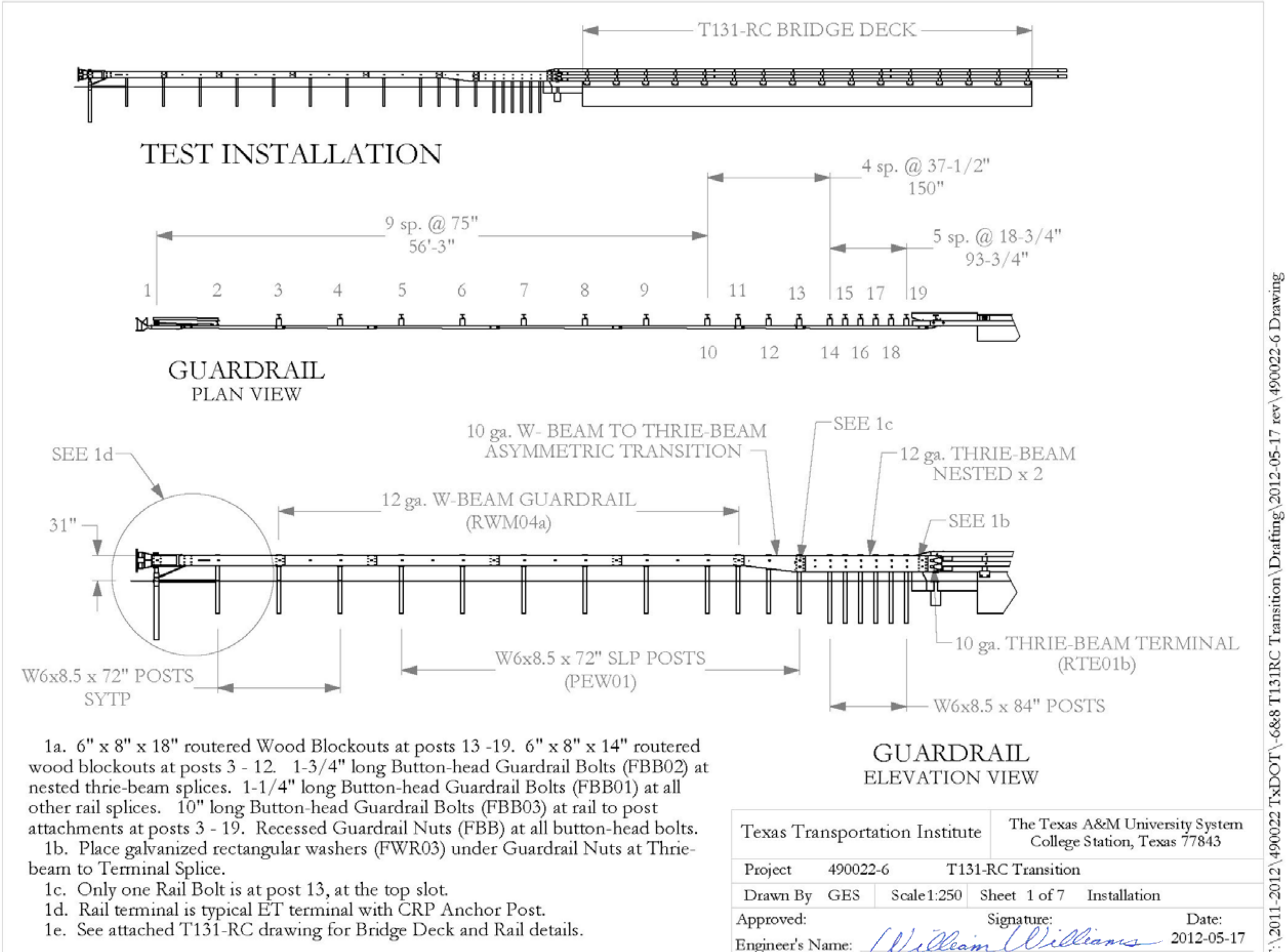


Figure 2.1. Details of the TxDOT T131RC Bridge Rail Transition Installation.

Figure 2.2. TxDOT T131RC Bridge Rail Transition before Testing.

2.2 MATERIAL SPECIFICATIONS

The fill blocks were fabricated using HSS6×6×¼ A500 Grade B material with welded A36 plate. All tubular rail elements were fabricated using HSS6×6×¼ A500 Grade B material. All reinforcing steel was specified to be ASTM A615 grade 60 material. All hex head bolts connecting the end shoe to the T131RC bridge rail were specified to be A325 structural bolts. All other bolts (button head bolts) used in the installation were A307 grade. Appendix B provides the material certification documents.

Concrete for the concrete curb and footing was specified to be 3600 psi. Compressive strength on the concrete used to construct the curb was measured at 4038 psi on the day of test no. 490022-6 (7 days of age). Compressive strength of the concrete on the day of test no. 490022-8 (11 days of age) was measured at 4436 psi.

2.3 SOIL CONDITIONS

In accordance with Appendix B of *MASH*, soil strength was measured on the day of each crash test. During installation of the TxDOT T131RC Bridge Rail Transition, two standard W6×16 posts were installed in the immediate vicinity of the transition, utilizing the same fill materials and installation procedures followed for the guardrail system and used in the reference tests (see Appendix C, Figure C1).

As the reference tests in Appendix C, Figure C1 show, the minimum post loads required for deflections at 5 inches, 10 inches, and 15 inches, measured at a height of 25 inches, are 3940 lb, 5500 lb, and 6540 lb, respectively (90 percent of static load for the initial standard installation).

On the day of test 490022-6, May 25, 2012, load on the test post at deflections of 5 inches, 10 inches, and 15 inches was 8969 lbf, 9575 lbf, and 9181 lbf, respectively. The strength of the backfill material met minimum requirements (see Appendix C, Figure C2).

On the day of test 490022-8, June 29, 2012, load on the test post at deflections of 5 inches, 10 inches, and 15 inches was 7667 lbf, 7636 lbf, and 7333 lbf, respectively. The strength of the backfill material met minimum requirements.

CHAPTER 3. TEST REQUIREMENTS AND EVALUATION CRITERIA

3.1 CRASH TEST MATRIX

According to *MASH*, two tests are recommended to evaluate bridge rail transitions to test level three (TL-3).

> ***MASH* Test Designation 3-20:** A 2425-lb vehicle impacting the critical impact point (CIP) of the transition at a nominal impact speed and angle of 62 mi/h and 25 degrees, respectively. This test investigates a barrier's ability to successfully contain and redirect a small passenger vehicle.

> ***MASH* Test Designation 3-21:** A 5000-lb pickup truck impacting the CIP of the transition at a nominal impact speed and angle of 62 mi/h and 25 degrees, respectively. This test investigates a barrier's ability to successfully contain and redirect light trucks and sport utility vehicles.

MASH test 3-20 for a transition section is an optional test to evaluate the occupant risk and post-impact trajectory criteria for all test levels. This test should be conducted if there is reasonable uncertainty regarding the impact performance of the system for impacts with small passenger vehicle. Due to the geometry of the transition design and certain structural components in the transition area, namely the curb, the research team decided that this test was necessary to evaluate the crash performance of the new transition design.

Procedures in *MASH* section 2.3.2.1 were used by the research team to calculate the CIP for each test. The target CIP for *MASH* test 3-20 with the small car was 5.0 ft upstream of centerline of anchor post in concrete curb (post 20). The target CIP for *MASH* test 3-21 with the pickup was 6.8 ft upstream of centerline of anchor post in concrete curb (post 20).

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 crash test was evaluated in accordance with the criteria presented in *MASH*. The performance of the TxDOT T131RC Bridge Rail Transition is judged on the basis of three factors: structural adequacy, occupant risk, and post impact vehicle trajectory. Structural adequacy is judged upon the ability of the TxDOT T131RC Bridge Rail Transition to contain and redirect the vehicle, or bring the vehicle to a controlled stop in a predictable manner. Occupant risk criteria evaluate the potential risk of hazard to occupants in the impacting vehicle, and, to some extent, other traffic, pedestrians, or workers in construction zones, if applicable. Post-impact vehicle trajectory is assessed to determine potential for secondary impact with other vehicles or fixed objects, creating further risk of injury to occupants of the impacting vehicle and/or risk of injury to occupants in other vehicles. The appropriate safety evaluation criteria from Table 5-1 of *MASH* were used to evaluate the crash test reported here and are listed in further detail under the assessment of the crash test.

CHAPTER 4. CRASH TEST PROCEDURES

4.1 TEST FACILITY

The full-scale crash tests reported herein were performed at Texas A&M Transportation Institute (TTI) Proving Ground, an International Standards Organization (ISO) 17025 accredited laboratory with American Association for Laboratory Accreditation (A2LA) Mechanical Testing certificate 2821.01. The full-scale crash test was performed according to TTI Proving Ground quality procedures and according to the *MASH* guidelines and standards.

The TTI Proving Ground is a 2000-acre complex of research and training facilities located 10 miles northwest of the main campus of Texas A&M University. The site, formerly an Air Force 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, durability and efficacy of highway pavements, and safety evaluation of roadside safety hardware. The site selected for construction and testing of the TxDOT T131RC Bridge Rail Transition evaluated under this project was along the edge of an out-of-service apron. The apron consists of an unreinforced jointed-concrete pavement in 12.5 ft × 15 ft blocks nominally 6 inches deep. The apron is over 60 years old, and the joints have some displacement, but are otherwise flat and level.

4.2 VEHICLE TOW AND GUIDANCE PROCEDURES

Each test vehicle 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, 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 two-to-one speed ratio between the test and tow vehicle existed with this system. Just prior to impact with the installation, the test vehicle was released to be unrestrained. The vehicle remained free-wheeling (i.e., no steering or braking inputs) until it cleared the immediate area of the test site, after which the brakes were activated to bring it to a safe and controlled stop.

4.3 DATA ACQUISITION SYSTEMS

4.3.1 Vehicle Instrumentation and Data Processing

Each test vehicle was instrumented with a self-contained, on-board data acquisition system. The signal conditioning and acquisition system is a 16-channel, Tiny Data Acquisition System (TDAS) Pro produced by Diversified Technical Systems, Inc. The accelerometers, that 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 size, solid state units designs for crash test service. The TDAS Pro hardware and software conform to the latest SAE J211, Instrumentation for Impact Test. Each of the 16 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 values per second with a resolution of one part in 65,536. Once recorded, the data are backed up inside the unit by internal batteries should the primary battery cable be severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark as well as initiating the recording process. After each test, the data are downloaded from the TDAS Pro unit into a laptop computer at the test site. The raw data are then processed by the Test Risk Assessment Program (TRAP) software to produce detailed reports of the test results. Each of the TDAS Pro units are returned to the factory annually for complete recalibration. Accelerometers and rate transducers are also calibrated annually with traceability to the National Institute for Standards and Technology. Acceleration data are measured with an expanded uncertainty of ±1.7 percent at a confidence factor of 95 percent (k=2).

TRAP uses the data from the TDAS Pro to compute occupant/compartment impact velocities, time of occupant/compartment impact after vehicle impact, and the 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 a 60-Hz 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 of the vehicle-fixed coordinate systems 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

An Alderson Research Laboratories Hybrid II, 50^{th} percentile male anthropomorphic dummy, restrained with lap and shoulder belts, was placed in the driver's position of the 1100C vehicle. The dummy was uninstrumented. According to *MASH*, the use of a dummy in the 2270P vehicle is optional. Researchers did not use a dummy in the test with the 2270P vehicle.

4.3.3 Photographic Instrumentation and Data Processing

Photographic coverage of the tests included three high-speed cameras: one overhead with a field of view perpendicular to the ground and directly over the impact point; one placed behind the installation at an angle; and a third placed to have a field of view parallel to and aligned with the installation at the downstream end. A flashbulb activated by pressure-sensitive tape switches was positioned on the impacting vehicle to indicate the instant of contact with the installation and was visible from each camera. The films from these high-speed cameras were analyzed on a computer-linked motion analyzer to observe phenomena occurring during the collision and to obtain time-event, displacement, and angular data. A mini-DV camera and still cameras recorded and documented conditions of the test vehicle and installation before and after the test.

CHAPTER 5. CRASH TEST NO. 490022-6 (*MASH* 3-20)

5.1 TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

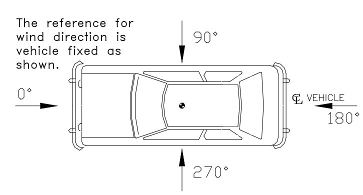
MASH test 3-20 involves an 1100C vehicle weighing 2425 lb ±55 lb and impacting the test article at an impact speed of 62.2 mi/h ±2.5 mi/h and an angle of 25 degrees ±1.5 degrees. The target impact point was 5.0 ft upstream of centerline of anchor post in concrete curb (post 20). The 2006 Kia Rio used in the test weighed 2423 lb and the actual impact speed and angle were 61.5 mi/h and 25.6 degrees, respectively. The actual impact point was 5.0 ft (60.5 inches) upstream of post 20. Target impact severity (IS) was 55.7 kip-ft, and the actual IS was 57.2 kip-ft.

5.2 TEST VEHICLE

A 2006 Kia Rio, shown in Figures 5.1 and 5.2, was used for the crash test. Test inertia weight of the vehicle was 2423 lb, and its gross static weight was 2602 lb. The height to the lower edge of the vehicle bumper was 7.12 inches, and it was 21.00 inches to the upper edge of the bumper. Table D1 in Appendix D give additional dimensions and information on the vehicle. The vehicle was directed into the installation using the cable reverse tow and guidance system, and was released to be free-wheeling just prior to impact.

5.3 WEATHER CONDITIONS

The test was performed on the morning of May 25, 2012. Weather conditions at the time of testing were as follows: wind speed: 14 mi/h; wind direction: 168 degrees with respect to the vehicle (vehicle was traveling in a northwesterly direction), temperature: 86°F, relative humidity: 65 percent.



5.4 TEST DESCRIPTION

The 2006 Kia Rio, traveling at an impact speed of 61.5 mi/h, impacted the TxDOT T131RC Bridge Rail Transition 60.5 inches upstream of post 20 at an impact angle of 25.6 degrees. At approximately 0.012 s after impact, the thrie beam guardrail began to deflect toward the field side, and at 0.024 s, the vehicle began to redirect. The concrete transition curb began to deflect toward the field side at 0.029 s, and a crack formed in the concrete bridge rail curb downstream of post 21 at 0.053 s. The concrete bridge rail curb under post 21 began to crack at 0.057 s with some of the pieces of concrete spalling off at 0.220 s. At 0.307 s, the vehicle lost contact with the bridge rail traveling at an exit speed and angle of 44.8 mi/h and 4.4 degrees, respectively. Brakes on the vehicle were not applied, and the vehicle came to rest 180 ft downstream of impact and 21 ft toward traffic lanes. Figures D1 and D2 in Appendix D show sequential photographs of the test period.

Figure 5.1. Vehicle/TxDOT T131RC Bridge Rail Transition Geometrics for Test No. 490022-6.

Figure 5.2. Vehicle before Test No. 490022-6.

5.5 DAMAGE TO TEST INSTALLATION

Figures 5.3 and 5.4 show damage to the T131RC Transition and bridge rail. The transition curb deflected toward the field side 0.5 inch. No cracking of the transition curb was noted. The concrete curb around post 21 was cracked significantly, and there was minor cracking around post 22. The vehicle was in contact with the installation 13.3 ft. Vehicle intrusion (formerly working width) was 7.4 inches. Maximum deflection of the thrie beam guardrail during the test was 7.4 inches, and maximum residual deformation after the test was 1.25 inches.

5.6 VEHICLE DAMAGE

Figure 5.5 presents damage to the 1100C vehicle. The left strut and strut tower were deformed. The front bumper, grill, hood, radiator, radiator support, left front fender, left front tire and wheel rim, left front door, left rear door, left rear quarter panel were deformed. The windshield sustained stress cracks from the left lower corner. Maximum crush to the exterior of the vehicle was 12.0 inches in the front plane in the left front corner at bumper height. Maximum occupant compartment deformation was 2.5 inches in the left front door near occupant hip height. The floor pan and firewall were also deformed. Tables D2 and D3 in Appendix D present the exterior crush profile and occupant compartment deformations.

5.7 OCCUPANT RISK FACTORS

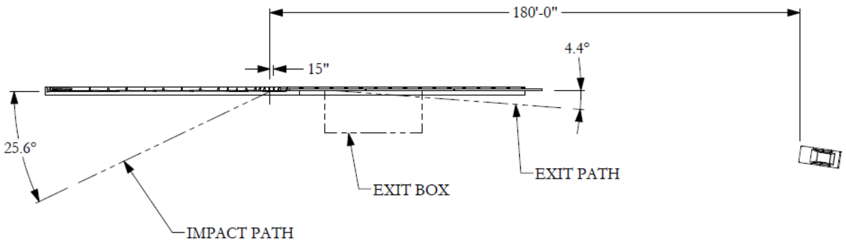
Data from the accelerometer, located at the vehicle center of gravity, were digitized for evaluation of occupant risk. In the longitudinal direction, the occupant impact velocity was 21.0 ft/s at 0.080 s, the highest 0.010-s occupant ridedown acceleration was 6.1 Gs from 0.083 to 0.093 s, and the maximum 0.050-s average acceleration was −10.8 Gs between 0.023 and 0.073 s. In the lateral direction, the occupant impact velocity was 27.6 ft/s at 0.080 s, the highest 0.010-s occupant ridedown acceleration was 6.3 Gs from 0.118 to 0.128 s, and the maximum 0.050-s average was 15.3 Gs between 0.025 and 0.075 s. Theoretical Head Impact Velocity (THIV) was 37.7 km/h or 10.5 m/s at 0.078 s; Post-Impact Head Decelerations (PHD) was 6.9 Gs between 0.117 and 0.127 s; and Acceleration Severity Index (ASI) was 1.92 between 0.025 and 0.075 s. Figure 5.6 summarizes these data and other pertinent information from the test. Vehicle angular displacements and accelerations versus time traces are presented in Appendix D, Figures D3 through D9.

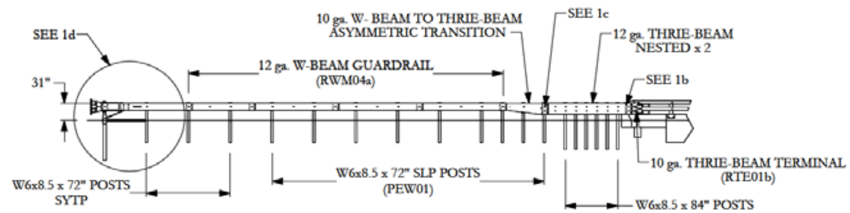
Figure 5.3. Vehicle/TxDOT T131RC Bridge Rail Transition Positions after Test No. 490022-6.

Figure 5.4. TxDOT T131RC Bridge Rail Transition after Test No. 490022-6.

Figure 5.5. Vehicle after Test No. 490022-6.

0.000 s | 0.120 s | 0.240 s | 0.360 s





General Information
- Test Agency: Texas A&M Transportation Institute (TTI)
- Test Standard Test No.: MASH Test 3-20
- TTI Test No.: 49002-6
- Test Date: 2012-05-25

Test Article
- Type: Transition
- Name: TxDOT T131RC
- Installation Length: 76.5 ft
- Material or Key Elements: W-beam to thrie beam asymmetric transition to nested thrie beam on W6x8.5 x 84-inch posts

Soil Type and Condition: Standard soil, dry

Test Vehicle
- Type/Designation: 1100C
- Make and Model: 2006 Kia Rio
- Curb: 2489 lb
- Test Inertial: 2423 lb
- Dummy: 179 lb
- Gross Static: 2602 lb

Impact Conditions
- Speed: 61.5 mi/h
- Angle: 25.6 degrees
- Location/Orientation: 5 ft upstrm post 20

Exit Conditions
- Speed: 44.8 mi/h
- Angle: 4.4 degrees

Occupant Risk Values
- Impact Velocity
  - Longitudinal: 21.0 ft/s
  - Lateral: 27.6 ft/s
- Ridedown Accelerations
  - Longitudinal: 6.1 G
  - Lateral: 6.3 G
- THIV: 37.7 km/h
- PHD: 6.9 G
- ASI: 1.92
- Max. 0.050-s Average
  - Longitudinal: −10.8 G
  - Lateral: 15.3 G
  - Vertical: −1.7 G

Post-Impact Trajectory
- Stopping Distance: 180 ft dwnstrm, 21 ft twd traffic

Vehicle Stability
- Maximum Yaw Angle: 33 degrees
- Maximum Pitch Angle: 6 degrees
- Maximum Roll Angle: 5 degrees
- Vehicle Snagging: No
- Vehicle Pocketing: No

Test Article Deflections
- Dynamic: 7.4 inches
- Permanent: 1.25 inches
- Vehicle Penetration: 21.0 inches

Vehicle Damage
- VDS: 11LFQ5
- CDC: 11FLEW4
- Max. Exterior Deformation: 12.0 inches
- OCDI: LF0000010
- Max. Occupant Compartment Deformation: 2.5 inches

Figure 5.6. Summary of Results for *MASH* Test 3-20 on the TxDOT T131RC Bridge Rail Transition.

5.8 ASSESSMENT OF TEST RESULTS

An assessment of the test based on the applicable *MASH* safety evaluation criteria is provided below.

5.8.1 Structural Adequacy

A. Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.

Results: The TxDOT T131RC Bridge Rail Transition contained and redirected the 1100C vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 7.4 inches. (PASS)

5.8.2 Occupant Risk

D. Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.
Deformation of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.3 and Appendix E of MASH. (roof ≤4.0 inches; windshield = ≤3.0 inches; side windows = no shattering by test article structural member; wheel/foot well/toe pan ≤9.0 inches; forward of A-pillar ≤12.0 inches; front side door area above seat ≤9.0 inches; front side door below seat ≤12.0 inches; floor pan/transmission tunnel area ≤12.0 inches).

Results: No detached elements, fragments, or other debris were present to penetrate or to show potential for penetrating the occupant compartment, or to present hazard to others. (PASS)
Maximum occupant compartment deformation was 2.5 inches in the left door at occupant hip height. (PASS)

F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.

Results: The 1100C vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 5 degrees and 6 degrees, respectively. (PASS)

H. Occupant impact velocities should satisfy the following:
Longitudinal and Lateral Occupant Impact Velocity

Preferred	*Maximum*
30 ft/s	*40 ft/s*

Results: Longitudinal occupant impact velocity was 21.0 ft/s, and lateral occupant impact velocity was 27.6 ft/s. (PASS)

I. Occupant ridedown accelerations should satisfy the following:

Longitudinal and Lateral Occupant Ridedown Accelerations

Preferred	*Maximum*
15.0 Gs	*20.49 Gs*

Results: Longitudinal occupant ridedown acceleration was 6.1 G, and lateral occupant ridedown acceleration was 6.3 G. (PASS)

5.8.3 Vehicle Trajectory

For redirective devices, the vehicle shall exit the barrier within the exit box (not less than 32.8 ft).

Result: The 1100C crossed the exit box 80.1 ft downstream of loss of contact with the installation. (PASS)

CHAPTER 6. CRASH TEST 490022-8 (*MASH* 3-21)

6.1 TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

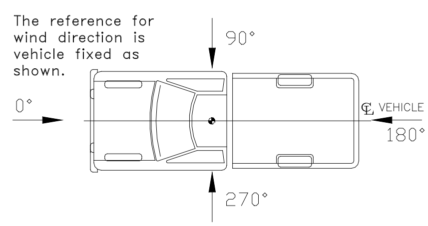
MASH test 3-11 involves a 2270P vehicle weighing 5000 lb ±100 lb and impacting the test article at an impact speed of 62.2 mi/h ±2.5 mi/h and an angle of 25 degrees ±1.5 degrees. The target impact point was 6.8 ft upstream of centerline of anchor post in concrete curb (post 20). The 2008 Dodge Ram 1500 pickup truck used in the test weighed 5015 lb and the actual impact speed and angle were 62.7 mi/h and 25.1 degrees, respectively. The actual impact point was 7.2 ft upstream of post 20. Target IS was 115.1 kip-ft, and actual IS was 118.6 kip-ft.

6.2 TEST VEHICLE

A 2008 Dodge Ram 1500 pickup truck, shown in Figures 6.1 and 6.2, was used for the crash test. Test inertia weight of the vehicle was 5015 lb, and its gross static weight was 5015 lb. The height to the lower edge of the vehicle bumper was 13.75 inches, and it was 25.38 inches to the upper edge of the bumper. The height to the vehicle's center of gravity was 29.0 inches. Tables E1 and E2 in Appendix E give additional dimensions and information on the vehicle. The vehicle was directed into the installation using the cable reverse tow and guidance system, and was released to be unrestrained just prior to impact.

6.3 WEATHER CONDITIONS

The test was performed on the morning of June 29, 2012. Weather conditions at the time of testing were as follows: wind speed: 6 mi/h; wind direction: 180 degrees with respect to the vehicle (vehicle was traveling in a northwesterly direction); temperature: 90°F, relative humidity: 63 percent.



6.4 TEST DESCRIPTION

The 2008 Dodge Ram 1500 pickup truck, traveling at an impact speed of 62.7 mi/h, impacted the TxDOT T131RC Bridge Rail Transition 7.2 ft upstream of post 20 at an impact angle of 25.1 degrees. At approximately 0.024 s, the thrie beam guardrail began to deflect toward the field side, and at 0.050 s, the vehicle began to redirect. The transition curb began to deflect toward the field side at 0.127 s, and the rear of the vehicle contacted the transition at 0.209 s. At 0.363 s, the vehicle lost contact with the installation traveling at an exit speed and angle of 47.1 mi/h and 5.6 degrees, respectively. Brakes on the vehicle were applied 1.8 s after impact, and the vehicle subsequently came to rest 202 ft downstream of impact with the left side of the vehicle aligned with the traffic face of the bridge rail. Figures E1 and E2 in Appendix E show sequential photographs of the test period.

Figure 6.1. Vehicle/TxDOT T131RC Bridge Rail Transition Geometrics for Test No. 490022-8.

Figure 6.2. Vehicle before Test No. 490022-8.

6.5 DAMAGE TO TEST INSTALLATION

Figure 6.3 and 6.4 show damage to the T131RC Transition and the bridge rail. Post 14 was deflected toward the field side 0.25 inch, and post 15 was deflected toward the field side 0.5 inch. The soil around post 16 and 17 was disturbed. Post 18 was deflected toward the field side 1.38 inches, and maximum residual deformation at post 18 was 1.0 inch. The soil around post 19 was disturbed. The transition curb deflected toward the field side 1.5 inches. The transition curb was not cracked, but was marred with tire marks. Significant cracking of the bridge rail curb occurred at post 21 with slight damage at post 22. Length of contact of the vehicle with the installation was 15.3 ft. Vehicle intrusion (formerly working width) was 15.9 inches. Maximum dynamic deflection during the test was 8.37 inches, and maximum permanent residual deformation was 1.0 inch.

6.6 VEHICLE DAMAGE

Figure 6.5 presents damage to the 2270P vehicle. The left upper ball joint and left front upper and lower A-arms were deformed and the rear axle was broken. The front bumper, grill, hood, radiator, fan, water pump, left front fender, left front tire and wheel rim, left front door, left rear door, left rear exterior bed, left rear tire and wheel rim and rear bumper were deformed. The windshield sustained stress cracks from the right lower corner due to impact with a secondary barrier. Maximum crush to the exterior of the vehicle was not attainable due to the secondary impact. Maximum occupant compartment deformation was 0.25 inch in the left front door near occupant hip height. The floor pan and firewall were also deformed. Figure 6.6 shows photographs of the interior of the vehicle. Tables E3 and E4 in Appendix E present the exterior crush profile and occupant compartment deformations.

6.7 OCCUPANT RISK FACTORS

Data from the accelerometer, located at the vehicle center of gravity, were digitized for evaluation of occupant risk. In the longitudinal direction, the occupant impact velocity was 18.4 ft/s at 0.092 s, the highest 0.010-s occupant ridedown acceleration was 6.6 Gs from 0.120 to 0.130 s, and the maximum 0.050-s average acceleration was −8.0 Gs between 0.040 and 0.090 s. In the lateral direction, the occupant impact velocity was 23.6 ft/s at 0.092 s, the highest 0.010-s occupant ridedown acceleration was 9.4 Gs from 0.221 to 0.231 s, and the maximum 0.050-s average was 12.4 Gs between 0.030 and 0.080 s. Theoretical Head Impact Velocity (THIV) was 32.4 km/h or 9.0 m/s at 0.090 s; Post-Impact Head Decelerations (PHD) was 9.5 Gs between 0.221 and 0.231 s; and Acceleration Severity Index (ASI) was 1.52 between 0.030 and 0.080 s. Figure 6.7 summarizes these data and other pertinent information from the test. Vehicle angular displacements and accelerations versus time traces are presented in Appendix E, Figures E2 through E8.

Figure 6.3. Vehicle/TxDOT T131RC Bridge Rail Transition Positions after Test No. 490022-8.

Figure 6.4. TxDOT T131RC Bridge Rail Transition after Test No. 490022-8.

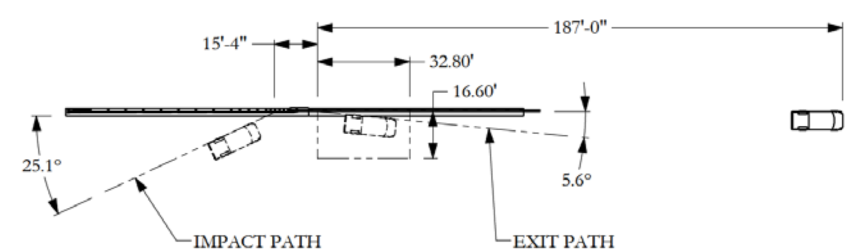
Figure 6.5. Vehicle after Test No. 490022-8.

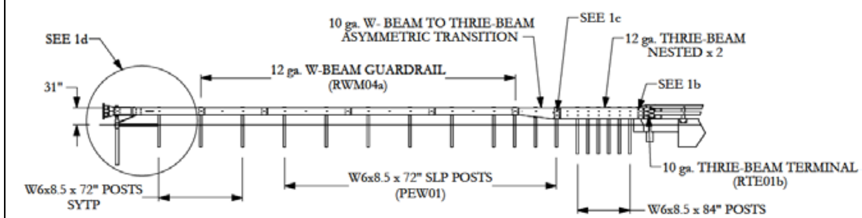
Before Test

After Test

Figure 6.6. Interior of Vehicle for Test No. 490022-8.

0.000 s | 0.120 s | 0.240 s | 0.300 s





General Information
Test Agency .... Texas A&M Transportation Institute
Test Standard Test No. .... (TTI)
TTI Test No. .... MASH Test 3-21
Test Date 490022-8
Test Article 2012-07-29
Type ....
Name .... Transition
Installation Length .... TxDOT T131RC Bridge Rail Transition
Material or Key Elements ...... 76.5 ft
W-beam to thrie beam asymmetric
transition to nested thrie beam on
Soil Type and Condition......... W6x8.5 x 84-inch posts
Test Vehicle Standard soil, dry
Type/Designation ....
Make and Model.................... 2270P
Curb .... 2008 Dodge Ram 1500 Pickup
Test Inertial .... 5022 lb
Dummy................................. 5015 lb
Gross Static.......................... No dummy
5015 lb

Impact Conditions
Speed................................62.7 mi/h
Angle.................................25.1 degrees
Location/Orientation ....7.2 ft upstrm post 20
Exit Conditions
Speed................................47.1 mi/h
Angle.................................5.6 degrees
Occupant Risk Values
Impact Velocity
Longitudinal....................18.4 ft/s
Lateral............................23.6 ft/s
Ridedown Accelerations
Longitudinal....................6.6 G
Lateral............................9.4 G
THIV..................................32.4 km/h
PHD ....9.5 G
ASI 1.52
Max. 0.050-s Average
Longitudinal....................−8.0 G
Lateral............................12.4 G
Vertical...........................−2.8 G

Post-Impact Trajectory
Stopping Distance .... 202 ft dwnstrm
Left side w/face
Vehicle Stability
Maximum Yaw Angle................ 30 degrees
Maximum Pitch Angle............... 8 degrees
Maximum Roll Angle................. 21 degrees
Vehicle Snagging .... No
Vehicle Pocketing..................... No
Test Article Deflections
Dynamic .... 8.4 inches
Permanent................................ 1.0 inch
Vehicle Penetration .... 15.9 inches
Vehicle Damage
VDS 11LFQ4
CDC 11FLEW3
Max. Exterior Deformation......... Not obtainable
OCDI LF0000000
Max. Occupant Compartment
Deformation .... 0.25 inch

Figure 6.7. Summary of Results for *MASH* Test 3-21 on the TxDOT T131RC Bridge Rail Transition.

6.8 ASSESSMENT OF TEST RESULTS

An assessment of the test based on the applicable *MASH* safety evaluation criteria is provided below.

6.8.1 Structural Adequacy

A. *Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.*

Results: The TxDOT T131RC Bridge Rail Transition contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 8.4 inches. (PASS)

6.8.2 Occupant Risk

D. *Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.*
Deformation of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.3 and Appendix E of MASH (roof ≤4.0 inches; windshield = ≤3.0 inches; side windows = no shattering by test article structural member; wheel/foot well/toe pan ≤9.0 inches; forward of A-pillar ≤12.0 inches; front side door area above seat ≤9.0 inches; front side door below seat ≤12.0 inches; floor pan/transmission tunnel area ≤12.0 inches).

Results: No detached elements, fragments, or other debris were present to penetrate of to show potential for penetrating the occupant compartment, or to present hazard to others. (PASS)
Maximum occupant compartment deformation was 0.25 inch in the left door at occupant hip height. (PASS)

F. *The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.*

Results: The 2270P vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 21 degrees and 8 degrees, respectively. (PASS)

I. *Occupant impact velocities should satisfy the following:*

Longitudinal and Lateral Occupant Impact Velocity

Preferred	*Maximum*
30 ft/s	*40 ft/s*

Results: Longitudinal occupant impact velocity was 18.4 ft/s, and lateral occupant impact velocity was 23.6 ft/s. (PASS)

I. Occupant ridedown accelerations should satisfy the following:

Longitudinal and Lateral Occupant Ridedown Accelerations

Preferred	*Maximum*
15.0 Gs	*20.49 Gs*

Results: Longitudinal ridedown acceleration was 6.6 G, and lateral ridedown acceleration was 9.4 G. (PASS)

6.8.3 Vehicle Trajectory

For redirective devices, the vehicle shall exit the barrier within the exit box (not less than 32.8 ft).

Result: The 22270P vehicle crossed the exit box within the limits specified in *MASH*. (PASS)

CHAPTER 7. SUMMARY AND CONCLUSIONS

7.1 SUMMARY OF CRASH TEST RESULTS

7.1.1 Crash Test No. 490022-6 (*MASH* Test 3-20)

The TxDOT T131RC Bridge Rail Transition contained and redirected the 1100C vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 7.4 inches. No detached elements, fragments, or other debris were present to penetrate of to show potential for penetrating the occupant compartment, or to present hazard to others. Maximum occupant compartment deformation was 2.5 inches in the left door at occupant hip height. The 1100C vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 5 degrees and 6 degrees, respectively. Occupant risk factors were within the preferred limits specified in *MASH*. The 1100C crossed the exit box 80.1 ft downstream of loss of contact with the installation, which was within the *MASH* recommendation.

7.1.2 Crash Test No. 490022-8 (*MASH* Test 3-21)

The TxDOT T131RC Bridge Rail Transition contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 8.4 inches. No detached elements, fragments, or other debris were present to penetrate of to show potential for penetrating the occupant compartment, or to present hazard to others. Maximum occupant compartment deformation was 0.25 inch in the left door at occupant hip height. The 2270P vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 21 degrees and 8 degrees, respectively. Occupant risk factors were within the preferred limits specified in *MASH*. The 22270P vehicle crossed the exit box within the limits specified in *MASH*.

7.2 CONCLUSIONS

The TxDOT T131RC Bridge Rail Transition performed acceptably as a *MASH* TL-3 transitions, as shown in Tables 7.1 and 7.2.

Table 7.1. Performance Evaluation Summary for *MASH* Test 3-20 on the TxDOT T131RC Bridge Rail Transition.

Test Agency: Texas A&M Transportation Institute — Test No.: 490022-6 — Test Date: 201205-25

MASH Test 3-20 Evaluation Criteria	Test Results	Assessment
Structural Adequacy A. *Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.*	The TxDOT T131RC Bridge Rail Transition contained and redirected the 1100C vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 7.4 inches.	Pass
Occupant Risk D. *Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.*	No detached elements, fragments, or other debris were present to penetrate of to show potential for penetrating the occupant compartment, or to present hazard to others.	Pass
Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.3 and Appendix E of MASH.	Maximum occupant compartment deformation was 2.5 inches in the left door at occupant hip height.	Pass
F. *The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.*	The 1100C vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 5 and 6 degrees, respectively.	Pass
H. *Longitudinal and lateral occupant impact velocities should fall below the preferred value of 30 ft/s, or at least below the maximum allowable value of 40 ft/s.*	Longitudinal occupant impact velocity was 21.0 ft/s, and lateral occupant impact velocity was 27.6 ft/s	Pass
I. *Longitudinal and lateral occupant ridedown accelerations should fall below the preferred value of 15.0 Gs, or at least below the maximum allowable value of 20.49 Gs.*	Longitudinal occupant ridedown acceleration was 6.1 G, and lateral occupant ridedown acceleration was 6.3 G.	Pass
Vehicle Trajectory *For redirective devices, the vehicle shall exit the barrier within the exit box (not less than 32.8 ft).*	The 1100C crossed the exit box 80.1 ft downstream of loss of contact with the installation.	Pass

Table 7.2. Performance Evaluation Summary for *MASH* Test 3-21 on the TxDOT T131RC Bridge Rail Transition.

Test Agency: Texas A&M Transportation Institute — Test No.: 490022-8 — Test Date: 2012-06-29

MASH Test 3-21 Evaluation Criteria	Test Results	Assessment
Structural Adequacy		
A. *Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.*	The TxDOT T131RC Bridge Rail Transition contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 8.4 inches.	Pass
Occupant Risk		
D. *Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.*	No detached elements, fragments, or other debris were present to penetrate of to show potential for penetrating the occupant compartment, or to present hazard to others.	Pass
Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.3 and Appendix E of MASH.	Maximum occupant compartment deformation was 0.25 inch in the left door at occupant hip height.	Pass
F. *The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.*	The 2270P vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 21 and 8 degrees, respectively.	Pass
H. *Longitudinal and lateral occupant impact velocities should fall below the preferred value of 30 ft/s, or at least below the maximum allowable value of 40 ft/s.*	Longitudinal occupant impact velocity was 18.4 ft/s, and lateral occupant impact velocity was 23.6 ft/s.	Pass
I. *Longitudinal and lateral occupant ridedown accelerations should fall below the preferred value of 15.0 Gs, or at least below the maximum allowable value of 20.49 Gs.*	Longitudinal ridedown acceleration was 6.6 G, and lateral ridedown acceleration was 9.4 G.	Pass
Vehicle Trajectory		
For redirective devices, the vehicle shall exit the barrier within the exit box (not less than 32.8 ft).	The 22270P vehicle crossed the exit box within the limits specified in *MASH*.	Pass

CHAPTER 8. IMPLEMENTATION STATEMENT

TTI researchers recently designed and successfully crash tested the TxDOT Type 131RC Bridge Rail. The T131RC Bridge Rail consists of two HSS6×6×¼ steel tubes supported by W6×15 steel posts spaced on 5 ft on centers. The posts were anchored to an 11-inch high concrete curb. The curb was 10 inches wide at the base and 8 inches wide at the top. The posts were anchored to the concrete curb using ¾-inch diameter adhesive anchors. The base plate for the T131RC post design was bent to conform to the shape of the concrete curb. The TxDOT T131RC Bridge Rail tested previously met all the strength and safety performance criteria of *MASH*.

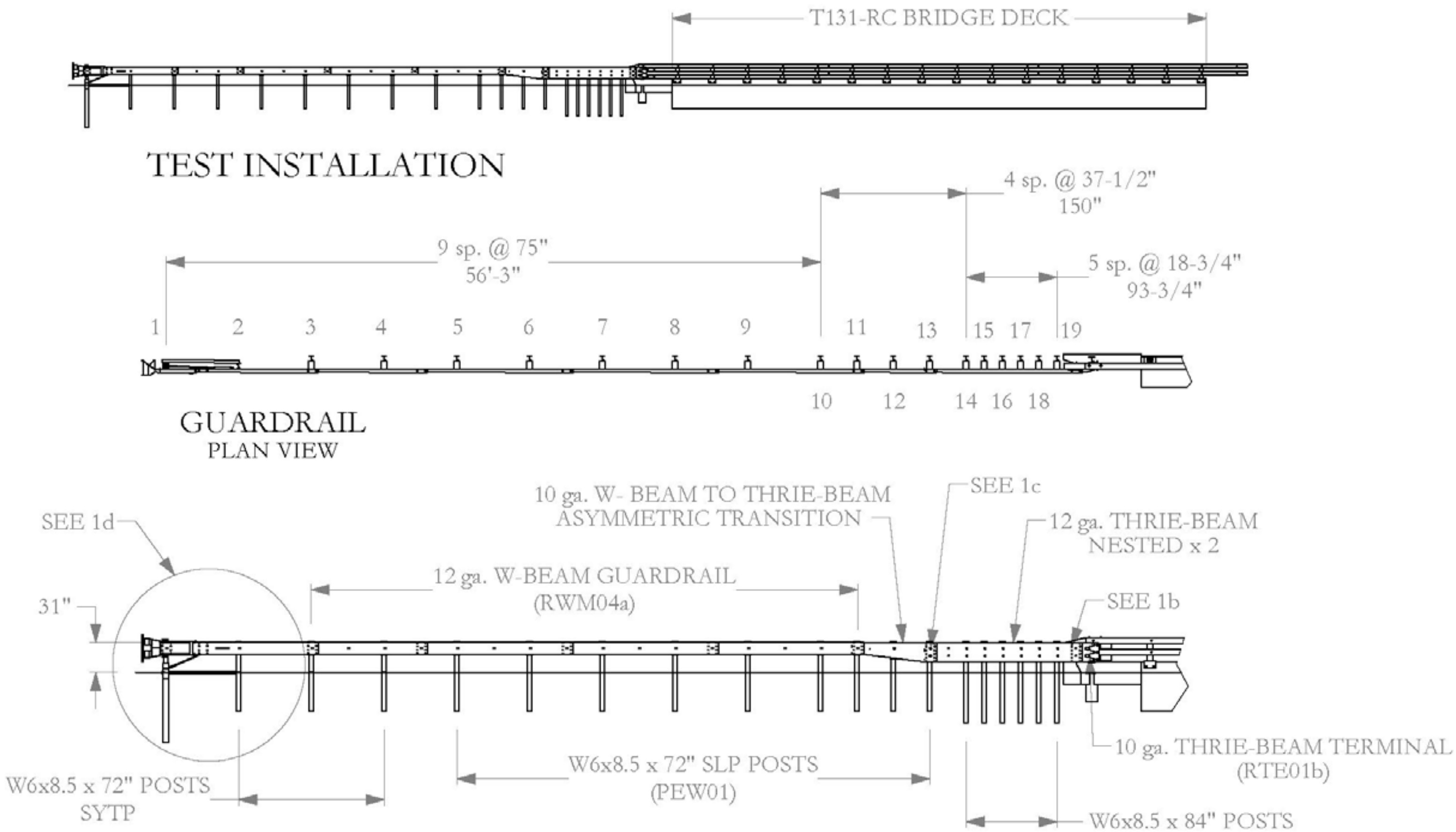
The purpose of this portion of the project was to develop a transition for connecting a 31-inch tall W-beam approach guardrail to the new T131RC Bridge Rail. The transition designed and tested for this project met all *MASH* safety performance criteria for a TL-3 transition. The transition is recommended for implementation on all projects using the new T131RC Bridge Rail design.

REFERENCES

1. AASHTO, *Manual for Assessing Safety Hardware*, American Association of State Highway and Transportation Officials, Washington, D.C., 2009.

2 W. F. Williams, R. P. Bligh, and W. L. Menges, *MASH Test 3-11 on the T131RC Bridge Rail*, Test Report No. 9-1002-1, Texas Transportation Institute, The Texas A&M University System, College Station, TX, June 2012.

APPENDIX A. DETAILS OF THE T131RC TRANSITION



1a. 6" x 8" x 18" routered Wood Blockouts at posts 13 -19. 6" x 8" x 14" routered wood blockouts at posts 3 - 12. 1-3/4" long Button-head Guardrail Bolts (FBB02) at nested thrie-beam splices. 1-1/4" long Button-head Guardrail Bolts (FBB01) at all other rail splices. 10" long Button-head Guardrail Bolts (FBB03) at rail to post attachments at posts 3 - 19. Recessed Guardrail Nuts (FBB) at all button-head bolts.
1b. Place galvanized rectangular washers (FWR03) under Guardrail Nuts at Thrie-beam to Terminal Splice.
1c. Only one Rail Bolt is at post 13, at the top slot.
1d. Rail terminal is typical ET terminal with CRP Anchor Post.
1e. See attached T131-RC drawing for Bridge Deck and Rail details.

GUARDRAIL
ELEVATION VIEW

Texas Transportation Institute	The Texas A&M University System College Station, Texas 77843		
Project 490022-6	T131-RC Transition		
Drawn By GES	Scale 1:250	Sheet 1 of 7	Installation
Approved: Engineer's Name: William Williams	Signature: William Williams	Date: 2012-05-17	

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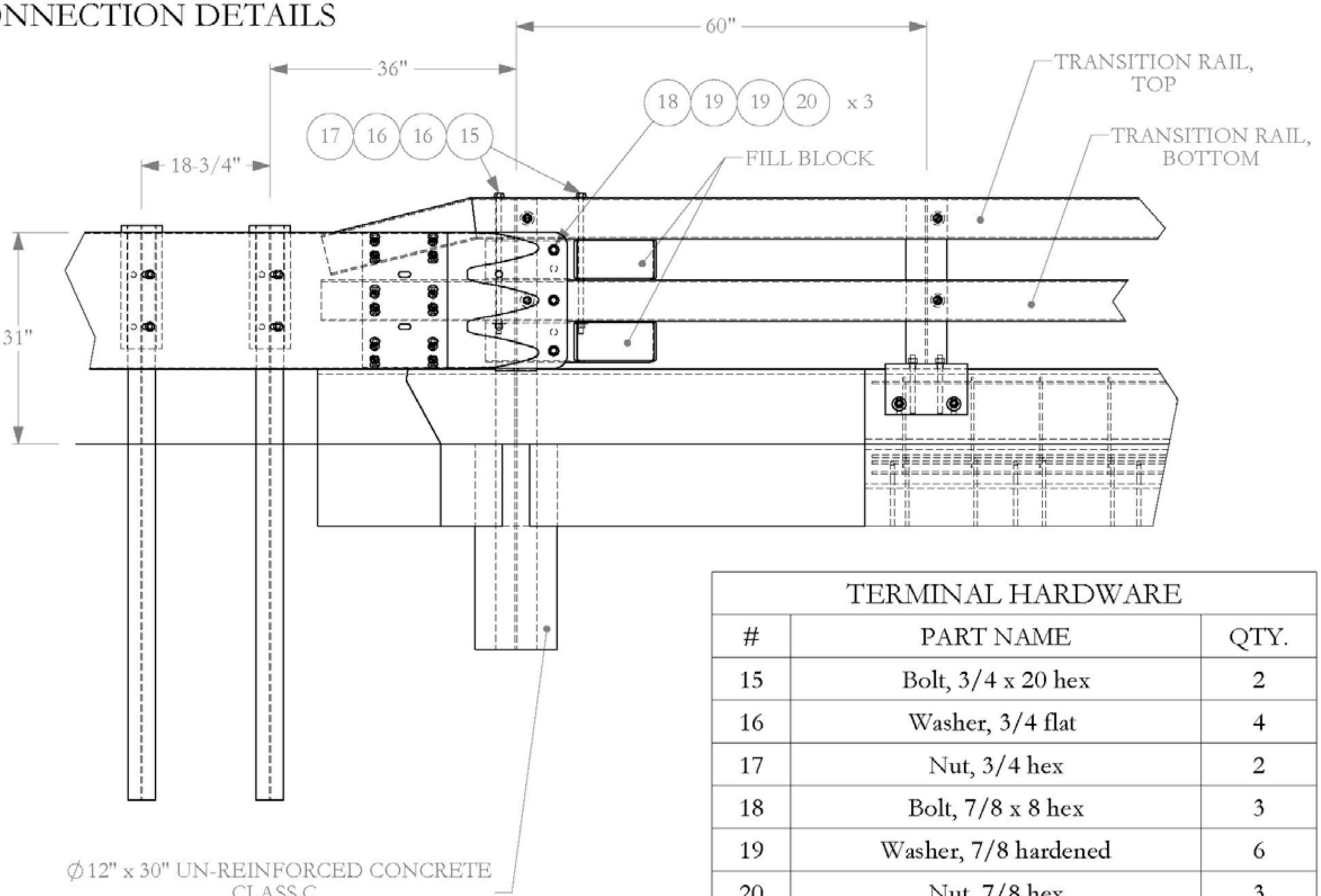
CONNECTION DETAILS



TERMINAL HARDWARE		
#	PART NAME	QTY.
15	Bolt, 3/4 x 20 hex	2
16	Washer, 3/4 flat	4
17	Nut, 3/4 hex	2
18	Bolt, 7/8 x 8 hex	3
19	Washer, 7/8 hardened	6
20	Nut, 7/8 hex	3

2a. All bolts this sheet are A325 and nuts are Heavy Hex. Grade 5 may be used for 3/4 x 20 bolt.

Texas Transportation Institute		The Texas A&M University System College Station, Texas 77843	
Project 490022-6	T131-RC Transition		2012-05-17
Drawn By GES	Scale 1:20	Sheet 2 of 7	Transition Details

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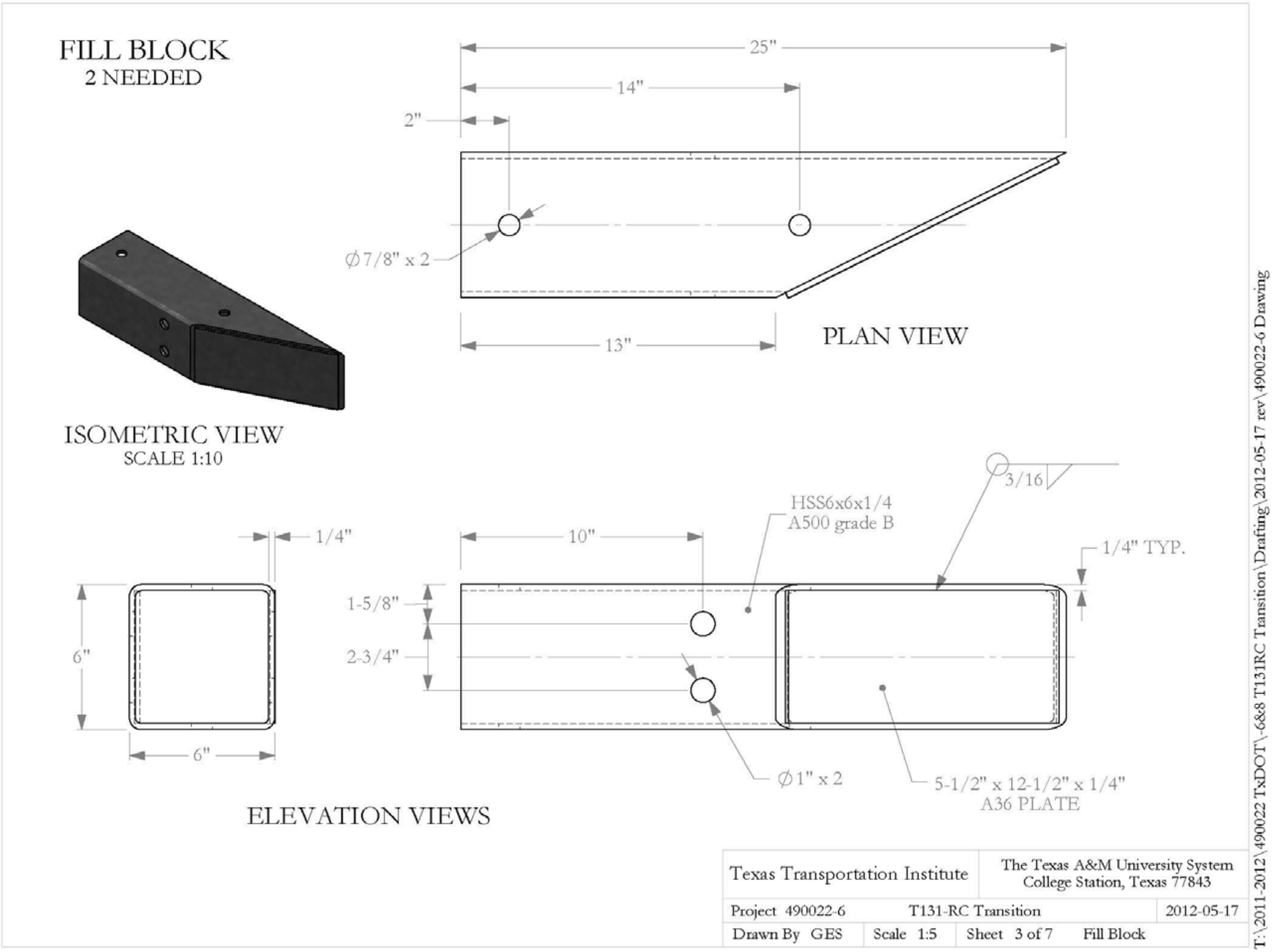
FILL BLOCK
2 NEEDED
ISOMETRIC VIEW
SCALE 1:10
25"
14"
2"
13"
∅7/8" x 2
PLAN VIEW
3/16
HSS6x6x1/4
A500 grade B
1/4"
10"
1/4" TYP.
1-5/8"
2-3/4"
6"
6"
∅1" x 2
5-1/2" x 12-1/2" x 1/4"
A36 PLATE
ELEVATION VIEWS
Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843
Project 490022-6
T131-RC Transition
2012-05-17
Drawn By GES
Scale 1:5
Sheet 3 of 7
Fill Block
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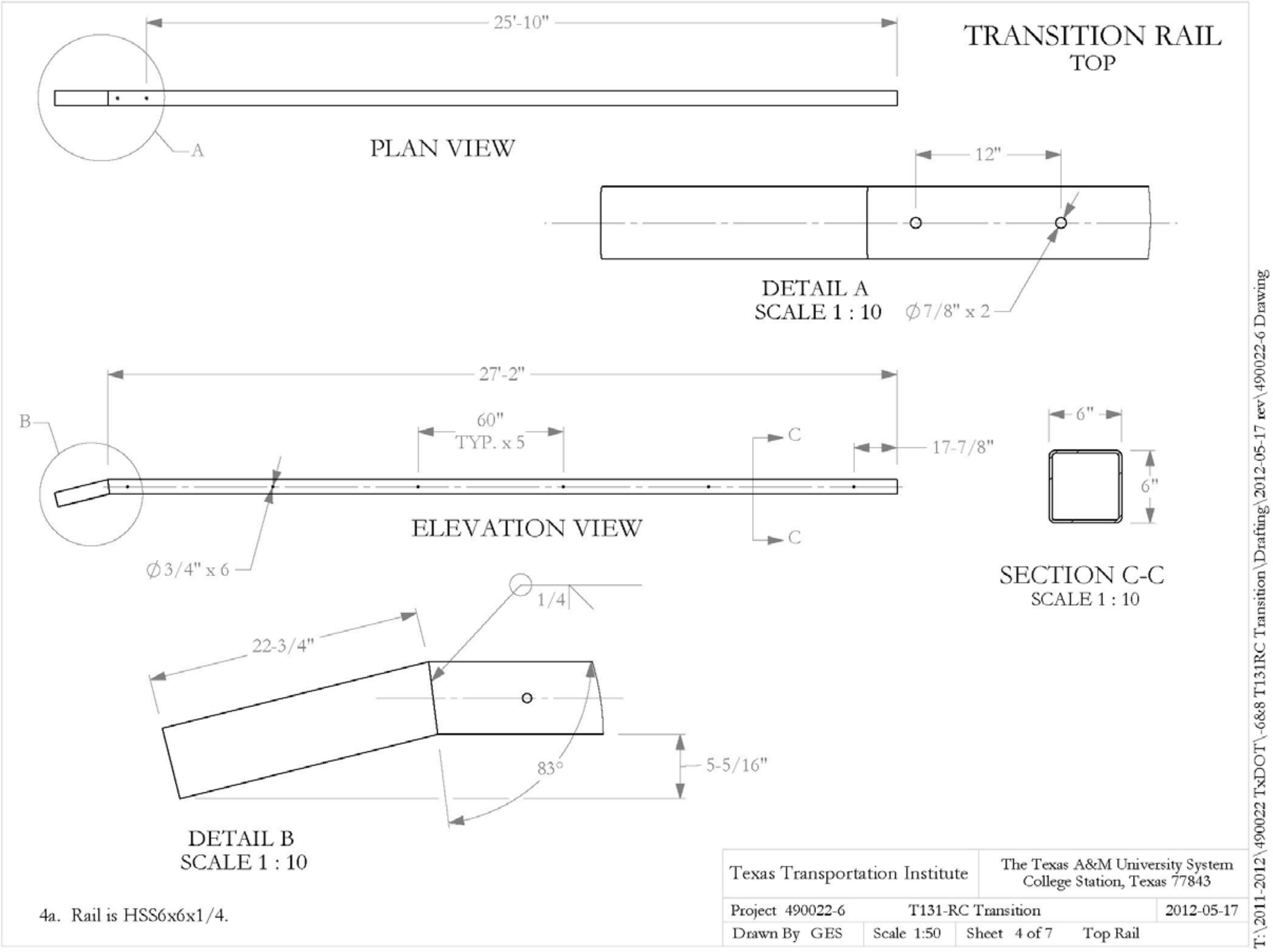
TRANSITION RAIL
TOP
25'-10"
A
PLAN VIEW
12"
DETAIL A
SCALE 1 : 10
∅7/8" x 2
27'-2"
60"
TYP. x 5
B
C
C
17-7/8"
ELEVATION VIEW
∅3/4" x 6
6"
6"
SECTION C-C
SCALE 1 : 10
1/4
22-3/4"
83°
5-5/16"
DETAIL B
SCALE 1 : 10
4a. Rail is HSS6x6x1/4.
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Project 490022-6
T131-RC Transition
2012-05-17
Drawn By GES
Scale 1:50
Sheet 4 of 7
Top Rail
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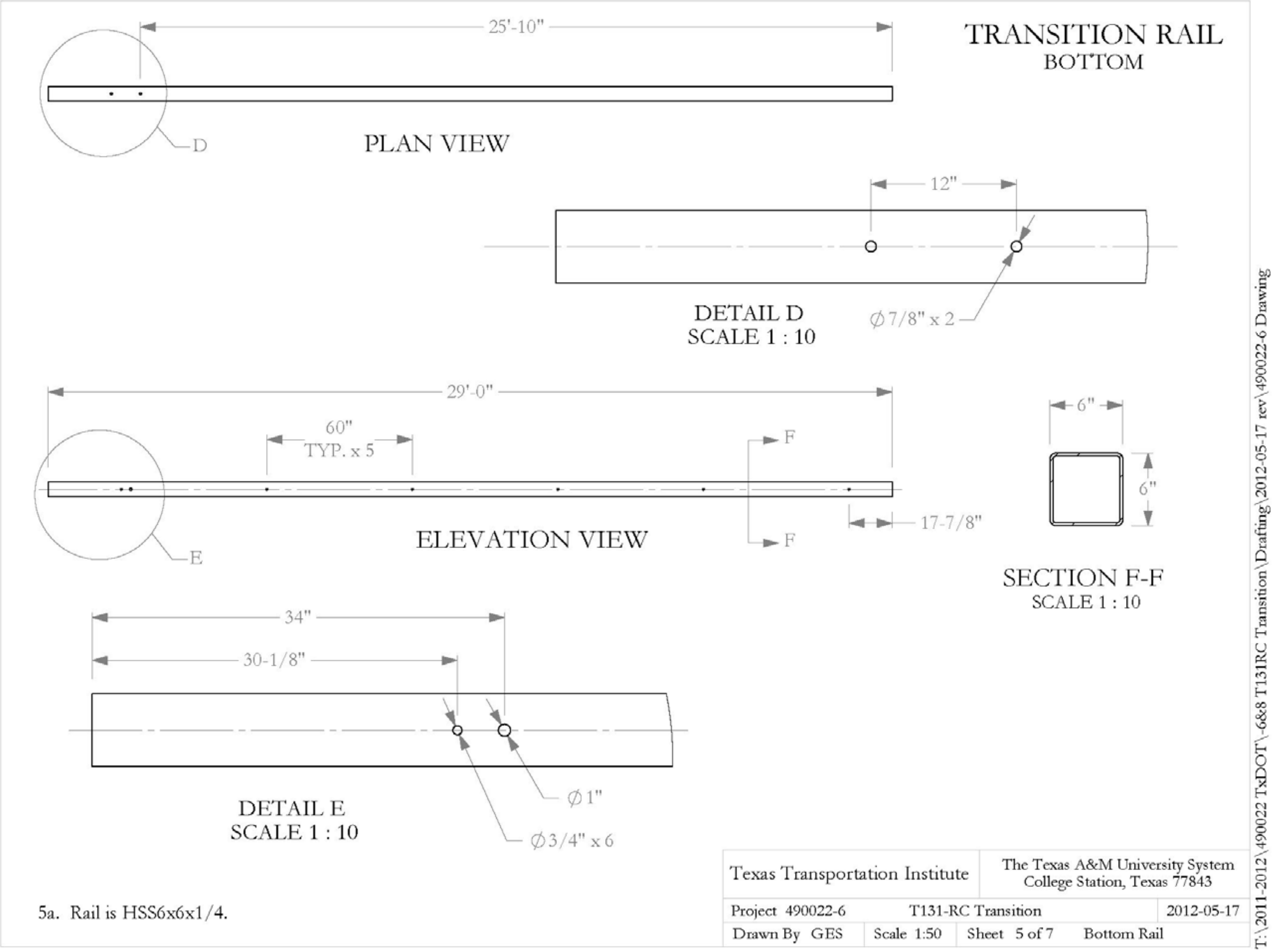
TRANSITION RAIL
BOTTOM
25'-10"
D
PLAN VIEW
12"
DETAIL D
SCALE 1 : 10
∅7/8" x 2
29'-0"
60"
TYP. x 5
F
F
17-7/8"
E
ELEVATION VIEW
6"
6"
SECTION F-F
SCALE 1 : 10
34"
30-1/8"
DETAIL E
SCALE 1 : 10
∅1"
∅3/4" x 6
5a. Rail is HSS6x6x1/4.
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Project 490022-6
T131-RC Transition
2012-05-17
Drawn By GES
Scale 1:50
Sheet 5 of 7
Bottom Rail
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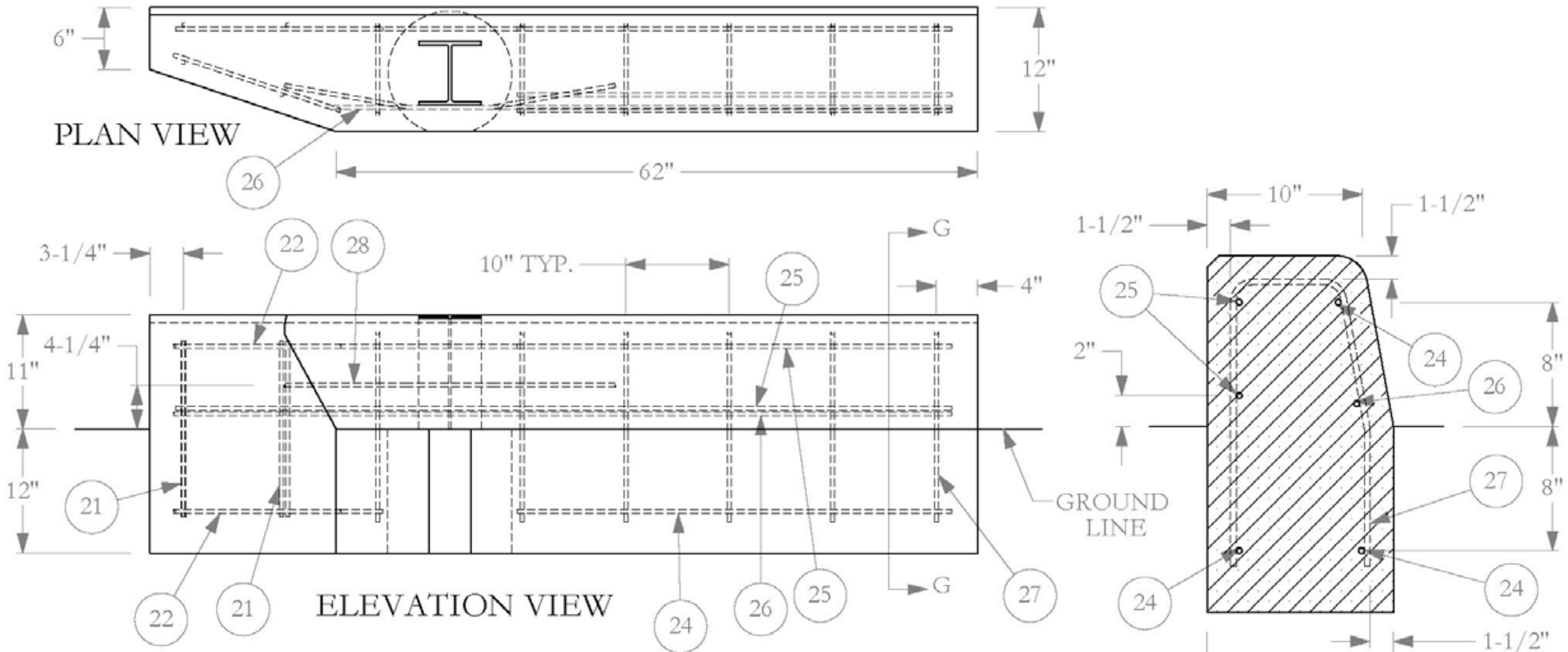
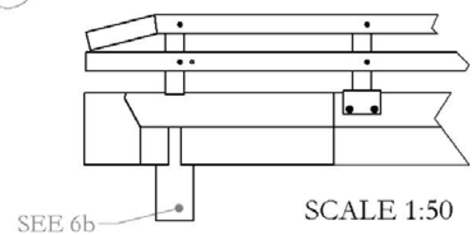
TRANSITION CURB DETAILS



SECTION G-G
SCALE 1 : 10



SCALE 1:50

#	PART NAME	QTY.
21	Rebar, #3 x 17"	4
22	Rebar, #3 x 16"	2
23	Rebar, #3 x 20"	1
24	Rebar, #3 x 42"	3
25	Rebar, #3 x 75"	2
26	Rebar, #3 bent	1
27	Stirrup for Transition Curb	6
28	Rebar at post	1

6a. Curb is Class C (3600 psi) concrete.
6b. Foundation for post is Ø12" x 30" un-reinforced Class C concrete.
6c. 3/4" chamfer back edge of the curb, and R2" the front edge.

Texas Transportation Institute	The Texas A&M University System College Station, Texas 77843	
Project 490022-6	T131-RC Transition	2012-05-17
Drawn By GES	Scale 1:15 Sheet 6 of 7	Curb Details

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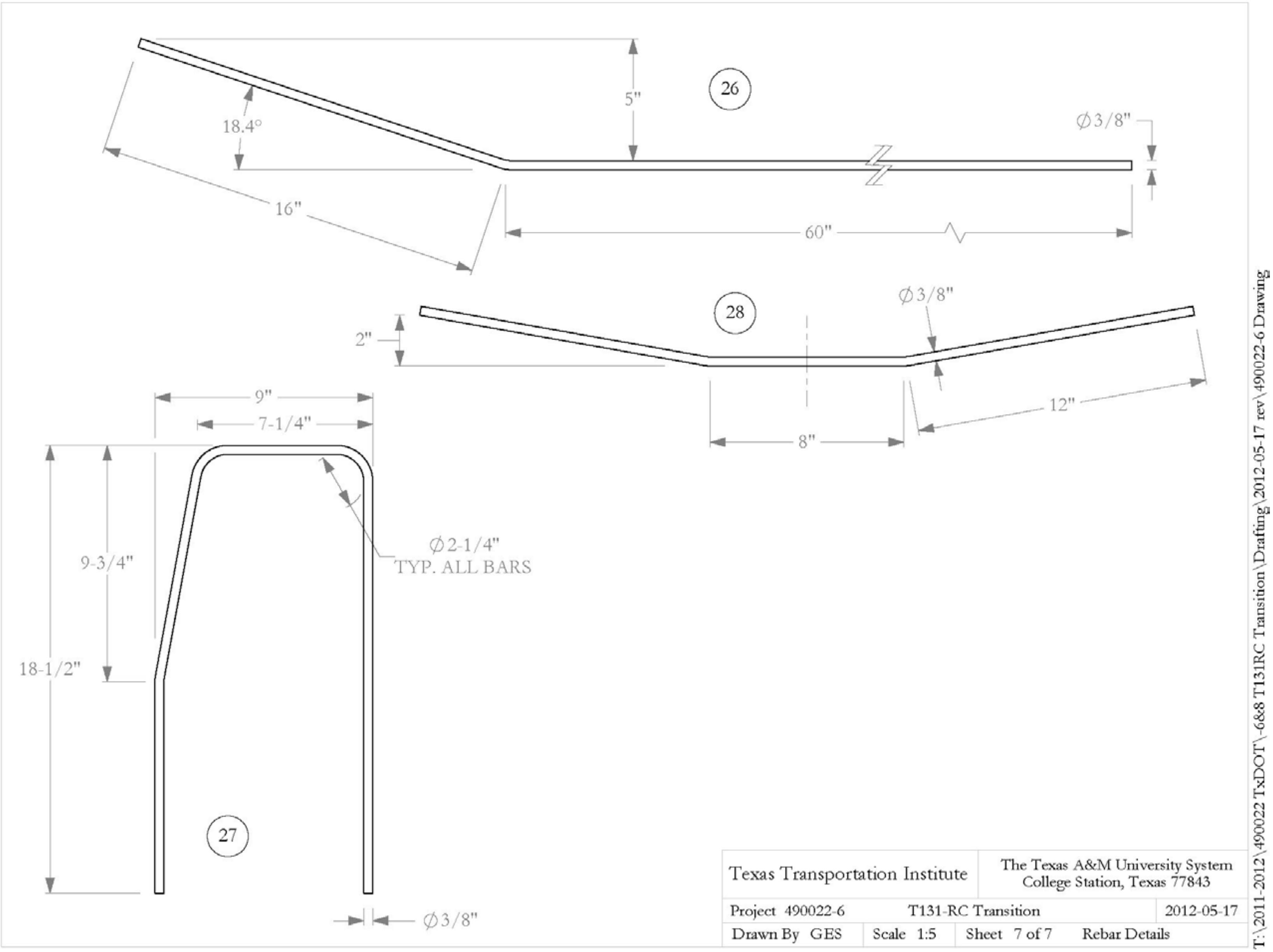

26
5"
18.4°
16"
60"
∅3/8"
28
2"
∅3/8"
8"
12"
9"
7-1/4"
9-3/4"
18-1/2"
∅2-1/4"
TYP. ALL BARS
27
∅3/8"
Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843
Project 490022-6
T131-RC Transition
2012-05-17
Drawn By GES
Scale 1:5
Sheet 7 of 7
Rebar Details
T:\2011-2012\490022 TxDOT\-6&8 T131RC Transition\Drafting\2012-05-17 rev\490022-6 Drawing

APPENDIX B. CERTIFICATION DOCUMENTATION

MATERIAL USED

TEST NUMBER	490022-6
TEST NAME	T131RC Transition
DATE	2012-05-25

DATE RECEIVED	ITEM NUMBER	DESCRIPTION	SUPPLIER	HEAT #	NOTE
2012-01-26*	Parts-15	Guardrail Parts	Brazos Industries	see file	1
2012-01-12	Rebar 03-06	3/8" x 20' grd 60	CMC-Sheplers	3028608	1
2012-01-12	Rebar 04-25	1/2" x 20' gr 60	CMC-Sheplers	see file	1
2012-05-02	Parts-20	Guardrail Parts	Trinity	see file	2

1 These parts were used on the Bridge Deck for test 490022-1.
2 These parts were used for the Transition for this test.

NUCOR STEEL - BERKELEY
P.O. Box 2259
Mt. Pleasant, S.C. 29464
Phone: (843) 336-6000

CERTIFIED MILL TEST REPORT

12/09/11 23:27:33

100% MELTED AND MANUFACTURED IN THE USA
All beams produced by Nucor-Berkeley are cast and rolled to a fully killed and fine grain practice.
Mercury has not been used in the direct manufacturing of this material.

Sold To: DAMASCO CORPORATION
500 COLONIAL CENTER PKWY.
SUITE 500
ROSWELL, GA 30076

Ship To: DAMASCO
SOUTH LOOP 4 (BUDA TX)
P.O. BOX 150367
AUSTIN, TX 78715

Customer #.: 485 - 48

B.O.L. #...: 517461

SPECIFICATIONS: Tested in accordance with ASTM specification A6-11/A6M-11 and A370. Quality Manual Rev 024.
AASHTO : M270-50-05
ASTM : A992-11:A36-08/A529-05-50/A572-07-50/A709-345M/A709-11 50S
CSA : G40.21-50W

Description	Heat# Grade(s) Test	Yield/ Tensile Ratio	Yield (PSI) (MPa)	Tensile (PSI) (MPa)	Elong %	C Cr XXXXXX	Mn Mo Ti	P Sn XXXXXX	S B XXXXXX	Si V N	Cu Nb XXXXXX	Ni XXXXXX CI	CE1 CE2 Pcm
W12x19 040' 00.00' W310X28.3 012.1920m	2113512 A992-11	.84 .84	66600 459 60130 414	72400 499 71900 496	25.80 26.45	.07 .05	.85 .02 .002	.008 .0132	.033 .0002	.21 .004 .0061	.22 .030	.06 4.84	.25 .2897 .1397
						8 Piece(s)		Customer PO: 5359303				Inv#:	0
W6X15 040' 00.00' W150X22.5 012.1920m	1115375 A992-11	.84 .83	57900 399 57500 396	68830 474 69500 479	27.79 25.15	.07 .03	.83 .02 .002	.011 .0073	.026 .0002	.19 .004 .0056	.15 .026	.04 1.78	.23 .2711 .1321
						27 Piece(s)		Customer PO: 6604051				Inv#:	0
W8X28 040' 00.00' W200X41.7 012.1920m	2115013 A992-11	.80 .80	58600 404 59000 407	73300 505 73300 505	23.58 23.39	.07 .05	1.10 .02 .002	.009 .0096	.030 .0002	.24 .004 .0071	.25 .025	.06 5.10	.23 .3339 .1509
						6 Piece(s)		Customer PO: 6607332				Inv#:	0
W8X31 040' 00.00' W200X46.1 012.1920m	2114981 A992-11	.81 .82	56600 390 57500 396	70300 485 70300 485	25.10 25.86	.07 .03	1.06 .02 .002	.006 .0073	.029 .0002	.26 .004 .0033	.16 .030	.05 1.80	.27 .3176 .1425
						12 Piece(s)		Customer PO: 6607332				Inv#:	0

Elongation based on 8' (20.32cm) gauge length. 'No Weld Repair' was performed. Hg free and no contact with Hg during manufacture.
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)
CE2 = C+((Mn+Si)/6)+((Cr+Mo+V+Cb)/5)+((Ni+Cu)/15)

I hereby certify 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.

Bruce A. Work
Metallurgist

ЭКСПОРТ EXPORT

лист 1 всего 1

Продавец(Экспортер)
Seller(Exporter)
ОАО ММК 455002 МАГНИТОГОРСК КИРОВА 93
MAGNITOGORSK IRON AND STEEL WORKS
93,ST.KIROV,MAGNITOGORSK 455002 RUSSIAN FEDERATION

Товаросопроводительный документ 120-30318
№ Shipping document №
(Сертификат качества
Quality certificate)

Грузополучатель, адрес, страна
Consignee, address, country
США United States
ОАО НОВОРОССИЙСКИЙ СУДОРЕМОНТНЫЙ ЗАВОД КОД 3812 П/И 353902,КРАСНОДАРСКИЙ КРАЙ,НОВОРОССИЙСК,СУХУМСКОЕ ШОССЕ
ДЛЯ СТАРГЛОУБ ЛИМИТЕД (STARGLOBE LIMITED)

Контракт № E163235 сп297
Contract № E163235 ep297

Вагон № Freight car № 54997168

Наименование товара Description of goods	НД Standards	Форма раск. Geometry	Вид и код тары Type of pack,code	№ мест Package №
РУЛОНЫ Г/К НЕДРЕССИРОВАННЫЕ HOT ROLLED COILS NON-SKIN PASSED	СТО ММК 280-2008		РУЛОНЫ 425 COILS	1-3

№ п/п Item №	№ мест Pkg No	Код товара Code of goods	Номер плавки-партии Nos of heats-lots	Номер рулона Nos of coil	Марка стали и категория Steel grade and category	Группа прочн. Strength group	Кат. вытяжки [illegible]	Вид поверх. Surface appear	Группа отд. Appl group	Группа поверх. Surface group	Хар. кромки Edge char	Сорт Grade	[illegible] rolling	[illegible] ding	Размеры мм Dimensions mm толщ*шир*длина thick*width*length	Масса т Mass t нетто netto	брутто gross
1	6	99131	1093843	0112	SS Grade 36-2 Type 2						K	1			12.300x1219	19.680	19.690
2	-"-	-"-	-"-	0212	-"-						K	1			-"-	20.570	20.580
3	-"-	-"-	-"-	0312	-"-						K	1			-"-	20.900	20.910
																61.150	61.180

Показатели качества товара Quality characteristics of goods

Номер плавки-партии Nos of heats-lots	C x100	Si x100	Mn x100	S x1000	P x1000	Cr x100	Ni x100	Cu x100	N x1000	Al x1000	Mo x1000	Nb x1000	V x1000	Ti x1000		Предел прочн. (Н/мм2) Ultimate strength (N/mm2)	Предел текуч. (Н/мм2) Yield point (N/mm2)	Относ. удлин. 50 (%) Elongation	Изгиб Bend test	
1093843	16	10	97	14	16	4	4	8	7	54	3	1	4	1		480	296	38.0	уд set_u	
1093843	16	10	97	14	16	4	4	8	7	54	3	1	4	1		450	295	39.0	уд set_u	
1093843	16	10	97	14	16	4	4	8	7	54	3	1	4	1		460	296	39.0	уд set_u	

HR 1/2 x 48

Lot# 17105
Heat# 1093843
PO# 6390465

Приме- код ТНВЭД=7208.
чание
Note

Дата Date: 05.06.11 05:33

Подпись представителя ОКП Signature of the QCD representative : Поляков Е.Н. Лоскутова С.М.

Указанный в настоящем документе товар соответствует по качеству действующим в РФ стандартам техническим условиям и может быть отгружен на экспорт.
It is hereby certified that the quality of goods mentioned in this Document is in conformity with the RUS Standards and Specifications, and the goods may be exported. 97

Atlas Tube Canada ULC
200 Clark St.
Harrow, Ontario, Canada
N0R 1G0
Tel: 519-738-3541
Fax: 519-738-3637

Atlas Tube
JMC STEEL GROUP

Ref.B/L: 80460468
Date: 12.22.2011
Customer: 990

MATERIAL TEST REPORT

Sold to

NAMASCO CORPORATION
Steel Warehousing Corporati
500 COLONIAL CENTER PR
ROSWELL GA 30076
USA

Shipped to

NAMASCO SOUTH WEST
SOUTH LOOP 4, P.O. BOX
BUDA TX 78715-0367
USA

Material: 5.0x5.0x250x48'0"0(4x2). Material No: 500502504800 Made in: Canada
Melted in: Canada
Sales order: 688743 Purchase Order: 6408907 Cust Material #: T514SQA5000576

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
762525	0.190	0.830	0.008	0.007	0.013	0.040	0.045	0.006	0.005	0.014	0.048	0.002	0.000	0.000	0.000

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification
M101100675	8	063850 Psi	078200 Psi	32.6 %	ASTM A500-10A GRADE B&C

CE: 0.36

Material Note:
Sales Or.Note:

Material: 6.0x6.0x250x40'0"0(3x3). Material No: 600602504000 Made in: Canada
Melted in: Canada
Sales order: 689536 Purchase Order: 6409841 Cust Material #: T614SQA5000480

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
762367	0.190	0.780	0.007	0.008	0.014	0.051	0.042	0.005	0.006	0.019	0.029	0.002	0.000	0.000	0.000

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification
M101096889	9	054900 Psi	067270 Psi	34.0 %	ASTM A500-10A GRADE B&C

CE: 0.34

Material Note:
Sales Or.Note:

Material: 8.0x4.0x250x40'0"0(2x4). Material No: 800402504000 Made in: Canada
Melted in: Canada
Sales order: 689536 Purchase Order: 6409841 Cust Material #: T8414RECTA5000480

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
762777	0.180	0.790	0.008	0.008	0.013	0.066	0.049	0.005	0.005	0.015	0.035	0.002	0.000	0.000	0.000

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification
M101096343	8	060430 Psi	075020 Psi	35.5 %	ASTM A500-10A GRADE B&C

CE: 0.33

Material Note:
Sales Or.Note:

Authorized by Quality Assurance:
The results reported on this report represent the actual attributes of the material furnished and indicate full compliance with all applicable specification and contract requirements.
C[illegible]lated using the AWS D1.1 method.

Steel Tube Institute OF NORTH AMERICA

Page : 2 Of 3

Metals Service Center Institute

2012-10-25

BLR466

BL - 3678018
Heat - B1U7759
Order-Line - 7109178 / 2

Load - 1135417

01-05-2012 08:06
Brazos Industries Inc
Cust. PO -

Page #:1 of 1

NUCOR

NUCOR STEEL TUSCALOOSA, INC.

MILL TEST CERTIFICATE

1700 HOLT RD N.E.
Tuscaloosa, AL 35404-1000
800-827-8272

Load Number	Tally	Mill Order Number	P.O. Number	Part Number	Certificate Number	Date
390866	00000000419759	M-107372-004	6361481		L335906-1	08/09/2011 13:46

Grade

Order Description:
A36, 0.6250 IN x 96.000 IN x 240.000 IN
Quality Plan Description:
A36MODMN-TRIPLE: ASTM A36-08 MOD MN/ASME SA36-03/A709-36-10

Customer:
Sold TO:
NAMASCO Buda TX
Ship TO:
NAMASCO Buda TX

Shipped Item	Heat/Slab Number	Certified By	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Cb	V	Al	Ti	N2	B	Ca	Sn	CEV
1H00930	B1U7759-03 ***	B1U7759	0.18	0.89	0.012	0.008	0.06	0.16	0.06	0.09	0.021	0.000	0.001	0.037	0.001	0.008	0.0001	0.0027	0.008	0.37
1H0093E	B1U7759-03 ***	B1U7759	0.18	0.89	0.012	0.008	0.06	0.16	0.06	0.09	0.021	0.000	0.001	0.037	0.001	0.008	0.0001	0.0027	0.008	0.37
1H0095B	B1U7759-02 ***	B1U7759	0.18	0.89	0.012	0.008	0.06	0.15	0.06	0.09	0.021	0.000	0.001	0.037	0.001	0.008	0.0001	0.0027	0.008	0.37

Shipped Item	Certified By.	Heat Number	Yield ksi	Tensile ksi	Y/T %	ELONGATION % 2"	ELONGATION % 8"	Bend OK?	Hard HB	Charpy Impacts (ft-lbf) Size mm	1	2	3	Avg	Shear % 1	2	3	Avg	Test Temp
1H00930	S1H0093FTT	B1U7759 ***	46.7	67.9	68.8	38.6													
1H00930	S1H0093MTT	B1U7759 ***	44.9	63.8	70.4	40.1													
1H0093E	S1H0093FTT	B1U7759 ***	46.7	67.9	68.8	38.6													
1H0093E	S1H0093MTT	B1U7759 ***	44.9	63.8	70.4	40.1													
1H0095B	S1H0092FTT	B1U7759 ***	49.0	68.7	71.3	41.0													
1H0095B	S1H0094FTT	B1U7759 ***	49.0	68.3	71.7	36.6													
1H0095B	S1H0092MTT	B1U7759 ***	46.8	63.3	73.9	40.9													
1H0095B	S1H0094MTT	B1U7759 ***	45.8	64.0	71.6	39.9													

Items: 3 PCS: 10 Weight: 40839 LBS

Mercury has not come in contact with this product during the manufacturing process nor has any mercury been used by the manufacturing process. Certified in accordance with EN 10204 3.1. No weld repair has been performed on this material. Manufactured to a fully killed fine grain practice. ** Produced from Coil **
ISO 9001:2008 Registered, PED Certified

*** indicates Heats melted and Manufactured in the U.S.A.

We hereby certify that the product described above passed all of the tests required by the specifications.

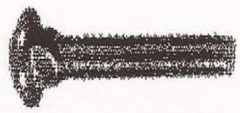
April Pitts

April Pitts - QA Engineer

Porteous Fastener Company

Product Information Sheet

Carriage Bolt, Inch Series, Grade A



- PFC Product Category: 00100
- Typical Material: Low Carbon Steel
- Material and Mechanical Properties: Purchased to meet ASTM A307 Grade A.
- Dimensions: ASME B18.5, Round Head Square Neck Bolt, Rolled Threads
  - Full thread to 6 inches in length.
  - Undersize body and 6 inches of threads on lengths over 6 to 12 inches.
  - 6 inches threads and full size body on lengths over 12 inches.
- Zinc Plating: Purchased to meet ASTM F1941 FeZn3A
- Hot-Dip Galvanized: Purchased to meet ASTM A153.
- Typical Hardness: HRB 69-100
- Tensile Strength: 60,000 PSI Minimum

Tensile Strength - NC Threads ASTM A307 Grade A

Size	PSI	Pounds
1/4-20	60,000	1900
5/16-18	60,000	3100
3/8-16	60,000	4650
7/16-14	60,000	6,350
1/2-13	60,000	8,500
9/16-12	60,000	11,000
5/8-11	60,000	13,550
3/4-10	60,000	20,050
7/8-9	60,000	27,700
1-8	60,000	36,350

Length Tolerances - Carriage Bolts

Nominal Length	Nominal Size: #10 to 3/8	7/16 & 1/2	9/16 to 3/4	7/8 to 1
	Tolerance on Length			
Up to & incl 1"	+0.02/-0.03	+0.02/-0.03	+0.02/-0.03	
Over 1" to 2 1/2", incl.	+0.02/-0.04	+0.04/-0.05	+0.06/-0.08	+0.08/-0.10
Over 2 1/2" to 4", incl.	+0.04/-0.06	+0.06/-0.08	+0.08/-0.10	+0.10/-0.14
Over 4" to 6", incl.	+0.06/-0.10	+0.08/-0.10	+0.10/-0.10	+0.12/-0.16
Over 6"	+0.10/-0.18	+0.12/-0.18	+0.14/-0.18	+0.16/-0.20

SOLD TO: ADELPHIA METALS I LLC
411 MAIN ST E
NEW PRAGUE, MN 56071-

NUCOR
NUCOR CORPORATION
NUCOR STEEL TEXAS

CERTIFIED MILL TEST REPORT

Ship from:

Nucor Steel - Texas
8812 Hwy 79 W
JEWETT, TX 75846
800-527-6445

SHIP TO: ADELPHIA METALS-CUST PU
N/A
JEWETT, TX 75846-

Date: 26-Oct-2011
B.L. Number: 586989
Load Number: 195932

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 March 9, 2011

HEAT NUM. *	DESCRIPTION	PHYSICAL TESTS: YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	CHEMICAL TESTS: C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# =>	801746												
JW1110880201	Nucor Steel - Texas	70,000	110,500	13.0%			.42	1.02	.016	.024	.12	.33	.62
	13/#4 Rebar 20'	483MPa	762MPa				.13	.15	.039	.003	.001		
	A615M Gr 420 (Gr60)												
	ASTM A615/A615M-09b GR 60[420]												
	AASHTO M31-07												
PO# =>	801746												
JW1110880301	Nucor Steel - Texas	70,700	108,900	12.0%			.42	.98	.019	.044	.14	.32	.61
	13/#4 Rebar 20'	487MPa	751MPa				.14	.17	.042	.003	.001		
	A615M Gr 420 (Gr60)												
	ASTM A615/A615M-09b GR 60[420]												
	AASHTO M31-07												

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.
1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form

QUALITY ASSURANCE: Nathan Stewart

CMC STEEL TEXAS
1 STEEL MILL DRIVE
SEGUIN TX 78155-7510

CERTIFIED MILL TEST REPORT

For additional copies call
830-372-8771

We hereby certify that the test results presented here are accurate and conform to the reported grade specification

Daniel J. Schacht

Daniel J. Schacht

Quality Assurance Manager

HEAT NO.:3028608 SECTION: REBAR 10MM (#3) 20'0" 420/60 GRADE: ASTM A615-09b Gr 420/60 ROLL DATE: 11/20/2011 MELT DATE: 11/19/2011	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900

Delivery#: 80634703
BOL#: 70224264
CUST PO#: 5390AB
CUST P/N:
DLVRY LBS / HEAT: 16848.000 LB
DLVRY PCS / HEAT: 2240 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.45%				
Mn	0.81%				
P	0.012%				
S	0.037%				
Si	0.17%				
Cu	0.34%				
Cr	0.17%				
Ni	0.16%				
Mo	0.059%				
V	0.002%				
Cb	0.001%				
Sn	0.013%				
Al	0.002%				
Yield Strength test 1	70.6ksi				
Tensile Strength test 1	108.3ksi				
Elongation test 1	13%				
Elongation Gage Lgth test 1	8IN				
Bend Test Diameter	1.313IN				
Bend Test 1	Passed				

THIS MATERIAL IS FULLY KILLED, 100% MELTED AND MANUFACTURED IN THE USA, WITH NO WELD REPAIR OR MERCURY CONTAMINATION IN THE PROCESS.

REMARKS :

11/22/2011 18:03:39

This Memorandum is an acknowledgement that a Bill of Lading has been issued and is not the original Bill of Lading, nor a copy or duplicate, covering the property named herein, and is intended solely for filing or record.

Carrier

Shipper's No. 16-41901

S/O No. 1172458

RECEIVED, subject to the classifications and tariffs in effect on the date of receipt by the carrier of the property described in the Original Bill of Lading,
at Ft Worth, TX 5/1 20, 12 from Trinity Highway Products,LLC 3

[illegible]

Consigned to: SAMPLES,TESTING,TRAINING MTRLS Cust. P.O. TTI-TEST 490022-6 Load No. 96-1

Destination: TTI - ATTN: GARY GERKE 3100 STATE HWY 47
SAFTY & STRUCT SYST. DIV BLDG 7090

Total Weight: 4,587.35

Ship: 5/1/12

City: BRYAN State: TX Zip: 77807

Arrive: 4/24/12 8:00:00AM

Contact: GARY GERKE Phone: 936-835-4661 333145

Delivering Carrier: FEDEX FX FE Vehicle or Car Initial: No.

Subject to Section 7 of Conditions of applicable Bill of Lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

TRINITY HIGHWAY PRODUCTS, LLC

Per Trinity Highway Products,LLC
(Signature of Consignor)

If charges are to be prepaid, write or stamp here, "To be Prepaid."
TO BE PREPAID

Received $
to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per
(The signature here acknowledges only the amount prepaid.)

Charges advanced:

Collect On Delivery:
$ **and remit to:**
Street **City** **State**

C.O.D. charge to be paid by Shipper ☐ Consignee ☐

Upon delivery, all materials subject to Trinity Highway Products,LLC Storage Stain Policy No. LG-002.

Project Info: SAMPLES AND TESTING PROJECT 490022-6

No. Pkgs.	Piece Count	Description of Articles	*Wt.	Class or Rate	✓ Col.
	6	110G 12/12'6/3'1.5/8			
	2	320G 12/12'6/6'3/8 PT2000 ANC			
	14	533G 6'0 POST/8.5/DDR			
	2	980G T10/END SHOE/SLANT 1"HO			
	2	3000G CBL 3/4X6'6/DBL			
	42	3300G 5/8" WASHER F844 A/W			
	24	3320G 3/16"X1.75"X3" WASHER			
	154	3340G 5/8" GR HEX NUT			
	64	3360G 5/8"X1.25" GR BOLT			
	48	3400G 5/8"X2" GR BOLT			
	42	3500G 5/8"X10" GR BOLT A307			
	10	3725G 7/8" WASHER F844 TYPE A/N			
	10	3735G 7/8" HEX NUT A-563			
	4	3900G 1" ROUND WASHER F844			
	4	3910G 1" HEX NUT A563			
	18	4076B WD BLK RTD 6X8X14			
	2	6019B REFL SHT 13X27.5 Y/B LT			
	16	6149B WD BLK RTD 6X8X18			
	10	6900G 7/8"X15.5" HXBLT A449 5"T			
	4	12227G T12/12'6/3'1.5x6@16.75/8			
	6	14578G 6'0 PST/8.5#/SYTP			
	12	14784G 7'0 POST/8.5#/3HI TX			
	2	14785G 6'0 POST/8.5#/3HI TX			
	2	14786G 6'0 POST/8.5#/TRANS TX			
	2	33726A ET+CAN-50',12'6 HBA/SYTP			
	2	33795G SYT-3"AN STRT 3-HL 6'6			
	2	35247A CONN PL 40"X20" RT MO			

No. Pkgs.	Piece Count	Description of Articles	*Wt.	Class or Rate	✓ Col.
		3-Palletes			
		1-BUNDLE			
		GUARDRAIL HWY STEEL NMFC ITEM 105460 CLASS 50			

SPECIAL INSTRUCTIONS:

SHIPPER LOAD - CONSIGNEE UNLOAD 16-41901

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight."
NOTE - Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding per

Total Weight # 4,587 3

ORIGIN — SHIPPER OR AGENT SIGN HERE: I hereby authorize this shipment and make the declaration of values (if any) and agree to the contract terms and conditions hereof. [signature] DATE 5/1/12

AGENT OR DRIVER (SIGN HERE): This shipment received subject to exceptions as noted and according to the terms and conditions hereof. DATE

DESTINATION — CONSIGNEE OR AGENT SIGN HERE: Received the above described property in good condition except as noted on the back hereof and agree to the foregoing contract terms and conditions. DATE TIME A.M. P.M.

DRIVER NO

Permanent post-office address of shipper.

TRI 609-RF (R 10/93) (This Bill of Lading is to be signed by the shipper and agent of the carrier issuing same.) CONSIGNEE/CUSTOMER COPY

Certified Analysis

Trinity Highway Products , LLC
2548 N.E. 28th St.
Ft Worth, TX 76111

Customer: SAMPLES,TESTING,TRAINING MTRLS
2525 STEMMONS FRWY

DALLAS, TX 75207

Project: SAMPLES AND TESTING PROJECT 490022-6

Order Number: 1172458
Customer PO: TTI-TEST 490022-
BOL Number: 41901
Document #: 1
Shipped To: TX
Use State: TX

As of: 5/1/12

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat #	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn	ACW
6	11G	12/12'6/3'1.5/S	M-180	A	2	103056	58,600	78,400	29.0	0.190	0.770	0.007	0.001	0.020	0.150	0.00	0.040	0.002	4
			M-180	A	2	137784	64,330	82,800	26.0	0.200	0.810	0.013	0.004	0.020	0.090	0.000	0.050	0.000	4
			M-180	A	2	203516	54,900	79,100	25.0	0.200	0.780	0.009	0.003	0.020	0.130	0.000	0.040	0.002	4
			M-180	A	2	203516	58,600	78,400	29.0	0.190	0.810	0.009	0.002	0.020	0.130	0.000	0.050	0.002	4
			M-180	A	2	203517	60,600	79,600	25.0	0.200	0.780	0.008	0.002	0.020	0.120	0.000	0.050	0.002	4
			M-180	A	2	204446	60,100	80,100	23.0	0.190	0.770	0.010	0.002	0.030	0.140	0.000	0.060	0.002	4
			M-180	A	2	a54903	53,600	85,300	27.1	0.210	0.830	0.009	0.004	0.040	0.080	0.000	0.040	0.001	4
			M-180	A	2	A54907	61,600	83,700	21.2	0.210	0.890	0.011	0.004	0.030	0.110	0.000	0.050	0.001	4
			M-180	A	2	A56188	61,600	82,800	27.0	0.220	0.850	0.012	0.004	0.020	0.080	0.000	0.060	0.001	4
			M-180	A	2	C53442	62,700	84,500	25.0	0.220	0.850	0.010	0.006	0.030	0.090	0.000	0.040	0.001	4
			M-180	A	2	C54778	66,200	88,300	23.6	0.210	0.840	0.009	0.004	0.030	0.070	0.000	0.050	0.001	4
2	32G	12/12'6/6'3/S ET2000 ANC	M-180	A	2	150045	57,310	75,300	26.0	0.180	0.730	0.017	0.004	0.010	0.130	0.00	0.070	0.000	4
			M-180	A	2	149773	54,310	70,830	31.4	0.190	0.740	0.011	0.003	0.020	0.120	0.000	0.050	0.001	4
			M-180	A	2	150044	55,520	72,990	29.5	0.180	0.720	0.012	0.005	0.010	0.120	0.000	0.060	0.001	4
			M-180	A	2	150046	60,750	79,070	26.0	0.200	0.740	0.009	0.003	0.020	0.120	0.000	0.100	0.001	4
			M-180	A	2	150058	59,780	77,600	28.0	0.190	0.740	0.008	0.003	0.020	0.130	0.000	0.050	0.001	4
			M-180	A	2	150060	59,460	76,830	28.5	0.190	0.720	0.009	0.004	0.010	0.130	0.000	0.050	0.001	4
14	533G	6'0 POST/8.5/DDR	A-36			1017684	54,730	71,963	28.2	0.120	0.930	0.011	0.042	0.180	0.340	0.00	0.120	0.003	4
	533G		A-36			1017674	56,593	73,194	30.5	0.110	0.920	0.016	0.035	0.180	0.340	0.00	0.190	0.004	4
2	980G	T10/END SHOE/SLANT	A-36			125745	58,100	66,100	31.9	0.050	0.570	0.012	0.003	0.030	0.100	0.01	0.050	0.000	4
4	12227G	T12/12'6/3'1.5:6@1'6.75/S	M-180	A	2	151877	58,680	77,470	26.0	0.190	0.720	0.013	0.004	0.010	0.120	0.00	0.050	0.002	4
6	14578G	6'0 PST/8.5#/SYTP	A-36			1018448	59,962	78,876	27.6	0.120	0.930	0.021	0.035	0.180	0.310	0.00	0.190	0.003	4

Certified Analysis

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Order Number: 1172458
Customer PO: TTI-TEST 490022-
BOL Number: 41901
Document #: 1
Shipped To: TX
Use State: TX

As of: 5/1/12

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat #	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn	ACW
12	14784G	7'0 POST/8.5#/3HI TX	A-36			1017007	53,613	72,244	25.7	0.120	0.930	0.012	0.040	0.180	0.360	0.00	0.140	0.003	4
2	14785G	6'0 POST/8.5#/3HI TX	A-36			1017007	53,613	72,244	25.7	0.120	0.930	0.012	0.040	0.180	0.360	0.00	0.140	0.003	4
2	14786G	6'0 POST/8.5#/TRANS TX	A-36			1016659	56,271	73,902	27.5	0.110	0.980	0.023	0.044	0.180	0.320	0.00	0.220	0.004	4
2	33726A	ET+CAN-50',12'6 HBA/SYTP	A-36			3031507	53,600	75,900	28.0	0.150	0.910	0.015	0.040	0.190	0.370	0.00	0.090	0.014	4
	33726A		A-500			813U66380	56,700	71,300	29.5	0.220	0.790	0.010	0.005	0.022	0.029	0.00	0.030	0.001	4
2	33795G	SYT-3"AN STRT 3-HL 6'6	A-36			3029682	58,000	79,900	33.0	0.160	0.910	0.014	0.023	0.190	0.300	0.00	0.120	0.017	4
2	35247A	CONN PL 40"X20" RT MO	A-36			37482C	44,200	69,500	34.0	0.190	0.750	0.010	0.013	0.011	0.040	0.00	0.050	0.000	4

TL -3 or TL-4 COMPLIANT when installed according to manufactures specifications

Upon delivery, all materials subject to Trinity Highway Products , LLC Storage Stain Policy No. LG-002.

ALL STEEL USED WAS MELTED AND MANUFACTURED IN USA AND COMPLIES WITH THE BUY AMERICA ACT.
ALL GUARDRAIL MEETS AASHTO M-180, ALL STRUCTURAL STEEL MEETS ASTM A36

ALL COATINGS PROCESSES OF THE STEEL OR IRON ARE PERFORMED IN USA AND COMPLIES WITH THE "BUY AMERICA ACT"
ALL GALVANIZED MATERIAL CONFORMS WITH ASTM-123, UNLESS OTHERWISE STATED.

BOLTS COMPLY WITH ASTM A-307 SPECIFICATIONS AND ARE GALVANIZED IN ACCORDANCE WITH ASTM A-153, UNLESS OTHERWISE STATED.

NUTS COMPLY WITH ASTM A-563 SPECIFICATIONS AND ARE GALVANIZED IN ACCORDANCE WITH ASTM A-153, UNLESS OTHERWISE STATED.
WASHERS COMPLY WITH ASTM F-436 SPECIFICATION AND/OR F-844 AND ARE GALVANIZED IN ACCORDANCE WITH ASTM F-2329.
3/4" DIA CABLE 6X19 ZINC COATED SWAGED END AISI C-1035 STEEL ANNEALED STUD 1" DIA ASTM 449 AASHTO M30, TYPE II BREAKING STRENGTH 49100 LB

2 of 3

Certified Analysis

Trinity Highway Products, LLC
2548 N.E. 28th St.
Ft Worth, TX 76111

Customer: SAMPLES,TESTING,TRAINING MTRLS
2525 STEMMONS FRWY

DALLAS, TX 75207

Project: SAMPLES AND TESTING PROJECT 490022-6

Order Number: 1172458
Customer PO: TTI-TEST 490022-
BOL Number: 41901
Document #: 1
Shipped To: TX
Use State: TX

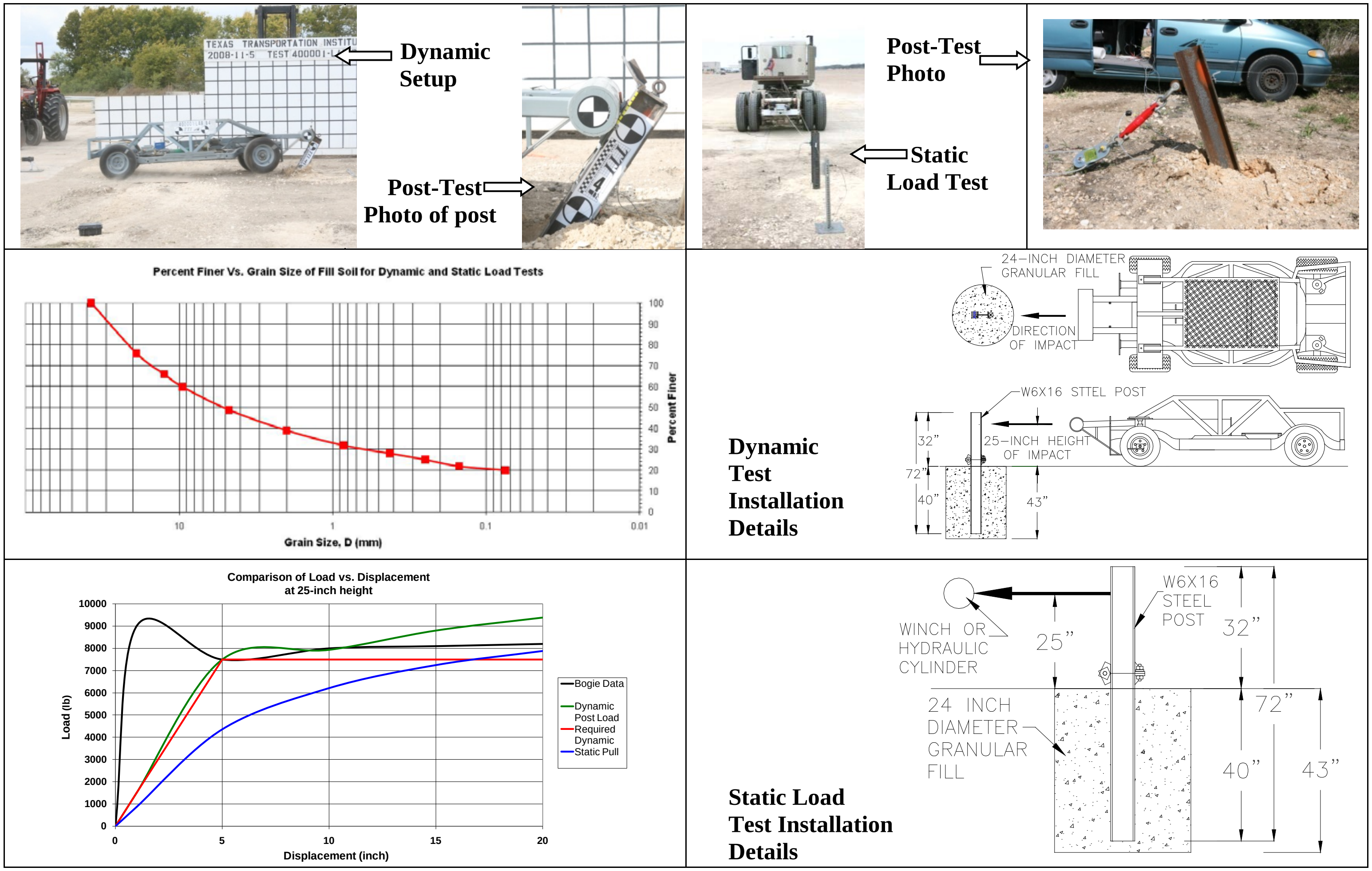
As of: 5/1/12

State of Texas, County of Tarrant. Sworn and subscribed before me this 1st day of May, 2012

Notary Public:
Commission Expires: /

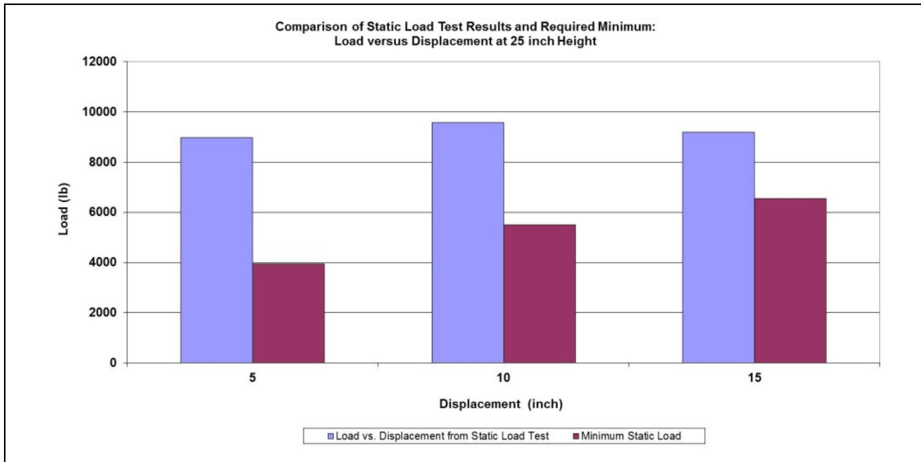
CARMEN A. RIVERA
NOTARY PUBLIC
STATE OF TEXAS
EXPIRES
1-26-2015

Certified By: Trinity Highway Products, LLC
Quality Assurance

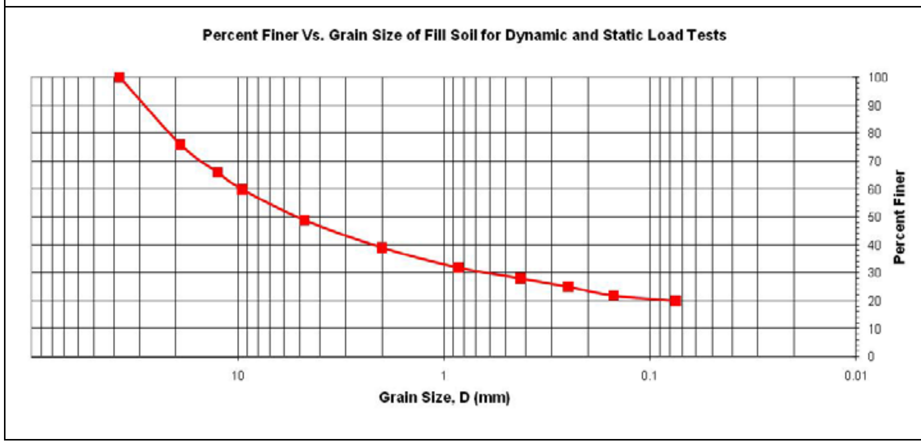


Date	2008-11-05
Test Facility and Site Location	TTI Proving Ground, 3100 SH 47, Bryan, TX 77807
In Situ Soil Description (ASTM D2487	Sandy gravel with silty fines
Fill Material Description (ASTM D2487) and sieve analysis	AASHTO Grade B Soil-Aggregate (see sieve analysis above)
Description of Fill Placement Procedure	6-inch lifts tamped with a pneumatic compactor
Bogie Weight	5009 lb
Impact Velocity	20.5 mph

Figure C1. Summary of Strong Soil Test Results for Establishing Installation Procedure.



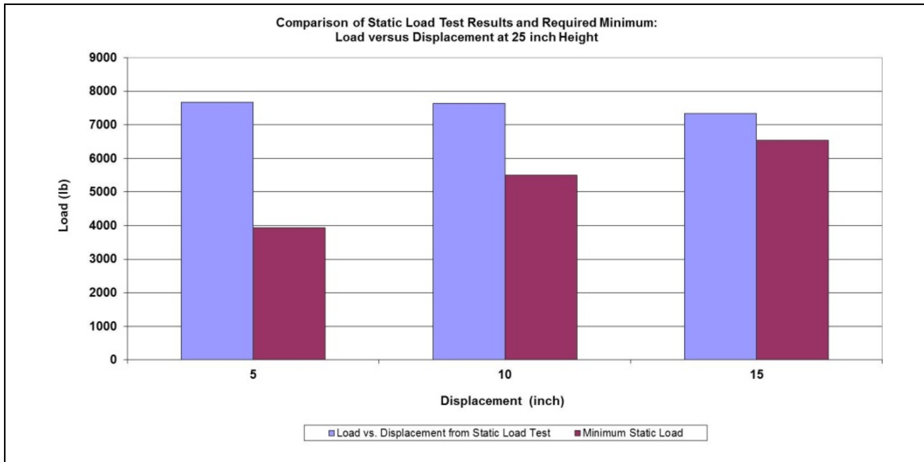
Static Load Setup



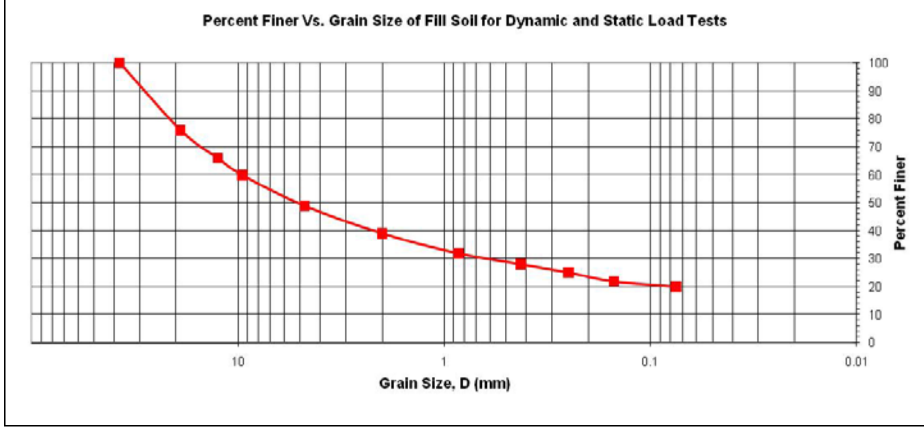
Post Soil Test

Date	May 25, 2012
Test Facility and Site Location	TTI Proving Ground, 3100 SH 47, Bryan, TX
In Situ Soil Description (ASTM D2487)	Sandy gravel with silty fines
Fill Material Description (ASTM D2487) and sieve analysis	AASHTO Grade B Soil-Aggregate (see sieve analysis)
Description of Fill Placement Procedure	6-inch lifts tamped with a pneumatic compactor

Figure C2. Test Day Static Soil Strength Documentation for Test No. 490022-6.




Static Load Setup




Post Soil Test

Date	June 29, 2012
Test Facility and Site Location	TTI Proving Ground, 3100 SH 47, Bryan, TX
In Situ Soil Description (ASTM D2487)	Sandy gravel with silty fines
Fill Material Description (ASTM D2487) and sieve analysis	AASHTO Grade B Soil-Aggregate (see sieve analysis)
Description of Fill Placement Procedure	6-inch lifts tamped with a pneumatic compactor

Figure C3. Test Day Static Soil Strength Documentation for Test No. 490022-8.

APPENDIX D. CRASH TEST NO. 490022-6 (*MASH* TEST 3-20)

D1. TEST VEHICLE PROPERTIES AND INFORMATION

Table D1. Vehicle Properties for Test No. 490022-6.

Date: 2012-05-25 Test No.: 490022-6 VIN No.: KNADE123366068232

Year: 2006 Make: Kia Model: Rio

Tire Inflation Pressure: 32 psi Odometer: 119617 Tire Size: P185/65R14

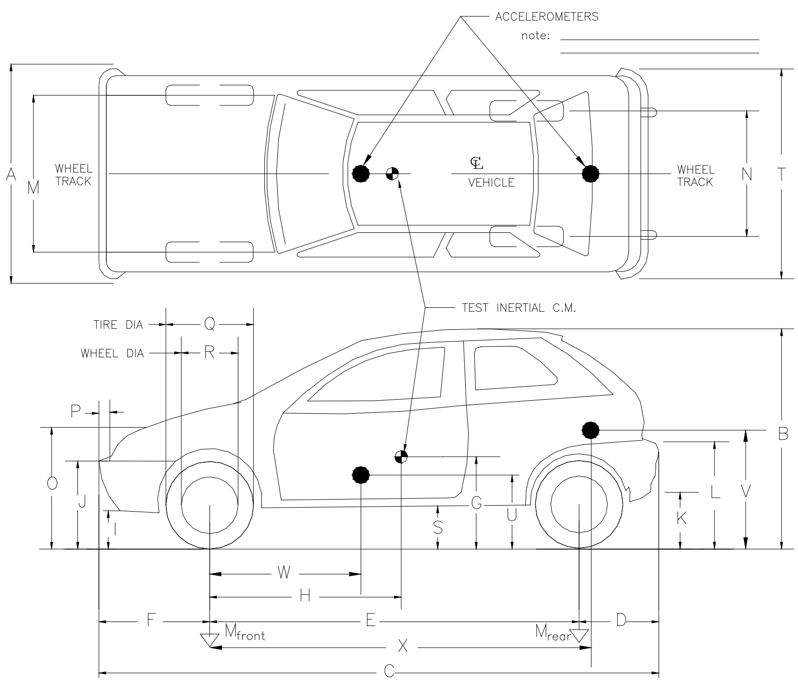
Describe any damage to the vehicle prior to test: ______

● Denotes accelerometer location.

NOTES: ______

Engine Type: 4 cylinder
Engine CID: 1.6 liter
Transmission Type:
x Auto or ____ Manual
x FWD ____ RWD ____ 4WD
Optional Equipment: ______

Dummy Data:
Type: 50th percentile male
Mass: 179 lb
Seat Position: Driver



Geometry: inches

A	66.38	F	33.00	K	11.00	P	4.12	U	15.75
B	57.75	G		L	24.12	Q	22.19	V	21.50
C	165.75	H	34.72	M	57.75	R	15.38	W	39.50
D	34.00	I	7.12	N	57.12	S	7.62	X	108.50
E	98.75	J	21.00	O	30.62	T	66.12		

Wheel Center Ht Front 11.00 Wheel Center Ht Rear 11.00

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	1918	M_{front}	1598	1577	1670
Back	1874	M_{rear}	891	852	932
Total	3638	M_{Total}	2489	2423	2602

Mass Distribution:
lb LF: 763 RF: 808 LR: 460 RR: 392

Table D2. Exterior Crush Measurements for Test No. 490022-6.

Date: 2012-05-25 Test No.: 490022-6 VIN No.: KNADE123366068232

Year: 2006 Make: Kia Model: Rio

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	Front plane at bumper ht	12	12	18	12	8	6	5.5	3	0	-9
2	Side plane at bumper ht	20	11	48	0	1.5	6.75	8.5	9	11	152
	Measurements recorded										
	in inches										

[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).

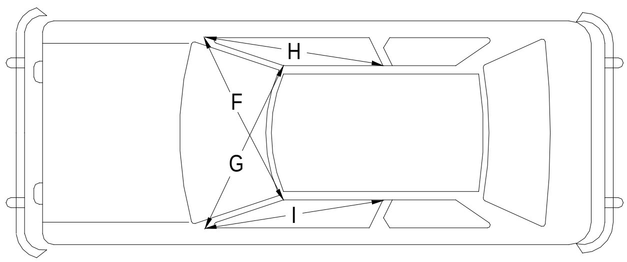
***Measure and document on the vehicle diagram the location of the maximum crush.

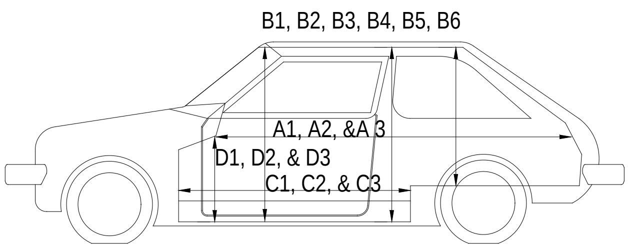
Note: Use as many lines/columns as necessary to describe each damage profile.

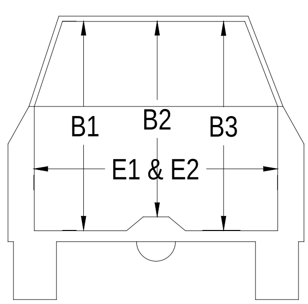
Table D3. Occupant Compartment Measurements for Test No. 490022-6.

Date: 2012-05-25 Test No.: 490022-6 VIN No.: KNADE123366068232

Year: 2006 Make: Kia Model: Rio





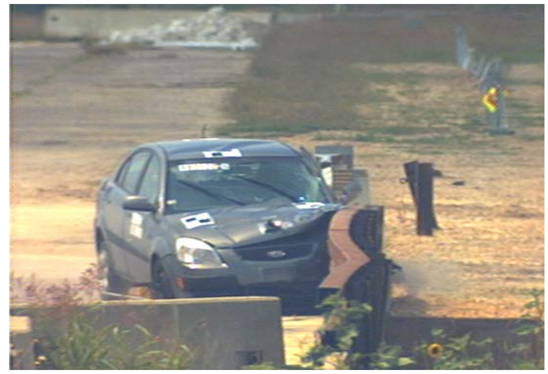


OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before (inches)	**After** (inches)
A1	67.50	67.38
A2	67.50	67.50
A3	67.50	67.50
B1	40.75	40.75
B2	36.75	36.75
B3	40.75	40.75
B4	36.25	36.25
B5	35.75	35.75
B6	36.25	36.25
C1	26.00	26.00
C2	----	----
C3	27.5	27.5
D1	9.75	9.75
D2	----	----
D3	9.50	9.50
E1	51.00	48.50
E2	51.00	52.25
F	51.00	51.00
G	51.00	50.00
H	37.00	37.00
I	37.00	37.00
J*	50.75	50.50

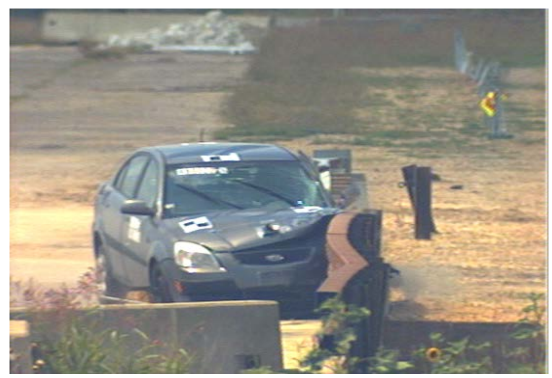
*Lateral area across the cab from
driver's side kickpanel to passenger's side kickpanel.

D2. SEQUENTIAL PHOTOGRAPHS


0.000 s



0.060 s



0.120 s
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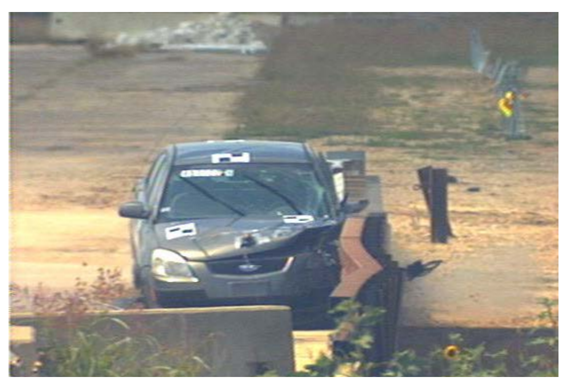
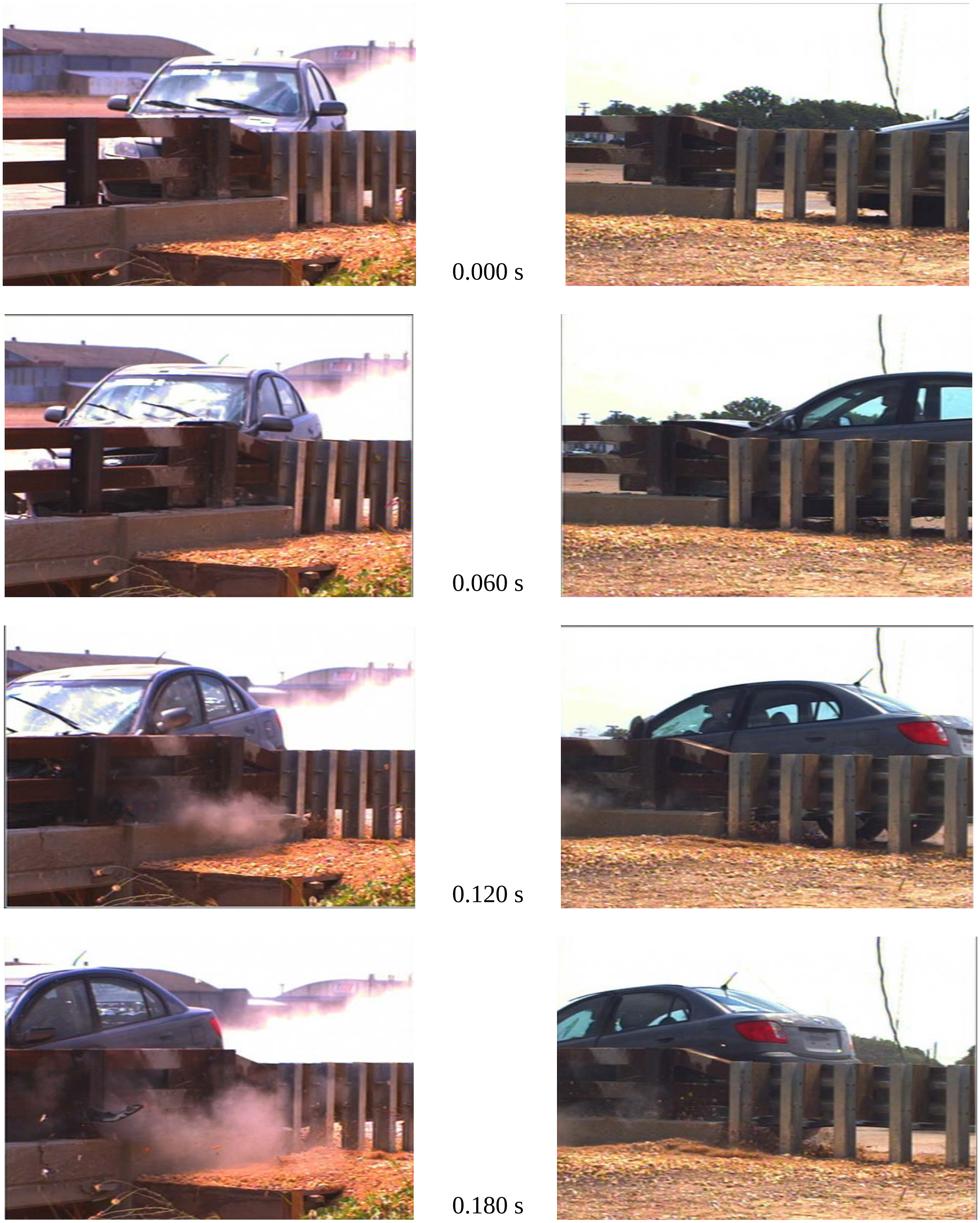


Figure D1. Sequential Photographs for Test No. 490022-6 (Overhead and Frontal Views).

Figure D1. Sequential Photographs for Test No. 490022-6 (Overhead and Frontal Views) (continued).



0.000 s

0.060 s

0.120 s

0.180 s

Figure D2. Sequential Photographs for Test No. 490022-6 (Field Side Transition Views).

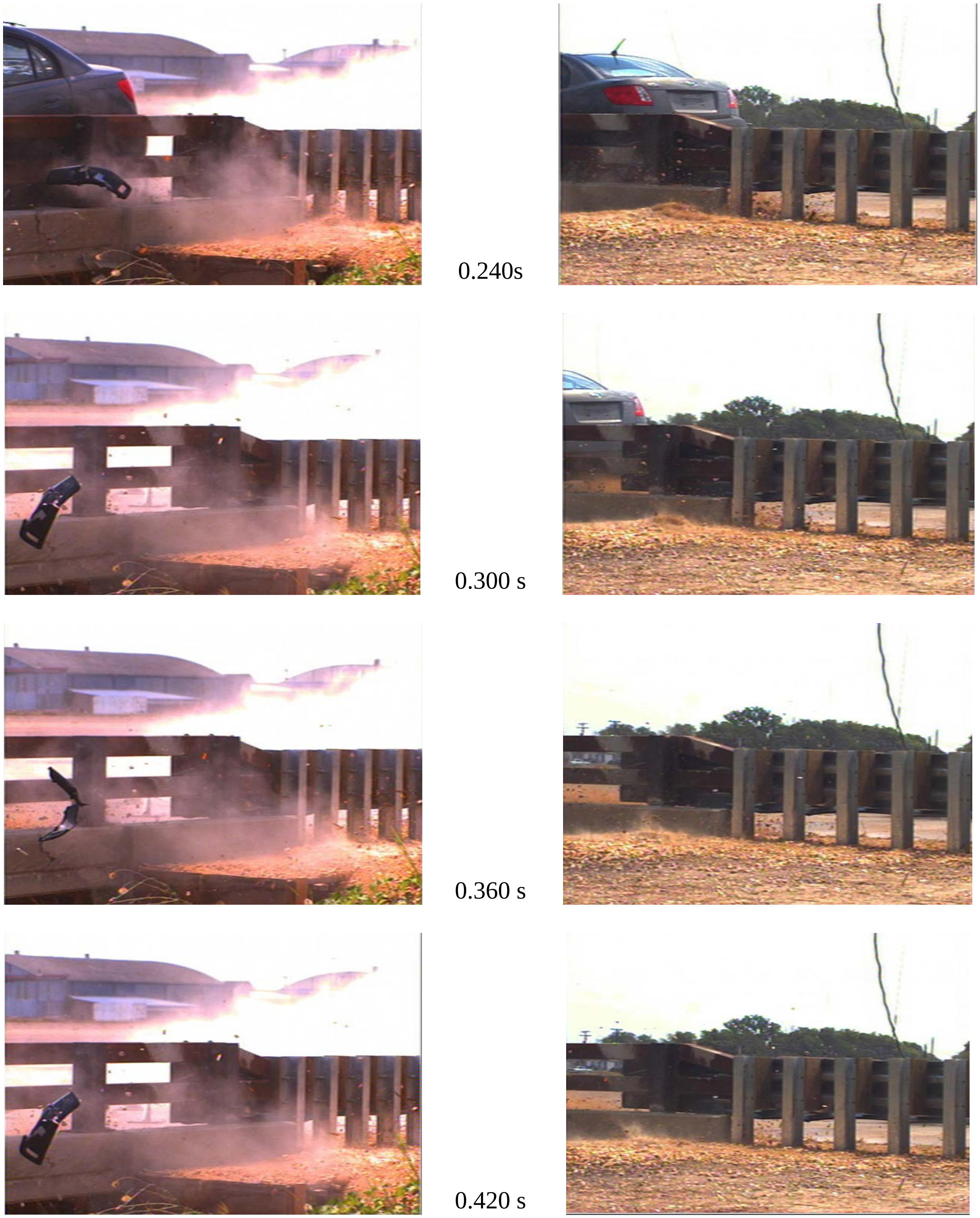


Figure D2. Sequential Photographs for Test No. 490022-6 (Field Side Transition Views) (continued).

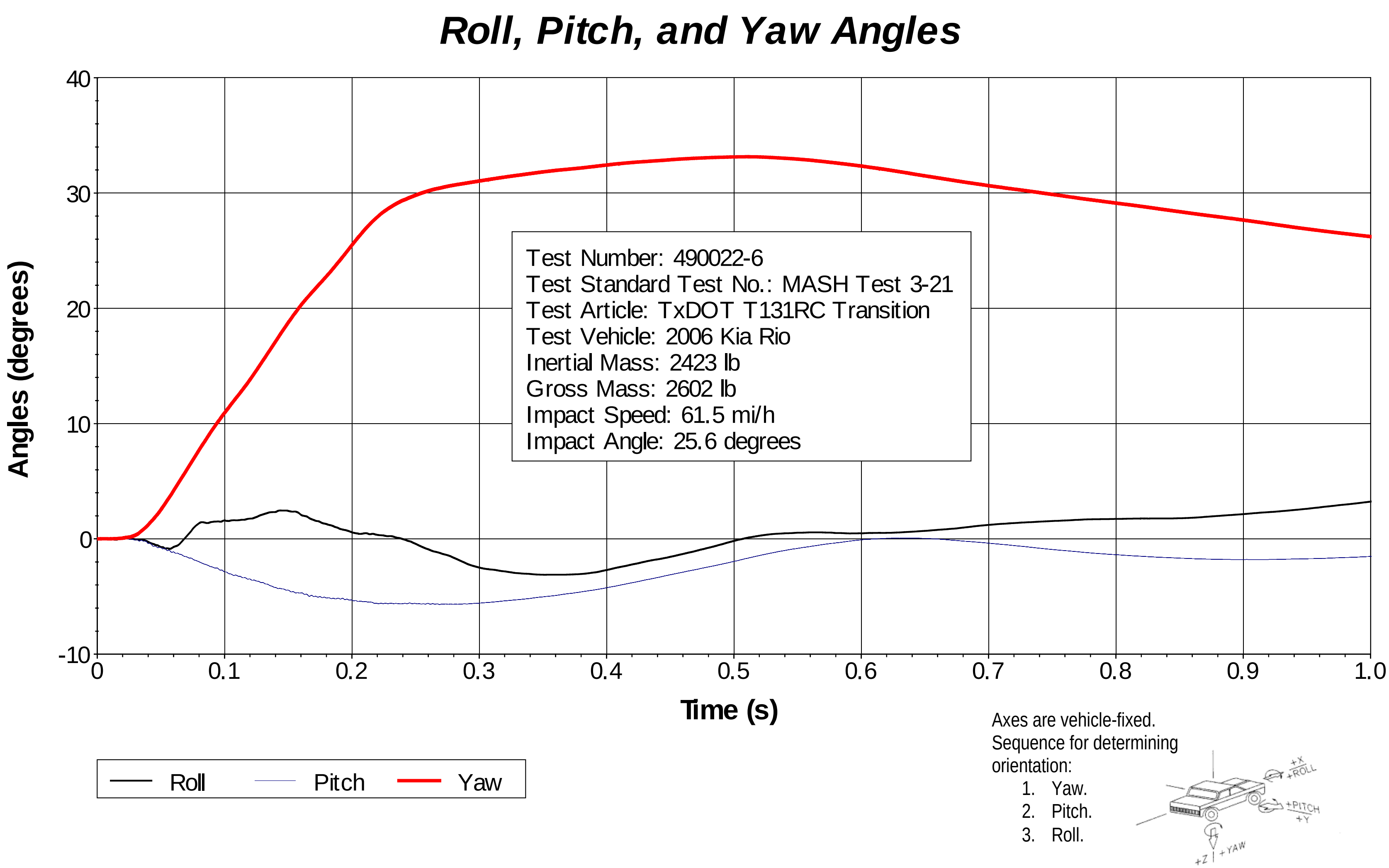


Figure D3. Vehicle Angular Displacements for Test No. 490022-6.

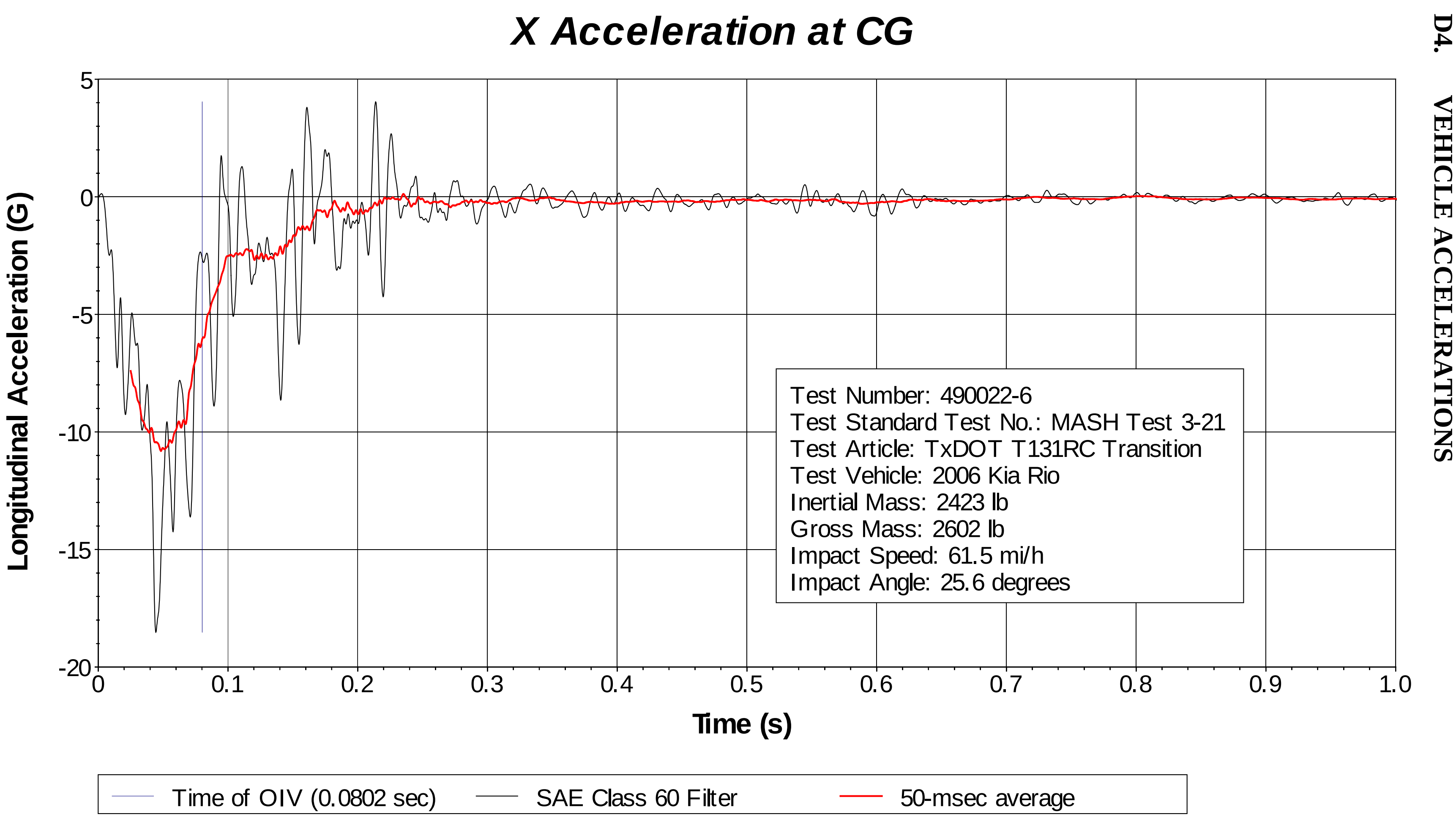


Figure D4. Vehicle Longitudinal Accelerometer Trace for Test No. 490022-6 (Accelerometer Located at Center of Gravity).

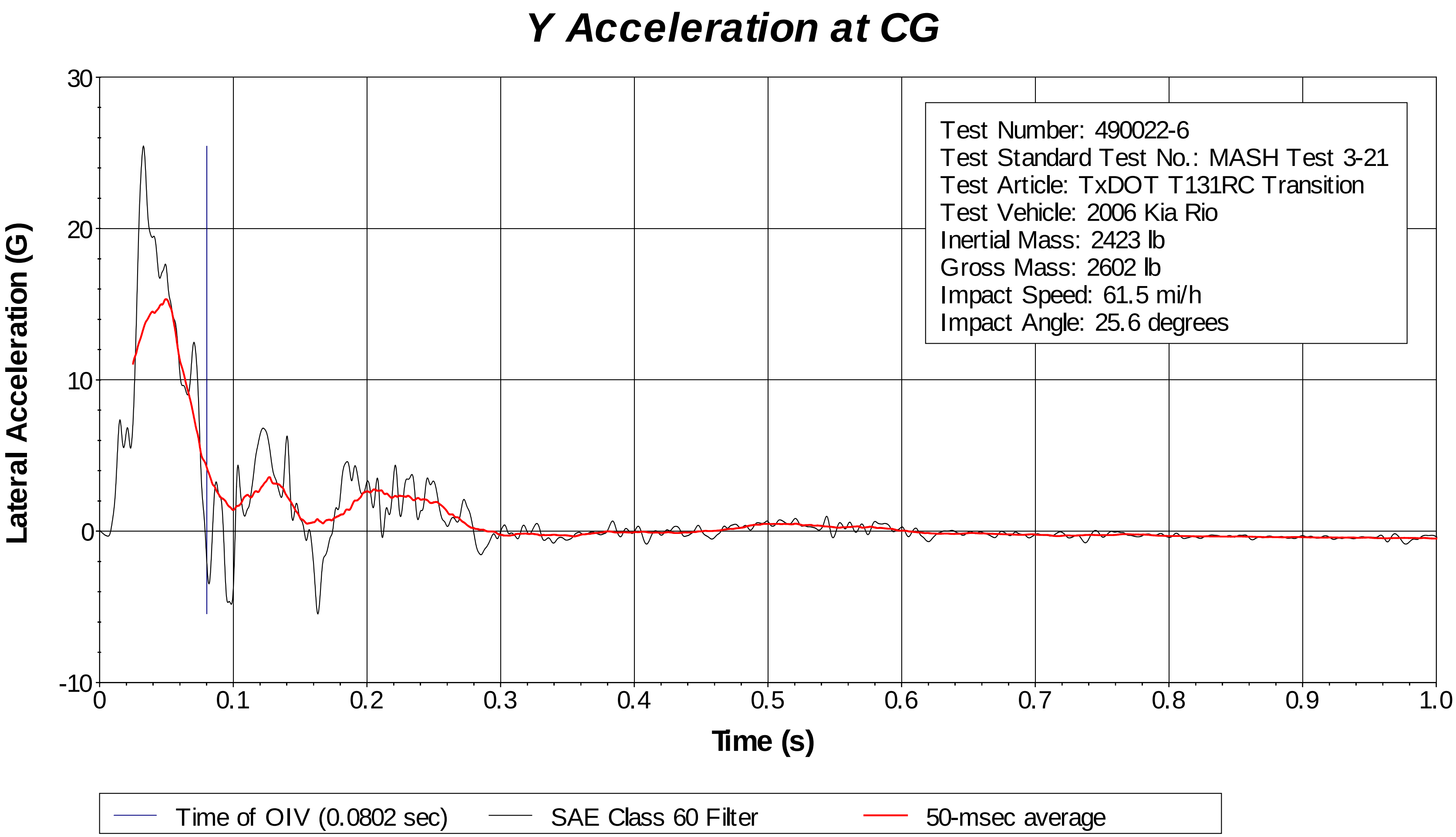


Figure D5. Vehicle Lateral Accelerometer Trace for Test No. 490022-6 (Accelerometer Located at Center of Gravity).

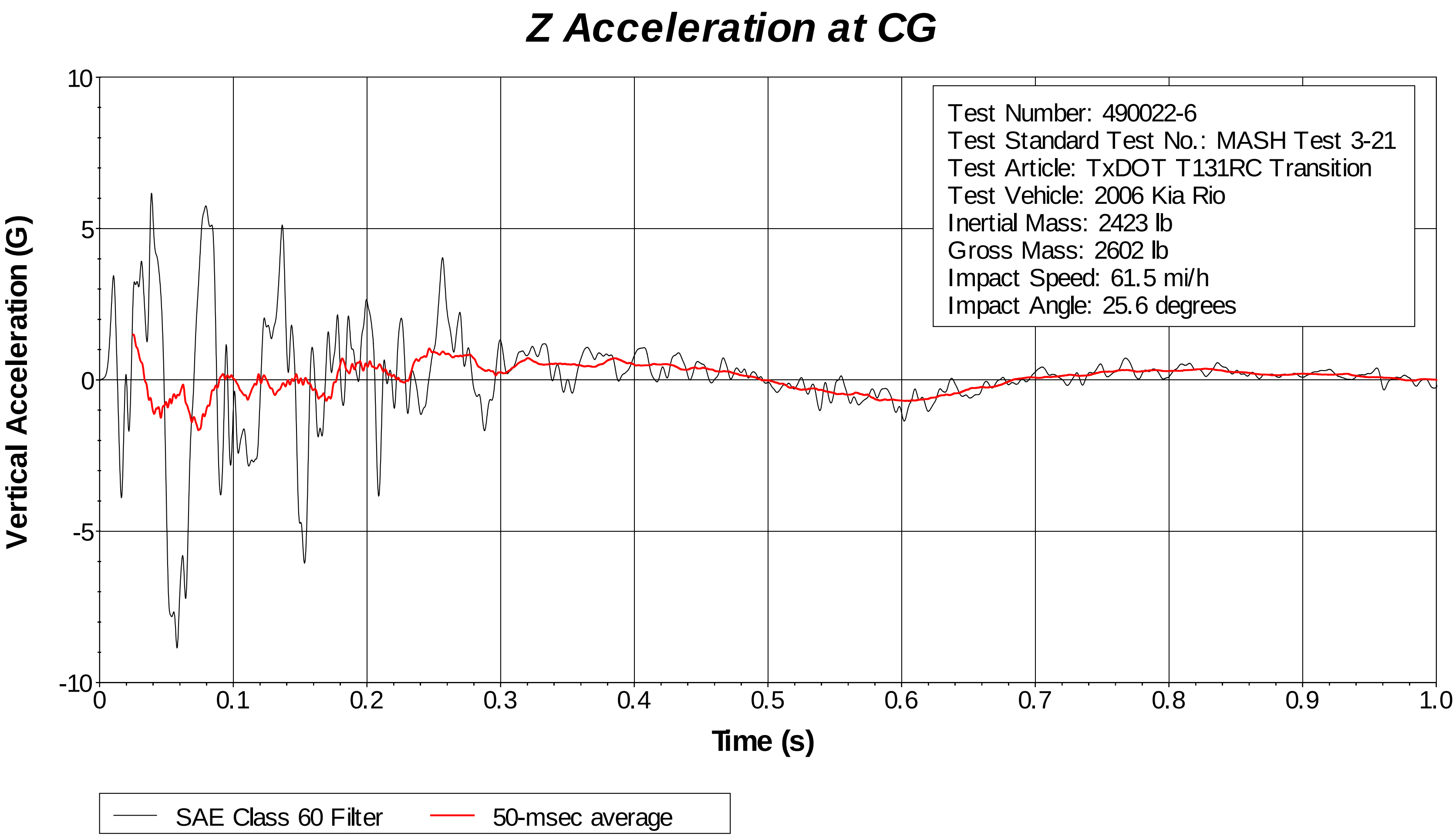


Figure D6. Vehicle Vertical Accelerometer Trace for Test No. 490022-6 (Accelerometer Located at Center of Gravity).

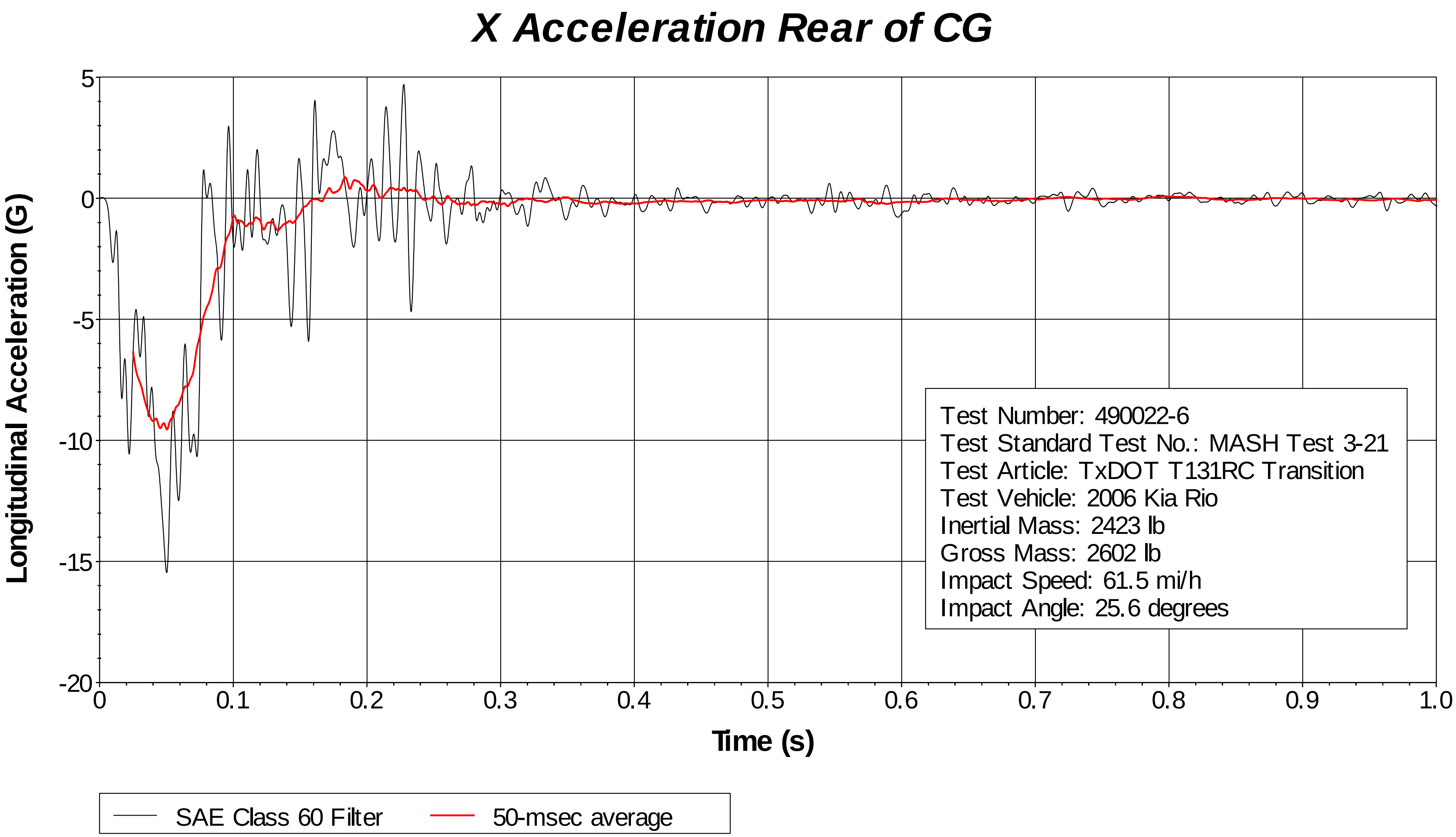


Figure D7. Vehicle Longitudinal Accelerometer Trace for Test No. 490022-6 (Accelerometer Located Rear of Center of Gravity).

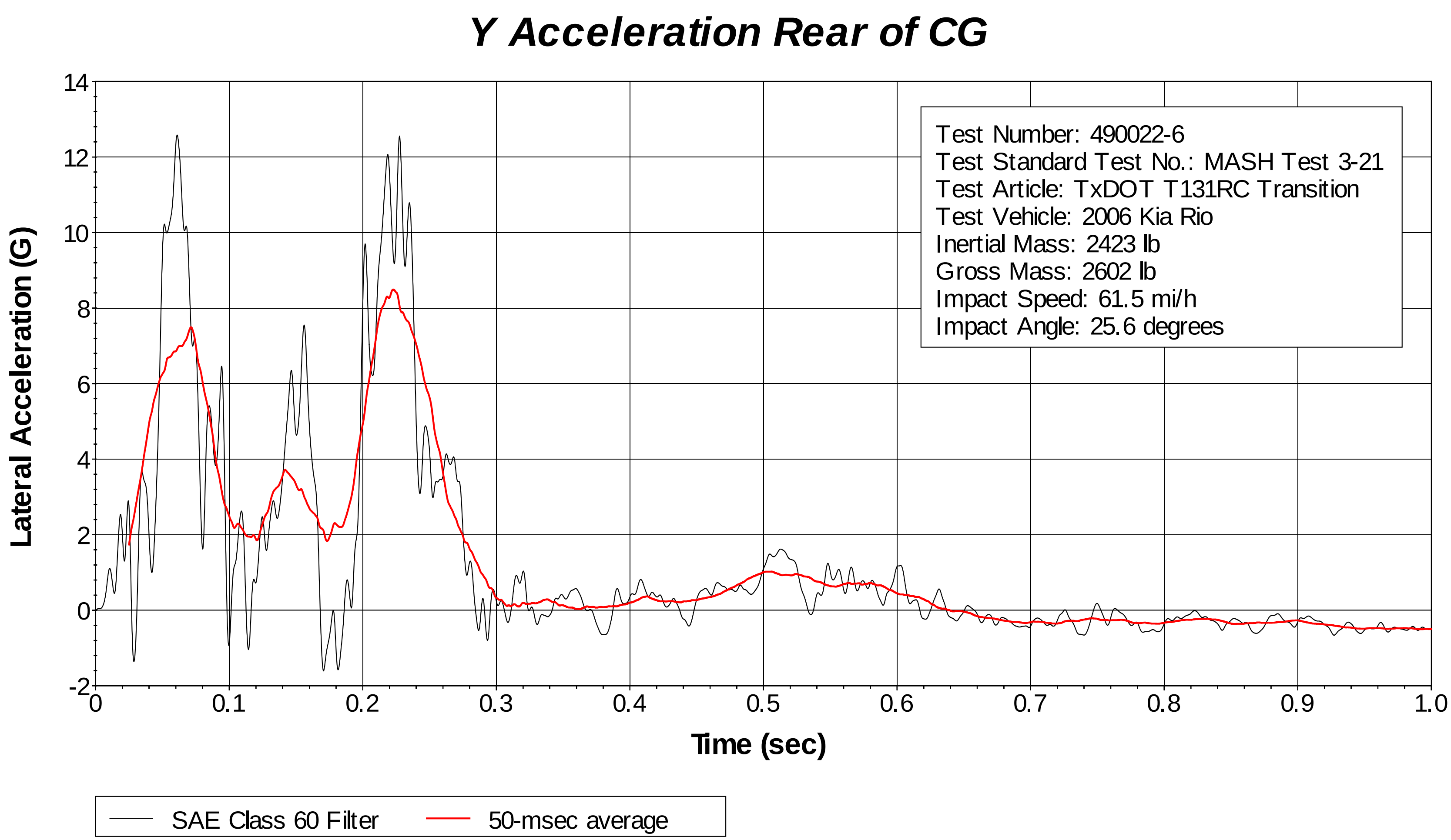


Figure D8. Vehicle Lateral Accelerometer Trace for Test No. 490022-6 (Accelerometer Located Rear of Center of Gravity).

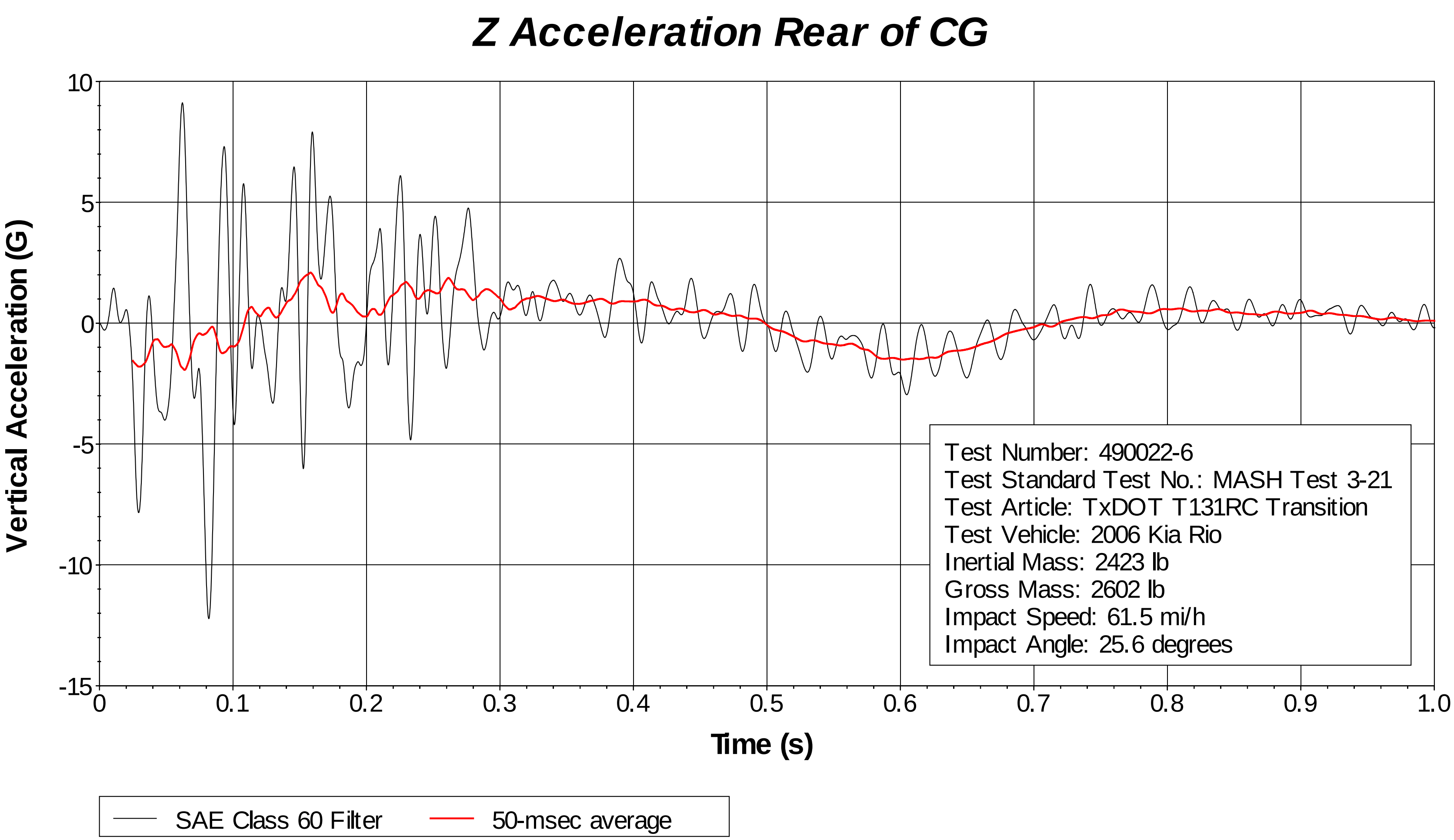


Figure D9. Vehicle Vertical Accelerometer Trace for Test No. 490022-6 (Accelerometer Located Rear of Center of Gravity).

APPENDIX E. CRASH TEST NO. 490022-8 (*MASH* TEST 3-21)

E1. TEST VEHICLE PROPERTIES AND INFORMATION

Table E1. Vehicle Properties for Test No. 490022-8.

Date: 2012-06-29 Test No.: 490022-8 VIN No.: 1DTHA18218J04150

Year: 2008 Make: Dodge Model: Ram 1500

Tire Size: 265/70R17 Tire Inflation Pressure: 35 psi

Tread Type: Highway Odometer: 139849

Note any damage to the vehicle prior to test: ____

● Denotes accelerometer location.

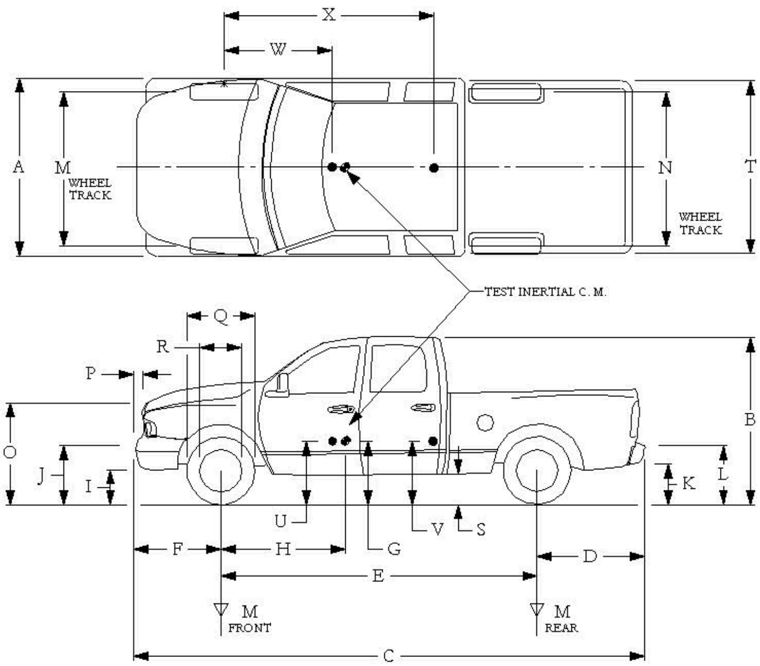
NOTES: ____

Engine Type: V-8
Engine CID: 5.7 liter

Transmission Type:
x Auto or ____ Manual
____ FWD x RWD ____ 4WD

Optional Equipment: ____

Dummy Data:
Type: No dummy
Mass: ____
Seat Position: ____



Geometry: inches

A	78.25	F	36.00	K	20.50	P	2.88	U	28.50
B	75.00	G	29.00	L	29.12	Q	31.25	V	29.50
C	223.75	H	61.21	M	68.50	R	18.38	W	59.50
D	47.25	I	13.75	N	68.00	S	12.00	X	78.00
E	140.50	J	25.38	O	44.50	T	77.50		

Wheel Center Height Front	14.75	Wheel Well Clearance (Front)	5.00	Bottom Frame Height - Front	17.125
Wheel Center Height Rear	14.75	Wheel Well Clearance (Rear)	10.25	Bottom Frame Height - Rear	24.75

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2870	2830	
Back	3900	M_{rear}	2152	2185	
Total	6700	M_{Total}	5022	5015	

Mass Distribution:
lb LF: 1426 RF: 1404 LR: 1069 RR: 1116

Table E2. Vehicle Parametric Measurements for Vertical CG.

Date: 2012-06-29 Test No.: 490022-8 VIN: 1DTHA18218J04150

Year: 2008 Make: Dodge Model: Ram 1500

Body Style: Quad Cab Mileage: 139849

Engine: 5.7 liter V-8 Transmission: Automatic

Fuel Level: Empty Ballast: 80 lbs in front of bed (440 lb max)

Tire Pressure: Front: 35 psi Rear: 35 psi Size: 265/70R17

Measured Vehicle Weights:		(lb)						
LF:	1426		RF:	1404		Front Axle:	2830	
LR:	1069		RR:	1116		Rear Axle:	2185	
Left:	2495		Right:	2520		Total:	5015	
						5000 ±110 lb allowed		
Wheel Base:		140.5	inches	Track: F:	68.5	inches R:	68	inches
	148 ±12 inches allowed				Track = (F+R)/2 = 67 ±1.5 inches allowed			
Center of Gravity, SAE J874 Suspension Method								
X:	61.21	in	Rear of Front Axle		(63 ±4 inches allowed)			
Y:	0.17	in	Left -	Right +	of Vehicle Centerline			
Z:	29	in	Above Ground		(minumum 28.0 inches allowed)			

Hood Height: 44.50 inches Front Bumper Height: 25.375 inches

43 ±4 inches allowed

Front Overhang: 36.00 inches Rear Bumper Height: 29.125 inches

39 ±3 inches allowed

Overall Length: 223.75 inches

237 ±13 inches allowed

Table E3. Exterior Crush Measurements for Test No. 490022-8.

Date: 2012-06-29 Test No.: 490022-8 VIN No.: 1DTHA18218J04150

Year: 2008 Make: Dodge Model: Ram 1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

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

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
Measurements not taken due to impact with secondary barrier.											

[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).

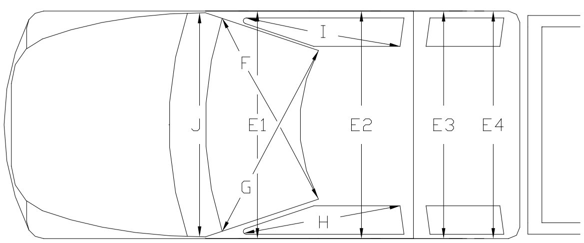
***Measure and document on the vehicle diagram the location of the maximum crush.

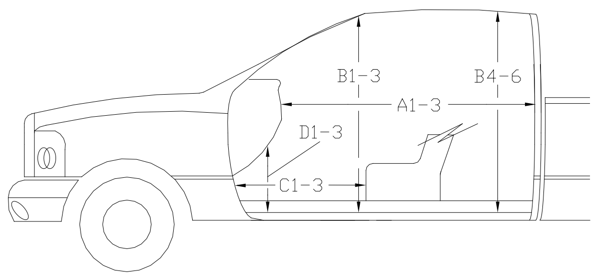
Note: Use as many lines/columns as necessary to describe each damage profile.

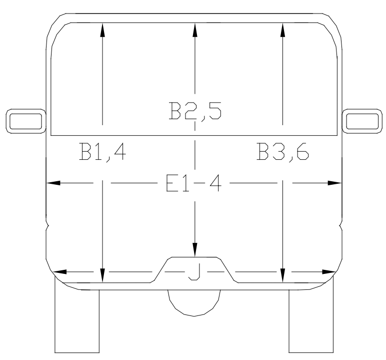
Table E4. Occupant Compartment Measurements for Test No. 490022-8.

Date: 2012-06-29 Test No.: 490022-8 VIN No.: 1DTHA18218J04150

Year: 2008 Make: Dodge Model: Ram 1500







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

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before (inches)	**After** (inches)
A1	65.00	65.00
A2	64.50	64.50
A3	65.00	65.00
B1	45.50	45.50
B2	39.12	39.12
B3	45.50	45.50
B4	42.12	42.12
B5	42.62	42.62
B6	42.12	42.12
C1	29.00	29.00
C2	----	----
C3	27.00	27.00
D1	12.88	12.88
D2	----	----
D3	11.75	11.75
E1	62.75	62.50
E2	64.50	64.50
E3	64.12	64.12
E4	64.12	64.12
F	60.00	60.00
G	60.00	60.00
H	39.00	39.00
I	39.00	39.00
J*	62.00	61.88

E2. SEQUENTIAL PHOTOGRAPHS

0.000 s

0.060 s

0.120 s

0.180 s

Figure E1. Sequential Photographs for Test No. 490022-8 (Overhead and Frontal Views).

0.240 s

0.300 s

0.360 s

Vehicle out of view

0.420 s

Figure E1. Sequential Photographs for Test No. 490022-8 (Overhead and Frontal Views) (continued).

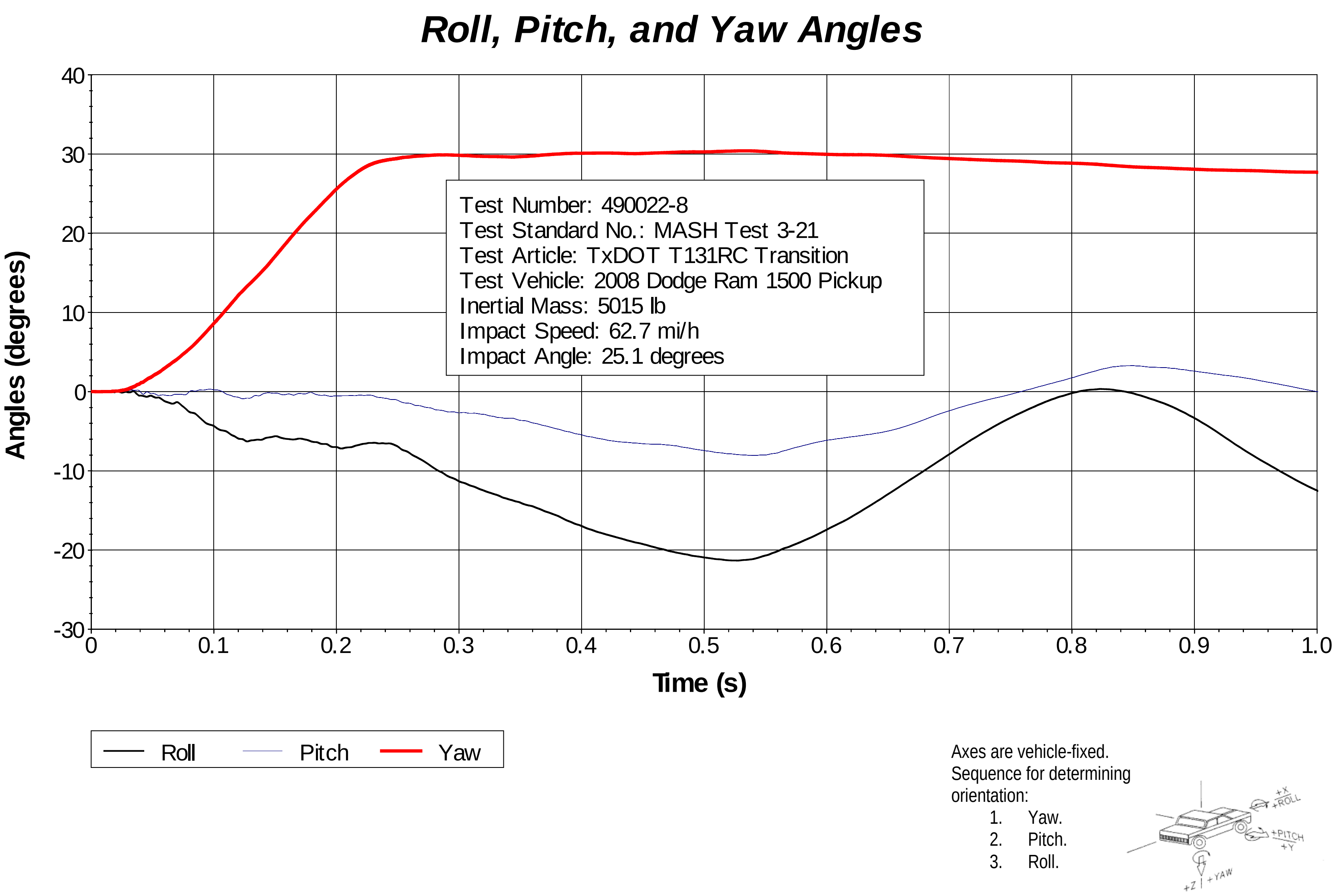


Figure E2. Vehicle Angular Displacements for Test No. 490022-8.

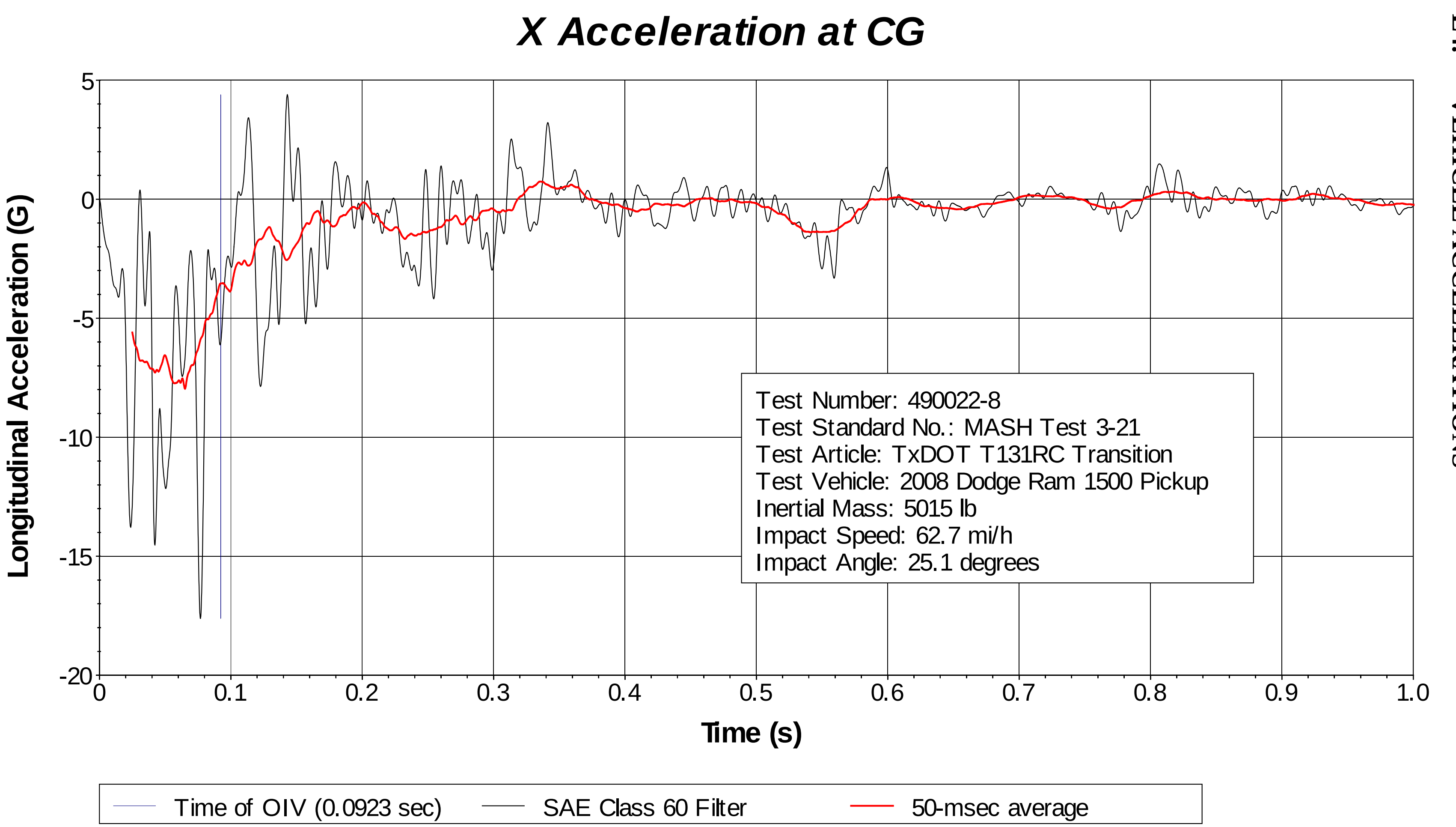


Figure E3. Vehicle Longitudinal Accelerometer Trace for Test No. 490022-8 (Accelerometer Located at Center of Gravity).

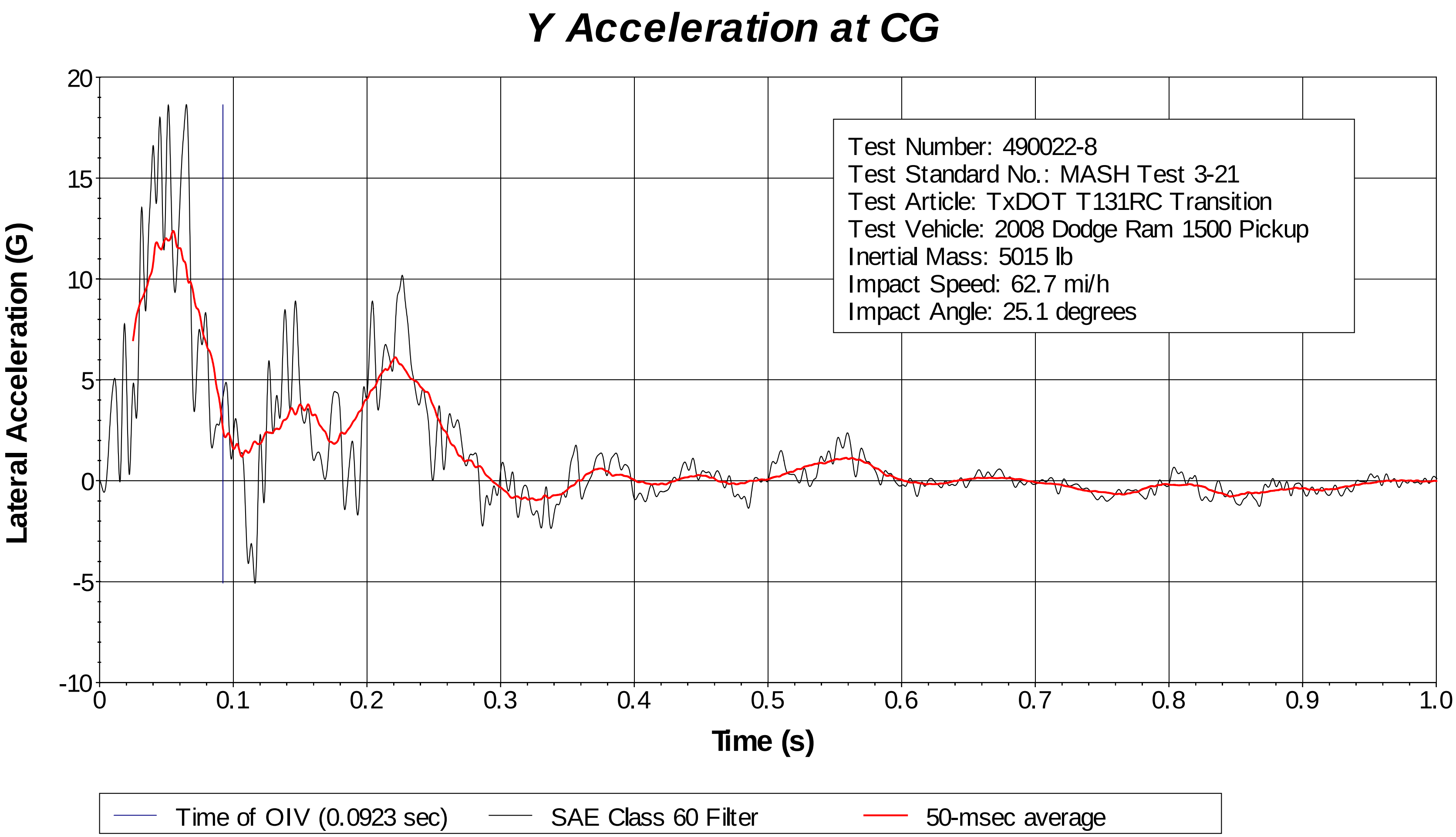


Figure E4. Vehicle Lateral Accelerometer Trace for Test No. 490022-8 (Accelerometer Located at Center of Gravity).

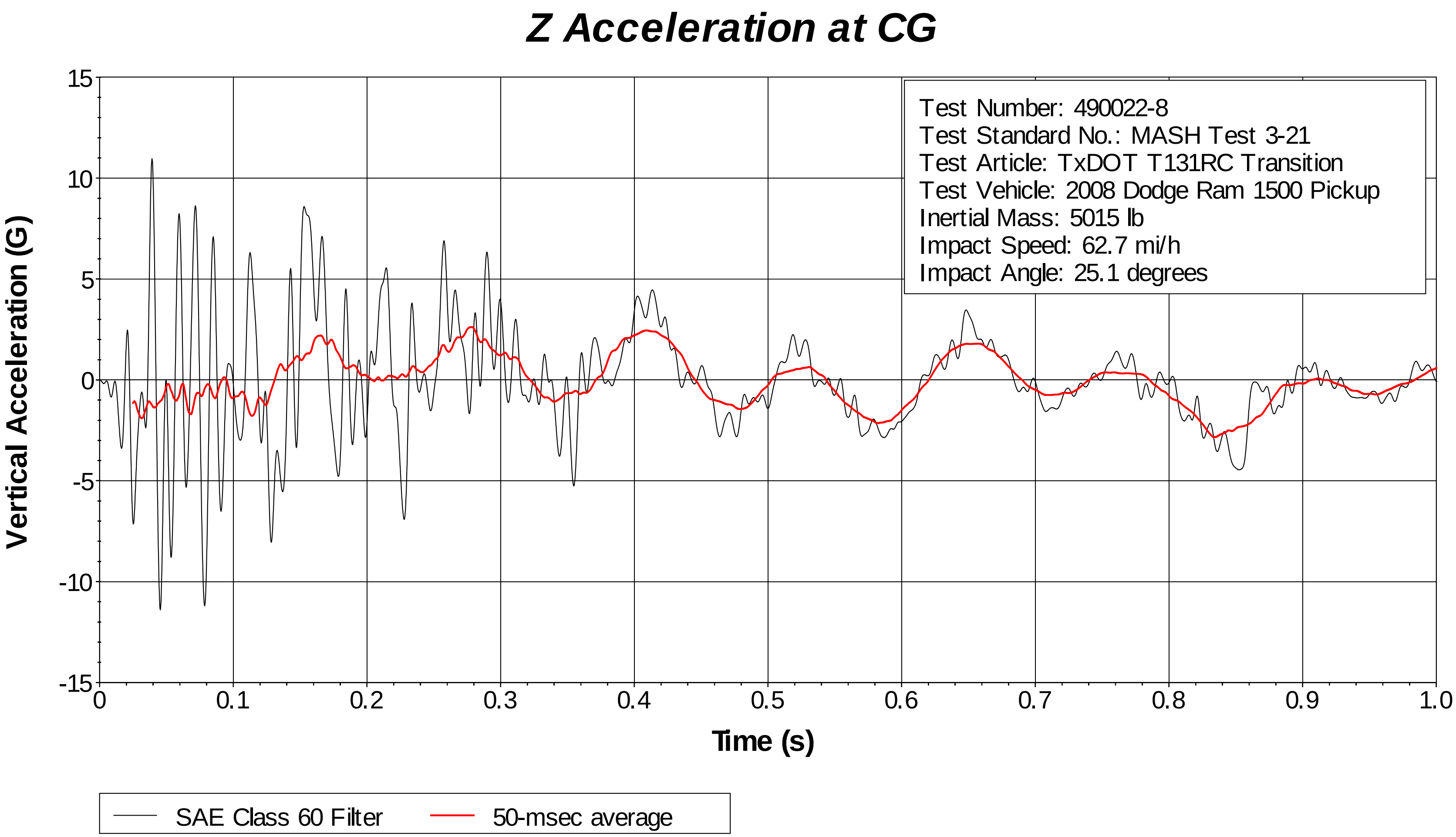


Figure E5. Vehicle Vertical Accelerometer Trace for Test No. 490022-8 (Accelerometer Located at Center of Gravity).

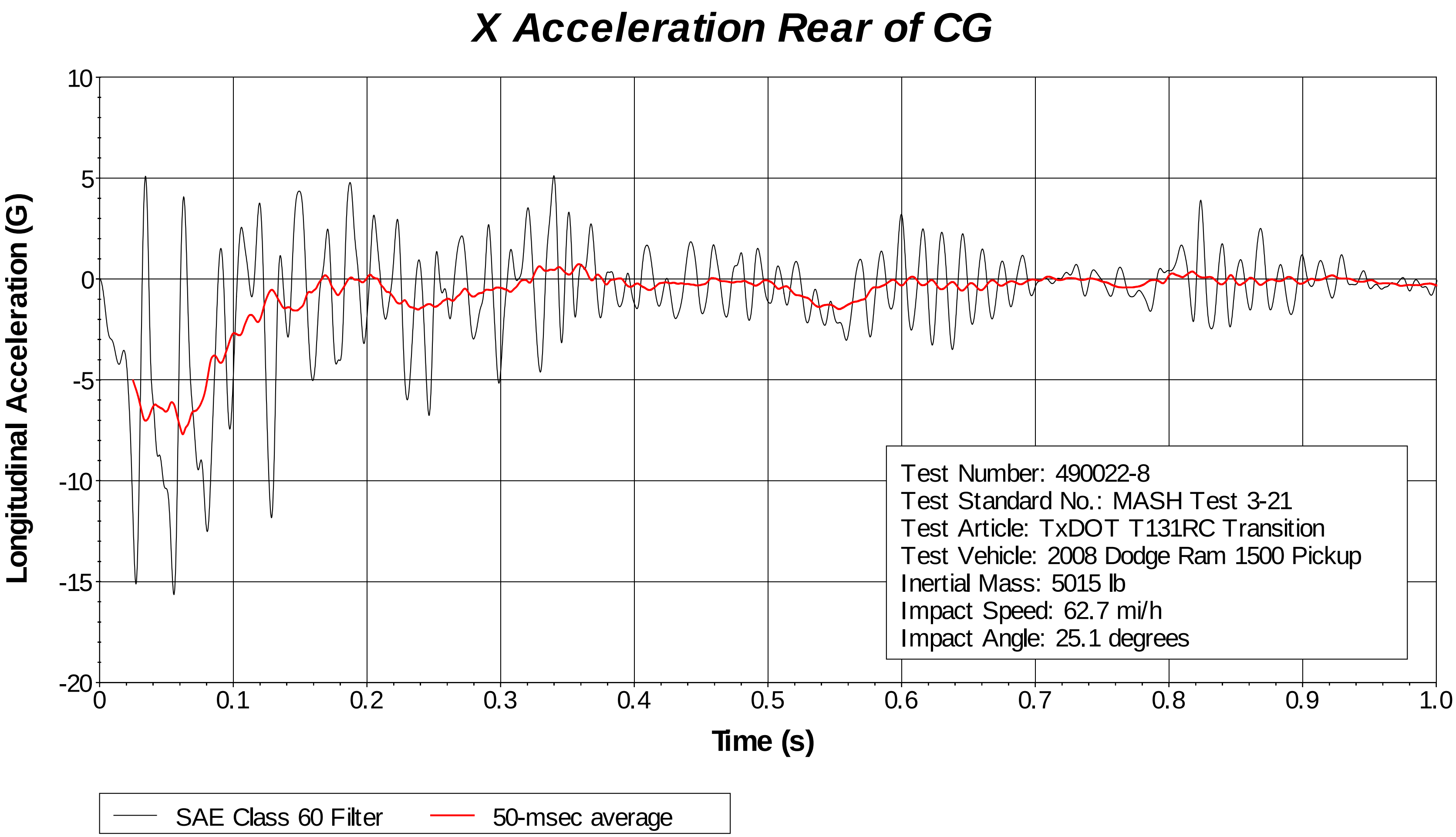


Figure E6. Vehicle Longitudinal Accelerometer Trace for Test No. 490022-8 (Accelerometer Located Rear of Center of Gravity).

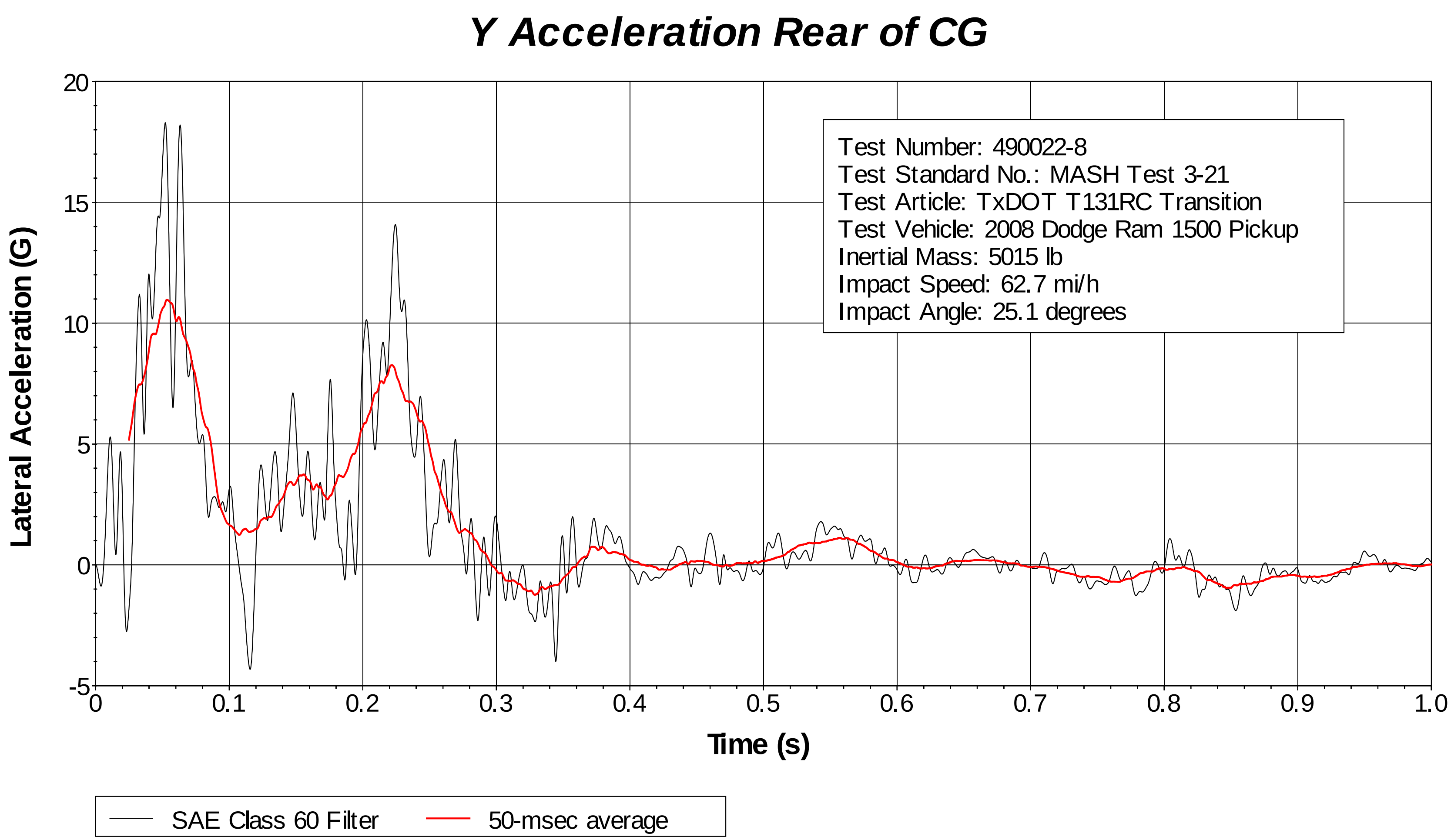


Figure E7. Vehicle Lateral Accelerometer Trace for Test No. 490022-8 (Accelerometer Located Rear of Center of Gravity).

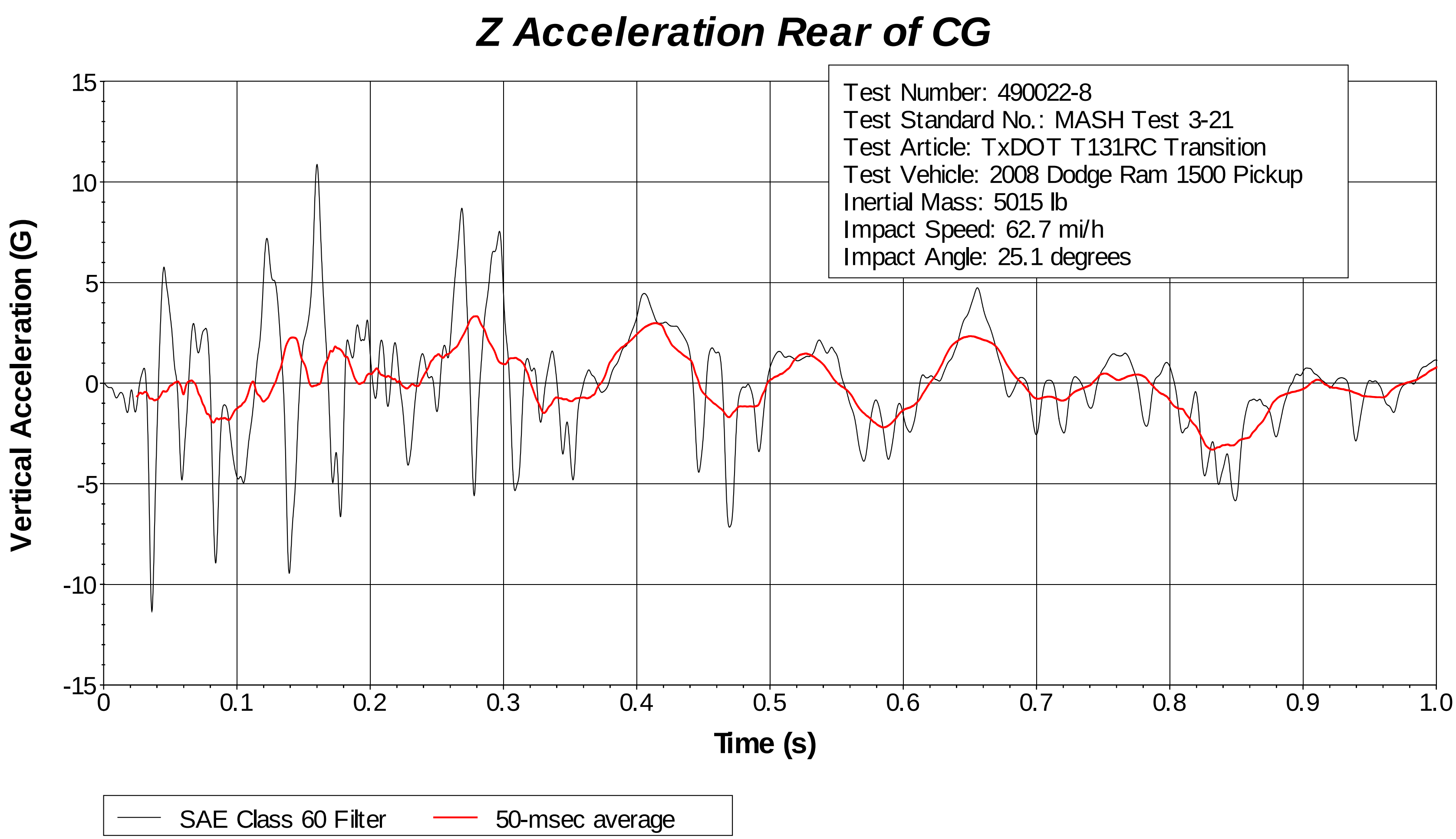


Figure E8. Vehicle Vertical Accelerometer Trace for Test No. 490022-8 (Accelerometer Located Rear of Center of Gravity).